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Evidence for cultivar adoption and emerging complexity during the mid-Holocene in the La Plata basin

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Multidisciplinary investigations at the Los Ajos archaeological mound complex in the wetlands of southeastern Uruguay challenge the traditional view that the La Plata basin was inhabited by simple groups of hunters and gatherers for much of the pre-Hispanic era^{1–4}. Here we report new archaeological, palaeoecological and botanical data indicating that during an increasingly drier mid-Holocene, at around 4,190 radiocarbon (¹⁴C) years before present (BP), Los Ajos became a permanent circular plaza village, and its inhabitants adopted the earliest cultivars known in southern South America. The architectural plan of Los Ajos during the following Ceramic Mound Period (around 3,000–500 ¹⁴C yr BP) is similar to, but earlier than, settlement patterns demonstrated in Amazonia^{5–10}, revealing a new and independent architectural tradition for South America.

Research on the emergence of complex societies in South America has mainly concentrated on Andean coastal and highland valleys^{11–14}, and more recently in the lowland forest and riverine regions of Amazonia^{5–10}. The La Plata basin (Fig. 1a) is a large and little explored river system that is beginning to reveal an early and long sequence of unique and complex cultural trajectories. The natural environment of the study area is dominated by subtropical grasslands interspersed with vast extensions of wetlands. In strategic locations circumscribed to wetland floodplains, archaeological mound complexes are large and numerous. They have mounded architecture geometrically arranged in circular, elliptical and horseshoe formats that surround a central communal space (Fig. 1b).

The first excavations at the multi-mound site called Los Ajos, by Bracco¹⁵, in the early 1990s consisted of a block excavation in Mound Alfa, a test unit in Mound Beta and a few opportunistic test units in off-mound areas. This work established the mid-Holocene age of the earthen mounds in the area. The Preceramic Mound Period (PMP) component at Los Ajos yielded five dates between 3,950 and 3,350 ¹⁴C yr BP (4,580 and 3,380 calibrated (cal.) yr BP)¹⁶. Closely comparable dates from the deeper PMP components of the Puntas de San Luis, Isla Larga and Potrerillo sites

collectively ascertained the antiquity of the PMP^{17–19} (Table 1).

Our new excavation programme consisted of the placement of a block excavation in Mound Gamma, a test unit in Mound Delta, two trench transects articulating mound and off-mound areas and a 50-m systematic interval transect sampling strategy of test units to target off-mound areas (Fig. 2) totalling an excavated area of 305 m² (ref. 20). Our work revealed that Los Ajos is one of the largest and most formally laid out sites in the study area and covers about 12 ha (Fig. 2a). Its Inner Precinct includes six flat-topped, quadrangular platform mounds (called 6, Alfa, Delta, Gamma, 4 and 7) closely arranged in a horseshoe formation and with a height above ground level of 1.75 to 2.5 m (Fig. 2a, b). Two dome-shaped mounds (called Beta and 8) frame the central, oval plaza with a size of 75 × 50 m (Supplementary Fig. 1a). The formal and compact Inner Precinct contrasts with more dispersed and informally arranged peripheral sectors, which include two crescent-shaped rises (named TBN (Supplementary Fig. 1b) and TBS), five circular and three elongated lower dome-shaped mounds, borrow pits and a vast off-mound area bearing subsurface occupational refuse.

A series of major social and economic changes took place at Los Ajos during the PMP. The broad contemporaneity of radiocarbon dates (Table 1), artefact content and similarities in Preceramic Mound Component (PMC) stratigraphy among mounds Alfa, Delta and Gamma suggest that the Los Ajos inhabitants began to live in a circular household-based community, partitioning the site into a number of discrete functional areas characterized by the placement of residential units around a central plaza area. Charcoal from the basal level of Mound Gamma, 270–275 cm deep (arbitrary depth), dates the beginning of the PMC at 4,190 ± 40 ¹⁴C yr BP (4,840–4,580 cal. yr BP). Another radiocarbon assay at 205–210 cm deep yielded a date of around 3,460 ¹⁴C yr BP (3,980–3,470 cal. yr BP). The upper portion of the PMC in Mound Delta yielded a date of around 2,960 ± 120 ¹⁴C yr BP. Taken together, the eight dates from Los Ajos place the PMC occupation between 4,190 ± 40 and 2,960 ± 40 ¹⁴C yr BP. The two oldest dates from the basal levels of the PMC at Mound Gamma and Alfa suggest that mound-building began between around 4,190 and 3,950 ¹⁴C yr BP (4,840–4,160 cal. yr BP). Mounds grew as a result of multiple overlapping of domestic occupations where a wide range of activities associated with food preparation, consumption, stone tool production and maintenance took place. The PMC Layer 4 is characterized by a ~85-cm-thick compact, very dark brown silty loam organic sediment (Fig. 3) consisting of relatively undifferentiated deposits composed of lithic debitage and tools, small fragments of charred bone, ash and soot lenses, and small pieces of burned clay.

