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Rodent consumption by hunter-gatherers in north Patagonian Andean forests (Argentina): Insights from the small vertebrate taphonomic analysis of two late Holocene archaeological sites

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ABSTRACT

Modern taphonomic studies carried out upon small rodent assemblages from arid Patagonia demonstrates rodent consumption in several late Holocene archaeological sites. Conversely, very little is known about the exploitation of these small mammals by hunter-gatherers that inhabited the North Patagonia Andean forest (NPAF). Human occupation in forests dates back to late Pleistocene – early Holocene but its use was non-existent until the late Holocene (1700 years BP), when a more recurrent and/or more extended stays in the forest took place. In order to advance in the understanding of the subsistence strategies displayed by hunter-gatherers in Patagonian forests, human involvement in the accumulation of rodent bones was evaluated from two archaeological sites located in the NPAF: Paredón Lanfré (SW Río Negro) and Risco de Azócar 1 (NW Chubut). The taphonomic analysis included the estimation of the MNE and MNI, the relative abundance, and the representation of skeletal elements. Heat alteration of bone surface and the presence of cut marks and digestion traces were also evaluated. Caviomorpha rodents dominate the small vertebrate's assemblages. Thermal alteration and differential representation of skeletal pieces –over-representation of skulls and distal elements of the limbs- suggest that human consumption was the main cause of accumulation of these rodents. The consumed species were *Galea leucoblephara*, *Microcavia australis*, *Ctenomys haigi* and possibly also *C. sociabilis*. We concluded that this consumption seems to reflect the exploitation of low ranked prey individuals in a low productive environment.

1. Introduction

In previous decades, the exploitation of small animals has been a key issue in the zooarchaeological research, since these animals are sensitive indicators of human density-related processes, e.g. human population growth, sedentarization, and increasing environmental impact (Hockett and Haws, 2005; Janetsky, 1997; Munro, 2004; Steele and Klein, 2009; Stiner et al., 1999, 2000; Weissbrod et al., 2012). The range of small vertebrates exploited was varied, and includes lagomorphs, tortoises, birds and rodents and their relative importance was variable. While the first three were central at Mediterranean Basin and South Africa (Munro, 2004; Steele and Klein, 2009; Stiner et al., 1999, 2000), rodents were comparatively less relevant in these regions (Weissbrod et al., 2012). In the Americas, a region characterized by a low diversity of mammals, rodents represent an important proportion of the native land-mammal species (Patton et al., 2015; Wilson and Reeder, 2005) and they were a common staple at varied places and periods (Hesse, 1985; Labarca, 2005; Nelson et al., 2006; Reinhard et al., 2007; Rosenfeld, 2008; Shaffer, 1992; Simonetti and Cornejo, 1991; Yohe et al., 1991, among others). Even in the Central Andes, one of the caviomorpha species was domesticated (Spotorno et al., 2006; Wing, 1986) and is included in ritual ceremonies (Bolton, 1979; Sandweiss and Wing, 1997, among others).

In Northwestern Patagonia, at the east side of the Andes, the possibility that small rodents (<260 g live weight) had been consumed by human populations was a topic of debate since the first systematic faunal analysis. The remarkable abundance of rodent remains in many archaeological sites has prompted some authors to conclude that the exploitation of certain species could be possible (Bond et al., 1981; Ceballos, 1982, 1987; Fernández, 1988–1990; Hajduk and Albornoz, 1999; Sanguinetti de Bórmida and Curzio, 1996; Silveira and Massoia, 1996). Mainly based upon the differential representation of the larger

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species (e.g. Caviomorpha, Bond et al., 1981) and the cranial fracture pattern (Fernández, 1988–1990), previous analyses did not advance on the evaluation of other indicators to distinguish cultural from natural depositional agents. Also, the absence of specific evidences (like cut marks) that could associate them with consumption practices as was observed in other regions (Fernández-Jalvo et al. 1999; Medina et al., 2011; Quintana 2005; Quintana et al., 2002) maintained the uncertainty about human agency.

Nowadays, modern taphonomic studies carried out upon small rodent assemblages from arid Patagonia demonstrates rodent consumption in several Late Holocene archaeological sites. Based upon the presence of cut marks, tools manufactured on rodent bones, and thermal alteration, it was concluded that the cricetid *Holochilus brasiliensis* and Caviidae rodents were a complementary component of the diet of hunter-gatherers in two sites in the middle and lower Negro River valley (Fernández et al., 2011; Mange et al., 2016). The over-representation of skull bones and distal elements of the limbs, the high degree of fragmentation, and a defined pattern of thermal alteration observed on the small mammal assemblages from the Cueva y Paredón Loncomán archaeological site (Río Negro province) were evidences that the species *Ctenomys* sp. and *Microcavia australis* (and possibly also *Galea leucoblephara*) were exploited by hunter-gatherers since at least 2000 years BP (Andrade, 2015). The combination of taphonomic, historical and ethnographical studies allowed us to propose that rodents were intensively exploited and this practice continued in Patagonian populations until the last century (Andrade and Boschín, 2015). Although no specific taphonomic studies were performed on the small mammal fauna, consumption of Caviidae rodents was also proposed for Epullán Grande (Pardiñas and Teta, 2013); Epullán Chica (Fernández et al., 2016); Casa de Piedra de Ortega, Cueva Sarita IV (Pardiñas, 1999; Teta et al., 2005), and Campo Cerda 1 sites (Pardiñas, 1999) taking into account taxonomic representation, differential burning and breakage pattern.

Contrasting the increasing evidence of rodent consumption along arid Patagonia, very little is known about the exploitation of these small mammals by hunter-gatherers that inhabited North Patagonia Andean forest. In spite of the high frequency of rodents in several archaeological sites from this biome, until now no taphonomic analyses were carried out to determine the actors involved in those rodent accumulations. Availability of faunal resources in North Patagonian Andean forest is limited to two ungulates (pudú, *Pudu puda* and huemul, *Hippocamelus bisulcus*), a few carnivores (Puma, *Puma concolor*, Gray fox *Lycalopex griseus* and Culpeo fox L. *culpaeus*), and a high diversity of small vertebrates, especially rodents and birds. Indeed, ungulates are small (10–12 kg), solitary, and cryptic (*P. puda*, Meier and Merino, 2007) or, as *H. bisulcus*, establish small social groups (male, female and yearling, Vila et al., 2010). Otherwise, human occupation of northern Patagonian forest dates back to the Late Pleistocene–Early Holocene (Bellelli et al., 2013; Hajduk et al., 2006), but with a discontinuous temporal sequence; relatively continuous signals start after 3500 years BP, and increase their intensity after 1700 years BP (Fernández et al., 2013). Since this date, a more recurrent and/or more extended stays in the forest are suggested by archaeological and isotopic evidences (Fernández et al., 2013; Fernández and Tessone, 2014). Under these conditions, and taking into account the faunal resource structure, it is expected to see an increase in the hunting pressure on the huemul, intensifying their use, and/or the inclusion of small preys into the diet.

