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The Andean Camelids, Llama and Alpaca

The Potentials and Prerequisites for Introducing these Animals into Other Mountain Environments

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PREFACE

The Andean mountains are well-known for promising plant and animal resources, among which *alpacas* and *llamas* are an outstanding example. Well-adapted to the high mountain farming systems, they also have a potential for improving the high mountain agro-pastoral farming systems of the Hindu Kush-Himalayan Region. Keeping this in mind, the Mountain Farming Systems' Programme of ICIMOD has accumulated some preliminary information about these Andean animals.

Two exploratory surveys of the Andean highland areas have been carried out by the MFS coordinating staff to acquire first hand information about the habitat and the farming systems of the Andean highlands, of which these camelids are an integral part. The awareness training facilities of some of the Andean Camelid Research Centres were also assessed in the context of the possibility of providing short-term training programmes for animal husbandry experts from the HKH countries.

Further, as a part of this exercise, a team of Andean camelid experts was engaged to prepare this report on the potentials and prerequisites for introducing these animals into the HKH Region. To facilitate appropriate decision-making among interested agencies in the HKH, the study has focussed on the science and management of these animals.

It is hoped that this document will generate interest in Andean camelids among several development agencies in the HKH countries and serve as a guideline for the future activities of the MFS Division in this area.

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PART A

PROSPECTS AND POTENTIALS OF ANDEAN DOMESTIC CAMELIDS IN HIGH MOUNTAIN ECOSYSTEMS: THE ANDEAN EXPERIENCE

Andean Camelids as Part of the Andean Highland Agroecosystem

Evolution of Andean Agroecosystems

Amerindian man arrived in the Andean Region from the northern part of the continent in successive migratory waves around 15,000 to 20,000 years ago. The subsistence strategy of this early settler was based on hunting and gathering, with a concentration on lamoids, cervids, and rodents. Whether these primitive hunters had a transhumant pattern with an oscillatory highland-lowland movement pattern or a rather upland sedentary settlement pattern is still a matter of controversy among contemporary archaeologists.

Whatever the case, over a 10,000 year period, increased dependency on lamoid and rodent (*Cavia porcellus L.*) hunting and highland tuber and chenopod collection led to a gradual simultaneous process of plant and animal domestication. The archaeological records confirm domestication of the *llama* and *alpaca* by 4,000 B.C. (for further information on camelid evolution and domestication please refer to Part B of this document).

The Andean traditional subsistence system is strongly based on a highly developed pattern of diversification of resource exploitation. A strategy for simultaneous exploitation of as many resources as possible along the dramatically differentiated altitudinal levels has being pointed out as the cultural "ideal" of the Andean indigenous households (Troll 1935 and Murra 1972). This so-called "vertical ecology" orientation of productive activities refers to both domesticated and wild biotic resources, as well as to other non-renewable resources (salt and minerals). It is certainly related to the agropastoral character of the traditional subsistence strategies.

The Andean traditional peasant society, principally oriented to assure security and self-sufficiency in a harsh and unpredictable environment, organises its productive activities through a strategy oriented to diversify as much as possible. Households located in deep valleys will, traditionally, have direct access to each soil and microclimatic condition through an extremely fractioned pattern of land ownership, comprised of as many altitudinal levels as possible. Only grazing lands located between the snow line (somewhere around 5,000masl) and the uppermost limits of cultivation (4,000 to 4,200masl) tend to be communally owned. In several regions, indigenous communities lost their pasturelands as a result of the encroachment of large ranches (*haciendas*) which were initially granted to Spanish conquerors (*conquistadores*) during the colonial period (1530s through 1820s). Some large landholdings were also consolidated or developed as privately-owned properties during the first century of contemporary republican history.

The uppermost agricultural belt (with its lowermost limit at between 3,800 to 4,000masl) is usually devoted to the cultivation of native varieties of "bitter" potatoes (*papa luki*) grown for preparation of *chuño*, a storable freeze-dried product, the Andean chenopods -- *quinoa* and *cañihua* (*Chenopodium quinoa* and *C. cañihua* respectively) and, more recently, wheat and barley. In this area, land is usually farmed once every six years and then left fallow. During the resting period, the land is open for grazing, thus enriching its soil with animal dung. Because of high altitude conditions, dung decomposition is slow and its contribution to soil fertility persists over many years.

Right under this uppermost agricultural production zone lies the most important food production belt of the Andes: the areas used for Andean tuber crops, principally potatoes, represented by many cultivars - of which close to 15,000 have been identified by the International Potato Centre- grown as a monocrop or with other Andean tuber crops; such as *ocas* (*Oxalis tuberosa*), *ollucos* or *lisas* (*Ollucus tuberosus*), *mashua* or *izaño* (*Tropaeolum tuberosum*). Potatoes in their many varieties are, however, the Andean staple. Other important crops at this level are broad beans (*Vicia faba*) of European origin, *tarhui* or *chocho* (*Lupinus* sp.), and vegetables of European origin (cabbage, carrots). The lowermost limit of this production zone is marked by the uppermost limit of maize (around 3,200masl). From there on below, native varieties of corn dominate the predominantly sloping landscape. Many of these areas have been carefully terraced. Corn is also the main crop on the flat bottom lands.

Traditionally corn and Andean squashes (*cucurbits*) are also grown in association with beans (*Phaseolus* sp.). Other crops usually grown in association with maize are *yacón* (*Polymnia sonchifolia*), *racacha* or *virraca* (*Racacia xhanthorriza*), and *mauka* (*Mirabilis expansa*).

As we descend into the tropical humid, lowland valleys along the eastern slope of the Central Andes, the sacred coca plant (*Erythroxylon coca*) became the main crop for farming on rather unappropriate lands. Coca leaves (nowadays a perverted commodity due to the illicit demand for cocaine, one of its fourteen alkaloids), traditionally chewed for its energetic properties, in addition to being a mild stimulant like betel nut, played a critical role in the pre-Columbian non-monetary economy. Coca leaves used in old style non-monetary barter and trade operated as a *cuasi* (coin) and played a crucial role in articulating different production zones. It was also important for traditional medicine and religious rituals.

During the last five decades the traditional subsistence strategies -- already under stress and in the process of transformation since Spanish colonisation -- underwent substantial changes as a result of several factors. Above all, the pressures of a market economy, the new demand for agricultural products from growing urban centres, the introduction of new crops and farming technologies (many of which proved inappropriate, inefficient, or, furthermore, disruptive) brought many changes into the system. In addition, policies unfavourable to farmers, and principally conceived to favour urban dwellers, and induced modernisation in the cities triggered rural to urban migration. Despite persistent population growth rates (depending on the country, from 2 to 3% in the cities and from 3 to 5% in the countryside), migration into coastal towns and cities, as well as into colonisation fronts in the eastern Amazonian lowlands, has prompted rural depopulation, farm abandonment, and a steady productivity drop. The most hard hit amongst subsistence strategies has been traditional farming, unable to meet cash demands and incapable of facilitating farmers with access to modernisation (schools, health, and communication systems).

The Place of Camelids in the Andean Agroecosystem and in Andean Culture

Since their domestication along with plants, camelids have played a critical role in the Andean agroecosystem. In the cold Andean highlands, as well as along parts of the Pacific Coast, the *alpaca* is the most important source of wool. The *llama*, also a secondary provider of wool, has become a most efficient pack animal, enabling the transportation of goods over long distances. As still occurs today in traditional villages, both species were a very important source of manure for agriculture, which also served as fuel in the high treeless *puna* environment. Although meat has always been considered of secondary importance in the Andean diet, salted and freeze-dried camelid meat is an eventual but important source of high quality protein.

Camelid bones provide the prime matter for work utensils and beautifully crafted items, while sinews are turned into thongs. Camelid lard, in addition to acknowledged health properties in the rich Andean medical lore, still plays an important role in religious rituals. Camelid foetuses, resulting from natural abortion -- a common trait in SACs (South American Camelids) are sold in rural markets and are widely used in fertility rites. Similarly, stone formations in the SAC digestive system--*bezoares*-- are considered to be charms and are believed to have magical properties.

Finally, and not the least important, SACs have always been an abundant source of images and concepts in the rich and metaphorical Andean ancestral mythology. Herders state that *"we take care of our animals and they take care of us"* (Palacios 1977), showing the strong interdependence between animals and humans. Peasants believe that *pachamama* (mother earth) gave SACs to men as a loan, and that the future of humanity depends on the proper conservation of herds. They believe lamoids originated in the underworld and came out from water springs. At the end of the world they will all return to those sacred springs. A sign that the end of the world is approaching, they say, will be the depletion of the *alpaca*.

Myth and rite also play an important role in enhancing animal fertility through propitiatory ceremonies that are part of the activities associated with mating and with controlling herd size through animal sacrifice during the dry season.

The Andean Agroecosystem: Camelids and Energy Flow

Within the traditional subsistence strategy, domesticated camelids play a critical role. Their high and cold habitat has a limited net production of biomass. Despite the crucial domestication of plants for human consumption, these crops do not grow over the 4,300masl limit. So, firstly, as opposed to cattle and sheep, camelids do not compete for land with agricultural practices since they normally graze on pastures above the limits of agriculture, or on agricultural plots under fallow. Highland pastures high in cellulose, which cannot be directly utilised by men, are transformed into energy by SACs.

Secondly, SAC dung becomes an essential part of the agroecosystem through effective energy transfer from grazing areas into agricultural plots. This is accomplished either by allowing the animals to graze on lands in their fallow period, or by gathering by hand the dung naturally collected in "latrines" (see Part B), then transporting it on the backs of *llama* and spreading it by hand on the fields prior to ploughing.

Dry SAC dung (*taquia*) is an important cooking fuel at high altitudes where firewood is scarce or non-existent. Besides burning well, it has high heating properties. However, use of dung as fuel reduces the quota for increasing yields in agriculture, and, therefore, in a context of land shortage and low productivity, this traditional practice needs to be discouraged. However, in order to limit the use of dung as fuel, alternative sources of economic energy need to be provided. Currently, kerosene is a commonly used fuel in the Andes. However, its cost makes it inaccessible to the poorer strata of rural society. Reforestation with Andean native trees and shrubs with firewood potential has been promoted in some areas. However, the slow growth of plants at high altitude makes this an initially inefficient alternative. Nowadays, in highland villages, it is not uncommon to see small industrial activities (such as bakeries) relying on the intensive use of *taquia*, cheaply bought from landless herders.

Other alternative and innovative sources of energy in mountain environments need to be explored and promoted. The potential of solar and wind-generated energy is being explored in the Andes. Geothermal and hydroelectric power are also alternatives with significant potential in the Andes.

Transportation of goods on the backs of *llama* represents an efficient as well as a wise energy alternative to the use of motor vehicles, particularly costly when running on steep and winding roads. This is specially true when the beneficiary is basically a self-subsistence peasant agriculturalist with little or practically no access to cash. This became quite evident during the oil crisis of 1968 when fuel prices went up dramatically and *llama* caravans temporarily gained popularity once again in certain regions of the Central Andes. During the rainy season landslides blocked highland roads, also opening up opportunities for *llama* herders to provide their services at proper rates.

Each *llama* can carry around 25 to 30kg over distances of 20 to 25km daily, and a *llama* caravan may consist of 100 to 120 animals. A whole caravan can be handled by one or two persons. On their way they consume wild grasses and natural fodder, requiring no special feed. Furthermore, when they arrive at villages they are always welcomed. In addition to news and products for exchange, the corrals, which are gladly offered for overnight stays, are left with dung that can be used as manure and fuel by the owner of the resting place.

However, the *llama* can only carry non-perishable goods such as grain, potatoes, freeze-dried goods, fibre, and manufactured products. The mining industry has always been a major beneficiary of the traditional practice of transporting minerals by *llama*. On the other hand, short-lived products which easily decompose are not suggested for transportation over long journeys, despite the favourable cool to cold and dry conditions of the *Puna*.

The fibre market may also be analysed from the perspective of energy flow. In addition to providing an efficient means for energy conservation through its use for clothing, SAC wool has an attractive price in the market. In many cases, particularly in highland communities with little or no access to agricultural lands or off-farm employment opportunities, the wool market is the only source of cash. In these highland communities, cash is converted into much needed, additional food energy and other supplementary nutritional requirements (limited factors in the human, highland diet include iodine, which is obtained through consumption of dry sea kelp, certain vitamins, and calcium, most of which can be obtained through trade and barter or at the rural markets).

Although meat (from SACs) has never been a principal item in the daily diet, old animals are sacrificed for their meat, which, once dried out in the cold *(charqui)*, becomes an important article for trade (see Part B for further information on SAC meat). In both fibre and meat, *llama* and *alpaca* have significant yields as exemplified in Table 1.

Table 1: Production Parameters in *Llama* and *Alpaca*

Species	*Llama*	*Alpaca*
Birthrate (%)	47.0	45.0
Mortality at birth (%)	25.0	30.0
Adult mortality (%)	8.0	10.0
Adult live weight (kg)	90.0	50.0
Carcase yield (%)	55.0	54.0
Extraction (%)	10.0	12.0
Fibre weight (kg)	2.0	1.6
Frequency of shearing (per year)	3.0	1.5

Source: Pre-identification Report, Regional Project on Sudamerican Camelids - FIDA, 1990.

SACs, as other forms of livestock in rural peasant society, function as capital accumulation and reserve, to be easily and readily convertible into cash when needed (see Part B).

Finally, it has been noted that reliance on children for herding tasks contributes significantly in an energy-efficient strategy for division of labour at high altitude. The efficiency of an agropastoral family is related to the number of children over six years old, the age after which they can take care of the animals (Brooke Thomas 1977).

Andean Camelids and European Farm Animals in Combined Herds

Early Impact of Introduction on Lamoid Populations. Introduction of cattle, sheep, horses, mules, and burros, as well as of other European farm animals, took place soon after the Spanish conquest (1530s). In the very beginning the local Amerindian population regarded the newcomers with amazement and fear. Early colonial history has recorded that initially the local population thought that the horse and the mounted soldiers were one whole being. Equally, the zest for gold and silver on the part of the *conquistadores*, in association with the metal mouthbit fitted on to horses, made some think that these animals fed on precious metals.

Although the colonisers promptly acknowledged the attributes of the Andean "lambs of the earth", as they generically referred to cameloids, the new settlers valued above all the farm animals that had roots in hispanic culture. The horse was perceived as an indispensable beast for mounted travel as well as a symbol of power and dominance. Along with horses came mules and burros. Cattle for milk and its derivates, as well as for meat, were also introduced early on. Oxen came along with the cultivation of wheat and barley (Spanish settlers would not eat maize or potatoes, initially considered "food for Indians", favouring products to which they were familiar). The introduction of a new farming technology, the oxen-driven plough, to the horror of the natives, left to the animals the sacred duty of ploughing mother earth (*pachamama*), previously done directly by men with the traditional Andean foot-plough (*chakitaclla*).

All these, but particularly the horse, required cultivated fodder. For the first time in Andean history, cultivated grasses were grown to feed animals, a previously inconceivable practice in the context of rather scarce agricultural land. Now, men and animals had to compete for land, a scarce commodity in the highlands.

Sheep and goats were introduced at about the same time. Both were prized for meat (although pigs were still the main source). However, sheep played an important role in the colonial textile home industries because of their prized pelts and hides used for, clothes, water bags, and storage vessels.

A little known fact is the introduction of north African camels, along with the introduction of the date palm and fig tree, to the Peruvian coastal deserts by the Spanish settlers. However, for unknown reasons, probably related to the Spaniards' lack of familiarity with this animal and to lack of proper management, Old World camels did not prosper and were neglected and allowed to stray off, becoming prey for escaped black slaves. The last camel in Peru is recorded in 1615 (Crosby 1972: 96).

Although there has not been much research on the initial impact of the new animals on the Andean highland agroecosystems, a substantial transformation had to take place to accommodate the newcomers in their new environment. In addition to the need for growing pastures, management of these new animals was not at all part of the herding tradition of the Andes, which specialised in easy-to-handle lamoids. Demarcation of grazing lands and delimiting them from agricultural plots required new and more restrictive arrangements by bordering the land with stone walls. The care required by the new animals meant additional investments of time as well as novel management technologies. These were all done at the expense of agriculture.

Another major impact of the introduction of farm animals from Europe, although it has not been thoroughly researched, was the introduction of new diseases. In contrast to lamoid defaecation habits, which concentrate manure in "latrines", the new animals excrete at discretion, thus encouraging the spread of parasites. In addition, sheep seem to have been a major transmitter of several new sicknesses to lamoids, particularly scabies, severely decimating the population of Andean SACs (Bernabe Cobos 1964).

Finally, quite early on, the *conquistadores* noted that the newly introduced animals, from chicken to cattle, were affected by high altitude in terms of their reproduction rates. This was even noted in humans. Diminishing reproductive rates in animals and humans were dealt with by the seasonal movement of herds into the lower parts of the valleys, thus further affecting the best bottom valley agricultural lands. Additionally, it has been reported that the Spaniards also relied on the use of some Andean plants to enhance human and animal fertility. Indian communities in central highland Peru were taxed with a root crop called *maca* (*Lepidium meyenii*) believed to increase the fertility of animal and human populations at high altitudes.

Herding Lamoids with Cattle and Sheep. Despite the initial resistance to and awareness of some of the problems that the introduced animals brought, most of them gradually made their way into the traditional agropastoral economies of the high Andes. Some, such as the horse, never became important in indigenous highland communities due to politically symbolic associations with the *conquistadores*. Even today highland Indians rarely own horses.

On the other hand, sheep and cattle were gradually incorporated into the highland agropastoral ecosystem. Sheep adapted rather well, despite having lower productivity than lamoids. They provided wool in addition to meat, both of which found a market in urban centres where lamoid meat was, and still is, looked upon as undesirable "Indian food". Towards the 1830s, increased foreign demand for sheep wool facilitated the development of large sheep farms, mostly in the southern highlands of Peru (at that time the main wool-producing economies were southern Chile and Argentina). Paradoxically, the bundles in which this wool was exported were fastened with the longer fibres of *alpaca* and *llama*. These fibres attracted the attention of Titus Salt, a British importer. By 1850 the total export of *alpaca* fibre was getting close to that of sheep wool. Since then, the market has kept growing.

Bovines of European origin, although also less productive in terms of highland biomass conversion compared to lamoids, were also gradually adopted by the Andean peasants. Once again, the urban demand for meat and dairy products turned cattle into a worthwhile contribution to the rural economies. Milk was not at all attractive to Andean natives, who, as other non-dairy consumers around the world, have a lactose assimilation deficiency. However, as cheese, milk found its way into the peasant diet.

On the other hand, both sheep and cattle became important items of capitalisation. As opposed to lamoids, the new animals were readily marketable for cash in towns and cities. As a capital reserve they offered better convertibility than the denigrated SACs, identified with the poor Indian peasant.

The culturally-rooted Andean desire for risk minimisation through wide resource-base diversification best explains the increased acceptance of the new farm animals in highland peasant society. In accordance with this Andean ideal, a new resource is always welcomed; a cultural pattern which sometimes does not carefully assess the ultimate consequences. The Andes has many examples of favourable as well as unsound introductions and innovations.

Nowadays SAC herders on an average can be characterised as poly-pastoral. Although, among traditional herders, lamoids constitute the dominant species, depending on region and altitude, there is always a place for sheep and cattle. In the *Puna* it is quite common to run into mixed herds of lamoids and sheep. A few bovines are kept in corrals, though they sometimes graze along with the rest of the animals. On an average, the *alpaca* is dominant in mixed herds (from 30 to 120 *alpacas*) due to the value of its fibre. They are followed by ovines (10 to 80) and *llama* (5 to 50). As far as cattle are concerned, if any, two or three cows and occasionally a bull are kept separate, although sometimes they can be seen grazing with the rest of the herd. Variations in the rates of mixed herd combinations occur from region to region. In northern Chile, for example, the *llama* predominates along with sheep (Gundermann 1984).

Handling a mixed herd is certainly more complicated than handling one of pure lamoids. The latter, even in large numbers, can be managed by one herder due to their docility and sheep, due to the habit of staying with their leader, require much more concentration. In many cases dogs are used to help with sheep. This presents a problem for SACs (as indicated in Part B). Finally, when bovines graze along with the rest of the mixed herd, they tend to be fastened with ropes to stones or poles to avoid straying.

Mixed herding, in addition to the sanitary risks indicated previously, may also affect the status of pastures. It has been noted that sheep-grazing patterns seriously affect the slow-growing highland pastures with short grass. Although not much research has been carried out on the effects of mixed herding, in comparison to pure lamoid herding, on pastures, because of the lower productivity of sheep at high altitudes (compared to SACs), a higher degree of overgrazing should result from the first option. Appropiate alternatives to mixed herding should be based on sound agrostological research and adequate rangeland and herd management. Each animal has also specific pasture preferences, a factor that should be taken into account in order to optimise the utilisation of highland prairies. Ensuring adequate balance in the consumption of different grasses is better in the long run than risking the degradation of pasturelands.

The relative significance of each one of the above-mentioned species, independent of herding arrangements, in two Central Andean countries, is exemplified in Table 2.

Table 2 : Bolivia and Peru: Relative National and Regional Proportions of Camelids in Relation to Other Ovines and Bovines

(1000 head)

Country	Prov.	Ovines	*Llamas*	*Alpacas*	Bovines	%Camel (1)
Peru	Ancash	828.7	960.0	576.0	225.0	0.15
	Huanuco	563.8	3.6	-----	134.0	0.51
	Pasco	555.3	21.5	2.1	87.2	3.50
	Junin	2015.3	68.9	9.6	213.0	3.40
	Huanca Velica	728.0	112.0	244.2	157.8	29.00
	Lima	493.7	32.0	32.5	250.0	8.00
	Ayacucho	597.6	89.0	137.7	200.5	22.00
	Apurimac	411.1	120.0	194.1	282.5	31.00
	Cusco	1744.4	150.0	345.6	347.0	19.00
	Puno	3008.1	314.4	1702.7	411.5	37.00
	Arequipa	258.8	122.0	294.3	186.4	48.00
	Moquegua	32.2	32.0	38.8	31.4	53.00
	Tacna	50.0	13.5	34.4	30.7	35.00
Total (1)		12509.1	1080.0	3037.0	3900.0	20.00
Bolivia	La Paz	2514.9	426.0	233.1	314.7	19.00
	Oruro	1949.5	739.8	86.0	39.0	29.00
	Potosi	2019.4	819.0	1.0	120.2	28.00
	Cachabamba	1149.5	37.2	4.1	285.4	3.00
Total (2)		8545.4	2000.5	324.3	5401.5	14.00

(1) Including *alpacas* and *llamas*
(2) Total includes populations from all departments
Source: FIDA 1990.

PART B

SCIENCE OF CAMELIDS

General Biology and Evolution

Taxonomy

The systematic classification of Old World camels has never been open to debate. The one-humped camel (dromedary) is named *Camelus dromedarius* and the two-humped camel (Bactrian), *Camelus bactrianus*. The classification of the South American Camelids (SACs) has been more debatable, and one of the factors that has contributed to this confusion is the commonly held belief that crosses between the four species either do not occur or that, when they do, the offspring are sterile.

Linnaeus placed the *llama, alpaca,* and Old World camels in a single genus, *Camelus*, in 1758. Other taxonomists proposed a separate genus status for SACs in the early nineteenth century, but none of this work was accepted by the International Commission on Zoological Nomenclature. The genus name, *Auchenia*, was proposed by Illiger for SACs in 1811 and is frequently seen in print, even today, in world literature. However, *Auchenia* had been applied earlier to a genus of insects and thus was not a valid name for any other animal. In 1827, Lesson published an acceptable paper classifying the New World camelidae in the genus *Lama*. In 1924, Miller assigned the *vicuna* to a separate genus, *Vicugna vicugna*.

One system classifies the *guanaco*, *llama*, and *alpaca* within the genus *Lama* and the *vicuna* as a single species in the genus *Vicugna;* and this is based on its open-rooted incisors, which have enamel in the labial face. Another system classifies all SACs within the genus *Lama*. Others classify the *llama* and *alpaca* as subspecies of *L.guanicoe guanicoe*. In this paper the terms *llama* (*Lama glama*), *alpaca* (*Lama pacos*), *guanaco* (*Lama guanicoe*), and *vicuna* (*Lama vicugna*) will be used.

Collectively, SACs are known as "lamoids" or New World Camelids, although the term *Auquenidae* is often found in older literature. Both camels and SACs are included in the term camelid. The zoological classification for SACs is listed in Table 3.