Our associated palaeoecological data²⁰ indicate that, similar to other regions in the Americas²¹, the mid-Holocene (between 6,620 ± 40 ¹⁴C yr BP (7,580–7,440 cal. yr BP) and 4,020 ± 40 ¹⁴C yr BP (4,570–4,410 cal. yr BP)) was a period of significant environmental flux marked by increasing aridity. At around 4,020 ¹⁴C yr BP (4,570–4,410 cal. yr BP) a maximum drying episode occurred, as evidenced by a massive spike of Amaranthaceae/Chenopodiaceae coupled with a sharp drop in wetland species (Supplementary Fig. 2). These changes probably caused a decrease in the surface water recharge to the inland wetlands and waterways. Although reduced in extent, wetlands probably became attractive places for pre-Hispanic populations by providing abundant, now more highly circumscribed plant and animal resources and a stable source of water. The mid-Holocene drying trend may thus have acted as an important catalyst for the reorientation of settlements towards the topographically higher freshwater wetlands, where permanent communities were established.

Despite the application of an intensive flotation program, seeds, roots and nuts were not recovered; however, phytoliths and starch grains were abundant (Methods are available as Supplementary Information). Phytoliths diagnostic of maize cobs²² (Fig. 4c) record their earliest appearance in the level from 255–260 cm deep, 15 cm

above the earliest dated context of the PMC (about 4,190 ¹⁴C yr BP), and continue to be present throughout the sequence (Table 1). Starch grains diagnostic of maize kernels²³ (Fig. 4d) were recovered from a subspherical mano excavated at a depth of 205–210 cm, 5 cm above a date of about 3,460 ¹⁴C yr BP (3,980–3,470 cal. yr BP) (Supplementary Fig. 3a). Large spherical scalloped phytoliths diagnostic of fruit rinds from domesticated species of *Cucurbita*²⁴ (Fig. 4e) occurred for the first time in PMC contexts at a depth of 255 cm, 15 cm above the earliest dated context around 4,190 ¹⁴C yr BP, and continue to be present throughout the sequence (Supplementary Table 1). Palm phytoliths were also present throughout

the sequence. In addition, starch grains from maize kernels were documented in contexts dating to 3,600 ¹⁴C yr BP at Isla Larga and 2,800 ¹⁴C yr BP at Los Indios, two other mound sites in the study area. At Isla Larga, starch grains from *Phaseolus* sp. beans (Fig. 4a) were derived from contexts dated to 3,050 ¹⁴C yr BP, and starch grains from *Canna* sp. rhizomes (Fig. 4b) were evidenced from contexts dated to 3,660 ¹⁴C yr BP²⁵. Larger preceramic mound complexes are situated along fertile wetland floodplains, suggesting that PMP people engaged in wetland margin horticulture during late spring and early fall when the water table is at its lowest and the organic, fertile and easy-to-till superficial peat horizon is readily exposed.

