Vegetation History and Archaeobotany (2021) 30:193–212
https://doi.org/10.1007/s00334-020-00777-z

ORIGINAL ARTICLE

The use of wood during prehispanic times in the Upper Paraná Delta revealed though analysis of ancient charcoal

R. Soledad Ramos[1] · M. Jimena Franco[1] · Mariana Brea[1] · Mariano Bonomo[2] · Gustavo Politis[2]

Received: 25 March 2019 / Accepted: 22 February 2020 / Published online: 9 March 2020

Abstract

Woody plant resources are important to human societies today and were also in the past. Here we assess the woody plant resources available to peoples in Northeastern Argentina in the pre-Hispanic period and assess how they were used. The Upper Paraná Delta (Entre Ríos province, Argentina) was occupied by indigenous societies during the last 2000 years, and evidence of those peoples has been found at Los Tres Cerros 1 archaeological site (inhabited at least between 765 to 1505 cal years AD). From the local traditional and ethnographical literature, a broad functionality of the determined taxa is proposed, to use as a basis for palaeoethnobotanical interpretations. Species of the Lauraceae, Passifloraceae, Fabaceae, Salicaceae, Boraginaceae and Apocynaceae families were found dispersed about the site; they possibly grew close to the settlement and had diverse indigenous uses (e.g. for the construction of canoes and other artefacts in daily use). Other species were found concentrated on the archaeological site. They were related to Euphorbaceae, Fabaceae, Cyperaceae, Anacardiaceae, Apocynaceae, Myrtaceae and Primulaceae and were probably used as fuel in domestic activities (e.g. to obtain light, heat and to cook food and fire pottery). Forty-three carbonized wood samples were studied. Charcoals related to *Sapium*, *Nectandra* and *Aspidosperma* genera were identified next to pottery and animal bones. The presence of *Schinopsis* in the anthracological record shows the extra-local link of the pre-Hispanic populations that occupied the Paraná river basin. Finally, these new advances increase the knowledge about the vegetation nearby the archaeological site at the end of the Late Holocene.

Keywords Anthracological · Firewood indigenous preference · Upper Paraná Delta · Entre Ríos province · South american lowlands · Late Holocene

Introduction

Research from archaeological sites demonstrates that identifying resources origins from ancient charcoal material can shed light on the dynamic relations of past societies with plant communities and the landscape (Berón and Fontana 1996; Capparelli and Raffino 1997; Marconetto 2008; Angrizani et al. 2013; Brea et al. 2013, 2014; Andreoni 2014; Mafferra 2015; Marconetto and Mafferra 2016; Ortiz et al. 2017). Three aspects of past societal function are commonly explored in this way: (i) how human beings have historically used plants for food, beverages, huts, clothes, tools, weapons, ornaments, containers, fuels, poisons and medicines; (ii) how cultural-natural conditions were created that favoured the selection of some plants over others to satisfy different needs; and (iii) how plants were intentionally modified for their use (Pearsall 2000; Pochettino and Capparelli 2009; Colobig 2012; Giovannetti et al. 2012). Furthermore, evidence from ancient charcoal can allow plant species distributions to be determined and mapped through time, and then correlated with cultural activity at both the micro- and macro-regional scale (ca. 10 km^2 and 100 km^2 respectively) (e.g. Pearsall 2000; Théry-Parisot 2002; Solari 2007; Théry-Parisot et al. 2010).

The study of ancient charcoal (anthracological) material extracted from archaeological sites has proved to be a useful tool in the identification of vegetation within landscapes and

Communicated by W. Gosling.

✉ R. Soledad Ramos
laresole@hotmail.com

1 Centro de Investigación Científica y de Transferencia Tecnológica a la Producción, CICYTTP (CONICET-Prov. Entre Ríos-UADER), España 149, E3105BWA Diamante, Entre Ríos, Argentina

2 CONICET-División Arqueología, Facultad de Ciencias Naturales Y Museo, Universidad Nacional de La Plata, Paseo del Bosque S/N°, La Plata, 1900 Buenos Aires, Argentina

the use of woody resources by humans (Donoghue 1989; Piqué i Huerta 1995; Garibotti 1998; Théry-Parisot 2002; Solari 2007; Marconetto 2008; Théry-Parisot et al. 2010). Indigenous societies processed woody resources for a range of reasons, including to obtain light, to generate heat, and to construct dwellings, canoes and other artefacts. Through the process of resource use, indigenous peoples acquired a deep knowledge of the properties of each wood type. For example, when people were selecting woody resources for burning, energy behaviour would have been important (Rojas et al. 2004).

Northeastern Argentina has had at least ten thousand years of human occupation, however little is known about the relationship between these peoples and their woody resources use and environmental interactions. The Spanish chronicler Fernández de Oviedo y Valdés (1851–1855 [1546–1547]) mentions the use of wood for spear-throwers, arrows and clubs by the Timbú and Caracaraes indigenous groups during the sixteenth century. Documentary information on the indigenous uses of wood between the sixteenth and eighteenth centuries was compiled by Chiri (1975); and provides insights into the construction of huts, the manufacture artefacts (including canoes, oars, weapons and tools) and the making of fire. However, the role played by woody, shrubby and herbaceous plants in pre-Hispanic indigenous societies of the Paraná Delta remains poorly studied.

Los Tres Cerros 1 (LTC1) archaeological site, located in the Upper Paraná Delta, has been identified as having excellent potential for enhancing our understanding of pre-Hispanic human–environment dynamics (Brea et al. 2013). This is because of the availability of local historical information (Chiri 1975) and the recent radiocarbon ages for the later occupations (Politis et al. 2011). In this paper, we enhance our understanding of human–environment dynamics at the LTC1 site by adding new charcoal identifications and developing the interpretation of the plant record. Specifically, we use archaeological charcoals to infer the human selection of fluvial forest resources. We evaluated the ethnographic data of identified taxa and contrast this information with the archaeological remains under study. We considered the preference for specific woods, particularly with regard to its caloric value and density. Subsequently, the woody resource availability was analyzed and discussed. In addition, our approach allows us to suggest an environmental context of past human occupation in the Upper Paraná Delta.

Study area: Upper Paraná Delta

Geographic setting

The delta of the Paraná river is ca. 320 km long and 60 km wide. The islands within the delta are shaped by the fluvial dynamics and have a dense forest gallery along the river and stream margins (Neiff 2005). Sometimes, rainfall in the High Paraná basin results in channel overflow (Cavallotto et al. 2005). The sediments deposited on the river margins during these overflow events add nutrients to the soil enhancing their fertility (Bonomo 2012).

Modern vegetation

The Upper Paraná Delta is located between the Espinal and Pampeana phytogeographical provinces in the Chaqueño Dominion (Neotropical region); the area is also influenced by components from the Paranaense Province (Amazon Dominion) (Cabrera 1994; Muñoz et al. 2005; Morrone 2017; Oyarzabal et al. 2018). This feature makes it an ecotonal and diverse area. Overall, Espinal province is characterized by the dominance of tree species of *Prosopis*, *Prosopis affinis* ex *P. algarrobilla* (*ñandubay*), *P. caldenia* (*caldén*) and *P. nigra* (*algarrobo negro*) being very abundant. There are also *Syagrus romanzoffiana*, *Butia yatay* (*yatay*) and *Trithrinax campestris* (*caranday*) palm groves, which generally are scattered. Pampeana province is characterized as a flat region with a temperate-warm climate. The dominant vegetation is steppe and grasslands (Cabrera 1976; Morrone 2017; Oyarzabal et al. 2018).

Along the Paraná river gallery forests (Paranaense phytogeography province) have been observed, with a predominance of laurels (*Nectandra falcifolia*), and some Sapotaceae (*Pouteria salicifolia*). Xerophytic forests are found in the ravines above the rivers and streams with floristic elements of Espinal province. *Celtis ehrenbergiana* (*tala*), *Prosopis alba* (*algarrobo blanco*) and *Phytolacca dioica* (*ombú*) predominate, among other species (Cabrera and Willink 1980).

The archaeological site is located in the Islands and Paraná Delta Eco-region (sensu Burkart et al. 1999). The continued presence of water bodies creates high humidity and a low annual temperature range. Surrounding the archaeological site, the forests are composed of *Salix humboldtiana* (*sauce criollo*), *Tessaria integrifolia* (*aliso del río*), *Erythrina crista-galli* (*ceibo*), *Sapium haematospermum* (*curupí*), *Myrsine laetevirens* (*canelón*), *Albizia inundata* (*timbó blanco*) and others; the shrublands are composed of *Vachellia caven* (*espinillo*), *Baccharis* (*chilca*), *Conyza* (*rama negra*), *Cestrum* (*duraznillo negro*) and *Phyllanthus* (*sarandíes*); and the grasslands and pasture area are composed of *Typha latifolia* (*totora*), *Zizaniopsis bonariensis* (*espadaña*), *Cyperus giganteus* (*pirí*) and numerous genera of Cyperaceae that are associated with numerous species of Poaceae (Cabrera 1976; Burkart et al. 1999).

Aceñolaza et al. (2004) described ca. 2,500 ha of vegetation in an area near the archaeological site, specifically on the middle course of the Paraná river that precedes the Upper Delta and includes the Pre-Delta National Park. They pinpointed five vegetation formations, which included:

(1) Cliff woodland with species of subtropical lineage such as *Ruprechtia laxiflora*, *Phytolacca dioica*, *Myrsine laetevirens*, *Zanthoxylum fagara*, *Coccoloba argentinensis* and *Celtis ehrenbergiana*;
(2) Monotypic woodlands on fluvial margins corresponding to monospecific woodlands of *Salix humboldtiana* and *Tessaria integrifolia* on the Paraná river or main streams. Shrubs and herbaceous species such as *Hyptis mutabilis*, *Baccharis salicifolia* and *Lippia* were also detected in this sector;
(3) Riparian mixed woodlands in fresh alluvial deposits constituted by mature woodlands of *Salix humboldtiana*. Also grouped in this unit are monotypic woodland of *Albizia inundata*, *Erythrina crista-galli*, or *Sapium haematospermum*. The shrub stratum has a variable coverage and is dominated by *Teucrium vesicarium*, *Urera aurantiaca* and *Cestrum guaraniticum*. The grass stratum is rich in *Iresine diffusa*, *Vigna adenantha* and *Panicum sabulorum*;
(4) Intermediate environments constituted by herbaceous communities and some shrubs as *Panicum prionitis*, shrub of *Baccharis* spp., of *Mimosa pigra* or *Sesbania virgate*, and "achirales" of *Thalia geniculate*;
(5) Lacunar vegetation constituted by herbaceous plant communities associated with aquatic environments.

Ronchi Virgolini et al. (2010) found that the understory of the right-bank of the Paraná river is dominated by closed formations of *Eryngium* sp. (*serruchetas*). In the oldest and best preserved forests, the presence of *Nectandra falcifolia* (*laurel*), *Inga uraguensis* (*ingá*), *Croton urucurana* (*sangre de drago*) and *Enterolobium contortisiliquum* (*timbó colorado*) were reported. The dense forest contains *Urera aurantiaca*, *Commelina diffusa*, *Cestrum guaraniticum*, *Lippia alba*, *Ipomea alba* and *Passiflora suberosa*. They also highlighted a considerable number of young plants and medium-sized *Myrsine laetevirens* trees and *Zanthoxylum* sp. (*tembetarí*) of recent appearance favoured by exclusion of livestock. Other species of relatively recent occurrence found by Ronchi Virgolini et al. (2010) are *Morus* spp. (*mora*), and *Ligustrum lucidum* (*ligustro*), both exotic and highly invasive species. Intensive grazing and human settlement developed clearings covered by dense shrubs with a predominance of *Baccharis* spp. Knowledge of the local vegetation cover is important, in order to contrast this information with the woody resources of the recent past.

Archaeological record

Human settlement construction in the Late Holocene was adapted to cope with, and benefit from, the dynamics of the river. This was achieved by building mounds on the islands within the delta and transforming these areas into places for crops and dwellings. Living on the islands provided people with easy access to inland waterways, the resources of the main river, and river marginal environments (Bonomo 2012; Colobig et al. 2015; Castiñeira et al. 2017). Consequently, the island environments of the Upper Delta of the Paraná River contain a long history of human activity and occupation; radiocarbon dates from the archaeological sites of this area indicates that human occupation occurred during Late Holocene, approximately in the last 2,000 years (Bonomo et al. 2010; Politis et al. 2011; Bonomo 2012; Scabuzzo et al. 2015).