Table 3: SAC Classification

Class	-	*Mammalia*
Order	-	*Artiodactyla*
Sub-order	-	*Tylopoda*
Family	-	*Camelidae*
Genus	-	*Lama*
Species		
		L.glama, llama
		L.pacos, alpaca
		L.guanicoe, guanaco
		L.vicugna, vicuna

The *alpaca* and *llama* exist only as domestic species. The *guanaco* and *vicuna* are wild animals.

Evolution

Camelid evolution began in North America 40 to 50 million years ago in the early Eocene epoch. (Geological and palaeontological time scales are estimated and are subject to revision.) The evolution of Pleistocene camelids published by Webb suggested three major tribes, separated as early as the Eocene epoch. This family tree, with insufficient fossil records to trace lines accurately, is formed by the tribes *Camelopini* (*Camelops*) and *Camelini* (*Camelus*), that evolved in North America west of the Mississipi River. The tribe *Lamini* (*Lamas*) was also found in Florida.

The Pleistocene epoch was characterised by a series of periods of extreme cold and glaciation in northern North America and Europe. The last glacial retreat occurred about 10,000 years ago, marking the beginning of the recent epoch in which lamoids and camels flourished. Many genera in the family *Camelidae* became extinct, for unknown reasons, before the recent epoch.

The first lamoids migrated to South America at the beginning of the Pleistocene epoch, approximately 3 million years ago, when an open land connection between North and South America developed. The major early lamoid genus appearing in South America was *Hemiauchenia* (*Tanupoloma*) which radiated throughout the flatter regions east of the Andes. During the mid-Pleistocene epoch, the genera *Paleolama* and *Lama* developed from the long-limbed, flatland-adapted *Hemiauchenia*. These genera had shorter limbs, thus were more adapted to the mountainous Andes. Various species of *Paleolama* migrated back to North America. Fossils have been found along the Gulf Coast and Florida in association with North American *Hemiauchenia*.

Domestication

Presently available archaeological evidence indicates that *llamas* and *alpacas* were domesticated in the Andean highlands, probably around Lake Titicaca or elsewhere, perhaps in the *puna* of Junin (Telermachay), Peru (elevation 4,000 to 4,900masl), by 4000 B.C. (for further information on the domestication process, see Part A).

Some of the most complete information yet available on *llama* and *alpaca* domestication has come from the reconstruction of prehistoric animal exploitation strategies at archaeological sites by Elizabeth Wing, on the basis of cranial morphology and incisor analysis, from sites located at lower elevations in Peru.

By the end of the Preceramic period around 2000 B.C., domestic camelids had spread along the highland drainage systems into elevations below 4,000m, as for example the Ayacucho Valley (2,850m), Huacaloma in northern Peru (2,700m), and Puripica near the Salar de Atacama in northern Chile (3,000m). The evidence for the first spread of domestic camelids to the coast comes from Trujillo, around 1500-1100 B.C. On the coast of southern Peru and northern Chile, *llama* feet and woollen textiles are frequently found in burial mounds dating from 500 B.C. State-owned herds of *llama* were maintained on the coast by the Incas until the time of the Spanish conquest. Some historians (Rostworowski) have argued that the coastal region was home to local varieties which disappeared soon after the conquest.

On the basis of cranial morphology, a German zooarchaeologist, suggested that the *guanaco* is the common ancestor of the *llama* and *alpaca*. Another concurs with the first on the *llama* but hypothesises, principally on the basis of behavioural traits, that the *alpaca* resulted from crossing domestic *llama* with *vicuna*, while a third one, also on the basis of behaviour, maintains that the *alpaca* is a domestic *vicuna*. Much more archaeological, palaeontological, and biological research is needed, however, before this problem can be resolved.

General Characteristics

Even though the four species of SAC possess some common characteristics, such as body shape, they differ markedly in other ways, such as colour pattern, body size, and usefulness to man.

All camelids have 37 pairs of chromosomes; the similarity of karyotypes probably explains the fecundity of the offspring produced by all possible crosses, of both pure and hybrid parents. Their haemoglobin has a very high oxygen affinity, advantageous at high altitudes.

Camelids have a complex, three-compartmentalised stomach. Gastric digestion is similar to, but not analogous with, ruminant digestion. The two sub-orders separated from each other 30 to 40 million years ago when primordial species were simple-stomached. Both groups utilised fibrous forage and developed similar foregut fermentation systems by parallel evolution. Camelids regurgitate and rechew ingested forage, as do ruminants, but they are more efficient than ruminants in extracting protein and energy from poor-quality forages.

They defaecate and urinate in relatively confined areas ("latrines") even when they have access to the whole of the pasture. This behaviour has both social and environmental significance. For the wild species, *guanaco* and *vicuna*, it has a short-term primary function of marking territories, especially for intragroup orientation. In the long term it has a secondary side effect of causing greater soil development on heavily vegetated strips as a result of long-term deposition and subsequent downhill washing of the manure by rain. The fertilising effects of the manure and urine are especially noticeable downhill from dung piles at the beginning of the rainy season in the summer. This behaviour is of great importance, since by defaecating only in regularly used dung piles, lamoids have a significantly lower risk of infestation by parasites, and thus parasitic cycles are interrupted. They also make common use of some areas of the pasture for rolling. Here they form pits that become bare on account of continuous use: this behaviour can transmit external parasites, particularly sarcoptic mange.

They have a foot adaptation rather like a cushion that is very sensitive and delicate. This enables them to avoid soil compactation and travel over dangerously steep areas on the mountains with ease.

They demonstrate great curiosity for anything that is new (people, animals, or things) and will often advance fearlessly to discover the object of their curiosity.

Herding with dogs is not possible, because SACs attack members of the dog family by "group moving", much like the treatment dogs receive from the North American elk (*Cervus canadensis*). When frightened, they are apt to spit and kick.

Ovulation is induced by mating and the embryo is implanted in the left uterine horn. The gestation period is around 345 days. They tend to regulate birth to the sunny days only and during full daylight when the temperature is favourable for the young. Daylight parturition is probably an adaptation to avoid giving birth during the freezing night-time temperatures of high altitude regions.

They have split upper lips that enable them to select leaves from the horny parts of forages and they also have very sharp incisor teeth on the lower jaw which continue growing and permit them to eat very short and lignine-rich forages.

The colour of the skin and fibre of the wild members, *guanaco* and *vicuna*, is invariably golden-brown, which permits very good camouflage on both rocks and in the mountain basin pastures.

The *guanaco* and *vicuna* have a well-defined social structure, living in family groups made up of one male and his harem of six to seven females. Remnants of this behaviour can be seen in *alpaca* or *llama* herds.

Habitat of the South American Camelids

The subcontinent of South America is comprised of 13 separate countries or territories and is the third largest land mass in the world. It contains the widest extremes of topography and climate and features the traditional and modern life and customs from many different sectors of human culture.

Along the western border of South America runs the high mountain range known as the Andes or *Cordillera de los Andes*. These mountains are relatively young and are still in the process of being formed due to the interaction of the South American and Pacific plates. Massive uplift has led to high, undulating land surfaces that contrast with the more continuous sharp relief of many other mountain systems.

Faulting, folding, and volcanic activity have produced a rugged and mountainous surface topography, while glaciation and erosion have created many deep valleys. The complex geological history of the Andes has produced a landscape of rolling, relatively flat plateaux, with occasional mountain chains rising above them (c. 6,000masl) and deeply incised gorges cutting into them. The term *puna* is used to refer to this intermediate zone, ranging in altitude from 3,700 to 4,800masl. It has relatively low relief and is characterised by bunch grasses and low herbage. It is this zone that constitutes the present habitat of the New World camelids.

Two general climatological seasons occur in this part of the Andes: a mildly warm, rainy, growing period from December to April and a cold, dry period from May to November. About 80 per cent of the rainfall occurs during the wet season and the remaining 20 per cent during the dry season in the form of hail and snow. Annual rainfall is within the range of 250 to 900mm, according to latitude, with very low precipitation in the southern part of the Andes. Weather data collected in the Department of Puno, where the Granja Modelo de Chuquibambilla is located (elevation at 3,850m), from 1931 to 1973, show the mean daily minimum temperature to be -3°C and the mean daily maximum temperature about 17.3°C. As in other high altitude regions, the diurnal variation in temperature is great, at times exceeding 30°C. At this high altitude there is low atmospheric pressure, a very dry climate, low oxygen availability, and intense solar radiation (high ultraviolet rays). In thin air, bodies absorb heat rapidly from the sun, and they lose it quickly when the rays of the sun are blocked by clouds. Moreover, wind, dry air, and low atmospheric pressure are all factors that increase the rate of evaporation.

These rugged conditions, both climatic and geographic, together with the low organic content of the soil, produce an unstable vegetation with a type of perennial graminiferous plant forming a discontinuous layer; and as a result there is little or no agriculture in this zone. Consequently, grazing camelids and, to a lesser extent, sheep, is the only alternative for the inhabitants of the highlands. By this means low quality natural pastures can be converted into useful animal products.

The *llama* (*Lama glama*) is the most cosmopolitan member of the SACs. Nowadays they are kept at elevations between 2,600 and 4,800masl and are found in south Colombia, Ecuador, Peru, Bolivia, Chile and Argentina. *Alpaca* (*Lama pacos*) rearing is restricted to elevations of 3,850m and above in Peru, Bolivia, and Chile. The zone with the greatest population and productivity is located between 11 degrees south and 21 degrees south latitude.

The *guanaco* (*Lama guanicoe*), unlike other SACs, lives in a variety of habitats. It thrives between sea level and 4,500m in either hot or cold, arid or humid zones. It is found in an area that extends from the northern part of Peru (8° S) through the pre-*cordillera* and coastal areas of northern Chile to Tierra del

Fuego, the southernmost region of Argentina and Chile. The largest population inhabits the *pampa*, or cold steppe, where "*coiron*" is the predominant vegetation.

Distribution of the *vicuna* (*Lama vicugna*) is limited to the *puna* zone of the Andes where they are most common at elevations of 4,200 to 5,200masl with a lower limit of 3,700m. The northernmost distribution of the *vicuna* at present is 9°30'S in the department of Ancash, Peru, and the southernmost limit presently is 29°0' in the province of Atacama, Chile.

Description of the Species

Alpaca

The *alpaca* is smaller than the *llama*, has short and pointed ears, a woolly face, and rounded rump. Their average height is 80 to 90cm at the withers, with adult males weighing 55 to 60kg in males and 47 to 57kg in females.

Centuries of selective breeding for quality wool (usually called "fibre" to differentiate it from sheep's wool) have produced two breeds of *alpaca* which are distinguished on the basis of their fibre characteristics. The *Huacaya* breed produces shorter, crimped fibres, giving the wool a spongy appearance, resembling that of the Corriedale sheep. The wool of the *Suri* breed is characterised by long, straight fibres arranged in locks which fall to each side of the body in much the same manner as those of Lincoln sheep.

There is a considerable variation in the quantity of fibre produced by the *alpaca*, from as low as 0.9 kg to as high as 4.0 kg per animal per year. The average fleece weight is 1.8 kg in the *Huacaya* breed and 1.9 kg in the *Suri* breed per animal per year. The average fleece fineness in different breeds of *alpaca* is 24 microns. The *Suri* breed exists only in Peru, representing no more than five per cent of the total *alpaca* population (Table 2).

Crosses between *Suri* produce approximately 17 per cent of *Huacaya*-type offspring, while crosses between *Huacaya* produce about two per cent of *Suri*-type offspring or *crias* (*cria* is the Spanish name for the newborn lamoid).

Due to the difficulty of separating multicoloured wool, breeding selection aims at solid colours. Pure white or light fawn are the most abundant colours in Peru (56.5 %) and the most prized, but other colours -- such as brown, black, gray, and roan -- are also valued.

Llama

The *llama* is the largest of the four species, with an average height of about 1.05 to 1.10m in males and 0.95 to 1.05m in females and weighing about 80 to 90kg in males and about 75 to 85kg in females (range 66 to 151kg). These figures are the average of adult animals of both breeds in three different countries in the Andean Region.

The ears are long and curved and the face is free of wool, with a long, straight to slightly-rounded nose. The back is flat from the shoulders to the rump, ending in a tail that curls up and back. Since the time of the Incas they have been used as a beast of burden and are still used as such.

Two breeds of *llama* are generally recognised in Peru, where there is a considerable tradition of *llama* breeding. These are the *Pelada* breed or *Kara* (Quechua dialect) and the *Lanuda* breed or *Chaku*. The woolly type or *Lanuda* is an animal with a thicker fleece all over the body, including the neck, and proximal portions of front and hind legs, with a slight crimp and uniform and soft-to-the touch fibres. Recent studies report that the average fibre diameter is 28.00 microns, with a high coefficient fibre length of variation (43.5% - 57.70%). The fibre length varies according to its time of growth, between five to 21cm. These types of animal are sheared every two years or more, but they can be sheared each year; the average fleece weight is around 1.31 kg per animal per year, but selected animals under good management conditions can produce four kg a year. This is the least abundant breed, accounting for 20 per cent of the whole *llama* population in Peru and Bolivia. However it is more abundant in Chile (around 40%).

The *Kara* breed is an animal with less abundant fleece, especially around the face, neck, and legs. One can easily identify two layers of fibre in the fleece: one layer is called the "undercoat" (also called "innercoat"), formed by fine wool fibres of small diameter and length (average 25 microns) and the other layer is called the "outercoat", formed by a layer of thick and coarse fibres, longer and thicker; the average fibre diameter is 87 microns. This breed presents a high degree of variability in wool fibre fineness and fibre length. The *kara* breed represents 80 per cent of the *llama* population in Peru and Bolivia. However, approximately 20 per cent of *llamas* in the Andean Region can be considered to be an "intermediate type", that is, the result of interbreeding between animals of both breeds. Generally these animals are sheared every three to four years, but annual shearing can produce 0.94kg of wool.

In both breeds of *llama*, we can find a range of thickness in fibre of between eight and 144 microns (high coefficient of variation), which clearly indicates the great variability that exists in different animals of the same breed and between animals of different breeds. The reason for this situation is the lack of selective breeding and crossing without control between both breeds of the *llama* (intermediate type). In the two breeds, coat colour varies from white, brown (different shades), grey, and black to even a high percentage of multicoloured animals, spotted or patched.

Vicuna

This wild species is the smallest of the SACs, with a shoulder height of approximately 80cm and an average body weight of 35kg. It is a slim and elegant animal with an extremely lively and agile nature. The head is small with large black eyes, and the neck is long and thin. The fleece is characterised by a short growth of extremely fine (12 microns on average), cinnamon-coloured wool and white underparts, and it has the unique characteristic of a large hank of fibre which grows only on the chest, longer and thicker than the fibres of the rest of the body, and which is white in colour.

The *vicuna* lives in family groups consisting of an adult male and four to seven females with their young of the year. The male establishes and maintains a permanent year-round territory which normally contains a high-ground sleeping area, a lower-elevation grazing area, and a water source. The size of the territory depends upon the quality of the pastures contained therein. Ritual defaecation and communal dung piles provide short-term, intra-group orientation in territorial demarcation. Juvenile males and females are expelled from the group prior to the January onset of the birth season. The young males join non-territorial troops of 20 to 30 animals, and the females join other family groups. Mature males separate from the groups and remain solitary until they establish a territory. It is believed that this peculiar behaviour and social organisation have favoured the survival of this species. The *vicuna* is easily hunted but is very intractable and difficult to tame. Efforts are being made by Andean countries to protect it in order to save it from extinction.

A particularly distinctive anatomical feature of the *vicuna* is that the incisors continue to grow almost throughout its lifetime, enabling the animal to eat tough forage plants, rich in silicic acid, as well as to take very small plants which are close to or lie directly on the ground. Apart from the distinctive teeth there are other anatomical and physiological characteristics that enable the *vicuna* to survive in the in-hospitable *puna* more successfully than any other domestic animal. Among these are the extraordinarily fine and thick fleece; the unusually low energy requirement, the surprisingly high weight of the new born animals, as well other adaptative characteristics to the high altitude environment.

Guanaco

The *guanaco* (*Lama guanicoe*), the other wild member of the SACs, has more or less a similar body size to the *llama* and weighs between 80 and 120kg, according to four geographic subspecies described. All four subspecies show only one colour pattern consisting of a light brown upper body, whitish underbelly, and blackish face.

The *guanaco* has always been hunted for its meat and for the fur of the young animal, called *chulengo*, which is mainly sold for export. In the adult animal, the fleece is made up of two layers: the internal or undercoat is very fine and short in length. The external or outercoat tends to be longer and coarser.

The *guanaco* lives in both migratory and sedentary groups. Family bands consist of one adult male and five to six adult females with their young, and some occupy permanent territories which the male defends against all other *guanacos*. Young males unite into migratory troops of up to 50 individuals, but eight per cent of the total population remain solitary, challenging the dominant males for control of their family groups and territories, especially during the breeding season.

Guanaco populations have drastically decreased since the arrival of the Spanish, and little has been done to protect this endangered species. It has been suggested that it might be integrated with sheep ranching; most of its feed comes from browsing on stunted shrubs, and thus it does not compete with the sheep for grazing.

Recent History and Present Status

As discussed earlier, lamoids were critical for the development of Andean culture. At the time of the European conquest, during Inca rule, lamoids had become almost mythical creatures, vital to the functioning and life of their empire. Lamoids were distributed throughout the 380,000 square miles of their territory, from the coastal desert of the Pacific Ocean to the snow line of the Andean mountains at 6,800masl. The *alpaca* and *llama* were the Inca's only large domesticated livestock, but even the wild *vicuna* and *guanaco* were rounded up at communal drives, *chacos*, held approximately every four years in each province, culling only surplus males and sick animals, and shearing and releasing the rest.

These animals provided clothing, meat, leather, fuel, fertiliser, and transportation of goods and were offered to deities as sacrificial animals (in place of humans) They were also tokens of wealth. *Llamas* carried the trade of the Incas on their backs throughout the length and breadth of the Empire, which at its zenith stretched more than 4,000km - as far as the Roman Empire reached at its greatest point in history (Britain to Persia).

Because these animals, with the exception of a marginal coastal population, lived at altitudes above those where people could survive, the Incas revered them. To the Incas, who called themselves "*Children of the Sun*", the animals were especially blessed by heaven because they lived closest to their god, the sun. In the 16th century, the Viceroy Toledo, said "*two treasures had the land of Piru* (sic), *the maize and the livestock of the land*".

It is impossible to calculate the domestic and wild camelid population in the South American Andes before the Spanish conquest, but all signs indicate that they were abundant until the downfall of the Inca Empire. Within little more than a century following the Spanish invasion, the population of the *alpaca* and *llama*, as well as of the wild species, had been decimated throughout the Andes. From the chroniclers we know that entire herds of *llama* were slaughtered to feed the *conquistadores* and their Indian allies during the Conquista war; and also later during the Civil War. In some instances a great number of *llama* were slaughtered to satisfy the refined taste of the Spanish *conquistadores* who would only eat the bone marrow of the *llama* or only very young animals. They were slaughtered also for the extraction of *bezoar* stones from their guts for medical purposes. During the conquest, the *llama* was abused and ignored and, because of newly-introduced diseases (see Part A), and lack of care and attention in general, disease spread throughout the existing herds and wiped out two-thirds of all lamoids (according to the chronicler Garcilaso de la Vega). It is very likely that the spread of diseases was faster and more severe in the coastal lowlands, irreversibly affecting lamoid populations that had adapted to sea level conditions.

On the other hand, the Incas were forced to sell or slaughter their *alpaca* and *llama* and to replace them with Castillian sheep brought over from Spain. Moreover, the Spanish spread the rumour that the *llama* and *alpaca* were syphilitic and that their spit transmitted mange, a belief that still exists (more than 30 years ago it was proven untrue by detailed experiments in Peru).

Later on, primary competition between the native and introduced livestock resulted in the disappearance of the *alpaca* and *llama* from the greatest part of their range, while the expansion of sheep herding was eventually limited by poor quality grazing lands and the problems of adaptation to high altitude.

As part of a colonial heritage, SACs became strongly identified with the traditional "backward" indigenous communities, with their neglected and dominated native culture. The irrational rejection of SAC meat in the urban markets exemplifies the impact of this mentality. Prejudice also affected SAC wool potential in the international market. It was only due to an accidental discovery in England in the 1830s that a new market for *alpaca* fibre opened up. This history of hostility and neglect meant that these Inca animals never attained their inherent potential, much less approached the global status of their fellow ruminants, sheep, cattle, and goats.

Today, *alpaca* and *llama* herds are relegated to lands located at, or above, the upper limits of agricultural productivity. These are of marginal value for sheep rearing, but the camelids have always been adapted to them and reign almost unchallenged. In the highland regions of the Andes, above 3,800m, there are over 40 million hectares in Peru, Bolivia, the north of Chile, and the northwest of Argentina, and, in Peru alone, approximately 150,000 families depend solely on camelid herding for their subsistence: there is no alternative. These *llama* and *alpaca* have survived within the framework of a traditional, non-European, socioeconomic organisation because they are an essential element of the Andean culture.

The *llama* is used primarily as a pack animal. It can transport loads weighing 25 to 30kg over distances of 20 to 25km daily and is employed in both local and long-distance inter-Andean trade of non-*puna* food products and other commodities. Its coarse wool is mainly used for carpets, saddle-bags, blankets, and even clothing. The *llama* is also a valuable source of meat. The *alpaca*, on the other hand, is employed primarily as a wool producer, although they are also important for meat. The *alpaca* fibre is used for the production of fine quality cloth. The skins, sinews, and bones of both animals can be used to make leather products, thongs, and weaving tools. Dung, gathered from the communal defaecation piles, is used as a primary source of fuel in the treeless *puna*, and as a fertiliser it is essential for effective potato, *quinoa*, and *canigua* production. At present all *llamas* and 95 per cent of all *alpacas* in the Andes are owned by native communities; five per cent of *alpacas* are in the hands of cooperatives and privately-owned properties.

Alpaca and *llama* wool began to reach the world market in the 1830s when British-owned export firms were established in the city of Arequipa, in southwest Peru. Trade in *alpaca* wool was controlled by private deals between brokers until the 1930s, while Peruvian sheep wool was auctioned in London. Despite the shift to direct sales in the 1940s, these firms have retained their importance as middlemen and England still remains one of the main centres for Peruvian *alpaca*, *llama*, and sheep wool.

For the past 150 years, the Andean countries have prohibited the export of any fertile *llama* and *alpaca*. This has given them a monopoly, but it has withheld the animals from international scientific scrutinity. Since 1980, more than twenty thousand *alpacas* and *llamas* were exported from Chile to the USA and other countries. In 1992 the Peruvian Government partially liberalised the international marketing of SACs.

Regarding the wild species of SAC, extensive exploitation of both the *vicuna* and *guanaco* for fibre and pelts resulted in alarmingly low populations in the early 1960s. However, since then legal protection measures have been enforced to preserve the species and to provide rational management in future.

World Population of SACs

According to the available census data, the current population of *llamas* and *alpacas* is 6,276,396, distributed along the Andean *cordillera* with the zone of greatest concentration located between 11° S and 21° S. Despite the relatively small population of *llamas* and *alpacas*, they play a role of primary importance in the economy of the high Andean regions of Peru, Bolivia, Chile, and Argentina. A very small population of *llamas* thrive in Ecuador where very recently the *alpaca* has been reintroduced.

Eighty-eight per cent of the world's 3,042,346 *alpaca* are found in Peru; likewise, the greatest percentage (62.5%) of the world's 3,234,050 *llama* are found in Bolivia. The rest of the South American population of domesticated camelids inhabit Chile, Argentina, and, a very few, inhabit Ecuador (Table 4). The highest population of *guanacos* is found in Argentina, where the estimated number is 600,000; in Chile there are an estimated 22,000 *guanacos*, while Peru and Bolivia have negligible populations. The *vicuna* population is distributed in Peru, with the highest population (107,421), Chile (27,900), Bolivia (13,000), and Argentina (15,000). At present, the *guanaco* and *vicuna* populations are probably larger than these estimates as a result of policies aimed at their protection. The exportation of hides from young *guanacos*, for instance, decreased from 86,062 in 1978 to 10,250 in 1984.

The population of SAC outside the Andean Region has not been very significant until now, but figures given by the exportation authorities from Chile and Bolivia, as well as the associations of *alpaca* and *llama* breeders in the USA, Canada, England, New Zealand, Australia, and other European countries, show that the population is significantly increasing in these countries. The number of *llama* in the USA is around 25,000 with a lesser number of *alpaca*; a similar number is said to exist in New Zealand.

Genetic Diversity

South American domestic camelids bred in different areas have sometimes been given local names, but it would be misleading to call them breeds. A recent survey studied the germplasm of South American Camelids from Bolivia, Peru, and Chile and the following conclusions were reached.

