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Paleodemography of Late Holocene hunter-gatherers from Patagonia (Santa Cruz, Argentina): An approach using multiple archaeological and bioarchaeological indicators

Solana García Guraieb [a, *], Rafael Goñi [b], Augusto Tessone [c]

[a] CONICET/INAPL, 3 de febrero de 1378, CABA C1426BJN, Argentina
[b] Universidad de Buenos Aires, INAPL, 3 de febrero de 1378, CABA C1426BJN, Argentina
[c] CONICET/ INGEIS, Pabellón INGEIS, Ciudad Universitaria, CABA C1428EHA, Argentina

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ABSTRACT

This paper summarizes and discusses the main results achieved over three decades of research on paleodemographic aspects of Late Holocene hunter-gatherers in Northwestern Santa Cruz (Argentina). Research has been guided by a model of regional settlement that proposes that, as a result of the progressive aridization process recorded in Patagonia during the Late Holocene, human groups would have reduced their residential mobility and concentrated their settlements in low altitude basins with water availability, such as Lake Cardiel and Lake Salitroso. Paleodemographic questions derived from the model relate to population regional continuity and dynamics and were tested using several lines of research at regional and local scales. The assessment of the chronological information and temporal trends of the archaeological record at the regional level allowed for a coarse grain paleodemographic approach, and acted as a mean to support hypotheses related to changes in mobility and land use strategies. Building on this, several lines of bioarchaeological evidence were used to address paleodemographic aspects of the model, including temporal, distributional, and compositional studies of the mortuary record, isotopic, morphometric and DNA analyses and the sex and age structure of the skeletal samples recovered in Lake Salitroso basin. Results point to a biological and cultural population continuity in the region during the Late Holocene. Also, a reduction in residential mobility would have favored a slight population growth of Lake Salitroso populations during the last millennium.

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1. Introduction

Paleodemography is interested in the study of population dynamics through time and the processes that explain these changes. Challenging as its archaeological study might be, the archaeological study of hunter-gatherers paleodemography is even more complicated. The same demographic characteristics of these populations -relatively low fertility rates and small population sizes, as well as their frequently high residential mobility pattern and funerary practices combine to create a sparse archaeological and bioarchaeological record, making it particularly challenging to address demographic research problems. In Northwestern and Central Santa Cruz Province, Argentina (Fig. 1), the implementation over the past three decades of an approach that took into account different paleoenvironmental, archaeological and bioarchaeological lines of evidence has led to the possibility of discussing some demographic aspects of the Late Holocene peopling of Southern Patagonia by hunter-gatherer groups.

From the outset of this regional archaeological investigation, the core supposition that guided research was that, in Southern Patagonia, colonization and the pattern of human occupation is highly dependent on climatic and environmental conditions (Goñi, 2000). These have undergone important shifts during the Holocene, particularly during the Late Holocene, a period for which a progressive desiccation trend is recorded in the region. Goñi and coauthors (Goñi, 2000, 2010; Goñi et al., 2000–2002, 2005) have presented a model linking these climatic and environmental processes with changes in human groups' mobility and land use strategies, as well as in some of their demographic characteristics.

* Corresponding author.
E-mail addresses: solanagg@gmail.com (S. García Guraieb), rafaelagustingoni@gmail.com (R. Goñi), gutitessone@gmail.com (A. Tessone).

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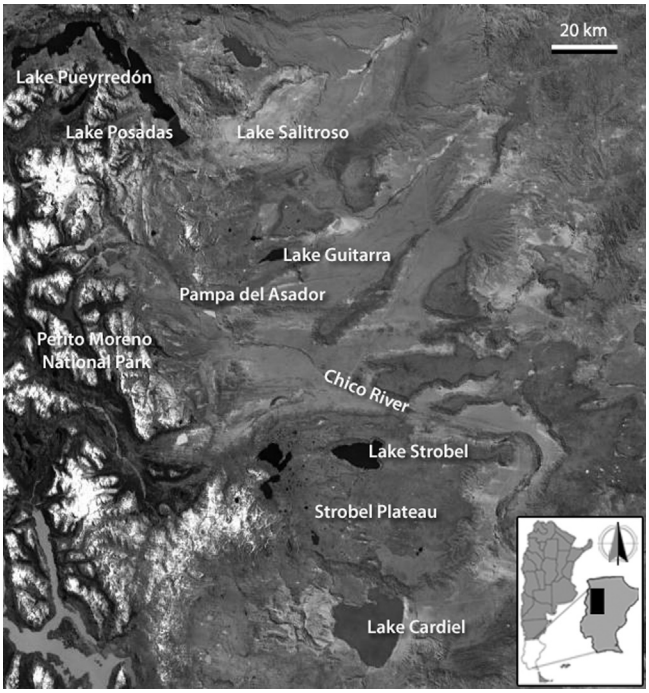

Fig. 1. Satellite Image of northwestern and central Santa Cruz (Patagonia, Argentina).

The model posits, first, that certain spaces in Southern Patagonia were not available for human occupation until the Late Holocene, as during previous times there were large bodies of water covering great land extents (Goñi, 2000, 2010). Second, it postulates that during the last 2500 BP, as the aridization process continued, water became concentrated in certain relict lake basins causing local hunter-gatherer populations to reduce their residential mobility drastically and nucleate their settlements in these loci which offered good habitability conditions (Goñi, 2000, 2010; Goñi et al., 2000–2002; Goñi et al., 2005). As a consequence, certain sectors of the Northwestern and Central Santa Cruz, such as Lake Salitroso and Lake Cardiel Basins (Fig. 1), would have experienced an increase in population size, particularly during periods of particularly low regional humidity (Goñi, 2000, 2010). These changes might have been produced solely by the relocation of local populations, without causing any real changes to population size at a regional level (Goñi et al. 2000–2002), or might have been accompanied by local population growth or decline processes, that might even have compromised population continuity in some sectors.

The main goal of the paleodemographic research presented here was to assess these hypotheses about the population dynamics of hunter-gatherer groups in the study area during Late Holocene times. To achieve this, several lines of research were considered as paleodemographic indicators. The starting point was the assessment of spatial and temporal trends in the composition, frequency and clustering of archaeological record at a regional level. Building on this, several lines of bioarchaeological inquiry, such as the main characteristics of the local funerary record and the sex and age composition and isotopic analysis of the skeletal collections were considered. Each contributed relevant information to the paleodemographic discussion. In the remainder of this paper, the main results of each of these lines will be summarized. As this is mainly a synthesis paper, readers are referred to the original publications or dissertations for further details on methodology and specific discussions of previously presented results.

2. Regional setting and paleoenvironment

The study area (Fig. 1) corresponds to a meso-region that comprises the area between the low altitude basin of Lake Salitroso and Posadas/Pueyrredón to the north (47° 22′ S), the Andes Mountains to the west (72° 19′ W), the Cardiel Chico Plateau to the south (49° 15′S) and Pampa del Asador Plateau to the east (70° 30′W). This territory stretches 250 km from north to south and 120 km from east to west, and includes the Perito Moreno National Park (PMNP), Lakes Cardiel and Strobel Basins, and the Strobel Plateau. It is a region of marked environmental contrasts. The landscape is dominated by glacial and tectonic lake basins, separated by Miocene basaltic plateaus (Ramos, 2002) and crossed by the Río Chico River Valley in a northeast – southwest direction.

The current climate is Temperate-Cold, with winds predominantly from the west (Oliva et al., 2001). Precipitation varies from 1000 to 150 mm per year and is concentrated in the winter. There is a marked west to east gradient producing changes in the vegetation structure, which is characterized by sub-Antarctic forests of *Nothofagus* sp. in the west and grass and shrub steppes with low vegetation cover in the east (Oliva et al., 2001). Altitude is one of the key determinants of the Patagonian landscape. Low basins such as Lake Salitroso, Posadas/Pueyrredón, and Lake Cardiel are situated between 100 and 300 m asl and are surrounded by high lands of more than 900 m asl, such as the high lake basins of the PMNP, the plateaus of Pampa del Asador, and the Strobel Plateau.