Study site

One of the main studied archaeological sites in the Upper Delta of the Paraná River is Los Tres Cerros archaeological locality (LTC). The LTC locality is formed of three main sites, (LTC1, LTC2 and LTC3). The LTC1 site has been dated to between cal AD 765 to 1505 and is the highest and central mound of the three sites (Politis et al. 2011; Castiñeira et al. 2013). The LTC1 mound is a human construction, comprised of successive layers of sediment and waste (pottery, bones, shells and other refuse), which rises ca. 2.1 m above the surrounding land surface (Fig. 1). The domestic activities inferred for the LTC1 settlement include the production, use and discarding of pottery assigned to the Goya-Malabrigo archaeological entity (sensu Ceruti 2003; Politis and Bonomo 2012, 2018); and the consumption of semi-aquatic fauna, especially *coypu* (*Myocastor coypus*),

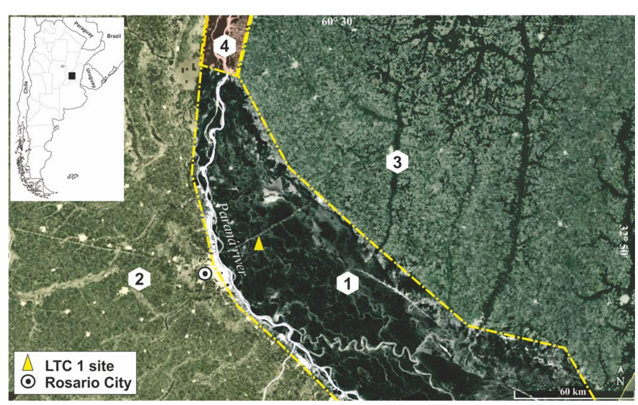

Fig. 1 Study area with the location of the LTC1 archaeological site. Vegetation units of Argentina sensu Oyarbazal et al. (2018). References: 1 = Forest and wetland delta, 2 = Grassland with riparian forest, 3 = Mesophytic pseudosteppes, 4 = Subtropical riparian forest

capybara (*Hydrochoerus hydrochaeris*) and different species of fish (e.g. *Hoplias malabaricus*, *Leporinus obtusidens* and *Cichlasoma facetum*) (Politis et al. 2011; Bastourre 2014). Horticulture is also thought to have been a component in the past subsistence, as evidenced by the presence of maize and squash phytoliths (Sánchez et al. 2013). Furthermore, evidence for funerary activities has been found at LTC1 in the form of primary and secondary burials and scattered bones, some with heat damage (Scabuzzo et al. 2015). To sum up, the occupation of the LTC1 mound is associated with canoe people whose subsistence was based on hunting, fishing and gathering, supplemented with small-scale horticulture.

Materials and methods

Methodological approach

It is common to find a mixture of plant remains from different provenances in archaeological sites with some of the occurrences related to human activities and others to natural processes. The woody remains found in archaeological deposits are frequently carbonized resulting from the incomplete combustion of waste materials. This carbonised material is preserved within deposits due to environmental and geochemical factors (Chabal et al. 1999; Théry-Parisot et al. 2010). Two factors determine the representativeness of carbonized wood: (i) if it is produced by a short and directed combustion event (such as in a hearth or an earth oven); or (ii) if it has been distributed by chance within archaeological deposits from combustion events elsewhere. In the first scenario high concentrations of charcoals that result from a specific time-bounded wood utilization are found. Typically these 'concentrated charcoals' do not provide a representative sample of surrounding vegetation, because collection would likely have been targeted at specific taxa, and therefore charcoal evidence from these contexts is often characterized by a low specific diversity (Rodríguez Ariza 1993; Scheel-Ybert et al. 2005–2006; Marconetto 2008; Théry-Parisot et al. 2010). In the second scenario charcoals likely originate from various locations around the wider archaeological site. Consequently, these 'dispersed charcoals' likely represent elements from secondary contexts, such as successive hearth cleaning events or fire sub-products (Garibotti 1998; Rodríguez 2000; Solari 2007).

Sampling strategy in the field

Los Tres Cerros 1 archaeological site (32° 51′ 17.3″ S and 60° 33′ 37.6″ W) is located in the centre of a row of three earth mound structures (LTC1, LTC2, LTC3), distributed along a 239 m long NW–SE orientated line adjacent to the Zanjón Almada (Fig. 1). The largest mound (LTC1) has a maximum diameter of 66.6 m and a minimum diameter of 57.5 m. Systematic excavations of 33 m^2 were undertaken on the LTC1 mound and all charcoal material encountered was recovered (Politis et al. 2011; Castiñeira et al. 2013, 2014; Sánchez et al. 2013; Bastourre 2014; Scabuzzo et al. 2015). The charcoal material was recorded as originating from either 'concentrated' or 'dispersed' contexts, and the stratigraphic position within the excavation of the site was recorded (Table 1).

Twenty-one radiocarbon dates were obtained of charcoal, bone and plant remains within the LTC1 archaeological site (Scabuzzo et al. 2015; Table 2). To avoid contamination, material for radiocarbon dating was collected using metal instruments, wrapped in aluminium foil and stored in plastic tubes. The stratigraphic position and quantities of all material for dating was recorded within the excavation site (Table 1).

Charcoal analysis: laboratory preparation, analysis and data handling

Identification of ancient charcoal material, and charcoal imaging, was achieved using a Nikon SMZ-1000 stereomicroscope and a Nikon Coolpix S4 digital camera. Charcoals were identified by examining freshly fractured surfaces (cross, radial and tangential sections) and comparison with standard microscopical wood keys and atlases (Metcalfe and Chalk 1950; Cozzo 1951; Tortorelli 1956; Tuset 1963; Garibotti 1998; Richter and Dallwitz 2000; Brea et al. 2013; InsideWood database 2004-onwards), and with reference to locally relevant reference material created for this project and from the Laboratorio de Paleobotánica CICYTTP (CONICET-Prov. Entre Ríos-UADER). Following analysis, the ancient and reference charcoals were deposited at Laboratory 3, División Arqueología, La Plata Museum, under the acronym C-LTC N° 1 to-43 (Lab code) for future use (Table 1).

The terminology for describing wood features follows the IAWA Lists of Microscopic Features for Hardwood Identification wherever possible (Wheeler et al. 1989). Systematic assignment follows the Angiosperm Phylogeny Group (Chase et al. 2016). The plant names used are as the ones stated in The International Plant Names Index (The Plant List 2010) and in the Index Nominum Genericorum (ING) (Farr and Zijlstra 1996).

Results

A total of 229 charcoal fragments (between 0.5–15 cm long and 0.5–20 cm diameter) were examined and 18 taxa within 11 families were identified from the LTC1 archaeological site. Six indeterminate taxa charcoal fragments were also

Table 1 Databases of each sample examined and provenance, archaeological context. Reference E = East; W = West; x = w/d

Lab code C–LTC No	Grid	Sector	Level (cm)	Weight (g)	No of fragments	Sampling area, concentration/dispersion	Related taxa
1	8	E	115–120	3	3	Dispersed	*Ocotea* sp. 1
2	5	W	115–120	1	3	Concentrated next to "campana"	*Sapium* sp.
3	5	W	130–135	3	1	Dispersed	*Passiflora* sp.
4	8	W	135–140	14	14	Concentrated	*Vachellia* sp.
5	8	W	180–185	15	1	Concentrated	unidentified
6	8	E	155–160	2	2	Dispersed	*Enterolobium* sp.
7	5	E	105–110	1	1	Dispersed	*Cordia* sp.
8	8	W	120–125	4	1	Dispersed	unidentified
9	6	W	140–145	3	3	Dispersed	*Prosopis* sp. 1
10	5	E	125–130	4	4	Dispersed	*Erythrina* sp.
11	9	x	120–125	3	3	Dispersed	*Vachellia* sp.
12	2	x	120–125	2	2	Dispersed	*Prosopis* sp. 1
13	8	W	135–140	18	18	Concentrated	*Vachellia* sp.
14	10	x	150–155	6	1	Dispersed	unidentified
15	10	x	120–125	1	1	Concentrated	*Cyperus* sp.
16	8	W	140–145	1	1	Dispersed	*Vachellia* sp.
17	2	x	155–160		4	Concentrated next to pottery	*Nectandra* sp.
18	9	x	225–230		3	Concentrated	*Schinopsis* sp.
19	1	W	180–185	3	2	Concentrated	*Aspidosperma* sp.
20	5	S	220–225		2	Dispersed	*Erythrina* sp.
21	1	x	225–230		2	Dispersed	unidentified
22	7	x	245–250		1	Dispersed	*Salix* sp.
23	3	x	155–160		5	Concentrated	*Vachellia* sp.
24	8	E	100–105		2	Dispersed	*Prosopis* sp. 1
25	6	W	190–195		8	Concentrated, next to bones	*Aspidosperma* sp.
26	1	E	155–160		2	Dispersed	*Cordia* sp.
27	1	W	160–165		10	Concentrated (burned pole)	*Croton* sp
28	6	W	190–195		5	Concentrated, next to bones	unidentified
29	15	x	120–125		11	Concentrated	*Prosopis* sp. 2
30	8	W	100–105		2	Dispersed	*Nectandra* sp.
31	6	E	185–190		2	Concentrated, next to bone	*Schinopsis* sp.
32	15	x	140–145		5	Concentrated	*Myrsine* sp.
33	9	x	165–170		7	Dispersed	*Aspidosperma* sp.
34	5	x	230–235		11	Dispersed	*Prosopis* sp. 1
35	7	x	225–230		1	Dispersed	unidentified
36	15	x	135–140		15	Dispersed	*Aspidosperma* sp.
37	8	E	185–190		2	Dispersed	*Prosopis* sp. 2
38	15	x	130–135		17	Concentrated	*Prosopis* sp. 2
39	9	x	225–230		1	Concentrated	*Schinopsis* sp.
40	8	E	235–240		1	Dispersed	*Ocotea* sp. 2
41	10	x	180–185		4	Concentrated	*Eugenia* sp.
42	15	x	145–150		21	Concentrated, (burned pole)	*Myrsine* sp.
43	15	x	135–140		24	Concentrated	*Myrsine* sp.
Total					229		

recovered at the site. The most diagnostic wood anatomical features observed in the taxa identified are summarized in Table 3 and displayed in Figs. 2, 3 and 4. Most charcoal fragments were well preserved, and the diagnostic anatomical features can be observed.

Analysis of charcoal fragments from concentrated contexts (i) resulted in the identification of ten taxa from

Table 2 Radiocarbon dates for the LTC1 archaeological site (data taken and modified from Scabuzzo et al. 2015)

Site	Sample code	^{14}C yrs BP	Material	Reference
LTC1 (level 5)	LP-2295	560 ± 80	*Diplodon* sp. shells	Politis et al. (2011)
LTC1 (level 13)	LP-2281	580 ± 70	Charcoal	Politis et al. (2011)
LTC1 (level 5)	LP-2289	650 ± 70	Charcoal	Politis et al. (2011)
LTC1 (secondary burial 2)	LP-2292	650 ± 70	Human bone	Politis et al. (2011)
LTC1 (individual 1)	AA-98852	657 ± 43	Human bone	Scabuzzo et al. (2015)
LTC1 (level 7)	LP-2284	660 ± 70	*Diplodon* sp. shells	Politis et al. (2011)
LTC1 (level 38)	AA-98848	750 ± 38	Charcoal	Gianotti and Bonomo (2013)
LTC1(level 13)	LP-2332	760 ± 70	Charcoal	Politis et al. (2011)
LTC1(individual 17)	AA-103893	763 ± 47	Human bone	Scabuzzo et al. (2015)
LTC1 (individual 16)	AA-93218	775 ± 85	Human bone	Bonomo et al. (2011)
LTC1 (level 9)	LP-2302	790 ± 100	Charcoal	Politis et al. (2011)
LTC1 (individual 18)	AA-103891	801 ± 46	Human bone	Scabuzzo et al. (2015)
LTC1 (secondary burial 3)	AA-103892	802 ± 48	Human bone	Scabuzzo et al. (2015)
LTC1 (test pit 2)	LP-2243	830 ± 50	*Diplodon* sp. shells	Politis et al. (2011)
LTC1 (individual 3)	AA-98853	849 ± 45	Human bone	Scabuzzo et al. (2015)
LTC1 (level 16)	LP-2296	860 ± 40	Charcoal	Politis et al. (2011)
LTC1 (level 18)	LP-2750	880 ± 50	Charcoal	Politis and Bonomo (2012)
LTC1 (level 35)	LP-2576	970 ± 60	Charcoal	Politis and Bonomo (2012)
LTC1 (level 33)	AA-98849	989 ± 30	Charcoal	Gianotti and Bonomo (2013)
LTC1 (level 23)	LP-2572	1,030 ± 50	Charcoal	Politis and Bonomo (2012)
LTC1 (level 45)	AA-98847	1,227 ± 45	Charcoal	Gianotti and Bonomo (2013)

eight families: Lauraceae, Euphorbiaceae, Fabaceae, Cyperaceae, Anacardiaceae, Apocynaceae, Myrtaceae and Primulaceae (20 samples: 18 samples identified and 2 indeterminate). This category includes samples associated with specific artefacts such as "campana" (bell shape) pottery, animal bones and burned poles. Analysis of charcoal fragments from dispersed contexts (ii) resulted in the identification of ten taxa within six different families (Lauraeae, Passifloraceae, Fabaceae, Salicaceae, Boraginaceae and Apocynaceae) (23 samples: 19 samples identified and 4 indeterminate) (Table 1).

Discussion

Human plant resource use at the LTC1 site

In this section, we address each taxon recorded in the dispersed and concentrated contexts of the LTC1 archaeological site, and we will relate them to present-day and historical use according to ethnographic and evidence from traditional inhabitants. Finally, we describe how they appear in other archaeological contexts of the study area in the Upper Delta of the Paraná river, and in different regions of Argentina.

Dispersed context

Lauraceae: *Ocotea* and *Nectandra*.—Ten fragments of charcoal from four samples (Lab code C-LTC 1, 17, 30, 40) with affinity to the Lauraceae were identified (see Table 1). Two samples share close affinity with *Nectandra lanceolata* (Figs. 2a, b). Samples 1 and 40 closely resemble *Ocotea* but different species within the genus.

