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CHAPTER 16

The Domestication of South American Camelids

A View from the South-Central Andes

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Introduction

South American camelids are the only large herd mammals that were domesticated in all the Americas. The origins of domestication and the development of native camelid herding are restricted to the Andes, particularly the Central and South-Central portion. In pre-European times, domesticated camelids were widely distributed from the highlands to the valleys, lowlands, and coast. They constituted a primary element in Andean economies and social life, and were pivotal for the expansion of early states starting with Tiwanaku and then with the Incas. There is no general agreement on the timing of this process or whether only one or several centers of domestication existed. In this chapter, we will consider both traditional and new archaeological tools for documenting domestication in South American camelids, and how the application of these tools to assemblages from the South-Central Andes is yielding a new perspective on the chronology and extent of this process.

The South American camelids are classified in two genera, *Lama* and *Vicugna*, based on their physical appearance and DNA data (Franklin 1982; Stanley et al. 1994; Wheeler 1995). At present, four existing species are recognized: two wild, the vicufia *(V. vicugna)* and the guanaco (L. *guanicoe)*, and two domesticated, the llama *(L. glama)* and the alpaca *(L. pacos)* (see Chapter 23). Vicufias are the smallest (35–50 kg), followed by the alpaca (55–65 kg), then the guanaco (80–130 kg), and finally the llama (80–150 kg), which is the largest (Raedeke 1978, 1979; Larrieu et al. 1979; Franklin 1982, 1983; Rabinovich et al. 1984; Cajal 1985; Cunazza et al. 1995). Based on genetic studies, some researchers currently believe that the alpaca is derived from the vicufia and the llama from the guanaco, and changes in nomenclature have been proposed (Kadwell et al. 2001). Recent studies have yielded evidence of remarkable variability, not only in the size of domestic camelids across the region (e.g., Stahl 1988; Miller and Gill 1990), but also in the number of breeds with fiber characteristics that have no present counterparts (Wheeler et al. 1992; Wheeler et al., 1995; Wheeler 1996).

Camelids are producers of both primary and secondary products: meat, hide, fiber, and dung are among the most significant products they offer, including their use as beasts of burden in the case of the llama. Both in the present and in the past, they have been important in rituals and ceremonies, and were frequently represented in prehistoric pottery, rock art, and figurines. Guanaco and vicufia were hunted for their meat, grease, and hide, while in Inca times, at least, vicufias were captured, sheared, and later released. Although both wild species are syrnpatric in some regions (e.g., the highlands of western Argentina), social groups stay naturally segregated and do not interbreed. In postconquest times, the alpaca has been bred mainly as a fine-fiber producer, with two varieties, *huacaya* and *suri,* both distinguished by pointed ears and droopy tails (Cardozo 1954). The *huacaya* has short and crimped fleece, while *suri* fiber is longer and wavy. The llama has a wider geographical distribution than the alpaca and is the most versatile form, as it has been used as a source of food, hide, and fiber, and also as pack animal. It also has two varieties, the *chaku* and the *ccara,* both with banana-shaped ears and raised tails (Cardozo 1954). The *chaku* has finer fiber than does the *ccara,* although both varieties can be used as beasts of burden (Calle Escobar 1984; Bonavia 1996). Recent studies in Argentina have shown a larger variety of coats and fleece types associated with other physical attributes (e.g., Lamas 1994). Most of the four camelid forms interbreed, giving birth to hybrids: e.g., *huarizos, misti,* and *paco-vicuña*.

Several overviews have been written during the last decades, each emphasizing different aspects of the process of domestication, its indicators, and the archaeological evidence available (Wing 1975a, 1975b, 1977a, 1977b, 1978, 1986; Novoa and Wheeler 1984; Kent 1987; Browman 1989; Lavallée 1990; Wheeler 1991, 1995, 1998; Bonavia 1996, 1999). These general overviews have primarily centered on the Central Andes (Peru), with few references to the South-Central Andes. As we will see in the following sections, the current picture of the origins of camelid domestication is largely shaped by the Central Andean focus of archaeological investigations over the past three decades, and may not give the full story of the domestication of South American camelids.

This chapter reviews the current information available for the Central and South-Central Andes, and includes a discussion of the principal indicators traditionally used for identifying domesticated forms. New criteria, including contextual information, new standards for osteometric analysis, and fiber analysis allow us to trace the process of camelid domestication. Based on this evidence, we propose a new chronology for the initial appearance of the llama (4500–4000 BP) and the existence of multiple centers of origin.

Prior Research: A View from the Central Andes

Since the 1960s, the Peruvian Central Andes have been the primary focus of archaeological and zooarchaeological research on the domestication of South American camelids. As a result, this region has been widely accepted as the heartland of camelid domestication, while the other regions of the Andes have been portrayed as secondary recipients of this new technology.

The origins of camelid domestication in the Andes were first addressed from a zooarchaeological perspective by Wing (1972) in her detailed study of the fauna at Kotosh, a site located in the upper valley of the Huallaga River (Peru), at an elevation of 2,000 m (see Figure 16.1). This information was complemented with that from Tarma, a site occupied during Inca times and located at a higher elevation (4,000 m) (Wing 1972). Wing used an overall increase in camelid utilization, a shift in the proportions of different camelid species utilized, and age profiles to argue for the appearance of llama and alpaca herding by 3400–2700 BP.

At that time, it was believed that all domesticated camelids present in valley sites were introduced from the puna, following a model of high mobility and pastoral transhumance (Lynch 1967) that was supported by evidence from throughout the Andes (e.g., Lynch 1967; Browman 1974; Núñez and Dillehay 1979). More recently, Lynch (1980: 310–311) introduced the idea of a more restricted transhumance (puna-upper valleys) that did not include the coast. The faunal information retrieved at cave sites located above 4,000 m from the Puna of Junín in Peru (see Figure 16.1) was particularly important in reinforcing this view. These sites include Uchcumachay, Pachamachay, Acomachay A and B, Telarmachay, and other related puna sites (Wing 1975c; Wheeler Pires-Ferreira 1975; Wheeler Pires-Ferreira et al. 1976; Wheeler et al. 1977; Kent 1982; Moore 1989).

Using indicators similar to those developed by Wing, plus newly developed tools for discriminating between wild and domestic camelid species, researchers in the later 1970s and 1980s were able to detect evidence that signaled the ongoing process of domestication at a much earlier date than previously thought. Initial work with assemblages from the cave sites of Uchcumachay (4,050 m), talus of Panaulauca (4,100 m), and Telarmachay (4,420 m) detected a progressive intensification of camelid exploitation between 7450 and 4450 BP. This pattern was interpreted as a long-term shift from more generalized hunting strategies that evolved first into more selective hunting of camelids and then to camelid domestication (Wheeler Pires-Ferreira et al. 1976; see also Wing 1989). Wheeler (1984a, 1984b, 1995, 1998) used the strikingly high mortality of neonatal animals in the assemblage from Telarmachay, plus the appearance of lower incisors with distinctive alpaca morphology, to argue for a management of domestic camelids at this site dating back to at least 6000 BP.

Kent's analysis of animal remains from later excavations at Pachamachay (4,030 m) and from the site of Chiipa (3,860 m) provides a remarkably long sequence of animal exploitation in the Central Andes stretching back to ca. 12,000 years ago

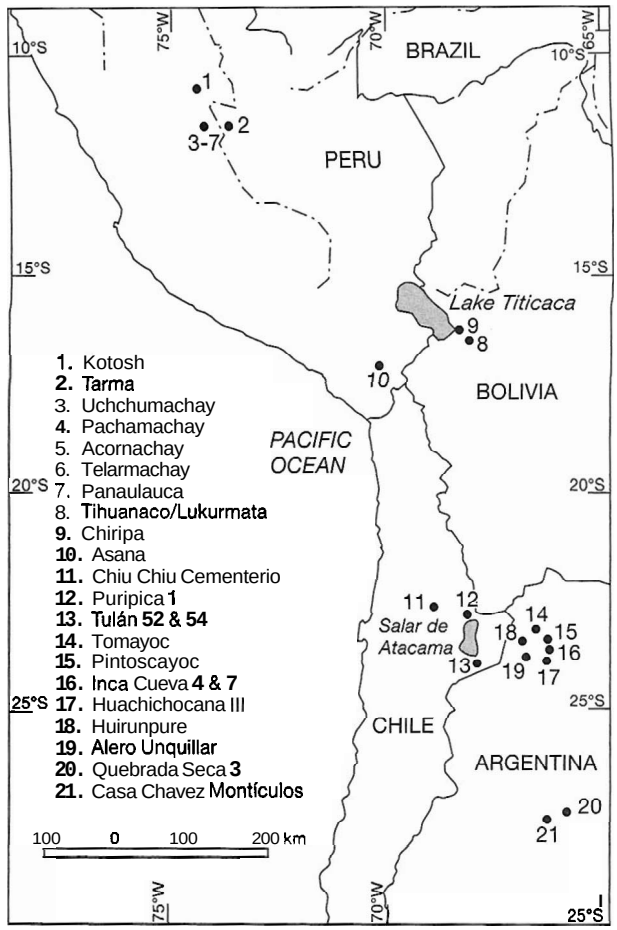

FIGURE 16.1 Map of the Andean area showing localities discussed in the text.

