Mid-Holocene environment and human occupation of the Puna (Susques, Argentina)

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Abstract

Paleoenvironmental information regarding the mid-Holocene in the Puna de Atacama generally shows extreme aridity and high temperatures ("Hypsithermal"). Moreover, the absence of human occupations in certain sectors of the region suggested a "Silencio Arqueológico", between 7500 and 5000 BP. However, recent research reveals that places with better conditions of humidity and resources had been used by hunter–gatherer populations during this period. The goal of this paper is to examine the general evidence, and to give information from the Susques area (Jujuy, Argentina) mainly derived from diatom assemblages sampled in fossil marsh (vegas) profiles, and archaeological sites. These data show a local situation marked by greater humidity than that at present, between 8230 and 7550 BP, and 6300–6100 BP. This evidence indicates the great heterogeneity that characterized the mid-Holocene environment.

1. Introduction

Mid-Holocene environmental conditions are regarded to have been a major obstacle in the development of hunter–gatherer populations in several parts of the Americas:

"*The period of greatest population sparseness appears to coincide with the allegedly dry Altithermal (…). Although there is some doubt as to how dry the Altithermal was (…), it is widely regarded as being a major factor in the prehistory of the drier parts of America*" (Goudie, 1995, p. 162).

Many authors state the idea that the poor environmental conditions of the mid-Holocene disrupted the land-use patterns of hunter–gatherer groups established in the Early Holocene. Hunter–gatherers could have abandoned entire areas to go to others that had better local conditions, defined as "refuges" (Grosjean and Núñez, 1994).

It is generally accepted that variability in hunter–gatherer populations are influenced or even shaped by environmental and climatic fluctuation (Kelly, 1995). Although this may be exaggerated, as people are active in constructing their way of living, environmental change affects or disrupts the human population or their activities in all types of societies, even our own, as the periodic ENSO (El Niño) shows.

Our objective is to present preliminary information about the local environmental condition of the Susques area in the Puna or Altiplano of northwestern Argentina, for the beginning and the end of the mid-Holocene, and its relationship with human occupations. Discussion will consider general data from the environment of the period in the highlands of the Southern Andes, mainly from Bolivia and Chile. The mid-Holocene environment was extremely variable, both spatially and temporally, and for that reason we have to know the local variability and intensity of the climatic and environmental modification and/or fluctuations that differentially affected the mobility patterns and social strategies of hunter–gatherer groups (Yacobaccio, 1998).

Although broad scenarios for the Mid-Holocene environment seem to be quite well-known, we have poor knowledge about local settings. In the Southern Andes the main proxy data used were palynology,

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limnology, geomorphological features, and ice-cores. Palynology has the most general scope in both space and time, while limnology and geomorphology usually provide good local environmental and temporal resolution. Ice-core data, on the other hand, have good chronological resolution, but variable spatial scope (Alley, 2000). In this paper we will use data from diatoms, and to a lesser extent from the archaeofaunas. Diatoms allow increased spatial resolution, as in mountain aquatic environments, the diatom assemblages show a zonal distribution (Servant-Vildary and Roux, 1990; Reed et al., 1999).

2. Early Holocene background

The Late Pleistocene as well as the early Holocene are reputed to have been cold and humid. It is very important to know the characteristics of the environment and climate during these periods, because this is when human populations colonized the Southern Andes, around 11,000 BP. For the northern altiplano, the highstand of Lago Titicaca can be correlated with the Tauca III phase ending around 10,500 BP. This suggests that Lago Titicaca could have overflowed into the southern basin (Poopó-Coypasa-Uyuni) (Sylvestre et al., 1999; Baker et al., 2001). After a drastic drop of the lake level, algal assemblages indicating humid conditions (e.g. *Botryococcus* and *Pediastrum*), reappear just after 9620 BP, lasting until about 8500 BP. Sylvestre et al. (1999) named this humid lacustrine phase the Coypasa event, which also has been recorded in the Southern Andes at Laguna Lejía from $11,480 \pm 70$ BP to 8430 ± 75 BP (Grosjean, 1994; Sylvestre et al., 1999). The correlation of a humid phase in the Amazonian lowlands, the main source of water vapour feeding the precipitation over the tropical Southern Andes, with the Coypasa phase, suggests that large-scale climatic variations were affecting lake-level changes in the Altiplano (Sylvestre et al., 1999, p. 64; Baker et al., 2001). Pollen analyses from different localities of the Dry Puna in Northwestern Argentina also indicate a humid and cold period in the Early Holocene (Markgraf, 1985; Fernandez et al., 1991; Lupo, 1998).