The samples Lab code C-LTC 1, 30 and 40 were collected dispersed through the excavation. It is proposed that they were the result of secondary and accidental deposits, due to the recurrent cleaning of hearths inside the settlement or due to the action of natural agents, like wind, water or root activity.

The sample Lab code C-LTC 17 was found near ceramic sherds, probably this taxon was used for firewood. Both the calorific values of *Nectandra* and *Ocotea* make them suitable for use as firewood (López et al. 1987). Beauclair et al. (2009) and Keller (2010) documented in settlements of Guarani indigenous populations the use of *Nectandra* and *Ocotea* as fuel in domestic kitchens. In the rural and fishing community called Las Cuevas (Entre Ríos province), relatively near to the site under study, "*laurel de río*" (*Nectandra* sp.) is among the preferred species for use as fuel (Bertos and Keller 2017).

Table 3 Anatomical features of archaeological charcoals

Taxa	Growth rings	Porosity	Vessels	Fibres	Parenchyma	Rays	Observations
Nectandra sp.	Distinct	Diffuse	Small to large, short, solitary, radial multiples (2–5) and in clusters, oblique end walls and tylosis present, simple and scalariform (1 bar) perforation plates, alternate intervessel pits	Arranged in radial rows	Paratracheal, scarce, inconspicuous	Heterocellular, width 1 to 2 cells	Oil and/or mucilage cells associated with ray parenchyma, vessel-ray pits similar to intervessel pits
Ocotea sp. 1	Absent	Diffuse	Short, solitary, radial multiples (2) and in clusters, oblique end walls, simple perforation plates, alternate intervessel pits		Paratracheal, vasicentric and scarce	Heterocellular,width 2 to 4 cells, 4 to 14 cells high, numerous	Oil and/or mucilage cells associated with ray parenchyma
Ocotea sp. 2	Distinct	Diffuse	Long, solitary, radial multiples (2–3) and in clusters, oblique end walls, alternate intervessel pits	Septate	Paratracheal, vasicentric, confluent, possibly in bands	Homocellular to heterocellular, width 5 or more cells	Oil and/or mucilage cells associated with ray parenchyma
Sapium sp.	Absent	Diffuse	Small and numerous, very short, solitary and radial multiples (2–3), bordered and alternate intervessel pits, transverse to oblique end walls	Arranged in radial rows	Apotracheal diffuse?	Heterocellular, width 1 to 2 cells, 7 to 17 cells high	
Croton sp.		Diffuse	Small and few, longs, solitary, radial multiples (2–5) and in clusters, oblique end walls, simple perforation plates, alternate intervessel pits	Arranged in radial rows	Paratracheal, vasicentric and scarce	Heterocellular, width 2 to 3 cells, short and narrow, numerous	
Passiflora sp.?	Absent	Diffuse	Large and numerous, solitary and radial multiple of 2 elements, simple perforation plates, alternate intervessel pits		Probably scarce or absent	Heterocellular numerous, very narrow and small	
Salix sp.	Absent	Diffuse	Medium to large, short, numerous, solitary, radial multiple, lightly oblique end wall	Arranged in radial rows		Homocellular and heterocellular, narrow, width 1 to 2 cells	
Vachellia sp.	Distinct	Diffuse	Small and few, solitary, radial multiples (2–3 elements) and in clusters, oblique end wall, simple perforation plates, bordered and alternate intervessel pits		Abundant, paratracheal, vasicentric, confluent and terminal	Very short, homocellular, width 4 or more cells	
Enterolobium sp.	Absent	Diffuse	Numerous, solitary and short radial multiple (two elements), tylosis present		Paratracheal vasicentric incomplete and scarce	Width 1 to 2 cells, narrow and linear	
Prosopis sp. 1	Distinct	Diffuse	Small to medium and few, solitary, radial multiple (2–4 elements) and in clusters, tylosis present, oblique end wall, simple perforation plates, bordered and alternate intervessel pits	Arranged in radial rows	Abundant, paratracheal vasicentric and confluent, apotracheal diffuse and terminal?	Heterocellular, width 2 to 5 cells, 13 to 17 cells high and broad	Parenchyma crystalliferous
Prosopis sp. 2	Distintc	Diffuse	Numerous, solitary, radial multiples and in clusters, short to long, oblique end walls, simple perforation plates, alternate intervessel pits, vessels of two distinct diameter classes, wood not ring-porous	Septate	Abundant, paratracheal, vasicentric and confluent; apotracheal in bands	Homocellular to heterocellular, width 2 to 4 cells, numerous	
Erythrina sp.	Absent	Diffuse	Short, solitary and radial multiples (2–5 elements), alternate, numerous and very smalls intervessel pits		In bans of six cells wide, abundant	Width 4 or more cells, large and narrow	Axial parenchyma storied
Eugenia sp.	Distinct	Diffuse	In diagonal pattern, oval and short to long, solitary and radial multiple of 2 elements, oblique end wall, very small and alternate intervessel pits, scalariform perforation plate? (3 bars)		Paratracheal vasicentric, incomplete, apotracheal diffuse-in-aggregates	Heterocellular, width 1 to 3 cells, narrow	Crystal in fibres or parenchyma
Schinopsis sp.	Distintc	Diffuse	Few to numerous and large to small, solitary, radial multiples (2–3 elements) and in cluster, alternate and large intervessel pits, oblique end walls, simple perforation plates		Paratracheal vasicentric, confluent and abundant, in marginal bands	Broad, homocellular and heterocellular, width 2 to 5 cells	1–2 canals in multiseriate rays. Possible insects trace
Aspidosperma sp.	Distinct	Diffuse	Numerous and large, with trend to a diagonal pattern, solitary, radial multiples of 2 or more and in clusters, tylosis present, transverse end walls, simple perforation plates		Abundant or rare	Narrow and short, homocellular to heterocellular, width 2 to 3 cells	Canals present in transverse section interpreted as possible insect trace
Myrsine sp.	Distinct	Diffuse	Smalls and numerous, solitary, radial multiple (2–3 elements) and in clusters	Arranged in radial rows	Paratracheal, abundant, vasicentric, confluent, in bands, apotracheal diffuse	Homocellular, width 4 or more cells, numerous	
Cordia sp.	Absent	Diffuse	Small and very few to numerous, solitary and radial multiple (2–3 elements), narrow	Arranged in radial rows	Paratracheal vasicentric, scarce, incomplete, apotracheal diffuse-in-aggregates	Heterocellular, width 4 to 5 cells, 11 to 20 cells high, broad and high	
Cyperus sp.	The stem is an atactostele (characteristic of monocot stem). The stem in transverse section has numerous scattered collateral vascular bundles and aerenchyma with lot of air cavities. The vascular bundles has a protoxylem lacunar and two metaxylem vessels						

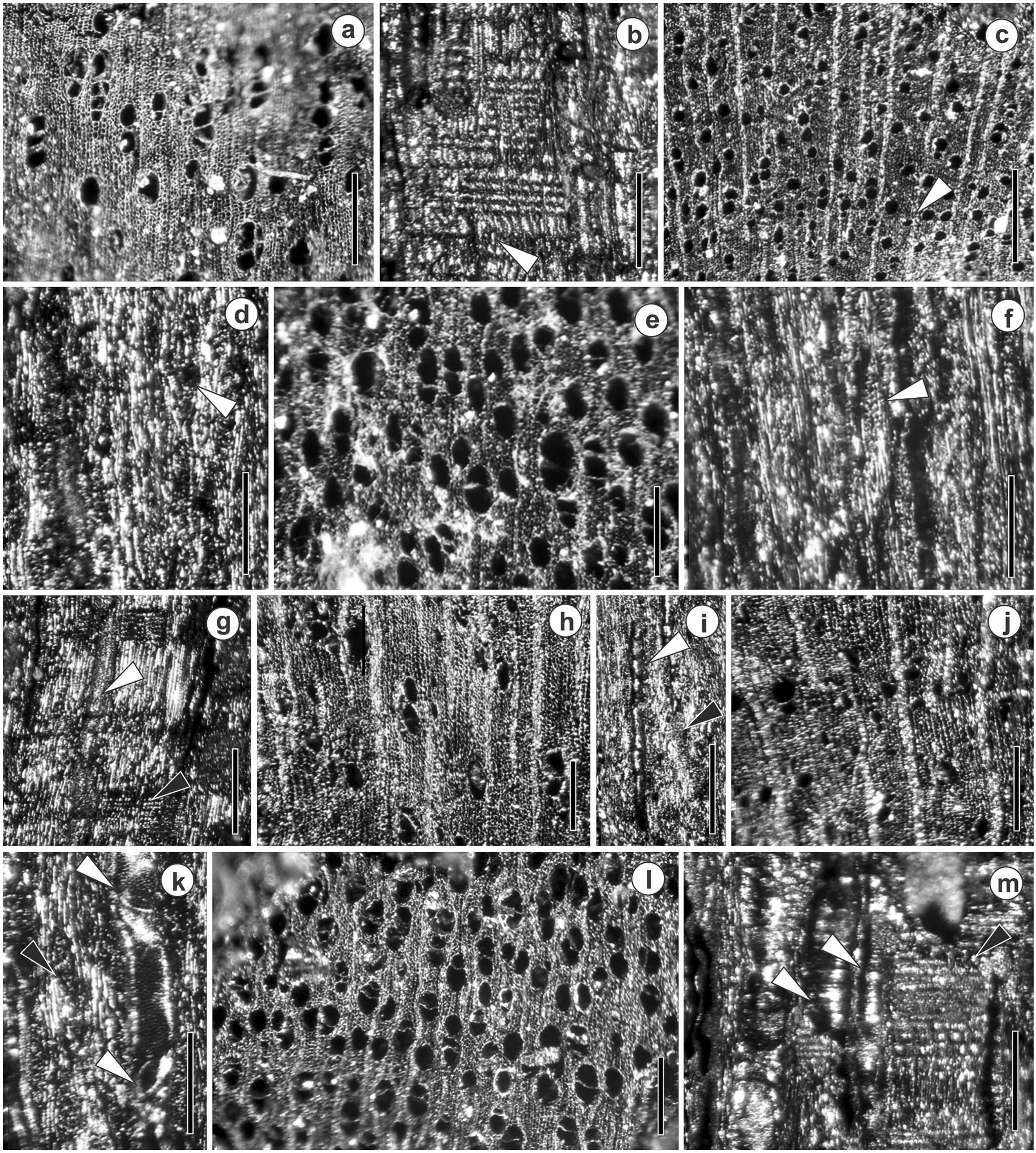

Fig. 2 **a** C-LTC 30, cross section, general view of *Nectandra,* 500 µm; **b** radial section, detail of oil and/or mucilage cells (arrow) associated with heterocellular ray, 250 µm; **c** C-LTC 39, cross section, general view of *Schinopsis* with distinct growth rings (arrow), 500 µm; **d** C-LTC 18, tangential section of *Schinopsis*, detail of canals in multiseriate rays (arrow), 250 µm; **e** C-LTC 19, cross section, general view of *Aspidosperma*, 500 µm; **f** C-LTC 36, tangential section of *Aspidosperma*, detail of multiseriate rays (arrow), 250 µm; **g** C-LTC 29, radial section of *Prosopis* (the white arrow indicates a vessel, the black arrow shows a ray), 250 µm; **h** C-LTC 34, cross section, general view of *Prosopis*, 250 µm; **i** C-LTC 37, tangential section of *Prosopis*, multiseriate rays (black arrow) and vessels (white arrow), 250 µm; **j** C-LTC 43, cross section, general view of *Myrsine*, 250 µm; **k** C-LTC 42, tangential section of *Myrsine*, detail of simple perforation plates (white arrows) and multiseriate rays (black arrow), 250 µm; **l** C-LTC 22, cross section, general view of *Salix*, 500 µm; **m** C-LTC 22, radial section of *Salix*, detail of heterocellular rays (black arrow) and vessel elements (white arrows), 250 µm