This paper is product of a research program that aims to reconstruct the taphonomic and paleoecological histories of small mammals from Northern Patagonia, comparing two particular habits: the humid forests and the arid steppe. Investigations were initiated in the steppe and first results were recently obtained (Andrade, 2015; Andrade and Boschín, 2015). The main objective in this case is to present a detailed taphonomic analysis performed on the small mammal assemblages from two archaeological sites located in North Patagonia Andean forests: Risco de Azócar 1 (RA1) and Paredón Lanfré (PL). Particularly, the main agents of deposition are evaluated and the possibility of human contribution in the deposition of caviomorph rodents is discussed.

2. The archaeological sites: stratigraphy and chronology

Archaeological sites RA1 and PL are located at the North Patagonian Andean forest, in the SW Río Negro and NW Chubut provinces, respectively (Fig. 1). The landscape in the area is characterized by mountain ranges (up to 2000–2500 m asl) and glaciofluvial valleys, covered by different forest types mainly related to the altitude and the deep rainfall gradient (Pereyra, 2003). *Nothofagus* spp. – *Austrocedrus chilensis* mixed forest is the dominant type when precipitation declines, and can be found around both sites. High-resolution pollen and charcoal records from Cóndor, Mosquito, and Huala Hué lakes, located between 45 and 11 km of RA1 and PL sites show that this forest type was already established at the time when sites were first occupied, ca. 1500 years BP (Iglesias et al. 2012a, 2012b). Nowadays, the steppe is about 20 km east of RA1 and 40 km from PL. The access to the steppe is easier from RA1 than from PL because of the presence of the Serrucho Norte mountain range (2100 m asl). Paleoenvironmental studies show that variable fire-regimes affected this forested area since the Pleistocene-Holocene transition (Iglesias et al., 2012a, 2012b). Coincidently, lithic and pot sherds affected by fire were observed in both sites.

Small vertebrates were the dominant faunal remains in both sites. Other taxa represented in the bone assemblages (excluding intrusive specimens) were -in order of importance- *Hippocamelus bisulcus* (huemul), *Pudu puda* (pudú), and *Lama guanicoe* (guanaco), the two last species only recovered in PL (Fernández and Andrade, in elaboration, Podestá et al., 2007).

2.1. Risco de Azócar 1 (RA1)

RA1 (42° 05′ S; 71° 21′ W, 240 m asl) is a rock shelter located in the floodplain of the Epuyén river, at the base of the Pirque Mountain. This river has recurrent floods that cover much of the floodplain. While there are no accurate records that the site would have been under water, it cannot be discarded due to possible flooding product of normal and extraordinary seasonal floods. The site measures 78 m of total length and extends over a rocky wall of granite porphyry. RA1 contain two sectors, differentiated by the presence of a rock collapse: Alero A (in the left), with rock art motifs, and two adjacent rock shelters, Alero B and C, both without rock art motifs. Archaeological materials were recovered in the three rock shelters (Table 1). Alero A (RA1A): Under the rock art motifs, three grids of 1 m × 1.5 m were excavated, with a maximum of 2.3 m depth. Archaeological evidences came from the first stratigraphic unit (Unit 1), which extends from the surface to ca. 1.1 m depth. It is characterized by sandy sediment with large amounts of organic matter, volcanic ashes, rock shelter blocks, and colluviums. This deposit was excavated by 10 cm artificial layers because no discontinuities were identified inside this unit. Unit 1 has low resolution, resulting of the combined effects of root growth, caves of fossorial animal, and earthworm activities (Podestá et al., 2007). Six samples of small charcoal concentrations were dated, giving ages between 820 ± 60 years (LP 1665) and 1690 ± 60 years BP (LP 1575). These charcoal samples could be product of background noise due to the frequent forest fires in the area; no hearth structures were identified. This makes it difficult to interpret the dates in terms of human presence at the site. So we considered these dates as Unit 1 sedimentary deposition rates (Podestá et al., 2007). Few archaeological materials were found in RA1A, among them animal bones, lithics -mainly (98%) debitage-, small pottery sherds -maximum length of 40 mm-, and pigments probably related to the rock art production (Table 1). Rodent remains were associated, spatial and vertically, with the archaeological materials. In the first 10 cm below the surface, modern bone material that belongs to *Ovis* sp. and *Lepus* sp. was also recovered, not related to the prehistoric occupation of the site (Podestá et al., 2007). Alero B (RA1B): One 1 × 1 m grid