The available paleoenvironmental information shows that during the Middle Holocene (*ca.* 6000 BP) an important climatic change occurred involving a shift in the direction of the westerly winds or Southern westerlies, followed by a change in their intensity during the Late Holocene (*ca.* 1800 BP) (Gilli et al., 2001). As a consequence, a progressive aridization process took place in Patagonia during the late Holocene (Stine and Stine, 1990) reaching its peak during the so-called Medieval Climatic Anomaly (MCA) with its epic droughts dated *ca.* 1200–600 BP (Stine, 1994). The available information shows that new environmental and ecological conditions were established in the region (e.g. Stine and Stine, 1990, Stine, 1994; Gilli et al., 2001; Markgraf et al., 2003). In particular, various lake basins, which had fluctuated significantly during the Holocene (Stine and Stine, 1990; González, 1992; Horta and Gonella, 2009), experienced a marked decline in their water level during the Late Holocene. This caused the distribution of water, a critical resource in Patagonia, to vary drastically in regional terms and become concentrated in certain particular places, such as low altitude lake basins.

3. A regional model for late Holocene human occupations in Patagonia

Building on this paleoenvironmental information, Goñi et al. (Goñi, 2000, 2010; Goñi et al. 2000–2002, 2005) proposed that during the Late Holocene the heterogeneous distribution of water in the region would have affected human population mobility strategies. Particularly, the concentration of water in low altitude steppe basins, such as Lakes Salitroso/Posadas and Lake Cardiel in Northwestern Santa Cruz (Fig. 1) along with their relatively benign local climatic conditions and availability of other critical resources for human habitation, such as wood and shelter, would have acted as attractors and concentrators of human populations, especially during periods of low regional humidity (Goñi, 2000, 2010; Goñi et al. 2000–2002, 2005). The occurrence of dry spells during which water was distributed more heterogeneously, concentrated in certain points in the landscape with wide extents of dry land between them, would have led hunting-gathering populations to reduce their residential mobility as a strategy to adapt to this new

scenario (Goñi, 2000, 2010). In addition to this gradual reduction of residential mobility, the potential spatial constraint caused by the environmental conditions would have led to a greater concentration of the population in clusters and the differential demographic increase in certain spatial sectors. At the same time, the model posits an expansion of the action ranges for logistic and seasonal activities in the surrounding high altitude areas, *e.g.* Strobel, Cardiel Chico, Pampa del Asador plateaus and Perito Moreno National Park, thus establishing a strategy of extensification at a regional level, with a full incorporation of the plateaus in the mobility strategy of forager populations (Goñi, 2000, 2010; Goñi et al. 2000–2002).

The demographic issues derived from the model relate, first, to the question of whether these changes in settlement patterns during the late Holocene compromised population biological or cultural continuity in the region. Second, there is the question of the mechanisms behind the local increase in population size in certain sectors, such as Lake Salitroso basin, as a result of changes in residential mobility, especially after MCA times (García Guraieb, 2010; Goñi, 2010).

To address these questions, different lines of archaeological and bioarchaeological research were considered. In the following sections, the main methodological aspects and results of each of them will be reviewed and discussed. For archaeological study, the area has been stratified in different sectors with similar ecological characteristics, especially determined by their altitude, one of the main variables considered in the model: a) the high altitude lake basins of the Perito Moreno National Park (PMNP); b) the low altitude basins of Lakes Salitroso, Posadas and Pueyrredón; c) the plateau of Pampa del Asador (including, Cerro Pampa and Lake Guitarra); d) the low basin of Lake Cardiel; e) Strobel Plateau (including the homonym lake area). Some of the data correspond to particular sectors of the region.

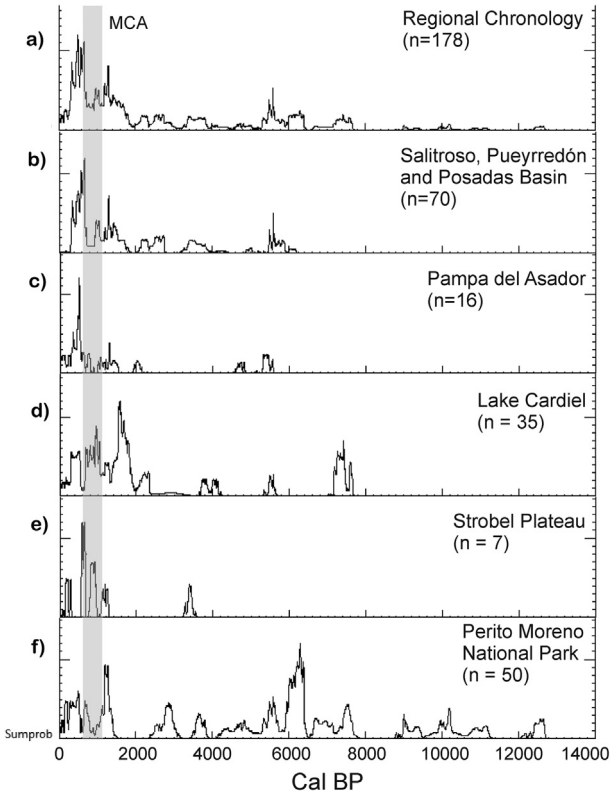

Fig. 2. Summed probability plots for radiocarbon dates available for each sector. a) Regional Chronology, b) Salitroso, Pueyrredón and Posadas Basin, c) Pampa del Asador, d) Lake Cardiel, e) Strobel Plateau, f) Perito Moreno National Park. Calibrated with CALIB. REV 7.0.0 (Stuiver et al., 2013) with SHCal13 (Hogg et al., 2013).

4. Temporal and spatial distribution of the archaeological record

The temporal and spatial distributions of 178 radiocarbon dates available for the study area were analyzed (see Supplementary Material for full data bases and references). The regional chronology was created from radiocarbon dates obtained on different materials – charcoal, bone, and human bone samples – from different proveniences, such as cultural layers from stratified open-air and rock-shelter sites as well as human burials, where these were present. Radiocarbon dates were calibrated using the recent Southern Hemisphere calibration curves published by Hogg et al. (2013) with the radiocarbon calibration program CALIB Rev. 7.0.0 (Stuiver et al., 2013). Temporal trends were analyzed by sector as defined in the previous section using summed probability plots.

Spatial analysis focused on the distribution of materials indicative of differential land use (e.g. hunting blinds, ceramics, grinding tools, stone burial structures). For this analysis the previously mentioned sectors were grouped in three broader sectors: low altitude basins (Lakes Cardiel, Salitroso, Posadas, Pueyrredón), high altitude basins (PMNP) and plateaus (Pampa del Asador, Cerro Pampa, Guitarra Plateau). Sites and the materials obtained or recorded in them come from systematic and directed sampling procedures including excavation and surveys (e.g. parallel transects) (Goñi, 2010).

The summed probability plot of cal BP ages available for the region and each sector is shown in Fig. 2. It has been prepared in connection with one of the strongest hypotheses proposed in this article, namely the effects of the decline in mobility as a consequence of the progressive desiccations of the late Holocene, in particular the Medieval Climatic Anomaly. The grey band in the graphs indicates the period corresponding to this climatic phenomenon.

The regional chronology presented in Fig. 2a shows that within a general trend of sustained occupation of the region during the Holocene, the Late Holocene stands out as presenting the strongest chronological signal of human occupation. When considering each sector separately, the high peaks seen in the late Holocene chronology of Lakes Salitroso, Posadas and Pueyrredón (Fig. 2b) and Lake Cardiel (Fig. 2d) support the argument that low altitude basins acted as areas that attracted human groups during the processes of gradual environmental desiccation of the Late Holocene. This is also interpreted as indicative of the process of reduction in residential mobility and a more stable and redundant use of these basins, which possess more suitable and habitable conditions for residential use (Goñi, 2000, 2010). Nevertheless, although, in general, low altitude basins present a strong late chronological signature, a time lag between Lake Cardiel and Lake Salitroso/Posadas occupations is also noticeable when comparing Fig. 2d and b. The chronology of Lake Cardiel shows high peaks between 2000 and 1000 cal BP and during the MCA times whereas Lake Salitroso/Posadas temporal signal increases considerably after 1000 cal BP, that is, after the MCA and its epic droughts. This can be interpreted as a human lowlands colonization process that, after the reduction of the hydric landscape, seeked to maintain a continuous adjustment to new dramatic environmental conditions (Goñi, 2000, 2010). Finally, there is an evident lack of chronological signal in Lake Salitroso for the last 300 years (Fig. 2b). This has been interpreted as an abandonment of this region due to another change in groups mobility strategies related to the adoption of horses in the region (Goñi, 2013).

