Ostracode and C/N based paleoecological record from Santiaguillo basin of subtropical Mexico over last 27 cal kyr BP

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ABSTRACT

Changes in ostracode species assemblage suggest presence of oligohaline and mesohaline waters in the Santiaguillo basin of subtropical Mexico over the last ca.27 cal kyr BP. Paleoecological reconstruction is based on the distribution of Limnocythere bradburyi Forester, Eucandona cf. patzcuaro Tressler, Cypridopsis vidua Brady and Limnocythere ceriotuberosa Delorme. Source of organic productivity is inferred from C/N ratios. The basin hosted shallow and oligohaline water during the late glacial (ca.27–19 cal kyr BP) and lacustrine phytoplankton contributed to the organic productivity. However, the water body of Last Glacial Maximum (LGM) was relatively warmer (>13°C) and more diluted compared to the pre-LGM. Increased salinity and reduced lacustrine productivity at ca.19 cal kyr BP marked a shift in the paleoecological conditions. Water body was mesohaline during ca.9.5–4 cal kyr BP and periodic desiccation of the basin possibly caused the absence of ostracode valves in sediments of the last ca.3.5 cal kyr BP. Comparison with other proxy-records from the region indicates that the hydrological variations in different parts of subtropical north and northeastern Mexico were not synchronous during the late Pleistocene and Holocene.

Keywords: lacustrine ostracodes; C/N ratio; Paleoecology; Late Quaternary; Santiaguillo basin; Mexico.

INTRODUCTION

In the last two decades, the reconstruction of late Quaternary paleoecological and paleoclimatic conditions of the subtropical northern Mexico has received a significant increase in the scientific attention (Urrutia-Fucugauchi et al., 1997; Metcalfe et al., 1997, 2002; Murillo de Nava et al., 1999; Ortega-Guerrero et al., 1999; Palacios-Fest et al., 2002; Lozano-García et al., 2002; Holmgren et al., 2003, 2007; Davis, 2003; Caballero et al., 2005; Castiglia and Fawcett, 2006; Ortega-Rosas et al., 2008; Roy et al., 2010, 2012a, 2012b, 2013a, 2013b, 2014a, 2014b). The initial proxy registers and climate models reported humid conditions during the late last glacial and associated them to more winter precipitation. The subtropical high pressure zone in the eastern Pacific displaced southward and increased the frequency of westerly winter storms (COHMAP members, 1988; Manabe and Broccoli, 1985; Kutzbach and Wright, 1985; Kutzbach et al., 1998). Most of the paleoclimatic records suggested the possible absence of summer precipitation in the region (e.g. Thompson and Anderson, 2000).
The perception about the late Quaternary climate changed after Holmgren *et al.* (2006) and Kirby *et al.* (2006) reported that the influence of summer precipitation was reaching the USA-Mexico borderlands and coastal southwestern USA during different intervals in the last glacial period. Recently, Roy *et al.* (2013a) reconstructed paleohydrological conditions of the northern part of subtropical Mexico over the last ca. 80 cal kyr BP and hypothesized that the major influence of the winter storms remained in the region located to the north of 29ºN latitude. The hydrology of northern Mexico was dominantly controlled by the summer precipitation and the intervals of increased summer precipitation were contemporary to warm interstadials (Roy *et al.*, 2013a). Summer precipitation was less during the Last Glacial Maximum (LGM) and it increased over the deglaciation (Roy *et al.*, 2010; Roy *et al.*, 2012b). During the Pleistocene-Holocene transition, increased summer precipitation led to wetter conditions in the region (Roy *et al.*, 2014a). However, the synthesis of Barron *et al.* (2012) suggested that the influence of summer precipitation reached different regions during different intervals over the Holocene.