(Rick 1980). Contrary to the interpretation of material from earlier excavations at Pachamachay (Wheeler Pires-Ferreira et al. 1976), Kent found no evidence of intensification in camelid use over time. Nor did he find shifts in mortality patterns that might mark the onset of domestication. Camelids consistently comprised over 80 percent of the assemblage from the site, and mortality profiles were dominated by adults in all levels. Osteometric evidence, however, suggests the introduction of domesticated forms (alpaca and llama) possibly by 5,000 years ago, and certainly by 4150 BP (Kent 1982).

Moore's (1989) analysis of the assemblage retrieved at the main excavation area from Panaulauca (4,010 m) further underscores the complexity of camelid use in the Andes. Once again, this new analysis found that the intensification of camelid use seemed less marked than earlier studies had indicated. Camelids always dominate at over 85 percent of the assemblage of animal bones from all levels at the site. However, Moore did find a significant shift in the types of camelids used through time, with vicuña steadily decreasing and being replaced by a slightly larger small camelid (alpaca?) that became important in later phases (Moore 1989: 373, and see also Figures 8:3 and 8:12) at the Formative period. During

the early Formative, the proportion of large camelids (considered to be guanaco, llama, or both) increased to 25 percent. Moreover, during this period there was an increase in the use of newborn animals, signaling a possible growing dependence on domesticated camelids at about 3600 BP.

Thus, multiple lines of evidence have been used to mark the transition from hunting to herding camelids in the Central Andes. At one site, Telarmachay, this transition has been dated to about 6,000 years ago, while analyses from other puna sites would put this transition at about 2,000 years later at about 4600–3600 BP.

Domestication and Its Indicators

Definitions of domestication vary depending upon whether it is defined from a human (e.g., Ducos 1978) or animal (e.g., Price 1984) point of view. In this chapter, we view domestication more from the human perspective, as a process through which animals are integrated into the domestic realm as property or prestige goods by controlling their reproduction and by providing them with the means for feeding and protection. We distinguish domestication from pastoralism, which we define as an economic system based on the use of domesticated animals as its core element. This is a particularly important distinction when speaking about South American camelids, not only because the initial domestication of camelids and the development of pastoral economies based on camelids may be separated by many hundreds of years, but also because detecting the process of animal domestication and the development of pastoral economy requires different types of archaeological indicators.

Human control over reproduction in domesticated animals may result in certain genetic or phenotypical changes that may be detected in the archaeological record, which we call direct measures of domestication. In South American camelids, direct measures of domestication include changes in dental morphology, in bone size and shape, and in fiber characteristics, as well as in DNA (see Chapter 23). Indirect measures of domestication are reflections of the economic strategies humans employ either in the production of domestic animal resources or in their use. Indirect measures focus not on individual specimens but on assemblage properties, such as species diversity, mortality profiles, part distributions, and contextual information, all of which are useful in detecting both camelid domestication and the advent of pastoral economies focusing on camelids. Examining these different direct and indirect measures over time and space provides mutually reinforcing pictures of the process both of domestication and of the development of pastoral economies.

Direct Measures

DENTAL MORPHOLOGY

Perhaps the greatest challenge in documenting domestication of South American camelids in the archaeological record is distinguishing between the two closely related wild progenitor species (guanaco and vicuiia) and their domestic descendents (llama and alpaca). Fortunately, there are distinctive morphological characteristics on the incisors of these animals that can help (Wheeler 1982, 1991). This is especially the case in distinguishing guanacos and llamas from vicuiias and alpacas (Table 16.1). The incisors of guanacos and llamas (both deciduous and permanent) are spatulate in shape, with enamel covering all sides of the crowns. Both deciduous and permanent incisors of guanaco and llama also have well developed roots. In contrast, deciduous and permanent incisors in the vicuiia and alpaca are parallel-sided, and enamel is restricted to the labial surfaces of the crowns. In the vicufia, the permanent incisors do not form a root.

Distinguishing wild from domestic forms on the basis of dental morphology is not as clear cut. In fact, guanaco and llama incisors are indistinguishable from another on the basis of morphology. It is also impossible to draw morphological distinctions between the deciduous incisors of vicuiia and alpaca, which in both species are root forming and have enamel restricted to the upper labial surface of the crown. However, the morphology of the permanent incisors of the vicuiia and alpaca can be readily distinguished. Permanent vicuiia incisors lack roots, and enamel covers the entire labial surface, while alpaca permanent incisors retain juvenile traits of forming roots and having enamel only on the upper labial surface. There are exceptions to these patterns in contemporary camelids as noted by Kent (1982: 142, i.e., "alpacas with either open-rooted or parallel-sided incisors"), but it is not yet clear if these exceptions are the result of hybridization (Wheeler 1998).

Recent histological analyses on contemporary domestic dental specimens have pioneered attempts to refine these distinctions (Riviere et al. 1997) but have achieved only partial results since a study of wild specimens is still pending. Once again, the long history of hybridization in domestic camelids may make it difficult to use modern animals in developing clear-cut methods for distinguishing between various camelid species in the archaeological record.

OSTEOMETRY

Many of the efforts to develop archaeological indicators of camelid domestication have been based on observable differences in the sizes of the four South American camelid species. These efforts are founded on the assumption that body size should correspond to the size of bones (Moore 1989; Mengoni Goiialons and Elkin 1990), an assumption supported by an allometric study of a large sample of alpaca of different age groups that showed a strong correlation between individual body size and bone measurements (Wheeler and Reitz 1987).

Some researchers have focused on craniometric differences, like Otte and Venero (1979) for Peruvian vicufia and alpaca, or Puig and Cajal (1985) for vicuiia and guanaco from Argentina (see Puig 1988 for a summary of craniometric characteristics that can be used to distinguish between the crania of the four South American camelid species). Because of the usually poor preservation of crania, however, most

TABLE 16.1
Matrix of Dental Morphology on South American Camelid Incisors

	Guanaco	*Llama*	*Vicuña*	*Alpaca*
Deciduous	Spatulate	Spatulate	Parallel-sided	Parallel-sided
	Entire crown	Entire crown	Upper labial	Upper labial
	Roots present	Roots present	Roots present	Roots present
Permanent	Spatulate	Spatulate	Parallel-sided	Parallel-sided
	Entire crown	Entire crown	Entire labial	Upper labial
	Roots present	Roots present	Roots absent	Roots present

zooarchaeological work aimed at drawing osteometric distinctions between South American camelids focuses on postcranial bones. Bones that tend to be well-preserved and, therefore, well-represented in the archaeological record are naturally favored in these analyses. Univariate analyses of the breadth and width measurement of the proximal first phalanx, for example, seem particularly effective in discriminating between various camelids (Miller 1979; Miller and Gill 1990; Miller and Burger 1995). Length measurements of these ubiquitous bones have not proven as useful, however, primarily because of difficulties in discriminating between the first phalanges of front and hind limbs, which are markedly different in length (Kent 1982). Bivariate analyses of astragali, calcaneum, and distal metapodials tend to corroborate the univariate analvses of first phalanx proximal breadth and depth measures (Miller 1979). Kent (1982) developed an innovative approach that used discriminant function analysis of a series of dimensions from many postcranial elements, but this technique has not been widely adopted by other researchers. Moore (1989) discovered proportional differences in the long bones useful in distinguishing between guanacos and llamas, as well as between vicuñas and alpacas. However, these techniques can be performed only on whole, articulated bones, which are rarely found in archaeological contexts.