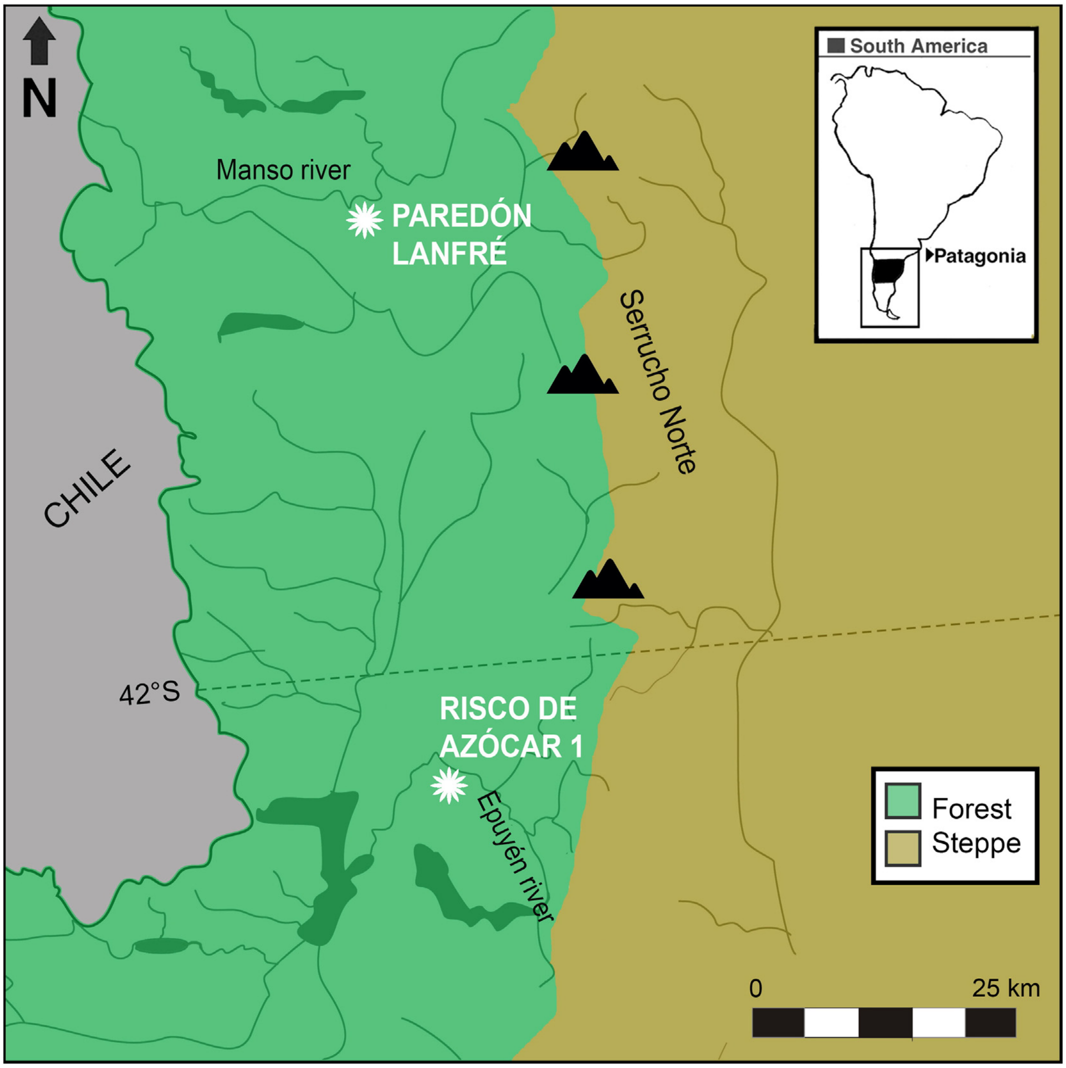

Fig. 1. Location of Risco de Azócar 1 and Paredón Lanfré archaeological sites.

was excavated with a maximum of 1.2 m depth. Archaeological evidences were even scarcer than Alero A (Table 1) and came from three stratigraphic units: Unit 1, Unit Q and Unit 2. Rodent remains were associated, spatial and vertically, with the archaeological materials. Units 1 and 2 were similar to Unit 1 from Alero A but rock shelter blocks and colluviums were more frequent. Unit Q was characterized by sandy sediment with large amounts of carbonate and small charcoal fragments (Podestá et al., 2007). All Units were excavated by 10 cm layers. Alero C (RA1C): One 1 × 1 m grid was excavated with a maximum of 2 m depth. Sediment was homogeneous along all the stratigraphy, composed by sandy sediment with large amounts of rock shelter blocks and colluviums. This deposit was excavated by 10 cm layers. Archaeological evidences were very scarce (Table 1). Ninety percent of rodent bones recovered at RA1C came from the base of the stratigraphy.

Table 1
Frequency of archaeological items from Risco de Azócar 1 (RA1) and Paredón Lanfré (PL) sites. Based on Bellelli et al. (2007), Fernández and Andrade (in elaboration), Leonardt (2014), and Podestá et al. (2007).

	RA1			PL
	Alero A	Alero B	Alero C	
Faunal remains	1110	433	773	2636
Bone artifacts	0	0	0	2
Lithic artifacts	573	3	5	545[a]
Pottery sherd	32	5	1	793
Pigments	67	0	0	84
Shell bead	0	0	0	1
Shell fragments	0	3	0	72

[a] Lithic analysis is in progress.

2.2. Paredón Lanfré (PL)

PL is located at the Manso river valley (41° 36′ S; 71° 32′ W, 500 m asl). The site measures 42 m in total length and extends over a rocky wall of granite at the base of the Foyel Mountain. PL has many rock painting motifs, at the base of which were excavated six 1 m^2 grids. Another four grids were excavated at different sectors of the rock shelter, but they were not included in the analysis because bones recovered were scarce. As RA1A, PL was excavated by 10 cm artificial layers because no sedimentary discontinuities were identified. Archaeological material (Table 1) was recovered from Unit 1, which extends from the surface to ca. 1.5 m depth. This unit was characterized by sandy sediment with large amounts of organic matter, volcanic ashes, rock shelter blocks and colluviums, and it was dated between 490 ± 60 years (LP 1642) and 1500 ± 60 years BP (LP 1429) (Bellelli et al., 2007). As RA1A, it was not possible to identify different times in human occupation along this sequence. Except for the oldest dating (ca. 1500 years BP) coming from a hearth structure, the other dates were obtained from charcoal concentrations. Rodent remains were associated, spatial and vertically, with the archaeological materials and their relative frequency was similar to that exhibited by the other archaeological evidences. The finding of modern materials (bones, plastic, leather, metal, glass), determined as intrusive, also contributed to the low chronological resolution. This material included sheep, Canidae, and horse bones. They came from the surface or the 10 cm immediately beneath, but in grids excavated closer to the wall these materials reach more depth. The existence of a small water runoff against the wall during winter could explain the alteration in these grids, because these temporary flows impact more over the wall than against the slope (Fernández and Andrade, in elaboration).

3. Materials and methods

Anatomical and taxonomical identifications of small vertebrate bone remains were made using reference materials housed at the *Instituto Patagónico de Ciencias Sociales y Humanas* (IPCSH-CCT CONICET-CENPAT, Puerto Madryn, Chubut, Argentina). Archaeological material was retrieved with a sieve (2 mm mesh), ensuring the recovery of small bones. The taphonomic analysis follows the proposal of Andrews (1990) and Fernández-Jalvo and Andrews (1992). As proposed by Andrade (2015), we included both cranial and postcranial bones of small mammals recovered from RA1 and PL excavations. The analyses were performed individually for Caviomorpha and Cricetidae rodents to evaluate possible differences in their taphonomic trajectories. It has been noted that the higher proportions of *Ctenomys* sp. and other Caviomorpha rodents in the archaeological sites in caves can be explained because these rodents have strong skulls and mandibles and remain almost intact in depositional contexts, while those more fragile and smaller of the Sigmodontinae rodents do not (Pardiñas, 1999). This idea conditioned the research on the small mammals fauna while dilating the discussion about the possible consumption of the Caviomorpha rodents between Patagonian archaeologists. Taking into account postcranial elements and carrying out the taphonomic analyses separately for Caviomorpha and Sigmodontinae rodents, the biases of this differential preservation can be avoided. This kind of analysis creates a more realistic and complete taphonomic history, independent of the size and fragility of the remains of each taxon. Because postcranial elements cannot be distinguished to species level, the analysis was performed considering the two taxonomic groups, arranged according to the animal size and bone morphology: Caviomorpha (families Ctenomyidae and Caviidae), and Cricetidae rodents (subfamily Sigmodontinae). The proportions of those taxa were included in the analysis as an indicator of the general taxonomic structure in samples.