1. Chile has only one breed of *alpaca*, the *Huacaya* breed, representing 100 per cent of the total *alpaca* population in that country. Likewise, Chile has two breeds of *llama*: the *Lutica* (60% of the total *llama* population), called *Kara* or *Kcara* in *Peru* and Bolivia, and the *Tajulli* (40% of the total *llama* population), called *Tampully* in Bolivia and *Chaku* in Peru (Table 5).

2. The same occurs in Bolivia which has only one breed of *alpaca*, the *Huacaya* (100 % of the total *alpaca* population), although a few *alpaca* of the *Suri* breed live in the northern part of Bolivia, close to the Peruvian border. Also Bolivia has two breeds of *llama*: the *Tampulli* or *Thampully* (20 % of the total *llama* population), named *Tajulli* in Chile and *Chaku* in Peru; and the *Kcara* or *K'ara* breed (80% of the total *llama* population), named *Lutica* in Chile and *Kara* in Peru (Table 6).

Table 4: Estimated Population and Distribution of *Alpacas* and *Llamas* in the Andean Region

Country	*Alpacas*	*Llamas*	Total	% Regional (1)
Argentina	Few	75000 (2.30%)*	75000	1.20
Bolivia	324326 (10.75%)	2022.126 (62.50%)	2346452	37.40
Chile	30657 (1.0%)	66383 (2.10%)	97040	1.50
Ecuador	Few	Few		
Peru	2687363 (88.30%)	1070541 (33.10%)	3757904	59.90
Total:	3042346	3234050	6276396	100.00
Per cent**	48.50	51.50	100.0	

(1)Regional percentage by country.
* Probably some per cent are *alpacas* and hybrids.
** Per cent of total domestic SACs.

Table 5: Regional Names of the Different Breeds of *Alpaca* and *Llama*

Country	*Alpaca*	Breeds	*Llama*	Breeds
Bolivia	*Huacaya*	*Suri*	*Tampully*	*Kcara*
Chile	*Huacaya*	--	*Tajulli*	*Lutica*
Peru	*Huacaya*	*Suri*	*Chaku*	*Kara*

3. Peru has two breeds of *alpaca*: the *Huacaya* (95% of the total *alpaca* population) and *Suri* (5% of the total *alpaca* population); there are two breeds of *llama* also, the *Kara* (80 % of the total *llama* population), named *Kcara* in Bolivia and *Lutica* in Chile, and the *Chaku* breed (20% of the total *llama* population), named *Tampulli* in Bolivia and *Tajulli* in Chile.

Table 6: Percentage of the Different Breeds of *Alpaca* and *Llama* in the Andean Region

Breeds	*Alpaca* % *Huacaya*	*Alpaca* % *Suri*	*Llama** %*Kara*	*Llama** % *Chaku*
Country				
Bolivia	100.0	**	80.0	20.0
Chile	100.0	--	60.0	40.0
Peru	95.0	5.0	80.0	20.0

* 10% of the *llamas* are considered to be of an "intermediate type", crosses between both breeds of *llamas*.
** There is a small number of specimens of the *Suri* breed.

4. It has been observed that approximately 20 per cent of the *llama* in the three countries are of the "intermediate breed or type", that is, the result of crosses between animals of both breeds. In the survey, these animals were classified as belonging to the *Kara* breed. There are no phenotipic intermediate types of *alpaca* (as a result of crosses between animals of the *Huacaya* and *Suri* breeds).

5. In Tables 7 and 8 we can see the colour of the coat or fleece of the *alpaca* and *llama* in the different breeds in Bolivia, Chile, and Peru. In Peru the most frequent colour (unicoloured) in both breeds of *alpaca* is white, followed by different shades of brown, black, grey, and roan; patched animals (two colour combinations, very rarely three colours) represent 14 per cent of the total population of both breeds of *alpaca*. On the other hand, the predominant colour in Bolivia and Chile is brown (in different shades), followed by black, white, grey, and roan; patched varieties account for 17.5 per cent and 13.5 per cent for Bolivia and Chile respectively. The grey colour (with different shades) is a mixture of white and black hairs in the fleece, and the roan colour is a mixture of white and brown hairs in the fleece. The changes in the intensity of the grey and roan colours (shades) depend on the quantity of white hairs in the fleece.

Table 7: Coat Colours and Their Percentages in the Two Breeds of Andean *Alpaca*

	Huacaya			*Suri*		
Country	Bolivia	Chile	Peru	Bolivia	Chile	Peru
Colour						
Brown	41.0	52.0	23.5	---	---	32.0
Black	15.0	13.0	4.0	---	---	3.0
White	13.5	11.5	56.5	---	---	50.0
Gray	.0	5.5	1.0	---	---	1.0
Roan	5.0	5.5	1.0	---	---	--
Multi-coloured	17.5	13.5	14.0	---	---	14.0
	100.0	100.0	100.0	---	---	100.0

Table 8: Coat Colours and Their Percentages in Andean *Llama*

Country	Bolivia	Chile	Peru
Colour			
Brown	23.0	11.0	25.0
Black	12.5	1.5	1.5
White	11.0	12.0	33.0
Gray	9.5	6.0	9.5
Roan	1.0	0.5	---
Multi-coloured	43.0	69.0	31.0
	100.0	100.0	100.0

6. The most frequent colour (unicoloured) for *llamas* in Peru is white (33%), followed by brown, grey, and black (Table 8); patched animals with two colours account for 31 per cent of the total *llama* population. On the other hand, dark colours, such as brown and black, are abundant in Bolivia, followed by white - accounting for 11 per cent - and grey - accounting for 9.5 per cent. In Chile, the solid white colour in *llamas* is the most abundant (12%), followed by the brown and the grey. The patched animals account for 43 per cent and 69 per cent of the total population of *llamas* in Bolivia and Chile respectively. Information about the colours, of *llamas* according to their breed was obtained only in Peru (Table 9); white and then brown, grey, and black are the most abundant solid colours in both breeds of *llama*, and the patched colours, or colour combinations, account for 33.5 per cent and 22.5 per cent of the *Kara* and *Chaku* breeds.

Table 9: Coat Colours and Their Percentages in the Two Breeds of Peruvian *Llama*

Breeds	*Kara*	*Chaku*
Colour		
Brown	24.0	28.0
Black	1.0	3.0
White	32.0	38.0
Gray	9.5	8.5
Roan	---	---
Multi-coloured	33.5	22.5
	100.00	100.00

7. Average adult live weight and withers' height of the different breeds of *alpaca* and *llama* in the countries surveyed are shown in Tables 10 and 11.

Table 10: Average Live Weight (kg) by Gender in the Different Breeds of *Alpaca* and *Llama* in the Region

	Alpaca				*Llama*			
Breeds	*Huacaya*		*Suri*		*Kara*		*Chaku*	
Sex	Male	Female	Male	Female	Male	Female	Male	Female
Country								
Bolivia	55	47	---	---	80	75	80	75
Chile	55	50	---	---	80	75	80	75
Peru	60	57	60	58	90	85	90	85

Table 11: Average Withers' Height (cm) in Different Breeds of *Alpaca* and *Llama* in the Region

	Alpaca				*Llama*			
Breeds	*Huacaya*		*Suri*		*Kara*		*Chaku*	
Sex	Male	Female	Male	Female	Male	Female	Male	Female
Country								
Bolivia	80	80	---	---	105	95	105	95
Chile	80	80	---	---	105	95	105	95
Peru	90	90	90	90	110	105	110	105

8. Tables 12 and 13 show us the weight and fineness of the fleece. The weights given of *alpaca* and *llama* fleece are from the literature. Conflicting weights are given, because the authors usually do not refer to the frequency of shearing, and this information is important for establishing the real fleece yield. We have carefully selected existing information, critically collecting that which would establish clearly the frequency of shearing (annual or biennial).

As we can see from Table 5, all the *alpaca* and *llama* belong to well-known breeds, although with different regional names; attempts to classify them into sub-breeds, as some scholars do, are meaningless. There are a number of *llama* "varieties", in Bolivia, bearing the name of the district in which they are bred but differing little from each other.

Table 12: Average Fleece Weight (kg) in Different Breeds of *Alpaca* and *Llama* in the Region

	Alpaca		*Llama*	
Breeds	*Huacaya*	*Suri*	*Kara*	*Chaku*
Country				
Bolivia	2.5*	---	0.94**	1.31**
Chile	2.4*	---	0.82***	
Peru	1.8**	1.9**	1.02***	

* Biennial shearing
** Annual shearing
*** Annual shearing, average for both breeds

Table 13: Average Fleece Fineness (microns) in Different Breeds of *Alpaca* and *Llama* in the Region

	Alpaca		*Llama*	
Breeds	*Huacaya*	*Suri*	*Kara*	*Chaku*
Country				
Bolivia	24.0-28.0	---	24.98(87.07)*	23.20(71.16)*
Chile	24.0-30.5	---	-----	-----
Peru	24.02	23.8	33.88**	28.06**

* These numbers refer to the fineness of the "inner coat" of the fleece and the number in brackets to the "outer coat" of the fleece.

** Average fineness between the inner and outer coats of the fleece.

In Bolivia, there are some variations in size, conformation, and fleece characteristics, but there are no types that are recognised as being distinct. The variations here are probably greater than elsewhere, but no local strains have been described.

The breeder can improve the herd or flock through variation or genetic diversity, and both heredity and environment are important in producing differences among individual animals and, in some instances, this variability is a result of their interaction. By studying variations alone, we are not able to determine whether certain variations are due to environment or heredity. Nevertheless, the relative importance of hereditary and environmental influences on variations for individual traits has been determined for other domestic species, but not for *alpaca* or *llama*.

Inbreeding is the mating of animals that are more closely related to each other than the average of the population, i.e, mating animals that have one or more ancestors in common. The primary problem with inbreeding is that it results in not only a concentration of the "good" or desirable genes, but the "bad" (undesirable or deleterious) genes as well. As the homozygosity of the herd increases, so does the incidence of genetic defects (this will be discussed in the following section). A serious problem with inbreeding is that, when it is combined with selection, it causes a decrease in genetic diversity. Currently, most of the small herds of *alpaca* and *llama* are maintained by a single human family, and male animals tend to be used for years, with minimal or no rotation, promoting inbreeding. Therefore, the genetic diversity is reduced in small herds of *alpaca* and *llama*, and many problems arise as a result.

However, the Andean Region is host to numerous genetically different populations of *alpaca* and *llama*, populations that have been geographically isolated, hence increasing the genetic diversity.

Recently there has been a renewed interest in the preservation of genetic variation in farm livestock. This has come mainly through the desire of breeders and geneticists to store genes or germplasms of the minority breeds, some of which were on the verge of extinction.

Germplasm can be stored as semen for some species (the haploid state) or fertilised ova (the diploid state), or in live animals kept in zoological gardens, national parks, and privately-owned game ranches. In Peru, we know of three State farms involved in increasing the population of some colours of *alpaca* or *llama* that were very low in number. In Bolivia, an ambitious programme of regional scope for the establishment of a research and promotion centre for SACs is currently being negotiated with FAO's International Fund for Agricultural Development.

Traditional Breeding Practices: Criteria and Results

Animal selection for specific traits is an old and important aspect of SAC breeding among traditional herders of the Andes. Although the criteria for selection have changed over time, particularly after *alpaca* fibre became an important export item, the highland peasant has selected some traits that have been considered culturally desirable.

Several researchers have focussed on the traditional systems that herders use to classify and identify each of their animals. Traditional herders, as elsewhere in the world, treat and deal with their animals on a strictly individual basis. Each animal is recognised for its physical appearance as well as for its behaviour. Herders can easily point out each one of their animals and describe them in terms of somatic as well as ethological characteristics.

Animals are identified and classified by a number of criteria: age, sex, race, fibre quality, and colour; current status in terms of shearing, genetic defects, or visible marks; and by their behaviour (leadership, attentiveness, bewilderment, timidity, wildness, etc).

In the context of the current fibre market economy, classification by fibre quality and colour is crucial. *Suri* and *Wakaya* fibres may, in turn, be subclassified into *chharqa* (coarse and heavy) or *llamphu* (soft and light), the second being preferred for weaving. On the other hand, with regard to *llama* and *wari* (crosses between *alpaca* and *llama*) fibre quality is referred to by the terms *allin millmayuq* (good quality) or *manan allin millmayuq* (poor quality).

Colour of fibre is particularly important. In addition to the extremes of white and black, a wide range of tones are recognised by the term *kulur*, for which over twenty possibilities can be found (from cream white, light brown, grayish, dark brown, etc). Colour terminology usually provides the basis for the giving of individual names to each animal. Furthermore, the actual colour pattern for distribution of the many colours over the animal's body is described by rather extensive and elaborate Quechua terminology (Flores Ochoa 1988).

Identification of ownership of the animal is very important, especially when mixed herds of different animals graze in communal pastures. Andean herders have traditional ways to mark their animals (*señalakuy, marka*) for ownership identification. The *señalakuy* of animals is an important ritual ceremony for communal participation. Depending on the region of the Andes, the marks can be done in different ways. Usually small pieces of the ears are cut in different patterns. Twenty alternative ear-cutting patterns and 480 combinations of these have been reported. In some regions the ears are traversed across with coloured yarns and laces. All these clearly identify a family's property and sometimes the adscription of families to communities. In a few cases the branding of SACs with hot iron markers has been reported.

In terms of sex and reproductive age animals are equally classified with specific denominations (see Table 14).

Table 14: Sex-age Classification Denominations For SACs

Male	Neutral	Female
Alpaca		
Orqo (male)	*Chifón* (sterile male)	*China* (female)
Tatala (adult male)	*Urwa* (" female)	*Mama* (mother)
Huayñachu (sire)	*Machora* (" ")	
Malto (male without brood)		
Wari		
Orqo (male)	*Urwa* (sterile female)	*Mama* (mother)
Tatala (adult male)		
Llama		
Orqo (male)	*Malto* (sterile male)	*Mama* (mother)
Tatala (adult male)	*Urwa* (sterile female)	
Chullumpi (sire)		

Age in itself is also an important classificatory criterion. An animal is considered young (*tuwi*) during its first two years. After the second year it becomes *ankuta*, an animal able to breed. Old males and females are referred to as *machu* and *paya*.

Huallcas (colored laces or yarns) are also placed on parts of the animal (around their collar or on the rear right or left thigh) to match recently born offspring with their mothers. Sex, and sometimes ownership, is also marked by one or more large locks of hair left aside during shearing on a specific part of the animal's body.

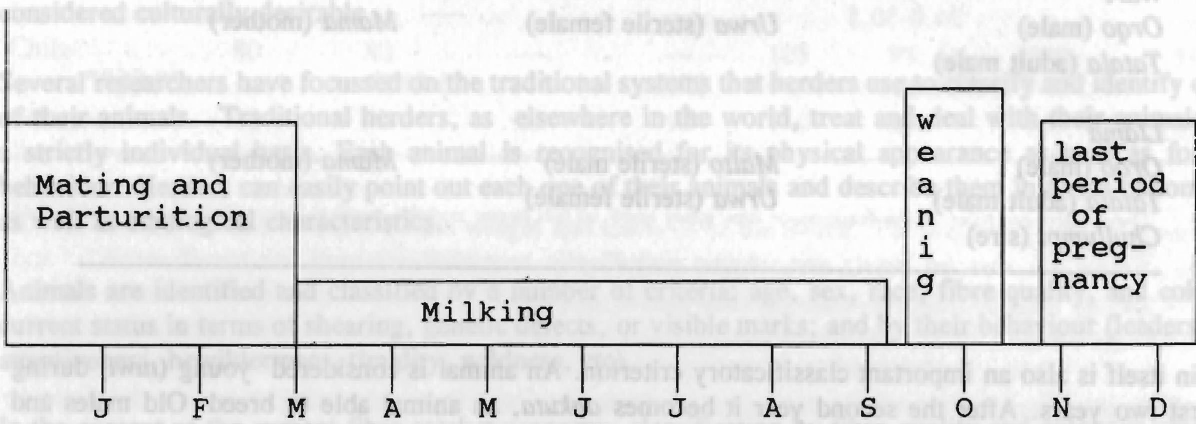
Although the elaborate ancient techniques related to animal selection and breeding were gradually forgotten after European colonisation, many aspects remain as part of the herding traditions of the highland indigenous communities. The reproductive period starts shortly after the onset of the rainy season, once pastures are abundant (anywhere from late November through January). New and full moon days are avoided. Healthy male sires, over two years old with preferred eye colour (light eye colour is a sign of disposition to infections), size, and fibre characteristics, are purposely placed in the female flock. Females should be receptive. If not, their back feet are tied and sometimes their tails are shorn. Once pregnant, a yarn or lace is tied around the female's tail to avoid confusion. Pregnant females also reject males. After a few months, pregnancy can be identified by the herders through actually touching the female's belly.

Sick or defective females are prevented from undesired pregnancy by covering their backs with plastic shields. Females with small teats and poor milk production are avoided. Some defects, such as polydactylity, are desirable and considered to be good luck. Market considerations nowadays favour pure white fibres, disregarding the many tones and shades.

Males with undesirable traits are usually castrated under the full moon once they are two years' old. Castrated animals are believed to become more resistant to infectious diseases, to fatten, and to produce more fibre. Castration is done by hand by cutting and pulling out the testicles.

Parturition occurs during the rainy season. Newly-born offspring are protected from the cold by wrapping their trunks with cloth (*wacachi*). This is believed to protect them from cold as well as from stomach pains. Towards March-April the offspring are counted and marked. After marking, old animals are destined for slaughtering for dried meat (*charqui*). The following figure offers a graphic representation of the *alpaca* vital cycle.

Figure 1: Critical Nutritional Periods in the Reproductive Cycle of the *Alpaca*



Source: FIDA 1990

SAC Products

Fibre (Wool)

The wool of the *alpaca*, or simply "fibre"as it is called to distinguish it from sheep's wool, is a product of high quality and has special properties which are greatly appreciated by artisans as well as by the modern textile industry. *Alpaca* wool has a high commercial value because it contains little kemp, has a low felting quality, is very fine, and can be woven into lightweight, soft, and lustrous fabric.

A considerable variation exists in the quantity of wool produced by the *alpaca*, depending upon various factors, such as age, sex, breed, genetic selection, and management conditions. The annual wool yield of an adult animal is about 1.8kg (range 0.8 to 4.2kg); average wool fineness is about 24 microns (on the Bradford scale, grade 80', compared to 60' for Merino wool). Shearing is annual or biennial or longer. Technically, annual shearing is better because the fleece is then less damaged by the environment (solar radiation, rain, dust, dryness, etc), it allows for better external parasite control, and weighing the live animal and his fleece allows for better control of production and genetic selection.

There is a highly significant correlation between body and fleece weight in the *alpaca*. How far fleece weight is inherited has not been estimated, but the considerable variation between individuals that are similarly managed and fed suggests a high hereditary value. As white fleece commands a better price in the market, commercial farmers pay more attention to selection for colour than to other traits.

The annual production of *alpaca* wool in Peru is around 3,500 metric tonnes and in Bolivia around 1,000 tonnes, from which 20 to 30 per cent is used locally by textile artisans.

The *llama* wool is coarser and stronger than the *alpaca* wool, and this fibre is mainly used for carpets, bags, sacks, and coarser clothing. In the woolly breed of the *llama* (*Chaku*), the fleece may average 1.3kg per animal, per year, and the average fineness is 28microns. The *llama* belonging to peasant communities are sheared every two years or more, depending upon how much money they need. The fibre accumulating on their backs is often safer than capital in the bank. They serve as mobile rural banks.

Meat

Alpaca meat is said to be similar to mutton and venison, but it is not strong smelling. It has a high nutritive value, similar to the meat of other domestic animals, but with the advantage of a very low fat content (1.33%). Meat from young animals is even superior in taste than lamb but, under practical farming conditions, only surplus males and adult animals are slaughtered, usually old males and females.

The carcase dressing percentage in *alpaca* is very high, between 52 to 55 (depending upon age, sex, breed, body condition, etc). These figures indicate unquestionably that *alpaca*, even when not selected for meat production, have a higher carcase yield than sheep or cattle. The off-take of most *alpaca* farms is only eight per cent, due to a high neonatal mortality and low fertility rates. The annual production of *alpaca* meat in Peru is around 5,000 metric tonnes, and it is marketed in cities of the *sierra* and highlands.

The meat of the *llama* is very similar in taste to that of the *alpaca* meat, but a little drier. The carcase dressing percentage is between 55 to 60. Animals of the *Kara* breed are considered to be meat producers. The off-take of most *llama* herds is around 10 per cent and the annual production of *llama* meat is about 4,900 metric tonnes, of which more than 50 per cent is sun-dried for storage. Dried meat, produced through freeze-drying during the cold and dry winters of the Southern Hemisphere, is called *charqui* in Peru. It was an important export product during the colonial era. A comparison of SAC meat with other livestock in terms of nutritional standing is presented in Table 15.

Table 15: Nutritional Status of SAC Meat in Comparison to Other Meats

Species	Proteins %	Fats %	Cenizas %
Pigs	14.50	37.00	0.75
Sheep	17.00	28.00	1.00
Chicken	18.00	0.34	0.99
Alpaca	18.93	1.06	1.11
Cow	21.00	5.05	1.00
Llama	21.72	2.50	1.00

Source: Benel 1990. Frigorific "Cabañillas", Puno-Perú; By Dr. Juan Fernán-dez Benel. *Corporación de Desarrollo de Puno,* 1978. Reproduced in FIDA : 1990.

Hides and Pelts

Hides of adult animals and pelts of very young animals represent a very important income for *alpaca* and *llama* dealers. It is calculated that around 100,000 hides and 50,000 pelts are handed annually to the fur industry, which is mostly run by artisans. Hides are used for manufacturing leather goods and the pelts for fur coats, which are in great demand in the international market. Arequipa in southern Peru has traditionally established its reputation and tradition in the production of *llama* hides while Juliaca, in the neighbouring highlands, has become the centre of the *alpaca* pelt industry. In 1987, Peru exported about 4 million dollars' worth of different articles made from *alpaca* and *llama* skins.

Work

The *llama* is the only South American camelid used as a pack animal. It can transport loads weighing 25 to 30kg, sometimes close to 50kg, over distances of 20 to 25km daily. It is employed for both local and long distance inter-Andean trade for obtaining non-*puna* products, such as maize, wheat, barley, and other goods. They easily adapt to the glacier-bound regions and highland passes as well as to lowland humid and warm valley conditions.

The pre-Inca civilisations domesticated the *llama* and by selective breeding made the *llama* a natural pack animal. Native to high altitude ecologic zones, *llama* have an intrinsic thriftiness, efficiency, and compatibility with the wilderness. Wilderness packing in the USA has brought about a great demand for *llama;* backpackers are concerned about the destructive impact of horses and mules, with their hard hooves on natural resources, and are looking for a way to travel in the wilderness with least environmental impact.

Pets

The *alpaca* and *llama* are pets and companions. The continuing urbanisation of society over the last twenty years has resulted in the rapid expansion of the pet market in the developed world. The *llama* approaches the ideal as a pet animal. Docile and low-key with a predictable temperament makes the *llama* easy to handle, even by novices. Intelligence, personality, and an elegant carriage makes it appealing. Natural hardiness and low maintenance requirements make it easy and economical to maintain and it does not need intensive care.

Fertiliser

Lamoid excreta are important in maintaining soil fertility in the Andean highlands. Almost all the "bitter potato" crops in the highlands depend on wastes from the *alpaca* and the *llama*. At high altitudes the SAC dung pellets decompose slowly, thus gradually enriching the soil over several rotational periods after initial application (for further information on SAC dung refer to Part A).

Fuel

Another product of the *alpaca* and *llama* is *taquia*, dried camelid dung. Since most of the SAC habitat is treeless grassland, dung is an important source of fuel for cooking and heating. The excrement is pellet-shaped and can be gathered efficiently because, as we mentioned, the *alpaca* and the *llama* "thoughtfully" use common 'latrines'. With forced air, *alpaca* dung fires can even reach a sufficient temperature to forge metal.

Capital Reserve

The *alpaca* and *llama* are often seen as assets that can be readily converted into cash in times of need, e.g., hospital expenses, school fees, emergency food purchases during drought, for weddings, etc. They serve as mobile rural banks. The fibre accumulating on their backs is often safer than capital in the bank. When the need arises, they can be sheared and the fibre sold.

Cultural

The *alpaca* and *llama* feature in many Andean highland societies in recreation, religious festivals, sacrifices, social gatherings, etc. They are traditional symbols of wealth and of communication between the spirit world and humans. They are a rich source of folk wisdom as expressed in metaphors registered in myths and tales. The national emblems of Peru and Bolivia depict members of the SAC family.