There are several factors that make drawing osteometric distinctions between South American camelids particularly difficult. The two primary camelid genera of *Lama* and *Vicugna* do seem to sort out clearly into two distinct size groups of larger *(Lama)* and smaller *(Vicugna)* animals. However, each genus contains wild and domestic forms that differ in size, and the degree of overlap between the various domestic and wild forms is difficult to measure. This difficulty is exacerbated by the above-noted degree of interbreeding and resultant hybridization between these various forms. Luckily, there does not seem to be marked sexual dimorphism in South American camelids (Vilá 2000), as seen in other domesticated species (see Zeder 2001, and also Chapter 14), that would further complicate this already complicated puzzle.

However, other factors do present significant challenges for the use of size in documenting initial domestication in camelids. The first is that the impact of climatic changes between the Late Pleistocene and Early Holocene, known to result in significant diminution in the size of a number of other species around the globe (Davis 1981; Ducos and Horwitz 1997). While there is some indication that camelids of the Late Pleistocene-Early Holocene boundary were considerably larger than camelids later in the Holocene (Yacobaccio 1991; Rosenfeld 2002), the precise nature of the impact of post-Pleistocene climatic amelioration on the size of South American camelids is unclear.

Perhaps even more significant is the dramatic geographic variation in the size of camelids as one moves southward toward the tip of South America. This clinal variation in size is most clearly seen in the guanaco, the most widely distributed of the camelid species, which can be found today from Peru to Tierra del Fuego (Franklin 1982). Those populations living at low latitudes (Peru, northern Chile, and northwestern Argentina) are the smallest, while those at the higher latitudes to the south are by far the largest (Raedeke 1978; Larrieu et al. 1979; Rabinovich et al. 1984; Franklin 1982, 1983; Cajal 1985). A similar pattern is also suspected for vicuña, although further studies are still needed (Wheeler 1995). The strong clinal variation in the size of South American camelids is reminiscent of a pattern documented by Zeder (2001, and Chapter 14) for modern wild goats from Iran. A similar pattern is inferred for pigs in the Alps by Albarella et al. (Chapter 15). In all cases, the increase in body size in colder regions may be a function of Bergman's rule that predicts increasing body size with decreasing temperatures.

Failure to recognize the impact of regional variation on the size of camelids has proven to be a significant impediment to the use of osteometric analysis in detecting initial camelid domestication in the Andes. Most of the early work along these lines used modern standards composed of vicuñas, alpacas, and llamas from Peru and guanacos primarily from Tierra del Fuego or Patagonia (Wing 1972; Miller 1979; Kent 1982; Miller and Burger 1995). As a result, the widely accepted size gradient between camelid species in the Andes has been that vicuña are always the smallest, alpacas are larger, llamas even larger, and guanacos the largest of them all.

Very different results are obtained when one compares species from the same geographical region, thus eliminating an important bias in size variation and providing more reliable size classes as a reference. Although the available osteometric data for wild camelids is still scarce, some important points can be stressed. Figure 16.2 illustrates a bivariate plot of the proximal latero-medial width (x-axis) and

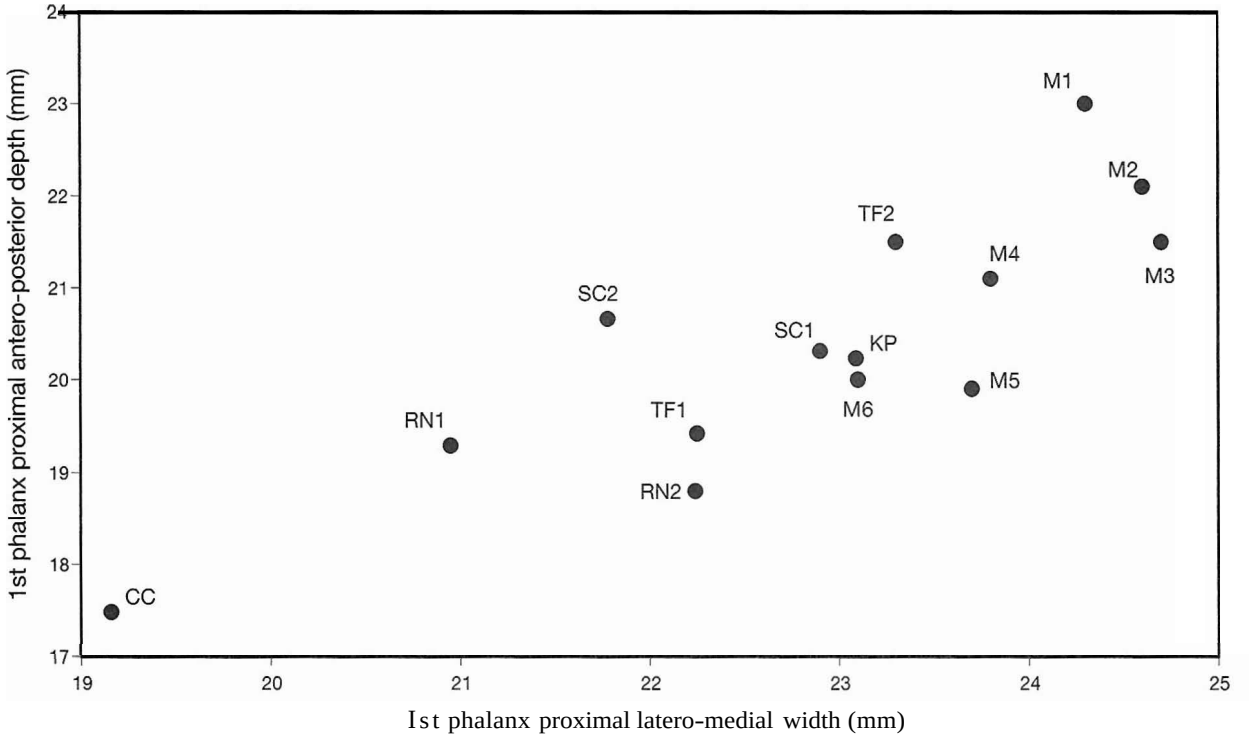

FIGURE 16.2 Size variation in contemporary guanaco based on the proximal width and proximal depth of the first phalanx (fore and hind toe averaged). CC, Cumbres Calchaquies, northwestern Argentina; *RNI-2,* Río Negro, northern Patagonia, Argentina; *SCI–2,* Santa Cruz, southern Patagonia, Argentina; *TFI–2,* Tierra del Fuego; *KP,* Patagonia, taken from Kent (1982, Appendix IV); *M1–6,* Tierra del Fuego, taken from Miller and Burger (1995, Fig. 6). All measurements plotted, except those produced by Miller, were measured following Kent's protocol (Kent 1982).

the proximal antero-posterior width (*y*-axis) taken on first phalanges from several contemporary guanacos along a latitudinal range (26°–55° S) that runs from northwest Argentina and northern Patagonia to southern Patagonia and Tierra del Fuego. A geographical size variation is clear, showing that the guanacos from Patagonia and Tierra del Fuego are the largest and those from northwestern Argentina are the smallest. This pattern has several consequences: (1) the guanacos from Tierra del Fuego should not be used as a standard for comparison with archaeological material coming from the Andean region; (2) contemporary camelids from the same or a neighboring region from which the archaeological material is derived must be used as size standards; (3) upholding a size gradient that considers guanaco as the largest camelid is inaccurate when analyzing bones from Andean sites (e.g., Wing 1972; Kent 1982; Miller and Burger 1995); and (4) the correct size gradient for analyzing materials from the Central and South-Central Andean regions should run from vicuña, the smallest, on to alpaca and then guanaco, ending with llama, the largest. This pattern is clearly seen when metric data from Andean vicuñas, alpacas, and llamas (from Kent 1982) are compared to an Andean guanaco from northwest Argentina (Figure 16.3).

BONE MORPHOLOGY

Skeletal differences among South American camelids are hard to find. Working with a total of 10 skeletons of adult guanaco, vicuña, alpaca, and llama Adaro and Benavente (1990a, 1990b; Benavente and Adaro 1991; Benavente et al. 1993) defined 51 qualitative features that they considered showed "clear and precise" identification. However, the subjective nature of deciding whether a feature is "very developed," "less developed," or "little developed" makes it sometimes difficult to apply these distinctions with much confidence. Moreover, some of these features could be the result of individual differences resulting from mechanical factors, including robusticity of muscles (see Benavente 1997–1998; Cartajena et al. 2001), and may not be reliable for drawing clean taxonomic distinctions. The fragmentary nature of most archaeological assemblages adds another difficulty to employing this technique. Nevertheless, this line of research deserves to be further explored.

