RESEARCH ARTICLE

# At the Feet of the Fortress: Analysis of Inka Period (ca. AD 1430-1536) Archaeofaunal Assemblages from Residential Unit 1 (RU1), Pucara de Tilcara (Jujuy, Argentina)

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## Abstract

This paper reports the results of a zooarchaeological analysis conducted on the occupation layer of a compound structure (Residential Unit 1) of the Pucara de Tilcara archaeological site (Jujuy Province, northwestern Argentina). Its occupation span extends between the 13th and 15th centuries AD, but evidence diagnostic of the Inka Period (AD 1430–1536) is predominant. Residential Unit 1 was a house-workshop that hosted specialized crafts like metallurgy and lapidary during the Inka Period. It was proposed in previous works that artisans living at Pucara de Tilcara were provisioned with agropastoral products by the Inka administration. This paper aims to test that hypothesis against the zooarchaeological evidence of Residential Unit 1. Three variables were used as proxies for state-sponsored distribution: taxonomic diversity (family and species ranks), and skeletal and age profiles of the predominant zoological family (Camelidae) in the assemblage. The results show a high degree of continuity with the regional record, characterized by a herding-hunting strategy focused on domestic and wild species of Camelidae and a mixed mortality pattern. The skeletal profile shows a strong and negative correlation with the desiccation potential of elements, which could be indicative of local production of *chalona*. Overall, faunal evidence does not show any sign of centralized distribution.

## Introduction

The onset of the second millennium AD marks a widespread development of middle range polities across the Circumpuna sub-area (South-Central Andes), including the Quebrada de Humahuaca in northwestern Argentina. These organizations have been compared to chiefdoms and federations [1], heterarchies [2], communal organizations [3] and ranked corporate

kin-groups [4,5]. Supra-domestic division of labor increased in tandem with political complexity (*e.g.* the scale and complexity of bronze metallurgy increased at many semiarid valleys in northwestern Argentina beginning ca. AD 1000) [1,6]. Division of labor also involved the control of diverse ecological zones (verticality) by groups ranging from lineages to ethnic groups [1,7]. The Inka Empire, or *Tawantinsuyu*, reinforced these trends after the conquest of the South-Central Andes at the beginning of the 15$^{th}$ century.

Change in social complexity brings up the issue of how agropastoral products were allocated within the population. Distribution of food and drink during reciprocal services, communal works and labor tributes was a traditional practice of Andean societies [8,9]. The Inka amplified this system and even intensified agricultural production to sustain corvée laborers, drafted soldiers and retainers [10,11]. However, distribution did not exclude self-sufficiency as even attached specialists received shares of land to grow their own food; actually, full-time attached specialists were a late development [11].

Zooarchaeology provides a set of analytical tools and models for research on distribution, since specialization and hierarchy often affect the acquisition of animal goods [12–14]. This paper presents a case study on the procurement of faunal resources by craft specialists during the Inka Period, based on the analysis of faunal remains from a late pre-Hispanic house-workshop: Residential Unit 1 of the *Pucara de Tilcara* archaeological site, in the *Quebrada de Humahuaca* region of Jujuy Province. To date, two mechanisms for the procurement of faunal resources by central settlements in this region during the second millennium AD have been hypothesized: 1) provisioning by specialist transhumant herders belonging to the same kinship-networks or domestic groups as the consumers beginning ca. AD 1200 [7], and; 2) elite or state-sponsored redistribution among craft specialists during the Inka Period (AD 1430–1536) [15]. The aim of this paper is to test the latter model.

## Background

The Quebrada de Humahuaca is a narrow and semiarid intermontane valley (Fig 1), whose maximally 120 km long by 3 km wide main corridor is formed by the Grande River. Its northern limit extends to the confluence of the *Tres Cruces* and *Cóndor* streams at Azul Pampa, approximately 3600 m asl. Its southern limit extends to the modern town of *Volcán* at approximately 2000 m asl [16]. The Quebrada de Humahuaca is flanked by two ecological zones: 1) the southern segment of the Andean plateau (*Puna*) to the west; and, 2) the Sub-Andean hills and eastern forests (*yungas*) to the east.

The pre-Columbian occupation of northwestern Argentina follows an evolutionary course common to the South Central-Andes (Table 1): initial settlement by hunter-gatherers minimally by 10,600–8400 BP, judging by the earliest dates from sites like Inca Cueva 4 and Huachichocana III [17]; subsistence intensification leading to domestication (Archaic Period, ca. 9000–1000 BC) [18,19]; the establishment of sedentary agropastoral lifeways (Formative Period, ca. 1000 BC–AD 900 in Humahuaca) [20,21], with political organizations characterized as tribal or non-ranked [16,20]; and, followed by the Regional Developments I period (ca. AD 900–1200), characterized by the earliest evidence of social ranking [16,22].

Subsequent archaeological periods include Regional Developments II (ca. AD 1200–1430) and Inka (ca. AD 1430–1536) [5,16]. The former is characterized by a florescence of complex pre-state polities, usually modeled after chiefdoms or ranked corporate kin-groups [5,23]. These polities were eventually subordinated by *Tawantinsuyu* after *ca.* AD 1430 [16]. *Tawantinsuyu* was an expansive state whose political economy was based primarily on imposed corvée labor from peasant communities [9–11,24].
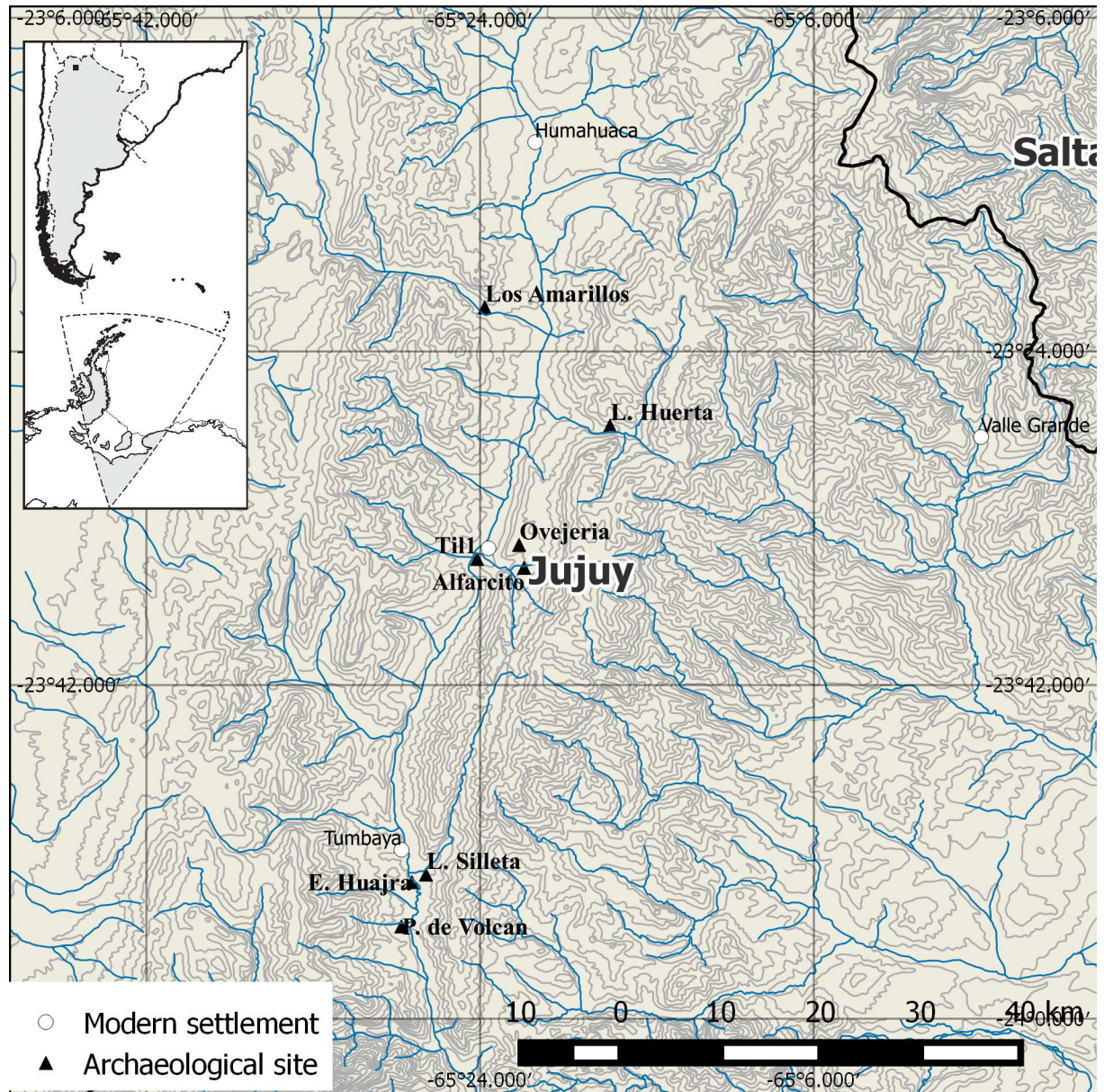
**Fig 1. Map of Humahuaca and location of the archaeological sites and localities mentioned in the text.** The present map was created with QuantumGIS based on data from the Instituto Geográfico Nacional de la República Argentina (http://www.ign. gob.ar/) and Natural Earth (http://www.naturalearthdata.com/).

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## Pucara de Tilcara, Residential Unit 1

Pucara de Tilcara (Til1) is an iconic site in northwestern Argentina and was the subject of several research projects throughout the last century [15,25–37]. It is located next to the confluence of the *Huasamayo* and *Grande* rivers, south of the modern town of Tilcara in the central segment of the main valley of Humahuaca (Fig 1) (23°35'11.10"S, 65°24'10.40"W). The site covers approximately 17.5 ha, extends over an 80 m high promontory (Fig 2) [37], and could have been occupied by up to 1500 people. Settlement began on the lower hillslopes of the promontory, eventually spreading upwards to the peak around the late 13th century AD [38,39].

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Zooarchaeology of Residential Unit 1, Pucara de Tilcara Site (Jujuy, Argentina), ca. AD 1430-1536

**Table 1. Cultural sequence of the agropastoralist stage of Humahuaca, based on the synthesis proposed by Nielsen [4,16].**

| Archaeological Period | Major trends |
|---|---|
| Inka (ca. AD 1430–1536) | • Construction of large agricultural and storage facilities by the state.<br>• Demographic relocations, including previously uninhabited sectors. |
| Regional Developments II (ca. AD 1200–1430) | • Political integration of various settlements.<br>• Ranked corporate kin-groups<br>• Warfare and demographic concentration in the main valley continue.<br>• Economic intensification.<br>• Caravan trade<br>• Large settlements on defensible terrains. |
| Regional Developments I (ca. AD 900–1200) | • Factionalist competition and individual ranking.<br>• Warfare and demographic concentration in the main valley.<br>• Caravan trade<br>• Economic intensification |
| Formative (ca. 1000 BC–AD 900) | • Diffusion of agropastoral sedentary lifeways.<br>• Household level organization.<br>• Population loosely distributed across the main valley and tributaries. |

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Til1 is believed to have been the center of a middle-range polity [1] and a regional hub for distribution of diverse goods [15] during the Regional Developments II period. The site became a center for specialized crafts and may have been the paramount administrative center of the Humahuaca *wamani* (province) under the Inka Empire. Evidence of metallurgy, as well as of manufacture of non-utilitarian goods like pendants, plaques and ritual figurines (*illas*) made of different kinds of valves and stones (onyx, limestone, flint and alabaster), and, to a lesser extent, pottery and weaving were recovered from more than 50 groups of structures [40]. Occupation of Til1 ended during the 16th century, some decades after the fall of *Tawantinsuyu*.

