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ScienceDirect
Quaternary International 180 (2008) 127–134

Delicious guinea pigs: Seasonality studies and the use of fat in the pre-Columbian Andean diet

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Available online 28 August 2007

Abstract

In the Nearctic ecozone (temperate, subarctic, and arctic environments) hunter–gatherers often have to rely on diets with inadequate caloric intakes during certain times of the year. Although the Neotropic ecozone has different and less extreme conditions, it can also be nutritionally challenging. While the tropical forests offer a more stable diet (in terms of carbohydrates, proteins, and fat availability), high altitude biomes, such as the central Andes, can challenge human populations to metabolize proteins properly in certain times of the year. Guinea pigs (*Cavia porcellus*) may have been incorporated in the Andean diet because they represented an additional source of fat, especially when carbohydrates were short in supply.

1. Introduction and background

For at least the past 500 years, guinea pigs (*Cavia porcellus*) have been used in the South American Andes (mainly Peru, Bolivia, and Ecuador) as a special food item in the indigenous diet, as well as an instrument to diagnose disease, and as a key component in religious offerings (Polo de Ondegardo, 1906 (1559); Gade, 1967; Weismantel, 1988; Guaman Poma de Ayala, 1992 (1615); Morales, 1994, 1995; Archetti, 1997; Fernandez Juarez, 1997). Guinea pigs or *cuys*, as locally known, are small rodents raised in peasants' kitchens that reproduce relatively rapidly and have large litters. So the question arises, why are they locally considered such a highly prized item of food?

This paper is an exploratory study of the role of guinea pigs in the pre-Columbian Andean diet. Based on nutritional information from the literature, it is proposed that these rodents were crucial in the diet because they represented an additional source of fat, particularly during the wet season. Seasonality studies are used to test the zooarchaeological evidence from the Wari site of Conchopata (Ayacucho, Peru) to discuss the working hypothesis. The nutritional role of guinea pigs in pre-Columbian times has rarely been addressed in the literature and, in particular, the unique niche it may have occupied has seldom been raised; it is thus important to explore this issue with archaeological data.

The role of guinea pig has been mainly discussed in religious and economic contexts (Morales, 1994; Sandweiss and Wing, 1997; Rofes, 2000, 2004). One exception is Bolton (Bolton, 1979; Bolton and Calvin, 1981) who applied Rappaport's (1968) cultural ecology analysis that examined the relation between proteins and New Guinea rituals to the use of guinea pigs in the Peruvian Andean diet. Rappaport argued that Tsembaga rituals serve to distribute local surpluses of pork throughout a region and assure that people obtain high-quality protein when they experience various forms of stress.

In a similar way, Bolton (1979, p. 249) claimed that major communal *fiestas* in rural Andean Peru serve guinea pigs "to distribute proteins, making it available at times when it will be maximally beneficial for the maintenance of health." From the data recorded in Santa Barbara (Cuzco, Peru), Bolton (1979, p. 246) stated that *cuys* are primarily eaten during Christmas, Carnival, Easter, and Corpus Christi. He asserted that the emphasis on these particular festivities as occasions to eat cuy is environmentally determined.

Dietary surveys in the Andes have found that caloric intake is highest in July, after the primary harvests of tubers and grain crops (Thomas, 1973). The amount of calories consumed gradually declines as food supplies

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doi:10.1016/j.quaint.2007.08.011

decrease and the quality of proteins from vegetables diminishes as well. In this sense, the wet season (November–April) is apparently a period of tuber and grain scarcity in Southern Peru. Bolton (1979) concluded that guinea pigs are consumed during the time of greatest protein need.

Surprisingly, Bolton (1979) did not consider other sources of proteins common in rural Peru today, namely the introduced chicken and pigs, and the native camelids. Furthermore, Bolton did not take into account the need for fat and carbohydrates in the Andean human diet. This paper proposes that guinea pigs consumption were most likely incorporated in the Andean diet because they represented an additional source of fat, especially during the wet season when carbohydrates and grain proteins were short in supply.

As demonstrated by Speth and Spielmann (Speth and Spielmann, 1983; Speth, 1991), high reliance on lean meat can lead to severe nutritional stress. A diet composed almost entirely of lean meat requires more calories to satisfy the same basic metabolic and physiological functions than a more balanced diet (Speth and Spielmann, 1983, p. 7). In their example from the Southern High Plains, Speth and Spielmann (1983) report that hunters avoided fat-depleted large game and abandoned lean cuts of meat while favoring waterfowl and some species of fish. These fat-rich animals, although they provide fewer calories, contribute the fat needed to properly metabolize proteins. Both fat and carbohydrates exert a protein or nitrogen-sparing action on protein metabolism. Carbohydrates could be even more effective than fat in promoting the utilization of dietary protein (Richardson et al., 1979, cited in Speth and Spielmann, 1983). Soluble carbohydrates from plant foods represent the most accessible and efficient source of energy in humans (Gunthrie, 1979). When carbohydrates are not abundant, humans must switch to animal fat as an energy source, and/or synthesize energy from protein (Marean, 1986). Therefore, if carbohydrates were in short supply during the wet season of the Andes (Thomas, 1973), guinea pigs could have provided the fat needed to help metabolize animal protein in order to have a balanced diet. This question will be examined using data from pre-Columbian times.