Compared to the northern part of subtropical Mexico, the paleoecological and paleohydrological information are scarce from the central and southern parts (Figure 1a). Similarly, most of the proxy-records are based on the geochemical and magnetic properties of lacustrine sediments and the use of ostracodes as a paleoenvironment indicator has not been sufficiently explored. Ostracodes are micro-crustaceans with low-Mg calcite valves (Turpen and Angell, 1971) and are sensible to the environmental and climatic changes. Their abundance and diversity in lacustrine sediments provide important information about the past ecology and physicochemical conditions of the water column (e.g. water chemistry, salinity, conductivity and temperature) (Forester, 1986; Pérez *et al.*, 2013). The results obtained from previous studies of ostracode paleoecology from the region (i.e. Babicora and Bahia Kino) are promising (Caballero *et al.*, 2005; Palacios-Fest *et al.*, 2002; Chávez-Lara *et al.*, 2012). In this work, we infer the paleoecology of the central-southern part of the subtropical Mexico over the last ca. 27 cal kyr BP by studying the distributions and abundances of fossil ostracode valves in two different sediment profiles from the western margin of Santiaguillo basin (Figure 1b). Productivity is inferred from the concentrations of total organic carbon and the source of productivity is distinguished by the C/N ratio.

### REGIONAL SETTING

Subtropical Mexico hosts large parts of Sonora and Chihuahua Deserts. The Santiaguillo basin (24º39’–24º58’ N, 104º39’–104º57’ W and ~1960 m asl) is located in a NW-SE oriented tectonic basin in the central part of the Chihuahua Desert of Mexico and forms part of the ‘Basin and Range’ sub-province of Sierra Madre Occidental Mountains (Figure 1b). The geology and tectonic evolution of the basin is described by Nieto-Samaniego *et al.* (2012). The semi-graben was formed between ca. 39 and 32 Ma and igneous rocks (rhyolite, ignimbrite and basalt) comprise the geology of the basin. Minor exposures of lacustrine and alluvium deposits and conglomerates are also present in the basin surroundings. The lacustrine basin covers an area of ~2000 km² and is surrounded in the east and west by ~2500 to 3000 m high hills.

The meteorological station at Guatimape (western part of the basin) registered an average annual precipitation of ~430 mm between AD 1951 an 2010 (Servicio Meteorológico Nacional, México). More than 80% of this annual precipitation occurred during the summer months of June to September as a result of monsoonal circulation and...
tropical cyclones, whereas the precipitation during winter months of November to March represented less than 10% of the annual rainfall (Figure 2). The registered maximum average temperature was ~34°C during June, and minimum temperature reached sub-zero during December-January. According to the classification of Köppen, the region represents semi-arid climate with precipitation during the summer (BSk) (García, 1973).

MATERIAL AND METHODS

Sediment samples were collected from two different pits (S1 and S2) at the western margin of the basin (Figure 1b). S1 and S2 pits have depths of 300 cm and 200 cm, respectively (Figure 3). Chronology of the sediment sequence from S1 pit is based on 4 different Accelerator Mass Spectrometry radiocarbon (AMS 14C) dates on organic carbon present in the bulk sediments. Similarly, the sediment profile of S2 pit is chronologically constrained by 2 different AMS 14C dates on sediment organic carbon (Figure 3). The 14C dates were calibrated in Calib 6.0 program using the IntCal09 calibration curve of Reimer et al. (2009) and the values of maximum probability within the 2σ range were considered for the reconstruction of age models.

A total of 61 samples at an interval of ~5 cm from the S1 pit and 20 different samples at an interval of ~10 cm from S2 pit were processed for the ostracode analysis. Each sample (~10 g) was oven dried and disintegrated by soaking in water for 2–3 days. The samples were washed through two sieves of 74 µm and 177 µm. The sieve residues were oven dried and examined under a Leica stereomicroscope to identify the different species and determine their abundance based on the descriptions provided by Morkhoven (1963), Delorme (1971a, 1971b, 1971c), Forester (1985) and Carreño (1990). Total ostracode abundance in each sample was calculated by adding the number of adult and juvenile valves of all the observed species and is reported as the number of valves in 1 g of dry sediment (valves/g). Adult valves of each species were counted in the dry sediment and presented as relative abundance (in %). The adult valves were extracted and stored in Plummer type microfossil slides. Images of the ostracode valves were taken using a Jeol JSM-5600LV LCM scanning electron microscope.