Additionally, the chronologial analysis shows that in the plateaus closest to these basins such as Pampa del Asador and Strobel Plateaus (Fig. 2e and f), there is also a marked increase in the frequency of dates during the late Holocene, with dates mainly falling within the last 2000 years, (although there are slight signs of human occupations during the Middle Holocene). This indicates the full incorporation of plateaus in the regional occupation ranges during that period (Goñi, 2010). It is also suggestive of a more intensive use of these areas during that time, in line with the hypothesis of extensification proposed in the regional model (Goñi, 2010, 2000).

Lastly, except for the presence of some 16th century Venetian glass beads in two of the burials in Lake Salitroso (Cassiodoro and García Guraieb, 2009), there was no *a priori* chronological marker in the sites that could have led to intentional biases in sample selection for chronological purposes. Thus, the clustering of dates in certain periods in certain sectors would be a fair reflection of the chronological signal of human occupations in the region.

With regard to the spatial distribution of the archaeological record, Table 1 presents the frequency and distribution of the technological items selected as markers of differential land use: pottery, grinding tools, hunting blinds, and stone burials (chenques), in each of the three main environments present in the region: low basins, high basins and plateaus. Pottery was selected because, as traditional ethnographic studies indicate, this is an infrequent technology among mobile hunter-gatherers (Binford, 2001). Recent studies have shown that the use of pottery is more common in low residential mobility groups (Cassiodoro, 2011), particularly during the winter, to process animal fat, of vital importance for the metabolism of local human populations (Rindel, 2009). Grinding tools indicate the continuous and systematic processing of a variety of resources and are usually located in residential home bases. Hunting blinds and chenques (burials) are stone structures that suggest a certain planning of land use. Stone made hunting blinds are structures intentionally made to stalk, hunt, and process prey in very open environments such as the Patagonian steppe. Therefore, they are spatial markers of programmed hunting activities of specific task groups (logistic groups, *sensu* Binford, 1980). Stone made burial structures, locally known as chenques, refer to particular spaces for mortuary practices. As they are highly visible, especially when forming clusters of burials, they suggest the claim for particular territories, at some times.

As presented in Table 1, low altitude basins show a higher frequency of technological items, such as pottery, grinding tools and burial structures, that suggest residential use or longer stays of the whole social group, whereas high basins and plateaus, that are better suited for seasonal hunting and related activities, show high frequencies of hunting blinds and no burial structures. Thus, the spatial distribution of these sites and materials in the region also supports the hypothesis of a residential and more stable use of low spaces *vs*. a logistic and seasonal role of the surrounding plateaus and high basins (for further details see Rindel, 2009; Goñi, 2010; Cassiodoro, 2011). This is particularly the case of Lake Salitroso Basin, which shows not only a particularly large concentration of human primary burials (very infrequent in the region), but also a number of open-air sites in dunes and similar landforms with grinding tools, pottery and lithic tools and faunal assemblages that suggest that a variety of domestic activities took place in these low spaces (Goñi et al., 2000–2002; Cassiodoro et al., 2004; Cassiodoro, 2011). The characteristics of the mortuary record in the basin also support the hypothesis of a more stable and residential use of Lake Salitroso Basin during the Late Holocene.

Table 1
Frequency of hunting blinds, pottery, grinding tools and chenques in each sector.

	Low altitude basins		High altitude basins		Plateaus		Total
	N	(%)	N	(%)	N	(%)	N
Pottery (fragments)	434	(69.4)	2	(0.3)	189	(30.4)	652
Grinding tools	185	(92.5)	3	(1.5)	12	(6)	200
Hunting blinds	0	(0)	13	(6.9)	175	(93.1)	188
Chenques (burials)	54	(96.4)	2	(3.6)	0	(0)	56

5. Bioarchaeological lines of evidence

5.1. Distributional, temporal and compositional analyses of the mortuary record

The spatial distribution of the funerary record was analyzed considering the regional sectors described in Section 3. As previously noted, most burials are concentrated in Lake Salitroso and will be the focus of the remainder of this paper. Here, 37 burial structures have been analyzed, for which 30 AMS dates obtained from human bones are available. They have been calibrated using the above mentioned calibration program and curve. The results of the temporal distribution analysis and the constructive characteristics of each burial (burial type) led to the conformation of three chronological groups of burials (García Guraieb, 2010). The main characteristics of each group are described and quantified, considering the burial type, the kind and number of inhumations per burial, the sex, age and position of individuals in them and the presence of grave goods. Due to preservation conditions, these variables could only be recorded in 32 of the 37 burials analyzed in Lake Salitroso.

As shown in Table 2, there is a clear differential distribution of the mortuary record in the region: most burials are concentrated in the Lake Salitroso sector whereas the other sectors, both low and high, only have few isolated structures or none at all, despite the extensive surveys carried out in all of them (Barrientos et al., 2014). A second evident characteristic is that the available dates point to a virtual absence of burials prior to the Late Holocene. Thus, at a regional scale, both features are indicative of a differential land use of Lake Salitroso Basin during this period.

The concentration of burials in Lake Salitroso stretches northeast to the lake, in an area of approximately 200 km^2. Burials form small clusters of up to nine structures and are located on the low elevated landforms that surround the basin. According to their construction characteristics, three types of mortuary structures have been identified: niches, burials under boulders (BUB) and chenques (Goñi et al., 2000–2002). Niches are formed in natural and shallow hollows present in a rocky outcrop in the northern margin of the basin (SAC 4) where bodies were just placed to be totally or partially covered by the natural sedimentation. Chenques are completely artificial structures, made up of local rocks; they

Table 2
Frequency and type of burials excavated and analyzed in each sector.

Sectors	Type of burial	N	(%)
Lake Salitroso	Niches	5	(11.4)
	BUB	5	(11.4)
	Chenques	27	(61.4)
Lakes Posadas/Pueyrredón	Chenques	2	(4.54)
Lake Cardiel	Chenques	2	(4.54)
	BUB	1	(2.27)
Perito Moreno National Park	Chenques	2	(4.54)
Pampa del Asador	Surveys with negative results	0	(0)
Strobel Plateau	Surveys with negative results	0	(0)
Total		44	

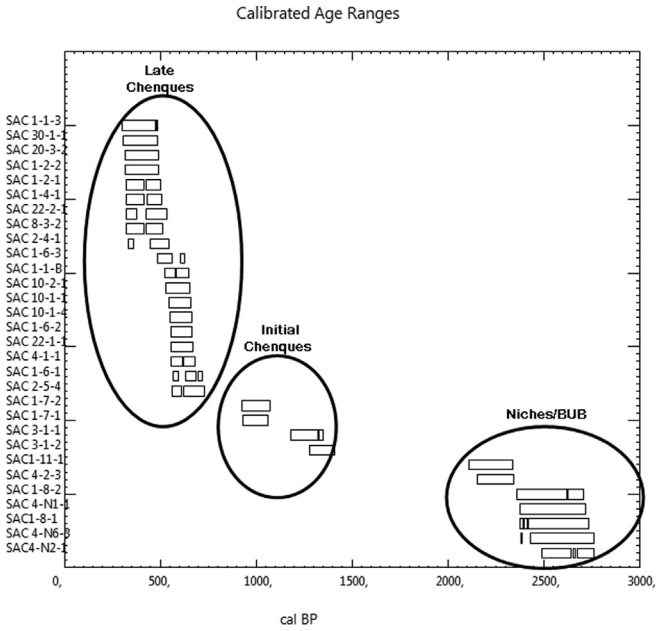

Fig. 3. Chronological groups of burials in Lake Salitroso based on their calibrated BP dates.

have oval or circular shapes, 3–5 m diameter, and are less than a meter high. Burials under boulders (BUB) are mixed structures where some natural landscape feature, such as a boulder or the crest of rocky outcrop, is used to make up a rock structure similar to a chenque (Goñi et al., 2000–2002). Out of 58 funerary structures recorded in Lake Salitroso, 44 have been excavated, 37 of which have given positive results and are analyzed here: 5 niches, 5 BUB, and 27 chenques. Thirty AMS dates have been obtained from human bones of the three types of burials and are presented in Table 3 with their corresponding BP and BC/AD calibrations. These dates were used to build Fig. 3 and have led to the identification of three chronological groups of burials. The earliest of these is represented by niches and BUB, which have dates between *ca.* 2600–2200 BP. This is followed by a smaller, early group of Initial Chenques with dates between *ca.* 1500–1200 BP. Finally, the Late Chenques are the most recent and numerous groups of these structures in the basin, and show dates clustered from 800 to 350 BP (García Guraieb, 2010). This chronology falls just after the available dates for the maximum drought periods of the Medieval Climatic Anomaly in the region (Stine, 1994 and Fig. 2).