FIBER CHARACTERISTICS

Fleece from the four varieties of camelids varies in color, diameter, and length (Dransart 1991a, 1991b; Benavente et al. 1993; Reigadas 1994a, 1994b). Given the arid conditions in many parts of the Andes and the remarkable preservation of many otherwise perishable materials, fiber holds considerable promise for determining the variety of camelids used. Color seems a particularly useful attribute for distinguishing between wild and domestic forms. Guanacos are reddish-brown to brown and white, while vicuiia are light fawn and white. By contrast, domesticated llamas and alpacas show a

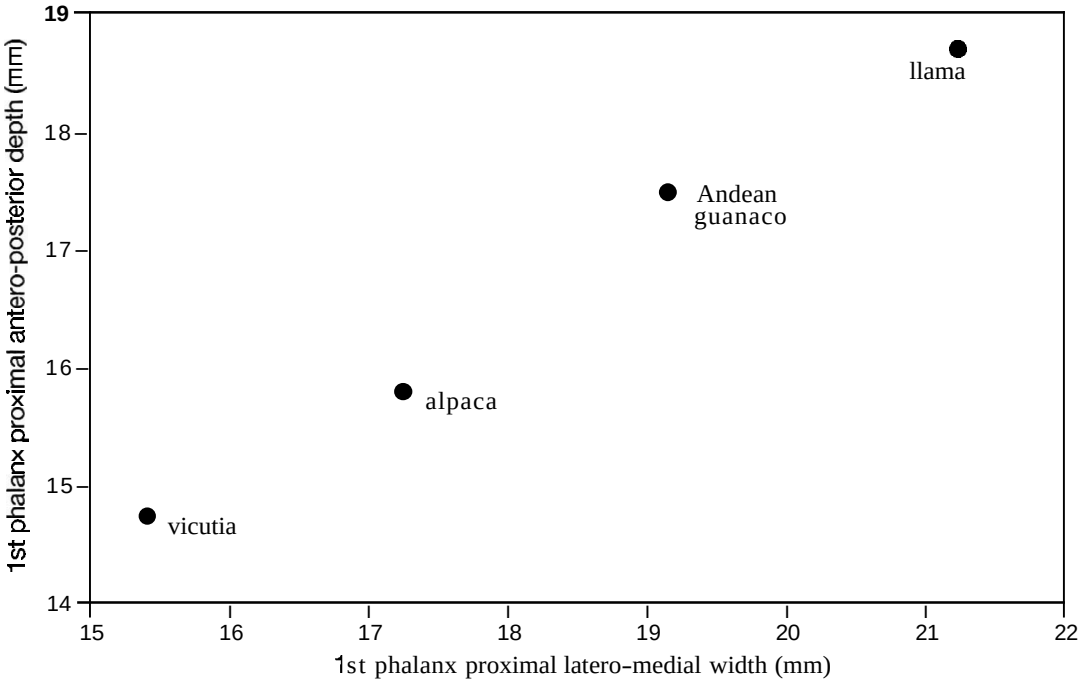

FIGURE 16.3 Size gradient in contemporary camelids using the Andean guanaco as standard. The measurements for the guanaco were taken from an individual from the Cumbres Calchaquies, northwestern Argentina. Those for vicuña, alpaca, and llama are the averaged values for the fore and hind toe as presented by Kent (1982, Appendix IV).

variety of colors, such as black, white, brown, and gray. Also, the patterning in coat colors shows a great variation in llamas and alpacas, an attribute reflected in the rich classification system based on color developed by Andean herders (Flores Ochoa 1981).

Diameter also seems a good indicator for distinguishing wild and domesticated camelids. Coats of wild species are comprised of a mix of very fine fibers (around 12 pm in vicuñas and 16 pm in guanacos) and very coarse ones (greater than 60 pm). In contrast, intermediate fibers (i.e., between 20–40 pm) dominate in modern domesticated camelids, which tend to have more homogenous coats as a result of artificial selection (Calle Escobar 1984; Lamas 1994). In certain areas of the South-Central Andes (e.g., Puna of Jujuy, Argentina), some present-day herds of llamas exhibit very fine fiber diameters (i.e., between 20–23 pm), with values below the averages known from Peru (Lamas 1994). Recent studies carried out on 1,000-year-old prehispanic camelid mummies from El Yaral (Wheeler 1995, 1996) have shown the existence of breeds with very homogeneous coats (e.g., extra-fine in alpaca (17.9 pm) and fine in llama (22 pm)) that have no present counterpart in Peru. While these remarkable mummies clearly demonstrate the emphasis placed on breeding animals with fine coats suited for high-quality textile manufacture, it is not clear whether changes in fiber quality is a later development linked to the intensification of a camelid-based pastoral economy, rather than a marker of initial camelid domestication.

Indirect Measures

SPECIES DIVERSITY AND TEMPORAL TRENDS

An increase in the representation of camelids over time and a corresponding decrease in the overall diversity of species in archaeological assemblages frequently have been taken as leading indicators of the process of camelid domestication in the Central Andes (Wing 1972,1980,1986; Wheeler Pires-Ferreira et al. 1976; Wheeler 1984a, 1984b). In particular, an increase in camelids relative to cervids has been cited as a useful index for monitoring the intensification in camelid use that ultimately resulted in their domestication. The magnitude of the increase in relative abundance of camelids varies depending on elevation. In the lower-elevation valley sites, outside the natural range of wild camelids, camelid representation may increase from 0% to as much as 50% of an assemblage. In the puna, where these animals occur naturally, in clear hunter-gatherer contexts camelids may begin at 50% and increase to as much as 96% at sites engaged in a highly developed pastoral economy.

The problem with using intensification as a marker of camelid domestication is that intensification is often seen both as creating the conditions in which domestication might occur and as an indicator that the process has taken place. The sudden appearance of camelids into lower elevation areas outside their natural habitat, like highland valleys or coastal areas, most likely represents the introduction of already domesticated camelids. However, in the higher-elevation natural habitat of these animals, where initial

domestication most likely occurred, species diversity and representation of camelids in archaeological assemblages by themselves cannot distinguish a selective hunting strategy that focuses on camelids from a reliance on domesticated camelids.

MORTALITY PATTERNS

Mortality patterns are a commonly used tool for determining whether a camelid assemblage represents a hunted prey population or the slaughter of domesticated herd animals. Mortality profiles have also sometimes been used to determine season of death, and therefore slaughtering practices and seasonality of occupations that also shed light on the transition from hunting to herding. Given the different species involved and the diverse array of resources they offer, camelids present a special challenge to those using mortality patterns to reconstruct culling strategies. An emphasis on the exploitation of camelids for fiber or for use as beasts of burden may result in very different mortality patterns than strategies aimed at promoting meat production. Being able to model expected mortality patterns with expected economic strategies that emphasize the exploitation of regenerative resources like fiber and labor is particularly important in monitoring the development of complex, specialized pastoral economies of later periods in Andean history. For the initial phases of domestication, however, it is more likely that a generalized strategy that emphasized the propagation of the herd, with meat being the primary resource of interest, was employed. Such a strategy would most likely emphasize the slaughter of young males with prolonged survivorship of females, and a few males, through their prime reproductive years. Thus, an emphasis on young camelids has often been taken as an indicator of management of breeding behavior to promote herd propagation, which is a leading-edge marker of domestication (i.e., Wing 1972; Moore 1989).

But not all mortality patterns reflect the conscious strategies of human hunters or herders. They can also be an indicator of the overall health of an animal population and the conditions under which animals lived. Wheeler, for example, linked the increasingly high representation of young, neonatal camelids at Telarmachay with human management of camelid populations. The proportion of neonates in layers from this site dating from between 9,000 to 6,000 years ago is about 36% (a figure similar to the proportion of neonates in contemporary wild camelid populations). By around 6,000 years ago, this figure rose to 57%, reaching a peak of 73% by 3,800 years ago. Wheeler interprets the unusually high neonatal mortality in these later levels as the result of a bacterial infection caused by Clostridium perfringens Type A, an infection that today is a major killer in camelid herds kept under unsanitary corralling conditions (Wheeler 1985, 1998). Coupled with a steady increase in the intensity of camelid use and the presence of incisors with distinctive alpaca morphology in layers dated to about 6,000 years ago, the very high neonatal mortality at Telarmachay is interpreted by Wheeler as a clear marker of initial camelid management and domestication. As yet there is no evidence for corrals of that age in the Puna of Junin or other Andean areas that would lend further support to this hypothesis.