Concentration of total organic carbon (TOC) in the bulk sediments was analyzed in all the samples in a Thermo Scientific HiperTOC solid analyzer after oven drying (50°C) and powdering the sediments in an agate pestle. Concentration of total carbon (TC) was measured by heating the sample to 980°C and the amount of inorganic carbon (TIC) was measured by acidifying the sediment with 10% H3PO4. Total organic carbon (TOC) content was estimated by subtracting the inorganic carbon (TIC) from total carbon (TC). Concentration of total nitrogen (TN) was measured in S1 samples (31 samples from S1 pit and 20 samples from S2 pit) in a CHNS/O 2400 series II Perkin Elmer elemental analyzer.

RESULTS

Sediment and Chronology

Figure 3 shows the sediment profiles of S1 and S2 pits. Sediments of S1 pit comprise clay and calcareous silt intercalations from 300 to 278 cm depth and massive calcareous silt and silty-sand from 278 to 75 cm depth. Silty-clay and silt intercalations are deposited between 75 and 0 cm. Massive silty-clay with abundant root remnants are present between 50 and 0 cm. Almost 65 cm long vertical desiccation fissures are present at 75 cm depth. In the S2 pit, the sediments are calcareous silt and silty-sand between 200 and 100 cm depth. Almost 10 cm long desiccation fissures were observed at depths of 140 cm and 100 cm. Intercalations of massive silty-clay are present at 100–50 cm and massive silty-sand with abundant root remnants represents the sediments of 50–0 cm depth.

Table 1 presents the 14C dates and calibrated values in the 2σ range. The maximum probability within the 2σ range of calibrated age vs. depth plot (Figure 4) provides the age models for both profiles. Age model of S1 pit is reconstructed from 4 different radiocarbon dates. The rate of sedimentation varies between 10.1 cm/kyr and 12.1 cm/kyr for sediments deposited during ca. 24.9–3.9 cal kyr BP (279–49 cm). The base of the sequence is assigned an age of ca.27 cal kyr BP by extrapolating the rate of sedimentation (10.5 cm/kyr) calculated between 205 and 279 cm. Sediments between 49 and 205 cm depth are assigned ages by interpolating the sedimentation rates calculated between consecutive 14C dates. We estimate sedimentation of 12.5 cm/kyr for the upper 49 cm of the sequence by assuming that the surface sediments represent present day. It is similar to the higher side of sedimentation rates calculated for S1 pit. Desiccation fissures at 75 cm depth indicate absence of any water body and dry conditions at the site of S1 pit at ca. 6.5 cal kyr BP.

The age model of S2 pit includes 2 different calibrated 14C dates and assigns ca.19 cal kyr BP to the base. Assuming the surface sediments to represent the present day, a sedimentation rate of 26.7 cm/kyr was estimated for the upper 99 cm of the sequence. Estimated sedimentation rate for upper part of the sediment profile is very different from the sedimentation rate calculated between 199 and 99 cm depths (6.7 cm/kyr). The vertical fissures at 140 cm and 100 cm depths indicate that the site of S2 pit experienced multiple events of desiccation between ca.18.6 and 3.7 cal kyr BP. Lower sedimentation calculated between 199 and 99 cm could be due to the aeolian activity eroding the earlier deposited sediments during the dry intervals and lake desiccation. Due to limitations associated with both the age models, we did not undertake detailed paleoecological reconstruction occurred over last ca.3.9 cal kyr BP in S1 pit and last ca.3.7 cal kyr BP in S2 pit.
Ostracode species assemblages

The ostracode assemblages comprise 5 species (Figure 5). Except for one, the species were present as adults and juveniles. Low abundance and presence of only juvenile instars of one species precluded an accurate taxonomic identification. The paleoecological inferences are strictly based on the adult counts as the last ostracode moult takes place during the optimal environmental conditions (De Deckker, 2002).