These groups were the basis for the analysis of the main characteristics of Lake Salitroso burials presented in Fig. 4. Thus, niches and BUB ($n = 10$) are less numerous than Late Chenques; most of them are primary (Fig 4a), individual (50%) or double (20%) inhumations (Fig. 4b) of extended bodies with a marked predominance of adults over subadults (Fig. 4c). Grave goods are present in a few burials (40%) and are relatively sparse (Cassiodoro and García Guraieb, 2009; García Guraieb, 2010). In contrast, Late Chenques are markedly more numerous ($n = 27$). They also have mainly primary, extended inhumations (Fig. 4a) but, unlike the former group, most chenques are multiple burial structures of up to 10 individuals, with an average of three per burial (Fig. 4b). Some chenques also show evidence of reuse of the same structure to bury individuals through various centuries (e.g. SAC 1-1 in Table 3). The sex and age composition of each chenque is highly variable, but on the whole, the skeletal sample of this group shows individuals of both sexes and all ages with a high representation of subadults (Fig. 4c; see below). Grave goods in these burials are frequent (60% of burials contain them), abundant and diverse, both in terms of the items and the raw materials represented in them and have shown a statistically significant association with subadults under age 10

Table 3
Conventional and calibrated radiocarbon dates for burials of Lake Salitroso.

Burial type	Individual	14C BP	Cal BP (2σ)[a]	Cal AC/AD (2σ)[a]	Lab. code	Source
Nicho	SAC 4-N2-1	2607 ± 41	2490–2765	816–541 AC	AA38568	Goñi et al. 2000–2002
Nicho	SAC 4-N6-3	2586 ± 54	2430–2762	813–481 AC	AA77146	García Guraieb, 2010
EBB	SAC 1-8-1	2532 ± 41	2422–2737	788–473 AC	AA38563	Goñi et al. 2000–2002
Nicho	SAC 4-N1-1	2520 ± 40	2378–2722	773–429 AC	AA38567	Goñi and Barrientos 2004
EBB	SAC 1-8-2	2494 ± 43	2359–2622	673–410 AC	AA38562	Goñi et al. 2000–2002
EBB	SAC 4-2-3	2274 ± 41	2152–2342	393–203 AC	AA38566	Goñi et al. 2000–2002
EEB	SAC 1-11-1	2208 ± 48	2114–2341	392–165 AD	AA81448	García Guraieb, 2010
Chenque	SAC 3-1-2	1486 ± 45	1280–1413	537–670 AD	AA81450	García Guraieb, 2010
Chenque	SAC 3-1-1	1408 ± 44	1184–1324	626–766 AD	AA77151	García Guraieb, 2010
Chenque	SAC 1-7-1	1147 ± 37	934–1065	885–1016 AD	AA38559	Goñi et al. 2000–2002
Chenque	SAC 1-7-2	1142 ± 42	926–1071	879–1024 AD	AA38561	Goñi et al. 2000–2002
Chenque	SAC 2-5-4	758 ± 51	625–732	1218–1325 AD	AA77148	Cassiodoro and García G. 2009
Chenque	SAC 1-6-1	756 ± 32	633–690	1260–1317 AD	AA38556	Goñi et al. 2000–2002
Chenque	SAC 4-1-1	728 ± 39	620–681	1269–1391 AD	AA38565	Goñi et al. 2003–2005
Chenque	SAC 22-1-1	704 ± 42	558–670	1280–1392 AD	AA77150	García Guraieb, 2010
Chenque	SAC 1-6-2	690 ± 40	556–664	1286–1394 AD	AA38557	Goñi et al. 2000–2002
Chenque	SAC 10-1-4	687 ± 43	554–665	1285–1396 AD	AA38570	Goñi and Barrientos 2004
Chenque	SAC 10-1-1	662 ± 43	546–659	1291–1404 AD	AA38569	Goñi and Barrientos 2004
Chenque	SAC 10-2-1	637 ± 47	530–655	1295–1420 AD	AA77149	Cassiodoro and García Guraieb. 2009
Chenque	SAC 1-1-B	622 ± 57	522–650	1300–1428 AD	AA38560	Goñi et al. 2000–2002
Chenque	SAC 1-6-3	539 ± 46	487–562	1388–1466 AD	AA38558	García Guraieb, 2006
Chenque	SAC 2-4-1	486 ± 43	447–546	1404–1503 AD	AA81451	García Guraieb, 2010
Chenque	SAC 8-3-2	435 ± 46	427–516	1434–1525 AD	AA77145	Cassiodoro and García Guraieb. 2009
Chenque	SAC 22-2-1	432 ± 43	428–513	1437–1522 AD	AA87702	García Guraieb, 2010
Chenque	SAC 1-4-1	424 ± 39	429–507	1443–1521 AD	AA38564	Goñi et al. 2000–2002
Chenque	SAC 1-2-1	418 ± 40	425–504	1446–1525 AD	AA38553	Goñi et al. 2000–2002
Chenque	SAC 1-2-2	389 ± 40	320–493	1457–1630 AD	AA38552	Goñi et al. 2000–2002
Chenque	SAC 20-3-2	380 ± 40	317–490	1460–1633 AD	UGA10623	Goñi and Barrientos 2004
Chenque	SAC 30-1-1	361 ± 45	305–486	1464–1645 AD	AA77147	Cassiodoro and García Guraieb. 2009
Chenque	SAC 1-1-3	352 ± 40	301–473	1477–1649 AD	AA38555	Goñi et al. 2000–2002

[a] Calibrated with CALIB. REV 7.0.0 (Stuiver et al., 2013) with SHCal13 (Hogg et al., 2013).

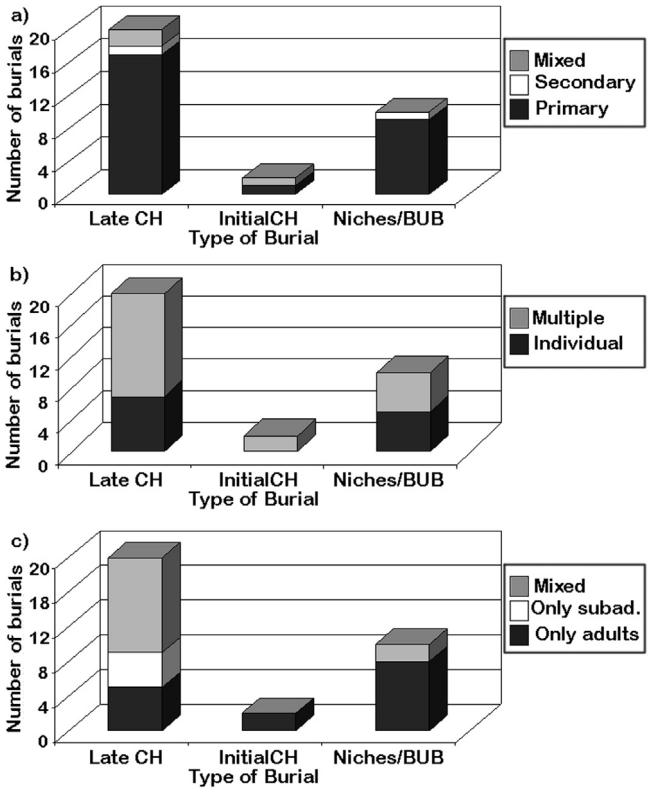

Fig. 4. Frequency of main characteristics of burials of Lake Salitroso per chronological group. a) type of inhumation; b) number of buried individuals; c) age composition of burials. Niches/BUB: $n = 10$; Initial Chenques: $n = 2$; Late Chenques: $n = 20$.