2. Proteins, lipids, and carbohydrate in the pre-Columbian Andean diet

In the pre-hispanic Andes, the main animal source of proteins and fat was camelids (Family Camelidae): the domestic forms, llama (*Lama glama*) and alpaca (*Lama pacos*), and the wild forms vicuña (*Vicugna vicugna*) and guanaco (*Lama guanicoe*). Camelids tend to be lean in fat content (Mengoni Goñalons, 1996; Coates and Ayerza, 2004; Polidori et al., 2006). Mengoni Goñalons, partially based on Parodi's (1976) and Arevalo's studies (1995) and on his own experimental research, reports weight-based values of fat for the entire carcass without the kidneys of 1% for guanacos and 8–25% for llamas (Mengoni Goñalons, 1996, 2001). From samples of muscle *Longissimus thoracis* and *lumborum* taken from 20 llama carcasses between the 12th and 13th verterbrae, Polidori et al. (2006) report a fat content of 3.51% of total meat chemical composition. Additionally, camelids have lipids in the form of marrow found in the femur, humerus, and tibia (Mengoni Goñalons, 1996, p. 39 and Table 5). No data of subcutaneous and visceral fat deposits have been recorded for camelids. However, according to Marean (1986), such values are usually low in ungulates.

According to Bolton (1979, p. 234), guinea pigs flourish between October and April when grass is abundant and gathering their food is easy, although as noted below cuys do not show a restricted birth season. As cuy flocks grow, the number of cuys occupying the living space in the kitchen reaches a critical limit. By December people began to eat excess animals, particularly around feast days. Most families reduce their flocks in anticipation of the dry season; and they give several reasons: they do not reproduce well during this period, they are hard to fatten and do not grow, and particularly the young die because of the cold and the lack of grass (Bolton, 1979, p. 234).

The chemical composition of guinea pig meat, as a weight-based proportion of the edible meat, is 70.6% water, 20.3% protein, 7.8% fat, and 0.8% minerals (Bolton, 1979, p. 240). This is not a high fat value but it could have been crucial as an additional source to that of camelids, particularly during certain times of the year and especially to the most needy segments of the human population (infants, pregnant, and nursing women) (Wing and Brown, 1979).

In terms of Native Andean carbohydrate intake, tubers like oca (*Oxalis* sp.) have 11–22% carbohydrates, 1% fat, and 1% fiber; they are high in sugar and they can have up to 9% protein (National Research Council and Office of International Affairs, 1989, p. 87). Maca (*Lepidium* spp.) has 13–16% protein, high contents of iron and iodine, and it is rich in essential amino acids (National Research Council and Office of International Affairs, 1989, p. 67). Potatoes (*Solanum tuberosum*) are high in vitamin C, high in starch, and low in fat (Lee and Kader, 2000).

Native Andean grains (pseudo-cereals) like quinoa (*Chenopodium quinoa*) are 16% protein, 58–68% starch, 5% sugar, 4–9% fat, and have high contents of calcium, phosphorus, and iron (National Research Council and Office of International Affairs, 1989, p. 153). Kiwicha (*Amaranthus caudatus*) also has high levels of protein (18%) and the essential amino acid lysine, which is usually lacking in plant protein. Interestingly, kiwicha protein is apparently almost comparable to milk protein (casein) in nutritional quality, and it complements the nutritional quality of foods that would be made from corn flour (National Research Council and Office of International Affairs, 1989, pp. 18, 143). Corn or maize (*Zea mays*) is high in calories but has 6.5% proteins (Hastorf, 1993,

p. 117) and it has been argued that it was a prized food commodity primarily used in beer preparation, not part of the commoner diet (Hastorf and Johannessen, 1993; cf. Finucane et al., 2006).

Native Andeans did not have many abundant sources of fat in their diet. Few fatty animals were consumed and there is no evidence of muscovy duck (*Cairina moschata*) intake in the Peruvian highland archaeological record. Furthermore, they did not have fat from dairy products; camelid milk was never a product consumed by humans (Bonavia, 1996). The high levels of fragmentation of camelid long bones found in hunter–gatherer sites may point to bone grease consumption (e.g. Rick and Moore, 1999) which was probably much needed especially in pre-domestication times.

The hypothesis is that guinea pigs were incorporated in the diet because they represented an additional source of fat, especially when carbohydrates and non-animal proteins were short in supply. Storage of plant supplies may not have been enough to overcome the seasonal stress. While some native grains, like kiwicha and quinoa, are high in protein content they show low productivity (National Research Council and Office of International Affairs, 1989, p. 125). This important limitation could have prevented major long-time storage.