Others

The sinews and bones of both animals provide thongs and weaving tools. The fat heated and mixed with some essential oils is used as medicine. Fat and foetuses resulting from miscarriages are also used in magic and fertility rites.

Productivity Levels under Varying Conditions

Preliminary research on productivity enhancement of lamoids through adequate breeding and rearing practices are indicative of their potential under improved conditions. Tables 16 and 17 clearly show this.

Introduction of SACs to Other Environments: Historical Perspectives

The first contact of Europeans with South American *llama* herds was most likely that of Captain Francisco Pizarro's crew when he first arrived at the port of Tumbes in northern Peru, some time in 1528. Pizarro took some *llamas* back to Spain and displayed them at the Spanish court. In those days the *llama* was known by the Spaniards as *Carneros de la Tierra* (Rams of the Land) and later on as *Carneros de Cuello Largo* (The Long-Necked Rams). Since then, many attempts have been made to introduce members of the SAC family to Spain, England, France, Germany, and Holland during the 16th, 17th, and early 18th centuries. No accounts of any of these introductions are available in literature.

Table 16: Estimated Output Indexes in *Alpaca* Breeds in the Highland Zone of Peru at Three Levels of Technology

	Level of Technology Improvement		
	High	Medium	Low
Female adult live weight, kg	45.0	43.0	40.0
Fertility index, %	62.0	58.0	33.0
Adult mortality, %	5.0	6.0	7.0
Mortality at birth, %	12.0	14.0	18.0
Carcase weight at slaughter, kg	28.0	26.0	23.0
Fibre weight, kg	1.6	1.4	1.2

Adapted from Bryant et al. (1989)
Source: FIDA 1990

Table 17: Zootechnical Indexes in the *Llama* and *Alpaca*

Indexes	Actual %	Possible %
Natality	45	80
Number of births per female	4	7
Age of weaning	9 months	5 months
Age of first mating	5 years	3 years
Age of first shearing	4 years	3 years
Fibre yield in *llama*	1 kg	3 kg
Fibre yield in *alpaca*	2 kg	4 kg
Meat yield in *llama*	24 kg	45 kg
Meat yield in *alpaca*	18 kg	35 kg

Source: Direct observation and investigation tests 1982-1988 by Max Paredes C. In: FIDA 1990.

By 1770, the Government of Holland auctioned a herd of 32 *alpacas* and *llamas*, belonging to King Wilfred II. It is said that this herd was purchased by the Frenchman, Buffon, Father of Veterinary Sciences, and sent to the Veterinary School of Alfort.

The greatest number of *llama* that were ever carried to Europe at one time was a herd that arrived in Cadiz in 1808. It originally consisted of thirty-six individuals, including the types called *llama*, *alpaca*, and *vicuna*. They were brought from the highlands of Peru to Buenos Aires, on the Atlantic coast, by slowly travelling two to three leagues a day, and then shipped to Cadiz. Only eleven arrived in Cadiz, two of which died there. These animals were carried to Europe as a present from the Prince of Peace, Godoy, to Empress Josephine. There is a report that six *alpacas* were imported to New Hampshire in the United States in 1849.

One of the most interesting accounts of the introduction of the *alpaca* to other countries is Charles Ledger's attempts to introduce them into Australia. He was particularly impressed by their adaptability and wrote: "*No animal in the creation, it is my firm conviction, is less affected by the changes of climate and food*". In 1858, he landed 274 animals in Sydney after four months at sea. However, in 1864 the Australian government decided to abandon the *alpaca* business entirely, forced by the Merino breeders who saw in the *alpaca* a fine wool producer and a future competitor.

In the late 1800s, the *llama* was introduced into the USA as a zoo exhibit; the number of imports was small and generally included *guanacos* or *guanaco* hybrids. One of the more significant importations was made in the early 1900s into the California coastal area by W.R. Hearst. In 1930, import of SACs was cut off by a "Foot and Mouth Disease" embargo on all South American hoofed stock. Finally, in the early 1980s, USA *llama* breeders started to import the *llama* and *alpaca* from Chile, and now the *llama* has developed from a zoo curiosity to a multi-million dollar industry growing at an exceptional rate. Nowadays the population of *llama* and *alpaca* in the USA consists of around 25,000 animals.

In the last 12 years, a total of 20,000 *llamas* and *alpacas* has been exported from Chile and Bolivia to the USA, Canada, Spain, Israel, Ecuador, and New Zealand. Australia is again in the *llama* and *alpaca* business, getting their animals from New Zealand. According to the "New Zealand Herald", lamoid breeders believe that, under New Zealand's climatic and management conditions, they can improve the quantity of fibre and natality that *alpaca* and *llama* are producing in the Andean Region.

Animal Health

Infectious Diseases of SACs

All four species are considered equally susceptible to the diseases mentioned. Furthermore, because SACs are closely related anatomically and physiologically to the Old-World camel, including the dromedary and Bactrian camel, we may extrapolate their infectious disease susceptibility.

Diseases Reported in the Alpaca and Llama

Enterotoxemia or Clostridial Disease.

Introduction and Cause. *Enterotoxemia* is the most important infectious disease in neonatal camelids. It is characterised by sudden death, with neonatal mortality rates as high as 50 per cent during the first month of life. The disease is also a problem for sheep enterprises.

Clostridium perfringens type A is usually involved. This bacterium mainly affects camelid neonates from one to four weeks' old. It lives in the soil and is normally found in the intestines of both humans and animals. Heavy rainfall, poor sanitation, and herd concentration encourage the spreading of the disease. *Enterotoxemia* can also be triggered by changes in normal digestive development that allow the bacteria to multiply, thus producing a potent toxin.

Diagnosis. During the camelid birth season, sudden deaths among newly-borns *(crias)* with good body conditions may indicate *enterotoxemia,* as do abdominal distention and neurological signs such as rapid convulsions and opisthotonus. Diarrhoea is usually not observed, except when sudden death is associated with viral or *E. coli infections*. During necropsy, fluid and gas accumulation, mainly in the small intestine, is commonly found. In some cases, changes in lung colour (congestion) and red spots on the external membranes of the intestines (haemorrhages in the intestinal subserosa) are also observed. Definitive diagnosis is achieved through laboratory detection of the *enterotoxin.*

Prevention and Treatment. Adequate care and management of neonates during the birth season will help prevent enterotoxemia. At present, no commercial vaccine exists, but one is being developed. Antimicrobial drugs and fluid and electrolyte replacement can be used in mixed *enterotoxemia* cases.

Alpaca Fever.

Introduction and Cause. A bacterial septicemia is caused by *Streptococcus zooepidemicus*, which rapidly becomes fatal. Often stress is the precipitating factor, with transport, shearing, and processing for any reason being the potential stress-creating conditions.

Diagnosis. Clinically, the disease is characterised by increased body temperatures (greater than 37°C), anorexia, weight loss, ascites, and relatively rapid death.

Prevention and Treatment. The disease can be prevented by minimising stressful situations; however, no absolute control measures have been found. It would appear that high-dose penicillin (10,000 U twice daily) is the therapy of choice.

Osteomyelitis of the Mandible.

Introduction and Cause. Firm swelling along the lines *(rami)* of the mandible are easily observed and palpated. Little or no pain may be associated with palpation. General signs of anorexia, fever, and depression are usually absent. Variable degrees of soft-tissue involvement are encountered, and a fistulous tract may lead from the lesion to the ventral border of the jaw.

Diagnosis. Any swelling of the mandibles should be considered suspicious. Surgical extirpation and microscopic examination of the lesions may aid in the diagnosis. Isolation and identification of the infective microorganism is necessary for definitive diagnosis.

Prevention and Treatment. No effective preventive measures have been developed. Early detection is imperative in order to facilitate a cure through drainage, as well as through sodium iodide and penicillin therapy.

Miscellaneous and Minor Bacterial Infections.

The following diseases have been reported at one time or another by veterinarians: their overall incidence is low and not of major economic importance.

Abscesses (*Corynebacterium* spp, *Actinomyces pyogenes*)
Anthrax (*Bacillus anthracis*)
Braxy or Malignant Oedema (*Clostridium septicum*)
Brucellosis (*Brucella melitensis* type 1)
Colibacillosis (*E. coli*)
Johne's Disease (*Mycobacterium paratuberculosis*)
Keratoconjunctivitis (*Staphylococcus aureus, Moraxella liquefacians*)
Necrotic Stomatitis (*Fusobacterium necrophorum*)
Listeriosis (*Listeria monocytogenes*)
Leptospirosis (*leptospira* spp)
Otitis (*Corynebacter pyogenes, S. aureus*)
Salmonellosis (*Salmonella* spp)
Tetanus (*Clostridium tetani*)
Tuberculosis (*M. tuberculosis, M. bovis, M. avium, M. microti*)

Diseases of Camels that May Affect SACs

These are listed not because of evidence of occurrence in SACs but as possible differential diagnoses, simply because of the similarities of the species. The following infectious diseases were reported to occur in the dromedary camel.

Anthrax
Brucellosis
Tuberculosis
Salmonellosis
Parteurellosis
Paratuberculosis (Johne's Disease)
Leptospirosis
Enterotoxemia types C and D

Viral Diseases

Camel Pox
Rabies
Rinderpest
Rift Valley Fever

Viral Diseases

The prevalence of viral diseases in SACs is unknown. Few clinically important viral diseases have been reported. Investigators have reported a few positive serologic test results, indicating exposure to viruses, but no evidence of clinical disease has been presented.

Whether or not lamoids are susceptible to a number of important viral diseases of other domestic or wild animals is still unknown. Perhaps lamoids have not been exposed to these viruses, or perhaps clinicians and researchers may not have conducted adequate virologic testing to discover them. For example, rinderpest has not been reported in SACs. Rinderpest does not occur in South America, but the *llama* has been experimentally tested and found susceptible to the rinderpest virus.

Current knowledge of lamoid viral diseases is rudimentary; we will describe very briefly some of the most important viral diseases that have been reported as clinical diseases or experimentally induced diseases.

Foot-and-Mouth Disease. This disease has been reported as an experimentally-induced disease in SACs, as well as in Old World Camels, and the species are relatively resistant to infection by the virus. The *llama* and *alpaca* are more likely to be involved in transmission of the virus, rather than in a severe clinical disease presentation.

Contagious Ecthyma. This has been reported as a clinical disease in the *llama* and *alpaca*. Signs and severity are similar to those seen in other small ruminants, with potential for transmission within the species. No specific treatment is recommended.

Rabies. As in all other mammals, this disease may occur when the animal is bitten by an infected animal. Signs are similar to those seen in other species. In some areas where the incidence of rabies is high, some veterinarians recommend the use of the killed vaccine in the *llama* and *alpaca*.

Herpes Virus. One herd of *alpaca* and *llama* imported into the United States from Chile was housed in an exotic animal farm where they became infected. Signs included blindness and neurologic signs, from nystagmus and head tilt to paralysis. Other clinical signs were dilated, non-responsive pupils, elevated body temperature, with permanent ocular damage. A virus indistinguishable from the equine herpes virus I was isolated from the affected animals. (If vaccines are to be used in the face of theoretical high risk, the product surely must be killed-virus vaccine and should be repeated often to attain immunity.)

Others. The following are some viral diseases with serologic evidence of formation of antibodies, but there have been no reports of natural disease.

Blue Tongue
Parainfluenza 3
Bovine Respiratory Syncytial Virus
Bovine Herpes Virus I
Bovine Virus Diarrhoea
Influenza A
Rotavirus

Internal Parasites.

Gastrointestinal Nematodes. Gastrointestinal parasites are reported to cause significant disease in the *llama* and *alpaca*. Faecal examinations have recovered species-specific parasites, such as *Graphinema*, *Spiculopteragia*, *Camelostrongylus*, *Nematodirus lamae*, and *Lamanema*. In addition *Ostertagia*, *Trichostrongylus*, *Cooperia*, *Nematodirus*, *Bunostomum*, *Oesophagostumun*, *Trichuris*, *Capillaria*, and *Haemonchus* are all reported to occur in SACs, as well as cattle, sheep, goats, and some wild ruminants.

The clinical signs of gastrointestinal parasitism in lamoids are similar to those seen in infected cattle and sheep. Parasitised animals infected with the parasite do not grow or mature as quickly as non-parasitised animals. Other clinical signs in *llama* and *alpaca* with heavy gastrointestinal parasites are diarrhoea, dehydration, emaciation, and anaemia. All of these signs are more common in young animals.

Many anthelmintics, although not specifically labelled for treatment of gastrointestinal parasitism in lamoids, can be used safely. Febendazole and Invermectin provide the most effective and safest treatment, removing mature gastrointestinal parasites and acting against the inhibited stages of these parasites.

Liver Flukes. The liver fluke, *Distoma hepatica*, has been reported to occur in the *alpaca* and *llama*. If fluke infections are suspected in lamoids, it is necessary to do a specific examination of the faeces for the eggs. Although fluke eggs are passed in the faeces, they are not detected by techniques normally used to detect roundworm eggs.

If fluke infections occur in cattle and sheep or other domestic animals in an area, lamoids grazing the same pastures can become infected also. Various anthelmintic drugs can be used for the treatment of liver flukes, and clorsulon is one of them (Curatrem, Merk Sharp, and Dohme).

Lungworms. *Dictyocaulus filaria*, the lungworm of cattle and sheep, has been reported to occur in SACs also. *Distyocaulus* infections are acquired by animals grazing in pastures containing infective larvae. Mature worms living in the air passage produce larvae that are coughed up, swallowed, and passed in the faeces. Larvae recovered from fresh faeces, taken rectally from the animal, should be considered lungworm larvae. Lungworms in the *alpaca* and *llama* can be treated effectively with Fenbendazole, Levamisole, or Invermectin at the dose recommended for gastrointestinal parasites.

Protozoan Parasites. Al least six species of the protozoan parasite, *Eimeria*, are reported to occur in *llama* and *alpaca*: *Eimeria lamae*, *E. alpacae*, *E. macusaniensis*, *E. peruviana*, *E. punoensis*, and *E. ivitaenses*. All of these species are host-specific to SACs and will not infect other domestic or wild animals. It is also true that the coccidia of other domestic animals and wild ruminants are host-specific and will not infect SACs.

Most coccidia infections in lamoids are asymptomatic. In areas of heavy oocyst contamination under conditions of intensive husbandry, young animals may show signs of clinical coccidiosis. The primary clinical sign seen in young animals is diarrhoea. Fresh blood is seen only rarely in the faeces of infected *llama*, and given that the lesions are confined to the small intestine.

Coccidiosis can be prevented on most farms by good management. Clinical coccidiosis in lamoids should be treated with the sulphonamides: *sulphamerazine*, *sulphamethazine*, or *sulphaquinoxaline*.

Toxoplasmosis. Toxoplasmosis is caused by a single species, *Toxoplasma gondii*. All felids act as the definitive host and any mammal, including humans, can be the intermediate host for the organism.

Toxoplasma is an important cause of abortion in ewes and prenatal mortality in lambs. Abortions can occur at any time during gestation or, if the foetus survives in the uterus, the lamb may be born dead or alive but weak.

In the United States, at least two cases of abortion in the *llama* have been associated with rising titers of *Toxoplasma* in the female. The control of *Toxoplasma* on the farm is very difficult. Feed should be covered to prevent contamination by cat faeces (young cats especially) and insects.

Sarcocystosis. Sarcocystosis is caused by a coccidial protozoon, *Sarcocystis*, which has a predatory-prey life cycle. Three species of *Sarcocystis* have been reported: *S. tilopodi* that infects the *guanaco*; *S. aucheniae* in the *alpaca*, *llama*, and *vicuna*; and *S. lamacanis* infecting the *alpaca*.

Sarcocyst, often visible to the naked eye and containing thousands of merozoites, are found in the muscles of the heart and squeleton, and microscopic oocyst are found in the faeces of dogs and other predatory animals. The various species seem to be highly host-specific.

Diagnosis of the condition in the *alpaca* and *llama* depends upon recognition of the sarcocyst in the muscles. In dogs, cats, and humans, this depends upon finding microscopic oocysts or sporocysts in the faeces. There is no treatment for this disease.

External Parasites.

Sarcoptic and Psoroptes Mange. Sarcoptic mange or *sarna*, as it is called in the Andean Region, is caused by *Sarcoptes scabiei* var. *aucheniae* and another similar disease is produced by *Psoroptes aucheniae* and has been well-described in the literature on the four species of SAC.

The scabies' mite spends its entire life on the host, burrowing within the epidermis of the skin. The life cycle (from egg to adult) is completed in about 18 to 26 days in *Sarcoptes* and 10 to 12 days in *Psoroptes*. Under ideal conditions, the mite can survive on the host for only a few days. The presence of the mite provokes an inflammatory response that initially produces a papular dermatitis. Animals infected with *Sarcoptes* initially develop a pruritic, papular, erythematous dermatitis over the inguinal, axillary, ventral abdominal, perineal, and distal extremity areas. Affected regions gradually become alopecic, crusted, thickened, and hyperpigmented. *Psoroptic* mange is less important, with a low incidence in the *llama* and *alpaca*, and the lesions are found in the neck and ears.

Diagnosis is based on skin scraping. Scrapings should be deep, retrieving large amounts of debris. Material from the scraping may be placed on a slide and covered with 10 per cent KOH to clear the hairs and facilitate the microscopic observation of the mites and mite eggs.

Many therapies have been used for mange in lamoids. Recently the popular therapy has been Ivermectin formulate for bovine use.

Others. Many other external parasites and parasitisms have been reported in the Peruvian literature or elsewhere and they are not so important. They are given below.

- Meningeal worm, caused by *Parelaphostrongylus tenuis*.

- Tapeworms caused by *Monieza expanza*, *M. benedeni*, and *Thysanieza giardi*.

- Lice, produced by *Microthoracius proelongiceps, M.minor*, and *Damalinia aucheniae*.

- Ticks (*Amblyomma parvitarsum*)

- Dear nasal bot (*Cephenemia* spp.)

- Sheep botfly (*Oestrous Ovis*)

- Spinose ear tick (*Otobius megnini*)

- Hard ticks (*Ixodidae*, various spp.)

For more comprehensive and detailed information on parasites in SACs, refer to the appropriate section in the references at the end of this report.

Toxicology. Only a few instances of poisoning have been reported in SACs, yet it is likely that they are susceptible to many toxic plants and chemicals that affect other domestic and wild animals. It is beyond the scope of this report to discuss all of the agents that might cause toxicity in SACs.

Intoxication of lamoids by toxic plants in their natural habitat in the Andes is rare and less frequent than in sheep; lamoids may be resistant to the substances encountered over millennia. However, lamoids outside the Andes, removed from their native environments, are likely to ingest toxic quantities of any one species. Even though most toxic species are unpalatable and unlikely to be consumed in quantity unless extraordinary circumstances force the animal to do so (severe drought, transfer of animals to a completely new environment, and new flora). We will briefly consider a few toxicities actually documented in SACs and mention those considered highly likely according to Andean literature and literature from the USA.

Astragalus Poisoning. *Astragalous* spp. (locoweed) is characterised by progressive muscular and nervous incoordination in animals that have grazed where these plants are present and where the soil contains abnormally high levels of selenium. Plant alkaloids may cause brain lesions. There are at least six suspect species in the Peruvian highlands, but their selenium content is unknown. The disease is usually observed during the dry season (May to November).

Initially, affected animals put on weight. But, thereafter, they become progressively emaciated and show nervous signs such as staggering, impaired sight and hearing, and ultimately severe muscular incoordination. During the course of the disease, abortions may occur during any stage of pregnancy. Stillbirths and weak and/or deformed young (*cria*) are observed.

Treatment of astragalus poisoning is non-specific. As prevention lamoids should not be allowed to graze where these toxic plants grow. Affected animals may recover on fresh pastures.

Others. Other plants that are likely to be poisonous in Peru are listed below.

- *Baccharis coridifolia*
- *Claviceps purpurea*
- *Bromus catharticus*
- *Erodium cicutarium*

The only reports of plant poisoning in lamoids in the USA involve oleander, *Nerium oleander*, and various species of the family *Ericaceae*. Other plants considered likely to be toxic to lamoids are given below.

- *Triglochin maritima*
- *Veratrum californicum*
- *Zigadenus* spp.
- *Solanun* spp.
- *Datura metaloides*
- *Prunus virginiana*
- *Helenium hoopesii*
- *Ledum glandulosum*
- *Leucothoe davisiae*
- *Rhododendron occidentale*
- *Rhododendron* spp.
- *Ricinus communiis*
- *Nicotiana* spp.

As with toxic plants, most insecticides, heavy metals, pesticides, and caustic chemicals, that are toxic to a wide variety of mammals, are fully expected to be toxic to SACs. Some metabolic diseases (ketosis, hypocalcemia, and hypothyroidism) are of minor importance. The treatment of most of these conditions is based upon extrapolation from domestic ruminants.

However, some recommendations to avoid poisoning by plants are given.

1. When animals have been deprived of forage, as during transporting or corralling, they should not be put on ranges containing poisonous species until they are well fed.

2. Ample water should be provided so that animals will not be induced to eat increased amounts of forage following water deprivation and subsequent watering.

3. Animals should not be forced to remain on the range after they have used the good forage species. Otherwise, they will turn to less desirable, and often, poisonous plants.

4. The range land should not be so misused as to bring about the invasion of new species or the spread of poisonous species that already exist in amounts not dangerous to animals.

5. Preventing plant poisoning is much easier than curing it. Once poisoned, there is little chance of survival at any time and almost no chance under range conditions.

6. The people in charge of the herd should acquaint themselves with the symptoms of poisoning. At the very least, they should know the plant species in their area or region that cause problems.

Traditional Sanitary and Healing Practices

Traditional herders have a rich lore concerning sanitary curing practices to assure the well-being of their herds. This is intricately related to myth and religion and thus does not correspond necesarrily with contemporary veterinary conceptions.

Although mythological beliefs ascribe supernatural causes to many of the sicknesses of animals, herders are aware of the empirical factors to which they relate. Pasture availability and quality are perceived as critical to the flock's well-being. Poor feed will obviously affect the animals, lowering their resistance to sicknesses as well as compromising their reproductive potential. However, due to prevailing, limiting environmental constraints and poor socioeconomic conditions, few preventive actions are taken. As a result reinfestation and recurrences are common. Lack of disinfection of corrals and night shelters aggravates this trend.

In the case of external parasites, such as scabies, burn oil (from motors or kitchen) is applied. Also SAC lard mixed with black sulphur powder obtained from volcanoes is used. Sometimes lard or soap mixed with commercial pharmaceutical products is applied. **Piojera (Microthoracius and Demalina)** are treated with ashes or with cinder mixed with lard. Internal parasites are confronted with either traditional herbal medicine, commercial pharmaceuticals, or a combination of both.

Sanitary actions are particularly important during the animals' pregnancy and with newly-borns during their nursing period. To stop offspring from extending lactation beyond what is considered adequate, some species of bitter plants are applied by hand to the females' udders.

Still waters are identified as the cause for widespread *Streptococcus zooepidemicus*. *Alpacas* affected by it are treated with several medicinal plants (such as lemon combined with *Escallonia mutis*) and pharmaceuticals. As with the rich plant pharmacopea used on humans in Andean medicinal traditions, healing plants used in folk veterinary medicine have received little if any attention from researchers.

Nutrition of Domesticated SACs

Basic Digestive Anatomy/Physiology

Buccal Cavity. SAC lips are thin. The upper lip is divided by a middle groove (liporine lip) and the lower lip is relatively large. Lips are mobile allowing enhanced selective capability.

Dental formulae are diverse and related to feeds and defense; the permanent dental formulae is:

$$2 \quad I \ \frac{1}{3} \quad C \ \frac{1}{1} \quad PM \ \frac{1\text{-}2}{1\text{-}2} \quad M \ \frac{3}{3}$$

In the lamoids, the upper incisor has a flexible caudal section in the jaw allowing horizontal and vertical movement to become caniniform. All four canines develop in the male. So, with the extra upper caniniform tooth it appears as if there are two canines in each upper jaw. SACs complete their tooth development and replacement between 4.5 to 5 years of age.

Salivary Glands. Salivary glands in SACs are similar to advanced ruminants. Secretory rates and composition of saliva in lamoids also appear to resemble advanced ruminants. However, other researchers showed that pH and concentrations in *alpaca* saliva were similar to sheep but *alpaca* salivary flow was greater, suggesting greater buffering power in the *alpaca*.