Camelid mortality profiles have been constructed using both dental eruption and wear patterns and long-bone fusion. Early attempts at reconstructing these patterns from long-bone fusion used fairly gross categories of "juvenile" for unfused bones and "adult" for fused bones (Wing 1972, 1975a, 1978). Since postcranial bones fuse at different ages, such an approach risks including early fusing elements from young animals in the "adult" category and later-fusing elements of older animals in the "juvenile" category. Moreover, these categories are too broad to detect differential mortality of neonatal and yearling animals or the difference between culling strategies that focus on prime-age animals as opposed to elderly animals. Over the years, several researchers have presented more refined sequences for both dental eruption and wear and long-bone fusion that allow for the reconstruction of much more accurate, detailed, and informative mortality patterns (Hesse 1982a; Kent 1982; Moore 1989; Wheeler 1999).

CONTEXTUAL INFORMATION

Different kinds of evidence can provide contextual information indicating the presence of domesticated animals, including corrals, dung layers, textiles, and art representation. Corrals and dung layers may be indicating practices of enclosing animals for particular management purposes (e.g., slaughtering, shearing, or marking). And in many cases, rock art or geoglyphs found in many localities throughout the Andean region show realistic depictions of several aligned animals led by a person or animals carrying goods, suggesting the representation of caravans. Although these indirect indicators can be ambiguous in some cases, they are still very important and should be considered when available in conjunction with direct indicators.

Recent Research in the South-Central Andes

As we have discussed, the picture of camelid domestication drawn to date has been based largely on research conducted in the Central Andes, in particular from the analyses and reanalyses of assemblages from several rock shelter sites in the Puna of Junin in central Peru. Together, this work has provided evidence of an in situ developmental trajectory in which specialized hunting of camelids developed into camelid management and domestication. It is important to ask, however, whether the identification of the Central Andes as the heartland of camelid domestication is an accurate characterization of this process, or an artifact of the intensive archaeological investigations and pioneering zooarchaeological analyses undertaken here.

Recent research outside this region in the South-Central Andes of southern Peru, northern Chile, and northwestern Argentina widens the lens of the investigation of South American camelid domestication, adding an important

new perspective on the process and timing of camelid domestication in South America. Although early research in the South-Central Andes tended to see animal domestication as a secondary, and derivative, result of the onset of agriculture (e.g., Ndfiez 1974), research of the 1980s and 1990s focused on a growing understanding of the social and economic complexity among hunter-gatherer populations in the puna and the changing nature of camelid exploitation that accompanied these changes (e.g., Aschero 1984, 1994; Yacobaccio 1985, 1991, 2001; Aschero and Podestá 1986; Mengoni Goiialons 1986; Ndfiez 1992).

In particular, archaeological investigations in Chile, northwestern Argentina, Bolivia, and southern Peru have detected a process of increasing social and economic complexity among hunter-gatherer groups marked by decreasing residential mobility or even sedentism, complex burial patterns, prestige technology, and elaborate ceremonial structures. From 5300 BP onward, substantial sites with stone-made habitation structures appeared in the region (Núñez 1981). Some of them, like Tulán 52 and Puripica 1 in northern Chile, have between 20 to 40 circular structures interspersed with courtyards, covering a surface of about 400 to 540 m^2. Evidence of domestic activities was found in the structures and, in one case, storage pits; great quantities of mortars and pestles were found in the courtyards. The evidence from northwestern Argentina shows the inhumation of isolated human heads at Morro del Ciénego Chico or selected body parts at Inca Cueva 4, layer la, that marks the beginning of a practice associated with rising socioeconomic complexity and bounded territories (Yacobaccio 2000). Also, burials with rich offerings appear at high-altitude locations during this period, for example at Huachichocana III, layer E2. These offerings are generally long-distance trade items like Pacific Ocean shells, feathers from lowland birds such as guacamayo (Ara *militaris),* and psychotropic drugs (cebil, Anadenanthera *colubrina*) (Fernández Distel 1986). At Inca Cueva 7, an assemblage, dated to 4080 BP, included prestige technology such as pyro-engraved flutes, bone flutes, decorated bone spatulae, hardwood sticks decorated with geometric designs, pipes made of puma (Felis concolor) long bones, baskets, a host of textiles, and pyro-engraved domestic gourds *(Lagenaria siceraria)* (Aguerre et al. 1973). Ceremonial structures appear from levels IX to VIII (5000-4400 BP) at the Asana site in the highlands of southern Peru. Following Aldenderfer (1998), these structures are defined by prepared clay floors, altars, stone circles and ovals, trenches, clay-surfaced basins, surface hearths, miniature ovals, and circles of posts, although showing changes through time, suggesting that "the ceremony and the ritual that took place within them moving across a continuum from open and public in the earliest levels to close and private in level VIII times" (Aldenderfer 1998: 256). Together, these developments suggest the emergence of a hierarchical society, with increasingly more developed notions of territory, expanded trade contacts, more elaborate social structure, and ceremonial practice.

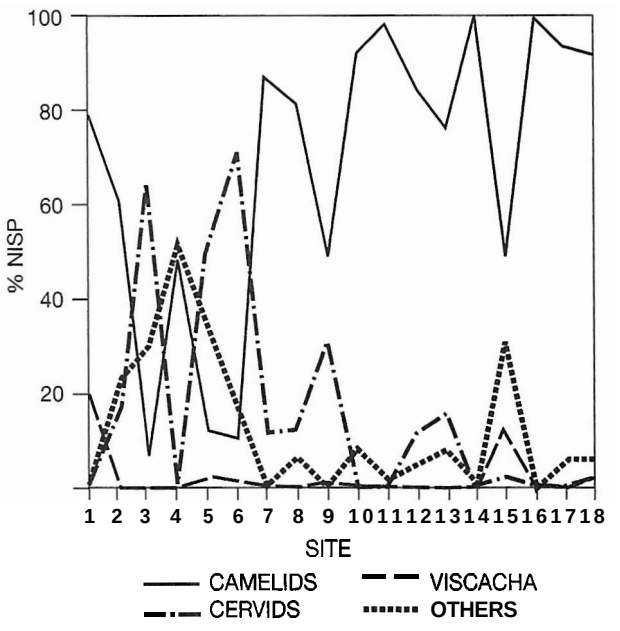

FIGURE 16.4 Temporal trends in the use of camelids for the South-Central Andes. 11,000–8500 BP: 1. Asana; 2. Tuina; 3. San Lorenzo; 4. Tambillo; 5. Pintoscayoc; 6. Inca Cueva-Cueva 4, Layer 2; 7. Huachichocana III, level E3; 8. Quebrada Seca 3, lower layers; 8500–5300 BP: 9. Homillos 2; 10. Quebrada Seca 3, middle layers; 11. Chiu Chiu Cementerio; 5300–3000 BP: 12. Tulán 52; 13. Puripica 1; 14. Tomayoc; 15. Inca Cueva-Cueva 7; 16. Huachichocana III, level E2; 17. Quebrada Seca 3, upper layers; 18. Alero Unquillar. Viscacha (*Lagidium* sp.) is a medium-size rodent.

Against this backdrop of emergent social and economic complexity, the question of the trajectory of camelid domestication in the South-Central Andes becomes especially significant. Much of the more recent work on camelids in the South-Central Andes has been conducted by Latin American researchers publishing in venues not widely available outside the region. But this work provides multiple lines of evidence for tracing the process of camelid domestication and the later development of a pastoral economy based on camelids.