Each bone was assigned to one anatomical and taxonomical category. If they could not be classified, they were consigned as Indeterminate. Anatomical and taxonomical quantifications were based on NISP (Number of Identified Specimens), MNE (Minimum Number of Elements) and MNI (Minimum Number of Individuals). The MNI counts were based on cranial and jaw elements. To evaluate losses of skeletal units in the sample, relative abundance of skeletal elements (*Ri*) was calculated (Dodson and Wexlar, 1979) according to the equation $Ri = [Ni/MNI * Ei] * 100$ where Ri is the relative frequency of element i; Ni is the minimum number of observed elements for element i and Ei is the number of times element i occurs in the complete skeleton.

Breakage pattern was investigated through categories defined according to bone type. Complete or fragmented bones were quantified separately. Long bones were consigned as proximal and distal epiphyses, as well as diaphysis.

Cultural and natural evidences were investigated in bone assemblages. Heat alteration was determined by the naked eye following color criteria, considering completely burned (blackened), partially burned and not burned. It was also determined which of the anatomical sections and taxonomic group (Caviomorpha and Cricetidae) was burned. Bone surface modifications like cut and percussion marks, and digestion traces produced by predators on molars and incisors, were observed with an 8 × and 10 × binocular lenses. Skeletal modification, including weathering was registered with stages defined by Andrews (1990) and Fernández-Jalvo and Andrews (1992). Two representation indices of skeletal elements were calculated to assess agent selectivity: Postcrania/crania relationship ($PC/C = femur + humerus/mandible + maxilla$) and distal/proximal relationship ($D/P = tibia + radius/femur + humerus$). A chi square goodness of fit test with the Yates´ correction was performed with the Past software (Hammer et al., 2001) to evaluate the significance of those relationships, under the null hypothesis that there are no discrepancies between the observed and expected values, assuming an equal representation of the different sections of the skeleton. Those tests were performed for samples with > 50 MNE. Agent selectivity was evaluated considering raptor birds and carnivores taphonomic models of small vertebrate accumulation (Andrade, 2015; Andrews, 1990; Andrews and Nesbit Evans, 1983; Gómez, 2005; Gómez and Kaufmann, 2007; Montalvo et al., 2007, 2008, 2012; Reed, 2005; among others). Rodent exploitation was assessed taking into account models derived from ethnographic and experimental data, and archaeological records (Andrade, 2015; Andrade and Boschín, 2015; Dewar and Jerardino, 2007; Henshilwood, 1997; Hesse, 1985; Medina et al., 2012; Shaffer, 1992; Simonetti and Cornejo, 1991).

4. Results

4.1. Risco de Azócar 1

Rodents were the main taxa in all RA1 sectors. At RA1A they reached 69.1% of the NISP, 97.5% at RA1B, and 99.6% at RA1C (Table 2). Caviomorpha rodents were dominant and the defined species were *Galea leucoblephara* and *Microcavia australis.* The Sigmodontinae rodents recovered in samples were *Oligoryzomys longicaudatus* (RA1A), *Abrothrix hirta* and *Reithrodon auritus* (RA1B), *A. hirta* and *A. olivaceus* (RA1C), all the species represented by one individual at each sector (Table 2). Some incisor fragments retrieved at RA1A and RA1B could be attributed to *Ctenomys* sp. In the latter sector, one individual of a big-eared brown bat (*Histiotus* sp.) was registered. No cut marks were observed on rodents' bones in RA1.

4.1.1. RA1A

A total of 286 rodent specimens were recovered at this sector of the site. Bone preservation was bad, probably due to changes in the moisture of the sediments, affected by seasonal variation of precipitation and normal and extraordinary floods. Bones were weathered and heavily fragmented. Caviomorpha was the main taxonomic group (64%) and only one Sigmodontinae rodent was determined on the basis of cranial bones. Thus, specimens classified as Indeterminate (34%) could correspond to Caviomorpha. Values obtained for the indices that evaluate the relationship between Caviomorpha body parts, showed a better representation of cranial elements ($PC/C = 0.3$), and distal elements of the limbs ($D/P = 1.83$), according to the *Ri* values obtained (Table 3). No statistical tests were performed to evaluate the significance because of the small sample sizes.

Heat alteration was moderately high (48% of the NISP). Compared to other taxa registered at RA1A, the proportion of rodent bones burned is noticeable: only 6.3% of huemul and 3.8% of indeterminate mammal bones showed signs of thermal alteration. Based on cranial bones, three Caviomorpha individuals were thermo-altered. Signs of predators -digestion marks- were observed on two incisors that belong to *O. longicaudatus* and on other Sigmodontinae rodent, probably also *O. longicaudatus*. Despite the weathering, no signs of digestion were observed on Caviidae incisors and molars.

4.1.2. RA1B

A total of 369 rodent bones and teeth were recovered along the three units of RA1B. As in RA1A, Sigmodontinae rodents were poorly represented (5.7%, only in Unit 1, $MNI = 2$) and the Caviomorpha were dominant (53.3%). Bones that could not be assigned to these taxonomic groups reached 40% (Table 2). Representation of skeletal elements

Table 2
Taxonomic composition of bone assemblages recovered at Risco de Azócar 1 and Paredón Lanfré archaeological sites.