Our zooarchaeological analysis is part of an ongoing research project directed by Clarisa Otero at the *Instituto Interdisciplinario de Tilcara* (*Universidad de Buenos Aires*), which continues on previous studies undertaken by Myriam Tarragó. In addition to other lines of research, Otero has reconstructed archaeological contexts of artifacts from the Pucara which are curated in museum collections [40]. It has been demonstrated that many households at the site were devoted to multi-craft production under the Inka [15]. The Imperial administration would have been in charge of providing artisans with food and raw materials [15] judging by the large agricultural facilities constructed at Humahuaca and nearby areas during the Inka Period [1,16]. Part of the food consumed at Til1 could have been produced at the agricultural complex of the Alfarcito-Ovejería area (Fig 1), and on the valley floor of the Grande River [15].

Our research focuses on the faunal collection from RU1, a compound structure located on the southwestern slopes of the promontory (Fig 2 and Fig 3). Tarragó conducted earlier fieldwork on this section of Til1 between 1988 and 1992, including the excavation of a large area of RU1 and an associated trash-dump (Midden 2) [35,36]. The southwestern slopes were selected because they were outside the restored and touristic sector of Til1, and neither were disturbed by previous research. Since 2006, Otero has been continuing fieldwork on RU1 [15,41].

RU1 consists of a series of conjoining enclosures built around a central courtyard (Enclosure 3.1, Fig 3) with a surface area of approximately 160 m². Most of RU1 was excavated down to the sterile horizon. Occupation strata (floors) were identified in all enclosures. Living floors were dated to *ca*. AD 1200–1500 [38] based on recent radiocarbon dates (Table 2), which include both Regional Developments II and Inka period occupations. However, analysis of radiocarbon dates and artefactual evidence indicate the predominance of Inka phase occupation [16], probably as a result of continuous settlement and floor sweeping, creating a true palimpsest (*sensu* Bailey [42]). The floors contained evidence of *in situ* activities such as food
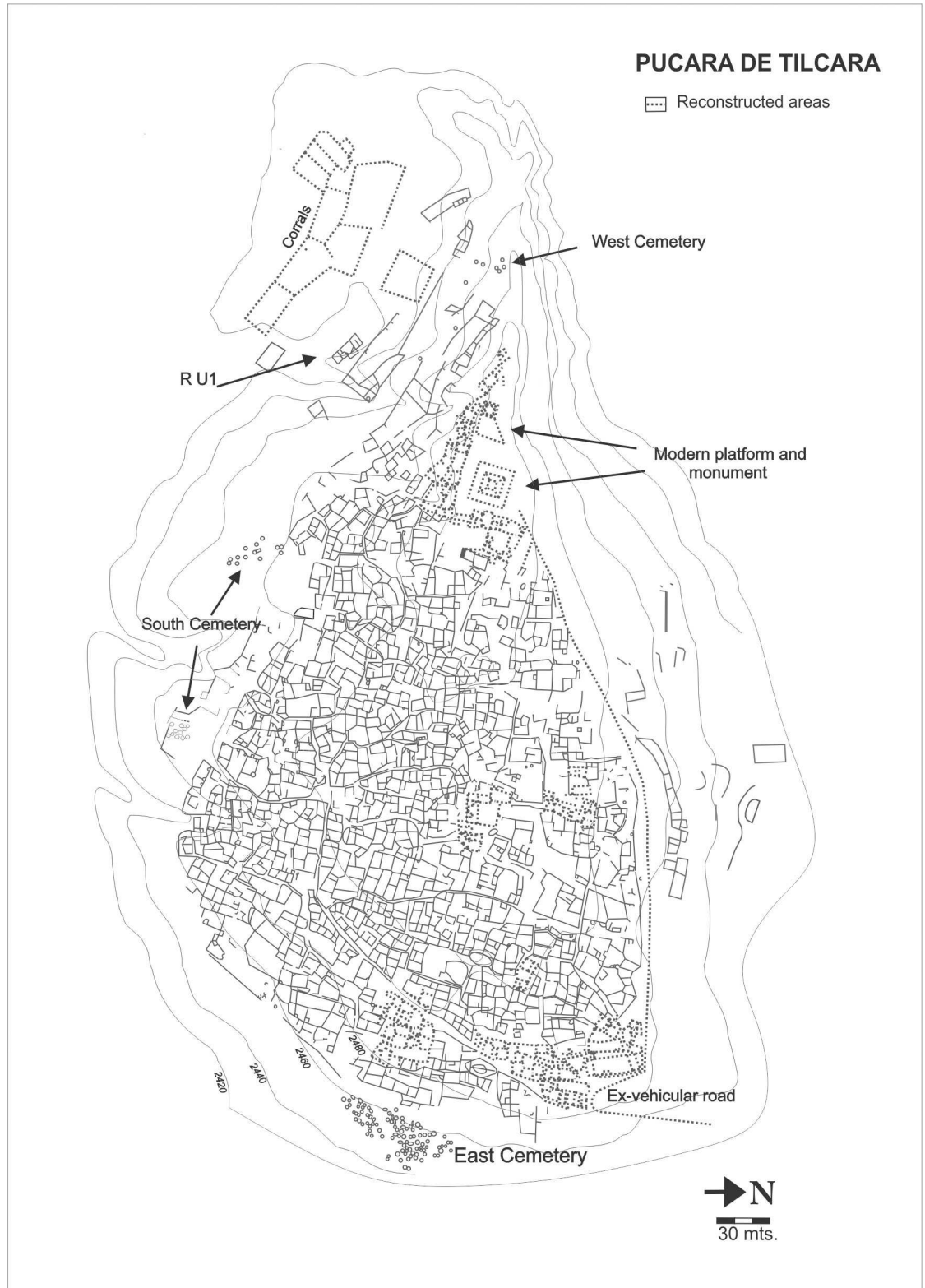
**Fig 2. Layout of the Pucara de Tilcara settlement and location of Residential Unit 1.** Source: Otero, C. 2015. Distribución y consumo de cerámica Inca en el Pucará de Tilcara (Quebrada de Humahuaca, Argentina). Chungara 47 (3), p. 402 (Figura 1), http://dx.doi.org/10.4067/S0717-73562015005000019.

**Fig 3. Residential Unit 1 (RU1), Midden 2 and excavated areas (gray).**

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preparation, knapping and use of lithic tools, pottery and metallurgy [15,28,34,36,41,43–45]. RU1 was characterized as a multi-functional space–a workshop-house–attached to the Inka administrators [15].

**Table 2. Radiocarbon dates from Til1-RU1.**

| Date | C14 dates (BP) | Calibrated dates (AD) 1σ | Calibrated dates (AD) 2σ |
|---|---|---|---|
| LP 2240 | 450±40 | • 1441–1499 (61.1%)<br>• 1599–1610 (7.1%) | • 1425–1513 (72.5%)<br>• 1547–1623 (22.9%) |
| LP 2231 | 450±50 | • 1436–1504 (54.7%)<br>• 1591–1615 (13.5%) | • 1419–1520 (65.3%)<br>• 1537–1626 (30.1%) |
| LP 2191 | 450±60 | • 1431–1508 (51.3%)<br>• 1585–1619 (16.9%) | • 1418–1627 (95.4%) |
| LP 2467 | 470±50 | • 1425–1498 (65.9%)<br>• 1602–1607 (2.3%) | • 1405–1513 (76.2%)<br>• 1545–1624 (19.2%) |
| AA88342 | 510±46 | • 1414–1455 (68.2%) | • 1395–1499 (94.3%)<br>• 1599–1609 (1.1%) |
| AA88340 | 512±41 | • 1418–1452 (68.2%) | • 1397–1484 (95.4%) |
| AA88341 | 561±42 | • 1400–1438 (68.2%) | • 1323–1346 (7.6%)<br>• 1388–1452 (87.8%) |
| AA89445 | 635±52 | • 1311–1359 (43.2%)<br>• 1380–1409 (25.0%) | • 1293–1425 (95.4%) |
| LP 247 | 800±50 | • 1225–1286 (68.2%) | • 1182–1313 (90.6%)<br>• 1358–1381 (4.8%) |
| LP 536 | 910±70 | • 1048–1083 (15.1%)<br>• 1139–1230 (49.0%)<br>• 1250–1261 (4.0%) | • 1033–1273 (95.4%) |

LP: Laboratorio de tritio y radiocarbono (LATYR, UNLP, CONICET). AA: NSF Arizona AMS Facility.

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RU1 is especially apt for exploratory research on the modes of procurement of faunal resources by craft specialists during the latest pre-Hispanic periods. Previous zooarchaeological research on Til1 amounts to a preliminary report on a sample from Midden 2 [44]. Only 127 bone fragments from a small sample of 343 specimens were identified, and these were predominantly camelids (NISP = 122, 96%), with five specimens of small rodents. The Camelidae subassemblage showed a marked predominance of appendicular skeletal elements from mature animals (88% based on epiphyseal fusion). Midden 2 is believed to have been accumulated in part by the inhabitants of Residential Unit 1.

## Animal exploitation at Humahuaca

Agropastoral societies from the South-Central Andes were highly specialized on three camelid species [46–50]: the wild southern vicuña (*Vicugna vicugna vicugna*) [51] and northern guanaco (*Lama guanicoe cacsilensis*) [52], and the domesticated llama (*Lama glama*) [53]. The current distribution of vicuña is restricted to elevations above 3500 m asl (Andean Plateau). The alpaca (*Vicugna pacos*) [53] is ill adapted to arid environments and thus is believed to have been absent from the study area [48]. Camelids were the main source of animal protein, grease and raw materials [49]; secondary exploitation included wool from wild and domestic animals, and llamas served as draft animals for caravan trade [7,46,54]. Camelid specimens contribute from 50 to 100% of identified bone specimens at Humahuaca agropastoral sites [55–73].

The mixed exploitation of wild and domestic species was characterized as a herding-hunting strategy by Yacobaccio *et al*. [47] and its ubiquity has been explained as a risk-aversion and livestock conservation strategy [47,74,75]. Pre-Hispanic pastoralism was monospecific [46,48] and domestic herds are vulnerable to yearly fluctuations due to environmental stress [76,77]. This pattern was reinforced by other practices, including intentional hybridization [78] and shearing of wild camelids [46].

Social organization of herding and hunting varied across different ecological zones and through time. At least two modes of indirect procurement of faunal resources–or camelids, to be precise- have been proposed for the central settlements of the main Humahuaca valley. First, Nielsen posited the existence of specialist transhumant herders since the Regional Developments II Period [7]. They would have settled at the higher tracts of tributary ravines next to the Puna, and in the Puna itself, in order to graze animals during the wet season (summer). They could have hunted wild camelids for immediate or delayed consumption (dried meat) during their stays. Pastoralists would travel down to the main valley during the harvest season, where herds could have been fed crop stubble and riverine vegetation. Nielsen hypothesized that herders belonged to the same nested kinship groups (*ayllus*) and domestic groups as the dwellers of the central settlements, and that exchange among them would have been enforced by reciprocal obligations [7].