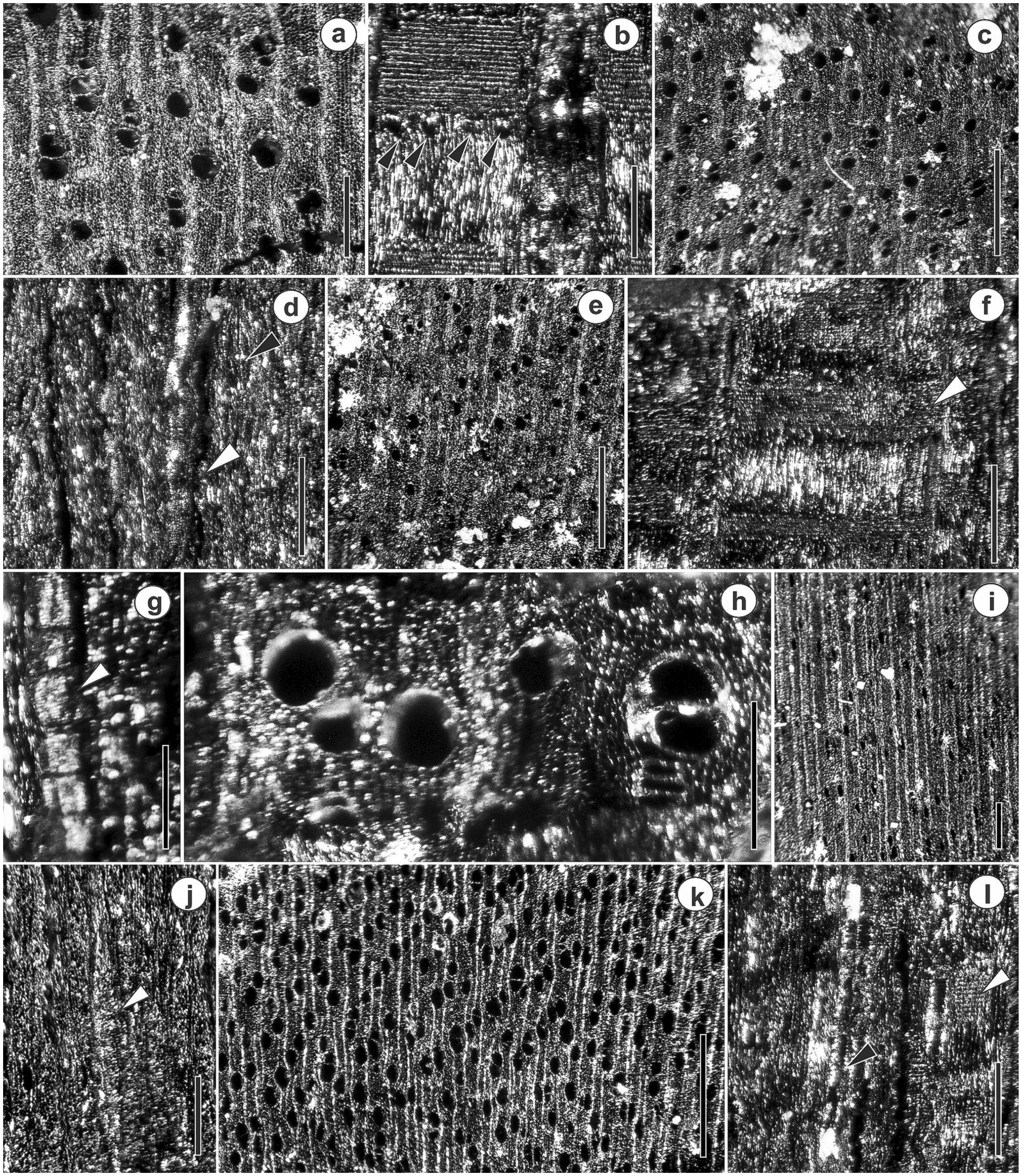

Fig. 3 **a** C-LTC 40, cross section, general view of *Ocotea*, 500 µm; **b** C-LTC 40, radial section of *Ocotea*, detail of oil and/or mucilage cells (black arrows) associated with ray, 250 µm: **c** C-LTC 27, cross section, general view of *Croton*, 1,000 µm; **d** C-LTC 27, tangential section of *Croton*, detail of rays (black arrow) and vessel elements (white arrow), 250 µm; **e** C-LTC 23, cross section, general view of *Vachellia*, 1,000 µm; **f** C-LTC 23, radial section of *Vachellia*, the arrow indicates a ray, 500 µm; **g** C-LTC 20, tangential section of *Erythrina*, detail of vessel elements (arrow), 1,000 µm; **h** C-LTC 20, cross section, general view of *Erythrina*, 500 µm; **i** C-LTC 26, cross section, general view of *Cordia*, 1,000 µm; **j** C-LTC 26, tangential section of *Cordia*, detail of high rays (arrow), 250 µm; **k** C-LTC 41, cross section, general view of *Eugenia*, 1,000 µm; **l** C-LTC 41, radial section of *Eugenia*, detail of rays (white arrow) and vessel elements (black arrow), 500 µm

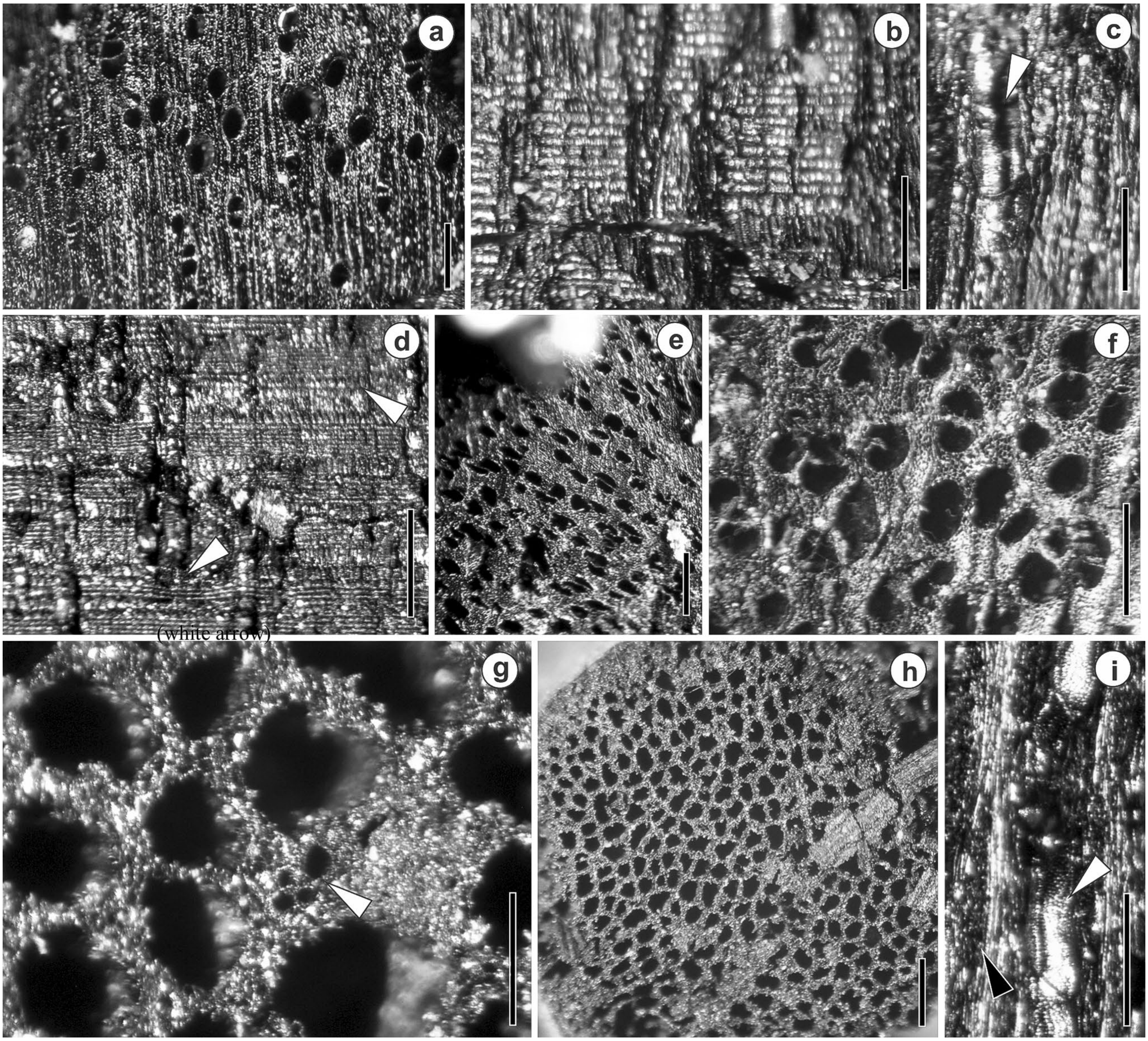

Fig. 4 **a** C-LTC 2, cross section, general view of *Sapium*, 250 µm; **b** C-LTC 2, radial section, detail of rays cells of *Sapium* (white arrow), 250 µm; **c** C-LTC 2, tangential section, detail of vessel elements of *Sapium* (white arrow), 250 µm; **d** C-LTC 3, radial section, detail of rays of *Passiflora* (white arrows), 250 µm; **e** C-LTC 3, cross section, porosity general view of *Passiflora*, 250 µm; **f** C-LTC 6, cross section, porosity general view of *Enterolobium*, 250 µm; **g** C-LTC 15, cross section, detail of vascular bundles (white arrow) surrounded by air channels or parenchyma of *Cyperus*, 250 µm; **h** C-LTC 15, overview of cross section of *Cyperus,* 250 µm; **i** C-LTC 16, tangential section, detail of vessel elements (white arrow) and multiseriate rays (black arrow) of *Vachellia,* 250 µm

Macro-remains related to *Ocotea* sp. and *Nectandra* sp. were also recorded at the Cerro Farall archaeological site, located adjacent to the Pre-Delta National Park, both forming part of a hearth (Ramos et al. 2019). In addition, on the Cerro Tapera Vázquez archaeological site, located in this National Park, *Nectandra* was identified as part of marginal river communities (Bonomo et al. 2011). In the Guaraní archaeological sites located in the Upper Uruguay river, Angrizani et al. (2013) identified carbonized woods related to *Nectandra* and/or *Ocotea* in the Barra do Santo Cristo 1 and Três Bocas 2 sites (ca. 400 and 500 years BP); the latter study does not specify the finding context. The presence of Lauraceae taxa in different archaeological sites of the Northeast region, the ethnographic record and current traditional importance, reflect the continuity of their use over centuries in different societies from the past and the present.

Passifloraceae: *Passiflora* sp.—Scattered in a level of the LTC1 site was found one fragment of charcoal of *Passiflora* sp. (Figs. 4d, e). The *Passiflora* genus is mostly vines, and a few species are shrubs and herbaceous; the dry species may have been used secondarily for kindling fires, after the use of its fruits and leaves. The use of the leaves in infusions and the fruits as edible were documented by Scarpa (2009). Del Puerto and Inda (2005) reported the only archaeological record of *Passiflora* from a palaeoethnobotanical perspective in their study of the mounds (*cerritos*) in the Northeast Uruguay. These authors reported the use of the red pulp of the *Passiflora* fruit as a face and lip paint.

Salicaceae: *Salix* sp.—The anthracological sample Lab code C-LTC 22 indicates the presence of *Salix* sp. (Figs. 3l, m) in the LTC1 archaeological site. *Salix* does not yield wood with good fuel properties (having low calorific value and low wood density; Table 4); probably the dry wood was used as kindling or to revive a fire because of its local availability. Its presence, though dispersed through the site, could have been evidence of the cleaning of hearths. In a pre-Hispanic population settled on the banks of the San Francisco river that integrates the Paraná basin in the province of Jujuy, there was evidence of *Salix* carbonized wood in an earth oven (Ortiz et al. 2017). The authors also alluded to a frequent use of this species as fuel due to its availability in the zone, and not to its qualities as firewood. In regard to its availability, in riverine areas or in the delta where the dynamics of the river are constant, *Salix* is the most representative tree of the zone. The presence of *Salix* in the floodplain, as in the riverine forests, plays an important ecological role as the trees act as windbreaks (Ramos 2009). Their roots help to prevent sandy soil erosion, and help uptake of nutrients.

Fabaceae: *Erythrina* sp.—The carbonized material related to *Erythrina*, was found dispersed in the profile of the site (samples Lab code C-LTC 10, 20. Table 1, 3. Figures 3g, h). *Erythrina* has a soft, porous and light wood, features making it suitable for canoe manufacture. Canoes, in delta areas, were indispensable for exploiting and transporting diverse resources. One possibility is that the presence of *Erythrina* is due to the alternative use of the trunks for the manufacture of dugout canoes, taking into account the ethnographic and historical record that reinforces this interpretation (Tortorelli 1956; Togo et al. 1990; Pensiero and Peña 2000; Hurrell and Lahitte 2002). Although the canoe records in the area mention particularly *Enterolobium* as raw material (see below), *Erythrina* wood has similar physical features to *Enterolobium* (light and soft), which make it appropriate for the manufacture of canoes. The sustainable resource management by indigenous and rural communities has been documented in numerous studies (Reyes-García 2008; Chávez Mejía and Herrera Tapia 2018). Probably, there is an alternate use of two or more species for the same purpose, e.g. to manufacture canoes. Other parts of the plant are currently used for a variety of purposes, so this does not rule out a wide functionality of *Erythrina* sp. (see Table 4). Indeed, in archaeological contexts of the Northwest region of Argentina, Ambrosetti (1907) found "keros" vessels and "drum" or "cylindrical boxes" made from woody material, which was recently determined by Sprovieri and Rivera (2014) as *Erythrina* sp.

Enterolobium contortisiliquum.—E. contortisiliquum, whose name *timbó* is a word of Guarani origin that means having a white or grey colour (Peña-Chocarro et al. 2006), is recorded at the LTC1 archaeological site (Fig. 4f). This species is characterized by having soft and light wood when it is dry, due mainly to the arrangement and size of its vessels (Table 3).

