

Did the ancient Inca make the finest woollen cloth the world has ever known?

By Heather Pringle

The following article is reproduced with kind permission of the author and Dougal Macdonald, editor of Alpaca Yaca, the Southern NSW Region's Newsletter. I have left in Dougal's comments as he has many things of interest to add (Jill).

Heather Pringle is a science journalist who specializes in writing about archaeology. In February, 2002, she received the prestigious Science Journalism Award from the American Association for the Advancement of Science. Her enthusiasm for alpacas and for Jane Wheeler's work is manifest in the following article. We as experienced alpaca owners may be forgiving when her enthusiasm bubbles over and she waxes lyrical about the novelty of matters which to us are daily routine. The following article is pretty much as it appeared in the April 2001 edition of the US magazine Horizon, after some shortening, metrication and adjustment of ideas to reflect Australian conditions, where appropriate. Southern Region acknowledges with thanks Heather Pringle's generous permission to publish the edited article free of charge. (Dougal Macdonald)

In November 1533, Francisco Pizarro entered the royal capital of the Inca empire with just 180 hardened soldiers of fortune, ambushed then executed the emperor Atahualpa, and sent the Inca army of 30,000 into retreat. Pizarro, a former swineherd, could scarcely believe the booty that awaited him. Some of his men had already pried loose golden plaques from the temple of the sun and filled their saddle packs with silver statues. They had stripped golden masks and staffs from the mummified bodies of Inca sovereigns and eyed the vast estates they would soon claim for their own. But Pizarro and his plundering band of adventurers ignored perhaps the greatest treasure of all: the rare and luxurious fabrics that were the foundation of Inca wealth.

The Inca were cloth makers such as Europe had never known. Inca weavers made bridges from cords, wove roofs from fibres, and counted their wealth not in scribbles on a page but in patterns of knots on woollen strands. And they wove a woollen fabric from alpaca fleece, so soft and alluring that the highland empire centered in what is now Peru prized it above almost all else. Among the people of the Andes, cloth was currency. Inca emperors rewarded the loyalty of their nobles with gifts of soft fabric made by expert weavers. They gave away stacks of fine woollen textiles to assuage the pride of defeated lords. They paid their armies in silky smooth material. Most Inca emperors were intent on glory, and cloth making was a major state enterprise. The imperial textile warehouses were so precious that Inca armies deliberately set them afire when retreating from battle, depriving their enemies of what made them strong.

Pizarro and his men had come for gold and silver, not cloth. Following the Spanish conquest, the soft seductive cloth coveted by Inca royalty disappeared with the Inca themselves. Meanwhile, all across remote Andean valleys, once prosperous villages fell into poverty that has continued ever since.

The mummies of El Yarál

The fabled fabric of the Inca was seemingly lost forever until Jane Wheeler, an American archaeozoologist, made a surprising discovery a decade ago while examining mummified alpacas and llamas unearthed in the small pre-Columbian village of El Yarál. The ancient animals were almost perfectly preserved, right down to the fringes of their eyelashes. "It was just incredible," recalls Wheeler. "The animals were invaluable, a thousand years old and still intact."

When Wheeler later examined skin samples from the animal mummies in microscopic detail, she noticed something more remarkable. The ancient fibres of the alpacas' fleece were as soft as a baby's hair compared with that of modern alpacas. If Peruvians could resurrect these lost breeds, she mused, they could produce textiles rivalling cashmere and, in the process, lift themselves out of poverty.

Wheeler took up the crusade. She knocked on embassy doors, cultivated Peruvian textile manufacturers, buttonholed politicians, and mustered an international team of geneticists and biodiversity experts. Today Peru is still years away from reproducing those pre-Columbian animals or producing Inca-quality cloth, but Wheeler has clearly proven that her quest is not quixotic. She has established a major alpaca DNA bank in Lima, shed light on the mysterious origins of the alpaca, devised tests for discerning alpaca hybrids from purebreds, and mapped out a project to search for the alpaca's fine-fibre gene.

"She's worked extremely hard," says English archaeozoologist Juliet Clutton-Brock, the managing editor of the *Journal of Zoology* and one of the world's leading authorities on the origins of animal domestication, "and she's produced some excellent results."

Wheeler, 57, is a visiting professor at San Marcos University in Lima and supports her research by stringing together grants. In her small office in a veterinary science building, she fumes as she lists some of the recent obstacles she's encountered in her work: recalcitrant Peruvian customs officials who refused to clear the expensive radioactive isotopes she needed for DNA testing; thieves who made off with her camera and best lens; and an absentminded laboratory assistant who blew the power supply of an expensive American machine for analyzing DNA by plugging it into a 220-volt Peruvian outlet. Wheeler takes each setback personally. "Sometimes I really feel like quitting," she says, shaking her head.