(Cassiodoro and García Guraieb, 2009). Initial Chenques (Fig. 4b) make up a peculiar group of two chenques. Apart from their particular chronological position (Fig. 3 and Table 3), one (SAC 3-1) is the only burial in Lake Salitroso situated on the basin bottom and not on an elevated landform. Also, this burial is one of the few that shows secondary inhumations in the entire sample. Similar to niches and BUB, the sex age composition of Initial Chenques consists exclusively of adults.

These characteristics of the funerary record in Lake Salitroso show similarities and differences in burial groups during the Late Holocene. On the one hand, they support the hypothesis of changes in the basin land use during this time (Goñi, 2000, 2010; García Guraieb, 2010). The important clustering of Late Chenques, with individuals of all ages and both sexes, disposed in primary extended positions suggestive of minimal transport of bodies and signs of reuse of the same burials through time, are in agreement with a more stable, prolonged and residential use of the basin by the entire social group during the centuries following the MCA maximum droughts. In contrast, Niches/BUB and Initial Chenques, containing mainly adults, and among these, males, are suggestive of a more sporadic use of the basin, in an earlier colonization phase of the basin (*sensu* Borrero, 1994–1995) (Goñi and Barrientos, 2004; García Guraieb, 2010).

On the other hand, there are similarities in mortuary practices through time that suggest a cultural continuity in the populations present in the basin during the Late Holocene. The primary, extended position of bodies in the burials, some constructive features, such as the rock structures present throughout the sequence of occupation, the repeated location of all burial types, niches/BUB and chenques, in the same landforms, are some of these elements of population continuity in the region. Other lines of bioarchaeological research have also found cultural and biological markers of this population continuity.

5.2. Stable isotopic analysis

As well as giving information on paleodiets, isotopic analysis of human bone samples from Lake Salitroso (Tessone, 2010) contributed to assessment of the residential mobility reduction hypothesis and, indirectly, to the demographic question on population continuity in the basin. The $\delta^{13}C_{coll}$ and $\delta^{15}N$ isotopic signals for 39 adult individuals of the three groups of burials were analyzed. Collagen extraction followed the protocol proposed by Tykot (2004) (details in Tessone et al., 2014). Paleodietary implications of these results were derived taking into account the available knowledge of the isotopic ecology of the regional resource base (Tessone, 2010; Barberena et al., 2011; Fernández and Tessone, 2014; Méndez et al., 2014; Tessone et al., 2014).

Table 4 presents the individual values of $\delta^{13}C_{coll}$ and $\delta^{15}N$ isotopic signals for the 39 analyzed individuals. The descriptive statistics for these data are shown in Table 5. The C/N ratio had a mean of 3.2 ± 0.07 ($n = 38$), with all ratios within the normal range (2.9–3.6, De Niro, 1985), indicating that the obtained isotopic signals are primary. Considering the whole sample, the mean value of $\delta^{13}C_{coll}$ for adult individuals is −18.6‰ ± 0.4‰, with maximum and minimum values of −17.9‰ and 19.7‰, respectively. For $\delta^{15}N$, a mean of 11.6‰ ± 0.6‰ was obtain, with values ranging between 10.1‰ and 12.9‰.

Considering the internal temporal variability of Lake Salitroso samples, there are no evident changes in $\delta^{13}C_{coll}$ and $\delta^{15}N$ values representing the *ca.* 2400 years of occupation of the basin (Tables 4 and 5). The differences in the mean values of $\delta^{13}C_{coll}$ for Niches/BUB, Initial and Late Chenques do not exceed 0.4‰. For the $\delta^{15}N$, the mean distance is greater, with an observed difference of 1.1‰ between Niches/BUB and Initial Chenques. Even though it is possible that the Initial Chenques result is influenced by the small size of this chronological group, the values of the three samples belonging to it fall between the maximum and minimum of the other two groups, Niches/EBB and Late Chenques (Table 4). Thus, it can be stated that the protein component of the diet of individuals from Lake Salitroso did not change during the Late Holocene.

To perform a paleodietary interpretation of these results, the relationship between the human diet and the available resource base was considered. This process involved the establishment of the isotopic space formed by the resources of the region (Phillips and Gregg, 2003). Recent isotopic investigations in continental Patagonia have allowed researchers to distinguish the isotopic signals of steppe and forest resources (Tessone, 2010; Barberena et al., 2011; Fernández and Tessone, 2014; Tessone et al., 2014; Méndez et al., 2014). Fig. 5 compiles information of the resources available in terrestrial continental Patagonia (Barberena et al., 2011; Fernández and Tessone, 2014; Méndez et al., 2014; Tessone et al., 2014) allowing the estimation of the relative importance of steppe and forest resources in hunter-gatherers paleodiets. In this analysis, an average value of the isotopic enrichment ($\delta^{13}C = 1‰$ and $\delta^{15}N = 4‰$, Bocherens and Drucker, 2003) was considered to obtain an estimated value of the paleodiets of hunter-gatherers. As Fig. 5 illustrates, the average value for the diets can be explained by the consumption of resources from the steppe, with none or minimal consumption of proteins from the forest, situated approximately 40 km to the west of Lake Salitroso.

Finally, in it is important to underscore that, considering the maximum and minimum values of the paleodiets, that range between 1.8‰ and 2.8‰ for carbon and nitrogen respectively, a low dispersion was recorded in a time span of 2400 years (Table 4). This

Table 4
$\delta^{13}C$ and $\delta^{15}N$ values for adult individuals from Lake Salitroso.

Sample	Burial type	Sex	Age	C/N	$\delta^{13}C_{col}$‰	$\delta^{15}N$‰	Reference
SAC 1-8-1	BUB	F	Adult	3.2	−18.68	11.60	Tessone 2010
SAC 4-2-2	BUB	M	Adolescent	3.3	−19.11	10.73	Tessone 2010
SAC 4-N6-4	Niches	M	Adult	3.4	−18.75	10.77	Tessone 2010
SAC 4-2-5	BUB	M	Adult	3.3	−18.69	11.11	Tessone 2010
SAC 4-2-4	BUB	M	Adult	3.3	−18.34	11.29	Tessone 2010
SAC 4-N-4	Niches	M	Adult	3.2	−18.30	11.57	Tessone 2010
SAC 4-N-3	Niches	M	Adult	3.2	−18.54	11.69	Tessone 2010
SAC 19-1-1	BUB	M	Adult	3.3	−18.56	11.82	Tessone 2010
SAC 1-11-1	BUB	M	Adult	3.3	−18.22	11.96	Tessone 2010
SAC-4-N 1	Niches	F	Adult	–	−18.81	11.95	Tessone 2010
SAC 4-2-1	BUB	F	Adult	3.3	−18.01	12.81	Tessone 2010
SAC 1-7-1	Initial Chenques	M	Older adult	3.2	−18.92	12.20	Tessone 2010
SAC 1-7-2	Initial Chenques	M	Young adult	3.2	−18.03	12.86	Tessone 2010
SAC 3-1-1	Initial Chenques	M	Middle adult	3.3	−17.97	12.89	Tessone 2010
SAC 1-6-2	Late Chenques	F	Adolescent	3.2	−18.34	12.40	Tessone et al., 2014
SAC 1-6-3	Late Chenques	F	Adolescent	3.2	−18.70	11.72	Tessone et al., 2014
SAC 1-1-3	Late Chenques	F	Middle adult	3.1	−18.89	12.03	Tessone et al., 2014
SAC 1-2-2	Late Chenques	F	Middle adult	3.1	−18.63	11.25	Tessone et al., 2014
SAC 1-1-B	Late Chenques	F	Middle adult	3.3	−19.38	10.93	Tessone et al., 2014
SAC 4-1-1	Late Chenques	F	Middle adult	3.2	−18.93	11.34	Tessone et al., 2014
SAC 1-1-6	Late Chenques	F	Middle adult	3.2	−19.35	10.57	Tessone et al., 2014
SAC 8-1-1	Late Chenques	F	Adult	3.2	−18.44	11.94	Tessone et al., 2014
SAC 2-5-4	Late Chenques	F	Older adult	3.4	−18.22	11.84	Tessone et al., 2014
SAC 30-1-1	Late Chenques	F	Young adult	3.2	−18.90	11.81	Tessone et al., 2014
SAC 10-4-3	Late Chenques	I	Young adult	3.3	−18.44	12.90	Tessone et al., 2014
SAC 12-1-1	Late Chenques	I	Adult	3.4	−19.40	11.04	Tessone et al., 2014
SAC 8-2-1	Late Chenques	I	Adult	3.3	−19.11	10.47	Tessone et al., 2014
SAC 20-1-1	Late Chenques	I	Adult	3.3	−18.05	12.15	Tessone et al., 2014
SAC 2-8-4	Late Chenques	I	Adult	3.4	−18.67	11.68	Tessone et al., 2014
SAC 30-1-4	Late Chenques	I	Adult	3.2	−18.48	11.30	Tessone et al., 2014
SAC 1-1-1	Late Chenques	M	Adolescent	3.2	−18.79	12.71	Tessone et al., 2014
SAC 10-1-1	Late Chenques	M	Adolescent	3.3	−19.69	11.47	Tessone et al., 2014
SAC 20-3-1	Late Chenques	M	Adolescent	3.3	−18.01	11.62	Tessone et al., 2014
SAC 10-3-1	Late Chenques	M	Adolescent	3.3	−18.88	10.69	Tessone et al., 2014
SAC 10-4-1	Late Chenques	M	Young adult	3.2	−19.37	12.24	Tessone et al., 2014
SAC 8-3-4	Late Chenques	M	Young adult	3.2	−18.34	11.51	Tessone et al., 2014
SAC 20-3-2	Late Chenques	M	Middle adult	3.2	−18.16	11.72	Tessone et al., 2014
SAC 1-3-1	Late Chenques	M	Older adult	3.3	−18.74	11.78	Tessone et al., 2014
SAC 22-1-1	Late Chenques	M	Middle adult	3.3	−19.77	10.13	Tessone et al., 2014