The record of the present-day use of *E. contortisiliquum* is diverse, including bark, leaves, fruits, and wood (Table 4). In North Argentina, the Wichí population from Chaco use the wide trunks of the species for the manufacture of canoes; the resin of the same species would act as a waterproofing (Peña-Chocarro et al. 2006). There are some identifications of the use of *timbó* for canoes found in the Paraná Delta and Río de la Plata (Márquez Miranda 1932; Brunazzo and Rivera 1997; Aldazabal and Castro 2000; Hurrell and Lahitte 2002; Bonomo and Ramos 2019). In addition, de Souza Pereira et al. (2016) documented the use of the leaves to facilitate fishing, because the photosynthetic organs of the plant have a sedative effect on fish leaving them readily accessible to capture. *Enterolobium contortisiliquum* was also recovered in the Cerro Farall archaeological site, as part of a hearth, and therefore used as fuel (Ramos et al. 2019). According to the secondary deposit of the samples of charcoal related to *Enterolobium* in the site, and its multiple uses, the use of this resource is inferred as a raw material for the construction of canoes. Canoes allowed fishing, hunting, transport of loads, movement of people and war in fluvial environments (Bonomo and Ramos 2019). Thus, *Enterolobium* and other trees that integrated the LTC1 landscape were essential in the economy of the groups that inhabited the Upper Paraná Delta in the Late Holocene.

Boraginaceae: *Cordia* sp.—The samples (Lab code) C-LTC 7 and 26 recovered in the site have a direct taxonomic relationship with *C. trichotoma* (Figs. 3i, j). *Peteribí* (as it is commonly called in Argentina) has a wood easier to hand work, because it is semi-hard and semi-heavy (Tortorelli 1956; Sprovieri and Rivera 2014). In the Northeast, near to the study area, Tortorelli (1956) and Keller (2008) described the use of the species in hut and canoe construction.

Recently, *Cordia* sp. was also found in the Cerro Farall archaeological site and was related to the use of fuel (Ramos et al. 2019). The information based on the above mentioned ethnographic and archaeological records shows that the identified material could have had diverse functions before being burnt. It could have been parts of huts and/or have been used for tool manufacture.

Related taxa	Wood density (kg/m^3)	Calorific value (kcal/kg)	Current uses	Habit				Land cover type							
								Paraná Delta						Other landscapes	
				Trees	Shrubs	Lianas	Herbs	*Algarrobo* and *espinillo* low open woodland	*Ceibo* woodland	Mosaic of woodland and marshes	Grassland	High closed woodland	Monotypic woodland	Semiarid woodland	Humid woodland
Lauraceae															
Nectandra sp.	480-550	4,570	1, 2	x	x							x			
Ocotea sp. 1	400-580	5,150	1, 2	x	x							x			
Ocotea sp. 2	400-580	5,150	1, 2	x	x							x			
Euphorbiaceae															
Sapium sp.	320-390	4,100	2, 5, 7	x	x							x	x		
Croton sp.	750	1,800-2,100	1, 5, 8, 14	x								x			
Passifloraceae															
Passiflora sp.	---	--	4, 5			x						x			
Salicaceae															
Salix sp.	490	3,500	3*, 5	x						x			x		
Fabaceae															
Vachellia sp.	800-980	4,200-4,600	1, 2, 3, 4, 5, 6, 7, 8, 12	x	x			x							
Prosopis sp. 1	850-1,500	4,200-4,600	1, 2, 3, 4, 5, 6, 7, 8, 12	x	x			x							
Prosopis sp. 2	850-1,500	4,200-4,600	1, 2, 3, 4, 5, 6, 7, 8, 12	x	x			x							
Erythrina sp.	250-296	4,800	5, 9, 13	x	x				x	x		x			
Enterolobium sp.	336-390	4,700-4,800	1, 2, 5, 9, 13	x								x			
Myrtaceae															
Eugenia sp.	1,175	4,040-4,545	1, 2, 8	x	x							x			
Anacardiaceae															
Schinopsis sp.	1.250	7,300	1, 8, 9, 10, 11	x										x	
Apocynaceae															
Aspidosperma sp.	850	7,300	1, 3, 5, 8, 9, 10, 11	x										x	
Primulaceae															
Myrsine sp.	480-610	4,700	1, 5, 7, 8	x	x							x			
Boraginaceae															
Cordia sp.	600-670	2,000-2,400	1, 2, 5, 8, 13, 14	x											x
Cyperaceae															
Cyperus sp.	---	--	2, 4, 5, 8, 12				x				x				

Table 4 Taxa identified from the LTC 1 site, including wood density, calorific value, habit and land cover type and current ethnographic uses. References: 1. fuel; 2. manufacture of artefacts (domestic tools); 3. cultural (funerary, medicinal, cultural ritual) *in agricultural; 4. food; 5. medicinal; 6. fodder; 7. dyeing; 8. hut construction (posts, beams, lumber and roof); 9. leather goods, tanning hides; 10. lighting; 11. railway sleepers; 12. making of beverages; 13. canoe construction; 14. melliferous species (data taken from Tortorelli 1956; Métraux 1973; Cristiani 1978; Martínez Crovetto 1981; Cialdella 1984; Santos Biloni 1990; Togo et al. 1990; Roig 1993; Castro 1994; Filipov 1994; Guaglianone 1996; Barrett 1998; Hilgert 1998; Bourdy et al. 2000; Pensiero and Peña 2000; Hurrell and Lahitte 2002; Arenas 2003; Alonso and Desmarchelier 2005; Mereles 2006; Peña-Chocarro et al. 2006; Pol et al. 2006; Athanasiadou et al. 2007; Del Valle Perea et al. 2007; Scarpa 2007; Keller 2008; Fabbio et al. 2009; Ramos 2009, 2010; Martínez 2010; Montani et al. 2010; Rosato et al. 2010; Zabala and Natalini 2011; Suarez and Arenas 2012; Valencia and Balesta 2013; Beovide and Campos 2014; Olazával 2014; Riat and Pochettino 2014; Sprovieri and Rivera 2014; Volkmann 2014; Andreoni 2015; de Souza Pereira et al. 2016; Bertos and Keller 2017; Fernández Marinaro 2018; Ramos et al. 2019)

Concentrated contexts

Usually the concentration of charcoal fragments in an archaeological site has a direct relationship to a combustion structure. In this paper it is assumed that the set of burnt wood fragments accumulated in a delimited sector of the excavation correspond to a hearth (or to a specific function in the site). Consequently, the identified taxa reflect human preference and selection due to the suitability of their distinctive features for the purpose. Overall, these taxa possess fuel-efficient features recorded in various ethnobotanical researches. Some of the features are easy ignition, slow burning, intense flame, little smoke, production of embers and availability of the species (Arenas 2003; Scarpa 2007; Riat and Pochettino 2014; Andreoni 2015; Fernández Marinaro 2018).

Fabaceae: *Vachellia* sp. and *Prosopis* sp.—Fabaceae, with five different taxa identified, is the most important in the charcoal assemblage and comprised 42.4% of the total amount of analyzed charcoal fragments. Within these Fabaceae, *Vachellia* sp. and *Prosopis* sp. are important with 17.9% and 13.1% of the total charcoal fragments (Figs. 2g–i; Figs. 3e, f; Fig. 4i). Two species were identified within *Prosopis*. *Prosopis* sp. 1 related to *P. affinis,* and *Prosopis* sp. 2 related to *P. alba.* Table 4 shows a high calorific value and density for *Vachellia* sp. and *Prosopis* sp., which define these woody species as good fuels. According to the ethnographic study carried out in the rural and fishing community of Las Cuevas by M. Bertos (pers. comm.), *Vachellia caven* or *espinillo* is the preferred wood fuel species.

In Argentina, *Prosopis* has been used since pre-Hispanic times until the present, by different indigenous populations such as Tobas, Wichí, Pilagás, Mocoví, Abipón, Guaraní, Puelche, Mapuche and Tehuelche, among others (de Viedma [1781] 1837; Capparelli 2007, 2008). Also, *Prosopis* charcoal samples were documented in the Cerro Farall (Ramos et al. 2019) and Cerro de Boari 3 archaeological sites from Entre Ríos province (Franco et al. 2017). Bonomo et al. (2011) point out that *Prosopis* sp. was used as fuel for firing pottery and cooking food at the Cerro Tapera Vazquez site.

In northwest Argentina, Ortiz et al. (2017) collected charcoal related to *Prosopis* and also *Vachellia* in a funerary context of the Pozo de la Chola archaeological site (Jujuy province) associated with the Formative period with an age of 2000 ± 50 years BP. For the same region, Marconetto and Gordillo (2008) identified *Vachellia* and *Prosopis* trunk samples, used as posts and beams in the construction of the Iglesia de los Indios and Piedras Blancas archaeological sites (ca. 700–1100 years BP) in Ambato valley (Catamarca province). In this regard, Marconetto and Mafferra (2016) discovered that the hardwood taxa *Prosopis* and *Schinopsis* were used for metallurgical work in an archaeological site in the Ambato valley. The species together produce heat at a high temperature, and their combustion produces a quite rigid charcoal and they are preserved very well in the archaeological record.

In Patagonia, Marconetto (2002) identified carbonized wood related to *Prosopis* in Alero Don Santiago archaeological site (Chubut province), dated between 4,470 and 1,750 years BP. Capparelli and Prates (2015) found remains of *algarroba* fruit that was consumed by hunter-gatherers of the Angostura 1 archaeological site (900 years BP, Río Negro province). Ciampagna (2014), in the Alero 4 site (1,690 years BP) on the north coast of Santa Cruz province, also recorded remains of *Prosopis*. *Vachellia* and *Prosopis* have numerous current applications (Table 4). As discussed above, the archaeological interpretations of *Prosopis* and *Vachellia* in Argentina also allude to multiple applications. In the LTC1 archaeological site, we do not rule out broad functionality of these taxa. Considering the physical properties of *Prosopis* and *Vachellia* (density and high hardness), the total amount of the samples and their distribution in the site under study, the most reasonable interpretation is their use as fuel.

Myrtaceae: *Eugenia* sp.—In a fertile level of the site, charcoals of *Eugenia* genus (Fig. 3k, l) were recovered. *Eugenia* sp. are highly valued for their resistance (hardness and high density) and for having a straight stem. Keller (2008) cites the *Eugenia uniflora* and *Cordia trichotoma* (Boraginaceae) species in huts of Guaraní construction in the province of Misiones. *Eugenia uniflora* has edible fruits. As a first interpretation of *Eugenia* sp. in the archaeological context, we consider that the straight and flexible stems of the taxon could have been used in the construction of huts. In addition, *Eugenia* sp. concentrated charcoal in the LTC1 site and their calorific value could indicate as use as firewood.

Cyperaceae: *Cyperus* sp.—At level 120–125 of grid 10, concentrated charcoals, related to *Cyperus* (Figs. 4g, h), were recovered. According to the archaeological context where the samples were found, probably the dead or dried plant was used as a starter or reviver of bonfires. However, its primary application was probably the use of its roots for food consumption, or its leaves for artefacts. This is based on the ethnographic records made by Guaglianone (1996) in eastern Argentina, and Beovide and Campos (2014) in northern area of Rio de la Plata. The authors suggest that *Cyperus* was used in the manufacture of baskets and *esteras* fabric for huts (Beovide and Campos 2014; see also Mereles 2006). *Cyperus esculentus* has tubers used in the making of a refreshing beverage called *chufa* or *horchola*, or is consumed as food, raw or toasted, and is used to make *racahoret* (Guaglianone 1996). In riparian ecosystems of Lake Titicaca, *Cyperus* sp. has multiple uses including its use in floors and roofs of huts; the archaeological record shows that it has been used from Archaic time (Olazával 2014).

Concentrated charcoal associated with specific artefacts

Euphorbiaceae: *Sapium* sp.—Charcoal remains of *Sapium* sp. (Figs. 3b, c) were recovered near a *campana*, possibly used as fuel. The practical function of the *campana* is still unknown, which has given rise to different alternative hypotheses of its use for maintaining fire embers (Frenguelli 1927), or in incense burners (Gaspary 1950).

Although *Sapium* sp. has a high calorific value (Table 4), currently it is not appreciated as fuel, because its wood produces a lot of smoke and few embers. Fernández Marinaro (2018) documents the low preference for its use as fuel in rural communities in the province of Cordoba. Togo et al. (1990, p. 93) describe the wood of *S. haematospermum* as "soft and light, they make musical instruments (e.g. drums or *bombos*) and various tools". In the series of poles found by Ambroseti (1907), *Sapium* sp. was the raw material for the manufacture of one type of these elements (Sprovieri and Rivera 2014).

Our initial interpretations around charred wood of *Sapium* sp. suggest its use as kindling or for flame production. However, they were found next to a *campana*, and the fact that *Sapium* smokes and does not produce embers could partially support Gaspary's (1950) hypothesis instead of that of Frenguelli (1927). Further studies are necessary to explore this idea. In relation to wood that produces large amounts of smoke, in the Cerro Tapera Vazquez site Bonomo et al. (2011) cite a charcoal sample of *Inga* sp. (Fabaceae) and the burning of its wood for smoking food on a grid of sticks. We do not rule out a similar use for *Sapium* sp. in the LTC1 site.

At the time of the arrival of Europeans in the sixteenth century, the islands of the Paraná Delta were inhabited by indigenous canoe people; one of their main sources of food was fish. Probably the combustion of *Sapium* sp. wood, as well as *Inga* sp., was used for smoking various types of fish and other meat to preserve food throughout the year, especially for the winter (Santa Cruz in Von Wieser 1908, p. 57).