	RA1A			RA1B			RA1C			PL		
Taxon	NISP	%NISP	MNI	NISP	%NISP	MNI	NISP	%NISP	MNI	NISP	%NISP	MNI
Subtotal Small vertebrates	298	67,73	11	376	97,41	14	758	100	25	1251	88,41	61
Mammalia												
Histiotus sp.	0	0,0	0	2	0,52	1	0	0,0	0	0	0,0	0
Lepus sp.	1	0,23	1	0	0,0	0	0	0,0	0	0	0,0	0
Lagidium viscacia	4	0,91	1	0	0,0	0	5	0,7	1	4	0,28	1
Ctenomys sp.	2	0,45	1	0	0,0	0	11	1,5	3	100	7,07	4
Microcavia Australis	0	0,0	0	5	1,30	3	29	3,8	6	52	3,67	11
Galea leucoblephara	3	0,68	1	23	5,96	7	46	6,1	12	13	0,92	4
Caviidae indeterminate	68	15,45	5	72	18,65	2	246	32,5	0	100	7,07	6
Caviomorpha indeterminate	0	0,0	–	4	1,04	–	5	0,7	–	13	0,92	–
Large rodent post-cranial	34	7,73	–	78	20,21	–	282	37,2	–	135	9,54	–
Large rodent bone indeterminate	70	15,91	–	20	5,18	–	30	4,0	0	0	0,0	–
Geoxus valdivianus	0	0,0	0	0	0,0	0	0	0,0	0	1	0,07	1
Irenomys tarsalis	0	0,0	0	0	0,0	0	0	0,0	0	2	0,14	1
Abrothrix olivaceus	0	0,0	0	0	0,0	0	2	0,3	1	2	0,14	1
A. hirta	0	0,0	0	2	0,52	1	2	0,3	1	3	0,21	2
Reithrodon auritus	0	0,0	0	2	0,52	1	0	0,0	0	6	0,42	2
Loxodontomys micropus	0	0,0	0	0	0,0	0	0	0,0	0	62	4,38	21
Oligoryzomys longicaudatus	1	0,23	1	0	0,0	0	0	0,0	0	7	0,49	4
Sigmodontinae indeterminate	0	0,0	0	3	0,78	–	4	0,5	–	46	3,25	–
Small rodent post-cranial	14	3,18	–	14	3,63	–	20	2,6	–	200	14,13	–
Indeterminate rodent post-cranial	98	22,27	–	153	39,64	–	74	9,8	–	471	33,29	–
Dasipodidae	3	0,68	1	0	0,0	0	2	0,3	1	0	0,0	0
Reptilia												
Squamata, Lacertilia	0	0,0	0	0	0,0	0	0	0,0	0	5	0,35	1
Amphibia												
Anura	0	0,0	0	0	0,0	0	0	0,0	0	18	1,27	1
Aves												
Passeriformes	0	0,0	0	0	0,0	0	0	0,0	0	11	0,78	1
Subtotal Large vertebrates	142	32,27	4	10	2,59	1	0	0,0	0	164	11,59	7
Mammalia												
Ovis aries	73	16,59	3	0	0,0	0	0	0,0	0	31	2,19	2
Equus sp.	0	0,0	0	0	0,0	0	0	0,0	0	1	0,07	1
Hippocamelus bisulcus	16	3,64	1	4	1,04	1	0	0,0	0	18	1,27	1
Pudu puda	0	0,0	0	0	0,0	0	0	0,0	0	8	0,57	1
Lama guanicoe	0	0,0	0	0	0,0	0	0	0,0	0	3	0,21	1
Indeterminate Canidae	0	0,0	0	0	0,0	0	0	0,0	0	42	2,97	1
Indeterminate Artiodactyla	0	0,0	–	0	0,0	–	0	0,0	–	24	1,70	–
Indeterminate Mammalia	53	12,05	–	6	1,55	–	0	0,0	–	37	2,61	–
Total	440		15	386		15	758		25	1415		68

Table 3
Minimum Number of Elements (MNE) and relative abundances (R*i*) of skeletal elements of Sigmodontinae (S) and Caviomorpha (C) rodents recovered at Risco de Azócar 1 and Paredón Lanfré archaeological sites. Thermo-altered elements are consigned between brackets. T-A = burned bones not included in MNE count (cranial fragments, incisors, molars and indeterminate bones), expressed as NISP.

	Risco de Azócar 1												Paredón Lanfré			
	Alero A				Alero B				Alero C							
	S		C		S		C		S		C		S		C	
	MNE	R*i*	MNE	R*i*	MNE	R*i*	MNE	R*i*	MNE	R*i*	MNE	R*i*	MNE	R*i*	MNE	R*i*
Humerus	0	0	0	0	2	50	1	4.1	4	100	7	19.4	28	43.8	7	14
Femur	4 (2)	100	6 (4)	50	2	50	6 (2)	25	2	50	14	38.9	46 (2)	71.9	8 (1)	16
Tibia	0	0	8 (5)	66.7	2 (1)	50	14 (1)	58	6	150	27	75	25 (2)	39.1	37 (12)	74
Fibula	0	0	0	0	0	0	0	0	0	0	1	2.8	1	1.56	0	0
Ulna	0	0	0	0	0	0	9	37.5	0	0	16	44.4	7	10.9	6 (3)	12
Radius	0	0	3 (3)	25	2	50	9 (1)	38	1	25	23	63.9	3	4.69	10 (1)	20
Metapodial	0	0	4 (2)	3.3	0	0	4	2	0	0	23	6.4	1	0.16	7	1.4
Phalange	0	0	0	0	0	0	0	0	0	0	8	0.8	0	0	0	0
Scapula	0	0	1 (1)	8.3	0	0	0	0	1	25	6	16.7	6	9.38	6	12
Rib	0	0	0	0	0	0	13	4	2	3.8	24	5.1	5 (1)	0.6	7	1.08
Vertebra	1	2.9	0	0	3	4.4	1	0.2	0	0	65	10.6	25	2.3	6	0.71
Pelvis	0	0	0	0	1	25	2	8	1	25	12	33.3	7	10.9	3	6
Maxillary	0	0	10 (4)	83.3	1	25	18 (4)	75	0	0	25	69.4	23 (4)	35.9	33 (11)	66
Mandible	1	50	10 (5)	83.3	3	75	12 (3)	50	4	100	28	77.8	48 (1)	75	36 (7)	72
Total	6		42		16		89		21		279		225		166	
T-A	2		82				5				10		4		35	

showed a high proportion of Caviomorpha cranial bones compared to postcranial (PC/C = 0.23, $X^2 = 7.929$; df = 1; p = 0.006) and distal limbs bones (D/P = 3.85, $X^2 = 6.439$; df = 1; p = 0.02). Conversely, Sigmodontinae rodents did not show a differential preservation of crania (PC/C = 1, Unit 1), and proximal limbs bones were better represented compared with distal ones (D/P = 0.75, Unit1). No statistical tests were performed to evaluate the significance for Sigmodontinae because of the small sample sizes. Body part indices match *Ri* values (Table 3).

Heat altered remains (10% of total NISP) were mainly from Caviomorpha rodents (41%). Only one Sigmodontinae bone was burned (3%). The remaining indeterminate (56%) were highly fragmented due to burning, and probably belongs to Caviomorpha. On the basis on cranial elements, one *M. australis*, and one *G. leucoblephara* individuals were thermo-altered. No signs of digestion were observed on incisors and molars of any taxa.