Stomach. The stomachs of SACs differ from advanced ruminants. They have three distinct compartments. A transverse pillar divides the large, first compartment (C1) into cranial and caudal sacs. The C1 is connected to a smaller second compartment (C2). SACs have a ventricular groove which apparently has the same function as the reticular groove in advanced ruminants. The ventricular groove terminates at the tubular passage to the third compartment (C3), an elongated compartment slightly dilated at its proximal end.

Two types of mucosa are found on the internal surface of C1 and C2. The recessed saccules are lined by a glandular mucosa in the ventral part while the exposed surfaces are covered by stratified squamous epithelium in the dorsal part. In *llama*, about half of the total surface area (6,700sq. cm.) is occupied by a glandular area. The surface of C3 is covered with glandular epithelium. The terminal one-fifth of the C3 is thick and corresponds to the site of gastric glands, similar to the abomasum in cattle. Of this one-fifth, half of the surface is covered with fundic epithelium and the rest, toward the pylorus, with pyloric epithelium. Most consider this small distal region separately from C3 and refer to it as the "hind stomach".

The stomach volume of C1, C2, and C3 accounts for 83, 6, and 11 per cent of total stomach volume respectively. In adult *llama*, contents in C1 and C2 account for 15 per cent of the body weight and C3 for one to two per cent . It was found that *llama* have a smaller C1-C2 volume than the sheep reticulo-rumen volume when compared on a metabolic body weight basis. At eight weeks of age, *alpaca* stomach tissue proportions are similar to adult animals. Microbial activity reaches adult levels at the age of twelve weeks, coincident with high volatile fatty acid production and a drop in pH in C1 and C2.

Secretion of Stomach Glands. The mucinogen glandular mucosa present in all compartments of the stomach (with the exception of the mucosa of the C3 distal fifth, hind stomach) has a similar structure to advanced ruminants, despite differences in physical arrangements. Some studies indicated that the glandular saccules secreted significant amounts of bicarbonate in association with a reciprocal uptake in C1 from the lumen which may provide a substantial contribution to buffering digesta in C1 and C2. Other researchers reported that the main function of this glandular region in the stomach of SACs is rapid absorption of solutes and water. Absorption rates reached about two to three times more than in the rumen of sheep and goat. With respect to C3, the rate of absorption was significantly higher than values measured in the omasum of sheep and goats, even considering differences in body weight.

Motility. Forestomach motility in SACs has been described by several researchers. Each contraction cycle begins with the ventricular groove, followed by a single rapid contraction of C2. Then the ventricular groove contracts again accompanied by the caudal portion of C1. This sequence is referred to as "A-contractions". Following these are "B-contractions" consisting of the cranial portion of C1 and C2 and the caudal portion of C1. This sequence of movements is repeated two to seven times per contraction cycle. In short, the SAC's forestomach undergoes a more continuous activity than in the advanced ruminants.

Fermentation. Production of volatile fatty acids (VFA) from bacterial fermentation in C1 has been studied in the *llama* and the *guanaco*. VFA concentration reached highest levels between 1.5 to 2.0h after feeding. In a comparative study, VFA production and pH in *alpaca* and sheep at two different altitudes (at sea level and at 3,320m), with the same feeding regime, found the same response reported for *llama* and *guanaco* at sea level. However, at 3,320m, the peak VFA concentration in *alpaca* was reached much later, at 6h after feeding. At high altitudes, sheep showed a significantly faster initial fermentation rate than *alpaca*; however, no differences were found at sea level. In both species, the magnitude of feed fermentation was always greater at high altitude than at sea level.

It is suggested that *alpacas* have a more efficient buffering mechanism than sheep because VFA concentrations are similar, but pH values are different. The pH value for sheep was more acidic than for the *alpaca*. This would allow SACs to approach higher bacterial yields because acidic conditions increase the maintenance energy requirements of forestomach bacteria. Further, cellulolytic bacteria apparently obtain lower yields at lower pH values.

In a study determining total VFA in gastrointestinal digesta of the *alpaca* and *llama*, great fermentative activity was found in the first two compartments. Important VFA concentrations also occurred in the proximal two-thirds of C3 and in the caecum and proximal colon. The greater concentrations in *alpaca* and *llama*, compared with available data for sheep, cattle, and deer, suggest a more efficient (almost complete) absorption of VFA from the stomach of SACs. With respect to concentrations of different VFAs, the amount of gas eructated in the *alpaca* was similar to cattle on a per unit of body weight basis.

Retention Time of Food in the Digestive Tract. Retention of digesta in the *alpaca* (50.3 h) was found to be longer than for sheep (43.2 h). Reported retention in *llama* 63.2 h and sheep was 40.9 h. In a study of gastrointestinal transit time in ten mammal species, it was found that the *llama* retained larger particles for a longer period of time than cattle or horses.

With respect to the liquid passage rate in the C1 and C2 of SACs in comparison to sheep, a faster rate in the *llama* (10.4%/h) was found than in sheep (7.7%/h). The more rapid liquid passage rate in *llama* might be due to the higher ratio of salivary flow to forestomach size. Other researchers reported an improvement in microbial protein synthesis of up to 25 per cent as a result of the increased liquid dilution rate from application of artificial saliva. On the other hand, the relatively shorter retention of ruminal fluid in the *llama*, compared to sheep, indicates that the *llama* may have improved microbial growth in C1 and C2, assuring a minimum amount of energy to maintain microbial population.

Nutritional Requirements

Nitrogen. Only one report exists on nitrogen requirements of SACs. In a nitrogen balance trial in *alpaca*, it was estimated that the maintenance requirements at 0.38 g digestible nitrogen or 2.38 g digestible protein per unit of metabolic weight (kg W 0.75), which was lower than for sheep and beef cattle (2.79g/kg W 075). In *llama* on a low protein ration, efficiently recycled body urea into the gastrointestinal tract and 85 per cent of recycled urea was utilised. *Llamas* excreted lower renal urea values than sheep and goats under similar feeding regimes. In addition, *llamas* seemed to hydrolise more urea in the forestomach than other ruminants; therefore, more nitrogen for protein synthesis by microbes would be available in *llamas*.

Energy. Using carbon balance techniques with the *llama*, it was estimated that the maintenance requirement of metabolisable energy was 61.2 kcal/kg W 0.75, a value lower than 98 kcal/kg W 0.75 for sheep. Likewise, the *llama*, especially during reduced food intake, has a lower basal metabolism than sheep and goats under similar conditions. *Llamas* were able to reduce energy expenditure from 61 kcal/kg W 0.75 during the control period to 52 kcal/kg W 0.75 during food restriction, which is lower than the fasting metabolism of advanced ruminants.

Minerals and Vitamins. No specific deficiencies in minerals have been reported in SACs. Studies on mineral contents of pastures grazed on by *llama* and *alpaca* indicate a low phosphorous (P) and copper (Cu) content during the dry season. *Alpaca* grazing on cultivated and natural pastures during the dry and rainy seasons were found to have the lowest values of serum P, and serum calcium did not change due to type of pastures or season.

Cu concentrations of 48mg per cent in *alpaca* livers of apparently normal animals were found. Although Cu concentration is influenced by dietary proportions of molybdenum and Sulphur, Cu levels from 25 to 75mg per cent in the liver of other ruminants constitute a valid diagnosis for deficiency. On the other hand, when trying to supplement with Cu sulphate, *alpacas* demonstrate high susceptibility to Cu toxicity.

It is interesting that SACs apparently are unable to lick. Numerous efforts to supplement mineral salts in adult *alpaca* or *llama* have met with little success. Under penned conditions, minerals supplied are chewed at the block rather than licked. However, they recovered, with the lips, grounded mineral salts when given in pots. Under most management conditions, salt should be made available as loose salt in a container out of the weather.

There is no information on vitamin deficiencies in SACs. However, we assumed that B-vitamin biosynthesis occurs in the forestomach, as in other ruminants, and is sufficient to supply their requirements. Despite injecting vitamins A, D, and ADE in pregnant *alpacas* two months before parturition, no birth weight differences were found in first service *alpaca* between treatments. Pre-mating injections of vitamins A, D, and E into adult *alpacas* have no effect on fertility.

Ability to Digest Forage

Several comparative studies in *in vivo* digestibility between *alpacas* and sheep, *llamas* and sheep, have been undertaken. One study found noticeable differences between *alpacas* and sheep, with *alpacas* exhibiting higher digestion coefficients. Other researchers reported higher digestion coefficients for *llamas* than sheep, while one study reported no differences. Discrepancies in digestibility between species might be attributed to the fact that animal selectivity was not taken into account in some experiments.

It has been shown that there is greater selectivity in sheep than in *alpacas*. Other researchers noted that feed portions refused by selector animals were more lignified usually. If selection is not quantified, it may lead to apparently higher digestion coefficients in selector animals. Another reason for discrepancies may be the quality of feed used. In diets with less than 75 per cent crude protein, differences between *alpacas* and sheep were greater than when dietary crude protein was above 10.5 per cent .

Greater digestion coefficients were reported for *llamas* than for sheep on low and medium quality diets, but digestion coefficients were similar for *llamas* and sheep on high quality diets. Greater SAC efficiency may be related to the longer retention time of digesta than in sheep. Digestibility of high quality diets is relatively unaffected by retention time in the reticulo-rumen. Greater efficiency of digestion in SACs also may be due to more frequent contractions of the forestomach, the rumination cycle, and the proportion of salivary flow to forestomach size. These attributes provide for more efficient maceration, mixing, and absorption of digesta. Greater digestibility values in SACs on low nitrogen feed could be explained by the ability to maintain higher $NH4+$ concentrations in C1 and C2 compared to sheep, which provides *llamas* with more nitrogen for microbial synthesis, thus improving digestibility.

Ability to Graze Selectively

Botanical Composition of Diets. Studies in Peru in the early 1970s, showed that *alpacas* consumed tall grasses in the wet season and short grasses in the dry season. Preferred species were *Festuca dolichophylla*, *Distichia muscoides*, *Trifolium amabile*, and *Bromus uniloides*.

Analysing faecal material for microhistological components of plants, it was found that grass consumption was higher during the driest months and consumption of grass-like species was inversely related to grass in the diet. Forbs in the diet increased in the early wet season. *Alpacas* ate more leaf material as the rainy season progressed. Young *alpacas* consumed more grass-like plants, forbs, and seeds than adults.

Other authors noted that *alpacas* are highly adaptable grazers; where grass was available, it made up the bulk of the *alpaca* diet, but on a site with low grass availability and abundant sedges, the diet was dominated by sedges. Although forbs did not contribute a large proportion of the animal diet, they were consistently eaten. As the dry season progressed, the diet of "*bofedal*" *alpacas* (those occupying perennially green areas) became largely sedges and reeds (78%), while Altiplano *alpaca* diets were dominated by grass (60%). In general, *llamas* preferred to graze on drier areas dominated by tall and coarse bunchgrasses, while *alpacas* used more moist bottomlands than sheep and *llamas*.

In the Peruvian highlands, 90 per cent of the total livestock are kept by smallholders and small communities, and *llamas* and *alpacas* are mixed with sheep and managed together. Few studies have compared dietary composition among these herbivores in order to understand how they share the forage resources. One study compared dietary botanical composition between *alpacas* and sheep in the southern highlands of Peru. *Alpacas* selected more tall grasses and less short grasses than sheep. Grass-like plants were important to *alpacas* in the early rainy season. The highest index (70%) of diet similarity was during the intermediate months between the dry and rainy season.

Likewise, the dietary composition of *llamas*, *alpacas*, and sheep under grazing conditions on three different pastures were studied; an improved pasture (*Festuca rubra*, *Lolium perenne*, and *Trifolium repens*); a *Festuca dolichophylla* range site (*Fedo*); and a *Festuca rigida* range site (*Feri*). On the improved pasture, sheep ate at least 2.6 times more legumes than SACs. This lower rate of legume selection by SACs might explain why bloat has not been reported in SACs. On the rangeland, *llamas* selected tall, coarse bunchgrasses and *llamas* ate more stems and less leaves than *alpacas* and sheep. This selection by *llamas* suggests that they can be classified as bulk and roughage eaters during the dry season - as other authors have classified Old World camelids.

Sheep showed a tendency to select less tall grasses and more leaves than *alpacas* and *llamas*. This tendency for intermediate selection, between the level of *llamas* and sheep, by *alpacas* suggests that *alpacas* are more grazer-selectors than *llamas*. *Alpacas* are more adaptable and appear to be able to use a wide variety of forage types. In the dry season, diet similarity was high between the *llamas* and *alpacas* on the *Feri* range sites and between *alpacas* and sheep on the *Fedo* range sites. In a complementary grazing system, the *llamas* and sheep offer the most efficient way of harvesting available forage, while *alpacas* seem to be adequate for single-species' use of rangeland.

<u>Nutritive Composition of Diets</u>. In the highland region of the Andes, few studies on diet quality under range conditions have been conducted. Studies working with *alpacas* and *llamas* indicated that, during the dry and late season, crude protein and digestibility reached the lowest levels. In the rainy season, diet quality was highest. The authors suggested that improved protein nutrition during the dry season may help solve the problems of low fertility common in *alpacas*. Sheep diet quality studies for the highland regions are also scarce.

In another comparative grazing study, the *llama* had the lowest dietary quality, sheep the highest, and the *alpaca* was intermediate. The higher dietary quality for sheep was attributed to greater selection than that observed for *alpacas* and *llamas*. Sheep preferred leaves, forbs, and short grasses, which are known to be higher in nutrient content. The *llamas* had less preference for these plants than sheep and *alpacas*. The intermediate dietary quality for *alpacas* confirmed their intermediate position in forage selection between those of *llamas* and sheep. Small ruminants like the *alpaca* are predicted to be more selective than large herbivores like the *llama*.

<u>Voluntary Intake</u>. Forage intake is an important aspect in formulating range and animal management strategies. Most intake information available for SACs comes from comparative studies of sheep under penned conditions. Feed consumption studies comparing SACs and sheep have shown an overall average intake by the *alpaca* and *llama* of 1.8 and 2.0 per cent of body weight respectively. Daily consumption of the *llama* on a metabolic weight (g/kg W 0.75) basis was lower than that of sheep.

Voluntary intake studies under grazing conditions are scarce. Consumption in the dry season, with some exceptions, is similar to or greater than in the rainy season. A lower intake in the rainy season when dietary quality is higher could be because animals increase gut capacity in response to lower diet quality during the dry season. Another factor may be the high water content of plants during the rainy season. However, addition of water, *per se*, to the rumen has little effect upon intake because it is largely absorbed and removed. Water retention caused by the "sponge effect" of coarse structural components of ingested forage can have an inhibitory effect on intake and could explain why intake is not higher in the rainy season than in the dry season.

Dry matter intake in terms of kg per metabolic body weight under grazing conditions for the *llama* and *alpaca* ranges from 38 to 67g, depending on the type of pasture and season of use. Similar to studies under penned conditions, consumption under grazing conditions is lower in SACs than sheep; on a metabolic weight basis, the *llama* and *alpaca* had the same level of intake grazing on improved and native range pastures, but intake values were 36 per cent lower for SACs than for sheep on improved pasture and 26 per cent lower on native range pastures. Table 18 presents a typical daily forage intake for the *llama* and *alpaca* during the dry and wet seasons.

Table 18: Daily Intake for *Llamas* and *Alpacas* by kg of Metabolic Weight (Pv. 75)

	Season	*Llama*	*Alpaca*	Reference
Festuca dolichophylla	Dry	50.5g OM*		Reiner et al.
Muhlenbergia fastigiata	Rain	44.3g OM		(1987)
F. rigida	Dry	42.0g OM		Farfan et al.
	Rain	40.0g OM		(1986)
F. dolichophylla	Dry	59.4g DM**		Huisa (1986)
Plantago tubulosa	Rain	51.7g DM		
F. rigida	Dry	44.3g DM	42.4g DM	San Martin
	Rain	39.7g DM	41.2g DM	(1987)

* Organic matter
** Dry matter
Source: FIDA 1990.

Lower intake values in SACs are probably a result of large body size and relatively lower energy requirements. This allows SACs to be less selective of plant parts (leaves) than smaller animals with smaller mouth parts. Stems, which are consumed more by SACs than sheep, would be retained for a longer time in the forestomach than leaf fractions. Also, SACs have smaller rumen volumes and lower particulate passage rates than sheep, and these are highly and negatively correlated with intake.

Domesticated SACs seem to be adapted to areas where more coarse forage is available and nutrients are diluted by structural carbohydrates that are difficult to digest. These characteristics are present in the Andean Highlands where long dry periods (6 to 7 months of every normal year) and cyclic years of drought are not uncommon. These climatic variations contribute to the scarce supply of quality forage. SACs have adapted by reducing intake and decreasing the transit time of digesta through the tract to enhance microbial attack of forage high in structural carbohydrates.

Stocking Ratios

Normal adult body weights for sheep, *alpacas*, and *llamas* in the Peruvian highlands are 40, 65, and 108 kg respectively. For comparative purposes, these values correspond to 15.9, 22.9, and 33.5 kg of metabolic weight (kg W 0.75), respectively. Thus, the respective *alpaca* and *llama* metabolic weights are 1.4 and 2.1 times those of sheep. Further, the metabolic weight of the *llama* is 1.5 times that of the *alpaca*. Considering a 30 per cent lower intake in SACs than in sheep, the stocking ratio would be 1.0:1.0 for *alpaca*:sheep (1.4x0.7) and 1.5:1.0 for *llama*:sheep (2.1x0,7). These *alpaca*:sheep and *llama*: sheep ratios are quite different from published stocking ratios which, without differentiation between the *alpaca* and *llama*, indicate ratios from 1.5 to 1.8 per sheep unit. It is important to note that these ratios do not incorporate herbage and environmental characteristics.

Reproductive Physiology and Behaviour

Male Reproduction

Male Reproductive Organs.

Testicles. In an adult *alpaca* or *llama*, the testicles are found in a non-pendulant scrotum, without a defined neck, and forming a sub-anal protuberance, comparable to swine and rodents. The average weight of a fully developed *alpaca* testicle is approximately 15 gr (at five years of age, a male is considered to have reached full development with an average body weight of 62.5 kg). Measurements of a few adult male *llama* testicles are as follows: length 5 to 7 cm, width 2.5 to 3.5 cm, and depth 3 to 4 cm. In *llamas* weighing 133 kg, the average weight of each testicle is about 24 gr (n=24). Considerable variations occur in testicle size and live weight. The weight of each testicle will vary between 0.02 and 0.03 per cent of the body weight.

In *alpacas*, testicle size will vary between four and five cm in length and 2.5 to 3.0cm in width. At birth, the testicles are found in the scrotum, being small and flaccid. At one year of age, usually the time to select future sires, both testicles should be in the scrotal sacs (1.10-1.38cm long). Sires are selected by testicle size, on the assumption of the direct relationship between testicle size and sperm production seen in other species.

The testicles in the *llama* and *alpaca* are small and elliptical, located in such a way that the major diameter is oblique with a dorsal and caudal orientation. Normally, both testicles are of the same size, firm but not hard with a free movement inside the scrotum. The epididymis is firmly connected to the testes, being small and conspicuous. The deferent duct is very thin (2mm) at its beginning, thickens (3 to 4mm) when it reaches the abdominal cavity, and ends near the bladder, forming what in other species is the ampulla deferens, without the characteristics of this structure. The total length of the deferent duct is approximately 40cm. The microscopic characteristics of the testicles and epididymis are essentially the same as for other livestock species.

Accessory Sexual Glands. The prostate is H-shaped, lying dorsally and laterally above the neck of the bladder. The bulbourethral glands are oval, located at the sides of the urethra in the pelvic outlet. SACs do not have seminal vesicles.

Penis and Prepuce. The penis is fibroelastic, with its end in the form of a curved hook to the right, with a small "urethral process" of one centimetre in length. The size of the erect penis is 35 to 40cm and the sigmoid flexure is pre-scrotal. The prepuce of the lamoid is triangular and non-pendant. In an unaroused male, the prepuce is directed caudally, and urine is projected backwards between the hind limbs from a semi-squatting position. When the male is sexually aroused, the cranial preputial muscles pull the prepuce cranially and the penis is extruded in the same manner as in the bull, between the hind legs.

Puberty. At birth, the penis is completely adherent to the prepuce. The adherences disappear gradually along with the growth of the animal under the influence of testosterone. At one year of age, the males show sexual interest in the females; however, only about eight per cent of the males show a complete liberation of the penis-prepuce adherences and are capable of copulation. At two years of age, approximately 70 per cent of the males have a liberation of the adherences, and 100 per cent at three years. Precocious behaviour and early mating are considered to be desirable traits in genetic selection programmes. Future sires are those that do not have prepuce-penis adherences as yearlings. However, the general practice is to use three year old males for reproduction.

Sexual Behaviour. Field observations have shown a *sui generis* behaviour of the *alpaca*. The male begins courting by running behind the female whether or not she is in heat. If the female is in heat, she will let the male mount her and adopt a seated position. Copulation will last for five to 50 minutes. During copulation, the male makes a guttural sound, in contrast to the female who remains submissive. Sometimes females will seat themselves next to a mating couple as a sign of also being in heat. At the beginning of the breeding season, when the males first join the females, the males show intense sexual activity, copulating up to 18 times per day. Recent studies indicate that the deposition of semen during normal copulation, is intrauterine.

Semen Collection. Collection of semen in SACs is complicated by the position of the mating animals and the long time of copulation. The first reported collection of semen was carried out using artificial vaginal sleeves which were recovered after copulation. Later on, vaginal pessaries, or sponges, were utilised, and it was reported that 20 per cent of the males did not have spermatozoa. However, both forms of semen collection are questionable, since they interfere with normal copulation and contaminate the semen. Also, in both studies, the volume of semen ejaculated was highly variable, fluctuating between 0.4 and 6.6 ml.

The use of the electroejaculator seems to be the most adequate means of semen collection. Nevertheless, during the electrical stimulus, the semen could be contaminated with urine and its quality is variable, with sperm concentration fluctuating between 1,000 and 255,000/mm^3.

More recently, the use of an artificial vagina (AV) has been reported. The AV was inserted inside an *alpaca* dummy in sitting position, obtaining up to 12.5ml of high quality semen with very good motility and around 500,000 sperms/mm^3. The semen of the *alpaca* or *llama* is highly viscous, causing difficulties in the separation of spermatozoa from the seminal plasma and hence estimation of sperm concentration by conventional methods. Due to the high viscosity of the seminal plasma, sperm motility is slow compared to that of other domestic species. Experimental evidence with the use of urethral fistula and artificial vagina indicates that ejaculation is a continuous process, with a uniform semen quality from the beginning to the end of copulation. Likewise, deposition of semen is intrauterine.

Female Reproduction

Female Reproductive Organs.

Ovaries. The ovaries are of globular, irregular shape, similar to those of the sow, particularly when they have multiple follicles. The left ovary in the *alpaca* is slightly heavier (2.40 $\pm$ 1.34g) than the right (1.87 $\pm$ 0.94 g) when neither has an active corpus luteum. The dimensions are: length, 1.64 $\pm$ 0.33 cm width, 1.07 $\pm$ 0.18 cm. Follicles are of five mm or bigger and the corpus luteum are prominent and conspicuous. Follicles between five and 12mm are normal and anything bigger than these dimensions can be considered pathological.

Oviduct, Uterus, and Vagina. Both oviducts are long and tortuous (length 20.0 $\pm$ 4.16cm), ending in a bursa which totally covers the ovary. The uterus in the *alpaca* and *llama* is bicornuate, with two uterine horns separated by a septum. The length of the left horn is slightly greater (7.89 $\pm$ 1.28cm) than the right (7.39 $\pm$ 0.98cm). The width of the uterus is relatively small (3.05 $\pm$ 0.71cm) and the cervix has two to three rings. In some ways, the uterus of the *alpaca* is similar to that of the ewe, although in the case of the ewe, the uterine horns become thinner nearer the utero-tubal junction. Both sides of the uterus are attached to the abdominal and pelvic walls by a wide ligament.

The isthmus of the oviduct enters the uterine horns in the shape of a small papilla, acting as a well-defined sphincter. The vagina has an approximate length of 13.37 $\pm$ 2.00cm, and a diameter of approximately 3.35 $\pm$ 0.67cm.

Puberty. Young female *alpacas* of 12 to 13 months show oestrous behaviour similar to that of adult *alpacas*. The majority of females show sexual receptivity at 12 months of age, even though ovarian activity begins at 10 months, with the presence of follicles of 5mm or more.

