

# A Brief History of Camelids in the Western Hemisphere

By Jane C. Wheeler

**T**axonomic classification of the South American camelids reflects their common history with the Old World camels. Both are placed together in the order Artiodactyla (cloven-hoofed), suborder Tylopoda (pad-footed), and family Camelidae, but subdivided into Lamini and Camelini at the tribe level. Two New World genera, *Lama* and *Vicugna*, and one Old World genus, *Camelus*, are recognized.

The division between the Old and New World camelids, represented by fossils of the genera *Procamelus* and *Plianchenia* respectively, took place between 9 and 11 million years ago in the Great Plains of western North America, and it was there that the direct ancestor of the South American camelids, *Hemiauchenia*, evolved from *Plianchenia* approximately 10 million years ago. The migration to South America occurred during the Pliocene/Pleistocene transition approximately 3 million years ago, and it is there that *Lama* and *Vicugna* evolved approximately one million years later in the lowlands east of the Andes. However, it is only with the climate change that produced the last Andean glacial advance 14 to 12,000 years ago, that their present distribution was established. Four species of New World camelids survive today: the wild guanaco (*Lama guanicoe* Muller, 1776) and vicuña (*Vicugna vicugna*, Molina, 1782) and the domestic llama (*Lama glama*, Linnaeus, 1758) and alpaca (*Vicugna pacos*, Linnaeus, 1758).



Painting by Jan Van Kessel: SANTO DOMINGO. 1664-1666 (Munich, Alte Pinakothek)

## THE WILD SOUTH AMERICAN CAMELIDS

The guanaco is the largest wild artiodactyl in South America. Prior to European contact, an estimated 30 to 50 million guanacos were found along the Pacific shore and into the high Andes from approximately 8° S to Tierra del Fuego, as well as east into the Paraguayan Chaco and across the pampas to the Province of Buenos Aires. Subsequent indiscriminate hunting and commercial sheep rearing, especially in Patagonia, have drastically reduced guanaco numbers and the northernmost populations are now in imminent danger of extinction.

All guanacos exhibit similar coloration varying from dark reddish brown in the southern populations to a lighter brown with ochre yellow tones in the north. The chest, belly and internal portion of the legs are more or less pure white, the head grey to black with white around the lips, eyes and borders of the ears. Fiber diameter varies from 16.5 to 24 microns and contains from 5 to 20% hair. Sexual dimorphism is absent except for the presence of large canines in the male. Faunal remains from Andean archaeological sites document the origin of llama domestication from the guanaco at high elevation localities in

central starting some 6,000 years ago.

The second wild South American camelid, the small, gracile vicuña is found at elevations from 3,500 to 4,600 meters above sea level between 9° 30' and 29°S latitude in the Andes. An estimated 2 million vicuña are thought to have existed prior to the European conquest, but unchecked hunting for its fine fiber brought the species to the edge of extinction, and by 1971 it was reported that only 5,000 animals survived in Peru, with 2,000 more in Chile, Argentina and Bolivia. In contrast with the continuing decline of guanaco numbers however, the vicuña has made a remarkable recovery over

the last 30 years and at present the Andean population totals almost 300,000. Since the founding of the first vicuña reserve at Pampa Galeras, Peru, in 1968, conservation strategies have gone from a policy of strict protectionism using armed park guards which provided no benefit to the local people, to a policy of sustainable utilization with live shearing and sale of the fiber benefiting the highland communities on whose land the vicuña lives. The economic impetus, made possible through the reclassification of the vicuña from endangered to threatened status by CITES, the international convention regulating trade in endangered species and their products, is reflected in the ongoing increase in vicuña numbers.

As with the guanaco, all vicuña exhibit similar coloration varying from dark cinnamon in the north to light beige in the south, with more extensive white cover on the lower portion of the face, the chest, belly, interior surface of the legs and ventral surface of the tail in the southern form. The eyes and edges of the ears are outlined in white, and a growth of long white chest hairs characterizes the northern populations. Average coat length is just over 3cm in adult animals and fleece fiber diameter ranges from 12 to 14 microns making it the finest commercial fiber in the world. Faunal remains from Andean archaeological sites point to the origin of alpaca domestication from vicuña at high elevation localities in central Peru 6 to 7,000 years ago.