4.1.3. RA1C

A total of 758 rodent bones were recovered at this sector, 90% concentrated at the base of the stratigraphy. Caviomorpha was dominant (87%) and Sigmodontinae rodents and indeterminate reach 5% and 8%, respectively. Caviomorpha cranial elements were over-represented (PC/C = 0.4, $X^2 = 7.2582$; df = 1; p = 0.01) and distal limbs bones were more frequent than expected (D/P = 2.38, $X^2 = 6.1878$; df = 1; p = 0.01). Sigmodontinae showed a similar proportion between proximal and distal (D/P = 1.17) and postcranial bones were better represented (PC/C = 1.5). No statistical tests were performed to evaluate the significance for Sigmodontinae because of the small sample sizes. *Ri* values agree with these results (Table 3). Only ten Caviidae molars showed thermal alteration, and no signs of digestion were observed on incisors and molars.

4.2. Paredón Lanfré

>85% of total NISP correspond to small vertebrates (NISP = 1271, Table 2). Rodents were dominant and amphibians, birds (Passeriformes), and Reptiles (Squamata) bones were recovered in low frequencies. Rodent individuals (MNI = 57) of the following taxa were identified: Chinchillidae (*Lagidium viscacia*), Caviidae (*G. leucoblephara* and *M. australis*), Ctenomyidae (possibly *C. haigi* and *C. sociabilis*) and Cricetidae (Sigmodontinae), *A. hirta*, *A. olivaceus*, *Geoxus valdivianus*, *Irenomys tarsalis*, *Loxodontomys micropus*, *O. longicaudatus* and *R. auritus* (Table 2). In PL, Sigmodontinae was better represented (27%) than in RA1; however Caviomorpha was still dominant (36%). Indeterminate specimens (37%) were mainly heavily fragmented postcranial bones. All skull and mandible fragments were taxonomically assigned.

A quite different pattern was obtained in the relationship between skeletal units for Caviomorpha and Cricetidae. Postcranial and cranial elements were equally represented in Cricetidae rodents (PC/C = 1.04, $X^2 = 0.03451$; df = 1; p = 0.9); for Caviomorpha, cranial elements were over-represented (PC/C = 0.22, $X^2 = 19.357$; df = 1; p = 1,76E−05). Considering the relationship between distal and proximal elements of the limbs, an over-representation of the first group was observed for Caviomorpha (D/P = 3.1, $X^2 = 8.8473$; df = 1; p = 0.005), while an under-representation was obtained for Cricetidae (D/P = 0.4, $X^2 = 10.928$; df = 1; p = 0.001), situation that also could be observed in the *Ri* values (Table 3). In this case, tibias, skulls and jaws were the most frequent bones for Caviomorpha.

Only 12.4% of the small mammal bones suffered heat alteration, totally or partially. These bones were concentrated in one of the excavation grids (80.5% in E24). From all the specimens with signs of heat alteration, 44.6% were Caviomorpha rodents, 12.7% were Cricetidae and 42.7% could not be identified. At least two individuals of *M. australis*, two of *G. leucoblephara*, four of indeterminate Caviidae and one of *Ctenomys* sp. (possibly *C. haigi*) showed signs of thermal alteration, based on jaw and crania remains. Considering incisive size, individuals of the two ctenomyid species were burned. Burning affected mainly Caviomorphs skulls and distal limbs (tibias, radius and ulnas, Table 3). Only two incisors (one indeterminate and one from *Ctenomys* sp.) showed digestion traces. No cut marks were observed on rodents' bones.

5. Discussion

The presence of caviids and ctenomyids in the RA1 and PL archaeological record is unexpected as these species are widely distributed in South America, but in un-forested and xeric environments. *Galea leucoblephara* occurs mainly in the northern portion of Patagonia while *Microcavia australis* occurs throughout arid Patagonia, ranging from the Colorado River to the Strait of Magellan and from the Atlantic coast to the Andean Piedmont (Udrizar Sauthier et al., 2016). Ctenomyids species live in the arid steppe and Precordillera, but not in dense forest regions (Pearson, 1984; Pearson and Christie, 1985). The presence of those species in the archaeological sequences raises additional questions and hypotheses regarding possible changes into the landscape by natural and/or anthropogenic causes. These scenarios are being evaluated taking into account the palynological records for the area and will be discussed in another paper that is under elaboration and will not be considered in this work. However, the implications of those caviomorph species for the human subsistence in the forests are discussed here. Transport of rodents from the steppe or forest-steppe ecotone is improbable because of distance (20–40 km currently) and that, if transport occurs, it is expected it involves large species (e.g. guanaco, *Lama guanicoe*). Indeed, there is no evidence of transport of such animals, except for three small fragments of guanaco´ phalanges that could be attached to a hide carried from the forest-steppe ecotone or the steppe. The isotopic signals obtained in rodents samples (three mandibles of Caviidae and two mandibles and one skull of *Ctenomys* sp.) from Población Anticura, a site near PL (<1 km, Fernández and Tessone, 2014), suggest that both Caviomorpha species lived at the Manso river valley in the past. Digestion signs on *Ctenomys* sp. incisor from PL suggest a local origin of these species.

Beside the biogeography issue, the taphonomic analysis developed allows the identification of some general patterns in the small mammals' assemblages of RA1 and PL sites, and reveals the deposition agents along the archaeological sequences. Diverse evidences enabled the taphonomic reconstruction and give support to the hypotheses that human consumption and raptor activities accumulated the bulk of the small mammals' remains. Signs of human activities related with the subsistence were inferred by a combination of diverse variables, such as the high frequency of fossorial, colonial, diurnal, relatively big sized Caviomorpha rodents (families Caviidae and Ctenomyidae), the differential skeletal representation of some bone pieces of these taxa, and the presence of a possible distinctive burning pattern affecting mainly distal bones and crania. Although still incipient and preliminary to make further conclusions, the comparison with the results obtained for a near archaeological site located in the steppe (Andrade, 2015) show that tendencies are similar and send support that inclusion of rodents in prehistoric diets would be a regional pattern. Evidences of a natural agent, possibly a slightly destructive raptor, were observed on Sigmodontinae rodents (RA1 and PL) and *Ctenomys* sp. (PL). These taphonomic signatures are considered and discussed below for each archaeological site.