In a study carried out in southern Peru to evaluate the effect of body weight during the breeding season, on reproductive performance in 280 female yearling *alpacas*, it was determined that a highly significant ($P < 0.001$) relationship existed between body weight at the time of mating and subsequent rates. For each kilogramme in excess, there was a five per cent increase in natality; but when body weight exceeded 33kg, the percentage of open females was relatively independent of body weight. Under present management and breeding systems in South America, 50 per cent or less of yearling *alpacas* reach 33kg of liveweight at mating time. In other domestic animals, puberty is genetically determined and is modulated by environmental factors, nutritional levels being one of the most important. It has been shown that with better nutrition after weaning (7 to 8 months), almost 100 per cent of yearling *alpacas* can reach 33kg.

In South American traditional production systems, the female *alpaca* and *llama* are bred every two to three years, reflecting inadequate nutrition and management. For the *llama*, it is generally recommended not to breed a female before she has reached two-thirds of her anticipated adult body weight (102 to 109kg). In the USA, some *llama* breeders claimed that the actual time of puberty varies from six to 24 months, being related to both nutritional status and age.

Breeding and Birthing Season. Since SACs have a gestation period of 345 days on average, birthing seasons and breeding seasons can coincide. Studies of the *alpaca* and *llama* in their natural habit in the highlands of the Andean Region showed that the breeding season lasts from December to March (summer months). These are the warmest months, with sufficient rain and abundant green forage. In most of the herds, where males and females are together all year, i.e., the herds in peasant communities, parturition occurs only in the summer months, indicating a seasonal mating period. Wild species such as the *vicuna* and *guanaco* also have a seasonal breeding period. However, when females are kept separate from males and copulation is allowed only once a month, both sexes are sexually active during the entire year. Ovulation and fertilisation rates, along with embryo survival, were not significantly affected by the season of the year.

Experimental observations show that the continuous association of females and males inhibits sexual activity of the latter and even causes it to disappear altogether. Factors responsible for the onset and cessation of sexual activity under natural conditions are unknown. Environmental factors, in addition to visual and olfactory stimulation, could influence sexual activity via the central nervous system. It is well documented that the effect of external stimulation on sexual behaviour is more pronounced in the male than in the female. A mating system has been developed for the *alpaca* and *llama*, changing the breeding males each week for another group of males (during 60 days), enhancing the mating rate in the herd and, consequently increasing the natality rate. Observations in different zoological parks of the world indicate that lamoids are year-round breeders, but with a higher parturition rate during the summer months of each particular region.

Normal Ovarian Activity in Unmated Females. The female *alpaca* and *llama* do not have oestrous cycles like other large domestic species; oestrus and ovulation are not repetitive, cyclic, and predictable.

When unexposed to a male the female *alpaca* shows long periods of sexual receptivity, up to 36 days, with short periods of rejection of the male that could last for two days. Studies of the duration and periodicity of oestrus in the *alpaca* suggest that there is considerable variability between individuals, regardless of the reproductive status (parous vs. non-parous). The variability that exists in both the duration of oestrus and regularity of its occurrence presumably reflects the fact that in unmated females, the follicular phase is not terminated by ovulation at a predetermined time, and that there is no luteal phase to delineate the timing of events after the end of oestrus.

The long periods of sexual receptivity and short periods of non-receptivity have not been very well documented, nor are they clearly delineated. However, these periods may be correlated with rhythmic increases and decreases in serum oestrogen levels. Based on laparoscopic examination of *alpaca* ovaries at different intervals, the growth, maintenance, and regression of a follicle each required an average of four days with a total of 12 days (range from nine to 17 days).

Oestrous and Mating Behaviour. The female *llama* and *alpaca* do not exhibit common outward signs of heat or receptivity. The receptive female adopts a special pattern of behaviour in the presence of the male; she may take the prone position when the male is approaching her, or approach a male that is copulating with another female and adopt the prone position. In other cases, the male pursues the female for a short time, then mounts her and finally the female takes the prone position. It is also common to see some receptive females mounting other females of the herd. If the female is non-receptive, rejection is shown by running away from and spitting at the male.

Ovulation. Since copulation is ordinarily a necessary prelude to ovulation, the *alpaca* and *llama* have been classified as **reflex** or induced ovulators, as opposed to spontaneous ovulators. The same mechanisms have been found in Old World Camels.

The minimum time from copulation to ovulation has been estimated to be 26 hours following natural mating and 24 hours after injection of HCG (500-700 IU, im). Based on laparoscopic examination, 48.8 per cent ovulated between 26 to 30h, 28.8 per cent ovulated between 30 to 72h, and 22.5 per cent failed to ovulate; yearling *alpacas* accounted for most of the failures to ovulate. Investigation on the *llama* using an ultrasonographic technique revealed that ovulation occurred, on average, two days after a single mating. Ovulation was also successfully induced using one mg of luteinising hormone; a dose of four to eight micrograms of GnRH was also necessary to provide the adequate stimulus for ovulation.

There are some indications that females can ovulate without coital or exogenous hormonal stimulis especially when initially isolated from, and then exposed to, a male, but without allowing intromission. Spontaneous ovulations have occurred in 10 to 42 per cent of the *alpaca* females exposed to males, especially during the height of the breeding season. In the USA, five per cent of spontaneous ovulation has been reported. It has also been shown that both *alpaca* and bull semen can induce ovulation in *alpacas* and *llamas*, provided the semen is introduced deep into the vagina of a receptive female.

Multiple ovulations occurred in three to 10 per cent of *alpacas* after natural mating and in nine to 20 per cent after application of gonadotrophins, but twins born alive are extremely rare. The ovulatory activity, indicated by the presence of a corpus luteum of pregnancy, was always in favour of the right ovary. However, the magnitude of the difference varied in several studies.

Corpus Luteum Formation and Function. Corpus Luteum (CL) function was studied in non-pregnant *alpacas* after sterile matings and in pregnant *alpacas* after fertilising services. *Alpacas* or *llamas* mated with a vasectomised male (sterile) will form a functional CL. Progesterone (P4) was secreted from day five and reached maximum concentration of 10 to 20 nmol/L on day seven to eight. A rapid decline in P4 levels occurred on days nine to 10 in connection with repeated surge releases of protaglandins F2 alpha. Oestriol levels were > 100 to 200 pmol/L during receptivity when the females were mated and stayed low, 20 to 40 pmol/L during the luteal phase, but rose in most animals after luteolysis to 40 to 60 pmol/L. Additional observations suggest that during three to four days after coitus, when P4 concentrations remain low, and the CL is being formed, female *alpacas* and *llamas* could be receptive to the male.

In most cases, a fertile mating results in the formation of a CL of pregnancy which secretes P4 throughout the gestation period. P4 levels of 16 to 17 nmol/L were found on the ninth day after mating, with levels of 16 to 18 mol/L on the sixteenth day, remaining more or less constant until 30 days of pregnancy.

Pregnancy. The length of gestation in *alpacas* of the *Huacaya* and *Suri* breeds has been quoted as 341 and 345 days respectively. For *llama* in the USA, an average of 344 days, with a wide range (331-347 days), was given. In another study in Peru, with 79 nulliparous and 61 pluriparous animals, where only two matings were allowed (at six to eight hours interval), and the day of parturition registered, the gestation length was 346 $\pm$ 8 days (range 327-357), with no differences between nulliparous and multiparous or sex of the *cria* (litter).

Almost all *alpaca* and *llama* foetuses were found to be implanted in the left uterine horn, even though both ovaries are active to an equal degree. This indicates that embryos originating in the right side migrate to the left horn in order to survive. Migration provides a mechanism for embryonic survival by avoiding the right uterine horn which appears to be inadequate for embryo development.

As we said previously, multiple ovulations occur in the *alpaca* and *llama*, but twins born alive are extremely rare. Cases of twin pregnancies are only occasionally seen in the early stages of gestation. Various authors reported the presence of live twin embryos 31, 38, and 40 days after mating, both located in the left horn. The embryo located in the right uterine horn was dead. One *alpaca* twin birth in Peru and two *llama* twin births in the USA, have been reported.

The role of the CL during pregnancy indicated that the CL is necessary for the maintenance of pregnancy during the entire gestation period in the *alpaca* and *llama*, and, thus, these species can be classified according to the source of P4 as CL-dependent, similar to the cow, goat, and sow.

Fertility Rates and Embryonic Mortality. During the first month, embryo mortality appears higher in *alpacas* than in other domestic species, and seems to be a serious reproductive problem. In a study carried out in Peru, only 50 per cent of the fertilised ova survived for more than 30 days of gestation. Another study suggests that the overall reproductive wastage in *alpaca* (ova, embryo, and foetal loss) was 83.2 per cent , based on the number of pregnancies occurring 30 days after mating. No embryo-foetal losses were found from 90 days after mating to term. The factors responsible for this high rate of embryonic mortality have not been identified, but low nutritional levels can cause this problem.

Diagnosis of Pregnancy. In the traditional system, pregnancy is diagnosed by external palpation (ballottement) at eight months, a process at which most herdsmen are highly skilled, but this is very late for good reproductive management of the herds.

The behavioural response of females in the presence of males has been described by several authors. Using vasectomised males and, without exception females that showed oestral behaviour four or more days after a previous service (mating) were not found to be pregnant. Also, all pregnant females rejected the males between 20 and 95 days of pregnancy. However, not all of the females that rejected males were found to be pregnant. In another study, using teaser males (vasectomised), it was found that the accuracy of pregnancy diagnosis through oestral detection in the *alpaca*, on the 70th and 125th days after mating, was 84 and 88 per cent respectively; and in the *llama*, 85 and 95 per cent accuracy was obtained at foetal ages of 75 and 125 days after mating. The accuracy of pregnancy diagnosis obtained for *alpacas* and *llamas* in this study (84 to 95%) on the 70th to the 125th day of gestation is comparable to the accuracy obtained in a study on sheep. Therefore, oestral behaviour has been shown to have moderate accuracy. The date of breeding is required if used very early after mating and is limited to the extent that non-pregnant females do not always show oestrous and some females allow mounting during luteal function, especially if the teaser male is heavy, big, and aggressive. This technique requires a good knowledge of the sexual behaviour of lamoids as well as careful observation. It has not been widely adopted to date.

Pregnancy diagnosis by rectal palpation has been reported to be possible as early as on the 30th day of gestation but is limited because of pelvic size, particularly in younger and small animals. In a medium-sized herd of *alpacas* and *llamas*, with good nutrition and management, 70 per cent of the yearlings and 90 per cent of the adult *alpacas* were palpated, as well as 100 per cent of all *llamas*. However, the accuracy of pregnancy diagnosis by rectal palpation on the 165th day after mating was 100 per cent ; however, it was impossible to palpate 18 per cent of the *alpacas* due to pelvic anatomy, fat deposition in the pelvic inlet, and size limitations.

Milk and blood progesterones were used for pregnancy diagnosis in the *alpacas* and *llamas*. A striking difference in milk P4 concentrations between non-pregnant and pregnant *alpacas* was observed on the 12th day after mating, from which it was suggested that this difference might furnish the basis for an early pregnancy test.

Plasma P4 changes during the first 30 days of pregnancy in the *alpacas* and *llamas* have been described as a method for early pregnancy diagnosis, as well as during the gestation period. P4 concentrations below six nmol/L indicated non-pregnancy status. Detection of a fluid-filled uterus, using an ultrasonic device (Ithaco Ultrasonic Scanopreg, Model 738, Ithaca, NY, USA), developed for sheep, has been used in *alpacas* and *llamas*. The equipment is recommended for use from 60 to 120 days of pregnancy. The transducer was placed on the hairless abdominal wall, three to five cm cranial to the right udder; in *alpacas*, the highest accuracy of 92 per cent was recorded at a mean foetal age of 80 days compared to 90 per cent at 70 days of gestation. In *llamas*, 100 per cent accuracy was obtained at 75 days of gestation; in both species, the accuracy of the test was reduced to 84 per cent and 65 per cent at 165 days of gestation in the *alpaca* and *llama* respectively.

Also, in recent years, transrectal ultrasonography (B-Mode) has been used in domestic SACs. With this method, pregnancies were detected as early as 15 days after mating, but 100 per cent accuracy was obtained at 25 days after mating; they used a five MHz probe and a linear array scanner (ALOKA, Japan).

<u>Parturition</u>. Births in *alpacas* occur only during the early hours of the day. No births occur between 17.00 hours and 04.00 hours (unless there is an emergency), the time when temperatures are low even in the summer (and also throughout the year at altitudes higher than 4,000m). In *llamas*, 87 per cent of all parturitions also occur in the morning hours and a few cases in the early afternoon, giving the young a chance to get warm and dry before the cold nights.

In the *alpaca*, unassisted labour lasted, on the average, from 193 $\pm$ 122 minutes and 203 $\pm$ 129 minutes for multiparous and primiparous females respectively. In the *llama*, it lasted a mean of 176.3 minutes for all the stages of labour. The *alpaca* and *llama* do not lick their offspring at birth, even given a poor nutritional status.

<u>Postpartum Period</u>. Up to the fourth day after parturition, the female *alpaca* is submissive and can be mounted by the male. However, she is not fertile, since the regression of the CL, follicular growth, and the involution of the uterus, are prerequisites to renewed sexual activity. Five days after giving birth, some females show acceptance of males and, following copulation, occasionally ovulation and fertilisation occur. Ten days after childbirth, the follicles are eight to 10 mm in size (the ovulatory size), the CL has regressed considerably, and the uterus involuted, weighing only a fifth of its weight, 24 hours after birth. Mating of females is recommended within 15 to 20 days after giving birth in order to obtain good fertility rates and one offspring a year.

The placenta in the *alpaca*, as in other camelids, is diffuse and epitheliochorial in type. The existence of a unique extra-foetal membrane, which encases the entire foetal body and appears to be an epidermal product from the basal layers of the epidermis, has been described in the four SAC species.

Artificial Insemination and Embryo Transfer. Several studies have been made on the feasibility of artificial insemination in *alpacas* and *llamas*, as well as some inter-species' crosses. Semen from males was obtained by electroejaculation or by artificial vagina. The most appropiate time for insemination after ovulation, induced either by vasectomised males or 1,500 IU of hCG, occurred 35-45 hours following mating or hormone treatment.

One study done at the High Altitude Research Station "*La Raya*", Cusco, Peru, reported the natality rates of different inter-species crosses. Six *llamas* were each inseminated with 0.5-1.0 ml of fresh *vicuna* semen,collected by electroejaculation, and one offspring was obtained (16.7 % natality rate); nine *alpacas* were inseminated with *vicuna* semen, and two offspring were obtained (22.2 %). When *paco-vicuna* semen was used for insemination, three hybrids were obtained after inseminating five *llamas* (60%), and 23 hybrids were obtained after inseminating 74 *alpacas* (31.1 %). In this study, insemination was performed using the rectal palpation technique and best results were obtained by using 700 IU of hCG for inducing ovulation.

It is necessary to note that the SACs offer advantages over other domestic species in the use of artificial insemination. Since females have no oestral cycles and are induced ovulators, showing more or less continuous oestral behaviour during the breeding season, ovulation can be induced with a vasectomised male or with exogenous hormones, and the insemination can be intrauterine into the left horn independent of the ovary containing the CL.

Embryo transfer has been conducted in *alpacas* and *llamas*. In the first research trial with *alpacas*, in the early 1970s, the embryos were collected by surgery and flushing took place from the oviduct towards the horn of the uterus. It is impossible to pass fluids from the uterus to the oviduct, as in sheep, due to a papilla in the utero-tubal junction projecting into the uterine lumen with a valve-like action. At that time, the natality rate was 10 per cent. There is a report from the USA about non-surgical embryo transfer, where two donor female *llamas* were flushed and one viable seven-day old embryo was recovered and transferred within four hours into a recipient female *llama* whose oestrus was synchronised with the donor by injecting GnRH. A normal and healthy male was born 326 days after transfer.

Hereditary and Congenital Abnormalities in Alpacas and Llamas

In recent years, increasing interest has been shown in the losses caused by congenital and hereditary malformations in *alpacas* and *llamas*. Observations in Peru, Bolivia, Chile, and the USA show that it is necessary and urgent to focus attention on the development conditions that cause economic losses by decreasing reproductive capacity, reducing fertility, increasing prenatal mortality, creating obstetrical problems, and diminishing the value of the viable defective *crias* and their relatives. However, it seems that most congenital or hereditary disorders are usually disregarded or are observed only with curiosity or passive interest.

Congenital defects in domestic SACs are undoubtedly more common than indicated by the few reports in the literature, and all the abnormalities described here were observed during investigations carried out during the last 25 years in the most important breeding area of Peru.

Many defective *alpaca* or *llama cria* are not observed, because of the prevalent animal husbandry practices in Peru, where there are very few veterinary practitioners. Therefore, it is difficult to assess the frequency of congenital diseases in SACs.

When a defective *cria* is born, the problem is whether the cause is genetic or environmental; in addition, it is often impossible to identify the father of a defective *cria*, due to the breeding system prevalent in large or small herds kept by peasants in the Andean countries. Other factors are the lack of knowledge of the breeders or veterinary practitioners in teratology; the lack of historical and other records, and (what I found to be very common among the most important *alpaca* breeders) hiding the defective *cria* for economic and prestige reasons.

Although more than 44 congenital diseases in domestic SACs have been identified, there is no information on the majority of these disorders. Many more defects probably exist that require more research and field studies. The breeders should have programmes for reporting, recording, and monitoring undesirable genetic traits.

None of the conditions that we are going to mention are conclusively proven to be hereditary; furthermore, we do not know about the environmental factors or teratogens that cause defective *crias*. Proof of a hereditary defect must be obtained carefully and meticulously. Genetic defects are pathophysiological results of mutant genes or chromosomal aberrations; genetic defects are recognised only when they occur in characteristic, intragenerational familial frequencies and intragenerational patterns. Although chromosomal aberrations have been observed in domestic animals for some time, chromosomal scanning is not routinely carried out, but we should encourage examination of chromosomes in live defective *crias*. In the case of environmental factors, few have been considered as teratogenic in domestic animals, and, in general, do not follow familial patterns but rather seasonal patterns or known or suspected maternal stress.

Ingestion of some plant teratogens, viruses, mineral deficiencies (especially iodine), hyperthermia, agricultural and veterinary drugs, irradiations, and maternal age have been suspected of being teratogenic in domestic animals. Meanwhile, almost all the defects in *llamas* and *alpacas* should be considered inherited until proven otherwise.

With the increasing growth of *llama* and *alpaca* breeding in the Andean Region, as well as their export to other continents and countries, it is probable that some inherited diseases may become widespread, if indiscriminate breeding takes place without a system to monitor and control inherited defects. Breeders need to consider that any element of "inbreeding", whether knowingly or unknowingly practised, will concentrate undesirable genes in the population and so tend to increase the frequency of genetically-induced disease.

Congenital defects may be lethal, semi-lethal, or non-lethal and they are usually classified by the body system that is primarily affected. The most frequently encountered congenital defects in *alpacas* and *llamas* involve the reproductive, appendicular, and facial skeletal systems, and the most common specific abnormalities are inferior prognathism (Brachignatia superior), polydactyly, craniofacial defects, cryptorchidism, testes hypoplasia, ovarian cysts, segmental aplasia of Mullerian ducts, etc.

The congenital defects reported in Peruvian and Chilean domestic SACs are given below, according to the principal body system involved.

<u>Defects of the Facial Skeleton</u>

- Inferior prognathism
- Superior prognathism
- Cerebral hernia or "Catlin mark"
- Choanal stenosis or stresia
- Fused nasal openings or arrhinia
- Cyclopia

Defects of the Axial Skeleton

Polydactyly
Syndactyly
Monobrachia
Peromelia

Defects of the Muscular System

Arthrogryposis

Defects of the Cerebrum

Hydrocephalus

Defects of the Intestinal System

Atresia ani

Defects of the Body Cavity

Umbilical hernia

Defects of the Male Reproductive System

Hypoplasia of the testes
Cryptorchidism
Aplasia of the testes
Cystic structures in the testes
Ectopia testes (a form of cryptorchidism)

Defects of the Female Reproductive System

Follicular cysts
Hypoplasia of the ovaries
Segmental aplasia of the uterine horn
Imperforate hymen
Uterus unicornus (with ipsilateral renal agenesis)
Dermoid cysts
Paraovarian cysts
Gartner cysts
Double cervix
Intersex
Polithelia
Hypoplasia of the mammary glands

Defects of the Sense Organs

Microtia
Anotia

Management of Traditional Rangeland and Pastures

In recent years, traditional herding practices have come to the attention of anthropologists originally concerned with land ownership and inheritance. The elaborate traditional rangeland management system responds to animal rearing needs, environmental constraints, and to sociocultural requirements. Certainly, the management of traditional pastures is severely restricted by those same socioeconomic factors which explain pastoral peoples' marginality in the social structure of Andean countries. Limited access to land, and to modern technologies, make herders rely almost exclusively on their rich pastoral lore, which, despite responding to the many needs and constraints of the high Andes, can be improved by introducing appropriate technology.

The characteristic wet and dry seasonal cycles of the Andes set the framework for pastoral activities. During the cold and dry Andean winter, herders take their animals to specially watered pastures (these are usually referred to as *bofedales* and, less commonly, as *ojonales*). These are carefully irrigated by redirecting streams over the plains. These man-made grasslands need time to grow into a *bofedal*. Before a grassland is turned into a *bofedal*, the former grass cover has to rot and new vegetation has to grow in its place. *Bofedal* vegetation is characteristic of highland swamps. This traditional system has made grazing more intensive and less extensive. However, grasslands are watered not just to form a *bofedal*; this could also be done with the exclusive purpose of watering existing pastures in order to increase their productivity. *Bofedales* are preferably not used during the rainy season when grasslands are abundant and productive. Better pastures ensure the well being of animals as well as enhanced productivity in terms of fibre and reproductive rates, increasing overall carrying capacity.

During the rainy season, herders carefully separate males and females. When the natural pastures grow after the monsoon, males, perceived as more active and daring, are taken to the hills and slopes. *Llama* males are taken to areas where coarser grasses thrive.

Males need to be separated from females to avoid their characteristically aggressive behaviour which may result in damage to females and offsprings (which are believed to have a "female odour", thus, attracting males). It has also been noted that if males are kept for too long with females, this tends to make them sexually uninterested in their mates.

Ideally, the flock should be split into three groups, each one attended by one herder, i.e., *llama* and *alpaca* males, *llama* females, and *alpaca* females. More usually, females of both species may pasture together, depending on the availability of good quality moist pastures which are absolutely necessary for the *alpaca*. If these are limited, *llama* females are taken to other pastures of lesser quality. However, juvenile males become sexually attracted by females towards the onset of the rainy season, thus making it necessary to keep them separately, at least until the marking period which takes place at the end of the rainy season.

While grazing, the *alpaca* tends to concentrate and remain in the same place, as opposed to the *llama* which moves around more openly. The herder has to keep a watchful eye over the flock, ensuring that animals do not go astray or invade cultivated plots. He has to carefully watch the animals one by one, observing if they graze properly and if their feeding behaviour is regular. A dedicated herder is capable of identifying potentially sick animals through careful observation.

In accordance with specific property arrangements, rangelands may be rotated. Throughout the Andes, grazing lands could either be privately or communally owned. In some regions, landless herders rent private grasslands. Sometimes the animals are taken alternately to watered *bofedales* and to drier grasslands. Depending on altitude and zonation as well as on population pressure, during the rainy season, an average of five days of grazing should be followed by fallowing the grassland for 25 to 30 days.

Amidst the grasslands there are specific spots without vegetal cover, called *qhospana*, where SACs enjoy rolling and wallowing.

Animals are kept at night in roofless stone corrals. In the early morning, once the herder has confirmed that the early morning dew has evaporated from the pasture leaves, the animals are taken out for grazing. There is a general belief that grazing on pastures covered with dew or frozen grasses causes diarrhoea.

The traditional herder can distinguish the many grass and pasture species of the Andes, carefully identifying by name and properties each variety as well as the more common associations of species. Some of the more common vegetative associations of the Andean grasslands are given in Table 19.

Table 19: Vegetative Associations in the High Andean Zone of Peru

Central Sierra	South Sierra
a) Watered Plains	a) Dry Areas
1) *Poa - Festuca - Calamagrostis*	1) *F. dolichophylla* *F. fastigiata*
b) High Altitude *Paramo* of Glacial Origin	2) *F. rigida*
2) *Festuca - Carex - Calamagrostis*	3) *F. ortophylla*
3) *Festuca - Poa*	4) *S. obtusa*
4) *Calamagrostis - Festuca*	5) *C. amoena*
	6) *Scirpus rigidus*
c) Mountain Slopes	
5) *Calamagrostis - Festuca*	b) Wet Areas
6) *Stipa - Calamagrostis*	7) *Distichia muscoides*
7) *Festuca - Stipa*	8) *F.dolichophylla - Plantago tubulosa*
8) *Calamagrostis recta*	
d) Heights	
9) *Festuca - Azorella*	

Source: FIDA 1990.