3. Mid-Holocene environment

Lake sediment records from the Altiplano suggest that the paleolakes dried very rapidly between 8400 and 8000 BP (Geyh et al., 1996; Sylvestre et al., 1999). The ^{18}O record of the Huascarán ice core shows that warmest Holocene conditions prevailed between 8400 and 5200 BP, with the maximum warming from 6500 to 5200 BP (Thompson et al., 1995; Geyh et al., 1996). The level of Lago Titicaca fell sharply from around 8500 BP, with a reversal of the drying trend between 7000 to 6000 BP, followed by an extremely dry period between 6000 and 5000 BP, resulting in the lowest level of the lake so far recorded in the last 25,000 years (85 m below the present level). The lake level increase began around 4500 BP (Baker et al., 2001). Further evidence from Río Desaguadero (northern Altiplano of Bolivia, south of Lago Titicaca), shows a nearly continuous fluvial sedimentation from 7000 BP until around 3200 BP. Two high-water intervals have been recorded in the northern sector of the river, at 4500–3900 BP and 2200–2000 BP (Baucom and Rigsby, 1999). Pollen analysis from the Dry Puna of NW Argentina show decreasing quantities of grasses and herbs, and increasing components of an arid environment such as *Compositae* (Markgraf, 1985). In the northern tip of the Puna at Yavi, a long arid period was recorded between 8000 and 6000 BP. The main indicator is the steppe vegetation, such as *Chenopodiaceae-Amaranthaceae, Pennisetum*, and *Poaceae* (Lupo, 1998).

For northern Chile, Messerli et al. (1997, p. 232) state: "*Such extremely arid conditions were interrupted by low-frequency, heavy storms. These are evidenced by individual debris flows in canyons, and flood deposits on the plains (i.e., in the Salar de Atacama). Radiocarbon dating showed return periods of about 200 years for such events*".

Thus, repeated wetting and drying cycles suggest short-term alteration between humid spells and dry events (Nuñez et al., 2001). In this way, the general environmental conditions for the mid-Holocene can be characterized by a general aridity interrupted by storms as episodic events. Puripica, Laguna Miscanti and Laguna del Negro Francisco provide evidence of regional storm activity between 6000 and 3600 BP, in alluvial deposits (Grosjean et al., 1997).

The factors that account for the regional climatic background of mid-Holocene aridity could be the following:

1. Decrease of tropical summer precipitation (Grosjean and Núñez, 1994); or
2. A strong Pacific anticyclone enhanced anticyclonic flow in the southeastern Pacific (Villagrán, 1993).

The first option is favored by Grosjean et al. (1997); see also Thompson et al., 1998), as the atmospheric moisture transport originated in the Amazon basin is the main source for the tropical summer precipitation in the Altiplano, and maximum aridity occurred in central Amazonia in the Mid-Holocene.

The uneven nature of the Mid-Holocene environment contributed to the concentration of resources in favored areas (the so-called "ecological refuges"), promoting human occupation in those places (Grosjean et al., 1997; Yacobaccio, 1998; Nuñez et al., 2001). However, the

variability of local conditions is poorly known in the highlands of the Southern Andes. As these environmental variations surely affected hunter–gatherers' mobility patterns, we also have to generate information on a local scale.

4. Susques

Susques is a locality in the Puna, Jujuy province, northwest Argentina, situated at the confluence of the Salado (Pastos Chicos) and Susques rivers. The region is flanked by two north–south mountain chains: Sierra de los Cobres to the east, and Sierra de Taire to the west. Geologically the area is composed of tufa and ignimbritic tufa in the north and along the left margin of the Salado River, and marine sandstone, lutites and calcareous layers along the right margin.

The environment is a desert located between 3600 and 4500 m asl. The current climate is cold and dry with summer rains (December–March) varying between 50 and 200 mm, with a mean precipitation of 190 mm per year. The average temperature is 7.5 °C, with a range between 2 °C and 11.1 °C, and frosts occur during the whole year. A high daily thermic amplitude and high evaporation exists due to the altitude above sea level (Buitrago and Larrán, 1994).

The environmental characteristics of the Puna in Susques share the general characteristics of the Puna environment (high daily thermic amplitude, high evaporation and well marked seasonality), but it does not have such a large area of gramineous lands as does the Dry Puna. Gramineous steppe is not so spatially constrained as in the Salt Puna.