The expectations are that guinea pigs were consumed more intensively during the time of need for fat, which is during the wet season. In the winter dry season when forage is limited and camelids are leaner protein-sparing would not be a problem because of the abundance of plant proteins and carbohydrates from crops. On the contrary, during the wet season the scarcity of grain proteins and carbohydrates (Thomas, 1973) could have affected the ability to metabolize the protein of perennial lean fat camelids.

The question is, then, how to test archaeologically for the consumption of guinea pigs in certain moments of the year when there is a need for extra sources of lipids, carbohydrates, and protein. Seasonality studies can potentially be very useful in this regard.

3. Seasonality studies

In archaeology, seasonality is used to mean the time of the year at or during which a particular event is most likely to occur (Monks, 1981). The coincidence of cultural activity with naturally occurring events provides a calendar of prehistoric human events (Davis, 1987; Reitz and Wing, 1999). By identifying seasonal patterning, archaeologists can better understand prehistoric cultures, their environmental adaptation, and their cyclical subsistence (Bowen, 1988). In this sense, key to the claim of the use of guinea pigs as a source of fat is the question of when these rodents were more intensively consumed.

Seasonality methods on faunal remains depend upon the occurrence of a well-defined birth season, and the presumption of a rate of change similar to its modern relatives (Davis, 1987, p. 76). The best case is when various seasonal factors can be applied to claim the season of use of a site. Clearly, the overall accuracy of these analyses relies upon the use of modern analogues (Gifford-Gonzalez, 1991) and more research is needed in order to have standards for more animal species.

Storage and transport of certain resources need to be taken into account because they can complicate seasonality estimations (Reitz and Wing, 1999; Yerkes, 2005). For example, there are various methods to extend the use of meat (e.g. freezing, smoking). *Ch'arki* is a Native Andean technique for preserving llama and alpaca meat, usually on the bone, by freezing it in the cold nights and drying in the hot sun in the Puna environment (Miller and Burger, 1995; Stahl, 1999; Valdez, 2000).

In the case of the present research question of whether guinea pigs were contributing fat in certain times of the year, although the age of death of guinea pigs can be determined by looking at the fusion sequence of long bones (Zuck, 1938), this method will not provide good data on seasonality. While some ethnographies claim that people slaughter most of the animals by the end of the wet season (Bolton, 1979), *cuys* show no restriction on months of birth (Bolton and Calvin, 1981, p. 275). They mature sexually by the age of 2 months, gestation is 10 weeks, and ovulation and copulation occur shortly after a female has given birth (Bolton, 1979; Morales, 1994).

It is then necessary to think of indirect lines of evidence to track seasonal use of guinea pigs in the Andean archaeological record. The first way is to identify seasonality in other animals directly associated with the guinea pig remains. Camelids are the first choice due to their usual abundance in archaeological sites. Camelids are born between December and March (Novoa and Wheeler, 1984; Bonavia, 1996). Studies of camelid bone fusion sequence and dental eruption can be used to determine their age of death (Wheeler, 1982, 1999; Miller, 2003) and thus the time of the year that the butchering occurred.

Camelid and cuy teeth could potentially be subjected to isotopic analysis to assess the season of the year these animals were killed. The author is only aware of one preliminary study that deals with incremental growth layers from camelid teeth (Aldenderfer, 1994), but no standards have been yet published.

Another way is to study cuy association with certain seasonal plants. In many areas of the Andes there is only one significant harvest per year (Bandy, 2005). The local timing of the harvest will give direct indications for consumption patterns if certain perishable remains, e.g. avocados (*Persea americana*) and other fruits, are recovered.

When applying indirect evidence to the use of guinea pigs, it is necessary to be confident of the direct association of the remains. Closed contexts such as pits or burials are generally good candidates to claim a fine-grained record.

4. Case study: The evidence from Conchopata

The archaeological site of Conchopata is situated at 2760 m above sea level in the valley of Ayacucho in the central Peruvian sierras (Fig. 1). Conchopata was a subordinate centre of the imperial capital city of Huari during the Middle Horizon (A.D. 600–1000) (Isbell, 2004). Originally the settlement probably covered 20 ha, but presently only three hectares remain, which have been interpreted as the core of the civic centre (Isbell, 2004, p. 6) (Fig. 2).

The author undertook the fauna analysis during two seasons at the Archaeology Laboratory of Universidad Nacional de Huamanga (Ayacucho, Peru). The sample consisted of 18,244 of identified specimens (NISP). These animal bones have been recovered from 65 excavated architectural structures (rooms) under excavations directed by William Isbell (SUNY Binghamton) and Anita Cook (Catholic University of America).