5.1. Rodent bone accumulation and deposition

5.1.1. RA1

The small mammal assemblage from RA1 is composed mainly by Caviidae rodents. Neither owls nor eagles form assemblages dominated by the fossorial, colonial, diurnal, and relatively big sized Caviidae rodents (*G. leucoblephara* and *M. australis*). Pellets accumulated by different owls and retrieved in forested habitats (Trejo and Ojeda, 2004;

Udrizar Sauthier et al., 2005) and also in the forest-steppe ecotone (Pillado and Trejo, 2000; Trejo and Lambertucci, 2007), are dominated by Sigmodontinae rodents. *Genaroaetus melanoleucus* (Black-chested Buzzard Eagle), other potential predators, consumes approximately 51% of Sigmodontinae and <10% of Caviidae, as was registered in pellets recovered at the forest-steppe ecotone (Trejo et al., 2006).

Although bone samples from RA1 were heavily fragmented due to weathering (a situation that was reflected in the small sample sizes and the high percentage of remains that could not be classified), some inferences about the deposition agent can be made, specially based on the taxonomical and skeletal representation. Tendencies observed in samples from the three sectors of RA1 show an over-representation of bones of the skull and distal elements of the limbs, situation that could be interpreted as the result of human discarded activities. Coincidently, some of those bones were thermo-altered. Consumption of rodents was proposed for some archaeological sites in America and South Africa based on the over-representation of cranial bones and some of them also distal limbs (Dewar and Jerardino, 2007; Shaffer, 1992; Simonetti and Cornejo, 1991). For Central Chile, this argument was supported by the high frequency of cranial remains of caviomorpha rodents that coincidently were burned (Simonetti and Cornejo, 1991). For the Atacama Desert (Chile) the consumption hypothesis was based on the archaeological record (domination of cranial elements of *Ctenomys* sp.) contrasted with the ethnographical evidence; the model proposed was a simple butchering and preparation: lop off the head and roast (Hesse, 1985). The archaeological effect of this activity is an over-representation of heads. Considering experimental and ethnographical data, differential burning of certain parts –incisors and bone around them and distal portions of un-meaty long bones– is expected if rodents were roasted over a fire (Henshilwood, 1997; Medina et al., 2012). Also, completed thermal alteration on heads suggest discard on hearts before or after roast. A recent taphonomic study of a rodent sequence from an archaeological site located in the steppe (Andrade, 2015) and its comparison with the ethnographic and historical record (Andrade and Boschín, 2015) demonstrate that this simple processing model would seem to be also used by Patagonian populations. The fact that skulls and distal limbs were removed before or after roast will only be distinguishable by a complete burning (before roast hypothesis) or a charring of the anterior part of the mandible and skull and on distal extreme ties (after roast hypothesis). Distinguishing between those hypotheses is impossible and highly speculative in the case of the RA1 because of the high degree of weathering and fragmentation of the sample, especially those burned bones.

No clear association of the burnt remains with combustion structures of human origin was detected in RA1; we do not discard the possibility that fires could have affected some of the rodent bones. However, the general pattern observed for RA1 differs to the one expected as the result of a natural event. Even though there are some signs that forest fires affected the site (e.g. almost 30% of lithic artifacts is thermo-altered), the distinct proportion of small (48%) and large vertebrates (7.5%) burned bones is inconsistent with a generalized wildfire, which would have affected all bones more or less equally, and, most importantly, all bone surfaces should be burned. Only an intentional discard of pieces would provoke this singular assemblage and taphonomic signals. As no cut marks were recorded on rodent bones, estimation of the minimum number of animals consumed was based on the thermo-altered bones. Taking into account this latter issue, at least five individuals of the species *Galea leucoblephara* and *Microcavia australis* were consumed at RA1. However, cut marks related to small prey processing are unexpected (Stahl, 1996) and in fact there are few cases in Patagonia (exception are the cut marks observed in rodent mandibles and tibias from the Negro River valley archaeological sites, northern Patagonia, Fernández et al., 2011; Mange et al., 2016).

Finally, it is important to clear up the discussion about rodent consumption in RA1 was based mainly on the evidences provided by the A and B sectors. While sector C showed similar tendencies in the taxonomical and skeletal representation, no more inferences could be made because this sector was difficult to interpret from the archaeological evidence. Only rodent bones, five lithic flakes and one pot sherd were recovered in a colluvial deposit of 2 m depth. However, caviomorpha bones could not be attributed to natural causes because no sign of digestion was observed and the differential skeletal representation do not agree with natural death (see PL discussion). At least three different burrowers' species were registered and it is unlikely that the three of them inhabited and died in the same burrow system. Rodent gnawing marks, other evidence that can indicate the use of RA1 by rodents is almost absent (5.3%). Indeed, placement of the site in the floodplain of the Epuyén River makes its use unlikely by fossorial rodents.

Although sigmodontinae bones were scarce, a different pattern of skeletal representation was observed for this taxon. The sigmodontines retrieved at RA1 (MNI = 5) were characterized by an equal preservation of skull and post-cranial elements (RA1B). This equal representation was also observed for proximal and distal elements of the limbs (RA1B and RA1C).·These signals allow deducing that natural death and/or a light predator could be the most plausible cause of accumulation of sigmodontines in RA1 as was observed in the steppe for Cueva y Paredón Loncomán archaeological site (Andrade, 2015). When animals die naturally, the assemblages recovered are constituted by few species and individuals, with sections of the skeleton equally represented, relatively unbroken and with no signs of digestive modification (Andrews, 1990; Stahl, 1996). The presence of light digestion marks in two incisors of RA1A indicates that a predation event, although ephemeral, took place.

5.1.2. PL

As was determined for RA1, Caviomorpha were dominant and skulls, jaws, and tibias were the most frequent bones for this taxon in PL. Although few rodent bones were thermo-altered (12.4%), the taxonomical representation and the spatial distribution lead to some conclusions. Burned bones were mainly from caviomorph rodents and were spatially concentrated almost exclusively in one of the excavation grids (grid E24). Ashes with tiny fragments of charcoal were recovered also in this grid. Underlying these ashes, a layer of orange sediment was detected. These evidences could be traces of combustion structures that were not fully defined during site excavation. The combustion structures idea could explain the high proportion of burned bones in grid E24 and adds evidences to the hypothesis that most of the altered bones are related with the discard of bone pieces into this hearth. Although scarce and possibly hidden by the high degree of fragmentation in the sample, the pattern observed in some bones resembles that proposed by experimental approaches for rodents roasted over a fire (Medina et al., 2012). Two tibias showed a distinct pattern of burning in the distal epiphysis, some incisors are burned or calcined, and jaws, when burned, at least showed the anterior portion thermo-altered (Fig. 2). As for the case of RA1, we propose that human refuse is the main cause of accumulation of Caviomorpha rodents inside this archaeological site. As in RA1, no cut marks were observed on PL rodent bones. On the basis of thermo-alteration it can be established that at least nine individuals of the caviids *Galea leucoblephara* and *Microcavia australis* and the two ctenomyids species were consumed inside PL.