Intensification

As in the Central Andes, the zooarchaeological record in the South-Central Andes shows a long-term trend of intensification of camelid use that parallels the Central Andean pattern in degree and timing. The representation of camelids in a sample of 18 sites from southern Peru, northern Chile, and northwestern Argentina, ranging in age from 11,000 to 3000 BP, shows this pattern well (Figure 16.4, Table 16.2). Camelids average 48.9 percent of the identifiable remains from sites dating to the 11,000–8500 BP range (1–8), with a great deal of variability at each locality, perhaps showing a generalized, opportunistic strategy for obtaining animal resources. By 8500–5300 BP (9–11) camelids increase to 70.3 percent, with little variability in the profile of exploited species from site to site across this broad region. Camelids are almost always more than 85 percent of the assemblages from sites

TABLE 16.2
Archaeological Sites in the South-Central Andes

Site	*Level*	*Country*	*Location*	*Elevation*	*Dates*	*Type*	*Reference*	*% Camelids*[a]	*% Small Camelids*[b]
Asana	PXXXIII–PX	S Peru	Moquegua	3,400 m	9500–8000 BP	Logistical camp	Aldenderfer 1998	80-90	na
Tuina 1	II–IV	N Chile	Loa	2,800 m	10,800–9000 BP	Temporary camp	Núñez 1983	61%	na
San Lorenzo 1	IV–IX	N Chile	Atacama	2,500 m	10,000 BP	Temporary camp	Núñez 1983	7%	na
Tambillo	—	N Chile	Atacama	2,300 m	9590–8590 BP	Base camp (?)	Hesse 1982a, 1982b	48%	na
Pintoscayoc	6	NW Argentina	Jujuy	3,650 m	10,700 BP	Temporary camp	Hernindez Llosas 2000	10%	na
Inca-Cueva 4	2	NW Argentina	Jujuy	3,650 m	10,600-9200 BP	Base camp	Yacobaccio 1994	10%	presence
Huachichocana III	E3	NW Argentina	Jujuy	3,400 m	10,200–8600 BP	Temporary camp	Fernindez Distel 1986	86%	0%
Quebrada Seca 3	Lower	NW Argentina	Catamarca	4,050 m	9050–8300 BP	Temporary camp	Elkin 1995	81%	44%
Hornillos 2	2	NW Argentina	Jujuy	4,020 m	6300 BP	Temporary camp	Yacobaccio et al. 2000	49%	na
Quebrada Seca 3	Middle	NW Argentina	Catamarca	4,050 m	8300–6160 BP	Temporary camp	Elkin 1995	92%	90%
Asana	IX–VIII	S Peru	Moquegua	3,400 m	4600 BP	Base camp	Aldenderfer 1998	na	na
Chiu Chiu Cementerio		N Chile	Atacama	2,300 m	4100 BP	Base camp	Cartajena 1994	98%	2.5%
Túlan 52	II–IV	N Chile	Atacama	3,200 m	4300 BP	Base camp	Hesse 1982a, 1982b	86%	32%
Puripica 1	II–IV	N Chile	Atacama	3,250 m	4500 BP	Base camp	Hesse 1982a, 1982b	76%	58%
Inca Cueva 7	EII	NW Argentina	Jujuy	3,600 m	4080 BP	Ceremonial	Aschero and Yacobaccio 1998–1999	50%	0%
Inca Cueva 7	EIII	NW Argentina	Jujuy	3,600 m	4030 BP	Corral	Aschero and Yacobaccio 1998–1999	—	—
Asana	III–I	S Peru	Moquegua	3,400 m	3640 BP	Base camp	Aldenderfer 1998	na	na
Huachichocana III	E2	NW Argentina	Jujuy	3,400 m	3400 BP	Burial	Femlndez Distel 1986	100%	0%
Tomayoc	III	NW Argentina	Jujuy	4,170 m	3480–3250 BP	Temporary camp	Lavallée et al. 1997	100%	na
Quebrada Seca 3	Upper levels	NW Argentina	Catamarca	4,050 m	6160–4510 BP	Temporary camp	Elkin 1995	94%	99%
Alero Unquillar	1–2	NW Argentina	Jujuy	3,700 m	3500 BP	Transient camp	Yacobaccio et al. 1997	93%	0%
Casa Chavez Montículos	VIII–Vc	NW Argentina	Catamarca	3,600 m	2120 BP	Base camp	Olivera and Elkin 1994	89%	20%
Túlan 85	—	N Chile	Atacama	2,300 m	2600 BP	?	Dransart 1991a, 1991b	—	—
Huirunpure	E2	NW Argentina	Jujuy	4,020 m	2040 BP	Temporary camp	Yacobaccio et al. 1997	92%	50%

na = not available.
[a] Percentage of camelids in total faunal assemblage.
[b] Percentage of small camelids in camelid assemblage.

dating to 5300–3000 BP (12–18), reaching 100 percent of the archaeofaunas from some sites, while exploitation of other animal resources declines dramatically. Thus, as in the Central Andes, over several millennia of intensive interactions camelids become the overwhelmingly dominant animal resource in the South-Central Andes.

Osteometric Data

Excavations in two regions in northwestern Argentina have yielded important osteometric data that contribute to the emerging picture of camelid domestication in the South-Central Andes. These regions are the Puna of Jujuy and the Puna of Catamarca, where a number of excavated sites provide a record of camelid exploitation ranging from 10,000 years ago to 2000 BP.

Several caves and rock shelters were located in dry puna environments to the east and west of the Quebrada de Humahuaca in Jujuy at altitudes ranging from 3,400 to 4,020 m (Figure 16.1, Table 16.2). Some camelid bones larger than those of the present North Andean guanaco were found in the oldest layers dated between 10,000 and 7400 BP at Pintoscayoc, Inca Cueva 4, Huachichocana III, and at Quebrada Seca 3 (Yacobaccio 1991; Yacobaccio and Madero 1992; Elkin 1996; Rosenfeld 2002). These measurements were taken from fragmented first and second phalanges and metapodials. While regrettably too small a sample to be statistically significant, no indicator suggests we are dealing with an extinct species. Most probably, these specimens mark an upper size range for the guanaco during the Late Pleistocene–Early Holocene, a similar pattern observed for other species (Davis 1981).

As discussed above (see also Chapter 23), recent genetic studies have shown the vicuña and the guanaco as the wild ancestors of the alpaca and llama, respectively. This means that the two domesticated camelids in the Andes are currently larger than their progenitors. It is possible, then, that at some point during the process of domestication, camelids larger than present guanacos (i.e., llamas) appeared. There is mounting evidence for such a development in the South-Central Andes, as well as in the Central Andes (see below). In order to evaluate a possible trend in size change through time, we have summarized the metric data available.

In Figure 16.5, we have compiled all the metric information available for guanaco from northwestern Argentina and northern Chile. In constructing this figure, we have followed Meadow's (1999) log-ratio technique, in which individual measurements of archaeological specimens are compared to the same measurement from a known standard animal, in this case a North Andean guanaco. Those specimens that fall to the left of the axis are smaller than the standard, and those to the right are larger. The bars represent the absolute frequencies of each size category, where one score is one individual bone. For the period 11,000–8500 BP, sites included are Inca Cueva 4, Pintoscayoc, Huachichocana III, and Quebrada Seca 3. For the 8500–5300 BP period, we used data from Pintoscayoc and Quebrada Seca 3. For the period 5300–3000 BP, the data come from Tulán 52, Puripica 1, Inca Cueva 7, Alero Unquillar, and Quebrada Seca 3. In the last period, 3000–2000 BP, sites included are Huirunpure and Casa Chávez Monticulos (see Table 16.2 for references).