For this study only the faunal specimens found in three architectural structures containing animal burials and small trash pits contexts will be discussed because they could be interpreted as fine-grained resolution records. The remaining animal specimens were found in large middens that were probably reused and in which the deposition of camelids and guinea pigs is most likely not part of the same deposition event. In that case, seasonal estimation cannot be extrapolated from camelid butchering to the guinea pig consumption. It is important to discuss the role of guinea pig in the pre-Columbian diet with archaeological data even if the sample size is fairly small (NISP 4065), although the results should be taken as explorative.

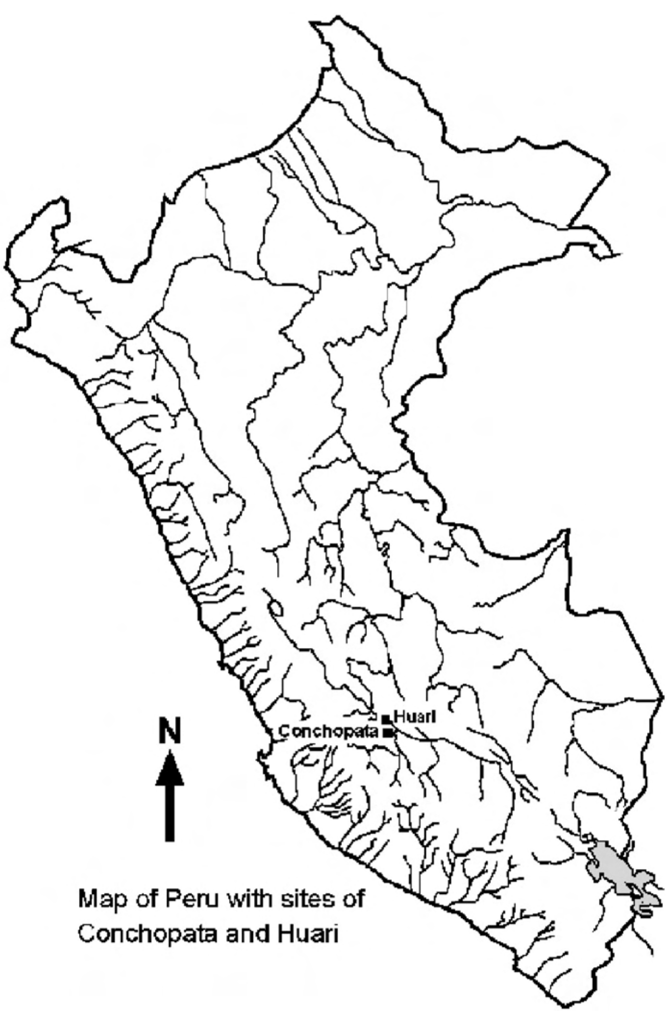

Fig. 1. Map of Peru showing the location of Conchopata (map courtesy of J.C. Blacker).

The architecture at Conchopata shows an urban nucleus containing two large patios surrounded by narrow rooms, characteristic of many Wari sites (Isbell, 2000). Structure 23 west, a small room adjacent to one narrow room next to a patio, revealed the highest frequency of faunal remains excavated from any room in the site (NISP 1698). The bone density was particularly high considering the small size of the room (2.5 m^2). Three newborn llamas around 3 months old had been deposited at the bottom of room 23 west and the burials intruded into the bedrock. These primary burials showed no cut marks. Another primary burial in the same room was that of a juvenile camelid of 13–17 months of age. The structure contained a minimum number of individuals of 11 camelids (age estimation is still in progress). Rodents accounted for a minimum number of 16 guinea pigs (all younger than 4 months old), 1 leaf-eared mouse (*Phyllotis* sp.), and 1 unspecified rodent. The age of the buried camelids indicates wet summer season (Table 1).

One of the most complex buildings in Conchopata was the mortuary compound composed of various structures some containing cist tombs with many human individuals. A primary interment of two semi-flexed, articulated camelid skeletons was found in the entrance room of the mortuary-building compound (NISP 769). They were deposited below the floor along with a complete guinea pig. The camelids were between 1 and 3 months of age, and they did not show any cut marks or evidence of thermal alteration. The guinea pig was under 8 months of age. One rock grinder and the remains of an architectural model were found in the same room. Given the age of the camelids, this sacrifice of animals was performed in the wet summer season (Table 1). However, there is no evidence of consumption, so these data do not contribute to the question of when guinea pigs were eaten.

In room 36 a large amount of faunal remains (1598 identified specimens) was discovered associated with the ceramic fragments of oversized vessels. Roughly 75% of the remains came from three trash concentrations; one was on the floor and two were small indentations or intrusions breaking into the floor, all had a high frequency of thermal alteration and cut marks. Unburnt bones showed low weathering stages (mostly stages 1 and 2) suggesting possible discrete events of deposition and quickly accumulation.