Second, Otero proposed that the craft specialists of Til1 could have been provided with food by the Inka state. In addition, Mengoni Goñalons proposed that camelid carcasses and cuts were distributed from different origins based on three Inka assemblages in Humahuaca and the Calchaquí valley [66]. State-sponsored distribution of food among tributaries and retainers, at least for the duration of their service, was a well-established institution of *Tawantinsuyu* [10,24]. The Empire also allocated raw materials like wool among tributary households for production of finished goods [10,11]. Evidence of this system in northwestern Argentina includes large agricultural and storage facilities dated to the Inka Period [15,16,79]. Historical accounts affirm that the state and clergy possessed large herds of llamas (*capac llama*), which were in the care of tributary workers and specialist retainers [10,80,81]. In addition, the Inka exerted some regulation on hunting [46,82]. Our working hypothesis is that the dwellers of RU1 were provided with food by the imperial administration.

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## Materials and Methods

### Residential Unit 1

Fieldwork at RU1 combined test-pits and area excavations, covering approximately 127 m$^2$ or 79% of the total compound area (Fig 3). All sediment was sieved through screens with a mesh size of 1/8-inch (3.2 mm). Three main stratigraphic units were identified at each room: 1) *post-occupation fillings*, which included remains of collapsed walls that had rolled downhill from structures located above RU1; 2) *living floors*; and, 3) *underlying sterile layers*. Smaller features such as hearths, postholes, and trash middens were also found; most were part of the floor layers with others from later occupation.

A total of 1804 bone specimens were recovered from every stratigraphic unit of RU1 excavated between 1988 and 2009. This analysis is restricted to specimens from the occupation layer (floor) (NSP = 1171). The floor assemblage was probably the outcome of casual discard following preparation and consumption. Most specimens are less than 100 mm in length (% NSP = 95); larger and more obtrusive fragments may have been discarded outside living areas. The horizontal distribution of bones is irregular, with highest concentrations occurring at the R2 group of enclosures (NSP/m$^2$ = 22.5), followed in decreasing order by N4 (6.2), R3 (3.4), and R1 (0.1). Excavation records for Room 2.2 report bone concentrations near the structure walls. This pattern reinforces previous inferences [15] on the functional differentiation of rooms (see also [83]).

Table 3 tallies the number of analyzed specimens by body-size class (NSP) and Table 4 tallies the number of identified specimens (NISP) by taxon and size class. Size classes follow the scale published by Izeta for Northwestern Argentina [75,84]. This scale includes five classes: 1. small, *e.g. Ctenomys* sp. <0.5 kg; 2. small, *e.g. Lagidium viscacia* ~1.6 kg, *Chaetophractus vellerosus* ~0.8 kg; 3. medium, *e.g. Pterocnemia pennata* ~30 kg; 4. big, *e.g. V. vicugna vicugna* ~50 kg, *Lama* sp. ~70–120 kg; 9. indeterminate size.

Table 5 details the number of identified specimens (NISP) of the Camelidae sub-assemblage. The sub-assemblage is composed of 354 specimens. The highest Minimum Number of Individuals (MNI) was six (left humerus). Three camelid morphotypes were morphometrically identified: *Lama* sp. NISP = 20, *L. glama* NISP = 30 and *V. vicugna vicugna* NISP = 14. The maximum MNI values for specific morphotypes were: cf. *L. glama* MNI = 3 (left scaphoid), cf. *V. vicugna vicugna* MNI = 1 (right calcaneus). The *Lama* sp. morphotype includes specimens whose measures cluster with *L. guanicoe cacsilensis* and the smallest reference measurements for *L. glama*, and which therefore could belong to any of the two species.

### Methods

Distribution and exchange are important topics in the zooarchaeology of complex societies [12,14]. Three aspects of the zooarchaeological record are useful for approaching these topics

**Table 3. Number of analyzed specimens (NSP) from the living floors by body-size class.**

| Body size | NSP | |
|---|---|---|
| | Non-identified | Identified |
| 1–2 | 2 | - |
| 2 | - | 2 |
| 2–3 | 1 | - |
| 3–4 | 309 | 16 |
| 4 | 92 | 413 |
| 9 | 336 | - |
| Total | 740 | 431 |

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**Table 4. Number of taxonomically identifiable specimens (NISP) from the living floors.**

| Taxon | Body size | NISP |
|---|---|---|
| Artiodactyla: | | |
|   Artiodactyla indet. | 3–4 | 16 |
|   Artiodactyla indet. | 4 | 57 |
|   Camelidae | 4 | 354 |
|   Cervidae | 4 | 2 |
| Rodentia: | | |
|   Chinchillidae (*Lagidium viscacia*) | 2 | 2 |
| | Total | 431 |

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across a wide range of archaeological settings [12,14]: taxonomic diversity, age profiles, and frequency of skeletal elements. However, none of these variables is straightforward [85]; they require an approach using models and frames of reference relevant to the area and period under study. Fortunately, there is a growing body of data on Andean pastoralism from which to draw ideal patterns that can be compared with zooarchaeological data.

Usually, zooarchaeological assemblages in northwestern Argentina are characterized by low taxonomic diversity (predominance of Camelidae or of indeterminate artiodactyls) (see also [48,49]). However, demographic increase and population concentration in large settlements, craft specialization and Inkan subjugation could all possibly affect these measurements. For example, small prey items accumulated through foraging in rural settings (*e.g.* armadillos, rodents) could be missing from nucleated villages like Til1. On the other hand, the Inka purportedly introduced exploitation of two domestic species to northwestern Argentina, the cuy or guinea pig (*Cavia porcellus*) and the muscovy duck (*Cairina moschata*) [86]. Also, purported Inkan regulations on the hunting of wild camelids [10] could have resulted in a decreasing frequency of guanacos and vicuñas between the Regional Developments II and the Inka periods.

In terms of age-profiles, Wapnish and Hesse [87] posit that in a consuming economy where animals are acquired from pastoralists, mortality profiles should exhibit a relative abundance of market-age animals (after weight gain tapers off), or a marked seasonality if animals are provided by transhumant herders. Conversely, production sites should exhibit higher rates of very young and senile animals [87]. A similar approach could be applicable to Andean assemblages. Yacobaccio published a series of epiphyseal fusion profiles from modern Puna pastoralists [88] who practice a mixed exploitation of herds (production of fiber and meat). These profiles show survival rates over 80% for the first three years of development and could serve as a model for production sites of transhumant pastoralists.

Regarding consumption at central settlements of complex polities, faunal samples from Chavín de Huántar in the Central Andes (Janabarriu phase ca. 400–200 BC) show different mortality patterns [89]. High-status Sector D is characterized by a predominance of camelids

**Table 5. Number of taxonomically identifiable specimens (NISP) of the Camelidae sub-assemblage by morphotype.**

| Taxon | NISP |
|---|---|
| Camelidae indet. | 290 |
|   *Lama* sp. | 20 |
|     *Lama glama* | 30 |
|     *Vicugna vicugna vicugna* | 14 |
| Total | 354 |

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under 36 months old, while 60% of animals were sacrificed after four years of age at the low-status Sector A. Mengoni Goñalons [66] observed the preferential killing of immature camelids (2–3 years old) at Humahuaca sites of the Regional Developments II and Inka periods. On the other hand, Til1 exhibits abundant evidence for caravan trade [15], which would suggest a secondary production profile (predominance of old animals) [90,91]. As for wild animals, historical sources state that the Inka restricted vicuña hunting to the capture of living animals for shearing (*chacu*), and only the culling of old animals was allowed [46].

In terms of skeletal profiles, a skewed distribution of animal parts may be a potential proxy for exchange/distribution as long as consumers are provided with butchered anatomical units instead of complete carcasses (*e.g.* the selection of meatier or optimal anatomical portions, as well as spatial discontinuity for butchering stages) [14]. Preferential consumption of dried meat is another potential signature of distribution [89]. Drying is a traditional practice throughout the Andes, allowing for storage and delayed consumption of meat. The earliest model for distribution of dried meat was the *ch'arki* effect posited by Miller [89,92], which distinguishes high-altitude production locations from lower-altitude consumer sites. The former should exhibit a higher ratio of heads and lower limbs (metapodials, phalanges), while the latter should exhibit higher frequencies of post-cranial axial bones and of meatier upper limbs. This model has been criticized on the basis that there are various kinds of dried meat, which are termed differently throughout the Andes. For instance, Stahl distinguishes two main kinds [93]: 1) *chalona*, equivalent to Miller *ch'arki*, which is not deboned during preparation; 2) *ch'arki sensu stricto*, which is deboned. Skeletal or body parts profiles produced by *chalona* consumption should exhibit a positive correlation with utility and a negative correlation with structural bone density, while *ch'arki* consumption would be archaeologically invisible. Another useful frame of reference is the Drying Index published by De Nigris and Mengoni Goñalons [94], which ranks skeletal elements according to their potential for drying.

Lab analyses were carried out at the Casanova Archaeological Museum, following methods and techniques detailed previously [95]. Production of primary data included (S1 File): anatomical and taxonomic identification of bone specimens based on morphological criteria [96–101] (only specimens identified to order level or lower taxonomic rank were counted as identified); fusion of secondary ossification centers of endochondral bones [102–104] (age determination based on teeth was precluded for the lack of preserved tooth-rows); taphonomic signatures [105–107]; and, morphometric measurements of a sample of Camelidae postcranial elements [104,108] (S2 File). Measurements were compared to modern specimens from osteological collections [68,84,109,110] through a set of multivariate morphometric analyses following protocols by Menegaz *et al.* [111] and Izeta [84,112]. As a result, sampled archaeological specimens were classified into modern specific morphotypes.

Quantification of primary data included the following measures: 1) **Number of Specimens** (NSP, analyzed specimens) and %NSP; 2) **Number of Identifiable Specimens** (NISP, order or lower taxonomic level) and %NISP. Additional measures for the Camelidae sub-assemblage included: 1) Minimum Number of Elements (MNE), based on counts of long-bone ends and shaft fractions [113], and counts of shaft landmarks [106,114]; 2) Minimum Number of Individuals (MNI) [115,116]; 3) Minimum Animal Units (MAU, %MAU) for whole elements, derived from MNE [106,117,118]; 4) and a second set of %MAU values derived from Camelidae bone-density scan-sites [93].

Taxonomic diversity in the family rank is described using the NTaxa and equitability indices [119,120]. In addition, individual based rarefaction curves (based on zoological family) were produced for RU1 and other Regional Developments II—Inka residential assemblages with PAST (Paleontological Statistics, http://folk.uio.no/ohammer/past/) [121–123].

Additional analyses were undertaken for camelid specimens. First, epiphyseal data were classified into three fusion groups [66,88,124] based on published sequences [102,104] and analyzed with zooaRch [125]. Second, a series of Spearman's *rho* correlation analyses was conducted on the skeletal profile of Camelidae using Statistica 7.0 (Statsoft). These include correlations between scan-site %MAU vs. shape-adjusted volume density (VD$_{SA}$) [93,126]; and, element %MAU vs. Food Utility Index (FUI) [127], Medullary Cavity Volume (MCV) [128], and Drying Index (DI) [94].

## Results

### Taxonomic Diversity

Ungulates are predominant (Camelidae NISP = 354, Artiodactyla indet. NISP = 73) and the majority of unidentified fragments belongs to size-classes 3–4 (NSP = 401). Small vertebrates are almost absent from the assemblage (NSP = 5), which could be partially attributed to screen mesh-size. According to Thomas [119,129], there is an estimated loss of up to 64% for vertebrates weighing >700 g between 1/8-inch and 1/16-inch meshes. However, factoring NSP for size-classes 1–2 by the estimated loss gives an additional NSP of only nine specimens.