## THE DOMESTIC SOUTH AMERICAN CAMELIDS

Direct evidence of alpaca domestication is preserved in the organic remains excavated at archaeological sites located in the wet puna between 4,000 and 4,900 meters above sea level in the Peruvian Andes. The huemul deer, vicuña and guanaco, have inhabited this region since the last Andean glacial advance approximately 12-14,000 years ago and were the prey of early hunters. Of the sites excavated to date, Telarmachay Rock Shelter in Peru (170 kilometers northeast of Lima, 4,420 meters above sea level) has produced the longest complete sequence (8,700 years) and the most abundant faunal remains. The study of more than 300,000 bones and teeth from this site has shown that alpaca, and possibly llama, domestication began around 7,000 years ago. The evidence for this process rests upon a progressive decrease in the frequency of huemul deer remains through time, with a concomitant increase in the frequency of mainly vicuña camelid remains. At the same time, the percentage of neonatal camelid remains increased markedly from 35 to 57 and eventually reached 75%, reflecting massive newborn mortality levels most likely produced by stress, disease and poor nutrition associated with the initiation of human control. Associated with this process, there is also evidence of physical change in incisor tooth shape that directly links the vicuña to the alpaca through the appearance of adult animals with permanent incisors shaped like vicuña milk incisors as in the alpaca today.

Although llama domestication may have occurred at the same time as that of the alpaca, the archaeological evidence is

less complete. It seems clear that, based on size differences with the guanaco, domestic llamas were present at Telarmachay, but there is also some evidence that one or more domestication events may have taken place in the dry puna (southern Peru, northwest Argentina and northern Chile) from the northernmost guanaco populations perhaps 6 to 10,000 years ago.

Alpaca and llama herding spread from its high puna area of origin, to the lower elevation Peruvian inter-Andean valleys and into northern Chile by 4,000 years ago. It was established along the coast between 1,000 and 1,400 years ago and reached the Amazon cloud forest along the eastern slope of the Andes by AD 200. When the Spanish arrived they encountered herds of llamas from southern Colombia to central Chile and northwestern Argentina, while alpaca distribution was restricted to Peru, Bolivia and northern Chile.

Camelid pastoralism has played a central role in the development of Andean culture. In the puna, wealth accrued from extensive alpaca and llama herds gave rise to the first urban center at Pucara in the Lake Titicaca basin around 200 B.C., and control of pack animals insured political and economic dominance of both the Tihuanaku and Inca states. The spread of highland influence and traditions to the coast is reflected in both the adoption of stock rearing and the extensive use of camelid fibre in cloth production. The dry coastal climate has preserved textile masterpieces spun and woven from camelid fibre by artisans of many cultures including the Paracas, Nasca and Moche around A.D. 200.

Between approximately 700 and 1300 AD, the powerful Chiribaya polity ruled along the coast of southern

Peru. Although it was originally thought that the Chiribaya were the descendants of Tihuanaku colonists who migrated into the area from the altiplano region around Lake Titicaca, continuing research and new radio carbon dates now place the Chiribaya culture contemporary with the highland based Tihuanaku state and show it to be of local, coastal origin. Archaeological remains excavated from the villages of cane wall houses and cemeteries spread along the lower course of the Osmore River at from sea level to 1,000 meters elevation in Moquegua, indicate that Chiribaya society was divided into two distinct groups specializing in land based and marine resources respectively. Fisherfolk were distinguished by elongated, narrow, somewhat pointed skulls produced by annular deformation, while farmers and herders practiced fronto – occipital deformation, leaving their skulls wider and flatter than normal. Group membership was also reflected in the diet and associated burial offerings, with the richest tombs contained abundant offerings of camelid products and remains. The dead were wrapped in camelid fibre textiles and buried in cemeteries accompanied by polychrome ceramics, baskets, metal items, sea shells, coca leaves and food offerings as well as sacrificial llamas and guinea pigs. In one site, pet dogs, possibly used in herding camelids, were interred in a separate cemetery. At the Chiribaya settlement of El Yaral, alpacas and llamas were ritually sacrificed by a blow to the head and buried in shallow pits covered with sand prior to house construction. The extreme aridity of the environment resulted in excellent preservation of these animals, permitting a first ever view of preconquest alpaca and llama

phenotypes.