According to Cabrera (1976), the Susques area is characterized by xerophytic vegetation, with three assemblages: the *vegas* (marshes), the *tolares* (scrubland), and the *pajonal* (open grassland/scrub). The *vegas* are composed of tender grazing in which rhizome species predominate (*Hypsella oligophylla*; *Werneria pygmaea*). They are located in the bottom of gorges, in headwaters as well as at the river mouth. The *tolares* are located between 3600 and 4200 m asl. The environment suits bush steppe with tola (*Parastrephia lepidophylla*), tolilla (*Fabiana densa*), and varieties of Poaceae such as *Festuca orthophylla*. The grasslands and scrub are located from 4200 to 5000 m asl. In this area gramineous steppe is ruled by *Festuca orthophyla, F. chrysophyla* (iros), *Poa gymnantha,* and other grasses.

The bottoms of gorges provide good sampling areas for searching for evidence of fossil *vegas*, which can give information about environmental modifications. The headwater of the Quebrada de Lapao (23° 21' 58''S; 66° 21' 57''W), with a very small *vega* today, has stratigraphic profiles and paleostreams potentially useful for research (Fig. 1).

Data were analyzed from three profiles located in the same topographic area. These profiles have been ^{14}C dated to between the end of the early Holocene and the beginning of the mid-Holocene (Table 1). They have diatom components, our main research focus. Stable isotopes and faunal analysis from a nearby archaeological site were used as complementary information.

5. Diatom analysis at Quebrada de Lapao

The preliminary results of the diatom analysis of three different profiles are presented. Although these profiles are only a part of the total number of samples that will be analysed further, these results contribute an interesting general ecological framework for the last part of the Early Holocene and the first part of the mid-Holocene.

5.1. Methods and techniques

Three samples from three different profiles at Quebrada de Lapao were analyzed. LG7, LG1, and LG6 are ^{14}C dated between 8230 BP and 7550 BP (Table 1). The samples were oxidized using Nitric Acid and Oxygen Water (30%). Distilled water was used to eliminate acidity. Finally, they were mounted on microscope slides using Canada Balsam. At least 400 valves were counted in each slide in a continuous transect, ensuring a statistical minimum to work with dominant species (Machiavello, personal communication). They were observed at 1000× for taxonomic determination. Only those fractured valves that represented at least 60% of a whole valve were counted in order to eliminate a re-count possibility.

The relevant bibliography was used for taxonomic assignment (Cleve-Euler, 1955; Germain, 1981; Krammer and Lange-Bertalot, 1986–1991; Herbst and Maidana, 1988). Ecological affinities were obtained from De Wolf (1982) and Van Dam et al. (1994). Table 2 displays the list of identified taxa and the associated ecological information.

5.2. Sample LG7 (8230 BP)

Sixteen species of the *Pennales* order were determined in this sample. The dominant species is *Epithemia adnata* (22.5%), and the co-dominants are *Rhopalodia gibberula*, *Denticula elegans* (15%), *Pinnularia viridis* (9.5%), *Rhopalodia constricta* (8%), *Nitzschia vitrea* (6%) and *Navicula cincta* (5%). *Epithemia sp.* and *Rhopalodia sp.* are common when nitrogen is low in streams (Stevenson and Pan, 2000) and when waters are rich in phosphorous (Hall and Smol, 2000). Particularly, *Rhopalodia gibberula* is considered by Fritz et al. (2000) as a saline-alkaline species pertaining to the sodium-chloride rich water, common during intervals of hydrological deficit.

Fig. 1. Archaeological locations mentioned in the text. 1. Quebrada Lapao; 2. Hornillos 2; 3. quebrada Puripica; 4. Yavi; 5. Pintoscayoc/Inca Cueva 4; 6. Huachichocana III; 7. Quebrada Seca 3. A. Zapaleri obsidian source; B. Alto Tocomar transparent obisidian source.