Two of the species belong to the genus Limnocythere (L. bradburyi Forester, 1985 and L. ceriotuberosa Delorme, 1967) and the other two are Eucandona cf. patzcuaro Tressler (1954) and Cypridopsis vidua Brady (1868). Most of the shells are well preserved and almost all are covered with authigenically precipitated carbonate minerals. Figures 6 and 7 summarize the total ostracode abundance (valves/g) and the relative abundance of each species (%) in both pits. Based on the variation in total ostracode abundance and relative abundances, S1 profile is divided into 5 different zones and S2 profile is divided into 3 different zones. The zones in both pits have comparable temporal distributions.

In the sediments of S1 pit, the total ostracode abundance varies between 0 and 125 valves/g (Figure 6). The juvenile shells are more frequent (up to 102 valves/g) than the adult shells (up to 57 valves/g). L. bradburyi (0–50 valves/g) is the most abundant species and it is followed by E. patzcuaro (0–9 valves/g). Both C. vidua (0–1 valves/g) and L. ceriotuberosa (0–1 valves/g) are the least abundant species. The zones are characterized by different total ostracode abundances and associations.

Sediments of zone 5 (300–265 cm, ca. 27–23.5 cal kyr BP) display a total ostracode abundance between 4 and 24 valves/g, and most of them are juveniles (up to 18 valves/g). This zone is characterized by highest species richness (4 species). L. bradburyi and E. patzcuaro constitute 69–100% and up to 31% of the adult ostracodes. Adult shells of L. ceriotuberosa are observed at depths of 299 and 281 cm. Similarly, one adult shell of C. vidua was observed at a depth of 299 cm. Sediments of zone 4 (265–220 cm, ca.23.5–19 cal kyr BP) shows the highest and variable ostracode abundance (8–125 valves/g) and most of them are...
pits are presented in Figures 6 and 7. Sediments of S1 pit have TOC of 0.2–1.2%, total nitrogen (TN) of 0.02–0.10% and C/N values between 3.5 and 34 (Figure 6). Sediments rich in TOC generally contained lower number of ostracodes (i.e., 300–255 cm and 50–0 cm). Zones 5 and 4 (ca. 27–19 cal kyr BP) have lower and uniform values of C/N (3.5–7). Sediments from zone 3 (ca. 19.5–9 cal kyr BP) and zone 2 (ca. 9.5–4 cal kyr BP) have higher and variable C/N (7–34). Zone 1 (last ca. 4 cal kyr BP) have intermediate C/N values (8–16).

Sediments of S2 pit have TOC concentrations of 0–1%, total nitrogen contents of 0.09–0.16% and C/N values of 0–10 (Figure 7). TOC abundance is inversely related to total ostracode abundance. Sediments of all the 3 zones have similar values of C/N. Zone 3 (ca. 19–9 cal kyr BP) has C/N values between 9 and 10 and zone 2 sediments (ca. 9–3.5 cal kyr BP) are characterized by C/N values of 2–10. Zone 1 sediments (last ca. 3.5 cal kyr BP) have C/N values of 1–10.

**DISCUSSION**

**Paleoecological reconstruction**

Ostracodes preserved in the sediments of Santiagougglo basin tolerate almost similar ranges of temperature (5–32°C) and pH (8–10) (Delorme, 1989; Palacios-Fest, 2007, 2010). It was not possible to reconstruct the water column temperature in the absence of trace element geochemistry of ostracode valves and modern training sets in the area. However, the changing ostracode species assemblages suggest that the water column salinity varied between oligohaline and mesohaline over the last ca. 27 cal kyr BP. The salinity reconstruction is based on the classification proposed by Meisch (2000). Accordingly, the oligohaline waters are characterized by salinity range of 500–5,000 ppm and the mesohaline waters have 5,000–18,000 ppm of salinity. Except for the last ca. 3.5 cal kyr BP, the sediments preserve 4 different ostracode species and L. bradburyi is the most abundant. Forester (1985) identified L. bradburyi in different shallow oligohaline to euhaline lakes from central Mexico. We relate the highest abundance of L. bradburyi to the presence of shallow water bodies at the western margin of Santiagougglo between ca. 27 and 3.5 cal kyr BP. Palacios-Fest (2010) relates the occurrence of E. patzcuaro to intervals of fresh to oligohaline water as a result of increased fresh water inflow into the basin. Similarly, the presence of C. vidua was observed in warm (>13°C) and fresh to oligohaline lakes in southwestern USA (Palacios-Fest, 2010). L. ceriotuberosa tolerates oligohaline to mesohaline conditions in USA and Canada (Delorme, 1971a, 1971b, 1971c; Palacios-Fest, 2007). In the interior plains of Canada, Smith and Delorme (2010) observed that L. ceriotuberosa was present in waters with low dissolved oxygen content (3 mg/L).