Compared with alpacas and llamas today, the El Yaral mummies are of exceptional quality. They exhibit uniform coloration, uniform fineness, single coat breeds. The alpaca fleeces grouped at 17.9 +/- 1.0 and 23.6 +/- 1.9 microns, with the majority of llamas at 22.4 +/- 2.3 microns.

None the less, coarse fiber llamas with 32.7 +/- 4.2 micron fleeces also existed. Crossbreeding between these animals could account for the range of fleece variation seen in contemporary animals, an entirely feasible possibility amid the chaos and destruction of the conquest. Colonial administrative documents record an approximate 90% reduction in llama and alpaca numbers within little more than a century of arrival of the Spanish.

### PRE-CONQUEST ALPACA AND LLAMA BREEDING

Both archaeozoological and ethnohistorical sources document the pivotal role of pastoralism in the Andean economy prior to European contact. The origins of this tradition began with domestication of the alpaca and llama in the high elevation (3,800+ meters above sea level) central Andean puna ecosystem of Peru 6-7,000 years ago. By 3,800 years Before Present (BP), evidence of camelid herding is found in the lower elevation inter-Andean valleys of Peru, in northern Chile and northwestern Argentina. Along the Pacific coast of Peru this practice is first documented some 1,600 years ago, at the same time that llama remains first appear in Ecuador. Approximately 700 years later, both alpacas and llamas were being raised on the south coast of Peru, as well as in the cloud forest along the eastern slope

of the Andes.

Based primarily on the study of fragmented bone remains recovered during archaeological excavations, the aforementioned reports provide no information on physical appearance of the domestic alpacas and llamas. Textile remnants found at sites in the Atacama desert of northern Chile record the appearance of black fiber from presumably domestic animals around 3,000 years ago, while the earliest known (but certainly not the oldest) use of camelid fiber in Peruvian weaving comes from fabrics preserved at coastal sites dated approximately 2500-700 BP. In northwestern Argentina, llama fiber cordage has been dated to 1450 BP. However, it is only with the discovery of 700-1,300 year old naturally desiccated llama and alpaca mummies from southern Peru that information on the physical appearance of ancient animals has become available.

The discovery of 26 perfectly preserved, naturally desiccated alpaca and llama mummies at the pre-Inca (A.D. 700-1300) Chiribaya culture site of El Yaral, provides a first ever view of preconquest animals. Located in the extremely arid coastal desert of southern Peru (17°01' south latitude, 71°00' west longitude), the site lies 50 km inland at an elevation of 1000 meters above sea level. Covering approximately 12.3 hectares, and containing more than 330 elongated residential terraces, El Yaral rises 120 meters up the barren hillside at the extreme south-western end of the Moquegua valley. It overlooks a natural corral, approximately one square kilometer in extent, which is enclosed by sand covered hills and watered by the Osmore River (Figure 1, next). Extensive river bottom agricultural land lies immediately to the north of the site.



**Figure 1. View of El Yaral.**  
 Note horizontal architectural terraces on the hillside above the river, where houses were built after ritual sacrifice and burial of llamas and alpacas. The grass area is a natural corral of approximately one square kilometer extent.

The El Yaral structures were built of cane walls with wooden support posts for cane mat roofs, and subdivided by rows of vertical canes into anywhere from two to eight rooms which were used for storage, cooking, chicha (a fermented maize beverage) preparation, sleeping and ritual activities. Compacted floors of fine gravel, sand and clay covered offerings of guinea pigs, coca leaves, thread wrapped sticks, turquoise and marine shell beads, small silver plaques, feathers, fish, maize and burnt charcoal, as well as sacrificial

alpacas and llamas. These animals had been killed by a massive blow between the ears and rapidly interred. The sand in which they were buried and the extreme aridity of the climate produced exceptionally well preserved specimens.

