

A MEASURE OF LOSS: PREHISPANIC LLAMA AND ALPACA BREEDS

RAZAS PREHISPANICAS DE LLAMAS Y ALPACAS; LA MEDIDA DE LO QUE SE HA PERDIDO

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SUMMARY

The discovery of 900-1000 year old naturally mummified llamas and alpacas at the archaeological site of El Yaral (Moquegua, Perú) has permitted detailed study of native andean breeds prior to european contact. The analysis of skin and fiber samples provides evidence of the previous existence of two llama and two alpaca breeds. The llamas included a fine fiber breed (fleece mean $22.4 \pm 2.3 \mu$) which is apparently extinct, and a coarse fiber breed (fleece mean $34.8 \pm 7.3 \mu$) which is similar to contemporary animals but with a more uniform fleece. Among the alpacas extra fine fiber (fleece mean $18.0 \pm 1.1\mu$) and a fine fiber (fleece mean $23.6 \pm 1.6 \mu$) breeds were distinguished. The prehispanic specimens exhibit a uniformity of fiber color, distribution and fineness characteristic of controlled systematic breeding which is absent in contemporary animals. Published statistics for contemporary peruvian llama fleeces vary from $27.0 \pm 15.6 \mu$ for *woolly* ccaras to $35.3 \pm 17.8 \mu$ for *nonwooly* chakus (Vidal, 1967); while *long wool* suri alpacas average $26.8 \pm 6.0 \mu$ (Von Bergen, 1963) and *short wool*

huacaya fleeces are $32.3 \pm 2.5 \mu$ (Carpio, 1991), but the range of variation throughout the Andes is undoubtedly greater. Degeneration in both llama and alpaca fiber quality can be explained as a result of hybridization due to a breakdown in controlled breeding, a not improbable scenario amid the chaos and destruction of the conquest. Sixteenth and seventeenth century spanish sources document the virtual disappearance of llama and alpaca herds, as well as up to 80 p.c. of the human population, within little more than a century following the conquest of Cuzco in 1532. Analysis of DNA from the prehispanic specimens will provide baseline data for evaluating the extent of hybridization in present llamas and alpacas.

RESUMEN

El descubrimiento de llamas y alpacas naturalmente momificadas hace 900 a 1000 años en el sitio arqueológico de El Yaral, Moquegua, Perú, ha permitido por primera vez la descripción de

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sus razas autóctonas prehispánicas. Mediante análisis de muestras de piel y fibra, se han obtenido evidencias de la preexistencia de dos razas de llamas y dos de alpacas. Existía una raza de llamas, aparentemente ya extinta, de fibra fina sin pelos (promedio del vellón $22,4 \pm 2,3 \mu$; y otra de fibra gruesa (promedio del vellón $34,8 \pm 7,3 \mu$) semejante a los animales de hoy pero más uniforme. Había alpacas con fibra extrafina (promedio del vellón $18,0 \pm 1,1 \mu$) y otras de fibra fina (promedio del vellón $2,6 \pm 1,6 \mu$). Las llamas y alpacas antiguas fueron seleccionadas intensivamente, pues se caracterizan por uniformidad de finura, conformación del vellón y color, mientras que las actuales se caracterizan por su gran variación en el grosor, pilosidad y color de su fibra, producto del cruzamiento no controlado. En las llamas peruanas actuales el diámetro promedio del vellón varía desde $27,0 \pm 15,6 \mu$ para las caras lanudas hasta $35,3 \pm 17,8 \mu$ para los chakus pelados (Vidal 1967); mientras que en las alpacas las cifras van de $26,8 \pm 6,0 \mu$ para la suri (Von Bergen 1963) y $32,3 \pm 2,5 \mu$ para la huacaya (Carpio 1991). Sin embargo, es probable que la variación a través de los Andes sea aún mayor que lo reportado. El deterioro de la calidad de fibra de las actuales llamas y alpacas andinas se puede explicar como producto de la hibridación entre ambas, hecho probablemente ocurrido durante el caos y la destrucción que acompañó la conquista española. Documentos de los siglos XVI y XVII registran la virtual desaparición de las llamas y alpacas, junto con 80 p.c. de la población humana, en menos de un siglo después de la conquista de Cuzco en 1532. El análisis del ADN de animales prehispánicos permitirá medir los cambios genéticos producidos por la conquista y la incidencia de hibridación en las llamas y alpacas de hoy.