The paleoecological conditions of Santiagougglo are divided into pre-LGM, LGM and post-LGM. The interpretations are supported by TOC and C/N data. TOC content in bulk sediment reflects the amount of primary productivity (Cohen, 2003) and C/N ratio reflects the contribution of terrestrial vegetation and lacustrine algae on the deposited organic matter (Meyers and Ishiwatari, 1995). Lacustrine algae and terrestrial plants have different contents of nitrogen and the increasing contribution of one of them to the organic matter is reflected by the C/N ratio. Sediment with higher C/N (>10) represents dominant contribution from terrestrial plants and lower C/N (<10) indicates that the organic matter originated from aquatic plants (Talbot and Johannessen, 1992; Meyers and Ishiwatari, 1995; Cohen, 2003).

Pre-LGM (ca. 27–23.5 cal kyr BP): Sediments of S1 pit (zone 5, 300–265 cm) documented the paleoecological conditions that occurred prior to the last glacial maximum (pre-LGM). The ostracode assemblage suggested presence of shallow water column and oligohaline conditions. Presence of a permanent water body in the western margin of the basin is indicated by lacustrine phytoplankton (C/N<10).
dominantly contributing to the organic productivity, as well as the continuous increase in ostracode productivity. Occurrence of both C. vidua and L. ceriotuberosa indicated relatively low salinity at ca.27 cal kyr BP. The absence of C. vidua during rest of the interval suggested a slight increase in salinity in the oligohaline range. L. ceriotubrosa at 299 cm and 281 cm depths represented the intervals of less oxygenated water column (e.g. Smith and Delorme, 2010).

LGM (ca.23.5–19 cal kyr BP): Paleoecological condition of the last glacial maximum (LGM) was recorded by the lower part of S1 pit (zone 4, 265–220 cm). Existence of the shallow and permanent water body continued during this interval and the organic productivity was contributed by the lacustrine phytoplankton (i.e. C/N≤10). The ostracode assemblage of L. bradburyi, E. patzcuaro and C. vidua suggested the presence of a warm (>13°C) and more diluted oligohaline water body. Total ostracode abundance was higher at ca.20–19 cal kyr BP (60–125 valves/g) compared to ca.23.5–20 cal kyr BP (8–35 valves/g). The inverse relationship between total ostracode abundance and TOC could be due to the result of ostracode dissolution in an acidic environment formed by the organic carbon decomposition.

Post-LGM (last ca.19 cal kyr): Sediments of zone 3 (220–105 cm) and zone 2 (105–50 cm) of S1 pit documented the paleoecological conditions that occurred post the last glacial maximum (post-LGM). This interval was also represented by sediments of zones 3 and 2 (200–85 cm) of S2 pit. Ostracodes of S1 pit represented ca.19–4 cal kyr BP and ostracodes of S2 pit indicated the paleo-hydrochemical characteristics occurred during ca.19–3.5 cal kyr BP. The ostracode assemblages suggested presence of oligohaline to mesohaline water bodies in the western margin.

Post ca.19 cal kyr BP, the decreasing abundance of E. patzcuaro and increasing C/N values reflected a shift in the paleoecological conditions. Higher C/N values (>10) indicated that the terrestrial vegetation contributed more to the organic matter as the lacustrine productivity decreased. Gradual reduction in the amount of pluvial discharge into the basin was reflected by the decreasing abundance of E. patzcuaro. More salinity (Na and HCO₃–Cl enriched water body) was reflected by an increase in the abundance of L. bradburyi (e.g. Forester, 1985). Absence of both E. patzcuaro and C. vidua in the sediments of ca.13–11.5 cal kyr BP indicated less fresh water inflow into
Figure 6: Total ostracode abundance (valves/g), distribution of the unidentified species, relative abundance of 4 different species (%), concentrations of total organic (TOC, %) and C/N relations in sediments of S1 pit.