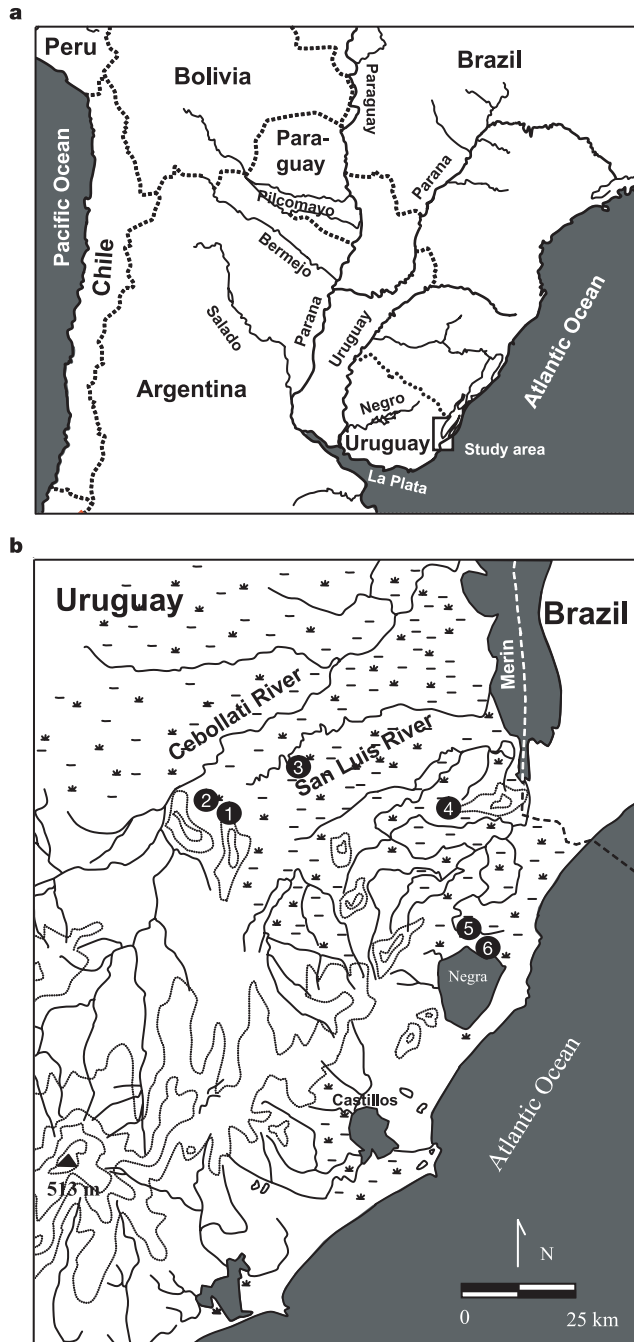


Figure 1 Maps showing the position of the study area and locations of archaeological sites within the study area. **a**, Location of the study area and the La Plata basin. **b**, Map of southeastern Uruguay showing archaeological sites. Key: 1, Los Ajos; 2, Estancia Mal Abrigo; 3, Puntas de San Luis; 4, Isla Larga; 5, Los Indios; 6, Potrerillo.