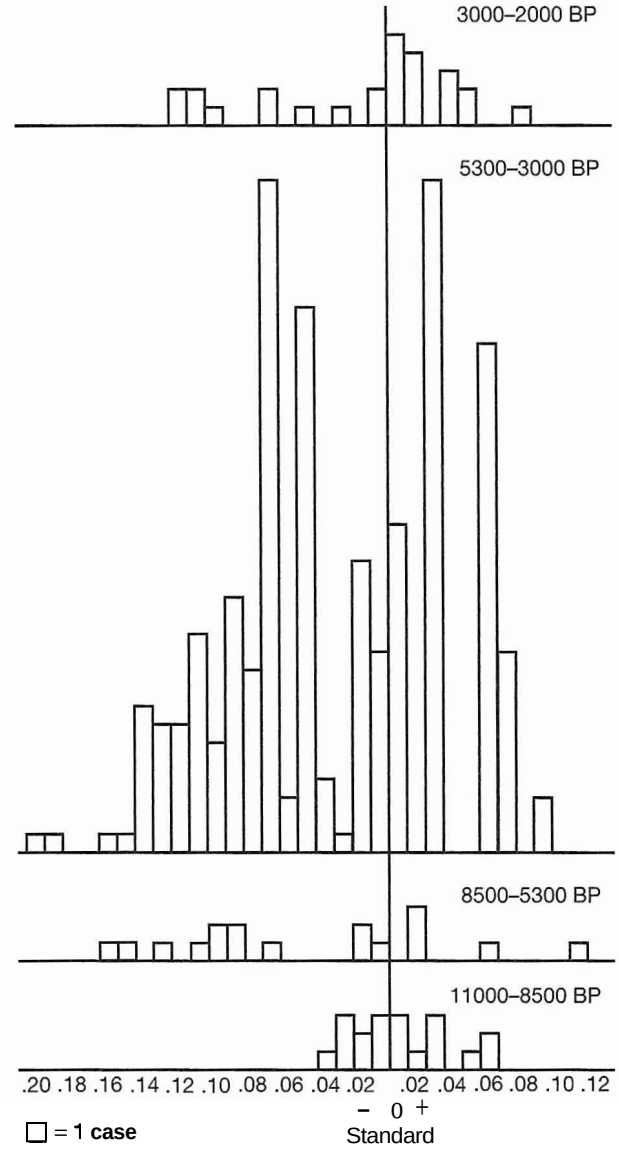

FIGURE 16.5 Histogram showing the log difference between measurements of modern North Andean guanaco and archaeological specimens from several sites located in the South-Central Andes.

During the Mid-Holocene, in northwestern Argentina and northern Chile, (8500–5300 BP), small camelids were dominant, while large camelids (likely guanacos) also were present. For this period, the existence of very few sites is associated with scanty metric information derived form relatively few bones.

In the next period (5300–3000 BP), information is derived from several sites and the samples are much larger. These samples show a wide range of variability and can be grouped into different size categories. On the left of the figure, there is group of small camelids that fall well apart from the

guanaco standard. This group is here interpreted as vicuiias. This interpretation is supported by the identification of vicufia incisors at many of the sites. No alpaca teeth were identified in these samples. There can be no doubt that vicuñas occupied an important economic role as prey animal, with small camelids ranging between 32 to 99 percent of the camelid samples from sites dating to this time (see Table 16.2). A second size group is observed around the standard of the modern guanaco, suggesting that at this time guanacos had an average size similar to the size of the present ones. At most sites, both small and large camelids appear together in the same site layers. A third group, composed of samples found at sites both in Chile and in Argentina, is composed of individuals larger than the present guanaco. The appearance of a relatively large number of these large camelids at a number of sites both in northwestern Argentina and in northern Chile at this time has not been noted previously. The biggest animals identified in these samples belong to layers dated around 4400 BP. We believe that these large camelids probably represent the initial steps of llama domestication. As discussed below, this interpretation is supported by other indicators such as mortality patterns and contextual information (corrals and dung layers).

There are also changes in the relative dimension of some of the limbs of these larger camelids that suggest a change in the shape of these bones accompanies the increase in size. This feature is especially apparent in specimens from northwestern Argentinean sites of Inca Cueva 7 (IC7), Alero Unquillar (UNQ), and Huirunpure (HUI) dated 4100–2000 BP. In Figure 16.6, we present the data for three measurements of the distal metacarpal (maximum width of the distal end (mc6), maximum depth of the lateral condyle (mc9), and the maximum depth of the medial condyle (mc10)) from these three sites and compare them with a modem North Andean guanaco standard. In all but one of these archaeological large camelids (UNQ), the average depth of the metacarpal is comparatively greater than the wild standard (North Andean guanaco), and in all cases the width is proportionally smaller.

In sum, these data signal the appearance of a bigger form of camelid, larger than present guanaco and matching the size of current-day large llamas such as pack-llamas or *kcara*, which are the upper range for this species. These larger camelids were widely distributed across the South-Central Andes, from the highlands of northwestern Argentina to the Salar of Atacama in northern Chile from about 4400 BP onward. In another sector of the South-Central Andes, osteometric analysis on camelid distal humeri and proximal metatarsal widths detected the presence of large camelids, presumably llamas, at two rural archaeological sites located south of Lake Titicaca in Bolivia dating to about 3500 BP (Webster 1993).

Dental Morphology

At Tomayoc, in the Puna of Jujuy (4,170 m), two incisors identified as alpaca were found in layers dated to 3300–3200 BP (Lavallée et al. 1997). However, the criteria used to identify these teeth as alpaca were not reported and, as noted above, deciduous vicuiia incisors and permanent alpaca incisors share several traits (see Table 16.1). Moreover, the presence of alpaca at this site seems rather unlikely, given environmental restrictions of the southern dry puna that would seem to preclude the keeping of alpaca. Until now, alpaca have not been recorded in assemblages from later periods and only mentioned in historical times.

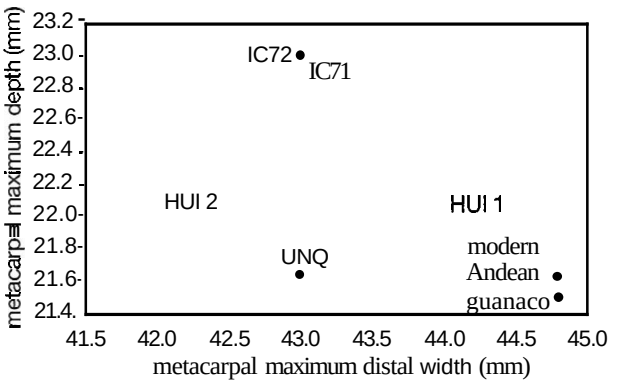

FIGURE 16.6 Bivariate plot of measurements of the distal metacarpal of selected large camelid specimens From northwestern Argentinean sites dated from 4100 to 2000 BP taken following Kent's protocols (Kent 1982). For the Andean guanaco, we present the measurements of two individuals from northwestern Argentina (Cumbres Calchaquies and Nevados del Aconquija). Measurements selected are maximum width of the distal end, and the averaged maximum depth of the lateral and medial condyles: *IC7* 1 and 2, Inca Cueva 7; UNQ, Alero Unquillar; *HUI* 1 and 2, Huirunpure.

Bone Morphology

Morphological characteristics for distinguishing between different camelids have been applied to several sites in the Loa River area, as well as in the Salar de Atacarna of northern Chile (Benavente and Adaro 1991; Cartajena 1994; Cartajena and Concha 1997; Núñez et al. 1999). For example, at Chiu Chiu Cementerio, a residential site with stone constructions dated 4100 BP, guanaco, llama, and vicufia were identified on the basis of morphological indicators (Cartajena 1994). Large camelids outnumber small ones at this site (see Table 16.2).

Mortality Patterns

There is a great deal of variability in camelid mortality profiles assemblages in the South-Central Andes. Applying techniques developed to study livestock domestication in the Near East, Hesse combined osteometric analysis and mortality profiling to address the question of camelid domestication in the southern Andes (Hesse 1982a, 1982b, 1984, 1986). Osteometric analysis of camelid remains from the sites of Tulán 52 (3,200 m) and Puripica 1 (3,250 m) in the Salar de Atacama of Chile revealed two distinct populations of large and small animals. Large camelids made up

about 68% of the camelid sample from Túlan 52, and about 42% at Puripica 1. Mortality profiles of the larger camelids at Puripica 1 showed a heavy emphasis on young animals that Hesse interpreted as indicating the management of domestic llama by 4800–4300 BP. In contrast, mortality profiles of the large camelids at Tulán 52 indicated an emphasis on adult animals and thus seemed to reflect the activities of ancient hunters.

At Chiu Chiu Cementerio, where large camelids dominate, mortality patterns also point to an emphasis on adult animals (87.5% of the total). The great majority of all the camelids (small and large) are adult individuals (Cartajena 1994: 37), showing that at this critical period (4400–3500 BP) there is great variability in mortality profiles.