INTRODUCTION

The European settlement and colonization of the New World unleashed

an environmental crisis of unprecedented magnitude. With the introduction of Old World cultigens, animals, farming practices, and legislation the landscape was irreversibly altered and native genetic resources impoverished (Crosby, 1972). In the Andes, previously unknown diseases reduced the human population by an estimated 80 percent leading to economic and social disintegration of native societies (Wachtel, 1977). Native llama and alpaca herds also virtually disappeared within little more than a century following the conquest of Cuzco in 1532 (Flores Ochoa, 1977 and 1982). European livestock (sheep, goats, cattle, and pigs) rapidly displaced llamas and alpacas from their coastal and highland valley range, and pushed them into marginal high elevation lands where the newly introduced animals could not survive. Early tax records, laboriously kept by the Spaniards, illustrate the extent of this disaster. In 1567, Garci Diez de San Miguel, inspector for the Spanish crown reported a single, privately owned herd of 50000 llamas and alpacas in the province of Chucuito on the western shore of Lake Titicaca. Five years later, in 1572, Pedro Gutiérrez Flores counted only 160000 head in the entire province, reflecting the devastation of native livestock in what was undeniably the most important center of llama and alpaca production in the Andes. The consequences of this catastrophe on contemporary camelid production are rarely considered and poorly understood.

The lack of written records from preconquest times, and the loss of orally transmitted specialist knowledge

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about llama and alpaca rearing makes it specially difficult to evaluate the extent to which ideas of european origin about stockrearing have influenced management practices. Now, llamas are primarily bred for use as pack animals and three different phenotypes are known, although it is likely that more exist. Nearly all Andean llamas are of the q'ara or *non-woolly* type, characterized by lack of fiber on the face and relatively sparse fiber growth. Less common is the ch'aku or *woolly* llama, which as its name implies, has a heavier fleece with fiber growing on its forehead and in its ears. The fiber characteristics of the third variety are intermediate between the q'ara and ch'aku llamas. Color tends to be patchy and varies from white, to brown, black or grey. The fiber is generally coarse and hairy, and the consensus of opinion is that the llama is not now and never has been bred for fiber production. In contrast, alpacas are kept specifically for fiber production, and two phenotypes can be distinguished based on fiber characteristics. Now, approximately 90 p.c. of alpacas exhibit the shorter, crimped fibers of the huacaya variety, while 10 p.c. have the long wavy fibers of the Suri type (Wheeler, 1991). In appearance, the huacaya is reminiscent of Corriedale, and the suri of Lincoln breeds of sheep. Animals with intermediate fiber types exist, but are rare. The genetic factors which control these characteristics are not known, and the 9/1 huacaya/suri ratio is a product of random breeding. Fiber color varies from white to black and brown, including all the intermediate shades, but tends

to be uniform across the body. Today, all llamas and 80 p.c. of alpacas in the Andes are under the control of traditional pastoralists (Novoa, 1981), who do not selectively breed for specific phenotypes. The european concept of breeds, with herd books and written records is not part of native andean stockrearing practice.

PRECONQUEST LLAMA AND ALPACA PRODUCTION

Sixteenth century documents indicate that llama and alpaca production and breeding was rigidly controlled by the Inca government (Murra, 1965). State herds supplied pack llamas for the royal armies and alpaca wool for textile production. Shrine herds, divided according to color, provided sacrificial animals for state religious observances. A hereditary cast of State herders, the *yana*, was apparently emerging prior to the conquest. Detailed herd records were kept using the quipu, a mnemonic device, and textile production and redistribution was largely State controlled. Offerings or sacrificial burning of cloth accompanied all social, religious, military and political events. Communally and individually owned herds also existed.

The fundamental importance of llama and alpaca production to the Inca economy is seen in their repeated attempts to conquer the circum Titicaca kingdoms to the south. The wealth of herds in this region descended from the earlier tiwanaku empire, and was unequalled elsewhere in the Andes. In contrast with the Inca, however, details concerning Tiwanaku

and earlier stockrearing practices are limited because there are no written records. Such information must be reconstructed from analysis of the material remains recovered in archaeological sites.

The recent discovery of well preserved 900 to 1000 year old naturally mummified llamas and alpacas at El Yaral, in the Moquegua Valley of southern Perú, has provided a unique opportunity to examine the physical appearance of these animals prior to European contact. Excavations at this site began in late 1986 under the direction of Don Rice (Southern Illinois University) and Geoff Conrad (University of Indiana) with support from the United States National Science Foundation (grant BNS85-10877), and more recently research on biocultural remains from El Yaral has been undertaken by Jane Buikstra (University of Chicago) (BNS89-20769). See García Márquez (1988), Rice, Stanish and Scarr (1989) and Watanabe, Moseley and Cabieses (1990), for details about the excavations at El Yaral and other sites in the Moquegua valley.