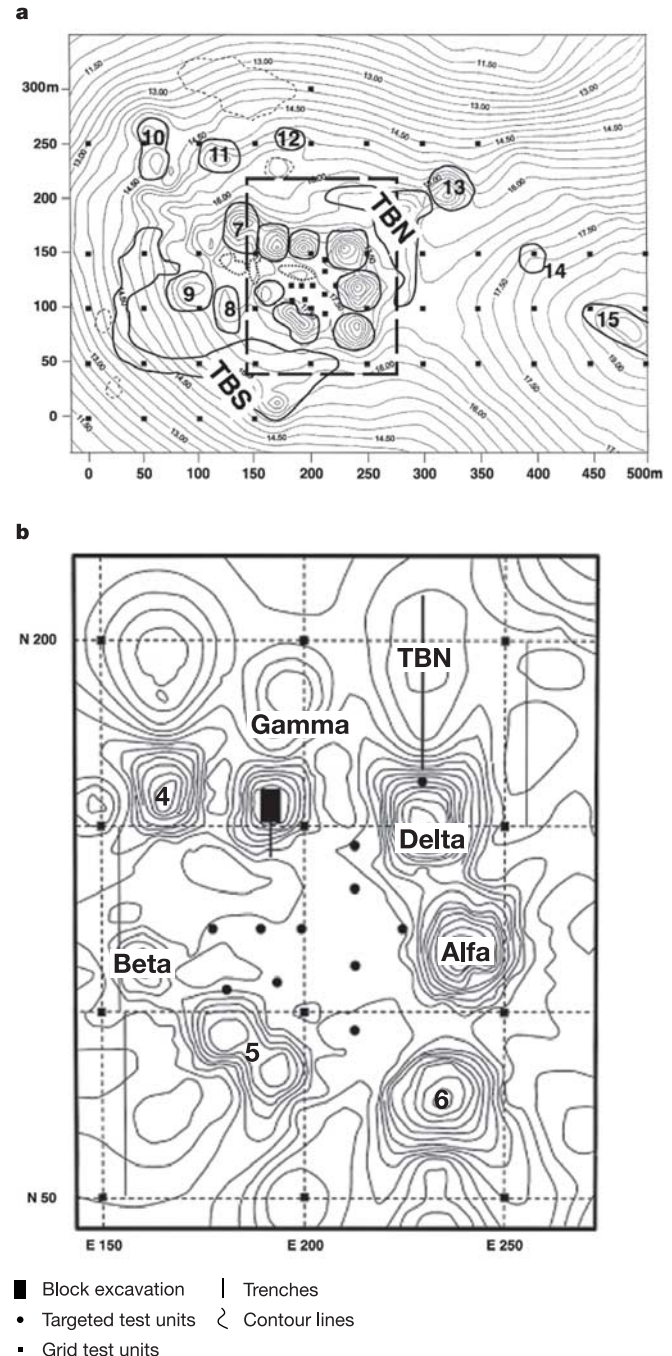


Figure 2 Topographical maps of the study site. **a**, Topographical and planimetric map of Los Ajos. Countour intervals, 0.33 m. Thick lines show perimeter of mounds. **b**, Topographical map of the Inner Precinct of Los Ajos. Countour intervals, 0.2 m. (Modified from Bracco¹⁹).

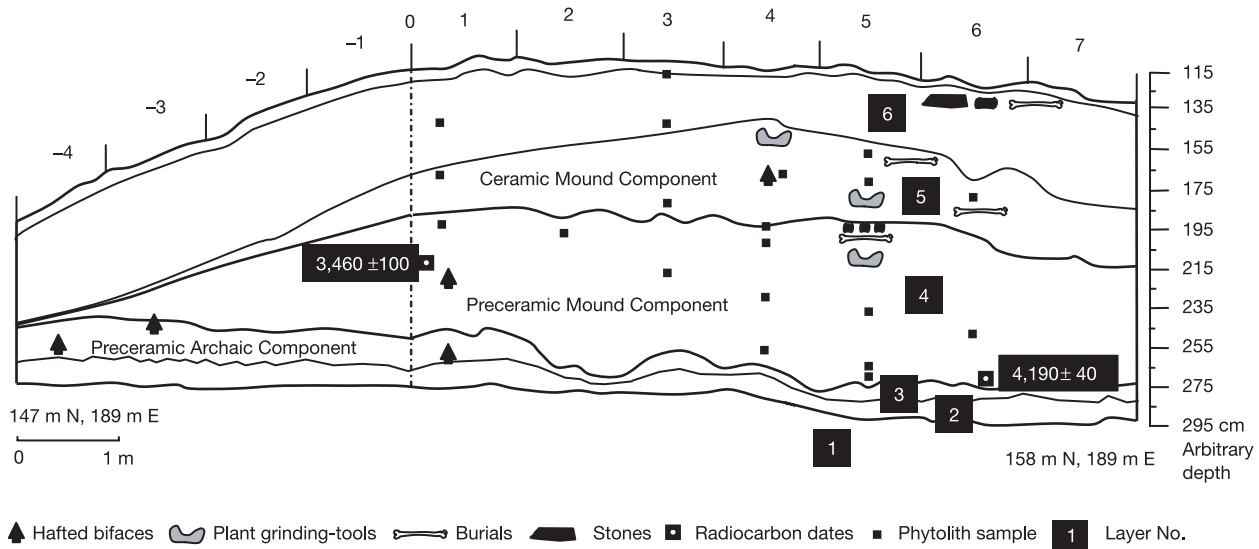


Figure 3 West wall stratigraphic sketch of Mound Gamma block excavation and part of trench. Vertical exaggeration $\times 2$.