The ecological characteristics shown by this sample point to the existence of a shallow water environment, possibly periodically flooded, with a significant vegetation cover. This is indicated by the abundance of epiphytic (53.75%) and aerophilous (36.75%) diatoms, the existence of benthic diatoms, and the total absence

Table 1
Radiocarbon dates from Early and Mid-Holocene geological profiles and human occupations

Location	Laboratory number	Sample	Technic	Date BP (non-calibrated)
Lapao 7 (L7)	UGA-8728	Soil	AMS	8230±40
Lapao 5 (L5)	LP-981	Soil	LSC	7770±80
Lapao 6 (L6)	UGA-8727	Soil	AMS	7750±40
Lapao 1 (L1)	LP-1025	Soil	LSC	7550±90
Hornillos 2, layer 6	UGA-8724	Wood	AMS	9590±50
Hornillos 2, layer 6	UGA-8723	Charcoal	AMS	9150±50
Hornillos 2, layer 4	LP-757	Charcoal	LSC	8280±100
Hornillos 2, layer 3	UGA-8722	Charcoal	LSC	7760±160
Hornillos 2, layer 3	UGA-7830	Charcoal	LSC	7430±80
Hornillos 2, layer 2	UGA-7829	Charcoal	LSC	6340±110
Hornillos 2, layer 2	Beta-11139	Charcoal	LSC	6190±70

Table 2
Taxa and ecology of sample L7C

Taxa	Fr(%)	pH	Salinity	Life form	Trofism
Cymbella ventricosa	1	Ind.	O	E	Eut.
Epithemia argus	41	Alp.	O	E	—
Nitzchia communis	4	Alp.	O	E	Eut.
Pinnularia brebissonii	0.5	Ind.	O.	B	—
Pinnularia viridis	13	Ind.	O.	E	Mes.
Rhopalodia gibba	0.5	Alb.	O.	E	Eut.
Rhopalodia gibberula	38	Ind.	O. Hal.	E	—
Rhopalodia parallela	1.5	Alp.	O.	E	—

Data from De Wolf (1982) and Van Dam et al. (1994).
References—pH: Alb. (alkalibionts), Alp. (alkalíphilous), Ind. (Circumneutral), Acf. (acidóphilous), Acb. (acidobionts); Salinity: Polihalobious, Mesohalobious, Oligohalobious Halófilous, Oligohalobious, Halófobous; Life form: Planktonic, Benthic, Epíphytic, Aerophilic, Eu-terrestric; Trofism: Eutróphic, Mesoeutróphic, Mesotróphic, Mesooligotróphic, Oligotróphic; Fr%: Relative frequency of each species in the sample.

of planktonic taxa. Moreover, the presence of some species such as *Rhopalodia gibberula* and *Epithemia argus* suggests a possible littoral environment (González and Maidana, 1998; Sylvestre et al., 1999). Some other ecological affinities shown by the diatoms of this sample are (1) high nutrient availability (at least phosphorous); (2) slightly brackish, and (3) slightly alkaline environment.

The isotopic information available for this layer also indicates extensive vegetation cover. The $\delta^{13}C$ obtained from the same soil sample is –25.2‰, showing a strong tendency to C_3 plant cover, perhaps Cyperaceae.

Some other aspects of this sample could be taken into account. *Rhopalodia constricta* has been found by Maidana et al. (1998) in Laguna de los Pozuelos (Jujuy, Argentina, at 3600 m asl), and is considered as a cosmopolite diatom which prefers brackish waters or fresh waters with a high electrolytic content. It is included by Vos and De Wolf (1993) in the marine/

brackish epiphytes group. Servant–Vildary (1978) found another species of the same genus, *Rhopalodia gibberula*, in Bolivian sediments, characterizing it as typical of interior salt lakes.

5.3. Sample LG1 (7550 BP)

Due to the lack of knowledge of significant components of the ecological parameters of the diatom species found in this sample, the results are not so accurate as for the others. Table 3 shows the percentage and quantities of species. *Navicula cincta* is dominant (40%), and *Diadesmis gallica* (17.5%), *Nitzschia frustulum* (16%), *Nitzschia perspicua* (7%) and *Fragilaria brevistriata* (5%) are co-dominant species.

The assemblage suggests a slightly alkaline, strongly aerophilous and eutrophic environment. As this sample comes from a peat, at a small spring tributary of the Pastos Chicos River, we may tentatively interpret these data as a shallow paleospring environment. The lack of ecological data for these diatoms precludes detailed interpretation until more results in this small area of the gorge are obtained.

5.4. Sample LG6 (7750 BP)

Twenty-one species were determined in this sample, all but one pertaining to the *Pennales* order (Table 3). *Amphora tucumana* is the dominant species with 32% of the total valves; *Fragilaria construens* (14.5%), *Amphora veneta* (9.5%), *Cocconeis placentula* (8%), *Anomeoneis sphaerophora* (6.5%), *Hantzschia amphioxis* (6%) and *Navicula cincta* (5.5%) are the co-dominant species.