The concentration on the floor had a minimal number of four camelids: one younger than 1 month old, two juveniles younger than 18 months old, and one adult older than

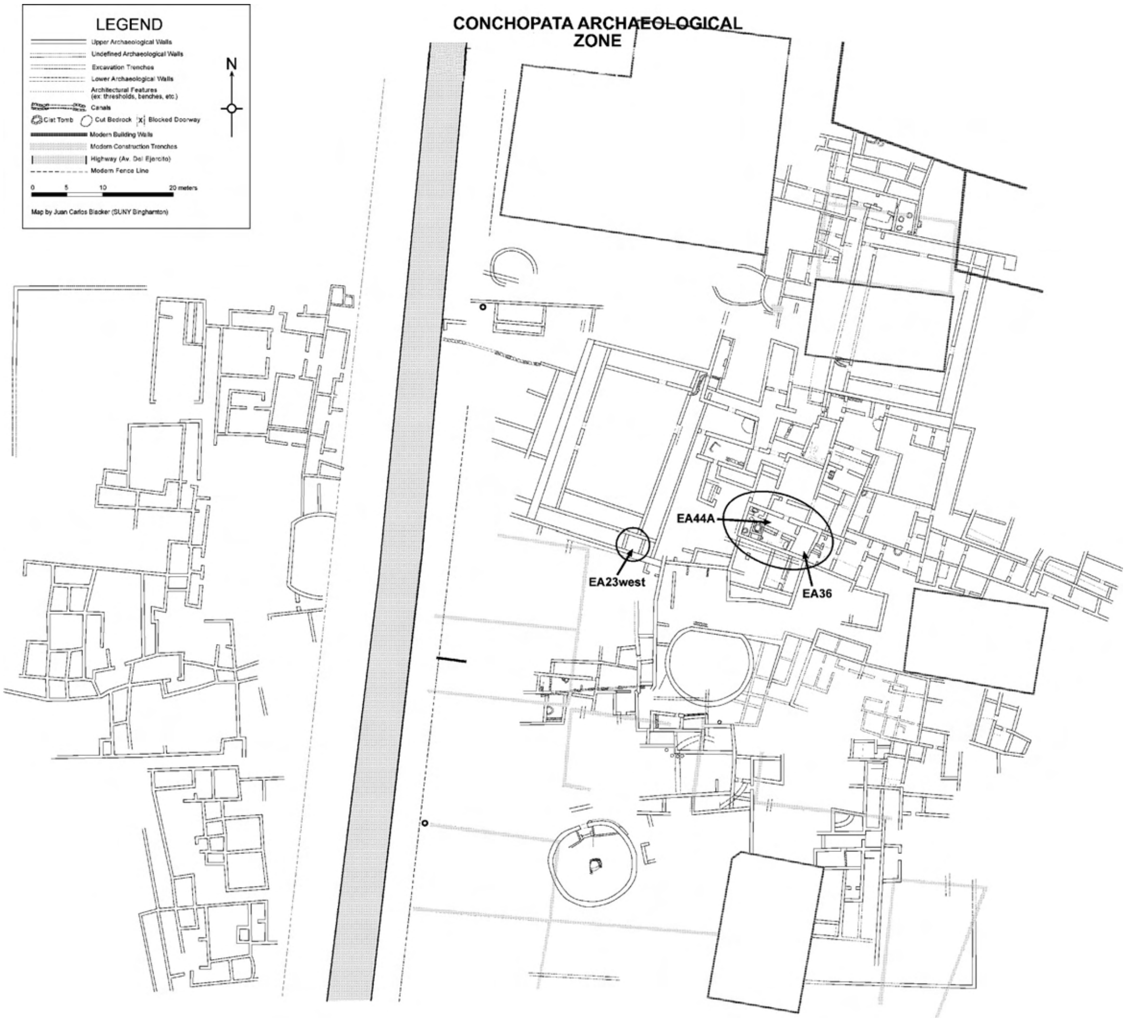

Fig. 2. Conchopata archaeological site and location of rooms discussed in the text (map courtesy of J.C. Blacker).

Table 1
Conchopata faunal data and seasonal estimation

Structure #	NISP	Context	MNI camelids	Camelid age	MNI cuys	Cuy age	Season estimation
23 west	1698	Burial 1	1	<3 months old			Wet season
		Burial 2	1	13–17 months old	16	<4 months old	
44a	769	Burial	2	1–3 months old	1	<8 months old	Wet season
36	1598	Accumulation	1	<1 month old	9	<5 months old	Wet season
			2	<18 months old	2	Indeterminated	
			1	42 months old			
		Pit 1	1	1–3 months old	2	<5 months old	Wet season
			6	<17 months old			
			1	>42 months old			
		Pit 2	1	<1 month old	6	<4 months old	Wet season
			1	<17 months old			
			1	24 months old			

42 months old. Eleven cuys were associated with the camelids remains and at least nine individuals were younger than 5 months old. The youngest camelid suggests wet season consumption (Table 1).