What keeps her going is a love of Peru and its alpacas. Her office is just around the corner from a campus clinic that tends to alpacas. Her Peruvian husband, a veterinary pathologist, is an expert on alpaca quarantine. Wheeler dines regularly on alpaca meat, preferring it to beef, dresses in alpaca sweaters, and wears an alpaca brooch. Her son Daniel has spent so much time in the company of alpacas that he has assumed some of their manners. When at age 4 he got angry, he would spit.

Before her encounter with mummified alpacas, however, Wheeler had no inkling that living alpacas would become such a fundamental part of her life. A decade ago, while a professor of anthropology at the University of Colorado at Boulder, she was analyzing ancient animal bones in Peru when archaeologist Gloria Salinas invited her to see El Yarál's dusty mummies. Buried

beneath house floors for nearly 1,000 years, the alpacas and llamas had grazed El Yará's pastures 500 years before the rise of the Inca empire. With their legs folded under them and their heads craned across their shoulders, they looked like a sleeping herd.

For Wheeler, who had devoted her career to counting and measuring tiny fragments of bone, the sight of ancient animals with their nubbles of shorn fleece and their long, lank ears was a shock. "I was really afraid to touch the mummies," she recalls. "I had no experience working with them." Curiosity, however, won out. Aging and sexing each animal, she searched for signs of disease and injury and took tissue samples. Most of the animals were males under two years old, and all but one had died from a conchoidal fracture of the skull made by a vigorous blow with a hard object. Almost certainly, says Wheeler, the animals were ritually sacrificed by El Yará's inhabitants. People in the Andes still sacrifice adult llamas for the gods and bury llama fetuses beneath their houses as sacred offerings.

Ancient alpaca fleece reveals secrets

Wheeler snipped off bits of skin and fibre from 11 standard spots on each mummy and took them to the Macaulay Land Use Research Institute in Aberdeen where laboratory staff individually mounted 200 fibres from each sample on slides and measured them by means of a projection microscope. El Yará's animals were remarkably uniform in both color and fibre size. And their fleece was astonishingly fine. Indeed, some alpacas possessed uniform fibres with average diameter of 17.9 microns, 4 micron less than those of a modern alpaca.

This minuscule difference holds enormous economic implications. Among woollen manufacturers, the finer the fibre, the softer the fabric and the higher the price. Cashmere fibre, for example, just 16 microns, is one of the world's most desirable woollens, fetching about US\$156/kg. By comparison, the finest modern alpaca fibre measures 22 micron and commands only US\$20/kg. But even that high quality fibre is uncommon. More than 90 percent of all modern alpaca fleece is considerably broader, bringing only a few dollars per kilogram.

Wheeler was taken aback by the quality of El Yará's ancient llamas' fleece as well. Modern llama fibre is so broad and prickly that it is rarely used for textiles and llamas are now used strictly as pack animals. But the llamas of El Yará felt silky to the touch and their fibre gleamed lustrously. Wheeler's analysis showed why. Many of the animals had a uniform fleece of 22.2 micron, as fine as the best alpaca. Moreover, as Wheeler could see from the unshorn animals, some had been walking fibre factories. One 12-month-old llama, for example, had grown fibres seven inches (approx. 180 mm) long - a length only reached in modern animals at 24 months (Note 1).

Wheeler believes the early Andeans had selectively bred their herds to supply the exact needs of an ancient textile industry. The calculating way in which families at El Yará and at a neighboring site, Chiribaya Alta, chose animals for sacrifice and burial supports this theory. They seldom slaughtered healthy, sexually mature animals. Instead they culled very young males, a choice that made perfect sense from an animal-breeding point of view. Only a few top-quality-fibre males were needed as studs for the females in a herd. The remaining males could be safely weeded out and butchered at a young age. "So maybe what we're looking at in the

mummies are the animals whose fibre isn't good enough," Wheeler says. "And if these are the animals they sacrificed, they had better ones."

(There's a lesson here for modern alpaca growers. Keep entire only the very best males that exhibit fibre and conformation characteristics that are worthy of being passed on, and castrate all the rest. But wait until the growth plates in the legs have closed up at about 18 months old. DM)

Wheeler thinks the Inca who later ruled the region would have been as skilled as the El Yaral herders. The Spanish chronicles make several brief mentions of their prowess as breeders. The priests of Cuzco, for example, required animals of specific colors for various sacrificial rites, which included slowly starving llamas to death in the city's central square so the gods would hear their screams and let loose the rains. To supply ritualists with exactly what they needed, Inca breeders raised pure white, black, and brown stock. "Given such rigorous demands," says Wheeler, "it's likely that specific llama and alpaca breeds were maintained."