Anacardiaceae and Apocynaceae: *Schinopsis* and *Aspidosperma*.—Related anthracological samples to *Schinopsis* (Anacardiaceae) and *Aspidosperma* (Apocynaceae) (Figs. 2c–f) were found concentrated in an area within the site. An interesting fact is that *Aspidosperma* and *Schinopsis* were found together with animal bones in the LTC1 site; this opens a range of possible interpretations regarding the functionality of the taxa.

According to ethnographic records, *Aspidosperma* and *Schinopsis* wood have a high-calorific value, and are firm and durable (Riat and Pochettino 2014; Fernández Marinaro 2018). Linked to a hearth, three samples related to *A. quebracho blanco* were identified in the Cerro Farall site (Ramos et al. 2019). In northwestern Argentina, Ortiz et al. (2017) also found charcoals of *Aspidosperma* and *Schinopsis* associated with funeral rituals and in hearths in a pre-Hispanic population of the San Francisco culture of the Formative period. *Aspidosperma* and *Schinopsis* were also recovered in domestic hearths in the Valle de Ambato in groups defined as Aguada Culture (Marconetto and Mafferra 2016).

Aspidosperma would had been part of the housing infrastructure in the form of beams in the sites *Iglesia de los Indios* and *Piedras Blancas* (ca. 700–1,100 years BP) in Catamarca province (Marconetto and Gordillo 2008). This last record supports the interpretation from sample (Lab code) C-LTC 19 related to *Aspidosperma*, which represents a charred stem in a vertical position. This would represent a mullion/post or part of a hut structure. Currently, *Aspidosperma* is used as a fuel, for domestic tools, or in ritual events (Fontana 1977; Peña Chocarro et al. 2006; Riat and Pochettino 2014). Therefore, beyond its value as good fuel, it is assumed that the presence of *Aspidosperma* and *Schinopsis* in the LTC1 archaeological site was also linked to many alternative uses.

Euphorbiaceae: *Croton* sp.—Charcoal fragments related to *Croton* sp. were identified (Figs. 2c, d). This charred trunk of *Croton* sp. was deposited in a vertically in the stratigraphy of the site. In this context, it is proposed that it sample was part of a more complex structure, probably a pole or part of a hut. It could have also been burned after a primary household use. In a rural community of Cordoba, *Croton* sp. together with other species are used to make brooms to clean furnaces because of their durability and resistance (Martínez 2010; Fernández Marinaro 2018). According to archaeological records from adjacent to the study area, on the Familia Primón archaeological site in Coronda locality, Santa Fe province, towards the end of the Late Holocene (470 years BP), *Croton* sp. was already part of a humid subtropical environment in the area (Balducci et al. 2017).

Primulaceae: *Myrsine* sp.—Charcoals identified as *Myrsine* (Primulaceae) were found concentrated in the LTC1 archaeological site (Figs. 2j, k). Sample (Lab code) C-LTC 42 was found in a vertical position in the stratigraphy. *Myrsine* spp. have a high calorific value suitable for use as fuel, amongst other uses (Table 4). In the Cerro Tapera Vázquez archaeocological site charred wood of *Myrsine* sp. was identified (Bonomo et al. 2011). According to the current record, *M. umbellata* wood is used in dwelling construction (Otegui and Maldonado 1998). Fruits of *M. coriacea* are used in the Yungas or Tucumano-Bolivian forests as a natural dye for sheep wool, and its trunk and branches are used as firewood (Fabbio et al. 2009). The ethnographic record and archaeological context in the site under study supports our inference of the use of *Myrsine* as part of an architectural structure (hut) and as fuel.

Woody, shrubby and herbaceous resource availability

The taxonomic identification of the carbonized material suggests that *Ocotea*, *Nectandra*, *Sapium*, *Croton*, *Passiflora*, *Salix*, *Erythrina*, *Prosopis*, *Vachellia*, *Enterolobium*, *Eugenia*, *Aspidosperma*, *Myrsine*, *Cordia* and *Cyperus* formed part of the environment of the pre-Hispanic population that inhabited the LTC1 mound. This floristic association is currently in the study area. *Salix humboldtiana*, *Nectandra angustifolia*, *Myrsine laetevirens*, *Croton*, *Passiflora* and abundant epiphytes in the present-day form part of "subtropical gallery woodland" and "deltaic woodland and wetland" (Aceñolaza et al. 2004). Ronchi Virgolini et al. (2010) described woodlands and riverbank vegetation constituted by these species, and Aceñolaza et al. (2004) referred to them as "mixed forests of internal riverbanks" and "forests on the slopes alongside the river". These woodlands are characterised by, among other species, *Enterolobium*, *Erythrina crista-galli*, *Sapium haematospermum*, *Salix humboldtiana* and *Myrsine laetevirens*. Recently, Oyarzabal et al. (2018) re-examined the Argentinean phytogeographic classification of Cabrera (1976) and define the area where the LTC1 site is located as "Forest and deltaic wetland", very near to "Sclerophyllous Forest" with *Prosopis affinis* and megathermic grasslands with gallery woodland. Figure 1 indicates the location of LTC1 and its area of influence characterized by the vegetation units of Oyarzabal et al. (2018).

The taxa identified here are characteristic of semi-deciduous woodlands or may occur both in the semi-deciduous and riparian woodlands, suggesting that during this period the past settlement was surrounded by an environment with a high availability of woody resources. The presence of growth rings was observed for about 50% of charcoal fragments analysed. The samples that did not show growth rings correspond to species that grow near to watercourses (rivers, streams), such as *Salix humboldtiana*, *Erythrina crista-galli* and *Sapium*. The preliminary results of these findings for the LTC1 archaeological site suggest an environment similar to the present one with little marked seasonality.

Three samples related to *Schinopsis* were identified in the study area. Today, *S. balansae* is distributed approximately more than 100 km north (Feliciano city, Entre Ríos, Argentina) of the LTC1 archaeological site (Muñoz 2010). *Quebrachos* of Anacardiaceae were generally adapted to swampy or waterlogged lands (Sender 2012), covering the transition between palaeoridges and watersheds in Northern and Central Argentina (including Entre Ríos province) (Dimitri et al. 1997; Muñoz 2010).

During the Holocene there has been climatic variability caused by numerous environmental factors (Milana and Kröhling 2015). Based on geomorphological and meteorological information, Iriondo (1991, 2010) documents the alternation of dry and humid climates during the Quaternary period for the Argentinean Northwest. In the Upper Holocene a dry and semi-arid interval with scarce vegetation cover and temperatures similar to the current ones would have occurred. Between 1,400 years BP and 700 years BP there was a humid-tropical climate, while towards the period 700–200 years BP the Little Ice Age took place. Subsequently, the wet and warm-temperate conditions were accentuated (Iriondo and García 1993; Iriondo 2010). The effects of climate change in the area under study could have affected the current distribution of *Schinopsis* during the period between ca. cal AD 765 to 1505.

On the contrary, an alternative hypothesis is that *Schinopsis* did not live the region when the pre-Hispanic groups inhabited the Upper Paraná Delta. Thus, this record could be indicating an extra-local provenance, in the case of its geographic distribution being similar to its current one (e.g. Pearsall 2000; Théry-Parisot et al. 2010). The exchange and transfer of these woods, along with allochthonous rocks and metal objects, shows that the economy of the indigenous people that occupied this insular area of the Upper Delta of the Paraná river was integrated within multiple networks of circulation of objects and socio-economic interaction during Late Holocene.

Conclusions

The use of charcoal in the study of the past provided relevant information when interpreting the archaeological and the ancient flora record of the Upper Paraná Delta. Most of the taxa could have been available near this mound settlement, since they are today present in the oldest and best-preserved forests of the Paraná river. However, *Schinopsis* could come from distances of more than 100 km from the north of Entre Ríos. In this regard, the presence in low frequencies of wood from extra-local sources supports the idea of its being obtained through intragroup exchanges rather than by direct access through special trips.

Concentrated charcoals sampled correspond to domestic hearths; they are represented by a heterogeneous composition of taxa with a calorific value appropriate for this use, except *Cyperus*. Charcoal of *Prosopis*, *Vachellia*, *Eugenia* and *Myrsine* in bonfires indicated the preference of these taxa for fuel use, and they are those which provide high caloric energy in combustion. In addition, some of them (e.g. *Sapium* sp.), could be used to smoke food for storage. According to the archaeological context in which *Aspidosperma*, *Croton* and *Myrsine* were found, it is concluded that these taxa were used in the construction of huts within the settlement.

Finally, anthracological analysis in archaeological contexts integrated with the ethnographic record, shows that not all charcoal is synonymous with burned wood in hearths, and its use as fuel may have occurred secondarily. *Enterolobium* and *Erythrina* could be direct evidence of waste from the manufacture of canoes and from past architectural or technological structures by pre-Hispanic populations lived in the Upper Delta of the Paraná river towards the end of the Holocene.

Acknowledgements The authors want to thank the landowner Enzo Mariani and his family, for allowing the archaeological excavation and for providing the land facilities during fieldwork. We thank Facundo E. Gregorutti and John Daniell for providing language help. We also acknowledge W. Gosling and the two anonymous reviewers for their valuable help in providing critical and constructive comments. This research was supported by two projects *Arqueología del sector meridional del Noreste argentino* (ANPCyT-PICT 1064) and *Arqueología de ambientes acuáticos del Centro-este argentino* (UNLP 11/N885).

References

Aceñolaza PG, Povedano HE, Manzano AS, de Muñoz DJ, Areta JI, Ronchi-Virgolini AL (2004) Biodiversidad del Parque Nacional Pre-Delta. In: Aceñolaza FG (ed) Temas de la Biodiversidad del Litoral fluvial Argentino. INSUGEO Misceláneas 12. Universidad Nacionale de Tucumán, San Miguel de Tucumán, pp 169–184

Aldazabal V, Agueda Castro M (2000) La construcción de canoas monoxilas en la cuenca del Plata. J Soc Américanistes 86:185–193

Alonso J, Desmarchelier C (2005) Plantas medicinales autóctonas de la Argentina. Bases científicas para su aplicación en atención primaria de la salud. Lola, Buenos Aires, pp 136–139

Ambrosetti JB (1907) Exploraciones arqueológicas en la ciudad prehistórica de “La Paya” (Valle Calchaquí - Provincia de Salta). Revista de la Universidad de Buenos Aires 8. Biedma é Hijo, Buenos Aires

Andreoni DF (2014) Plantas leñosas y estrategias humanas en el Sur de Mendoza: una aproximación arqueobotánica. Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, Tesis de doctorado

Andreoni DF (2015) Explotación de recursos combustibles en el monte Mendocino: el caso del sitio arqueológico Agua de los Caballos -1 (departamento de San Rafael). Intersecciones en Antropol 16:253–269

Angrizani RC, Mange E, Romero Alves M (2013) Determinación de maderas carbonizadas procedentes de contextos arqueológicos de la Tradición Guaraní. Rev Mus La Plata, Sección Antropología 13:333–344

Arenas P (2003) Etnografía y alimentación entre los Toba-Ñachilamole#ek y Wichí-Lhuku´tas del Chaco Central (Argentina). Pedro Arenas, Buenos Aires, Argentina

Athanasiadou S, Githiori J, Kyriazakis I (2007) Medicinal plants for helminth parasite control: facts and fiction. Animal 1:1,392–1,400

Balducci F, Garralla S, Sartori J (2017) Condiciones paleoambientales y ocupaciones humanas en el sitio Familia Primón (Coronda, Santa Fe): aportes desde la arqueopalinología. Arqueología 23:63–80

Barrett WH (1998) Antecedentes y situación actual del cultivo del quebracho colorado *(Schinopsis balansae)* en el Chaco argentino. SAGPyA Forestal (Argentina) 7:7–18

Bastourre ML (2014) Estudios Arqueofaunísticos en el Delta Superior del Paraná: el Sitio Los Tres Cerros 1 (Provincia de Entre Ríos, Argentina). Rev Chil Antropol 30:109–115

Beauclair M, Scheel-Ybert R, Faraco Bianchini G, Buarque A (2009) Fire and ritual: bark hearths in South-American Tupiguarani mortuary rites. J Archaeol Sci 36:1,409–1,415

Beovide L, Campos S (2014) Interacciones entre las sociedades y las plantas durante el Holoceno medio-tardío en el área septentrional del Río de la Plata (Uruguay). Rev Esp Antropol Am 44:575–601

Berón MA, Fontana SL (1996) Determinación taxonómica de restos vegetales arqueológicos carbonizados. Actas de la VI Jornadas Pampeanas de Ciencias Naturales. Coprocna, Santa Rosa, pp 31–39

Bertos M, Keller H (2017) Etnobotánica de los pobladores ribereños de Las Cuevas Entre Ríos, Argentina. Dissertation, I Jornadas sobre Etnobiología y Sociedad “compartiendo caminos”, San Salvador de Jujuy, Argentina

Bonomo M (2012) Historia Prehispánica de Entre Ríos. Universidad Maimónides, Fundación de Historia Natural Félix de Azara

Bonomo M, Ramos RS (2019) Las canoas monóxilas halladas en el Río de la Plata y Delta del Paraná depositadas en el museo de la Plata. Dissertation, VIII Encuentro de discusiones Arqueológicas del Nordeste, Posadas

Bonomo M, Politis G, Castro JC (2010) Primeros resultados de las investigaciones arqueológicas en el Delta Superior del Paraná y su contribución al Atlas Arqueológico de la provincia de Entre Ríos. Folia histórica del Nordeste 18:33–58