Located just 50 km from the Pacific coast, at an elevation of only 1000 meters above sea level, in one of the worlds driest deserts, El Yaral may seem an unlikely place to find llama and alpaca remains. None the less, evidence from animal bones recovered during archaeological excavations at sites in Perú, Chile and Ecuador clearly indicates that the present restricted distribution of domestic camelids to areas of extreme elevation in the Andes is of recent

origin, and a direct result of their displacement by spanish introduced livestock. To the best of our knowledge, llama herding began on the coast approximately 1400 years ago (Pozorski 1979, Shimada and Shimada, 1985) but the first clear evidence of alpaca breeding in this zone comes from the site of El Yaral with an antiquity of 900 to 1000 years. Alpacas may also have been present on the north coast of Perú at this same time (Shimada and Shimada, 1985). Both llamas and alpacas were originally brought under human control as domestic animals in the high andean *puna* at least 6.000 years ago (Wheeler, 1984 and 1986; Wing, 1986), and the commonly held belief that they cannot survive at low elevation is a heritage of the spanish conquest.

El Yaral is located on the west bank of the Osmore River, approximately 20 km south of the city of Moquegua, Perú. The area is extremely dry, with condensation from winter fog supplying most of the annual 15 to 20 mm precipitation total during the months from May through August. Winter temperatures average 8°C, but during the dry, sunny summer months from January through March may reach 28°C. Agriculture cannot be practiced here without irrigation and fields are largely confined to the river bed. Just to the south of El Yaral the Osmore River disappears into subterranean channels, emerging 20 km downstream towards the coast.

The Chiribaya settlement of El Yaral began approximately 1000 years ago and lasted less than 400 years. Three radiocarbon dates have been

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obtained from the excavations: 970 + 50 B.P. (Beta 22845), 960 + 80 B.P. (Beta 19323) and 790 + 50 B.P. (Beta 22846). Ceramic remains indicate that Chiribaya developed near the present port of Ilo, out of the earlier (A.D. 600) tiwanaku occupations in the Osmore drainage (Bermann et al. 1989, Stanish 1989). These settlers from the Lake Titicaca basin brought highland traditions and livestock to the coast, forming the basis of what evolved into the Chiribaya culture following the breakup of the Tiwanaku empire. Since there is no evidence that Chiribaya was in contact with other contemporary highland groups, the apacas and llamas of El Yaral can be considered descendants of the original Tiwanaku stock. This is particularly important because it means that not only do these animals predate the Inca empire, but also that they came from what both the inca and spanish conquerors considered to be the heartland of alpaca and llama production.

The site of El Yaral covers approximately 12.3 hectares. It consists of a series of steep, elongated terraces, extending approximately 300 meters along the river bank, which were built to provide a base for architectural construction. The remains of cane wall, earthen floor buildings of varying size were found strung out along the terraces. Although the number of rooms varied from structure to structure, living, cooking, storage and chicha (corn beer) preparation areas could be identified within the houses. Excavations in two of the larger, more complex buildings revealed

subfloor alpaca and llama burials. These animals had been ritually sacrificed by a blow between the ears which fractured the skull, then immediately buried in shallow pits and covered with sand. Due to the extreme aridity of the environment, this process resulted in the desiccation and preservation of these animals as natural mummies. Other offerings, including cuyes (guinea pigs), coca leaves, sticks wrapped in thread and camelid fiber, spondylous (a marine shell imported from Ecuador) and turquoise beads, small pieces of beaten silver, feathers, fish bones, marine shells and corn were found with the alpacas and llamas.

PRECONQUEST LLAMA AND ALPACA BREEDS

The exceptional state of preservation of the El Yaral alpaca and llama mummies has made possible the first systematic analysis of the fiber characteristics of preconquest animals. In all, we have been able to study skin and fiber samples taken at 12 different locations across the body (6 along the midline from neck to tail, 4 at mid-rid from fore to hind limb, and 2 midway down the fore and hind limbs) from 4 alpaca and 6 llama mummies. Special attention has been placed on the analysis of fiber diameter in order to obtain information about fleece composition, but microstructure studies utilizing the scanning electron microscope and skin histology have also been undertaken. A total of 200 fibers (the textile industry standard)

were examined from each sample utilizing a projection microscope, IWTO standards and the MLURI GWBASIC FIBRE2 program. This data has permitted detailed evaluation of fiber fineness and uniformity in the mummies, and provided the first direct information on the fleece characteristics of preconquest llamas and alpacas.