Figure 7: Total ostracode abundance (valves/g), distribution of the unidentified species, relative abundance of 4 different species (%), concentrations of total organic (TOC, %) and C/N relations in sediments of S2 pit.
the basin and more salinity (mesohaline) during the Younger Dryas (YD). However, the reappearance of both the species in sediments of the Pleistocene-Holocene transition suggested presence of relatively diluted oligohaline water column. Based on the concentrations of Ti and K in bulk sediments from another core in Santiaguillo, Roy et al. (2014) also identified a humid interval during the Pleistocene-Holocene transition and related it to enhanced summer precipitation in the region. During ca.9.5–4 cal kyr BP, the water body was ephemeral and was possibly present only during the summer months. Ostracode abundance gradually decreased, while the concentration of TOC increased. The occurrence of only L. bradburyi at 111–50 cm depths in S1 pit suggests presence of mesohaline water body in the western margin of the basin. Arid conditions caused enhanced aeolian activity in the surroundings of Santiaguillo during ca. 9.3–4.3 cal kyr BP (Roy et al., 2014a). Similarly, the desiccation fissures at 75 cm depth indicate that the location of S1 pit remained dry for a longer duration at ca.6.5 cal kyr BP.

Although both the pits are located in the western margin of the basin, the sediments collected from them have different characteristics. Compared to sediments of S1 pit, the sediments of S2 pit are characterized by lower total ostracode abundance (up to 38 valves/g), C/N relation (<10) and rate of sedimentation (6.7 cm/kyr). Total ostracode abundance (up to 70 valves/g), C/N relation (>10) and sedimentation rate (10.1–12.1 cm/kyr) are higher in sediments of S1 pit. The desiccation fissures at 140 cm and 100 cm depths and lower sedimentation rate suggest that the site of S2 pit experienced multiple events of desiccation and erosion of previously deposited sediments during ca.18.6–3.7 cal kyr BP. The arid intervals might have caused oxidation of organic matter and poor preservation of ostracode valves in S2 pit.

Sediments representing the last ca. 4 cal kyr BP in S1 pit and last ca.3.5 cal kyr BP in S2 pit do not contain ostracodes. Sediments of this interval are relatively coarser (i.e. fine sand) compared to the lower parts (i.e. clay, silt, silty-sand and silty-clay). Over the last ca. 3.5 cal kyr BP, the amount of sediments deposited at the location of S2 pit (99 cm) is almost twice of the sediment deposited at S1 site (<50 cm). This was possibly due to the higher inflow into the site of S2 pit. The difference in the amount of inflow into two different sites in the western margin is also reflected by the C/N values indicating a terrestrial source for the organic matter deposited at S1 pit and lacustrine source for the organic matter deposited at S2 pit.

**Comparison with regional records**

Comparison of the paleoecological information from Santiaguillo with other paleoecological records from northern and southwestern Mexico (see Figure 1a for locations) suggests that the region experienced different climatic and hydrological conditions over the last ca.27 cal kyr BP. Paleoecological and paleoecological information are available from Babicora (Metcalfe et al., 2002; Roy et al., 2012b), El Fresno and Santa María (Castiglia and Fawcett, 2006) from Chihuahua, San Felice (Lozano-García et al., 2012a) and Chapala (Davis, 2003) from Baja California, Purísima-Iray-Magdalena from Baja California Sur (Murillo de Nava et al., 1999) and Las Cruces from San Luis Potosí (Roy et al., 2013b). Between ca.27 and 19 cal kyr BP, the salinity of Santiaguillo basin was lower compared to the salinity of water column at Babicora. The ostracode species assemblage suggested presence of oligohaline water body at Santiaguillo and oligohaline to mesohaline water bodies at Babicora. Multi-element geochemistry of the sediments indicated reduced runoff into Babicora and San Felice basins (Roy et al., 2010, 2012a, 2012b). During this interval, the vegetation in the surroundings of Babicora comprised Pinus and Picea (Metcalfe et al., 2002) and vegetation in the surroundings of San Felice basin were Abies, Pinus and Eryngium (Lozano-García et al., 2002).