A problem is the lack of ecological information for the dominant species *Amphora tucumana*. Several ecological tendencies could be inferred, however. The most important characteristic is the high percentage of planktonic species (16.5%). This might be a consequence of the presence of a true water body (because of the requirements of planktonic organisms) with high

Table 3
Values percentage per sample, and diatoms species ecology in Lapao's gorge, Susques, Jujuy

Specie	Samples			Ecology					Ecological groups by Vos & De Wolf, 1993
	LG7	LG1	LG6	Salinity	Habitat	pH	Trophic Status	Author	
Achnantes exigua	0	2	0	Oligo-indiffer.	Epiphytic	Alkalifilous	Oligotrophic	De Wolf, (1982)	Marine/brackish epipsamon
Amphora pediculus	0	0	1	Oligo-indiffer.	Bentic	Unknown	Unknown	De Wolf, (1982)	–
Amphora tucumana	0	0	32	Unknown	Unknown	Unknown	Unknown	–	–
Amphora veneta	1	0,75	9,5	Oligo-halophil.	Bentic	Alkalibion	Eutrophic	De Wolf, (1982)	–
Anomeoneis sphaerophora	0	0	6,5	Oligo-halophil.	Bentic	Alkalibion	Eutrophic	De Wolf, (1982)	–
Caloneis silicula	2	0	0	Oligo-indiffer.	Aerophilous	Alkalifilous	Mesoeutrophic	De Wolf, (1982)	–
Cocconeis placentula	0	0,25	8	Oligo-indiffer.	Epiphytic	Alkalifilous	Mesoeutrophic	De Wolf, (1982)	Brackish/freshwater epiphytes
Cyclotella meneghiniana	0	0	1,5	Oligo-halophil.	Planktonic	Alkalifilous	Eutrophic	De Wolf, (1982)	Brackish/freshwater plankton
Cymbella affinis	3	0	0	Oligo-indiffer.	Epiphytic	Alkalifilous	Eutrophic	De Wolf, (1982)	–
Cymbella cistula	0	0	0,5	Oligo-indiffer.	Aerophilous	Alkalifilous	Mesotrophic	De Wolf, (1982)	–
Denticula elegans		0,75	0,5	Oligo-indiffer.	Aerophilous	Unknown	Unknown	Van Dam *et al.*, (1994)	–
Epithemia adnata		0	0	Oligo-indiffer.	Epiphytic	Alkalibion	Oligotrophic	Van Dam *et al.*, (1994)	–
Epithemia argus	4,5	0	1,5	Oligo-indiffer.	Epiphytic	Alkalifilous	Unknown	De Wolf, (1982)	–
Epithemia turgida	1	0	0	Oligo-indiffer.	Epiphytic	Alkalibion	Mesoeutrophic	De Wolf, (1982)	Freshwater epiphytes
Fragilaria brevistriata	0	5	0	Oligo-indiffer.	Epiphytic	Alkalifilous	Meso-oligotrophic	De Wolf, (1982)	Brackish/freshwater tychoplankton
Fragilaria construens	0	0	14,5	Oligo-indiffer.	Planktonic	Alkalifilous	Mesotrophic	De Wolf, (1982)	Brackish/freshwater tychoplankton
Gomphonema angustatum	0	0	1,5	Oligo-indiffer.	Epiphytic	Alkalifilous	Mesoeutrophic	De Wolf, (1982)	Freshwater epiphytes
Hantzschia amphioxys	2	4	6	Oligo-indiffer.	Aerophilous	Indifferent	Eutrophic	De Wolf, (1982)	Brackish/freshwater aerophilous
Navicula cincta		40	5,5	Oligo-halophil.	Aerophilous	Alkalifilous	Eutrophic	De Wolf, (1982)	Marine/brackish epipelon
Navicula cuspidata	0	0	4	Oligo-indiffer.	Aerophilous	Alkalifilous	Mesoeutrophic	De Wolf, (1982)	–
Navicula gallica	0	17,5	0	Unknown	Unknown	Unknown	Unknown	–	–
Navicula schadei	0	0	1	Oligo-indiffer.	Unknown	Circumneutral	Oligotrophic	Van Dam *et al.*, (1994)	–
Nitzschia dissipata	0	0,5	0	Oligo-indiffer.	Bentic	Alkalifilous	Eutrophic	De Wolf, (1982)	–
Nitzschia frustulum	0	16	0	Oligo-halophil.	Bentic	Alkalifilous	Eutrophic	De Wolf, (1982)	–
Nitzschia perspicua	0	7	0	Unknown	Unknown	Unknown	Unknown	–	–
Nitzschia subtilis	0	1	0	Oligo-indiffer.	Unknown	Acidophilous	Unknown	Van Dam *et al.*, (1994)	–
Nitzschia vitrea		1	1,5	Mesohalobous	Bentic	Unknown	Eutrophic	De Wolf, (1982)	Marine/brackish aerophilous
Pinnularia borealis	0,25	0	2	Oligo-indiffer.	Aerophilous	Indifferent	Mesotrophic	De Wolf, (1982)	Brackish/freshwater aerophilous
Pinnularia brebissonii	0	1	0	Oligo-indiffer.	Bentic	Indifferent	Unknown	De Wolf, (1982)	–
Pinnularia microstauron	3	0	0,5	Oligo-indiffer.	Aerophilous	Acidophilous	Oligotrophic	De Wolf, (1982)	–
Pinnularia viridis		0	0	Oligo-indiffer.	Aerophilous	Indifferent	Mesotrophic	De Wolf, (1982)	Brackish/freshwater aerophilous
Rhopalodia constricta		2	0	Mesohalobous	Epiphytic	Indifferent	Unknown	Vos & De Wolf, (1993)	Marine/Brackish epiphytes
Rhopalodia gibberula		1	0	Oligo-halophil.	Epiphytic	Indifferent	Unknown	De Wolf, (1982)	Marine/Brackish epiphytes
Rhopalodia paralella	0,25	0	0	Oligo-indiffer.	Epiphytic	Alkalifilous	Unknown	De Wolf, (1982)	–
Surirella ovalis	0	0	1	Mesohalobous	Bentic	Indifferent	Eutrophic	De Wolf, (1982)	Marine/Brackish epipelon
Surirella striatula	0	0	1	Mesohalobous	Bentic	Unknown	Unknown	De Wolf, (1982)	–
Synedra ulna	0	0	0,5	Oligo-indiffer.	Planktonic	Indifferent	Mesoeutrophic	De Wolf, (1982)	Freshwater epiphytes