is consistent with the expectation of low isotopic variability of human paleodiets according to the proposed reduced residential mobility strategy that local groups of hunter-gatherers would have implemented during the late Holocene.

5.3. Assessment of population continuity during the late Holocene

Apart from contributing evidence to the main hypothesis of the regional model of reduced residential mobility during the late Holocene, both the isotopic and the funerary records show elements of cultural (i.e. diet and mortuary practices) continuity in Lake Salitroso occupations during this process. These results are consistent with the findings of other lines of research, such as morphometric studies (Pérez et al., 2004; Bernal, 2008; Béguelin, 2009) and ancient DNA analyses of human samples (Moraga et al. 2009), which have helped assessing the biological continuity of populations in the area. In a morphometric analysis of part of the Lake Salitroso skeletal sample, Pérez et al. (2004) recorded continuous and discrete cranial and continuous postcranial variables in adults of both sexes, finding no significant differences between individuals from the earliest and the latest burials. When they extended the scale of the analysis and included other skeletal samples from Southeastern and Southern Patagonia, an isolation process for Lake Salitroso populations was suggested by the results. In addition, when Lake Salitroso samples were included in studies of morphological dental (Bernal, 2008) and postcranial variation (Béguelin, 2009), with a broader geographical scale that included many regions of Argentina or even South America, the intra-sample low variation exhibited by Lake Salitroso sample was readily noticeable. Preliminary results of ancient human mDNA studies of Lake Salitroso samples compared with other Holocene Patagonian samples from both sides of the Andes ratified these findings

Table 5
Descriptive statistics for human bone values of $\delta^{13}C_{col}$‰ and $\delta^{15}N$‰ from Lake Salitroso.

	Total Lake Salitroso		Niches/BUB		Initial chenques		Late chenques	
	$\delta^{13}C_{col}$‰	$\delta^{15}N$‰	$\delta^{13}C_{col}$‰	$\delta^{15}N$‰	$\delta^{13}C_{col}$‰	$\delta^{15}N$‰	$\delta^{13}C_{col}$‰	$\delta^{15}N$‰
N	39	39	11	11	3	3	25	25
Mean	−18.6	11.6	−18.5	11.5	−18.3	12.6	−18.7	12
Stand. dev	0.4	0.6	0.3	0.5	0.5	0.3	0.4	1
Minimum	−19.7	10.1	−19.1	10.7	−18.9	12.2	−19.7	10
Maximum	−17.9	12.9	−18	12.8	−17.9	12.8	−18	13

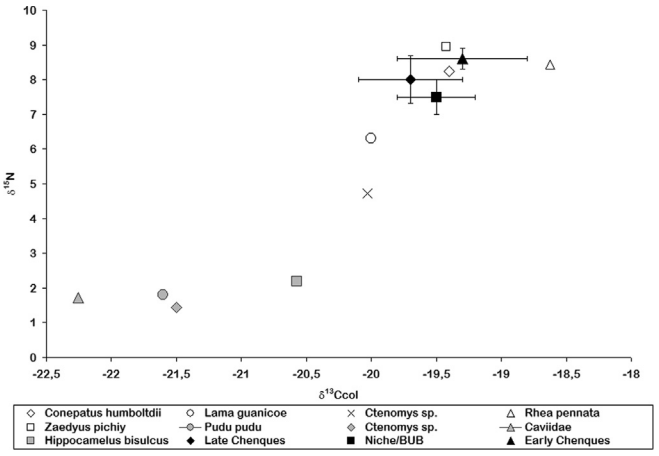

Fig. 5. d^{13} C_{coll} and $d^{15}N$ average and standard deviation values for human and resource samples.

showing a high frequency of the D1 + 1687T haplotype in Lake Salitroso samples of the different chronological groups (Moraga et al., 2009).

To sum up, one of the main arguments in our research is that the biological and cultural evolution of populations in the area was not interrupted during the Late Holocene. The main findings of the research lines presented above appear to sustain this statement. Building on the data presented so far, the following section will be devoted to the description paleodemographic analysis carried out with Lake Salitroso skeletal samples. As this corresponds to unpublished data, analytical methods will be explained in greater length. Readers are referred to the original dissertation for further details (García Guraieb, 2010).

6. Paleodemographic analysis: sex and age structure of Lake Salitroso skeletal sample

The sex and age of 97 individuals from the 37 burials of the three chronological groups of Lake Salitroso were determined. Subadult age estimation was based on the sequence of teeth formation and eruption, the fusion of secondary ossification centers and, in a few cases, long bone lengths using the methods and standards compiled by Scheuer and Black (2000). No attempts were made to estimate the sex of subadults. To sex adults the protocol compiled by Buikstra and Ubelaker (1994) for skulls and pelvic bones was followed. When these elements were absent, the maximum femoral and humeral head diameters were considered in relation to the average and standard deviation measurements obtained for individuals sexed by skulls and pelvis morphological traits (Bernal et al. 2004). Adults' ages were estimated on the basis of the protocols for pelvic bones compiled by Buikstra and Ubelaker (1994) and Iscan et al.'s (1984, 1985) method for the sternal end of the fourth rib.

Results are presented for each chronological group in Tables 6, 7 and 8, using age categories of five years for subadults (under 20 years) and the three age categories for adults: young adults (20–34.9 years), middle adults (35–49.9 years) and older adults (over 50 years). When, due to preservation conditions age and sex could not be assigned for an individual, it was placed in an "indeterminate adult" or "indeterminate subadult" category.

The niches/BUB group yielded a sample of 21 individuals, 71.4% ($n = 15$) of which were preserved well enough to be assigned to an age group. As shown in Table 6, age-at-death profile for this sample is discontinuous, with a higher representation of adults and only a few isolated cases of adolescents and children under age 10. Older adults are the adult age group best represented, followed by young adults and middle adults. As for sex distribution, taking together adults and adolescents ($n = 18$), there appears to be a predominance of males (55.6%) over females (22.2%) and sex indeterminate adults (22.2%). The Initial Chenques sample (Table 7) shows a much smaller size ($n = 5$) but similar characteristics to the previous group as it is formed only by adults of different age (3 males and 2 of indeterminate sex).