Camelidae is the dominant taxon at the family rank (%NISP 99.5), which is reflected also by richness (NTaxa 3) and the Equitability Index (V' 0.06). A predominance of Camelidae is common in almost every agropastoralist assemblage from northwestern Argentina (*ex supra*). It is similar to Midden 2 in this respect, which also exhibited a marked predominance of Camelidae. Fig 4 plots rarefaction curves (family) for RU1 and other faunal assemblages recovered from residential contexts spanning the Regional Developments II–Inka periods: Los Amarillos unit 400 (LAu400) [59], La Huerta enclosure 353 (LHr353) [67], and La Silleta (LSill) [73].

The RU1 rarefaction suggest a low equitability for RU1 in comparison to LAu400 and LH353. In addition, interpolation with LAu400 is indicative of lower richness. However, the 95% Confidence Intervals of the RU1 rarefaction overlap with those of the remaining assemblages. Finally, none of the species that could be diagnostic of state-sponsored distribution during the Inka regime were found at RU1 (*e.g. C. porcellus*, *C. moschata*). In sum, the RU1 floor assemblage is taxonomically similar to other agropastoral sites from Humahuaca since the Regional Developments II period.
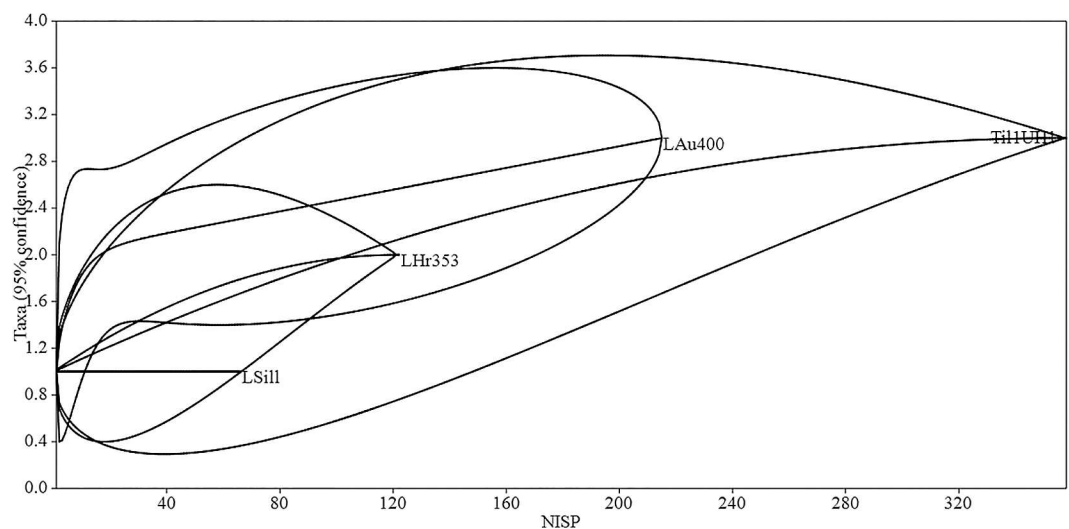


**Fig 4. Rarefaction curves for Residential Unit 1, Los Amarillos unit 400, La Huerta enclosure 353 and La Silleta.**

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Co-occurrence of both llama and vicuña is indicative of the aforementioned herding-hunting strategy. Vicuña bones indicate also the exploitation of the Humahuaca higher ravines and the Puna. Other evidence of hunting includes obsidian projectile points and waste flakes found on the living floor of RU1 and sourced to Puna outcrops [43].

## Camelidae

The analysis of mortality and skeletal profiles focuses on Camelidae, as it is the most abundant taxon. However, morphometric identification of specific morphotypes was restricted to a small sample of the Camelidae sub-assemblage due to taphonomic processes affecting the preservation of measurable elements (NISP = 64, %NISP = 18). Therefore, quantification was necessarily restricted to the family taxonomic rank in order to obtain an assemblage amenable to statistical analyses. This is the standard procedure of zooarchaeological studies carried out in the South-Central Andes, but a methodological corollary is that most quantifications will average the outcome of hunting and pastoralism as the Camelidae assemblage would include bones from domestic (*L. glama*) and wild (*V. vicugna*) species.

Camelid bones were heavily fragmented (%NISP broken bones = 65); the only unbroken specimens were phalanges, carpals and tarsals. High levels of fragmentation are a common occurrence in faunal assemblages from northwestern Argentina and, although non-cultural agents cannot be dismissed, it is plausible that at least some breakage was due to butchering. Yacobaccio *et al.* [90] observed that Highland pastoralists boiled most carcasses, breaking long bones into three or four pieces to fit into pots (pot-sizing). This practice facilitates the addition of bone marrow to available food resources [90]. The same practice was recorded by Miller, who observed how upper limb bones could be broken in as much as five or six pieces [92]. Another hypothesis for breakage is fat extraction by boiling bone splinters [130]. Optimal extraction could be reached by boiling ≤5 cm long splinters for approximately two hours [131].

Fragmentation ratios for green and non-green breaks from limb bones (NISP:MNE) [105,132] range between 2.5 (Tibia) to 3.7 (Femur). For long bones, there were more fractures on green bones (NISP = 57) than non-green or columnar breaks (NISP = 36). The average length of splinters from green bones is 67.35 mm (Std. dev. 27.83 mm). It is relevant for both the pot-sizing and fat extraction hypotheses that 5170 potsherds were recovered at RU1. Partially refited vessels (n = 250) were classified as cooking and serving wares with mouth-diameters between 35–40 and 60 cm [15]. There is insufficient evidence to attribute fragmentation to either hypothesis, given that bone splinters are small, yet above the optimal size for fat-extraction. Nevertheless, intensive exploitation of in-bone nutrients seems plausible.

The assemblage exhibits post-mortem modifications that in many cases are diagnostic of human behavior. Butchering marks were recorded on 23 specimens (%NISP 6.5). This figure is low in comparison to experimental studies (*e.g.* [133]) and many archaeological cases (*e.g.* [106,134]), but falls within the range exhibited by other domestic assemblages from agropastoral sites of northwestern Argentina (*e.g.* [55,75,95]). It has been observed that butchering mark frequencies are highly variable and that one relevant factor could be intensive fragmentation (*ex supra*) [135]. Cutmarks were compared to actualistic studies for interpretation [118,136,137]. Six specimens present filleting marks (scapulae NISP 5, humerus NISP 1), three specimens show disarticulation marks (radius-ulna NISP 1, tibia 1). Indeterminate cutmarks were recorded for ten specimens, including ribs, radius-ulna and basipodia. Flake-scars and percussion pits were recorded for five long-bone splinters (radius-ulna, metatarsals and humerus). Filleting marks could be indicative of *in situ* defleshing for preparation and consumption.

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**Table 6. Number of identified specimens (NISP) by epiphyseal fusion and fusion group, and survivorship (%NISP).**

| Fusion group | Elements | NISP | | %NISP Fused (Survivorship) |
|---|---|---|---|---|
| | | Unfused | Fused | |
| A (< 12–18 months old) | Innominate (acetabulum), distal humerus, distal scapulae. | 2 | 8 | 80 |
| B (< 18–36 months old) | Proximal phalanges, calcaneus (tuberosity), distal tibia, distal metapodial. | 28 | 69 | 71 |
| C (< 36–48 months old) | Distal radius-ulna, proximal humerus, proximal femur, distal femur, proximal tibia. | 6 | 5 | 45 |

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**Age-profile.** Table 6 tallies the number of specimens by stage of epiphyseal fusion and Fig 5 plots the resulting survivorship curve, including modern values for the fiber-meat mixed strategy [88]. The profile shows a high rate of camelid survival at least until the second year (71%), followed by a marked decrease toward the third year, which is an opposite trend to natural mortality in modern herds [77] and below that of the mixed fiber-meat strategy [88].

A similar but more accentuated decline of survivorship was observed at Esquina de Huajra, which Mengoni Goñalons interpreted as a young or immature-oriented mortality profile resulting from a surplus of young animals [66]. Selection of domestic animals for reproduction or for training as draft animals takes places between the animal's second and third years. A survival rate of 45% for group C could reflect an equilibrium between secondary and primary production, *i.e.* a mixed strategy, but more biased towards meat production. However, the confidence interval for group C of RU1 is too wide and the resulting survival rate could be a sampling artifact (Type I error).
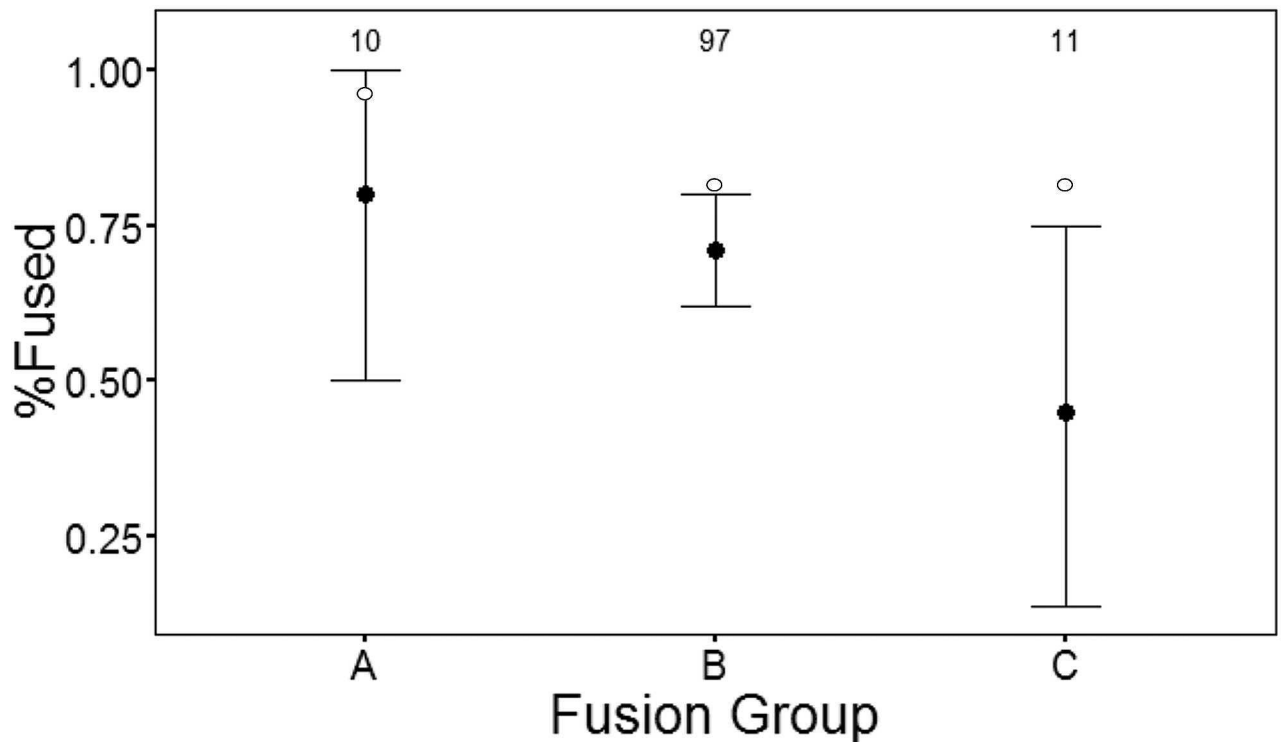


**Fig 5. Survival curve for the RU1 Camelidae sub-assemblage.** Black dots: frequency of fused bones by fusion group (survival). Whiskers: confidence intervals for survival. White dots: survival values from modern pastoral sites.