Contemporary llamas and alpacas are classified on the basis of fiber characteristics and physical appearance. Recognized llama phenotypes include the hairy, coarse, sparsely fibered ccara; the coarse, more densely fibered chaku; the long, wavy fiber suri and animals with an

intermediate fiber type. Most alpacas exhibit dense, crimped huacaya fleeces, but a small number (<10%) are distinguished by long, wavy suri fiber. Intermediate alpaca fleece types also exist but are not a recognized phenotype. Virtually all llamas, and 75% of all alpacas, are held by traditional herders who fail to consistently breed for selected phenotypes and both inbreeding and hybridization between llamas and alpacas are acknowledged problems. Nonetheless, elaborate classification systems based on color and conformation characteristics exist among Quechua and Aymara herders, suggesting that earlier management strategies selectively bred for fiber characteristics in both alpacas and llamas. Although written records were not part of Andean civilization, detailed data on size and color of flocks was kept utilizing the quipu, a memory aid made of knotted camelid fiber strands. Under Inca rule, an annual census was taken of the state and shrine herds. Special emphasis was placed on breeding pure brown, black and white animals for sacrifice to specific deities, as well as on quality fiber production for the state controlled textile industry and the production of sturdy pack llamas for the Inca army. Given such rigorous demands, it is likely that specific llama and alpaca breeds were maintained which subsequently disappeared during the Spanish conquest. The data from El Yaral, presented here, suggests that the origin of such breeds may predate the Inca Empire.

**PRE-CONQUEST BREEDS**

The El Yaral llamas and alpacas were identified on the basis of phenotypic attributes (conformation, fiber distribution) and confirmed by incisor morphology. The age and sex of each specimen was

determined, when possible, on the basis of dental eruption and preserved genitalia. Observations on fleece type and color were recorded, and evaluation of the fiber producing qualities of 6 llamas and 4 alpacas from the site was carried out. Samples of skin with attached fiber (1.5x1.5cm) were taken when possible, at 11 standardized sites on the left side of the animals: on the lower neck (A2), at equidistant points from the fore to hind legs at the level of the sacral tuberosity (A3-A6) and mid-way between the dorsal and ventral surfaces (B3-B6), as well as half-way down the fore (C3) and hind (C6) legs. Fiber length was recorded, and 1mm segments of 300 to 500 fibers were cut from next to the skin of each sample and diameter measurements were recorded for 200 fibers per sample.

Experimental desiccation of fresh llama skin samples was carried out under varying conditions, and statistical analysis of the results, revealed no significant alteration in fiber diameter during these processes.

Fiber diameter measurements from the El Yaral alpacas and llamas (Figure 2) revealed the existence of four distinct groups of animals (Figure 3, next page). The raw data reflect natural variation in fiber diameter across the body, with coarser/hairier samples coming from the neck (site A2) and legs (sites C3, C6). The finest fiber is located along the back (sites A3-A6), with a tendency towards a gradual increase in diameter at mid-rib height (sites B3-6). Taken together, the eight samples from sites A3-6 and B3-6, correspond to the fleece, and represent that portion of the fiber which is shorn

site	ALPACAS				LLAMAS					
	119 ±24m	317 9m	314 <18m	228 21m	243 <18m	231 ≈27m	273 >9m	248 ----	237 6-9m	247 3m
A2	17.2	17.9	23.0	21.7	19.7	27.2	22.3	22.0	28.4	29.6
A3	16.0	17.7	21.8	22.7	18.2	20.4	21.2	21.4	23.4	31.9
A4	17.1	17.5	21.2	22.1	19.5	19.7	20.7	24.1	21.9	29.3
A5	17.7	17.5	24.0	24.5	25.1	22.8	22.1	n.s.	23.5	n.s.
A6	19.1	18.8	23.0	25.6	23.9	22.4	21.8	21.6	23.2	37.0
B3	17.0	16.5	27.6	26.2	n.s.	22.4	20.4	22.5	25.9	34.3
B4	17.2	19.5	22.7	24.0	18.8	n.s.	22.5	21.6	24.4	26.5
B5	18.6	n.s.	21.4	23.6	n.s.	n.s.	23.4	23.9	21.7	39.6
B6	19.3	18.8	21.0	26.3	n.s.	23.4	24.5	20.6	21.0	30.5
C3	30.1	20.5	44.2	26.7	n.s.	30.8	28.5	45.4	n.s.	n.s.
C6	29.5	21.3	36.6	29.8	n.s.	n.s.	43.9	25.7	30.1	n.s.