■: dominant in sample; ▨: co-dominant in sample; ▢: statistically important.

nutrient concentrations, as shown by the percentage of eutrophic, meso-eutrophic and mesotrophic diatoms (around 62% of the total). A moderate quantity of benthic (19.25%) and epiphytic (10.25%) organisms reinforces the inference of the existence of the water body, and suggests the presence of peripheral and/or aquatic vegetation. Alkaline or slightly alkaline waters are indicated by the pH affinities (Table 3). A slightly brackish environment also is evident.

It is important to highlight the lack of ecological information for *Amphora tucumana*, the dominant species in this sample. Herbst and Maidana (1988) have recently described this species. It has been observed in the sediments of a shallow pond (Laguna Nostra, Cumbres Calchaquíes, 4300 masl) in Tucumán province. The presence of *A. tucumana* was established in the Charaña Formation of the Bolivian Altiplano (4000–5000 m asl), with a radiometric dating of the base of the formation between 0.8 and 2.2 million years. Recently, Maidana et al. (1998) established the presence of *A. tucumana* in Laguna de los Pozuelos, Jujuy, Argentina. Although this species was previously
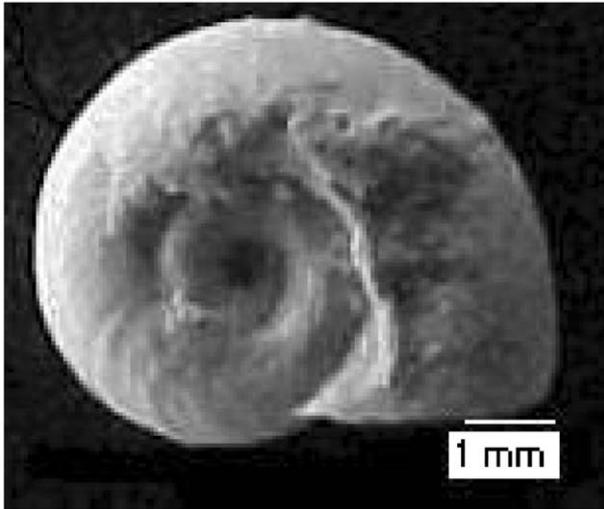
Fig. 2. Biomphalaria peregrina from L6 sample. Photo courtesy of Marcelo Cardillo.

considered to have persisted in this region only until the mid-Pleistocene and then disappeared, the presence of *A. tucumana* in Laguna Nostra and Laguna de los Pozuelos extends its range to the present (Herbst and Maidana, 1988; Maidana et al., 1998). Agreeing with these authors, the presence of *A. tucumana* in Jujuy province is confirmed during the mid-Holocene.