Bonomo M, Colobig MM, Passeggi E, Zucol AF, Brea M (2011) Multidisciplinary studies at Cerro Tapera Vázquez site, Pre-Delta

National Park, Argentina: the archaeological, sedimentological and paleobotanical evidence. Quat Int 245:48–61

Bourdy G, DeWalt SJ, Chávez de Michel LR et al (2000) Medicinal plants uses of the Tacana, an Amazonian Bolivian ethnic group. J Ethnopharmacol 70:87–109

Brea M, Franco MJ, Bonomo M, Politis GG (2013) Análisis antracológico preliminar del sitio arqueológico Los Tres Cerros 1 (Delta Superior del río Paraná), provincia de Entre Ríos. Rev Mus La Plata, Sección Antropología 13:345–360

Brea M, Mazzanti D, Martínez GA (2014) Selección y uso de los recursos madereros en cazadores-recolectores de la transición Pleistoceno-Holoceno y Holoceno medio, sierras de Tandilia oriental, Argentina. Rev Mus Argentino Cienc Nat 16:129–141

Brunazzo GA, Rivera SM (1997) Rescatando dos canoas de las aguas del olvido. Un aporte al conocimiento de embarcaciones indígenas recuperadas en el Partido de Berisso. Rev Mus La Plata 2:87–91

Burkart R, Bárbaro NO, Sánchez RO, Gómez DA (1999) Eco-regiones de la Argentina. Administración de Parques Nacionales (A.P.N.) y Programa Desarrollo Institucional Ambiental (PRODIA), Buenos Aires

Cabrera AL (1976) Regiones Fitogeográficas Argentinas. Enciclopedia argentina de agricultura y jardinería, Tomo 2, fasc. 1. ACME, Buenos Aires

Cabrera AL (1994) Regiones Fitogeográficas Argentinas. Enciclopedia Argentina de Agricultura y Jardinería, Tomo 2, fasc. 1. ACME, Buenos Aires

Cabrera AL, Willink A (1980) Biogeografía de América Latina. Secretaría General de la Organización de los Estados Americanos, Programa Regional de Desarrollo Científico y Tecnológico, Washington DC

Capparelli A (2007) El algarrobo blanco y negro –*Prosopis chilensis* (Mol.) Stuntz y *P. flexuosa* DC, Fabaceae– en la vida cotidiana de los habitantes del NOA: subproductos alimenticios. Kurtziana 33:103–119

Capparelli A (2008) Caracterización cuantitativa de productos intermedios y residuos derivados de alimentos del algarrobo (*Prosopis flexuosa* y *P. chilensis*, Fabaceae): aproximación experimental aplicada a restos arqueobotánicos desecados. Darwiniana 46:175–201

Capparelli A, Prates L (2015) Explotación de frutos de algarrobo (*Prosopis* spp.) por grupos cazadores recolectores del noreste de Patagonia. Chungara Rev Antropol Chil 47:549–563. https://doi.org/10.4067/S0717-73562015005000030

Capparelli R, Raffino R (1997) La etnobotánica de "El Shincal" (Catamarca) y su importancia para la arqueología I: recursos combustibles y madereros. Parodiana 10:181–188

Castiñeira Latorre C, Apolinaire E, Blasi A, Politis G, Bonomo M, Mari F (2017) Pre-Hispanic earthwork engineering variability in the Upper Delta of the Paraná River. A comparative study between Los Tres Cerros mounds (Entre Ríos province, Argentina). J Archaeol Sci 13:322–332. https://doi.org/10.1016/j.jasrep.2017.04.002

Castiñeira C, Blasi A, Politis G et al (2013) The origin and construction of pre-Hispanic mounds in the Upper Delta of the Paraná River (Argentina). Archaeol Anthropol Sci 5:37–57

Castiñeira C, Blasi A, Bonomo M, Politis G, Apolinaire E (2014) Modificación antrópica del paisaje durante el Holoceno tardío: las construcciones monticulares en el Delta Superior del río Paraná. Rev Asoc Geol Argent 71:33–47

Castro MA (1994) Maderas argentinas de Prosopis. Atlas anatómico (Algarrobos, vinal, calden, itin y otros). Secretaria General de la Presidencia de la Nación, Buenos Aires

Cavallotto JL, Violante RA, Colombo F (2005) Evolución y cambios ambientales de la llanura costera de la cabecera del río de La Plata. Rev Asoc Geol Argent 60:353–367

Ceruti CN (2003) Entidades culturales presentes en la cuenca del Paraná Medio (margen entrerriana). Mundo de Antes 3:111–135

Chabal L, Fabre L, Terral JF, Théry-Parisot I (1999) L'anthracologie. In: Bourquin-Mignot et al. (eds) La Botanique. Errance, Paris, pp 43–104

Chase MW, Christenhusz MJM, Fay MF et al (2016) An update of the angiosperm phylogeny group classification for the orders and families of flowering plants: APG IV. Bot J Linn Soc 181:1–20

Chávez Mejía C, Herrera Tapia F (2018) Acercamiento al conocimiento tradicional y a los recursos bioculturales. In Chávez Mejías et al. (eds) Conocimiento ambiental tradicional y manejo de recursos bioculturales en México. Análisis geográfico, ecológico y sociocultural. Universidad Autónoma del Estado de México, Toluca

Chiri OC (1975) El empleo de la madera y algunos otros productos vegetales por los indígenas del nordeste argentino según las referencias de algunas fuentes. Relaciones de la Sociedad Argentina de Antropología 9:83–109

Ciampagna ML (2014) Estudio de la Interacción de los Grupos Cazadores Recolectores que Habitaron la Costa Norte de Santa Cruz y las Plantas Silvestres: Recolección y Gestión. Universidad Nacional de La Plata, La Plata, Tesis de doctorado

Cialdella AM (1984) El género *Acacia* (Leguminosae) en la Argentina. Darwiniana 25:59–111

Colobig MM (2012) Estudios paleoetnobotánicos en muestras del sitio 1, Localidad arqueológica Lobería I, Buenos Aires, Argentina: aproximación al manejo de recursos vegetales. Relaciones de la Sociedad Argentina de Antropología 37:137–158

Colobig MM, Sanchez JO, Zucol AF (2015) Análisis de macrorrestos vegetales en el sitio arqueológico Los Tres Cerros 1 (Isla las Moras, Victoria, Entre Ríos). Rev Mus Antropol 8:115–124

Cozzo D (1951) Anatomía del leño secundario de las leguminosas Mimosoideas y Cesalpinoideas Argentinas silvestres y cultivadas. Rev Inst Nac de Invest Ci Nat C Bot 2:63–146

Cristiani LQ (1978) Identificación de maderas comerciales argentinas. Rev Inst Municipal Bot 4:5–75

De Souza Pereira G, Silva Noelli F, Bitencourt Campos J, Pereira Santos M, Zocche JJ (2016) Ecologia Histórica Guarani: As plantas utilizadas no Bioma Mata Atlântica do litoral sul de Santa Catarina, Brasil (Parte 1). Cadernos do Lepaarq 13:198–246

De Viedma A [1781] (1837) Diario de un viaje a la costa de Patagonia. In: de Angelis P (ed) Colección de Viages y Expediciónes à los Campos de Buenos Aires y a las costas de Patagonia (V). Imprenta del Estado, Buenos Aires

Del Perea Valle M, Pedraza G, Del Valle LJ (2007) Relevamiento de la flora arbórea autóctona en la provincia de Catamarca. Consejo Federal de Inversiones, Buenos Aires, pp 38–40

Del Puerto L, Inda H (2005) Paleoetnobotánica de los constructores de cerritos de túmulos del noreste del Uruguay: Análisis de silicofitolitos de la estructura monticular YALE 27 y su entorno. In: Gianotti García C (ed) Proyecto de cooperación científica: Desarrollo metodológico y aplicación de nuevas tecnologías para la gestión integral del Patrimonio Arqueológico en Uruguay. Tapa 36. Laboratorio de Arqueoloxía de Paisaxe, Instituto Padre Sarmiento de Estudios Gallegos, Santiago de Compostela, pp 109–122

Dimitri MJ, Leonardis RFJ, Biloni JS (1997) El nuevo libro del árbol. Tomo I, El Ateneo, Buenos Aires

Donoghue D (1989) Carbonised plant macrofossils. In: Beck W, Clarke A, Head L (eds) Plants in australian archaeology. Tempus 1. Museum of Anthropology/University of Queensland, St. Lucia, pp 90–110

Fabbio FA, Hilgert NI, Lambaré DA (2009) Los tintes naturales de Los Toldos y alrededores. 1º ed. CYTED-RISAPRET, San Salvador de Jujuy

Farr ER, Zijlstra G (1996) Index Nominum Genericorum (Plantarum). https://botany.si.edu/ing/. Accessed 15 Feb 2016

Fernández de Oviedo y Valdés G (1851–1855 [1546–1547]) Historia general y natural de las Indias, Islas y Tierra-Firme del Mar Océano. Imprenta de la Real Academia de la Historia, Madrid

Fernández Marinaro AE (2018) Conocimiento, Provisión y Uso de Plantas Alimenticias y Combustibles en Pobladores Rurales de los Ambientes Serranos de la Calera (Dpto. Colón, Córdoba): Una Perspectiva Etnobotánica Diacrónica. Tesis de doctorado, Universidad Nacional de Córdoba, Córdoba, Argentina

Filipov A (1994) Medicinal plants of the Pilagá of Central Chaco. J Ethnopharmacol 44:181–193

Fontana LJ (1977) El Gran Chaco. Solar, Buenos Aires

Franco MJ, Ramos RS, Castro JC (2017) Nuevos registros de Madera Carbonizada en el Sitio Arqueológico Cerro de Boari 3 (Gualeguaychú, Entre Ríos). Scientia Interfluvios, Suplemento de Resúmenes. VII Encuentro de Discusión Arqueológica del Nordeste Argentino Diamante—Entre Rios del 20 al 23 de septiembre de 2017.

Frenguelli J (1927) Nuevo tipo de alfarería indígena ornitomorfa. Boletín de Educación de Santa Fe 4:2–11

Garibotti IA (1998) Análisis de la estructura anatómica de carbones arqueológicos de sitios Incaicos (ca. 1480–1530 d.C.) del Valle de Uspallata (Mendoza, Argentina). Bol Soc Argent Bot 33:195–205

Gaspary F (1950) Investigaciones Arqueológicas y Antropológicas en un ”Cerrito” de la Isla Los Marinos (Pcia. de Entre Ríos). Publicaciónes del Instituto de Arqueología, Lingüística y Folklore 23. Imprenta de la Universidad, Córdoba

Gianotti C, Bonomo M (2013) De montículos a paisajes: procesos de transformación y construcción de paisajes en el sur de la cuenca del Plata. Comechingonia Revista de Arqueología 17:59–94

Giovannetti M, Lantos I, Defacio R, Ratto N (2012) Construcción de un banco de almidones de Variedades nativas de *Zea mays* L. del Noroeste argentino. Propuesta metodológica y primeros resultados. In: Babot M del Pilar, Marschoff M, Pazzarelli F (eds) Las manos en la masa. Arqueologías, antropologías e historias de la alimentación en Suramérica. Museo de Antropología, Instituto Superior de Estudios Sociales, Córdoba, pp 361–385

Guaglianone ER (1996) Cyperaceae. In: Zuloaga FO, Morrone O (eds) Catálogo de Plantas Vasculares de la República Argentina. 1. Pteridophyta, Gymnospermae y Angiospermae (Monocotyledoneae). Monogrographs of Systematic Botany Missouri Botanical Garden 60. Missouri Botanical Garden, St. Louis, pp 28–197

Hilgert NI (1998) Plantas vinculadas con el ámbito doméstico y la subsistencia de los campesinos de la cuenca del río Zenta, Dpto. Orán, Provincia de Salta. Thesis, Universidad Nacional de Córdoba, Córdaba, Argentina

Hurrell JA, Lahitte HB (2002) Biota Rioplatense VII. Leguminosas Nativas y exóticas. L.O.L.A, Buenos Aires

Inside Wood database (2004) https://insidewood.lib.ncsu.edu/search. Accessed 20 Apr 2018

Iriondo M (1991) El Holoceno en el Litoral. Comunicaciones del Museo Provincial de Ciencias Naturales “Florentino Ameghino” 3. Subsecretaría de Cultura de la Provincia de Santa Fe, Santa Fe

Iriondo M (2010) Geología del Cuaternario en Argentina. Museo Provincial de Ciencias Naturales “Florentino Ameghino”, Santa Fe, Argentina

Iriondo M, García N (1993) Climatic variations in the Argentine plains during the last 18,000 years. Palaeogeogr Palaeoclimatol Palaeoecol 101:209–220

Keller HA (2008) Las plantas usadas en la construcción y el acondicionamiento de las viviendas y templos guaraníes en misiones, Argentina. Bonplandia 17:65–81

Keller H (2010) Plantas relacionadas con tabúes del ciclo reproductivo de los guaraníes de Misiones, Argentina. Bol Soc Argent Bot 45:201–208

López JA, Little EL, Ritz GF, Rombold JS, Hahn WJ (1987) Árboles comunes del Paraguay: ñande yvyra mata kuera. Imprenta Mitami, Paraguay