The biggest intrusion in the floor (Pit 1) contained the remains of at least seven camelids: six younger than 17 months old (at least four were between 1 and 3 months old, and one between 3 and 9 months old), and one adult. Two cuys younger than 5 months old were found in association with them. Fragments of charcoal, obsidian, and ceramic were also found in the same context. These data suggest that these camelids were consumed during the wet summer season. It could be argued that if the 3–9 months old is actually 9 months old and was born in December, then August would be the butchering month. However, given the association with the very young camelid it is not possible that the butchering took place in August because no 1–3 months camelid can be expected to be present in that time. Thus, the event must have taken place in the summer (Table 1).

The second intrusion in the floor (Pit 2) had remains of at least three camelids: one younger than a month old, one younger than 17 months, and one individual older than 24 months. Rodent remains were identified as six *Cavia* individuals less than 4 months of age. Here, the data again suggest summer butchering given the presence of the very young camelid, and the other two camelids do not provide an accurate enough age information to make any estimation (Table 1).

Large quantities of camelid long bone fragments were found in Pits 1 and 2, which could suggest breaking and boiling for grease consumption. However, further research is needed on this aspect. Although there is no direct evidence of boiling camelid bones in Conchopata, the technology was certainly available, as a high number of ceramics were identified as cooking equipment (Cook and Benco, 2000; Cook and Glowacki, 2003). In this sense and according to Wandsnider (1997, pp. 8, 9), heat treatment of fat foods has several goals: lipid hydrolysis makes the fat more digestible, it may inactivate rancidity, it prepares flavourful meals, and it makes food more chewable. Camelid bone grease could have also been a good source of fat to help synthesize animal proteins in Conchopata.

The archaeobotanical analysis has identified quinoa (*C. quinoa*), potato (*S. tuberosum*), oca (*Oxalis* sp.), maize (*Z. mays*), beans (*Phaseolus* sp.), and molle (*Schinus molle*) (Sayre and Whitehead, 2003). However, the provenience contexts are not discrete, and therefore there are no clear associations to any other remains with seasonality information. It is not yet understood in what times of the year these plants were consumed. No other possible seasonal indicators have been detected in the Conchopata analysis.

5. Discussion and final comments

The original question is still in need of further research in order to be completely answered. Seasonal indicators in the Andes, and in Conchopata, are not abundant. Camelid age determination is probably the most reliable determinant at this point in time. Also, many faunal deposits show coarse-grained resolution and the association of different species is, in many cases, difficult to claim.

In spite of these problems, the small faunal sample from Conchopata does not contradict the hypothesis of guinea pigs being consumed in the wet season. Although more research on their dietary role is needed, it is likely that cuys were actively contributing with fat to metabolize muscle proteins in the absence of plant carbohydrates and grain proteins.

On the other hand, other theories on the role of guinea pig fat in the Andean diet need to be tested. However, more information on the total macronutrient content of the diet over the entire annual round needs to be gathered. Clearly, more data are needed on the nutritional values of traditional food and on the traditional cropping and harvesting times to further pursue this research. While in general the harvest is at the end of the wet season (autumn) (Thomas, 1973), it would be useful to know the precise harvest times for each individual food crop. Also, wild plants could have supplemented the necessary carbohydrates during the wet season. It is important to understand when all these food items are available during the year to be able to explain how they can overlap and close possible nutritional gaps.

It is also crucial to find new methods to assess seasonality in the Andes in an accurate way. For example, growth increment analysis of camelid and guinea pig teeth would be an innovative and useful method to develop.

To conclude, seasonality studies can play a key role in archaeological research. The role of *cuys* has been particularly under-theorized in the Andean literature and hopefully this study will begin to address this deficit. This paper demonstrates that in Neotropical zooarchaeology new techniques and ideas should be explored in order to contribute to the research of pre-Columbian diets.

Acknowledgements

I would like to thank William Isbell and Anita Cook, directors of the Conchopata Project, for inviting me to work in Ayacucho. I am grateful to Diane Gifford-Gonzalez who offered valuable comments on an earlier draft of this paper. I wish to thank Juan Carlos Blacker for providing the maps.

References

Aldenderfer, M., 1994. Dental microstructure analysis as a means of age/seasonality estimation in camelids. In: Elkin, D., Madero, C., Mengoni Gonalons, G., Olivera, D., Reigadas, M.d.C., Yacobaccio, H. (Eds.), Zooarqueologia de Camelidos. Perspectivas Teoricas y Metodologicas, vol. 1. GZC, Buenos Aires, pp. 9–21.

Archetti, E., 1997. Guinea Pigs. Food, Symbol and Conflict on the Knowledge in Ecuador. Berg, Oxford.