Quite unexpectedly, five of the six El Yaral llama mummies studied were found to belong to an apparently extinct fine fiber breed. The quality of fiber from these animals is impressive. Based on mean fiber diameter at 8 sample sites per animal, their fleeces average 22.4μ with a between sample standard deviation of 2.3μ , compared to fleece measurements of $27.0 + 15.6 \mu$ for female and $29.1 + 12.7 \mu$ for male woolly chaku llamas in the Andes today (Vidal 1967). The small range of variation in fiber diameter of the ancient llamas reflects selection for a uniform, single-coat fleece through reduction in the size difference between primary hairs and secondary undercoat fibers. The fleece of the sixth llama mummy was coarse, averaging 34.8μ with a standard deviation of 7.3μ between the 8 sample sites. Although only one specimen of this class was included in our sample, this animal clearly represents a second breed of llama. The variation in diameter indicates a tendency to a double-coat with coarser hairs and a finer undercoat, but this is much less pronounced than in present day llamas.

In comparison to the preconquest llamas, contemporary Peruvian llama

fleeces lack uniformity, ranging from $32.5 + 17.9 \mu$ (o) to $35.5 + 17.8 \mu$ (o) for coarse *nonwoolly* ccaras, $30.5 + 18.5 \mu$ (o) to $30.5 + 17.9 \mu$ (o) for intermediates, and $27.0 + 15.6 \mu$ (o) to $29.1 + 12.7 \mu$ (o) for *woolly* chakus (Vidal 1967). The variability of present day llama fiber is related to an increase in hairs and general coarsening of the fleece, which probably began at the time of the Spanish conquest. Increased hairiness is produced by lack of controlled breeding, and crossing between the two pre-Spanish llama breeds from El Yaral could account for the entire range of fleece variation observed in today's animals.

As with the llamas, two probable breeds of preconquest alpacas were found among the El Yaral mummies. Based on mean fiber diameter at 8 sample sites per animal, fine fiber and extra fine fiber alpacas were distinguished. The former have fleeces averaging 23.6μ with a between sample standard deviation of 1.6μ , while the latter fleeces average 18.0μ with a between sample standard deviation of 1.1μ . Both groups exhibit uniform single-coats. In comparison, contemporary Andean Huacaya and Suri fleeces, at $31.2 + 3.8 \mu$ (Carpio, 1991) and $26.8 + 6.0 \mu$ (Von Bergen, 1963) respectively, are coarser, may have a tendency to hairiness, and are of uneven quality. Some coats containing up to 40% hair have been reported for both living varieties, and considerable variation is reported in published statistics on fiber diameter. The origin of this degeneration almost certainly lies in the Spanish conquest, but a breakdown in controlled breeding

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between the fine and extra fine El Yaral breeds would alone account for the variation observed today.

The most probable cause of coarsening and hairiness in both huacayas and suris would be through hybridization with the coarse fiber llama breed, a not improbable scenario amid the chaos and destruction of the conquest. Clearly, however, such a process would not have affected only the alpaca gene pool. The El Yaral mummies indicate the possibility that extensive crossbreeding between alpacas and llamas may have occurred during the sixteenth century and has played a much more important role in the formation of today's livestock than has been realized.

DISCUSSION

The truly unexpected results obtained from fiber analysis of the El Yaral mummies indicate both how much has been lost, and how much remains to be learned about alpacas and llamas. Many of the confused ideas and contradictory statements about these animals coming from both native andean herders and north american breeders, to say nothing of camelid specialists, are more a heritage of the spanish conquest than we have realized. The crux of the problem lies in the lack of written records in prehispanic andean society, and the loss of orally transmitted specialist information about breeds and breeding within the first century after european contact. What has survived is probably as distorted by poorly understood european-origin ideas and traditions

as the animals themselves have been modified by hybridization. We have known for a long time that the primary reason why llamas and alpacas are said to have a low reproductive success rate is because native andean herders tend to raise them as if they were sheep not because they are inherently infertile or maladapted to the high andean environment as has been claimed. We are now beginning to learn from the El Yaral mummies what the real potential of these species as fiber producers is. Unfortunately, too little is known about alpaca and llama variation in the Andes to even determine if the preconquest variants still exist in the general population and can be rescued by careful breeding. The absolute urgency of identifying and preserving relict populations before any further genetic loss or modification occurs cannot be emphasized strongly enough. Genetic markers must be identified which can be used to distinguish breeds and hybrids, and research underway on both mitochondrial and nuclear DNA sequences from all four south american camelids is producing promising results (Stanley and Wheeler 1992). The inclusion of ancient DNA from the El Yaral llamas and alpacas will be of crucial importance in documenting the historical development of today's llamas and alpacas. Because they include apparently extinct breeds, the mummies may provide baseline data against which to measure the probable effects of hybridization and reduced genetic diversity which are thought to have accompanied the Spanish conquest.

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