Mortality data from the long sequence at the site of Quebrada Seca 3, in northwest Argentina, do not provide any evidence of the development of management of the small camelids (presumably vicuña) that dominate the assemblage after 8300 BP (Elkin 1996). Both dental and long-bone fusion data were used to divide the camelid sample into two age classes: newborn (<1 yr) and juvenileladults. Although the percentage of newborns changes from one layer to another (between 20 percent and 50 percent), there is no clear temporal trend over the 5,000-year occupation at the site. Thus, rather than a decline in the health of camelid herds resulting from a change in management strategy as suggested by Wheeler (1984a, 1984b, 1995, 1998) at Telarmachay, the shifting proportions of newborns in different layers at Quebrada Seca 3 probably represent variations in the seasonal occupation of the site and the opportunistic hunting of newborns during certain seasons of the year.

Fiber

Analysis of fiber remains found throughout the long sequence at Quebrada Seca 3 is also difficult to interpret. Reigadas (1992, 1994a, 1994b) identified both vicuiia and guanaco fleece in almost all the levels. However, there were also samples of camelid fiber with characteristics analogous in color, diameter, and medullation to those of some contemporary llamas in levels dating to as early as 9100 BP. These samples showed similarities to an "intermediate llama type," a breed presently used by local herders for production of both meat and fiber (Lamas 1994). Fiber with similar characteristics to that recovered at Quebrada Seca 3 was also found in levels at Inca Cueva 4 in the Puna of Jujuy dating to 10,600–9200 BP. One possible explanation for the presence of these fibers at this early time is that they represent fleece types found among wild camelids (probably guanaco) that were later selected for in early domestic llama.

Analysis of yarns and fleeces from several sites in the Quebrada Tulán by Dransart (1991a, 1991b, 1999) points to the presence of stock at Tulán 54 with fleece characteristic of domestic camelids by 3100 BP, and increased use of domestic camelids by 2600 BP. At the base camp of Chiu Chiu Cementerio, fiber of vicuña, guanaco, and llama were identified (Cartajena 1994).

Contextual Indicators

Evidence of corrals and the penning of camelids can also be found at sites in the South-Central Andes. In the first occupation of Inca Cueva 7, a small cave located in the Argentine puna (dated to 4080–4030 BP), dung pellets cover the surface of the cave floor and a stone wall encloses the mouth of the cave (Aschero and Yacobaccio 1998–1999). At Asana, an open-air site located in southern Peru with layers dated to 3640 BP, dung-derived soil deposits are outlined by a series of post-molds that have been interpreted as forming the oldest open-air corral found in the Andes (Aldenderfer 1998). These two cases are the oldest evidence of enclosures for the entire high Andes.

Comparison of Carnelid Exploitation in the Central and South-Central Andes

Taken together, these different lines of evidence point to a trajectory of intensification and domestication of camelids in the South-Central Andes taking place parallel to similar developments in the Central Andes. Beginning about 8400 BP, there was a region-wide intensification in the exploitation of camelids and a corresponding decrease in the exploitation of other species that peaked during the period 5300–3000 BP, when camelids are routinely 85–100 percent of faunal assemblages from the region. From 4400–2000 BP a large variety of camelids, larger than present guanacos, are found at sites across a broad region, including Late Archaic sites in the Salar de Atacama and the Puna of Argentina, as well as Early Formative sites at Lake Titicaca. We suggest that these large camelids represent a transitional form between hunted guanacos and herded llamas. Later on, these large forms seem to have undergone some reduction in the average size of individuals in the population, and an increase in overall metric variability.

Mortality data for large camelids from northern Chile and evidence for corralling camelids in both cave and open-air sites in northwest Argentina and southern Peru further indicate that these animals were managed. A picture then emerges of the development of a system of protective herding in the South-Central Andes, growing out of a gradual period of increasing intensification and specialization in hunting camelids that crystallizes with the domestication of the llama sometime between 4400 and 3000 BP. This process is set in the context of decreasing mobility of hunter-gatherer groups and corresponding increases in social, ideological, and economic complexity. The later part of this period (from 3000 to 2000 BP) was characterized by continued intensification in domestic camelid use (although wild camelids were still hunted), including the development of more specialized uses of camelids in textile production, associated with the appearance of highland agriculture and the incorporation of ceramic technology.

This pattern is strikingly similar to that seen in the Central Andes where the majority of indicators for camelid domestication converge somewhere between 4600 and 3000 BP.

For example, alpaca and llama are documented at the site of Pachamachay during the phase dated to 4150–3450 BP (Kent 1982). The long sequence at Panalauca shows the persistent importance of hunted vicuiia until the onset of the Early Formative, ca. 3600 BP, when domesticated camelids were introduced (Moore 1989). Moore notes the presence of particularly large camelids in the assemblage in levels dating to between 4590 and 3570 BP, as well as a trend toward size increase that begins in early phases and increases in intensity between 5750 and 4590 BP. These large camelids are quite similar in size to those from sites in the South-Central Andes, which are interpreted here as llamas. Moore (1989) emphasizes the existence of a statistically significant size increase in bones of the lower hind limb, especially in the distal depth of the metacarpal, which is also a feature noted above in the large camelids from northwestern Argentina shown in Figure 16.6.

The only way in which the Central Andes sequence deviates from that emerging for the South-Central Andes is the apparent early appearance of domestic camelids at Telarmachay, where both a pattern of high neonatal mortality and the presence of alpaca incisors occurred in a phase dated to between 6000 and 5500 BP (Wheeler 1984a, 1984b, 1985, 1994, 1995). The disparity between the evidence for early camelid domestication at Telarmachay and the more delayed appearance of domestic forms at other sites in the Puna de Junin has been attributed recently to the persistence of camelid hunting and the presence of both hunter-gatherer and pastoral groups in this puna region (Lavallée 1995).

Although it is entirely likely that hunting of wild camelids continued well after initial domestication, it is important to note that the temporal framework for the development of camelid domestication in the Central Andes rests on a very different foundation from that in the South-Central Andes. The chronology of some of the sites in the South-Central Andes, which were excavated recently, is anchored to radiocarbon dates derived from materials found in closed contexts with camelid bones. Although direct dating of camelids, especially the large specimens, has not been performed, and although some of the criteria commonly used for accepting or rejecting these dates may not have been routinely applied, the overall chronological framework for these developments in the South-Central Andes is quite refined and secure. In contrast, the age and timing of the development of camelid domestication in the Central Andes is based on a much looser chronological framework of archaeologically defined cultural phases that, although taking into account radiocarbon dates, may span several centuries or even millennia, giving this temporal framework a low resolution. Thus, it is impossible to say precisely when events occurred within broad periods that may cover more than 1,000 years. Clearly, more refined radiocarbon dating techniques need to be applied to these older collections before arguments of temporal primacy can be advanced.

Thus, when data from the South-Central Andes are considered alongside those from the Central Andes, we see a much broader spatial context for the development of camelid domestication in South America, occurring within a possibly a much tighter temporal framework. In both regions, there are parallel developments including intensification of camelid exploitation, changes in culling practices, and efforts to restrict the movement of managed animals, with most of the data pointing to the period between 4600 and 4000 BP for the appearance of domesticated llamas. The wide geographic spread of this evidence, which comes from localities ranging over a vast geographical area 2,300 km long (ca. between lat 10° S and lat 26° S), raises the possibility that there were multiple centers of llama domestication across a vast region that includes the Central Peruvian Andes, as well as the South-Central Andes of southern Peru, northwest Argentina, western Bolivia, and northern Chile. We could argue further that the process of alpaca and llama domestication may have occurred independently at different times and places within the Andes.

Directions for Future Research

Only continued analysis of assemblages across this large geographic region will sort out the story of South American camelid domestication. Larger samples from sites that span the key period from 8500 to 4600 BP are needed. More systematic application of techniques of osteometric analysis is essential. In particular, it is critical that analysts working with this material recognize the need for regional comparability in developing modern standards and in drawing comparisons between archaeological assemblages. Application of more refined techniques of mortality profiling, especially those that combine osteometric data with age data, are also key to tracing the shifts in exploitation strategies that accompany the transition from hunting to herding of different camelid species. Finally, chronological placement of these developments requires direct radiocarbon dating of camelid remains from these sites.

The process of South American camelid domestication, involving multiple species spread over a large and environmentally varied area, is clearly complex and difficult to monitor archaeologically. Recent work in the South-Central Andes has succeeded in broadening the focus of the inquiry from its initial, narrower concentration on Central Peru. Continued refinement of the pioneering methods developed by researchers working in both the Central and South-Central Andes promises a more detailed and refined picture of this complex process in the future.

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