Carrying capacity evaluations under different highland Andean prairie conditions have been elicited. Tables 20 and 21 offer a perspective on these.

Table 20: Relationship between Animals Demand and Carrying Capacity of Natural Prairies as Assessed in Different Altiplano (upland plateau) Ecoregions

Ecoregion	Carrying Capacity and Condition	Balance	Source
Semi-arid	0.45 O.U. (poor) 3.8 O.U.	-3.35 O.U.	Cardozo y Riera, 1972
Semi-arid	2.00 O.U.(good) 4.8 O.U.	-2.00 O.U.	Bellour, 1980
Arid	0.3 O.U. (poor) 0.48 O.U.	-0.18 LL.U.	Alzérreca e Izco, 1987
High Andean Sub-humid	0.9 AL.U. (regular) 3.06 AL.U.	-2.15 AL.U.	La Fuente et al., 1987

Source: Alzérreca 1988, cited in FIDA 1990.
* Data of Evaluation Studies in Specific Areas
O.U.=Ovine Unity; LL.U.=*Llama* Unity; AL.U.=*Alpaca* Unity

Table 21: Condition, Area, and Carrying Capacity of Ranges Used by Camelids Evaluated Until 1990

Condition	Type of Prairie	Range Area Suitable for Grazing		Carrying Capacity of *Llamas*
		ha	%	
Excellent	2,17	1857	0.8	2.1
Good	2,5,12,13,14,15	73973	33.2	1.6
Regular	6,11	1431	0.6	0.8
Poor	1,3,4,7,8,9,10, 16,18	144295	64.9	0.3
Very Poor	9	1155	0.5	0.1
Total		222714	100.0	

1 = Stipa spp. rangeland
2 = *Festuca dolichophylla* rangeland
3 = *Parastrephia* tholar
4 = *Frankenia* shrub
5 = *Mulenbergia* and *Distichlis*
6 = *Parastrephia* and *Mulenbergia*
7 = *Parastrephia* shrub
8 = *Stipa ichu* rangeland
9 = *Tetraglochin* shrub
10 = *Festuca ortophylla* rangeland
11 = *Bromus uniloides* prairie
12 = Prairie under fallow
13 = Watered prairie
14 = *Festuca ortophylla* and pastures
15 = *Calamagrostis* watered grassland
16 = *Festuca ort.* and *Parastrephia*
17 = High Andean watered grassland
18 = *Achiane* grassland

Source: FIDA 1990.

Adaptative Characteristics of SACs to High Altitude and Semi-desert Environments: Ecological Importance

Animals living in high altitude environments must be able to survive extreme conditions such as radical temperature fluctuations (from -15 ° to 20 ° C), low food quality, dehydration, dryness, winds, and low ambient oxygen. It is not surprising, therefore, that SACs have developed, through evolution and domestication, special adaptative characteristics for dealing with life at nearly 5,000masl.

Nutrition

A review of the existing literature on the nutrition of the *llama* (*Lama glama*) and *alpaca* (*Lama pacos*), revealed that these South American camelids are better adapted to the harsh environment of the Andean Region than advanced ruminants. Lamoids differ from advanced ruminants in stomach morphology and digestion, and they eat selectively. Protein and energy requirements of SACs are lower than those of other domestic ruminants. Also, they thrive on sites where phosphorous and copper are so severely lacking that cattle suffer debilitating deficiency diseases and sheep are affected by a crippling disease associated with low copper content in the soil.

Available data indicate that stocking ratios should be 1.0:1.0 for *alpaca:* sheep and 1.5:1.0 for *llama*:sheep. Thus, one *alpaca* of 65kg, will be equal to a sheep of 40kg (i.e.,will eat the same amount that a sheep eats), and two *llamas*, will be similar to three sheep. From the digestive point of view, they are able to adapt to extreme conditions better than most other large herbivores.

Bloat is defined as tympany of the first stomach compartment. Bloat in other ruminant species is usually classified as primary (frothy) or secondary (free-gas). The consultant, in his 25 years of experience, has not encountered, either personally or in the literature, any cases of frothy bloat in SACs. *Alpacas* and *llamas* have been observed to graze on alfalfa or clover pastures without bloating, and this would normally produce bloat in conventional ruminants. Cases of free-gas bloat do occur, albeit infrequently, probably due to toxic plants.

Circulatory System

Adaptation to low ambient oxygen tension consists of changes in the primary biochemical processes of energy expenditure and oxygen utilisation at the intracellular levels and in the mechanisms concerned in the transport of oxygen to the mitochondrial sites of these processes. Their haemoglobin shows a high affinity for oxygen, thus, increasing the oxygen carrying capacity of the blood and perhaps is one of the most important mechanisms. The large number of very small red cells (microcytosis) are advantageous at high altitudes but are not necessarily specific adaptations to the environment for they also occur in the low altitude desert camels of Africa. Microcytosis is certainly important in increasing the oxygenation rate in red cells. The elliptical shape of the red cells of camelids may also be useful but this has not been studied.

Parturition Behaviour

Births in the *alpaca* and *llama* occur during full daylight when the temperature is favourable for the young. Daylight parturition is probably an adaptation to avoid giving birth during the freezing night-time temperatures of high altitude regions. This is also in contrast with other domestic ungulates, among which the majority of births occur during the dark hours. One of the most important causes of the high neonatal mortality rate of lambs in Peru is pneumonia caused by below zero temperatures very late at night and very early in the morning.

Feet

The *puna* is an ecosystem highly susceptible to degradation as a result of the extreme climate which is characterised by sparse vegetation and very low temperatures most of the year. The special anatomical features on the extremities of the SACs allow them to walk firm-footed across any type of terrain. The SAC's foot has digits and the planar surface is covered with a soft cornified layer similar to that on the bulb epithelium of the heel in sheep or goats. Beneath the protective epithelium lies a fatty fibroelastic pad, similar to the digital cushion of the horse. The nail or claw is small and carries no weight. The broad, elastic pads prevent them from causing damage to plants and soil. This is in contrast to the sharp-edged hooves and claws of domestic animals, such as sheep, goat, cattle, and horses, which tear up the soil's surface and destroy the sparse turf, especially during periods of drought.

Teeth

The distinctive lower incisors of the lamoid enable it to eat small plants, which are close to or lie directly on the ground, without tearing out or loosening the forage plants. (When the Incas first saw sheep, they named them "fire-mouth" because of the way they tore out the vulnerable vegetation cover of the high Andes.) Increased utilisation of these areas by the SACs will bring about a decrease in the degradation of the ecosystem, thus avoiding large-scale destruction and erosion of the topsoil.

Skin Cover

The fine, thick hair is an important protection against heat gain from the intense solar radiation at high altitudes and in a treeless environment. It also serves as protection against below zero temperatures during almost all the nights of the year. The resistance of these animals to cold is remarkable. For example, they can withstand temperatures of -25° C and lower and, in snowstorms, they happily hunker down and often get covered up until only their heads can be seen.

Resistance to Drought

It is worth noting that under uncertain climatic conditions, such as drought, the domestic SACs have shown better adaptive abilities than other domestic species. During the drought that severely affected the Department of Puno, Peru, during 1956-1957, approximately 80 per cent of the cattle and horses died, whereas 40 per cent of the sheep and only 25 per cent of the camelids perished. If this is representative of other areas of high-Andean ecology, it suggests that the *alpaca* and *llama* constitute the most reliable nutritional and economic resources available to the peasants who inhabit this zone.

Disease Resistance

Although disease resistance is not an adaptative characteristic to high altitude and semi-desert environments, we will discuss this advantage. Lamoids are resistant to pulmonary adenomatosis (or ovine pulmonary carcinoma), a major economic problem in Peruvian sheep husbandry. This disease is caused by a virus that produces an ultimately fatal lung tumour, which has been experimentally transmitted to lambs. This chronic, progressive, and ultimately fatal, disease is untreatable. Sheep pulmonary adenomatosis frequently coexists with ovine progressive pneumonia. Culling affected animals is as yet the only way to fight both diseases.

Also, lamoids are resistant to footrot, by far the most common disease in sheep. It is highly contagious, particularly during the rainy season. *Alpacas* are animals that like to graze in *bofedales*. *Bofedales* are areas with constant moisture underground, retaining a fresh green colour during the dry season. It appears that the species most characteristic of *bofedales* is *Distichia muscoides*, a member of the *Juncaceae* family. Footrot has never been reported in the *alpaca* and it is very rare in *llamas* that like to graze in drier areas.

Epididymitis is a testicular inflammation found in a variety of domestic male animals, especially in sheep, causing ram infertility and abortion in some pregnant ewes. This disease is mainly caused by *Brucella ovis*. *Alpaca* or *llama* epididymitis has not been reported, except in cases of traumatic injury of the scrotal content.

Legal Aspects of the Exportation of SACs from South America

The highlands of the Andean Region are the natural habitat of SACs, and almost 100 per cent of the *alpacas*, *llamas*, *guanacos*, and *vicunas* inhabit this region. Peru and Bolivia have common laws concerning the export of lamoids. Since the last century, both countries have declared lamoids a national treasure, and exportation of live animals has been forbidden.

During Spanish rule in South America, especially in the Andean countries (1532 - 1821), the four species of SAC were exported to Spain and other European-allied countries. But enemy countries smuggled in some specimens and, from that time, many countries have had these animals.

Nevertheless, Chile, which has a very small lamoid population, started exporting *llamas* to the USA in 1980. Later on, the exportation of animals increased enormously (including the *alpaca*, a species almost unknown outside South America and frequently confused with the *llama*. Most of the animals were exported to the United States, Canada, New Zealand, Israel, and Ecuador. The New Zealanders are re-exporting *alpacas* and *llamas* to Australia and many European countries.

In 1989, Bolivia lifted the prohibition on exporting live lamoids and started to export a limited number to the USA and Ecuador. Finally, on August 1st, 1991, Peru passed the Decree-Law No.653 for Promotion and Investment in the Agrarian Sector (*Decreto Legislativo No.653, de Promocion de Inversiones en el Sector Agrario*), allowing the exportation of domestic lamoids (*alpacas* and *llamas*). However,the export of *llamas* of the *Chaku* or Woolly breed, *alpacas* of the *Suri* breed, and coloured *alpacas* of the *Huacaya* breed is forbidden temporally and until these lamoid breeds increase their population.

A list of south American institutions engaged in SAC research and transfer of technology is provided in Annex 1.

PART C

PREREQUISITES FOR INTRODUCTION

Feeding Strategies and Ecological Environmental Need for Habitat

A review of the existing literature on the nutrition of the *llama* (*Lama glama*) and *alpaca* (*Lama pacos*) revealed that these South American camelids are better adapted to the harsh environment of the Andean Region than are other domestic ruminants. Moreover, with their outstandingly efficient digestive system, the *alpaca* and *llama* survive on coarse native grasses, wire sedges, and rushes. Thus, in contrast to sheep and cattle, they require no pasture improvement or other modifications in the unique, high altitude environment. Also, they thrive on sites where phosphorous and copper are so severely lacking that sheep and cattle suffer debilitating deficiency diseases.

As mentioned earlier South American camelids have been introduced to completely different environments of the world such as those of Spain, Russia, England, Israel, the United States, Ecuador, New Zealand, and Australia. The great differences in climate, soil, and vegetation, between these widely varying countries, are self-evident. When the lamoids were imported, feeding was not a real problem, since the importing countries had other domestic and wild ruminants, and they were sure that the new residents would have enough grass, shrubs, forb, perennial grass, annual grass, natural pastures, and many types of cultivated forage. Consequently, no problems were encountered with feeding the animals whether they were kept in pens, corrals, stables, or grazed on natural pasturelands.

When *alpacas* and *llamas* were exported from Chile during the early 1980s, the lamoids were kept in corrals and artificially fed with alfalfa for the first time in their lives because they had to be quarantined. *Alpacas* and *llamas* quickly accepted this new forage as they became accustomed to it, and the owners reported that these animals gained weight.

During quarantine periods, at the point of disembarkation (importing country), the animals were fed with ample quantities of cultivated forage, such as alfalfa hay, or fresh green alfalfa, oat hay, whole corn, barley hay, Dactylis hay, oat silage, etc. In some cases, the animals were put on cultivated pastures (ryegrass + clover, dactylis + clover, or dactylis + alfalfa). In many cases, concentrated salt pellets were made available as loose salts in some kind of container. In reality, feeding options are virtually unlimited.

Therefore, we think that it is useless to list and describe the great number of plants that are palatable to the lamoids in the Andean Region and in other continents. It is most important to know that lamoids will eat the same plants as other herbivores.

Lamoids, in general, are relatively tolerant to a degree of water deprivation; depending on activity and environmental temperature, the intake will vary from four to eight per cent of body weight.

In the case of importation of lamoids by the Government of Nepal, we made the following recommendations in reference to feeding strategy.

A. During the quarantine period, animals should be fed on some kind of very good quality hay; alfalfa or oat hay are very good choices. Fresh and free water supply should be available at all times as well as some kind of mineral supplement.

B. After quarantine, the animals should be put in grazing paddocks at the research station or any place chosen in advance. The animals should not be grazed on ranges containing poisonous species and they should not be forced to remain on the range after they have used the good forage species.

C. The people in charge of the herd should acquaint themselves with the toxic plant species in their area or region that cause the symptoms of poisoning. A close vigilance should be maintained for some months after the animals are introduced to the new environment and during the development of the herd.

Large human populations are living in high altitude ecosystems (Andes, Himalayas, etc), and they rely on some type of animal breeding for their subsistence, since agricultural productivity is very low. The Andean people domesticated the *llama* and *alpaca* and the Himalayan people the *yak* (*Bos grunniens*).

The most appropriate ecological environments that can be recommended for breeding lamoids are given below.

D. Cold and very cold ecosystems, highly susceptible to degradation, as a result of the extreme climate and sparse vegetation (tundra).

E. Ecosystems above 3, 000 with low atmospheric pressure (low oxygen availability), intense solar radiation, low organic content of the soil, and hence, poor-quality, highly lignified pastures (High Andes, High Himalayan Mountains, etc).

F. Many other cold and very cold ecosystems, with fragile and unstable vegetation (Alpine meadows, semi-desert steppes).

G. Temperate, cold, and very cold semi-desert areas of the world, and any temperate or cold marginal pasturelands.

We are sure that hundreds of thousands of hectares in the Hindu Kush-Himalayan Region can be easily classified under any one of the ecosystems described above . Cold, high altitudes, poor-quality forage, dryness, and marginal lands are constraints that lamoids can overcome.

Preferable Farming Economies

In their long history of domestication and rearing in the Andean Region, *llamas* and *alpacas* have been an integral part of the peasant family's agropastoral subsistence economy. They are imbedded in the subsistence strategies of the highland herder to such an extent that the *llama* and *alpaca* are perceived as members of the family. Although pasturelands may be communal property, or subject to suprafamily control and management, the flocks are family owned and animals are dependent on their owners. Flock management is a family (be it either nuclear or extended) affair. Despite colonial and early republican development of large landholdings (*haciendas*) or the promotion and development of SAC breeders' co-ops, the old traditional Andean system of raising SACs remains a basically peasant family endeavour. Wherever suprafamily ownership arrangements have been promoted or imposed, such as *haciendas* and co-ops, the herder's family has ultimately been the unit effectively in charge of the proper rearing of the animals, with very few exceptions. Furthermore, the failure of several SAC breeders' co-ops, promoted by the Peruvian government in the early seventies, could be attributed to either poor enterpreneurial qualifications and/or disengagement of the peasant family from the actual rearing of the animals. The more successful SAC rearing operations at the suprafamily level in rural Andean society have been those which have heavily relied on the pastoral family as the basic operational herding unit.

This statement certainly cannot be extended to contemporary SAC rearing operations conducted under substantially different socioeconomic and technological conditions by wealthy farmers in Europe, North America, or New Zealand. Everyone of these operations could be classified as unique, welfare style, high-energy input experiments, most of which have been very successful under specific conditions. In almost all these countries, SACs are bred as pets, not as work animals and not within the traditional framework of peasant economies which operate under the constraints of the harsh highland habitat. It is our belief that, despite knowledge gained from rearing SACs under novel conditions in Western countries, their experiences cannot be emulated in the rural environments of the Hindu-Kush-Himalayan Region.

First of all, rearing SACs is an efficient adaptive response of rural inhabitants to the cultural ecology of mountain environments. They play a key role in a typical, mountain-oriented, mixed- agropastoral peasant farming strategy aimed at diversification. They are an efficient response to the characteristic mixed multicyclical strategy designed to optimise labour use in a diversified "vertical" environment (Guillette 1986). As such, raising SACs in traditional rural societies living in mountain environments is usually carried out in combined herds similar to many areas of the Hindu Kush-Himalayas, where goats, sheep, and cattle are reared and graze (see Part A) together.

The Andean, agropastoral strategy is based (as noted in Part B), as in the Himalayas, on transhumant activity. Whereas in the Andes, flock movement is related to the seasonal wet and dry periods (upper and lower areas), in the HKH Region the cycle oscillates between winter (when the animals are taken to the lowlands) and summer (the season when upland grasses grow due to the rains and animals are taken uphill). The basic difference in seasons between the Andes and the HKH Region is related to their tropical and subtropical characteristics, the southern Andes being closer, in terms of alternative options, to the HKH Region. Possibly the environment more suitable for a trial experiment in raising SACs in the Himalayas would be the areas in which *yak* and their hybrid offspring thrive. The Khumbu area of Nepal, inhabited by Sherpas (Brower 1990), appears to have conditions suitable for both *llama* and *alpaca* rearing. Sherpas seem to be open to alternative subsistence options, and their pastoral traditions correspond closely to those in the Central Andes.

The persistence of communal control over land resources, particularly pastures (the *di* system of the Sherpas as described by Brower), increases the potential of rural Himalayan societies for adequate breeding of SACs. Similar communal regulations and ordinances dominate the social environment of Andean rural communities. The Himalayan community officer *-nawa-* described by Guillette (1986) as the individual responsible for careful observance of communal regulations regarding proper use of grazing lands - is surprisingly similar to the *arariwa*, the traditional Andean rural appointee in charge of similar functions.

Taking into account the weather patterns prevalent in the HKH Region, the western areas (Kashmir, Himachal Pradesh, Mustang) as well as the Tibetan Plateau, with conditions, that are drier than other HKH areas, appear to have more suitable conditions for *llama* breeding. In addition, these are areas where caravan trading is important and where the craft of carpet-making could profit from *llama* fibre. On the other hand, the wetter slopes of southeastern Nepal and Bhutan appear to be more suitable for the breeding of *alpacas;* without disregarding *llamas*.

Reproductive Adjustments

We mentioned that the breeding season and birthing season overlap in lamoids due to the long gestation period (345 days). Therefore, under natural conditions in the highlands of the Andean Region, where males and females are together all year round, both the birthing and breeding season last from December to March, the warmest months, when it rains and there is green forage. This is also true of the wild SAC species. However, when females are kept separate from males and mating is allowed only once a month, both sexes are sexually active during the entire year. Thus, natural conditions in Peru are a consequence of food availability and management.

Observations in zoological parks throughout the world indicate that lamoids are year-round breeders, but with higher parturition rates in the summer months of each particular region of the world. It has been argued that the superior quality of zoo diets, and their consistent availability, may influence certain natural seasonal breeders to distribute the birth season throughout the year.

The most complete information on the birthing season of *llamas* in the United States came from the Rocky Mountain *Llama* Association; out of 467 births registered, 61.4 per cent occurred in the warmest months, from May to September. Only 14.1 per cent of all births were recorded during December to March. In this case, matings and births occur throughout the year, although the summer months have the highest parturition rate.

For good reproductive management in some domestic animals (sheep, goats, beef cattle, lamoids), births should take place during a few weeks or months of the year and in such a way that the litter will be more or less uniform in size and only a short period of labour-intensive investment will be required. Furthermore, in lamoids, parturition and mating seasons should coincide with the best time of the year.

Therefore, we are sure that the lamoids that are transferred to the Himalayan Region will experience a shift in their birthing and breeding seasons to the warmest months of the year in that place, unless another reproductive management is wanted. Regarding this topic, our recommendations are given below.

H. Males should be separated from females and allowed to mate only during the best time of the year, and under close supervision of the veterinary service. An "alternative breeding system" for 60 days is the best choice.

I. The reproductive cycle in the transferred herd of lamoids, after adaptation to the new environment, should start with the mating period. Therefore, the import of pregnant animals is not recommended, due to numerous reasons, which are explained further on in the text.

J. The adaptation period for the *llama* herd in Nepal, before starting the reproductive cycle, should be for at least two or three months.

Species, Herd Size, and Management Conditions

Considering all the advantages and disadvantages of the two domestic species, *alpaca* and *llama*, and the need for an animal that can produce medium to coarse wool for tapestry or Persian rugs, the following recommendations have been made.

K. We recommend the *llama* species and the *Chaku* or woolly type of breed (also named *Tajulli* in Chile and *Thampully* in Bolivia). The colour of the fleece should be chosen according to the favourite colours of the tapestry industry.

Regarding recommendations concerning the herd size, we have to consider the following aspects.

Budget Investment

The number of animals that are to be imported has to be considered while estimating budget investment, and this is entirely dependent on the requirements of the importing country.

Facilities at the Research Farm

Depending on the facilities available at the research farm of the importing country for handling the animals and the capacity of range sites, the herd size should be calculated.

Labour

This variable depends on the number of animals that have to be managed. In general, labour investment is higher for large ruminants, and lower for small ruminants. It is estimated that one person, full-time, can handle around 150 to 200 *llamas*.

Cost of Transportation

This variable depends on the mode of transport (by air or by sea), the number of animals that have to be transported, and the distance. The best route is by air, but it is costly. However, an average cargo plane can carry around 300 to 350 lamoids. Moreover, the air route is quick, without problems of feeding and watering and there are less health risks.

Experiences

The first introduction of exotic animals to a given country is not without risk because the importers will obviously lack experience, Therefore, the first introduction should be of a small or medium-sized herd. As an example of the size of herd to be imported to the Himalayas, the following size is recommended.

L. A total of three hundred-fifty (350) *llamas*, which is a fair-sized herd, should be imported. Yearling females (two year old females) should form the breeding stock, selected by an expert hired for this task (from a group of females presented by the seller). No pregnant animals should be transported, for two reasons: (1) females can abort during the trip, and this may pass unnoticed with grave health risks, and (2) it will be difficult to identify the father of the *cria*.

M. Ten per cent of the herd should be breeding males of about four years, and they should be selected by an expert. Attention should be paid to the phenotypic conformation and genital soundness.

The management of the herd is difficult to delineate without knowledge of the climatic conditions of the importing country (distribution of rainfall throughout the year, temperature fluctuation during the year and during the day, humidity, altitude, etc). However, some basic guidelines can be given.

N. Various management practices are suggested for proper care of lamoids.

Shearing. This should be carried out annually, before the summer months (to avoid heat stress). The animals can be sheared by scissors or mechanically. Sheep are sheared by one person; a *llama* needs two persons.

Bathing or Spraying against Ectoparasites. External parasites , especially sarcoptic mange, can be controlled more effectively after shearing; the medical compound should be sprayed near the skin for better pharmacological action.

Pregnancy Diagnosis. Pregnancy can be diagnosed by rectal palpation, progesterone levels, or the behavioural response of the females to the presence of the male. Pregnant females should be kept in a separate herd or group and sent to the best grazing places.

Parturition. Special attention should be paid during this stage. It is not necessary to confine the females in stables or pens, unless the weather is severe. Open field parturition under close observation is recommended in order to help the mother (difficult birth, retained placenta). Inmediate care and inspection of the neonate should include navel dipping in seven per cent tincture of iodine, drying, weighing, a brief physical examination, and close inspection for evidence of nursing.

Postpartum Period. Mating of females is recommended within 15 to 20 days after giving birth in order to obtain good fertility rates and avoid metritis.

Breeding Season. Yearling and open adult females should be mated first during the sixty days of the breeding season. The "alternate breeding system" (described in Chapter 10) is the best alternative. Females with *crias* at foot are eligible for breeding after a rest of 15 to 20 days. Sluggish males should be replaced.

Weaning. Weaning is commonly carried out at seven to eight months. In one selected day, all the *crias* (young) are weaned. There should be a 60 day difference between the first born *cria* and the last of the season. All the weaned animals should be kept in one herd, and in good pastures, until they complete one year.