Our inferences about paleoenvironmental conditions are reinforced by the ecological affinities of some gastropods of the same stratigraphic unit. These gastropods were identified as *Biomphalaria peregrina* (Planorbidae) (Cardillo, 2002) (Fig. 2). Biological and ecological affinities of this species are quoted in Rumi (1991). It is a gastropod widespread in Argentina, preferring, in common with most of the Planorbidae family, low or medium energy environments. This taxon inhabits and feeds on rooted macrophytes, in neutral or slightly alkaline, carbonated and slightly brackish waters.

In sum, the diatom results clearly indicate the existence of a true water body as indicated by the abundance of planktonic species, the presence of *A. tucumana*, and the biological and ecological affinities of *Biomphalaria peregrina*. This demonstrates the existence of a shallow water body in this site at least at some time during the first part of the mid-Holocene.

6. Discussion

6.1. Environment and local human occupation

Some regular characteristics indicating wetter conditions than today and alkaline and brackish environments were shown by all the samples. LG7 and LG1 suggest a vegetation cover in a shallow or muddy environment. LG6 suggests the existence of a true water body with vegetation cover (peripheral and/or aquatic type). There is little doubt that wetter conditions than today existed, on average, between 8200 BP and 7550 BP.

The high water availability in the headwater of the Quebrada de Lapao probably attracted fauna, particularly camelids and other resources, allowing hunter–gatherer occupation. Furthermore, in the terraces surrounding the water body, several lithic artifacts were found, including rhomboidal projectile points ("Tambillo" type), and other types such as leaf shaped, and lanceolated; side-scrapers; circular end-scrapers, and several flakes and lithic debris. Some of these projectile points have been found in the nearby Hornillos 2 rockshelter, dated at 7760 and 7430 BP. Similarly, at Tambillo 1 rhomboidal points have been dated to 8870 ± 70 BP and 8591 ± 130 BP (Núñez, 1992; Nuñez et al., 2001). These occupations could have been contemporary with a more humid local environment as shown by the water body.

Data from Hornillos 2 is germane to this discussion because this site has the most complete record of mid-Holocene human occupation in the area. In layer 2, dated at 6230 and 6190 BP, osteological evidence of *Hippocamelus antisensis* was recovered, frequently found in high altitude open grassland, as well as queñoa (*Polylepis*) forests, between 4300 and 4900 m asl (Redford and Eisenberg, 1992). Today, environmental conditions in Susques prevent the development of this cervid habitat, suggesting that other environmental conditions, such as patches of high-altitude grasslands, occurred. Furthermore, foraging models show that usually foraging radii of hunter–gatherers are around 6 km, so it is reasonable to think that *Hippocamelus* was hunted near the site (Kelly, 1995; Winterhalder, 2001).

We are not implying that this time span (8200/7750–6200 BP) was environmentally homogeneous. However, the evidence suggests that the local environment during this period was, on average, more humid at both the beginning and the end of the mid-Holocene than the present time.

6.2. Environment and regional human occupation

The patchiness of the environment in the highlands of the Southern Andes was characteristic of the Mid-Holocene. A general dry ("hyperarid") environment, perhaps with high temperatures, but with restricted (discrete) areas where resources concentrated ("refuges") is the general scenario. This probably increased the difference between desert resource-devoid areas, and those in which water availability generated better conditions for human occupation.

The onset of Mid-Holocene environmental conditions produced a high degree of variation concerning the record of human occupation in the region. We can summarize these situations as follows:

6.2.1. Salar de Atacama

Although several sites have evidence of human occupation during the Early Holocene (11,000–8500 BP), the whole area seems to have been abandoned by 8130 until 6150 BP, when occupation at Quebrada de Puripica started. In this locality nine small fireplaces have been dated between 6100 and 5900 BP. The characteristics of the assemblages such as P39/40 suggest short-term occupations. After 5880 BP occupations seem to be more diversified, as shown by the extensive use of obsidian (a non-local raw material), and the diversity of tool-types. Camelids dominate the faunal record of all occupational levels (Grosjean et al., 1997; Nuñez et al., 2001). However, in the northern high Loa river basin, several small occupations were dated between 7990 and 6000 BP (i.e., Alero Confluencia, Chulqui, Isla Grande) (Aldunate et al., 1986), demonstrating that hunter–gatherer groups were moving around the headwaters of the river. This evidence suggests punctuated short-term occupations.