**FIGURE 2. El Yaral alpaca and llama fiber diameter in microns, by sample site, 200 fiber count.**  
 A2-A6: adjacent to midline from neck to tail, B3-B6: at midrib from shoulder to hip, C3: lower front; and C6: lower rear legs, - n.s. = no sample

Contemporary South America		Prehispanic, AD 700-1300	
Species & Varieties	_m	Breeds	_m
vicuña, n=10 adult males	12.5±0.4		
alpaca x vicuña F1, n=5 adult	15.3±0.2	Chiribaya extra fine alpaca	17.9±1.1
alpaca huacaya, n=5 males, 24m	32.1±2.4	119, male ± 24 m, 17.8±1.1	
alpaca huacaya, n=54 males, 24m	27.9±3.7	317, male, 9 m, 18.0±0.0	
alpaca suri, n=5 females, 48m	26.8±6.0	Chiribaya fine alpaca	23.6±1.9
		314, male 18 m, 22.8±2.0	
		228, male 21m, 24.4±1.5	
alpaca x llama, unknown sample	u=34.0		
llama chaku, n=7 males, 12m	18.8u/39.8h	Chiribaya fine llama	22.4±2.3
llama chaku, n=6 females, 24 m	22.0u/42.2h	243, male, 18 m, 21.1±2.0	
llama intermediate, n=7 males, 12m	20.0u/55.6h	273, male, 9 m, 22.1±1.3	
llama intermediae, n=8 males, 24 m	25.3u/73.4h	248, male, age?, 22.2±1.2	
llama ccara, n=7 males, 12 m	20.1u/3.1h	237, male 6-9 m, 23.1±1.5	
llama ccara, n=10 males, 24 m	25.2u/77.7h	231, male 25-29 m, 23.2±3.5	
		Chiribaya coarse llama	32.7±4.2
		247, male, 3m, 32.7±4.2	
llama x guanaco, n=1 male, adult	23.6±2.2		
guanaco, n=20 males, adult	16.5u/2.8h		

Figure 3. Mean fleece diameter of contemporary and prehispanic South American camelids. All figures represent complete fleece counts except where noted (u = undercoat, b = hair). El Yaral fleece data represent the mean of 8 sample locations.

environmental stressors become more severe, but the relationship of these factors to fiber diameter remains to be demonstrated. Nevertheless, the presumed correlation between fine fiber and high altitude is often cited as evidence that alpacas can be reared successfully only in this habitat.

In Peru, fiber diameter values reported for contemporary Andean llamas and alpacas vary greatly. This is due, in part, to differences in the samples studied, measurement techniques and reporting. It is not always clear, for example, if published figures come from complete or dehaired fleeces, and extreme care must be taken to select comparable data sets. Even with this caveat, the range of values reported for alpaca and llama fleeces is so great that it would be misleading to give a single value for each. Alpaca fibers have been reported from 9 to 88µm, and llama fibers from 8 to 144µm, indicating a variable but significant presence of coarse guard hair in both groups. In comparing the El Yaral mummies with contemporary animals, we have chosen age matched samples insofar as possible (Figure 3).

The fiber diameters of the ancient alpaca specimens were found to be significantly finer relative to today's animals. The Chiribaya extra fine fiber alpaca group (named after the culture to

which El Yaral pertained) measured from 10-14µm less than huacaya alpacas of the same age, while the Chiribaya fine fiber alpaca group registered 4.7-8.5µm less. Comparable age and sample data on Peruvian suri fleeces is not available. It is generally considered that the wavy suri fiber is finer than the crimped huacaya fiber, but insufficient information is available to confirm this. Among the mummified alpacas, however, the finest fiber came from animal 119, a 24 month old male with crimped fiber (Figure 4), while the other fleeces were wavy (animals 317 and 228 (Figure 5) or contained both crimped and wavy fibers (animal 314; Figure 6).