The Late Chenques skeletal sample is the largest of the three chronological groups and, unlike the others, presents a continuous age-at-death distribution. Out of 71 individuals, 58 (81.7%) could be assigned to an age category (Table 8). The remaining 18.3% ($n = 13$) lacked the necessary preservation and could only be classified as indeterminate adults ($n = 11$) or indeterminate subadults ($n = 2$). Considering all individuals older than 15 years, the middle adults age group is the most represented one, followed by adolescents and

Table 6
Age and sex structure of Niches/BUB (*ca.* 2600–2200 BP) skeletal sample.

Age groups (years)	Males		Females		Indeterminates		Total	
	N	%	N	%	N		N	%
0–4.9	0	0	0	0	2	9.52	2	9.52
5–9.9	0	0	0	0	1	4.76	1	4.76
10–14.9	0	0	0	0	0	0	0	0.00
15–19.9	1	4.76	0	0	0	0	1	4.76
20–34.9	3	14.29	1	4.76	0	0	4	19.05
35–49.9	1	4.76	1	4.76	0	0	2	9.52
50+	4	19.05	1	4.76	0	0	5	23.81
Indet. adult	1	4.76	1	4.76	4	19.05	6	28.57
Indet. subadult	0	0.00	0	0	0	0	0	0
Total	10	47.62	4	19.05	7	33.33	21	100

Table 7
Age and sex structure of Initial Chenques sample (*ca.* 1500–1200 BP) skeletal sample.

Age groups (years)	Males		Females		Indeterminates		Total	
	N	%	N	%	N	%	N	%
0–4.9	0	0	0	0	0	0	0	0
5–9.9	0	0	0	0	0	0	0	0
10–14.9	0	0	0	0	0	0	0	0
15–19.9	0	0	0	0	0	0	0	0
20–34.9	1	20	0	0	0	0	1	20
35–49.9	1	20	0	0	0	0	1	20
50+	1	20	0	0	0	0	1	20
Indet. adult	0	0	0	0	2	40	2	40
Indet. subadult	0	0	0	0	0	0	0	0
Total	3	60	0	0	2	40	5	100

Table 8
Age and sex structure of Late Chenques sample (*ca.* 800–350 BP) skeletal sample.

Age groups (years)	Males		Females		Indeterminates		Total	
	N	%	N	%	N	%	N	%
0–4.9	0	0	0	0	15	21.13	15	21.1
5–9.9	0	0	0	0	12	16.90	12	16.90
10–14.9	0	0	0	0	7	9.86	7	9.86
15–19.9	3	4.23	3	4.23	0	0.00	6	8.45
20–34.9	3	4.23	2	2.82	1	1.41	6	8.45
35–49.9	2	2.82	6	8.45	2	2.82	10	14.08
50+	1	1.41	1	1.41	0	0.00	2	2.82
Indet. adult	0	0	0	0	11	15.49	11	15.49
Indet. subadult	0	0	0	0	2	2.82	2	2.82
Total	9	12.68	12	16.90	50	70.42	71	100

young adults with similar percentages and older adults with a marked lower one. Sex distribution among adults and adolescents ($n = 35$) is fairly even with 34.3% identified as females, 25.7% as males and 40% as sex indeterminate adults due to poor preservation conditions (further details in García Guraieb, 2010).

A distinctive feature of the Late Chenques sample is the high proportion of subadults under 15 years that make up more than 50% of the total sample. This feature was identified early in the research (Barrientos et al., 2004; Bernal et al., 2004) and has remained unchanged even though the sample has increased considerably. Among these age groups, infants between 0 and 4.9 years show the highest representation, closely followed by children between 5 and 9.9 years, and then, with lower percentages, individuals between 10 and 14.9. The small difference identified between the first two age classes of subadults will be discussed below.

When comparing the main characteristics of the sex and age profiles of the three chronological groups, some features stand out. The first and most noticeable thing is the difference in sample sizes, particularly the larger size of the Late Chenques sample relative to the two earlier groups. Second, the virtual absence of subadults in the early chronological group age profiles is in high contrast with their overrepresentation in the Late Chenques sample. Last, the three chronological groups show differences in the adults and adolescents sex distribution with niches/BUB and Initial Chenques showing a predominance of males whereas Late Chenques present a more even sex distribution. However, the comparison of the two largest samples (Niches/BUB *vs*. Late Chenques) showed no statically significant differences both considering and not adults of indeterminate sex (Fisher Exact Test $p > 0{,}05$).

Regarding the difference between samples in size and subadult representation, the extensive and intensive surveys carried out in Lake Salitroso over the years render it unlikely that sampling issues could explain them. Neither would taphonomic processes be the main cause of these dissimilarities. Although the first taphonomic studies carried out with this sample had found a higher relative damage of remains in older burials (Zangrando et al., 2004; Barrientos et al., 2007), in recent years, the incorporation of new Late Chenques has made it evident that there is a wide variation in bone preservation and skeletal integrity in this type of burials. Apart from the selective action of taphonomic processes (diagenesis, roots action, rodents, etc.) (Barrientos et al., 2007), many chenques have suffered the action of cultural processes both past (*i.e.* reuse of the burial structure) and modern (e.g. plunder and old non-scientific excavations) which appear not to have disturbed older, less visible, burials in niches. Thus, differences in sample size and subadult representation between groups of burials appear to be a property of Lake Salitroso mortuary record related to differences in land use through time. The first two groups of burials would be representative of colonization phases of the area, whereas the Late Chenques would be the product of a more stable and prolonged settlement by low residential mobility groups after MCA times (García Guraieb, 2010). This interpretation is supported by the composition, temporal and spatial distribution of the regional archaeological record (Goñi, 2010; Cassiodoro, 2011).

Insofar as the Late Chenques sample shows the biggest size and an age-at-distribution consistent with an attritional profile, it is the one with greater potential for paleodemographic analysis. To assess its potential to give demographic information, a series of comparative analyses were carried out, the main results of which are presented below (details in García Guraieb, 2010).

6.1. Comparative analyses of the Late Chenques age-at-death profile

First, the Late Chenques sample was compared to other skeletal samples of hunter-gatherers. Fig. 6a presents a comparison

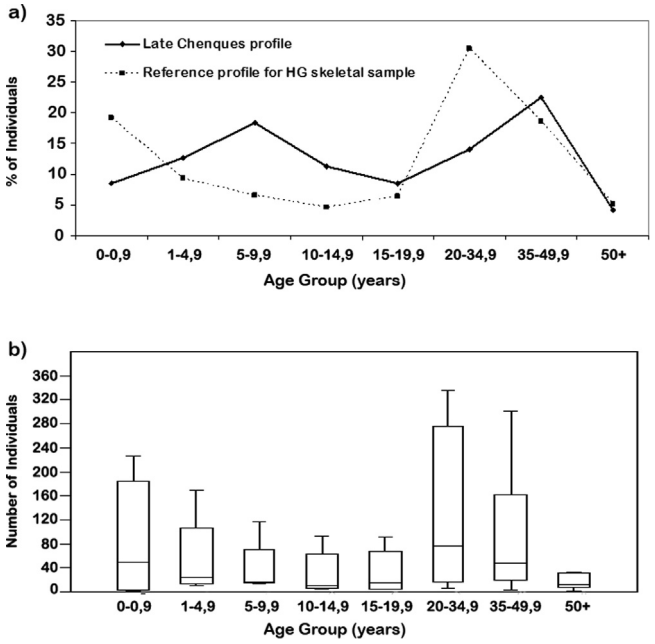

Fig. 6. a) Comparison of the Late Chenques mortality profile with reference mortality profiles for hunter-gatherers skeletal samples. Late Chenques profile: $n = 71$; Reference Profile: $n = 253$; b) box-plot for the distribution of individuals of the comparative samples for each age category.

between the age distribution profiles of Late Chenques (SAC) and a synthetic curve representative of hunter-gatherer skeletal collections. This reference profile was built using the median value of individuals represented in each age group for the Indian Knoll (Johnston and Snow, 1961), Libben (Lovejoy et al., 1977), Carlston Annis (Mensforth, 1990), Lokomotiv and Ust'Ida (Weber et al., 2002) and Lihué Calel (Luna, 2008) osteological samples. To assess differences in sample size and distribution of the comparative data employed, a box-plot with the raw distribution for each age category is presented in Fig. 6b (García Guraieb, 2010 for further methodological details and references).