During the following Ceramic Mound Period (CMP) occupation dated between $\sim 3,000$ and 500 ^{14}C yr BP¹⁷, Los Ajos experienced the formalization and spatial segregation of its mounded architecture. Mound Gamma's Layers 5 and 6 consist of a dark brown sediment bearing a medium to high concentration of gravel within a mottled silt loam matrix (Fig. 3) containing burned clay, charcoal and ash lenses. Capping episodes consisting of gravel loads remodelled Mound Gamma from the extant PMP 0.6–0.8 m high, circular, dome-shaped mound to a larger, quadrangular, 1.40 m tall, flat-topped, bevelled-edged platform mound. The presence of similar gravelly layers in Mound Alfa and Delta attest that the remodelling of mounds was a generalized practice at Los Ajos. The horseshoe arrangement of imposing platform mounds, the TBN and Mound 13 appear to represent an integrated architectural plan oriented to the north-east that contrasts with the less conspicuous and informally arranged southwestern sector, marking an asymmetrical distribution of architecture in the Inner Precinct.

Around 1,660 ^{14}C yr BP, the TBN and the TBS experienced substantial accumulation of occupational refuse attaining up to 0.80 m of anthropic deposits, and indicating a more intense and

permanent occupation of the site. Subsurface occupational refuse distributed over the vast peripheral off-mound areas covering over 12 ha suggest a large resident population for the site during the CMC. There is no evidence of major changes in the Los Ajos food economy during this period. Maize cob phytoliths and maize starch grains were recovered from two milling stone bases^{22,23} (Supplementary Fig. 3b, c) and continue to appear in the archaeological sediments (Supplementary Table 1) along with domesticated squash phytoliths. Maize leaf cross-shaped phytolith assemblages were detected^{26–28} in the central part of the TBN trench transect, showing that maize was planted and/or husked in this part of the site (Supplementary Table 2; Fig. 4f). The ceramic assemblage recovered at Los Ajos closely resembles the broadly defined Vieira tradition² dated to around 2,500 ^{14}C yr BP, which is widely distributed over southeastern Uruguay and the Brazilian state of Rio Grande do Sul.

The unexpected cultural sequence at Los Ajos reveals an early expression of social complexity not registered before now in this region of southern South America. Our data correspond with cultural developments recently documented during the mid- and late Holocene in Amazonia^{5–10}, the Atlantic coast of Brazil²⁹ and

Table 1 Preceramic Mound Component radiocarbon dates from southeastern Uruguay

Provenience (site)	Arbitrary depth (cm)	Laboratory number	Dated material	Conventional ^{14}C yr BP	2-Sigma cal. yr BP
Los Ajos					
TBN Trench					
Sector 7	160–165	Beta-158278	Charcoal (AMS)	1,050 \pm 40	1,050–920
Sector 6	190–195	Beta-158281	Charcoal (AMS)	1,660 \pm 40	1,690–1,660
Mound Delta	205–210	Beta-158277	Charcoal	2,960 \pm 120	3,400–2,740
Mound Gamma					
Sector 1/D	210–215	Beta-158279	Charcoal	3,460 \pm 100	3,980–3,470
Sector 6/C	270–275	Beta-158280	Charcoal (AMS)	4,190 \pm 40	4,840–4,580
Mound Alfa					
Layer III	280–285	URU 0052	Charcoal	3,350 \pm 90	3,830–3,380*
	285–290	URU 0033	Charcoal	3,870 \pm 280	5,030–5,010 and 4,990–3,550*
	295–300	URU 0034	Charcoal	3,690 \pm 270	4,830–3,370*
	340–345	URU 0089	Charcoal	3,950 \pm 80	4,580–4,160*
	345–355	URU 0088	Charcoal	3,750 \pm 140	4,520–4,470 and 4,450–3,710*
Puntas de San Luis					
Mound II					
Layer II		URU 009	Charcoal	3,550 \pm 60	3,980–3,680*
Layer III		URU 009	Charcoal	3,650 \pm 50	4,100–3,840*
Layer III		URU 010	Charcoal	3,730 \pm 100	4,410–3,830*
Isla Larga					
Mound I					
	260–270	URU013	Charcoal	3,660 \pm 120	4,380–3,670*
		URU014	Charcoal	3,630 \pm 60	4,100–3,820*
Potrerillo					
Mound I					
	Basal level	URU 083	Charcoal	3,790 \pm 90	4,420–3,900*
		URU 165	Charcoal	3,820 \pm 100	4,510–4,480 and 4,440–3,910*