Mafferra LE (2015) Arqueología de los paisajes forestales del norte de Mendoza. Facultad de Filosofía y Humanidades, Universidad Nacional de Córdoba, Córdoba, Tesis

Marconetto MB (2002) Análisis de vestigios de combustión de los sitios Alero Don Santiago y Campo Moncada. In: Pérez de Micou C (ed) Plantas y cazadores en Patagonia. Facultad de Filosofía y Letras, Universidad de Buenos Aires, Buenos Aires. pp 33–54

Marconetto MB (2008) Recursos forestales y el proceso de diferenciación social en tiempos prehispánicos en el Valle de Ambato, Catamarca, Argentina. BAR International Series 1785. South American Archaeology Series 3. Archaeopress, Oxford

Marconetto MB, Gordillo I (2008) “Los Techos del Vecino”: análisis antracológico de restos de construcción carbonizados de los sitios "Iglesia de los Indios" y "Piedras Blancas" (Catamarca). Darwiniana 46:213–226

Marconetto MB, Mafferra L (2016) Todos los fuegos el fuego: discusión en torno a las categorías modernas en la interpretación de registros antracológicos en contextos prehispánicos y coloniales. Cadernos do Lepaarq 13:460–483

Márquez Miranda F (1932) La navegación primitiva y las canoas monóxilas. Rev Mus La Plata 9:57–87

Martínez Crovetto R (1981) Las plantas utilizadas en medicina popular en el noroeste de Corrientes (Républica Argentina). Miscelánea/ Fundación Miguel Lillo 69. Ministerio de Cultura y Educación, Fundación Miguel Lillo, Tucuman

Martínez GJ (2010) Los remedios naturales en la prevención y cuidado de la salud oral de los tobas del Chaco Central (Argentina). Bol latinoam Caribe plantas med aromát 9:109–122

Mereles MF (2006) La diversidad los usos y la conservación de las especies vegetales en los humedales del Paraguay. Rojasiana 7:171–185

Metcalfe CR, Chalk L (1950) Anatomy of the Dicotyledons, vol 1. Claredon Press, Oxford

Métraux A (1973) Religión y magias indígenas de América del Sur. Aguilar, Madrid

Milana JP, Kröhling D (2015) Climate changes and solar cycles recorded at the Holocene Paraná Delta, and their impact on human population. Sci Rep 5:12,851. https://doi.org/10.1038/srep12851

Montani MC, Vega Riveros C (eds) (2010) Raíces Huarpes: uso medicinal de plantas en la comunidad de Lagunas del Rosario, Mendoza. Universidad Nacional de San Juan, San Juan, Argentina

Morrone JJ (2017) Neotropical biogeography. CRC Press, Boca Raton, Regionalization and Evolution

Muñoz JD (2010) Anacardiaceae Flora Fanerogama Argentina 65:1–28

Muñoz J de Dios, Milera S, Romero C, Brizuela AB (2005) Bosques Nativos y Selvas Ribereñas en la Provincia de Entre Ríos. In: Aceñolaza FG (ed) Temas de la Biodiversidad del Litoral fluvial argentino II. INSUGEO, Miscelánea 14. Universidad Nacional de Tucumán, Tucumán, pp 169–182

Neiff JJ (2005) Bosques fluviales de la cuenca del Paraná. In: Arturi MF, Frangi JL, Goya JF (eds) Ecología y manejo de los bosques de Argentina. Editorial de la Universidad Nacional de La Plata, La Plata, pp 1–26

Olazával HA (2014) Los orígenes de la agricultura: nuevos paradigmas. Investigaciones Sociales 18:53–86

Ortiz G, Ramos RS, Alavar A (2017) Fire, rituals and domesticity. Forest resource management in the sub-Andean region of Jujuy, Argentina (2000 BP): First anthracological evidence. J Anthropol Archaeol 47:96–108

Otegui M, Maldonado S (1998) Morfología foliar de las especies de *Myrsine* L. (Myrsinaceae) del Cono Sur de América del Sur. Candollea 53:349–363

Oyarzabal M, Clavijo J, Oakley L et al (2018) Unidades de vegetación de la Argentina. Ecología Austral 28:40–63
Pearsall DM (2000) Paleoethnobotany: a handbook of procedures. Academic Press, San Diego
Peña-Chocarro MC, De Egea Juvinel J, Vera M, Maturo H, Knapp S (2006) Guía de árboles y arbustos del Chaco húmedo. The Natural History Museum, Asunción, Paraguay
Pensiero JF, de la Peña MR (2000) Flora y Avifauna de la provincia de Santa Fe. El Litoral, Santa Fe
Pique i Huerta R (1995) La gestión de los recursos forestales en Tunel VII. In: J. Estevez Escalera, A. Vila Mitjà (eds) Encuentros en los concheros fueguinos. Treballs d´Etnoarqueologia 1. CSIC, Barcelona, pp 194–238
Pochettino ML, Capparelli A (2009) Aportes para una paleoetnobotánica/arqueobotánica argentina del siglo XXI. Xama 19:135–156
Pol RG, Camín SR, Astié AA (2006) Situación ambiental en la Ecorregión del Monte. In: Brown A, Martinez Ortiz U, Acerbi M, Corcuera J (eds) La Situación ambiental argentina 2005. Fundación Vida Silvestre Argentina, Buenos Aires, pp 227–233
Politis GG, Bonomo M (2012) La entidad arqueológica Goya-Malabrigo (ríos Paraná y Uruguay) y su filiación Arawak. Rev Arqueol Soc Arqueol Brasileña 25:10–46
Politis GG, Bonomo M (2018) Estado actual y perspectivas de Goya-Malabrigo, una sociedad indígena del noreste argentino. In: Politis GG, Bonomo M (eds) Goya-Malabrigo. Arqueología de una sociedad indígena del Noreste argentino, Editorial UNICEN, Tandil, pp 9–44
Politis GG, Bonomo M, Castiñeira C, Blasi A (2011) Archaeology of the upper delta of the paraná river (Argentina): mound construction and anthropic landscapes in the Los Tres Cerros locality. Quat Int 245:74–88
Ramos RS (2009) Factores Culturales, Ambientales y de Manejo Involucrados en la Pérdida y/o Conservación de Variedades Criollas de Maíces en la Comunidad Rural de Caspalá. Tesis, Universidad Nacional de Jujuy, San Salvador de Jujuy, Provincia de Jujuy
Ramos RS (2010) Potencialidad Etnomedicinal de las Especies de Fabaceae de la Quebrada de Humahuaca (Jujuy, Argentina). Universidad Nacional de Jujuy, San Salvador de Jujuy, Informe Beca de Iniciación para la Promoción de la Investigación
Ramos RS, Silva C, Brea M (2019) Análisis antracológico preliminar del sitio arqueológico Cerro Farall (Diamante, Entre Ríos). Arqueologia 25(3):59–85
Reyes-García V (2008) El conocimiento tradicional para la resolución de problemas ecológicos contemporáneos. Papeles 100(2007–2008):109–116
Richter HG, Dallwitz MJ (2000) Commercial timbers: descriptions, illustrations, identification and information retrieval. https://www.biodiversity. uno.edu/delta/. Accessed 15 Apr 2018
Riat P, Pochettino ML (2014) ¿Para usar o para eliminar? El uso local del Monte Santiagueño (Argentina) y el avance de la agricultura industrial. Zonas Áridas 15:68–91
Rodríguez MF (2000) Woody plant species used during the Archaic period in the southern Argentine Puna. Archaeobotany of Quebrada Seca 3. J Archaeol Sci 27:341–361
Rodríguez Ariza M (1993) Los procesos de formación y transformación del registro arqueológico en los estudios antracológicos. Procesos posdepositacionales Arqueológica espacial 16–17:371–390
Roig FA (1993) Aportes et la etnobotánicos del Género *Prosopis*. In: IADIZA (ed) Contribuciones mendocinas a la Quinta Reunión de Regiónal para América Latina y el Caribe de la Red de Forestación del CIID. Conservación y Mejoramiento de Especiesdel Género Prosopis. Mendoza, Argentina
Rojas Rodríguez FE, Canessa Mora R, Ramírez Rojas J (2004) Incorporación de árboles y arbustos en los cafetales del Valle Central de Costa Rica. ICAFE/ITCR, Cartago
Ronchi-Virgolini AL, Lorenzón RE, Beltzer AH, Alonso JM (2010) Ensambles de aves del Parque Nacional Pre-Delta (Entre Ríos, Argentina): análisis de la importancia ornitológica de distintas unidades ambientales. Hornero 25:27–40
Rosato VG, Hernández MP, Civitella SM (2010) Uso medicinal popular de plantas y líquenes de la Isla Paulino, Provincia de Buenos Aires, Argentina Boletín Latinoamericano y del Caribe de Plantas Medicinales y Aromáticas. https://www.redalyc.org/articulo.oa?id=85615195003. Accessed 23 Mar 2017
Sánchez JO, Colobig MM, Zucol AF, Politis GG, Bonomo M, Castiñeira C (2013) Primeros resultados sobre el uso prehispánico de los vegetales en el sitio arqueológico Los Tres Cerros 1 (Victoria, Entre Ríos, Argentina): análisis del registro biosilíceo. Darwiniana, nueva serie 1:201–219
Santos Biloni J (1990) Árboles autóctonos argentinos. Tipográfica Editora Argentina, Buenos Aires
Scabuzzo C, Ramos van Raap A, Bonomo M, Politis GG (2015) Estudios bioarqueológicos en el sitio Los Tres Cerros 1 (Delta Superior del río Paraná, Entre Ríos, Argentina). Bol Mus Para Emílio Goeldi Cienc Hum 10:509–535
Scarpa GF (2007) Etnobotánica de los criollos del oeste de Formosa: Conocimiento tradicional, valoración y manejo de plantas forrajeras. Kurtziana 33:153–174
Scarpa GF (2009) Etnobotánica médica de los indígenas chorote y su comparación con la de los criollos del Chaco semiárido (Argentina). Darwiniana 47:92–101
Scheel-Ybert R, Klökler D, Gaspar MD, Figuti L (2005–2006) Proposta de amostragem padronizada para macrovestígios bioarqueológicos: antracologia, arqueobotânica, zooarqueologia. Rev Museu Arq Etn, São Paulo 15–16:139–163
Sender MB (2012) Regeneración de especies leñosas en comunidades boscosas de diferentes posiciones topográficas del sureste de Formosa. Universidad Nacional de Rosario, Rosario, Argentina, Thesis
Solari M (2007) Discusiones en torno a la antracología y los sitos arqueológicos de la Región Sur-Austral de Chile. In: M.B. Marconetto, P. Babot, N. Oliszewki (eds) Paleoetnobotánica del Cono Sur: Estudios de caso y propuestas metodológicas. Ferreyra Editor, Córdoba, pp 127–137
Sprovieri M, Rivera SM (2014) Las maderas de la "Colección La Paya". Circulación y consumo en el valle Calchaquí (Salta). Intersecc Antropol 15:89–102
Suarez E, Arenas P (2012) Plantas y hongos tintóreos de los wichís del Gran Chaco. Bol Soc Argent Bot 47:275–283
The Plant List (2010) Version 1. https://www.theplantlist.org/. Accessed 15 Feb 2018
Théry-Parisot I (2002) Gathering of firewood during the Palaeolithic. In: S. Thiébault (ed) Charcoal analysis. Methodological approaches, palaeoecological results and wood uses. BAR International Series 1063. Archaeopress, Oxford, pp 243–249
Théry-Parisot I, Chabal L, Chrzavzez J (2010) Anthracology and taphonomy, from wood gathering to charcoal analysis. A review of the taphonomic processes modifying charcoal assemblages, in archaeological contexts. Palaeogeogr Palaeoclimatol Palaeoecol 291:142–153
Togo J, Basualdo MA, Urtubey N (1990) Aprovechamiento socioeconómico de la flora autóctona de Santiago del Estero (Listado de especies y uso popular más frecuente). Indoamérica 3:1–161
Tortorelli LA (1956) Maderas y Bosques Argentinos. Editorial ACME, Buenos Aires
Tuset R (1963) Descripción y clave macroscópica de maderas indígenas del Uruguay. Silvicultura 19:5–56
Valencia MC, Balesta B (2013) ¿Abandono planificado? Restos forestales carbonizados en sitios arqueológicos de La Ciénaga (Catamarca, Argentina). Bull Inst Fr Etudes Andin 42:145–172

Volkmann LR (2014) Joyas vegetales : un recorrido botánico para reconocer verdaderas joyas vegetales características o exclusivas de los ambientes naturales de la Argetnna central, sus usos y aplicaciones. Detodoslosmares, Capilla del Monte, Córdoba

Von Wieser F (1908) Die karten von amerika in dem islario general des Alonso De Santa Cruz. Wagner, Innsbruck

Wheeler EA, Baas P, Gasson PE (1989) IAWA list of microscopic features for hardwood identification. IAWA Bulletin n.s. 10. Published for the International Association of Wood Anatomists at the National Herbarium of the Netherlands, Leiden, pp 219–332

Zabala MT, Natalini MB (2011) Maderas del Nordeste Argentino. Departamento de Estabilidad, Facultad de Ingeniería, Universidad Nacional del Nordeste, Corrientes, Características Físicas y Mecánicas