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The bulk ratio of fused elements (%NISP 69) is below that of Midden 2 (%NISP 88) [44], pointing to a moderately lower degree of livestock conservation. However, it must be observed that the Midden 2 report does not classify specimens by fusion groups and comparison is thus unwarranted.

**Skeletal profile.** Table 7 tallies the abundance of skeletal elements (NISP, MNE, MNI, and MAU) and Fig 6 plots the standardized Minimum Animal Units (%MAU) for Camelidae. A higher frequency of limb bones is clear, especially for the first phalanx, humerus, radio-ulna, metapodial, and tarsus. This pattern is the opposite of that observed at modern pastoralist sites [90,138], but it is not uncommon for archaeofaunas from northwestern Argentina [95]. In addition, it does not conform to the *ch'arki* effect suggested by Miller [89,92]. Overabundance of phalanges at RU1 could be attributed to transport of these elements as riders of meatier limb bones [130].

On a side note, the NISP skeletal profile of RU1 is similar to that of Midden 2; a Spearman's $r$ correlation between them was strong and significant (%NISP by element, $r_s = 0.678$, p. $<$ 0.01), reinforcing the hypothesis of an interconnected taphonomic history. However, a comparison based on %MAU or %MNE would be preferable to one based on NISP as the latter is influenced by fragmentation, but the original report on Midden 2 includes neither of the former measures.

An intra-bone Spearman r correlation analysis was conducted on scan-site %MAU vs. bone density ($VD_{SA}$) for single elements with $> 3$ *scan-sites* to monitor for density-mediated attrition [93,126]. The correlations were weak to moderate and non-significant, except for the mandibles (Table 8).

Table 9 resumes a series of Spearman's $r$ correlation analyses on %MAU against various utility indices (Food Utility, Marrow Cavity Volume and Drying) and bone density (VDsa). The Food Utility Index (FUI) for non-long bones and the Drying Index (DI) show strong and significant correlations (reverse utility curves). The former is problematic as it includes the highest ranking elements (ribs), which simultaneously are both hard to identify beyond the ordinal level [93] and more sensitive to attritional processes [139]. Marean and Frey propose conducting correlation analyses on long bones counts based on both articular ends and shaft fragments to avoid these issues [139]. The correlation obtained following their protocol was moderate and positive, but non-significant, suggesting an unbiased strategy. Neither the FUI nor the structural density correlations conform to the profiles proposed by Stahl [93] for *chalona* production or consumption sites.

A negative correlation between skeletal profile and Drying Index was observed by Mengoni Goñalons at other assemblages dated to the Inka period [66]. This reverse curve suggests two scenarios: 1. dwellers of RU1 were fed with fresh cuts from animals used to produce both fresh and dried meat, a hypothesis previously suggested by Mengoni Goñalons for other assemblages [66]; and, 2. RU1 produced dried meat to be consumed at another location or by different consumers.

## Discussion

Sociocultural complexity requires the allocation of resources among diverse and specialized social subsystems. This could be accomplished through diverse institutions, from reciprocity and barter to markets and state-sponsored distribution. Market exchange was foreign to the pre-Hispanic Andes and the peasantry usually retained dominion over their means of production under different social formations [9,10]. Even retainers expatriated from their ethnic communities were granted small shares of land for subsistence [11]. Supra-household economic cooperation was attained through different kinds of reciprocity, communal duties, and labor tributes [8,9].

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**Table 7. Skeletal profile of the Camelidae sub-assemblage.**

| Element | NISP | MNE | MNI | MAU | %MAU |
|---|---|---|---|---|---|
| Cranium | 12 | 2 | 2 | 2.0 | 26.2 |
| Mandible | 4 | 2 | 1 | 2.0 | 26.2 |
| Teeth | 3 | 3 | 1 | 0.0 | 0.0 |
| Hyoid | 1 | 1 | 1 | 1.0 | 13.1 |
| Atlas | – | 0 | 0 | 0.0 | 0.0 |
| Axis | – | 0 | 0 | 0.0 | 0.0 |
| Cervical V. | 2 | 1 | 1 | 0.2 | 2.2 |
| Thoracic V. | – | 0 | 0 | 0.0 | 0.0 |
| Lumbar V. | 3 | 1 | 1 | 0.1 | 1.9 |
| Sacrum | – | 0 | 0 | 0.0 | 0.0 |
| Caudal V. | 1 | 1 | 1 | 0.0 | 0.0 |
| Sternebra | 1 | 1 | 1 | 0.2 | 2.2 |
| Ribs | 23 | 5 | 1 | 0.2 | 2.7 |
| Scapula | 14 | 7 | 5 | 3.5 | 45.9 |
| Innominate | 7 | 3 | 2 | 1.5 | 19.7 |
| Humerus | 26 | 10 | 6 | 5.0 | 65.6 |
| Radius-Ulna | 22 | 7 | 4 | 3.5 | 45.9 |
| Lunar | 3 | 3 | 2 | 1.5 | 19.7 |
| Cuneiform | 1 | 1 | 1 | 0.5 | 6.6 |
| Magnum | 4 | 3 | 3 | 1.5 | 19.7 |
| Pisiform | 2 | 2 | 1 | 1.0 | 13.1 |
| Scaphoid | 4 | 4 | 3 | 2.0 | 26.2 |
| Trapezoid | 2 | 2 | 1 | 1.0 | 13.1 |
| Unciform | 4 | 4 | 3 | 2.0 | 26.2 |
| Metacarpals | 4 | 3 | 2 | 1.5 | 19.7 |
| Femur | 15 | 4 | 3 | 2.0 | 26.2 |
| Patella | 2 | 2 | 1 | 1.0 | 13.1 |
| Tibia | 10 | 4 | 3 | 2.0 | 26.2 |
| Astragalus | 12 | 10 | 6 | 5.0 | 65.6 |
| Calcaneus | 6 | 4 | 3 | 2.0 | 26.2 |
| Navicular | 7 | 7 | 5 | 3.5 | 45.9 |
| Cuboid | 5 | 5 | 4 | 2.5 | 32.8 |
| Ectocuneiform | 2 | 2 | 1 | 1.0 | 13.1 |
| Malleolus | 2 | 2 | 2 | 1.0 | 13.1 |
| Metatarsals | 3 | 3 | 3 | 1.5 | 19.7 |
| Metapodial | 46 | 11 | 3 | 2.7 | 36.1 |
| Sesamoid | 10 | 10 | 1 | 0.6 | 8.2 |
| Phalanx 1 | 66 | 61 | 8 | 7.6 | 100.0 |
| Phalanx 2 | 20 | 20 | 4 | 2.5 | 32.8 |
| Phalanx 3 | 5 | 5 | 2 | 0.6 | 8.2 |

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The beneficiary and organizer of reciprocal services or labor tributes was obliged to provide food and drink to Andean laborers [8], and the *Tawantinsuyu* was no exception [10,24]. Production and storage of staple goods to sustain armies, tributaries, and full-time specialists, as well as for ritual and political events, was a top priority for Inka rulers [24]. The state and the church possessed large herds of llamas and alpacas, and the former declared itself the owner of all wild camelids [10,24,81]; domestic camelids were used to produce wool that was later
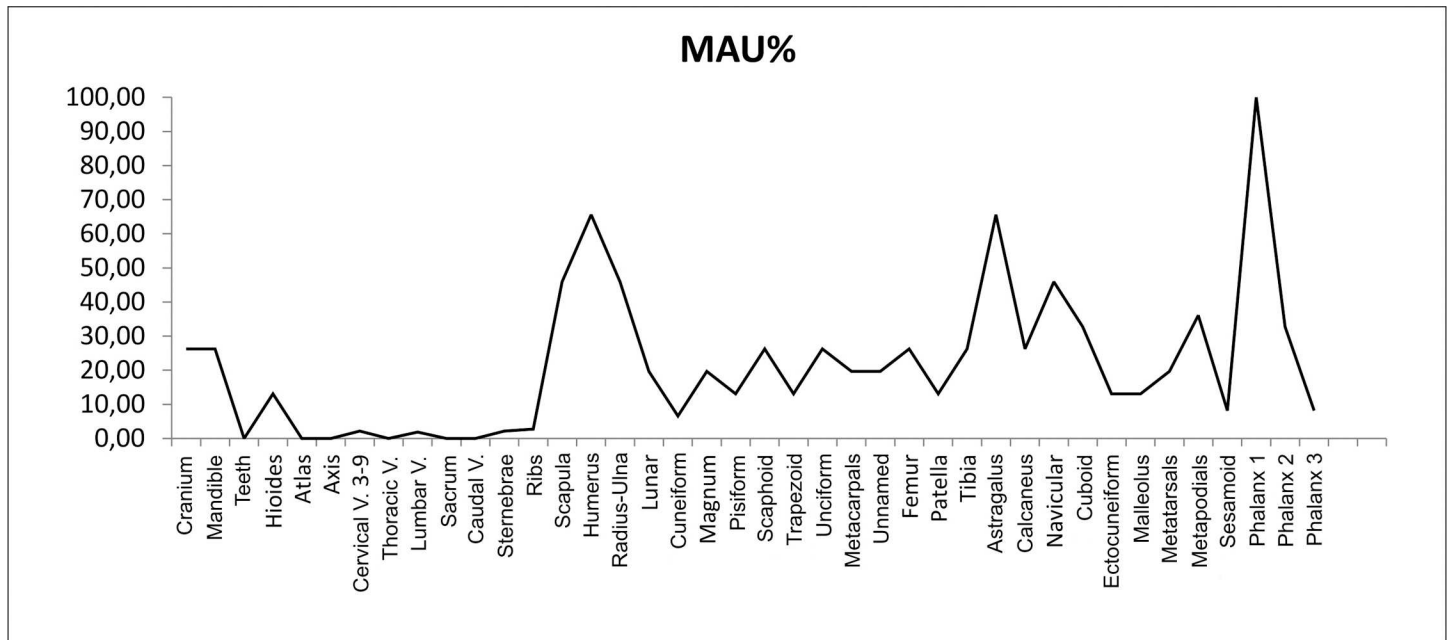
**Fig 6. Camelidae Skeletal profile (%MAU).**

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distributed among tributary households for textile production [11], as draft animals for the armies and to produce fresh and dried meat [10]. Vicuñas were captured alive for shearing (*chacu*) from whose wool attached specialists (*aclla*) made fine fabrics (*cumbi*), while guanacos were hunted for production of dried meat [10,46].