* $^{13}\text{C}/^{12}\text{C}$ ratio estimated.

possibly the Pantanal³⁰, regions that along with the La Plata basin had previously been considered marginal^{1–4} when compared with the states and chiefdoms of the Andes and Mesoamerica. Our data also provide the first evidence of permanent village living in southeastern South America by people who subsisted on mixed economies and adopted major crop plants such as maize (*Zea mays* L.) and squash (*Cucurbita* spp.) long before previously thought^{1–4}. The palaeoecological data show that, as in other regions of the world²¹, the mid-Holocene was characterized by significant climatic and ecological changes, and that these perturbations were associated with important cultural transitions involving permanent mounded settlements situated within resource rich, circumscribed wetlands. The presence of at least four excavated mound complexes (Los Ajos, Puntas de San Luis, Isla Larga and Potrerillo (Fig. 1b)) with broadly contemporaneous PMP dates, suggests that southeastern Uruguay was a locus of early population concentration in lowland South America. The later CMP formal architectural plan of Los Ajos is earlier and sufficiently different from similar developments in Amazonia^{5–10} as to indicate an independent architectural tradition for the region. The results of this study will now allow for a broader consideration of the part that dynamic human–environment

interactions, imported cultivars and social conditions played in the emergence of early complex societies in the La Plata basin. □

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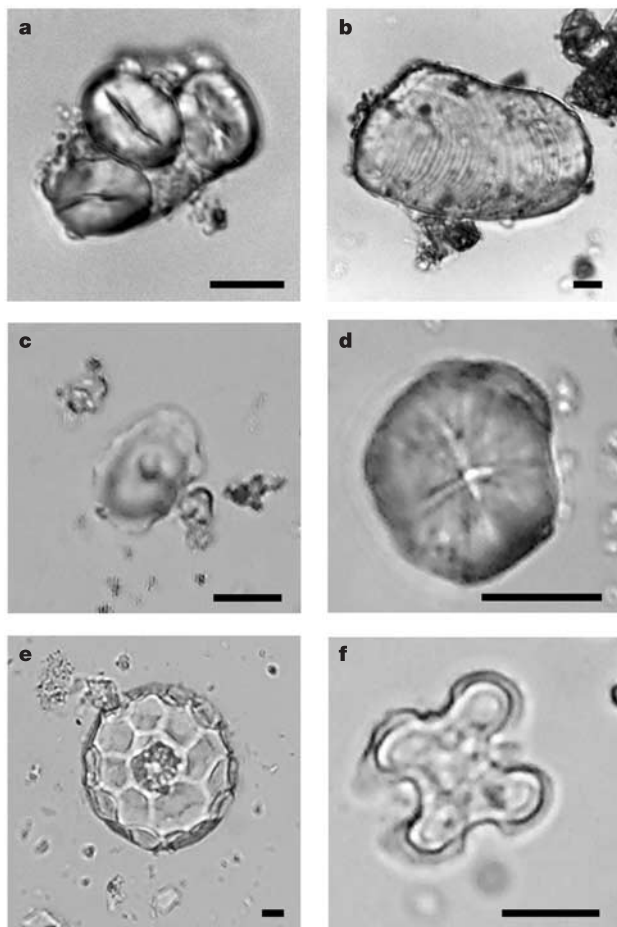


Figure 4 Selected phytoliths and starch grains. **a**, *Phaseolous* sp. starch grains (Los Indios, Mound III, 120–130 cm). **b**, *Canna* sp. starch grain (Isla Larga, Mound I, 275 cm deep). **c**, *Zea* sp. specific ruffle-top rondel phytolith (Los Ajos, Mound Gamma, 155–160 cm deep, sector 3/E). **d**, *Zea mays* starch grain (Los Ajos, Mound Gamma, 155–160 cm deep, sector 3/E). **e**, *Cucurbita* sp. spherical scalloped phytolith (Los Ajos, Mound Gamma 180–185 cm deep, sector 3/B). **f**, *Zea mays* large Variant 1 cross-shaped phytolith (Los Ajos, TBN, 170–175 cm deep, sector 7). Scale bar, 10 μ m.