6.2.2. Southern Puna of Argentina

In the Salty Puna of Catamarca, human occupation extends throughout the mid-Holocene (Fig. 1). The Quebrada Seca 3 site has nine occupation levels between 8300 and 6100 BP. There also is evidence in other sites, such as Cueva Salamanca dated to 7400 BP (Pintar, 1996). Evidence from Quebrada Seca 3 suggests that mobility increased during this period, as shown by a greater use of the open grassland/scrub area, and the exotic plant remains, such as *Chusquea lorentziana*, *Prosopis torquata*, *Acromia totai*, and *Bambusa quadra*, all from the lowlands (Rodríguez, 1998). The use of obsidian also increased in this period (Pintar, 1996). Camelids, particularly *Lama Vicugna vicugna*, are the main animal resource exploited in the mid-Holocene occupational levels (Elkin, 1996).

6.2.3. Dry Puna of Argentina

Several Early Holocene occupations were recorded at Yavi, Pintoscayoc, Inca Cueva 4, Huachichocana III, and Hornillos 2 (Fig. 1). In the eastern border of the Puna, a hiatus exists between the Early and the Late Holocene as suggested by the absence of dates from 8200 to 5300 BP (date of layer 1a at Inca Cueva 4). The only exception is Pintoscayoc, with an occupational level dated in 7850 BP (Hernández Llosas, 2000). In the Yavi drainage basin, new occupations began at 4800 BP (Lupo, 1998), Huachichocana III is re-occupied at 3400 BP. Hornillos 2, located in a western sector of the Puna, has several occupations in the Mid-Holocene.

The archaeological record shows that the environmental heterogeneity of the Mid-Holocene caused varied human responses related with different land-use patterns. We cannot talk about a widespread "silencio arqueológico": on the contrary, there is evidence of use of several areas, such as Quebrada Seca and Hornillos, from the Early Holocene onwards. Furthermore, these two areas, together with the upper Loa River (Chile), were not exclusively inhabited as closed refugees between 8200 and 6000 BP. Hunter–gatherers had a large range, from which supplies, including food, were obtained (Gamble, 1993), either by foraging or exchange. This large range can be seen in the location of obsidian and plant sources. Hornillos 2 is a good example of the result of the large range, as the obsidian used at the site came from either 120 km distance (black variety), or 60 km in the opposite direction (translucent variety) (Fig. 1A, and B). Quebrada Seca 3 also shows a huge catchment area, as can be inferred from the plants originating 500 km away in the Chaco region (Rodríguez, 1998). Puripica, as well, shows a similar great range as can be seen from obsidian raw material recovered from P33. Notwithstanding this, occupations in Puripica seem to be short-term during the last part of the mid-Holocene, whereas in Hornillos 2, and Quebrada Seca 3 they were more diversified and punctuated during the whole period.

7. Conclusion

The humid conditions of the Late Pleistocene/Early Holocene allowed a rapid peopling of the Puna by hunter–gatherer groups. The shift towards aridity, and perhaps higher temperatures, between 8000 and 5300 BP, prompted people to change mobility patterns and social strategies. Paleoenvironmental evidence shows that the mid-Holocene was extremely dry. However, several places had good conditions for human occupation. Such places, called "ecological refuges", allowed hunter–gatherers to include them in their ranges. These refuges, then, were not closed places in which all natural and social resources were available, but simply places that permitted punctuated occupations of people that were moving in the Puna landscape. The "silencio arqueológico" is only verifiable in the Salar de Atacama, and in the eastern border of the Dry Puna of Argentina.

The long-term environmental changes that increase spatial heterogeneity, as seem to have occurred in the mid-Holocene of Puna, generate a series of behavioral and/or strategic modifications in order to average out local shortages in resources (Dincauze, 2000). The Puna hunter–gatherers modified their patterns of mobility by moving and concentrating where crucial resources were available, amplifying their range, and introducing technological innovations (i.e., mortars). These changes

reveal the complex relationship between people and environment during this long period of time.

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