State distribution of animal goods or resources existed alongside traditional peasant patterns of property and the exploitation of communal herds (*waccha llama*) [10,81]; day to day subsistence was largely in charge of the peasantry itself. Craft specialists could have been provisioned on a more regular basis by the state, especially if they practiced a complex productive process like metallurgy [11]. It is also possible that specialists continued acquiring faunal resources

Table 8. Spearman correlation ($r_s$) of %MAU vs. VDsa (bone density) for elements of the Camelidae sub-assemblage with >3 scan-sites.

| Element | Scan-sites | $r_s$ | p. <0,05 |
|---|---|---|---|
| Mandible | 8 | 0.866 | 0.005 |
| Ribs | 5 | 0.224 | 0.718 |
| Scapula | 4 | -0.105 | 0.895 |
| Humerus | 5 | 0.667 | 0.219 |
| Radius-Ulna | 5 | -0.087 | 0.870 |
| Metacarpal | 6 | -0.507 | 0.305 |
| Innominate | 7 | 0.493 | 0.261 |
| Femur | 6 | 0.088 | 0.870 |
| Tibia | 5 | -0.154 | 0.805 |
| Calcaneus | 4 | -0.775 | 0.225 |
| Metatarsal | 6 | -0.414 | 0.414 |

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Table 9. Spearman $r$ ($r_s$) correlation analyses of %MAU against shape-adjusted density values and utility indices.

| Correlation analysis | $r_s$ | p. < 0.05 |
|---|---|---|
| %MAU vs. FUI (whole skeleton) | -0.38 | 0.11 |
| %MAU vs. FUI (non long bones) | -0.71 | 0.02 |
| %MAU vs. FUI (long bones) | 0.50 | 0.31 |
| %MAU vs. MCV | -0.75 | 0.08 |
| %MAU vs. DI | -0.68 | <0.01 |
| scan-site %MAU vs. VDsa | -0.06 | 0.56 |

doi:10.1371/journal.pone.0163766.t009

through traditional kin-networks and reciprocal obligations. As pointed out by deFrance [13], pre-modern complex polities often left traditional subsistence mechanisms barely touched.

Two main modes of distribution of faunal resources have been posited for the larger central settlements of Humahuaca during the Regional Developments II and Inka periods. One suggests reciprocal exchange between specialist transhumant herders and consumers belonging to the same domestic groups or kin-groups, a pattern that should be included into a broader system of vertical control of ecological zones [7]. Another posits the centralized distribution of food-staples and faunal resources among attached specialists during the Inka Period [15].

Zooarchaeology coupled with contextual information and settlement patterns is a potential avenue for understanding the modes of distribution deployed by the Inka state. The faunal assemblage from the living floor of Residential Unit 1 was a potentially informative case-study on the modes of procurement of faunal resources during this period as the architectural compound hosted both domestic and specialized craft activities, the latter under the patronage of the Imperial administration. Three main proxies of distribution and exchange of animal products at urban settings were selected for this work following the relevant literature: taxonomic diversity, skeletal profiles and age-profiles.

Taxonomic diversity at RU1 is low but well within the normal values of agropastoralist sites since the Formative Period across northwestern Argentina. In addition, there is no trace of any domestic species, like *C. porcellus*, potentially introduced by the Inka. This suggest a strong techno-economic continuity from previous periods, regardless of the mode of acquisition of faunal resources. The same can be said for other sites subjugated by the Inka, like Pucara de Volcán, Esquina de Huajra and La Huerta [63,64,66]. Nonetheless, sampling problems cannot be discarded as the low equitability of the record implies that marginal taxa could be missed from all but the largest assemblages. Regarding wild camelids, the recovery of obsidian projectile points and waste flakes at RU1 demonstrates exploitation of Puna environments and suggest a strong relationship with transhumant herders. Obsidian knapping together with vicuña faunal remains has been recorded at other sites from intermontane valleys since the beginning of the Formative Period across northwestern Argentina [140,141], pointing again to a strong continuity.

The Camelidae survivorship curve shows rates below those of modern herders who practice a mixed strategy, possibly implying a greater emphasis on meat production. The increased mortality of camelids between two and three years of age could reflect the selection of young animals or the culling of surplus [66]. On the other hand, fusion groups A and C amount to a few specimens and their confidence intervals are too wide, making it difficult to discriminate between RU1 and other archaeological or actualistic profiles.

Filleting marks, green breaks and the recovery of cooking wares are indicative of *in situ* preparation and consumption. Correlation analysis of long-bone FUI suggests an unbiased selection of skeletal elements, while the strong and negative correlation with the drying index

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suggest two scenarios: 1. provision of fresh-cuts from carcasses used to produce *chalona*, and, 2. the local production of *chalona* to be consumed elsewhere. This is counterintuitive, as hunting of wild camelids in the Puna would display a positive correlation, and the same as distribution from state deposits. Therefore, local production of *chalona* seems at first glance to be the more parsimonious hypothesis. Dried meat can be produced at a wide range of altitudes below the Highlands or Puna [93]. *Chalona* could have been produced as part of the corvée, since dried meat made from wild camelids was listed as one of the animal products given in tribute to the Inka [10].

## Conclusions

The faunal assemblage from RU1 shows remarkable continuities with sites and localities prior to the Inka Period. Taxonomic diversity on the family and species levels was low and broadly similar to other residential units dated to ca. AD 1200–1536, as well as to most agropastoral sites from semiarid intermontane valleys in northwestern Argentina. The skeletal profile of Camelidae was neither indicative of differential access nor of centralized distribution; negative correlation with the Drying Index could be interpreted in terms of local production of dried meat (*chalona*) for consumption elsewhere. Fusion-based survivorship data showed a mixed pattern and a slight increase of mortality for camelids around three years-old.

In sum, evidence reviewed here does not support the hypothesis of change to state-sponsored distribution for the Inka Period. On the contrary, continuity with the Regional Developments II Period is the most ostensible pattern. Further research on Til1 and other contemporaneous sites is required for evaluation of the results and conclusions reached here.

## Supporting Information

**S1 File. Identification.** Anatomic, taxonomic and taphonomic identification of bone specimens from RU1.
(XLSX)

**S2 File. Morphometry.** Morphometric measurements of camelid specimens from RU1.
(XLSX)

## Acknowledgments

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## References

1. Tarragó MN (2000) Chacras y Pukara. Desarrollos sociales tardíos. In: Tarragó MN, editor. Los Pueblos Originarios y la Conquista. Buenos Aires: Editorial Sudamericana. pp. 257–300.

2. DeMarrais E (2013) Understanding Heterarchy: Crafting and Social Projects in Pre-Hispanic Northwest Argentina. Cambridge Archaeological Journal 23: 345–362. doi: 10.1017/s0959774313000474

3. Acuto FA (2007) Fragmentación vs. integración comunal: Repensando el Período Tardío del Noroeste Argentino. Estudios Atacameños: Arqueología y Antropología Surandinas 34: 71–95.

4. Nielsen AE (2006) Plazas para los antepasados: Descentralización y poder corporativo en las formaciones políticas preincaicas de los Andes circumpuneños. Estudios Atacameños 31: 63–89.

5. Nielsen AE (2007) Celebrando con los antepasados. Arqueología del espacio público en Los Amarillos, Quebrada de Humahuaca, Jujuy, Argentina. Argentina: Mallku Ediciones.

6. González LR (2004) Bronces sin nombre. La metalurgia prehispánica en el noroeste argentino. Buenos Aires: Ediciones Fundación Ceppa.

7. Nielsen AE (2009) Pastoralism and the Non-Pastoral World in the Late Pre-Columbian History of the Southern Andes (1000–1535) Nomadic Peoples 13: 17–35. doi: 10.3167/np.2009.130202

8. Mayer E (2004) Casa, chacra y dinero. Economías domésticas y ecología en los Andes. Lima: Instituto de Estudio Peruanos.

9. Espinoza Soriano W (2008) Economía política y doméstica del Tahuantinsuyu. In: Contreras C, editor. Economía prehispánica. Perú: Banco Central de Reserva del Perú, Instituto de Estudios Peruanos. pp. 315–442.

10. Murra JV (1978) La organización económica del estado inca. México D. F.: Siglo XXI.

11. Costin CL (1996) Craft production and mobilization strategies in the Inka empire. In: Wailes B, editor. Craft Specialization and Social Evolution: In Memory of V Gordon Childe. Philadelphia: The University Museum of Archaeology and Anthropology, University of Pennsylvania. pp. 211–255.

12. Gumerman G IV (1997) Food and complex societies. Journal of Archaeological Method and Theory 4: 105–139. doi: 10.1007/bf02428056

13. deFrance SD (2009) Zooarchaeology in Complex Societies: Political Economy, Status, and Ideology. Journal of Archaeological Research 17: 105–168. doi: 10.1007/s10814-008-9027-1

14. Crabtree PJ (1990) Zooarchaeology and complex societies: some uses of faunal analysis for the study of trade, social status and ethnicity. Archaeological Method and Theory 2: 155–205.

15. Otero C (2013) Producción, usos y circulación de bienes en el Pucará de Tilcara (Quebrada de Humahuaca, Jujuy). PhD Thesis. Buenos Aires: Universidad de Buenos Aires.

16. Nielsen AE (2001) Evolución social en la Quebrada de Humahuaca (AD 700–1536). In: Berberian EE, Nielsen AE, editors. Historia Argentina Prehispánica. Córdoba: Brujas. pp. 171–264.

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17. Aschero CA (2000) El poblamiento del territorio. In: Tarragó MN, editor. Los Pueblos Originarios y la Conquista. Buenos Aires: Editorial Sudamericana. pp. 17–59.

18. Yacobaccio HD (2001) La domesticación de camélidos en el Noroeste argentino. In: Berberian EE, Nielsen AE, editors. Historia Argentina Prehispánica. Córdoba: Editorial Brujas. pp. 7–40.

19. Lagiglia HA (2001) Los orígenes de la agricultura en la Argentina. In: Berberian EE, Nielsen AE, editors. Historia argentina prehispánica. Córdoba: Brujas. pp. 41–81.

20. Albeck ME (2000) La vida agraria en los Andes del Sur. In: Tarragó MN, editor. Los Pueblos Originarios y la Conquista. Buenos Aires: Sudamericana. pp. 187–228.

21. Scattolin MC (2006) De las comunidades aldeanas a los curacazgos en el Noroeste argentino. Boletín de arqueología PUCP 10: 357–398.

22. González AR, Pérez JA (1972) Argentina indígena, vísperas de la conquista; Halperin Donghi T, editor. Buenos Aires: Paidós.

23. Tarragó MN (2011) Poblados tipo pukara en Yocavil. El plano de Rincón Chico 1 (Catamarca, Argentina). Estudios Sociales del NOA / nueva serie 11: 33–61.

24. Rostworowski de Diez Canseco M (1999) Historia del Tahuantinsuyu. Lima: Instituto de Estudios Peruanos.

25. Ambrosetti JB (1908) Exploraciones arqueológicas en la antigua ciudad Pukará de Tilcara. Buenos Aires: Archivo del Museo Etnográfico, Facultad de Filosofía y Letras, Universidad de Buenos Aires.

26. Casanova E (1950) Restauración del Pucará. Buenos Aires: Facultad de Filosofía y Letras, Universidad de Buenos Aires.

27. Casanova E, Difrieri H, Pelissero N, Balbuena J (1976) Un corte estratigráfico en el Pucará de Tilcara. Actas y memorías del IV Congreso Nacional de Arqueología Revista del Museo de Historia Natural 3: 21–30.

28. Cremonte MB, Otero C, Gheggi MS (2009) Reflexiones sobre el consumo de chicha en épocas prehispánicas a partir de un registro actual en Perchel (Dto. Tilcara, Jujuy). Relaciones de la Sociedad Argentina de Antropología 34: 75–102.

29. Debenedetti S (1930) Las ruinas del Pucará de Tilcara, Quebrada de Humahuaca (Provincia de Jujuy). Buenos Aires: Facultad de Filosofía y Letras, Universidad de Buenos Aires.

30. Krapovickas P (1958–59) Un taller lapidario en el Pucará de Tilcara. Runa 9: 137–151.

31. Lafón CR (1969) Dos notas de arqueología Humahuaca. Etnia 9: 15–20.

32. Madrazo GB, Ottonello MM (1966) Tipos de instalación prehispánica en la región de la Puna y su borde. Olavarría: Museo Municipal de Olavarría "Dámaso Arce".