Deworming. Depending upon the type of pasture, stocking rate, and climatic conditions, internal parasites can become a major health concern. No one deworming schedule can be recommended. Deworming frequency should be determined by the factors just mentioned and by routine faecal checks. The animals should be dewormed once or twice a year, which may be sufficient. Otherwise, deworming should be carried out every two or three months. It is important to give anthelmintics at regular intervals to the animals.

Vaccination. Herd health programmes for domestic SAC in the Andean region do not have any kind of vaccination. However, when the animals leave their natural environment, they are prone to suffer different bacterial or viral diseases. Therefore, several vaccines have been advocated for use in *alpacas* and *llamas*. To date, however, little is known for sure concerning which products are efficacious and what the proper vaccination schedule might be.

As a rule, SAC importers do not like any type of vaccination, because vaccines can mask a real disease and many countries require negative serologic tests. However, a vaccination schedule in the new environment depends largely on the prevalence of the disease in endemic areas. As a rule, vaccination programmes are designed by the Animal Health Department or Division of each particular country.

Record Keeping. Keeping records is very important for proper management of an animal farm. The following information, i.e., the number of animals, date of birth, weight, breed, colour, weight at one year, date of breeding, yield of fibre, health problems, and deworming dates should be recorded.

Genetic Resources

As mentioned earlier (Genetic Diversity), variation, or genetic diversity, is the raw material available to the breeder for herd or flock improvement. Also, inbreeding will be promoted if new blood lines are not incorporated into the stock of the herd. Therefore, inbreeding, with hazards well known to breeders of other domestic animals, should be avoided by introducing new genotypes. However, with several sires, a herd can be closed for many generations before the average inbreeding reaches a dangerous level. Anyhow, South America will provide new genotypes, in case the inbreeding coefficient reaches high levels.

Developing Animal Health Care Capabilities

Infectious diseases affect domestic animals and play a prominent role in the economy of animal production. Therefore, each country has developed special programmes for prevention, diagnosis, and treatment of animal diseases. The Veterinary Services or Animal Health Programmes are implemented by the agricultural ministries or agricultural secretariats, depending on each country.

The Animal Health Programme of each particular country conducts investigations on diseases affecting different domestic and wild animals living in their territories and provides animal health information, concerning endemic diseases and their control, to any organisation, national or international. Also, it must be able to clinically and serologically diagnose the most common and prevalent diseases that affect livestock.

The same basic principles of disease prevention, diagnosis, and treatment ensure herd health in domestic lamoids as well as in other livestock species. However, some factors make lamoid herd health unique. This is because lamoids, in general, are considered exotic animals, and their diseases are unknown outside the Andean Region. This is partly because much of the information concerning the *alpaca* and *llama* has been reported in journals published in Spanish in South America. However, very recently, two books about *Llama* Medicine have been published in English in the United States, and those interested in this topic can read the bibliography published by the Information Centre on South American Camelids at the IVITA Research Centre at San Marcos University, Apartado 4270, Lima, Peru and the Red De Rumiantes Menores (RERUMEN), Apartado 110097, Lima 11, Peru.

Meanwhile, there are some suggestions we would like to make concerning the establishment of a Lamoid Health Programme before the animals are imported.

O. At least two veterinary practitioners from Nepal should receive special training in *llama* medicine and *llama* herd health, including animal management and production of *SACs*. This report can be read as an introduction and later theoretical knowledge should be acquired from English, as well as Spanish books and pertinent information gathered through Peruvian institutions.

P. A study visit should be arranged for veterinary practitioners and animal husbandry officers to one or more of the South American camelid producing countries: such as Peru, Bolivia, or Chile. We recommend Peru, for its large lamoid population, experience, and institutions directly involved in camelid production and medicine. Different short-term courses on domestic SACs, medicine, production, genetics, selection, herd management, handling, and restraints are offered in some Veterinary Medicine Faculties (Lima, Puno, and Cusco) some practical work and studies at some of the Camelid Research Stations in Puno, Cusco, and Arequipa are also conducted. An eight-week study visit is sufficient to gain knowledge and experience.

Q. After the *llama* herd is imported in Nepal, we are sure that most of the health afflictions will be related to management or environment and possibly some infectious diseases not known to occur in lamoids will be transmitted from other Nepalese domestic or wild animals. Therefore, clinicians should be alert in recognising and dealing with the presence of undiagnosed infectious diseases in *llamas*, and with emergencies. Knowledge of the most important bacterial and viral diseases of Nepalese domestic animals is imperative for all the technical personnel engaged in *llama* breeding.

In general, we have to take into consideration that a *llama* or *alpaca* is a mammal and, for the most part, they react as other mammals in their physiological response to disease states. The same basic medical principles are generally applicable to the SAC species that are applicable to others; in most cases, only the normal baseline value may be different and training and interest will enable the veterinary practitioners to gain the necessary competence to overcome any health problem.

Export - Import Procedures

SAC Exporting Countries

The Andean Region of South America is the most important breeding area for the *alpaca* and *llama* in the world and, hence, the most important SAC exporting countries are located there. Chile started commercial export in 1980 to different countries in America and Europe as well as to the Far East. They established very well organised exporting agencies with adequate funding and preparation, pre-quarantine selection of animals, legal quarantine procedures, government regulations, and a general policy regarding international exportation. It is the most experienced country by far in exporting lamoids. Before 1980, it was declared a foot-and-mouth disease-free country.

Bolivia is not a foot-and-mouth disease-free country. It recently started exporting *llamas* (since 1989), and, as far as we know, a few hundred animals were sent to some countries where there were no strong regulations concerning foot-and-mouth disease. But some problems arise from time to time as a result of the inefficiency of the exporting agencies and protests are made by some *Llama* Breeders' Associations against export of the *llama*.

Finally, Peru lifted the ban on export of domestic SACs and, just this year (1992), started exporting the *alpaca* and *llama* to Ecuador. One limitation is that Peru is not a foot-and-mouth disease-free country, but it has the advantage of having the greatest white *alpaca* population of superior genetic quality and a very good stock of *llamas*.

The United States, Canada, New Zealand, and England are able to export a very limited number of *llamas* and *alpacas* at very high prices. However, the genetic quality is inferior, and there are too many hybrids. They are free of foot-and-mouth disease, but these animals can carry many viral diseases that do not exist outside the United States.

Domestic Camelid Exportation Procedures and Issues

Exportation procedures must concur with the quarantine regulations and other rules set by the Animal Health Services of the exporting country as well as with those of the importing countries. According to the regulations of the exporting-importing countries, the animals must be free from specified diseases, must test negative to serologic examinations, and undergo clinical checkups. The minimum quarantine period for the animals is no less than forty days but, as a rule, it is longer than that.

According to the Peruvian regulations for exporting live animals, they must be free from tuberculosis, brucellosis, and all kinds of ectoparasites. During transportation, the animals can suffer from puncture wounds, therefore, they must be vaccinated with tetanus toxoid (about one month is required for antibodies to develop).

In Peru, the export of domestic camelids is authorised by the Director General of Livestock under the Ministry of Agriculture (Direccion General de Ganaderia del Ministerio de Agricultura), after a certificate is given by the National Council of Domestic South American Camelids (Consejo Nacional de Camelidos Sudamericanos Domesticos).

Chile and Bolivia have their own regulations for exporting camelids, but, generally, they are similar to the Peruvian regulations. However, regulations in the importing countries are more strict.

Importation Procedures

Importation procedures are very variable, and depend to a great extent on each importing country. Each country has its own health regulations and quarantine procedures. Some countries have strong regulations to avoid importation of animals from countries not free from foot-and-mouth disease, because these countries are free from that disease. But, in general, each country imposes regulations regarding animal diseases, vaccinations, and serological test controls against certain diseases, physiological examinations, pre-shipping conditions, etc.

The animal health authorities from Nepal should instruct lamoid-exporting agencies (see Annex 2) about special tests to prevent the import of sick animals, so as to avoid the potential danger of spreading diseases in the country of destination. Such tests might include those for tuberculosis, brucellosis, blue tongue, and any other tests requested by the animal health officials. These have to be submitted for diagnosis to competent laboratories.

Farm animals are routinely vaccinated for disease control in enzootic areas; several vaccines have been advocated for use in *llamas*. To date, however, little is known concerning products that are efficacious and the proper vaccination schedule. A prevention programme for animals that are to be exported is dependant upon the knowledge of the prevalent diseases and the strains known to occur in domestic animals in the country of destination. Whether or not lamoids are susceptible to a number of important infectious diseases of cattle and sheep is still unknown.

Pre-shipping conditions include deworming the animals against gastrointestinal parasites; and also against external parasites, such as mites, lice, and ticks.

Conclusions

Analytical Commentary on the Issue of Import in Terms of the Prospects and Problems

Herbivores are found in habitats as diverse as deserts, arctic tundras, and warm, mesic environments. Domesticated or semi-domesticated, they have a similar range of adaptability to that of man, so grazing herbivores are a feature of most societies. The ability to use fibrous feeds through their symbiosis with microbes enables the grazing herbivores to survive the often extreme variation in quality of the available feed through dry or cold seasons.

Over the last 500 years, European man has taken herbivores to populate South America, North America, Southern Africa, Australia, and New Zealand. In these new environments, these animals were able to utilise the native grasses to provide food and essential services to the pioneers in their development of these new territories.

All domesticated herbivores are multipurpose animals. The Western developed countries have tended to forget this, unlike the developing countries where the multipurpose role of the herbivores is still of utmost importance.

The natural habitat of SACs is a high altitude, fragile ecosystem where they are constantly exposed to cold, heat, intense solar radiation (ultraviolet), a dry and coarse diet, etc. It is under these conditions that the most of the present-day *llama* and *alpaca* production takes place. Herds of domestic camelids do, in fact, constitute the most reliable animal breeds in the highlands or *punas*. Introduced species, such as sheep, goats, and cattle, adapt poorly to the environmental stresses of high altitude regions and give reduced yields of inferior quality even after almost five centuries of acclimatisation.

It is in this context that experience and the results of biological research in the past 30 years clearly document the productive superiority of the *llama* and *alpaca* at high elevations. As an example, we must assume that the best place for SACs is a high altitude harsh environment. This is true, but not necessarily true in every case. Recent introductions of the *alpaca* and *llama* to the United States, Israel, Canada, and New Zealand have shown that they can be reared in areas outside the Andes with successful commercial production. Nevertheless, lamoids are undoubtedly more profitably raised on better-quality pastures and in native environments.

However, what really made the breeding of the *alpaca* and *llama* important is that they are perhaps the most environmentally gentle ruminant livestock in the world and, also, they have the capacity to utilise marginal pastureland that would otherwise be ungrazed or improperly used, resulting in great damage to the ecosystem.

Large human populations are living in high altitude ecosystems (Andes, Himalayas, etc), and they need to rely on some type of animal breeding for their subsistence since agricultural productivity is very low. The Andean people domesticated the *llama* and *alpaca* and the Himalayans, the *yak* (*Bos grunniens*). The *alpaca* and *llama* are remarkable animals upon which the survival of millions of the poorest peoples in Latin America depend.

Also, with worldwide concern for environmental degradation and unsustainable agriculture, it is vital to evaluate the role of the *llama* and *alpaca* in the fragile, high altitude ecosystems. We have already mentioned that these animals are possibly the most environmentally gentle ruminant livestock. With their soft-padded feet, they do not scour steep hillsides. With their sharp front teeth, they clip off grass rather than tearing it off like sheep and cattle.

Moreover, with their outstandingly efficient digestive systems, the *alpaca* and *llama* survive on coarse native grasses. Thus, in contrast to sheep and cattle, they require no pasture improvement or other modifications in the unique, high-altitude environment.

Taking into consideration all the advantages described here, lamoids would appear to be a reasonable substitute for the sheep that are presently grazing on the vast, arid lands of the Third World - with marginal profits. The adaptation of the *llama* to limited forage, scarce water supplies and high, arid lands, and its nutritious meat, its wool, which is used by artisans and modern textile industries, and overall hardiness and adaptability, make it a "super species" with fascinating qualities, and global utility.

In order to increase animal production in the last fifty years, impoverished countries of the Third World have been importing different livestock species from temperate, developed zones, and this strategy has usually met with failure. High-yielding milch cattle or sheep produce fine wool but had to confront poor feeding conditions, improper management, parasites, and difficult climatic environments in the importing countries, and they were unable to perform as they were used to in their countries of origin where they were bred with high quality, balanced diets and high-tech management.

However, there is already a tendency to avoid the ill-timed introduction of exotic domestic animals, particularly in environments already sensitive to ecological degradation. Such introductions are unjustified and, unfortunately, they are often facilitated by modern technical resources (freezing of semen, embryos, etc), the absence of resistance from traditional livestock-raising groups, or a thoughtless liking for novelty, coupled with ignorance of the world's genetic resources. So, instead of making further attempts to transplant unsuitable exotic breeds, it would make more sense to transplant domestic species suitable to harsh and high-altitude environments.

In the late 1970s, the U.N. Food and Agricultural Organisation defined the ideal animal of the future. The animal should be, said FAO, a ruminant, it should need little water, be highly fertile, and it should provide people with protein and other products. The *llama* and *alpaca* fit that ideal. To find the animal of the future, people need look no further than lamoids. Our strong feelings are that lamoids will adapt extraordinarily well to the environment of Nepal as well as to the socioeconomy and culture of the peasant communities. The *llama* does not compete with native sheep for grazing areas and complementary grazing can be considered on Himalayan rangelands with cattle, horses, or yak. They can be watered less frequently than other domestic species, and, therefore, the lamoids can be used in places where water supplies are scarce. Lamoids can easily be integrated into the farming system and economy of Nepal, because rearing lamoids requires very little investment in terms of labour and technology. The medium-fine quality of *llama* wool can be used in the famed local carpet industry in which the Nepalese people are skilful. Also, the animals can be used as beasts of burden for transporting goods over dangerous areas in the Himalayan mountains, as well as being used to provide meat.

After introducing lamoids to their new habitat, special emphasis must be placed on infectious diseases, transmitted by local livestock, and unfamiliar toxic plants must be avoided. If the animals are managed according to our recommendations and common sense, there will be no serious problems.

Suggested Systematic Steps for Introduction of Domestic South American Camelids

1. More theoretical knowledge about SACs is needed in Nepal.

2. A study visit should be arranged for ICIMOD professional staff and Animal Health Services' staff from Nepal, to one or more South American countries, in order to attend courses on lamoid medicine, production, genetics, and management.

3. During the study visits, information can be gathered on animal health regulations existing in the exporting countries as well as other administrative procedures.

4. ICIMOD should organise an inspecting, teaching, and study mission for Peruvian professionals in order to inspect the environment where the animals will be placed; teach medical care and camelid husbandry to the professional and technical staff engaged in the introduction of lamoids to Nepal; and study the prevalent animal diseases in Nepal and other risks for the introduced lamoids.

5. A complete list of the most important domestic and wild animal diseases in the Himalayan Region should be obtained to instruct exporters about the specific prerequisites needed by Nepalese Animal Health Officers. Likewise, comprehensive information on toxic plants that can eventually cause problems for newly-introduced animals should be obtained.

6. Contact should be established between the importers and the South American exporting agencies to procure information about species, prices, and other terms of reference.

ANNEXES

Annex 1

South American Institutions Engaged in SAC Research and Transfer of Technology

Regional

Junta del Acuerdo de Cartagena (Andean Common Market Organisation): Esquina Aramburu y Paseo de la Republica, San Isidro, Lima, Peru

Argentina

Instituto Nacional de Tecnologia Agraria - INTA. Secretaria de Agricultura (National Institute of Agrarian Technology. Agriculture Secretariat), Buenos Aires, Argentina

Bolivia

Government Institutions. Instituto Boliviano de Tecnologia Agropecuaria - IBTA- Ministerio de Asuntos Campesinos y Agricolas - MACA (Bolivian Agropecuary Technology Institute. Ministry of Agriculture and Rural Affairs), Casilla No. 5783. La Paz, Bolivia

Instituto Nacional de Fomento Lanero - INFOL
(National Institute for Wool Promotion)
Av.Arce 2142, La Paz, Bolivia

Programa de Autodesarrollo Campesino de la Corporacion de Desarrollo de Oruro -PAC-. Proyecto de Camelidos de Turco (PROCATUR), Oruro, Bolivia,

Universidad Mayor de San Andres - Facultad de Agronomia. (San Andrés University, Agronomy Faculty), La Paz, Bolivia

Universidad Tecnica de Oruro - Facultad de Agronomia
(Technical University of Oruro. Agronomy Faculty) Calle Potosi No.6820, Oruro, Bolivia

Non-government Organisations.

Asociacion Integral de Ganaderos en Camelidos de los Andes Altos - AIGACAA,
La Paz, Bolivia.

Centro de Investigacion Promocion del Campesinado-CIPCA
(Rural Investigation and Promotion Centre),
La Paz, Bolivia

Asociación de Artesanía y Moda-ADAM
Agrupación de Artesanos y Pequeños Industriales Apoyados
USAID/Bolivia, Orientados Hacia los Mercados de Exportación.

Centro Orureño de Planificación-COPLA
(Planning Centre of Oruro)

Corporación de Desarrollo de Oruro-CORDEOR
(Development Corporation of Oruro).

Confederación Sindical Unica de Trabajadores Campesinos de Bolivia-CSUTCB
(United Confederation of Bolivian Rural Workers)

Fundación de Apoyo al Desarrollo-FADES
(Development Support Foundation)

Federación de Asociaciones de ONG-FENASONGS

Federación Nacional de Mujeres Campesinas de Bolivia-Bartolina Sisa-FNMB-BS
(Bolivian Rural Women National Federation)

Instituto Boliviano de Tecnología Agropecuaria-IBTA
(Bolivian Institute of Agricultural and Livestock Technology)

Programa de Autodesarrollo Campesino-PAC
(Rural Self-development Programme)

Programa Campesino Alternativo de Desarrollo-PROCADE
(Peasant's Programme for Alternative Development)

Programa de Camélidos de Turco, Oruro-PROCATUR
(Camelids Programme of Turco)

Servicios Múltiples de Tecnología Apropiada-SEMIA
(Multiples Services for Appropriate Technology),

Unión Nacional de Instituciones para el Trabajo de Acción Social-UNITAS
(National Union for Social Action Institutions)

Chile

Government Institutions

Instituto Nacional de Desarrollo Agropecuario - INDAAP
(National Development Institute)
Ministerio de Agricultura, Arica, Chile

Red de Investigaciones en Pastos Alto Andinos - REPAAN
Departamento de Produccion Animal, Universidad Catolica
(High Andean Pastoral Research Institute)
Dept. of Animal Production
The Catholic University of Chile
de Chile, Santiago, Chile

Secretaria Regional Ministerial de Agricultura
(Secretariat of the Regional Ministry of Agriculture)
I Region, Arica, Chile

Corporacion Nacional Forestal - CORFO
(National Forestry Corporation)
I Region, Arica, Chile

Instituto Nacional de Tecnología Agraria - INTA
(National Institute of Agrarian Technology)

Non-government Organisations

Taller de Estudios Aymara - TEA- Casilla 1344. Arica, Chile

Peru

Government Institutions. Instituto Veterinario de Investigaciones Tropicales y de Altura -IVITA-
Universidad Nacional Mayor de San Marcos

(Veterinarian Institute of Tropical Research, San Marcos University)
Apartado 4270, Lima, Peru

Universidad Nacional del Altiplano - Facultad de Medicina Veterinaria
(Medicine and Veterinary Faculty, Altiplano National University)
Apartado No.291, Puno, Peru

Universidad Nacional Agraria "La Molina", Facultad de Zootecnia, Programa de Ovinos y Camelidos
(Faculty of Zoology-Ovine and Camelid Programme; National Agrarian University "La Molina")
Apartado 456, Lima, Peru

Universidad Peruana Cayetano Heredia- Instituto de Investigaciones de Altura
(High Altitude Research Institute, University of Peru - Cayetano Heredia)
Apartado 6083, Lima, Peru

Instituto Nacional de Investigacion Agraria y Agro-Industrial - INAA
(National Institute of Agrarian and Agro-industrial Investigations)
Casilla 2791, Lima 12, Peru

Universidad Nacional San Antonio Abad del Cusco - Facultad de Agronomia Zootecnia, National Faculty of Agronomy and Zoology, San Antonio Abad University of Cusco, Apartado 921, Cusco, Peru

Non-Government Organisations

Asociación de Alpaqueros de Caylloma - ADECALC

Asociación Internacional de la Alpaca - AIA
(International Alpaca Association)

Centro Internacional de Cooperación Agrícola - CICDA
Santo Tomás, Chumbivilcas, Cusco

Centro de Investigación, Desarrollo y Educación - CIED
Peral 321, Arequipa

Asociación de Productores de Ocongate - APO
(Ocongate Producers' Association)

Centro de Capacitación Agro-industrial "Jesús Obrero" - CCAIJO (Agro-industrial Assistance Centre), Calle Lagunilla s/n, Ocongate, Cusco

Centro Canadiense de Estudios y Cooperación Internacional - CECI
(Canadian Centre for Studies and International Cooperation)
Centro de Estudio para el Desarrollo de las Comunidades Alpaqueras del Perú-CEDCAP

Centro de Promoción e Investigación Andina-CEPIA

Centro de Proyectos Integrales en Base a la Alpaca-CEPIA
9 de Diciembre 288, Apartado 23, Juliaca, Puno

Centro de Información Campesina-CFC

Centro de Información Científica de Camélidos Sudamericanos-CICCS

Cooperacion Tecnica del Gobierno Suizo - COTESU -. Proyecto Alpacas. Casilla 901, Puno, Peru

Coordinadora Interinstitucional del Sector Alpaquero - CISA

Federación Interegional de Criadores de Camélidos Andinos del Perú - FIRCCAP

Grupo de Investigacion y Extension de Tecnologia Popular, TALPUY, Jiron Cusco No.327, Piso 4, Huancayo, Peru

Programa Colaborativo de Apoyo a la Investigacion en Rumiantes Menores. Peru-SR-CRSP

Proyecto de Desarrollo Alpaquero - PAL

Proyecto de Investigacion en Sistemas Andinos - PISA-. Puno, Peru

Asociación RUNA MAKI
Apartado 972, Cusco

Proyecto Alpacas PAL-INIAA-CORPUNO-COTESU/IC
Casilla 901, Puno

Centro de Estudios y Desarrollo Rural - CEDRU
Casilla 405, Puno

Centro de Estudios Andinos Cusco - CEAC
Apartado 582, Cusco

Comisión de Coordinación de Tecnología Andina - CCTA
Ahuacpinta 598, Cusco

Centro de Investigación y Capacitación Campesina - CICCA
Calle Bolívar 167, Chalhuanca, Apurímac

Asociación KAMAC MAQUI
Casilla 54, Huancayo

Asociación Intercomunal de Desarrollo - ASINDE
Apartado 10, Huancavelica

Grupo de Investigación y Extensión de Tecnología Popular - TALPUY. Jirón Cusco 327, Piso 4, Huancayo

Annex 2

Export Agencies

Bolivia

Maipo S.R.L
Av. 16 de Julio 1440, Edif.Herrmann Piso 13, Of.1303
Telef. 340993 Fax: 391547
La Paz, Bolivia.

Chile

Asociacion de Criadores de Alpacas y Llamas de Chile
Cirujano Guzman No.40. Telf. 2250136
Santiago, Chile.

Instituto de Investigaciones y Desarrollo de Camelidos Andinos
Teatinos 251 - Of. 803. Telef.724811 - 725620,
Fax No. 56 02 727483
Santiago, Chile (Attn.Dr Alvaro Gonzalez Lorca).

Alpac Chile Ltda.
Sotomayor 227. Telfs. 56 80 241645 - 252356 - 230037
Arica, Chile.

Estancia Chungara
Alejandro Flores 2314, Villa Chaquipina.
Arica, Chile.

Peru

Sais Tupac Amaru Ltda. No.1
Parque Union Panamericana 122, Balconcillo.
Telefs. 722211 - 721915
Lima, Peru.

Sais Pachacutec Ltda. No.7
Av. 28 de Julio 1166. Tels. 237304 - 246941
La Victoria, Lima 13. Peru.

Sais Marangani Ltda. No.24
Av. San Martin 102. Telf. No.233036 (Cusco).
Marangani, Cusco, Peru.

New Zealand

Alpaca and Llama Marketing Ltda.
P.O.Box 4101. Fax No.64/524/58-231
Wellington, New Zealand.

United States

Camelids of Delaware, Inc.
130 E.Nine Mile Rd. Ferndale, Michigan 48220
Telf.(313) 545-2820, Fax. No.(313)545-4125.
United States.

Kesling's - Llamas & Alpacas of Indiana
3300 Tallyho Drive, Kokomo. In. 46902. Telf. (317)453-7070
United States

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