Arevalo, S.A., 1995. Nuevos recursos alimenticios: los Camelidos Sudamericanos. Tesis de Licenciatura, Facultad de Ciencias Agrarias, Universidad Catolica Argentina, Buenos Aires.

Bandy, M., 2005. Energetic efficiency and political expediency in Titicaca Basin raised field agriculture. Journal of Anthropological Archaeology 24, 271–296.

Bolton, R., 1979. Guinea pigs, protein, and ritual. Ethnology 18, 229–252.

Bolton, R., Calvin, L., 1981. El Cuy en la cultura peruana contemporanea. In: Lehtman, H., Soldi, A.M. (Eds.), Runakunap Kawasayninkupaq. La Tecnologia en el Mundo Andino. Universidad Nacional Autónoma de México, Instituto de Investigaciones Antropológicas, Mexico, DF.

Bonavia, D., 1996. Los Camelidos Sudamericanos. Una Introduccion a su Estudio. Instituto Frances de Estudios Andinos, Lima.

Bowen, J., 1988. Seasonality: an agricultural construct. In: Beaudry, M.C. (Ed.), Documentary Archaeology in the New World. Cambridge University Press, Cambridge, pp. 161–216.

Coates, W., Ayerza, R., 2004. Fatty acid composition of llama muscle and internal fat in two Argentinian herds. Small Ruminant Research 52, 231–238.

Cook, A., Benco, N., 2000. Vasijas para la fiesta y la fama: produccion artesanal en un centro urbano Huari. Boletin de Arqueologia PUCP 4, 489–504.

Cook, A., Glowacki, M., 2003. Pots, politics, and power: Huari ceramic assemblages and imperial administration. In: Bray, T. (Ed.), The Archaeology and Politics of Food and Feasting in Early States and Empires. Kluwer Academic/Plenum Publishers, New York, pp. 173–202.

Davis, S., 1987. The Archaeology of Animals. Yale University Press, New Heaven.

Fernandez Juarez, G., 1997. Entre la Repugnancia y la Seducción. Ofrendas Complejas en los Andes del sur. Centro Bartolome de Las Casas, Cusco.

Finucane, B., Maita Agurto, P., Isbell, W., 2006. Human and animal diet at Conchopata, Peru: stable isotope evidence for maize agriculture and animal management practices during the Middle Horizon. Journal of Archaeological Science 33, 1766–1776.

Gade, D., 1967. The guinea pig in Andean folk culture. The Geographical Review 57, 213–224.

Gifford-Gonzalez, D., 1991. Bones are not enough: analogues, knowledge, and interpretative strategies in Zooarchaeology. Journal of Anthropological Archaeology 10, 215–254.

Guaman Poma de Ayala, F., 1992 (1615). Nueva Cronica y Buen Gobierno: Crónicas de Indios y Mestizos II. Enciclopedia Histórica de la Literatura Peruana, Lima.

Gunthrie, H., 1979. Nutrition. C.V. Mosby, St. Louis.

Hastorf, C., 1993. Agriculture and the Onset of Political Inequality before the Inka. New Studies in Archaeology. Cambridge University Press, Cambridge.

Hastorf, C., Johannessen, S., 1993. Pre-Hispanic political change and the role of maize in the central Andes of Peru. American Anthropologist 95, 115–138.

Isbell, W., 2000. Repensando el Horizonte Medio. Boletín de Arqueología PUCP 4, 9–68.

Isbell, W., 2004. Mortuary preferences: a Wari culture case study from Middle Horizon Peru. Latin American Antiquity 15, 3–32.

Lee, S., Kader, A., 2000. Preharvest and postharvest factors influencing vitamin C content of horticultural crops. Postharvest Biology and Technology 20, 207–220.

Marean, C., 1986. Seasonality and seal exploitation in the Southwestern Cape, South Africa. The African Archaeological Review 4, 135–149.

Mengoni Goñalons, G., 1996. La domesticacion de los camelidos sudamericanos y su anatomia economica. Zooarqueologia de Camelidos. Perspectivas Teoricas y Metodologicas 2, 23–35.

Mengoni Goñalons, G., 2001. Variabilidad de la anatomia economica en la llama. In: Mengoni Goñalons, G., Olivera, D., Yacobaccio, H. (Eds.), El Uso de los Camelidos a traves del Tiempo. Ediciones del Tridente, Buenos Aires, pp. 145–153.

Miller, G., 2003. Food for the dead, tools for the afterlife. In: Burger, R., Salazar, L. (Eds.), The 1912 Yale Peruvian Scientific Expedition Collections from Machu Picchu. Human and Animal Remains, vol. 85. Yale University Publications in Anthropology, New Heaven, CT, pp. 1–63.

Miller, G., Burger, R., 1995. Our father the cayman, our dinner the llama: animal utilization at Chavin de Huantar, Peru. American Antiquity 60, 421–458.