33. Madrazo GB (1969) Los sectores de edificación en el Pucará de Tilcara (Provincia de Jujuy). Etnia 9: 21–27.

34. Otero C, Cremonte MB (2014) Local ceramic technology of the Pucara of Tilcara during the inka period (Quebrada of Humahuaca, Argentina). Journal of Anthropological Archaeology 33: 108–118.

35. Tarragó MN, Albeck ME (1997) Fechados radiocarbónicos para el sector medio de la Quebrada de Humahuaca. Avances en Arqueología 3: 101–130.

36. Tarragó MN (1992) Áreas de actividad y formación del sitio de Tilcara. Cuadernos 3: 64–74.

37. Zaburlin MA (2009) Historia de ocupación del Pucará de Tilcara (Jujuy, Argentina). Intersecciones en Antropología 10: 89–103.

38. Greco C, Otero C (2015) The Chronology of Settlements with Pre-Inca and Inca Occupations Superimposed: The Case of Pucará De Tilcara (Humahuaca Gorge, Argentina). Archaeometry: n/a-n/a.

39. Otero C, Rivolta MC (2015) Nuevas interpretaciones para la secuencia de ocupación de Tilcara (Quebrada de Humahuaca, Jujuy). Intersecciones en Antropología 16: 145–159.

40. Otero C (2015) Distribución y consumo de cerámica inca en el Pucará de Tilcara (Quebrada de Humahuaca, Argentina). Chungara, Revista de Antropología Chilena 47: 401–414.

41. Otero C (2006) Análisis cerámico del Recinto de la Unidad 1, Sector Corrales del asentamiento urbanizado de Tilcara (SJuj Til1-UH1). Licenciate Thesis. Buenos Aires: Universidad de Buenos Aires.

42. Bailey GN (2007) Time perspectives, palimpsests and the archaeology of time. Journal of Anthropological Archaeology 26: 198–223.

43. Álvarez MR- (2004) Producción lítica en el Pukará de Tilcara. Mosaico: Trabajos en Antropología Social y Arqueología. Buenos Aires: Instituto Nacional de Antroplogía y Pensamiento Latinoamericano. pp. 25–33.

PLOS | ONE

Zooarchaeology of Residential Unit 1, Pucara de Tilcara Site (Jujuy, Argentina), ca. AD 1430-1536

44. Cicala B (1998) Ganadería de camélidos en el Pucará de Tilcara: avances en el estudio de una muestra ósea. In: Cremonte B, editor. Los desarrollos locales y sus territorios, arqueología del NOA y sur de Bolivia. Jujuy: Universidad de Jujuy. pp. 305–317.

45. Tarragó MN, González LR (1998) La producción metalúrgica prehispánica en el asentamiento de Til-cara (Provincia de Jujuy). Estudios preliminares sobre nuevas evidencias. In: Cremonte B, editor. Los Desarrollos Locales y sus territorios Arqueología del NOA y del sur de Bolivia. Jujuy: UNJU. pp. 179–198.

46. Vilá B (2012) Camélidos sudamericanos. Buenos Aires: Eudeba.

47. Yacobaccio HD, Madero CM, Malmierca MP, Reigadas MdC (1997–1998) Caza, domesticación y pastoreo de camélidos en la Puna argentina. Relaciones de la Sociedad Argentina de Antropología 22–23: 389–418.

48. Mengoni Goñalons GL (2008) Camelids in ancient Andean societies: A review of the zooarchaeologi-cal evidence. Quaternary International 185: 59–68.

49. Olivera DE (1997) La importancia del recurso *Camelidae* en la Puna de Atacama entre los 10.000 y 500 años A.P. Estudios Atacameños 14: 29–41.

50. Izeta AD (2008) Late Holocene camelid use tendencies in two different ecological zones of North-western Argentina. Quaternary International 180: 135–144.

51. Molina GI (1810) Saggio sulla Storia Naturale del Chili. Seconda edizione, accresciuta e arricchita di una nuova carta geografica e del ritratto dell' autore. Bologna: Masi.

52. Lönnberg E (1913) Notes on guanacos. Arkiv För Zoologi 8: 1–8.

53. Linnaeus C (1788) Systema naturae per regna tria naturae secundum classes, ordines, genera, spe-cies, cum characteribus, differentiis, synonymis, locis. Leipzig: Georg. Emanuel Beer.

54. Yacobaccio HD (2012) Intercambio y caravanas de llamas en el Sur Andino (3000–1000 AP). Come-chingonia, revista de arqueología 16: 31–51.

55. Mercolli PH, Olivera DE, Nielsen AE (2014) La explotación de camélidos en la Quebrada de Huma-huaca a comienzos del Período Tardío: el caso de Muyuna. Cuadernos del Instituto Nacional de Antropología y Pensamiento Latinoamericano—Series Especiales 2: 24–43.

56. Mercolli PH (2011) El truco está en la diversidad: estrategias de manejo pastoril en la Quebrada de Humahuaca, provincia de Jujuy, Argentina, entre el 900 y el 1.200 AD. Arqueología 17: 81–95.

57. Mercolli PH (2010) Estrategias de subsistencia en la Quebrada de Humahuaca, provincia de Jujuy. Dos casos de estudio relacionados al manejo ganadero y la trascendencia de la caza a través del tiempo en las sociedades humanas. In: Gutiérrez MA, De Nigris M, Fernández PM, Giardina M, Gil A et al., editors. Zooarqueología a principios del siglo XXI Aportes teóricos, metodológicos y casos de estudio. Buenos Aires: Libros del Espinillo. pp. 273–284.

58. Valda PA (2008) Análisis zooarqueológico del sitio Malka. Localidad de Tilcara (Quebrada de Huma-huaca, Provincia de Jujuy). San Salvador de Jujuy: Universidad Nacional de Jujuy.

59. Mercolli PH, Seldes V (2007) Las sociedades del Tardío en la Quebrada de Humahuaca. Perspecti-vas desde los registros bioarqueológico y zooarqueológico. In: Nielsen AE, Rivolta C, Seldes V, Váz-quez MM, Mercolli PH, editors. Producción y circulación prehispánicas de bienes en el sur andino. Córdoba: Editorial Brujas. pp. 259–276.

60. Mercolli PH (2004) Un aporte desde el estudio de las arqueofaunas de un sitio de la Quebrada de Humahuaca correspondiente al Periodo de Desarrollos Regionales. Licenciate Thesis. Buenos Aires: Universidad de Buenos Aires.

61. Hernández A (2015) Procesamiento y consumo de restos faunísticos en Antumpa: análisis zooar-queológico para una ocupación del Holoceno Tardío. Anuario de Arqueología, Rosario 7: 95–110.

62. Leoni JB, Sartori J, Fabron G, Hernández A, Scarafia G (2012) Aportes al conocimiento de las socie-dades aldeanas del período Temprano en la Quebrada de Humahuaca: una visión desde Antumpa. Intersecciones en Antropología 13: 117–131.

63. Madero CM (1993–94) Ganadería incaíca en el Noroeste argentino: análisis de la arqueofauna de dos poblados prehispánicos. Relaciones de la Sociedad Argentina de Antropología 19: 145–169.

64. Madero CM (1993) Explotación faunística, tafonomía y economía en Humahuaca antes y despues de los Yupanqui. In: Raffino R, editor. Inka: arqueología, historia y urbanismo del Altiplano Andino. Buenos Aires: Corregidor. pp. 145–168.

65. Valda P, Valda M (2012) Manejo ganadero en el Pucará de Volcán durante el Período Inca. Sector Meridional de la Quebrada de Humahuaca-Jujuy (Argentina). Arqueoantropológicas 2: 163–184.

66. Mengoni Goñalons GL (2013) El aprovechamiento de fauna en sociedades complejas: aspectos metodológicos y su aplicación en diferentes contextos arqueológicos del NOA. In: Williams VI,

Cremonte MB, editors. Al borde del Imperio, paisajes sociales, materialidad y memoria en áreas peri-féricas del Noroeste argentino  Buenos Aires:  Sociedad Argentina de Antropología. pp. 311–396.

**67.** Llago MA (2009) Análisis zooarqueológico del recinto 353 del sitio La Huerta, Huacalera. La Zaranda de Ideas Revista de Jóvenes Investigadores en Arqueología  5: 185–193.

**68.** Belotti López de Medina CR (2013) Usos económicos y rituales de la fauna en la región valliserrana del Noroeste argentino entre los inicios del periodo Temprano y hasta la conquista Inka (ca. 600 AC —1600 DC): zooarqueología del valle de Yocavil (Catamarca), centro y norte del Valle Calchaquí (Salta) y la Quebrada de Humahuaca (Jujuy). Buenos Aires: Universidad de Buenos Aires.

**69.** Olivera DE, Palma JR (1997) Cronología y registro arqueológico en el Formativo Temprano en la región de Humahuaca. Avances en arqueología  3: 77–100.

**70.** Palma JR, Olivera DE (1992–1993) Hacia la contrastación de un modeo arqueológico para el Forma-tivo regional en Humahuaca: el caso de Estancia Grande. Cuadernos del Instituto Nacional de Antro-pología y Pensamiento Latinoamericano  14: 237–259.

**71.** Yacobaccio HD, Catá MP (2006) El uso de camélidos en la Quebrada de Humahuaca (1100 DC). In: Olivera DE, Miragaya M, Puig S, editors. Actas del IV Congreso Mundial de Camélidos.

**72.** Yacobaccio HD (2010) Osteometría de llamas (*Lama glama* L.) y sus consecuencias arqueológicas. In: Gutiérrez MA, De Nigris M, Fernández PM, Giardina M, Gil A et al., editors. Zooarqueología a prin-cipios del siglo XXI Aportes teóricos, metodológicos y casos de estudio.  Buenos Aires:  Libros del Espinillo. pp. 65–75.

**73.** López Geronazzo LN (2015) Zooarqueología de sitios del centro-sur y norte de la Quebrada de Humahuaca, provincia de Jujuy. Manejo del recurso faunístico (ca. 1000 a 1536 d.C.). Licenciate Thesis. San Salvador de Jujuy: Universidad Nacional de Jujuy.

**74.** Escola PS (2002) Caza y pastoralismo: un reaseguro para la subsistencia. Relaciones de la Socie-dad Argentina de Antropología  27: 233–245.

**75.** Izeta AD (2007) Zooarqueología del sur de los valles Calchaquíes (Provincias de Catamarca y Tucu-mán, República Argentina). Análisis de conjuntos faunísticos del primer milenio A.D.  Oxford:  British Archaeological Reports.

**76.** Göbel B (1994) El Manejo del Riesgo en la Economía Pastoril de Susques. In: Elkin D, Madero CM, Mengoni Goñalons GL, Olivera DE, Reigadas MdC et al., editors. Zooarqueología de Camélidos. Buenos Aires: GZC. pp. 43–56.

**77.** Sotomayor Berrío MA (1984) La explotación ganadera en las comunidades campesinas. Allpanchis  20: 97–103.

**78.** Wing ES (1975) La domesticación de animales en los Andes. Allpanchis  8: 25–44.

**79.** González LR (2000) La dominación inca. Tambos, caminos y santuarios. In: Tarragó MN, editor. Los Pueblos Originarios y la Conquista.  Buenos Aires:  Editorial Sudamericana. pp. 301–342.

**80.** Murra JV (2002) Rebaños y pastores en la economía del Tawantinsuyu. El mundo andino: Población, medio ambiente y economía Lima: IEP-PUCP. pp. 308–327.