The focus of this comparison was set on the subadult portion of the samples curve. As previously noted (Table 7), Late Chenques had only a slightly higher representation of individuals in the 0–4.9 age group than in the 5–9.9 age group, whereas a much bigger difference in representation would be expected according to demographic mortality models for hunter-gatherers (e.g. Howell, 1979; Kelly, 1995; Hill and Hurtado, 1996). In the comparison between the Late Chenques profile and the reference profile, infants less than 1 year of age were discriminated as an age group. It is apparent that the reason for the discrepancy is the relatively low representation of this age group in the Late Chenques sample (Fig. 6) (García Guraieb, 2010). This, although not demographically expected, is a frequent finding in skeletal samples due to differential preservation of immature remains (Gordon and Buikstra, 1981) and age biases in mortuary practices (Jackes, 1992). The adult section of the curves also shows differences in the proportional representation of adult age groups of each profile. Most of them are probably explained by the methodological difficulties and biases that are common in adult age estimation, particularly when ageing older adults (Hoppa and Vaupel, 2002). However, they are not addressed here in detail as they are not the focus of the discussion.

To complement the comparative analysis, two paleodemographic values were estimated for this sample: the juvenile to adult ratio (J/A) and the mean childhood mortality (MCM) proposed by

Jackes (1992). The J/A is the ratio of individuals in age groups 5–14.9 to adults over 20 years and the MCM is the average probability of death for ages 5–9.9, 10–14.9 and 15–19.9 ($_5q_5$, $_5q_{10}$, $_5q_{15}$) (Jackes, 1992). These estimators have the advantage of not being affected by the frequent underrepresentation of subadults under 5 years or errors in the estimations of adults' ages (Jackes, 1992). Also, their joint use in the analysis of age profiles has proven useful in the assessment of demographic characteristics of past populations or the identification of biases in their derived skeletal samples (Jackes, 1992). Here, they were compared with the reference values published by Jackes (1992) for populations undergoing a declining, stationary, or growing phase and for biased samples. Values presented by Jackes (1992) for this three situations range between 0.04 and 0.2 for J/A and between 0.02 and 0.08 for MCM, while values above these numbers are characteristic of samples with some kind of bias. Results obtained for these paleodemographic estimators in the Late Chenques sample were $J/A = 0.724$ and $MCM = 0.197$. Both fall well beyond the threshold set for biased samples, particularly for those with a low representation of adults (Jackes, 1992).

On the whole, the results of these comparative analyses led to the identification of biases in the Late Chenques samples that need to be considered before any paleodemographic interpretation can be drawn from the data. Regarding the underrepresentation of infants less than a year old, the fact that a number (although not as many as biologically expected) were recovered from these burials suggests that infants were probably not subject to a systematic segregation in mortuary practices. However, it is possible that they received a more flexible funerary treatment than older subadults. It is more likely that taphonomic processes were responsible for this low representation. Partial taphonomic results failed to identify preservation biases towards subadults (Zangrando et al., 2004; Barrientos et al., 2007). However, since these analyses were carried out, the Late Chenques sample has increased in size and variety, and taphonomic studies are still underway. Finally, and despite preservation biases of the youngest infants, the relatively large proportion of subadults in the 5–9.9 age group could also be the result of "mortality sampling biases". In small populations such as the one under study, an event causing the death of several children at once: a widespread infection, an accident, a violent episode, could result in a clustering of subadult deaths that would affect the small sample age-at-death derived profile (Paine and Boldsen, 2002). In relation to this, the high prevalence of dental enamel hypoplasias found in this sample in the permanent anterior dentition of individuals suggests that systemic episodes of stress were generalized, frequent and recurrent during the infancy and first childhood of these populations (García Guraieb, 2010). To sum up, in this small skeletal sample, the subadult section of the mortality profile could be explained by a combination of factors such as a poorer preservation of more fragile immature remains, a greater flexibility in funerary practices for infants less than a year old, and pathological and accidental processes affecting older subadults (García Guraieb, 2010).

The underrepresentation of adults in the Late Chenques sample is also explainable for a combination of taphonomic factors, land use strategies in relation to mortuary practices and, finally, demographic factors. First, regarding the taphonomic factors, as previously mentioned, some chenques have been the subject of plunder or old non-systematic excavations by travelers and explorers (e.g. Steffen, Roth) whose aim was usually the recovery of adult skulls and skeletons, as shown by the frequent adult composition of Patagonian skeletal collections in local and international museums. Second, the low residential mobility model proposed for the region for the final Late Holocene includes the implementation of a logistic mobility with special parties for the acquisition of particular resources in the surrounding plateaus and western forests (Goñi, 2000; Goñi et al.,. 2000–2002; Goñi and Barrientos, 2004; Rindel, 2009; Cassiodoro, 2011). As the hunter-gatherer ethnographic (Kelly, 1995) and ethnohistoric records (Musters, 2005) illustrate, these logistic parties are usually made up of male adults and adolescents. Hence, it is possible that accidental deaths occurring during these special activities resulted in male adults buried outside the basin following atypical dispositional patterns or in the impossibility of the body retrieval by other members of the group. In this context, isolated burials, especially chenques of a single male individual, are a relatively frequent finding in Central and Southern Patagonia (*e.g.* Goñi, 2000; García Guraieb et al., 2009; Belardi et al., 2010). Those could be considered the counterpart of the concentration of burials with high representation of subadults and female adults such as the Late Chenques of Lake Salitroso (Goñi et al., 2000–2002).

Notwithstanding the effects of the above mentioned factors causing infant and adult underrepresentation, we propose that they could be acting superimposed on a mortality profile reflecting a demographic process that would also account for the high representation of subadults relative to adults, such as an increase in fertility. As Sattenspiel and Harpending (1983) have established, under conditions of nonstationarity, mortality profiles are more affected by slight changes in fertility rather than by bigger changes in mortality, and tend to show younger age-at death distributions. Therefore, the higher representation of subadults relative to adults could be a consequence of a slight population growth after the MCA, due to a relaxation of the constraints that high residential mobility may have imposed over fertility (García Guraieb, 2010). Such population recovery processes have been documented in societies that had previously undergone retractions after extreme climatic conditions (Kelly, 1995), such as the ones that might have affected Patagonian populations during the extreme droughts of the MCA. In short, the reduction in residential mobility posited for the region after the MCA, could have led to reduction on fertility constraints and a consequent slight population growth that could still be inferred from the Late Chenques age-at-death distribution in spite of the aforementioned sample biases.

7. Concluding remarks

The aim of this paper has been to summarize the main results and lines of research developed in northwestern and central Santa Cruz to address and discuss some demographic aspects of the hunter-gatherer populations that inhabited this region during the past millennia. Considering Goñi's model for the regional settlement and land use patterns during the Late Holocene as a starting point, several lines of inquiry were put into play to obtain relevant demographic information at different scales. Thus, the spatial and temporal distribution analyses of more than 170 radiocarbon dates at a regional level were the first approach to the regional land use patterns during the Late Holocene. Particularly, the hypothesis of a reduction in residential mobility and nucleation of settlements in low altitude basins with water availability as a result of the progressive environmental aridization recorded during the Late Holocene was supported by the temporal and spatial trends seen in the archaeological record. Also, an intensification of the reduction after MCA times in Lake Salitroso basin was confirmed. This allowed us to obtain coarse grain paleodemographic information on population dynamics in the region.

Building on them, the analysis then focused on several bioarcheological lines of research (i.e. regional and local mortuary analysis, isotopic, DNA and morphometric studies) that contributed with evidence to test other demographic implications of the model; namely, whether the postulated changes in land use during the late Holocene compromised population cultural or biological

continuity. The evidence gathered points to such a continuity, at least in the Lake Salitroso basin. Finally, the age and sex distribution profiles of skeletal samples from Lake Salitroso were analyzed giving a unique opportunity in the region to address issues of hunter-gatherer demographic dynamics with a first-hand line of inquiry. Notwithstanding the previously discussed biases, the age-at-death distribution of the Late Chenques skeletal sample suggests a slight population growth after MCA times, probably as a result of the relaxation of the higher constraints that higher residential mobility can cause to fertility. Finally, we would like to emphasize the importance of the joint study of different lines of research to fully assess their potential and biases in the construction of the elusive demographic knowledge of past hunter-gatherers populations.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.quaint.2014.09.054.

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