Monks, G., 1981. Seasonality studies. Advances in Archaeological Method and Theory 4, 179–240.

Morales, E., 1994. The guinea pig in the Andean economy: from household animals to market economy. Latin American Research Review 29, 129–142.

Morales, E., 1995. The Guinea Pig. Healing, Food, and Ritual in the Andes. The University of Arizona Press, Tucson.

National Research Council, and Office of International Affairs, 1989. Lost Crops of the Incas Little-Known Plants of the Andes with Promise for Worldwide Cultivation. National Academy Press, Washington, DC.

Novoa, C., Wheeler, J., 1984. Llama and alpaca. In: Mason, I. (Ed.), Evolution of Domesticate Animals. Longman, New York, pp. 116–128.

Parodi, J., 1976. Evaluacion cuali-cuantitativa de reses de guanacos (*Lama guanicoe*) de la provincia de Rio Negro. Informe INTA, Argentina.

Polidori, P., Renieri, C., Antonini, M., Passamonti, P., Pucciarelli, F., 2006. Meat fatty acid composition of llama (*Lama glama*) reared in the Andean highlands. Meat Science 75, 356–358.

Polo de Ondegardo, J., 1906 (1559). Los errores y supersticiones de los indios, sacados del tratado y averiguaciones que hizo el licenciado Polo. Revista Histórica 1, pp. 207–231.

Rappaport, R.A., 1968. Pigs for the Ancestors: Ritual in the Ecology of a New Guinea People. Yale University Press, New Heaven.

Reitz, E., Wing, E., 1999. Zooarchaeology. Cambridge Manuals in Archaeology. Cambridge University Press, Cambridge.

Richardson, D.P., Wayler, A.H., Scrimshaw, N.S., Young, V.R., 1979. Quantitative effect of an isoenergetic exchange of fat for carbohydrate on dietary protein utilization in healthy young men. American Journal of Clinical Nutrition 32, 2217–2226.

Rick, J., Moore, K., 1999. El Precerámico de las Punas de Junín: El punto de vista desde Panaulauca. Boletín de Arqueología PUCP 3, 263–295.

Rofes, J., 2000. Sacrificio de cuyes en El Yaral, comunidad prehispanica del extremo sur peruano. Boletin Instituto Frances de Estudios Andinos 29, 1–12.

Rofes, J., 2004. Prehispanic guinea pig sacrifices in southern Peru, the case of El Yaral. In: O'Day, S.J., Van Neer, W., Ervynck, A. (Eds.), Behavior Behind the Bones. The Zooarchaeology of Ritual, Religion, Status and Identity. Oxbow Books, Oxford, pp. 95–100.

Sandweiss, D., Wing, E., 1997. Ritual rodents: the guinea pigs of Chincha. Journal of Field Archaeology 24, 47–58.

Sayre, M., Whitehead, W., 2003. New paleoethnobotanical data from Conchopata. Paper presented at the 68th Annual Meeting for the Society for American Archaeology, Milwaukee, Wisconsin.

Speth, J., 1991. Protein selection and avoidance strategies of contemporary and ancestral foragers: unresolved issues. Philosophical Transactions: Biological Sciences 334, 265–270.

Speth, J., Spielmann, K., 1983. Energy source, protein metabolism, and hunter–gatherer subsistence strategies. Journal of Anthropological Archaeology 2, 1–31.

Stahl, P., 1999. Structural density of domesticated South American camelid skeletal elements and the archaeological investigations of prehistoric Andean ch'arki. Journal of Archaeological Science 26, 1347–1368.

Thomas, R.B., 1973. Human adaptation to a high Andean energy flow system. Occasional Papers in Anthropology No. 7. Department of Anthropology. The Pennsylvania State University.

Valdez, L., 2000. On Ch'arki consumption in the ancient central Andes: a cautionary note. American Antiquity 65, 567–572.

Wandsnider, L., 1997. The roasted and the boiled: food composition and heat treatment with special emphasis on pit-hearth cooking. Journal of Anthropological Archaeology 16, 1–48.

Weismantel, M., 1988. Food, Gender, and Poverty in the Ecuadorian Andes. Waveland Press, Illinois, USA.

Wheeler, J., 1982. Aging llamas and alpacas by their teeth. Llama World 1, 12–17.

Wheeler, J., 1999. Patrones prehistóricos de utilización de los camélidos sudamericanos. Boletín de Arqueología PUCP 3, 297–305.

Wing, E., Brown, A., 1979. Paleonutrition. Method and Theory in Prehistoric Foodways. Academic Press, New York.

Yerkes, R., 2005. Bone chemistry, body parts, and growth marks: evaluating Ohio Hopewell and Cahokia Mississippian seasonality, subsistence, ritual, and feasting. American Antiquity 70, 241–265.

Zuck, T., 1938. Age order of epiphyseal union in the guinea pig. The Anatomical Record 70, 389–399.