Fiber diameter measurements of the six El Yaral llamas revealed the presence of fine and coarse fiber animals. Chiribaya fine fiber llama fleeces (n=5) averaged 22.2 ± 1.8µm. Comparative figures for 12 months old males from Puno, Peru, vary from 18.8µm undercoat/39.8µm hair in the more heavily fibered chakus to 20.1µm undercoat/73.1µm hair in ccaras, increasing to 22.0µm undercoat/42.2µm hair in chakus and 25.2µm undercoat/77.7µm hair in ccaras at 24 months (Figure 3). Although these figures cannot be directly compared with the complete fiber counts on the El Yaral specimens, the nondehaired ancient fleeces are as fine as the dehaired modern

ones. Abundant coarse hairs were present in all the contemporary samples, while in contrast, only one of the five ancient llamas (237) had visible fine hair in the fleece. Two others had very fine hair (248, 231) and two were single coated with no perceptible hair in the fleece (243 Figure 7 - next page , 237). In contrast, the sixth El Yaral llama (247), a 3 month old male, had a coarse hairy coat with an almost equally coarse undercoat. At 32.7 ± 4.2 µm, the fiber diameter of this animal is greater than that reported in contemporary llamas (Figure 3).

Based on fiber diameter, it would appear that 3 possible fiber producing breeds of domestic camelids may have existed at El Yaral. These include the Chiribaya extra fine and fine fiber alpacas and the Chiribaya fine fiber llama. Although alpacas continue to be raised for fiber up to the present, llama fiber is generally deemed too coarse and hairy for textile production, and these animals are reared primarily for use as pack animals and for meat. Early Spanish writers were impressed by the large pack trains which accompanied the Inca army, and llamas were valued as beasts of burden during the colonial period. But, not all llamas are reared for cargo, and in some communities they are selectively bred for fiber production. The Chiribaya fine fiber llamas suggest that this practice, which has virtually disappeared, may have

for use in textile manufacture. Based on complete (not dehaired) samples (n=8 per animal), average fleece diameters for the two alpaca groups were found to be 17.9 (sd ± 1.0µm) and 23.6 (± 1.9µm). Llama fleeces likewise included a fine fiber group at 22.2± 1.8µm, as well as a coarse fiber animal at 32.7 ± 4.2µm. Analyses of variance indicate that the differences between these ancient groups are significant.

To the best of our knowledge, the heritability factor of fiber fineness has not been determined for llamas and alpacas,

although 0.22, 0.27 and 0.38 have been reported for fleece weight. It has been observed, however, that fiber diameter generally increases with age and number of shearing events. There is also some indication that a rich diet may increase fiber diameter, while finer fiber may be produced by animals kept on a low plane of physiological stress. In the Peruvian Andes, it is generally believed that a relationship exists between elevation and alpaca fiber fineness. As altitude increases, pasture quality decreases and





Figure 7. Llama 237 from structure 70 at El Yaral.

ancient roots. Regardless, because so many environmental factors can affect it, fiber diameter data alone is insufficient for affirming the existence of breeds.

Evidence that selective breeding was practiced at El Yaral is seen in a uniformity of fleece characteristics which are lacking in contemporary Andean llamas and alpacas. In the ancient specimens, variation in fiber diameters across the fleece is minimal, and hairy patches are rare even in the coarse fiber llama, while in living animals fiber diameter tends to vary greatly and hairiness is a problem in both alpacas and llamas. Even though the alpaca is considered to have a single coat comprised entirely of undercoat fiber, animals with up to 40% hair in the fleece are known today. Additionally, the existence of single coat llamas with uniformly fine fiber at El Yaral, provides evidence of a variety or breed which is no longer recognized.