All Wheeler's research pointed to one conclusion: A critical secret of the wondrous cloth of the Andes lay in the fine fibres of these animals' coats.

On a sunny morning, after taking a photographer into the mountains outside Arequipa to see a sparse wild herd of vicuña, the smallest of the four South American camelid species, Wheeler surveys a large herd of alpacas jammed head to tail in a roadside corral, seeming almost to vibrate with their humming. She watches herders releasing animals through a narrow gate, drafting out two dozen or so marked individuals. Despite their nearly identical white coats, each possesses a striking individuality. "If you look long enough," says Wheeler with a smile, "you can see the face of everyone you have ever known in these herds."

The herders wrap their arms around the chosen animals, wrestling them into compliance, and half push, half carry them toward a waiting truck that will take them to mate with alpacas in other herds. One of the herders, a local veterinarian, approaches Wheeler. Slipping off his dusty baseball hat, he smiles. "Jane Wheeler," he says, "Jane Wheeler." A note of awe creeps into his voice. "I heard you speak at a conference a few months ago."

What he heard was one of the many pep talks that Wheeler has been delivering lately in Peru. While reporting on the progress of her research, she often sketches out the disasters that befell the lost Inca herds. The early Spanish, she explains, butchered prize alpacas for meat and rounded up entire herds to be sent to the silver mines as pack animals. They introduced foreign germs that may have decimated both the animals and their skilled tenders. Without the benefit of the breeders' knowledge, the surviving Andeans ended up applying traditional sheep-rearing practices to camelids. They ran alpaca and llama males with the females all year round, thereby inhibiting the males sexually. Alpaca and llama herds dwindled.

Ironically, Peru's modern textile industry further contributed to the catastrophe. Until recently manufacturers paid herders not by the fineness of their fleece but by its weight: The heavier the fleece, the higher the price. This system had the virtue of simplicity, but it led to other unfortunate breeding practices. To bolster their paltry earnings, Andean herders crossed alpacas

with larger and heavier llamas. This produced animals enveloped in a coarse fleece riddled with useless guard hair, the antithesis of the fibre that made Inca cloth famous.

During Wheeler's student years at Cambridge, one of her professors had insisted that to do good archaeozoology, a researcher had to understand and work with living animals. Wheeler never forgot. And seeing the sad state of modern alpacas and llamas has fueled her determination over the years to resurrect the Inca fibre.

As a first step, she needed a quick genetic test to distinguish alpaca hybrids from purebreds. Wheeler had to start from scratch, first building a DNA bank containing representative blood samples from all four species of South American camelid, including the vicuna, a species hunted almost to extinction for its superfine fleece, and the guanaco, another endangered wild species. Undaunted, she set off with her husband, Raul Rosadios, and British geneticist Helen Stanley on an extended trip to remote mountain communities in Peru, Chile, Bolivia, and Argentina. At each stop, Rosadios bled 580 animals, storing the samples in rows of lilac-colored vacuum containers, the beginnings of a DNA bank that now covers more than 2,000 camelids.

The ancestors of the alpaca

At the Institute of Zoology in London, geneticists Miranda Kadwell and Michael Bruford began analyzing the samples, searching for molecular markers capable of distinguishing one species from another. They concentrated on small, repeated nuclear DNA sections known as microsatellites, which have proven useful in detecting hybrids in other species. Bruford and Kadwell found two microsatellites whose variants clearly separated the two wild camelids - the vicuna and guanaco - from one another. Then they looked to see the proportion of these markers in the domesticated camelids. Wheeler had long maintained, based on her earlier work with camelid skeletons, that the alpaca was a domesticated vicuna and as such belonged in a different genus from the llama. Many zoologists had disagreed, tracing the lineage of the alpaca either to the guanaco or the llama on the basis of certain physical traits. But Bruford and Kadwell's work suggested that Wheeler was correct.

"The vicuna is the most likely ancestor of the alpaca, and the guanaco the most likely ancestor of the llama," says Bruford, a biodiversity researcher now at Cardiff University. Next, Bruford developed a DNA test to identify purebred alpacas and llamas. With this, Wheeler and her Peruvian colleagues began methodically testing samples in the new gene bank. Hybridization, she soon discovered, was a far greater problem than anyone had suspected. Forty percent of the tested llamas were hybrids, with at least one or more alpaca or vicuna ancestor. Ninety-two percent of the alpacas were crosses. "The other thing that we discovered is that it's not possible to tell whether an alpaca or a llama is a purebred by looking at it," says Wheeler. "It's necessary to do DNA tests to certify purity."