**81.** Valcárcel LE (1964) Historia del Perú antiguo. Lima: Juan Mejia Baca.

**82.** Vilá B (2014) Una aproximación a la etnozoología de los camélidos andinos. Etnoecológica  10: 1–16.

**83.** Stahl PW, Zeidler JA (1990) Differential Bone-Refuse Accumulation in Food-Preparation and Traffic Areas on an Early Ecuadorian House Floor. Latin American Antiquity  1: 150–169.

**84.** Izeta AD (2004) Zooarqueología del Sur de los Valles Calchaquíes: Estudio de conjuntos faunísticos del Periodo Formativo. PhD Thesis. La Plata: Universidad Nacional de La Plata.

**85.** Huelsbeck DR (1991) Faunal Remains and Consumer Behavior: What *is* Being measured? Historical Archaelogy  25: 62–76.

**86.** Rodríguez Loredo C (1997–1998) Estudio arqueozoológico del sitio Inca Potrero-Chaquiago, Barrios La Solana y Retambay, Andalgalá, Pcia. de Catamarca (Argentina). Relaciones de la Sociedad Argentina de Antropología  22–23: 203–245.

**87.** Wapnish P, Hesse B (1988) Urbanization and the Organization of Animal Production at Tell Jemmeh in the Middle Bronze Age Levant. Journal of Near Eastern Studies  47: 81–94. PMID: 16468198

**88.** Yacobaccio HD (2007) Andean camelid herding in the South Andes: ethnoarchaeological models for archaeozoological research. Anthropozoologica  42: 143–154.

**89.** Miller GR, Burger RL (1995) Our Father the Cayman, Our Dinner the Llama: Animal Utilization at Chavin de Huantar, Peru. American Antiquity  60: 421–458.

**90.** Yacobaccio HD, Madero CM, Malmierca MP (1998) Etnoarqueología de pastores surandinos.  Bue-nos Aires:  Grupo Zooarqueología de Camélidos.

PLOS | ONE

Zooarchaeology of Residential Unit 1, Pucara de Tilcara Site (Jujuy, Argentina), ca. AD 1430-1536

91. Kuznar LA (1990) Economic models, ethnoarchaeology, and early pastoralism in the high sierra of the south central Andes. PhD Thesis. Illinois: Northwestern University.

92. Miller RG (1979) An Introduction to the Ethnoarchaeology of the Andean Camelids. PhD Thesis. California: University of Califorinia, Berkeley.

93. Stahl PW (1999) Structural Density of Domesticated South American Camelid Skeletal Elements and the Archaeological Investigation of Prehistoric Andean Ch'arki. Journal of Archaeological Science 26: 1347–1368.

94. De Nigris ME, Mengoni Goñalons LG (2002) The guanaco as a source of meat and fat in the Southern Andes. In: Mulville J, Outram A, editors. The Zooarchaeology of Milks and Fats. Durham: ICAZ. pp. 160–166.

95. Belotti López de Medina CR (2015) Subsistence and Economy at the Calchaquí Valley (Salta, Argentina) during the Regional Developments Period (ca. 1000–1430 AD): Zooarchaeology of Las Pailas locality. Journal of Archaeological Science: Reports 4: 461–476.

96. Benavente A. MA, Adaro A. L, Gecele C. P, Cunazza P. C (1993) Contribución a la determinación de especies animales en arqueología: familia Camelidae y Taruca del norte. Santiago: Universidad de Chile, Vicerrectoría académica y estudiantil, Departamento Técnico de Investigación.

97. Galotta DR, Galotta JM (1988) Osteología del llama (*Lama glama guanicoe* f. d. *glama* Linnaeus, 1758). Revista de Ciencias Agrarias y de Tecnología de los Alimentos 9: 19–61.

98. Hillson S (2005) Teeth. Cambridge: Cambridge University Press.

99. Pacheco Torres VR, Altamirano Enciso A, Guerra Porras ES (1979) Guia osteológica de camélidos sudamericanos. Lima: Universidad Nacional Mayor de San Marcos.

100. Adaro LA, Benavente MA (1990) Identificación de Patrones Óseos de Camélidos Sudamericanos. Avances en Ciencias Veterinarias 5: 76–86.

101. Wheeler JC (1982) Aging llamas and alpacas by their teeth. Llama World 1: 12–17.

102. Burger RL, Salazar LC (2003) The 1912 Yale Peruvian Scientific Expedition Collections from Machu Picchu: Human and Animal Remains. New Haven: Yale University Publications in Anthropology.

103. Chaix L, Méniel P (2005) Manual de arqueozoología. Barcelona: Ariel.

104. Kent JD (1982) The domestication and exploitation of the South American camelids: methods of analysis and their application to circum-lacustrine archaeological sites in Bolivia and Perú. PhD Thesis. St. Luis: Washington University.

105. Lyman RL (1994) Vertebrate Taphonomy. Cambridge: Cambridge University Press.

106. Mengoni Goñalons GL (1999) Cazadores de guanacos de la estepa patagónica. Buenos Aires: Sociedad Argentina de Antropología.

107. Fisher JW Jr (1995) Bone surface modifications in zooarchaeology. Journal of Archaeological Method and Theory 2: 7–68.

108. Izeta AD, Srur MG, Labarca R (2012) Guía osteométrica de camélidos sudaméricanos. Córdoba: Universidad Nacional de Córdoba.

109. Elkin D (1996) Arqueozoología de Quebrada Seca 3: indicadores de subsistencia humana temprana en la Puna Meridional Argentina. PhD Thesis. Buenos Aires: Universidad de Buenos Aires.

110. Izeta AD, Otaola C, Gasco A (2009) Estándares métricos y variabilidad de falanges proximales de camélidos sudamericanos. Su importancia como conjunto comparativo para interpretaciones en arqueología. Revista del Museo de Antropología 2: 169–180.

111. Menegaz A, Salemme M, Ortiz Jaureguizar E (1988) Una propuesta de sistematización de caracteres morfométricos de los metapodios y las falanges de Camelidae. In: Ratto N, Haber A, editors. De procesos, contextos y otros huesos. Buenos Aires: FFyL-ICA. pp. 53–64.

112. Izeta AD (2010) Variabilidad osteométrica de camélidos de sitios arqueológicos del NOA. In: Gutiérrez MA, De Nigris M, Fernández PM, Giardina M, Gil A et al., editors. Zooarqueología a principios del siglo XXI Aportes teóricos, metodológicos y casos de estudio. Buenos Aires: Libros del Espinillo. pp. 29–38.

113. Klein RG, Cruz-Uribe K (1984) The Analysis of Animal Bones from Archaeological Sites. Chicago: The University of Chicago Press.

114. Morlan RE (1994) Bison Bone Fragmentation and Survivorship: a Comparative Method. Journal of Archaeological Science 21: 797–807.

115. Chaplin RE (1971) The Study of Animal Bones from Archaeological Sites. New York: Academic Press.

116. White TE (1953) A Method of Calculating the Dietary Percentage of Various Food Animals Utilized by Aboriginal Peoples. American Antiquity 18: 396–398.

117. Binford LR (1984) Faunal Remains from Klasies River Mouth. Orlando: Academic Press.

118. Binford LR (1981) Bones: ancient men and modern myths. New York: Academic Press.

119. Lyman RL (2008) Quantitative paleozoology. New York: Cambridge University Press.

120. Reitz EJ, Wing ES (1999) Zooarchaeology. Cambridge: Cambridge University Press.

121. Raup DM (1975) Taxonomic Diversity Estimation Using Rarefaction. Paleobiology 1: 333–342.

122. Tipper JC (1979) Rarefaction and rarefiction—the use and abuse of a method in paleoecology. Paleobiology 5: 423–434.

123. Gotelli NJ, Colwell RK (2001) Quantifying biodiversity: procedures and pitfalls in the measurement and comparison of species richness. Ecology Letters 4: 379–391.

124. De Nigris ME (2004) El consumo en grupos cazadores recolectores. Un ejemplo zooarqueológico de Patagonia meridional. Buenos Aires: Sociedad Argentina de Antropología.

125. Price M, Wolfhagen J, Otárola-Castillo E (2016) Confidence Intervals in the Analysis of Mortality and Survivorship Curves in Zooarchaeology. American Antiquity 81: 157–173.

126. Izeta AD (2005) South American camelid bone structural density: what are we measuring? Comments on data sets, values, their interpretation and application. Journal of Archaelogical Science 32: 1159–1168.

127. Mengoni Goñalons GL (1991) La llama y sus productos primarios. Arqueología 1: 179–196.

128. Mengoni Goñalons GL (1996) La domesticación de los camélidos sudamericanos y su anatomía económica. In: Elkin D, Madero CM, Mengoni Goñalons GL, Olivera DE, Reigadas MdC et al., editors. Zooarqueología de camélidos. Buenos Aires: GZC. pp. 33–45.

129. Thomas DH (1969) Great Basin Hunting Patterns: A Quantitative Method for Treating Faunal Remains. American Antiquity 34: 392–401.

130. Binford LR (1978) Nunamiut ethnoarchaeology. New York: Academic Press.

131. Church RR, Lyman RL (2003) Small fragments make small differences in efficiency when rendering grease from fractured artiodactyl bones by boiling. Journal of Archaeological Science 30: 1077–1084.

132. Norton CJ, Gao X (2008) Hominin–carnivore interactions during the Chinese Early Paleolithic: Taphonomic perspectives from Xujiayao. Journal of Human Evolution 55: 164–178. doi: 10.1016/j.jhevol.2008.02.006 PMID: 18387651

133. Egeland CP (2003) Carcass Processing Intensity and Cutmark Creation: An Experimental Approach. Plains Anthropologist 48: 39–51.

134. Lyman RL (2005) Analyzing cut marks: lessons from artiodactyl remains in the northwestern United States. Journal of Archaeological Science 32: 1722–1732.

135. Domínguez-Rodrigo M, Yravedra J (2009) Why are cut mark frequencies in archaeofaunal assemblages so variable? A multivariate analysis. Journal of Archaeological Science 36: 884–894.

136. Galán AB, Domínguez-Rodrigo M (2013) An Experimental Study of the Anatomical Distribution of Cut Marks Created by Filleting and Disarticulation on Long Bone Ends. Archaeometry 55: 1132–1149.

137. Nilssen PJ (2000) An actualistic butchery study in South Africa and its implications for reconstructing hominid strategies of carcass acquisition and butchery in the Upper Pleistocene and Plio-Pleistocene. PhD Thesis. Cape Town: University of Cape Town.

138. Madero CM, Yacobaccio HD (1994) El Registro Faunístico del Pastoreo Actual y sus Implicancias Arqueológicas. In: Elkin D, Madero CM, Mengoni Goñalons GL, Olivera DE, Reigadas MdC et al., editors. Zooarqueología de Camelidos. Buenos Aires: GZC. pp. 73–94.

139. Marean CW, Frey CJ (1997) Animal Bones from Caves to Cities: Reverse Utility Curves as Methodological Artifacts. American Antiquity 62: 698–711.

140. Belotti López de Medina CR (2011) Zooarqueología del sitio formativo Soria 2, valle de Yocavil (Catamarca), siglo I d.C. Revista del Museo de Antropología 4: 3–16.

141. Carbonelli JP (2011) "Motivos porque y para" en la tecnología lítica de un sitio formativo en el valle de Yocavil, provincia de Catamarca. Intersecciones en Antropología 12: 31–44.