Another indication of selective breeding for fiber production is seen in the uniform coloration of the mummies. Only two of the El Yaral specimens are multicolored, the coarse fiber llama male which was eliminated from the gene pool at 3 months, and a brown and white alpaca (317). The

possibility that the coarse fiber llama represents a non fiber producing (possibly cargo bearing) breed should be taken into account. The Chiribaya fine fiber llamas included one pure white, two red brown, and two grey/beige animals. Under Inca rule, animals of pure color were required for sacrifice to particular deities and the shrine herds bred for this demand. White llamas were sacrificed to the sun, red brown animals to Viracocha at the beginning of the agricultural year, and black animals were starved and sacrificed in times of crisis. Whether or not the llamas at El Yaral were sacrificed to the same deities is unknown, but with one exception, the requirement for pure color high quality animals seems to have been met. The mummified alpacas, included the brown and white animal mentioned above, as well as a white, a brown and a vicuña-colored alpaca.

One final line of evidence suggestive that the Chiribaya fine fiber llama was selectively bred for fiber production is an indication that fiber growth may have been more rapid than in contemporary animals. In the unshorn or partly shorn specimens (243, 273), a discrepancy was noted in the age predicted on the basis of fiber length

and the age of the animal as predicted by dental eruption. Although the data on fiber growth comes from animals raised at high altitude and may not therefore be fully comparable, fiber lengths of 13 and 18 cm for llama 273 would suggest an animal more than 2 years of age, but in fact the animal is >9 (likely 12) months. The same is true for llama 243, with fiber lengths of 14 and 16 cm, the expected age would be more than 2 years, but the real age is <18 (likely 15) months. Clearly selection for faster fiber growth would be of economic importance if the goal of breeding is for fiber production. None the less, it should be observed that a good plane of nutrition is also required in order to sustain such growth. Unfortunately, all four alpacas had been shorn prior to sacrifice, so comparable data is lacking.

Clearly the coastal desert was not a bad place to raise llamas and alpacas: fleece fineness and uniformity, accelerated fiber growth, uniform coloration, and the existence of a single coat llama all point to controlled breeding, reproducible results and the probable existence of breeds. The skill of the Chiribaya culture herders is recorded in the mummified alpacas and llamas from El Yaral, and further confirmed by the faunal assemblage from Chiribaya Alta, a nearby, contemporary site (Figure 8). Examination of 140 sacrificial llamas from intact burials revealed that they had been selected in accordance with herd management priorities. Only 12.9% of the llamas killed were of prime breeding age (>24 months), and 3 (or 2.1%) of these had dental pathologies which would have been cause for sacrifice. Of the remaining 122 animals, 69.6% were culled before first breeding at 21 months; 15.7% were killed after the first and before the end of the

second breeding season at 21-42 months, and 2.9% were old adults probably past reproductive age. Such a pattern would be produced by the elimination of undesirable and infertile animals from the herd which was raised locally under a controlled breeding program. The end product of these efforts were fiber producing alpacas and llamas of unparalleled quality.

In contrast with the pre-conquest alpacas and llamas from El Yaral, today's animals are characterized by a lack of uniformity. Coarsening of the fiber, increased hairiness and the increased variation in fiber diameter across the fleece of huacaya and suri alpacas, as well as the apparent disappearance of fine fiber llamas, can almost certainly be explained by a breakdown in controlled breeding accompanied by extensive hybridization produced by events of the conquest. Taken together, the four pre-conquest breeds bracket the range of fiber diameter measurements in today's animals, and crossing with the hairy Chiribaya coarse fiber llama could have produced this result. Scientific study of the role of hybridization in the evolution of today's llamas and alpacas has only recently been undertaken utilizing DNA, and has revealed alarming levels of hybridization. On a trans-Andean level it has been found that only 20% of alpacas have not suffered hybridization with llamas at some point in their ancestry. As of yet unpublished data place the incidence at just less than 6% in some regions of Peru. Sadly, hybridization between alpacas and llamas - heritage of the conquest - continues apace making the genetically pure alpaca an endangered species. Although attempts to determine the genetic purity of the mummies through DNA analysis have

not yet proven possible, preliminary study in contemporary alpacas points to a possible relationship between fine fiber and purity. Much research remains to be done, but one thing is clear, we urgently need to identify and protect the few remaining unhybridized alpacas, and these may well turn out to be the true descendants of the Chiribaya alpacas and llamas.

#### Author's Note:

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(11)



Figure 8. Looted llama and alpaca remains at the site of Chiribaya Alta, Il.