With the new DNA testing, the team plans to survey alpacas and llamas across the Andes in search of relict purebred populations. Herders could then segregate the purebreds in elite herds and begin breeding animals with fine fleece much the way their ancestors did, by weeding out inferior males. "The basis will then be laid for improving alpaca fibre production in general

because initial results indicate that there is at least some link between fine fibre and pure animals," says Wheeler.

She and Bruford are developing methods of improving herds by searching for a genetic marker for fine fibre. A simple DNA test for the trait would permit breeders to assemble purebred herds possessing exactly the right genes for producing superfine fibre (Note 2). Breeders could then superovulate females from these herds and transfer their purebred, fine-fleeced embryos to low-quality- fibre females. "You could in a relatively short time have a herd with fine fibre that is genetically pure," Wheeler says.

As the team searches for financial sponsors for these projects, Wheeler is working on ways to lower the price of existing technology. At \$200 per animal, the DNA test for purity is too expensive for most Andean breeders. So she and Rosadios are developing one that eliminates the expensive imported radioisotopes. "In the very short term, we'll have the price down to less than \$50 and hopefully considerably lower." Wheeler says. Moreover, she is scouting for international backers for a new camelid research institute in Lima. "The idea is to include all aspects of the problem, from DNA tests to analyzing fibre, and getting the results out to benefit the herders."

Wheeler acknowledges that many scientific and practical obstacles lie ahead before Peruvians can once again produce fabric as seductive as the cloth of the Inca. But her dogged quest has attracted interest from both international woollen experts and Peru's own textile manufacturers. "What we see with Jane's mummies is that the Inca were very good at developing the genetics of good quality and uniform-color fibre," says Francois Patthey, a director at Grupo Inca, one of Peru's largest alpaca-cloth manufacturers. "If we had that today, it would be really fantastic."

The following was added by Dougal Macdonald:-

I asked my step-daughter who's getting high marks in a degree based on things like genetics and DNA and other micro-biological marvels, if she had any comments to offer about the following footnotes, especially No.2. This is her reply:

How any biologist could put interbreeding strains in different genera is beyond me... however: The point you have made is valid. Fineness is what's known as a multifactorial trait, influenced both by genetics and environment. It is unlikely that it is the result of one single gene - there may be some sheep studies done on this kind of thing. Whatever the reason, there is a genetic element and we should definitely be encouraging people not to use sub-standard males (my emphasis).

As an aside, it may be worth contacting Jane's (Wheeler's) mob. If all Australian certified males have to be blood tested anyway, it would nice both to add them to her database, and to see how much alpaca they truly are!

This last, over to AAA National Committee to see how fair dinkum they are about sharing the Australian DNA database and putting it to wider use possibly for everybody's benefit. - *Dougal McDonald*

Note 1 -By today's Australian standards, fibre this long would be classed as over-grown and fetch a lower price than fibre in the length range of 125-150 mm preferred by modern millers. The better nutrition of alpacas in Australia than in South America means that the fibre grows faster and is possibly broader. One school of thought holds that while fleece cv (indicating the degree of uniformity of fibre diameter throughout the animal's fleece) is highly heritable, fibre diameter is less so, being controlled more by environmental (nutrition especially) than by inherited factors and that a lower nutritional level may lead to finer fibre. But the full ramifications of such lower nutrition, for example, on reproductive performance, have not yet been evaluated. Jane Wheeler's work may uncover unexpected secrets.

Note 2 -There are two propositions about fibre diameter. One is that the fine fibre of ancient pure-bred alpacas such as Jane Wheeler found at El Yarál was genetically determined by selective breeding from only the finest sires (for Inca herdsmen lacking modern measuring equipment to identify finest sires by feeling the fibre, that would have been a remarkable but not impossible achievement). The other is that, through the influence of llama ancestry however many generations ago, fibre grown by modern mestizo animals is inherently broader. It is important to keep those two propositions separate. With modern animals, getting the micron down can be resolved to a large extent by husbandry measures. Using DNA techniques to identify "pure" alpacas (if any now exist) may well indeed be one key to making lower fibre diameter more heritable.

The comments in the footnotes are mine, not those of Jane Wheeler or Heather Pringle. - *Dougal McDonald*