As in RA1, we cannot discard the possibility that some of the bones could be burned by being buried beneath a combustion structure (Bennet, 1999) –this may be the case for the sigmodontinae remains- and/or by the effect of natural fires –phenomenon documented for thousands of years in the North Patagonian Andean forest-. Thermo-alteration of lithic material (23% in PL) suggests that this site was also affected by one or more of these fires. However, this could not be the generalized pattern since burned bones were concentrated spatially and burned remains of sigmodontines were <1/3 of caviomorpha's. If an incidental burning could have occurred, it would be expected similar frequencies of burned bones for both taxa.

Fig. 2. Tibia of Caviomorpha burned in the distal epiphysis (A, E); mandible of Caviidae burned (B); incisive of Caviidae completely blackened (C); incisive of *Ctenomys* sp. calcined (D).

The bone pattern observed for cricetid rodents agrees with an assemblage accumulated by a light predator like the raptor *Tyto alba*. Low levels of bone fracture and loss of skeletal parts are expected for the prey consumed by this raptor (Andrade, 2015; Andrews, 1990; Dodson and Wexlar, 1979). The equal representation of crania and post-crania and the tendency to lose distal elements was observed in actual and stratigraphic assemblages produced by this raptor in extra-Andean Patagonia (Andrade, 2015). The high species richness, with the presence of taxa like Passeriformes, reptiles, and amphibians in association with rodents supports the predator hypothesis in opposition to natural death. However, it is surprising the low levels of digestion traces on incisors and molars. Only two incisors (one from *Ctenomys* sp. and one indeterminate) showed digestive marks. This is unexpected since *Tyto alba*, although a light predator, produces assemblages with some degree of modification (Andrews, 1990; Fernández-Jalvo and Andrews, 1992). For the arid Patagonia, values were even greater, with mean values of 20% of teeth affected (Andrade, 2015). However, natural death could also be discarded because of the dissimilarity in the ecological habits of the cricetid species recovered. Arboreal and scansorial species like *I. tarsalis* and *O. longicaudatus* were grouped altogether in the same assemblage with fossorial (*G. valdivianus*) and cursorial species (*A. hirta*, *A. olivaceus* and *L. micropus*). Besides, no signals of bioturbation by subterranean rodents were observed during the excavation of PL, and the rodent gnawing marks were infrequent (6.1%).

Finally, a mammalian carnivore was discarded as a possible deposition agent, both for RA1 and PL, because it produces severe damages in bones and the assemblages produced show considerable loss of distal elements, usually as great as or greater than any of the avian predators (Andrews, 1990). Patagonian carnivores produce heavy digestion damage on the structure of the incisors and molars (Gómez and Kaufmann, 2007; Montalvo et al., 2007, 2008, 2012), and, on contrary, signs of digestion were scarce on incisors and molars from RA1 and PL.

5.2. Rodent consumption in Patagonian forests

The consumption of Caviomorpha at RA1 and PL took place in a moment of transformation in the utilization of the forest by the hunter-gatherer populations. In Northwestern Patagonia, intensified interactions across the Andes (Barberena et al., 2014) and/or a demographic increase that took place ca. 1500–1000 years ago (Pérez et al., 2016), could lead to more recurrent and/or prolonged stay into the forest in the last 1700 years BP (Fernández et al., 2013). At Manso and Epuyén areas, the recurrence is mainly expressed at local scale (valley) rather than at a site scale. A dispersal pattern of numerous sites along the river valleys and lake shores -the easiest way to travel in the forest- was recorded (Bellelli et al., 2007; Podestá et al., 2007). Sites were occupied by small groups in not prolonged stays (e.g. RA1), and some of them have a small number of rock art motifs without other evidence witnessed (Podestá et al., 2007). The few sites that present more than a single occupation are more extensive, and have profuse rock art motifs (e.g. PL, Podestá and Albornoz, 2007). Prolonged stays in the forest are suggested by the isotopic signal of human bones (Fernández and Tessone, 2014), and the emergence of a rock art style extended exclusively along the northwestern Patagonian forest, between ca. 40° S and 42° S (Albornoz and Cúneo, 2000; Podestá and Albornoz, 2007).

In this context, what does the consumption of Caviomorpha rodents at RA1 and PL implies for the human subsistence? Huemul was the main staple in these and other sites located inside the forest. Although this cervid is the only high ranked prey in this environment, there is no evidence of increased hunting pressure or processing carcass intensification. Other preys, such as pudú and puma (*Puma concolor*), had a complementary role in the subsistence, and were exploited in low numbers in some of the sites (Fernández and Carballido Calatayud, 2015). While in other areas of Argentina the consumption of rodents was related with a faunal intensification driven by the increase in population density (Acosta and Pafundi, 2005; Medina et al. 2011; Quintana et al. 2002; Quintana, 2005; among others), the ethnographic and historical record evidence that in continental arid Patagonia and Tierra del Fuego, rodents were an important item in the diet and were intensively exploited by some human populations (Andrade and Boschín, 2015). Although still incipient, results obtained in this study suggest that at northern Patagonian Andean forest this consumption reflects the exploitation of low ranked prey individuals in a lesser productive environment. Thus, the pressure over the faunal resources derived from the more recurrent and/or prolonged stays was alleviated by a high mobility strategy and reduced groups, and not by resource intensification.

6. Conclusions

The predominance of large, diurnal, and colonial rodents, the differential representation of some bone pieces, and a possible burning pattern suggest that human refuse is the main cause of accumulation of rodents inside PL and RA1 archaeological sites. The consumed species were *Galea leucoblephara*, *Microcavia australis*, *Ctenomys haigi*, and possibly also *C. sociabilis*. A light predator like the raptor *Tyto alba* and/or natural death could explain the presence of cricetid rodents and other small vertebrates. Differences in the taphonomic histories of cricetid and caviomorph rodents seem to be a constant in the archaeological sites from Northern Patagonia. This comparison is possible because similar taphonomic analyses were performed for the steppe and the forest, and carried out independently for Cricetidae and Caviomorpha rodents. Consumption of rodents since at least 1700 years BP, proposed previously for the steppe (Andrade, 2015), could be now extended to the forest over the same temporal range. This consumption occurred in the moment when hunter-gatherer populations experienced more recurrent and/or prolonged stay into the forest.

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