Over the last ca.19 cal kyr BP, the runoff into Santiaguillo gradually reduced and the water body became more saline. However, Babicora received more precipitation post ca.18 cal kyr BP (Roy et al., 2013b) and the runoff into San Felipe increased after ca.13 cal kyr BP (Roy et al., 2010). The formation of linear and mega-baranchan dunes indicate hot and arid conditions at the Purísima-Iray-Magdalena basin during ca.14–8 kyr BP (Murillo de Nava et al., 1999). During the early to middle Holocene, the Santiaguillo sediments indicated mesohaline conditions (ca.9.3–4 cal kyr BP), enhanced aeolian activity (ca.9.3–4.3 cal kyr BP) and multiple events of desiccation. In general, both Babicora and San Felice received more runoff over the Holocene. However, Babicora experienced an event of desiccation at ca.3 cal kyr BP and San Felice sediments documented more aeolian activity at ca.8 cal kyr BP. Laguna El Fresno and Laguna Santa María experienced wet conditions and higher lake stands at ca.9.4–9.3 cal kyr BP, ca.7.5–7.2 cal kyr BP and ca.4.9–4.2 cal kyr BP (Castiglia and Fawcett, 2006). The pluvial discharge into Las Cruces was more during ca.8.4–5 cal kyr BP compared to the last ca.5 cal kyr (Roy et al., 2013b). A permanent lake was present in the Chapala basin till ca.8.4 cal kyr BP and dune formation commenced post 7.5 cal kyr BP (Davis, 2003). At Purísima-Iray-Magdalena, the dune activity was stabilized and the present lagoon system was developed at ca.6–5 kyr BP.

**CONCLUSIONS**

Several multi-proxy studies have attempted to reconstruct the late Pleistocene-Holocene paleoecological and paleoecological conditions of subtropical Mexico. However, the information is less from the central and southern parts compared to the northern part. Similarly, ostracodes have received limited attention so far compared to the study of sediment geochemistry and palynology. In the present study, we intend to improve the paleoecological information of the central-southern part of subtropical Mexico by studying the abundances and species associations of 4 different ostracode species in combination with TOC and C/N data in sediments deposited over the last ca.27 cal kyr BP in the Santiaguillo basin. More specifically;

- Ostracode assemblage consists of 4 species (*Limnocythere bradburyi*, *Eucandonia cf. patzcuaro*, *Cypridopsis vidua* and *Limnocythere ceriotuberosa*) and the highest (125 valves/g) abundance occurred during the LGM.

During pre-LGM (ca.27–23.5 cal kyr BP), the western margin of the basin hosted shallow and oligohaline water body and experienced dominant lacustrine productivity. Changes in the abundances of *C. vidua* and *L. ceriotuberosa* indicated relatively lower salinity at ca.27 cal kyr BP compared to ca.27–23.5 cal kyr BP. *L. bradburyi*, *E. patzcuaro* and *C. vidua* suggested presence of warm (>13°C) and more diluted oligohaline water body during the LGM (ca.23.5–19 cal kyr BP).

Lower abundance of *E. patzcuaro* and higher C/N ratio reflected a shift in the paleoecological conditions at ca.19 cal kyr BP. Both the pluvial discharge into the basin and lacustrine productivity decreased. Higher abundance of *L. bradburyi* suggested that the water column became more saline.

The water body was mesohaline during ca.9.5–4 cal kyr BP and the absence of ostracode shells in sediments of last 3.5 cal kyr BP was possibly caused by ephemeral conditions and periodic desiccation.

Comparison with other proxy-records from the region suggests that the paleoecological and paleoecological changes occurred over the last ca.27 cal kyr BP in different parts of sub-tropical northern Mexico were not synchronous.
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