Supporting Information

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SI Text

Macrobotanical Maize Remains. Seventeen cobs and one husk sample, recovered from units 20 and 22 at Paredones, Peru, are stratigraphically associated with the early part of the middle preceramic phase, ~6500–5500 calibrated years before the present (cal BP), and represent 4.51% of the total collection. Three cobs of the later part of the middle preceramic phase (~5500–5000 cal BP) were found in unit 25 at Huaca Prieta, Peru. Added together, the total number of corn remains recovered for the middle preceramic phase is 5.20% of the total collection. Twenty-two cobs were associated with the Cupisnique early ceramic period (~4000–3000 cal BP), which makes up 7.6% of the total. Proto-Confite Morocho is still predominant (45.4%) for this period, followed by Confite Chavinense (31.8%) and Proto-Alazan (22.7%). Seven cobs were associated with the subsequent Gallinazo ceramic period (~2800–2300 cal BP), which comprises 2.4% of the total. All of these specimens came from unit 1, an off-mound habitation area near Huaca Prieta. Proto-Confite Morocho predominated (57.1%) in this period, followed by Confite Chavinense (14.2%) and a hybrid of Proto-Confite Morocho and Confite Chavinense (28.5%). The corn remains excavated by J. Bird (1) from this period and studied by R. Bird (2) roughly correspond with our findings, although the latter did not define racial composition. The two cobs of the subsequent Moche period (~1500 cal BP) are 0.69% of the total and were found in domestic contexts of unit 30 at Paredones. There are 28 cobs of uncertain cultural placement from Bird's backdirt piles, which constitute 9.7% of the total collection.

The late preceramic period (~5000–4000 cal BP) is represented by a total of 201 cobs. Confite Chavinenese was the predominant race with a frequency of 50.7%, followed by Proto-Confite Morocho with 35.6%, and Proto-Kculli with 1%, and hybrids of Proto-Confite Chavinense and Proto-Confite Morocho constitute 10%. Proto-Kculli is the ancestor of the present-day highland race Kculli, which is characterized by purple cobs and cupule floors due to high-anthocyanine pigmentation. There is a predominating high frequency of cobs exhibiting the purple anthocyanine pigmentation in all primitive races of Peruvian archaeological corn. The high frequency of this pigmentation might be interpreted as an indicator of the early diffusion of maize from the highlands, where plants pigmented with purple or sun-red phenotypes have a selective advantage and have prevailed (3, 4). A more evolved race, Proto-Alazan (2.5%), which is similar to the present-day race of Alazan, appeared at the end of the late preceramic period (Fig. 3*C*). Corn of this race has not been found before in a preceramic context. The Proto-Alazan cobs are longer (~3.5 cm), less cylindrical, and have more rows (~12–14). Also excavated in a late preceramic context was a single corn kernel (Fig. 2*C*), which is equally 7 mm wide and long. It has a red pericap color and a flinty interior texture, as determined by a tiny drilled incision into the endosperm.

The chronology of 28 corn fragments could not be ascertained, except in one case, because 27 were screened from Junius Bird's backdirt piles of the 1940s. One specimen was from later ceramic contexts in an off-mound area near Huaca Prieta. These specimens and those excavated in units 3, 21, and HP-3 from the mound at Huaca Prieta constitute 87.5% of the total collection. The 34 samples of corn recovered from Paredones and unit 16 represent 12.5% of the total collection.

During the terminal preceramic period, the Proto-Alazan race appeared, which later became the ancestor of the floury-kerneled landraces Pagaladroga and Alazan (3). The appearance of Proto-Alazan, which alternatively could have been preceded by the Pagaladroga race, is also evidenced in the composition of the landraces from Paredones and Huaca Prieta.

Radiocarbon Dates on Corn Macro Remains. Several aspects of the radiocarbon dating are addressed below.

i) We have relied exclusively on radiocarbon dating to determine the time span of site use at Paredones, Huaca Prieta, and at unit 16. There are no temporally diagnostic artifacts from these sites other than cotton, etched gourds dating to at least 4500 cal BP (5) to establish an independent line of evidence for dating. Most significantly, the dates considered valid for the macrocorn remains from these sites conform to their expected chronological order corresponding to their stratigraphic position and to the few radiocarbon measures obtained by Bird (1) from his excavations in the 1940s and to more than 160 accelerator mass spectrometry (AMS) dates processed from our excavations (5). Conventional radiocarbon dates, along with 1 and 2 sigma error ranges for all of our corn dates and directly associated wood charcoal measures, are presented in Table 1.

ii) Table 1 shows several anomalous and stratigraphically inconsistent radiocarbon dates on uncharred cob remains from Huaca Prieta, Paredones, and from unit 16. (5) These dates range widely from ~1300 cal BP to recent postbomb years, despite their direct association with and stratigraphic bracketing by older valid dates on single chunks of wood charcoal and other macrocorn remains (i.e., husks, shanks, charred cobs).

iii) The macro remains from which the anomalous dates were derived were from intact, undisturbed cultural deposits, defined by hard floors and, in the case of Huaca Prieta, lying under 1.2–12 m of intact stone architectural structures. At Paredones, the maize remains are associated with hearths and other features also embedded in undisturbed floors at depths of 2.2–5.5 m (see Figs. S1 and S2). There is no taphonomic or stratigraphic evidence (e.g., pits, animal burrows, tree roots, postholes, truncated strata) to indicate intrusiveness of younger materials or postoccupation disturbance in any of these contexts. The two sites are located on a high terrace platform that is ~15 m above the floodplain of the valley and thus are not subject to alluvial deposition from flooding. Although there is always the possibility of sample contamination or error at any research stage, we do not have any specific grounds for questioning either the archaeological field or laboratory procedures, or the cleaning and dating procedures of the radiocarbon laboratories.

iv) The most complete stratigraphic sequence on dated macroremains is a series of AMS assays obtained from features in intact floors of unit 22 at Paredones (Fig. S1). A charred cob fragment from floor 6 at a depth of 1.2 m was dated at 4821–4527 cal BP (AA86934). An uncharred cob fragment from the fill directly below floor 10, at a depth of ~4.0 m, was dated at 133–34 cal BP (Beta263988). Dates on single chunks of wood charcoal from floor 10, floor 15, and floor 16 were processed at 5435–5044 cal BP (Beta263320), 5585–5325 cal BP (Beta263321), and 5711–5335 cal BP (AA86947), respectively, indicating that the 133–34 cal BP assay is incorrect. Furthermore, a corn specimen composed of the articulated cob, husk, and charred shank from floor 18 at a depth of 5.2 m in unit 22 yielded an acceptable date of 6775–6504 cal BP (OS86020) for the sample husk and charred shank and also the four young, anomalous dates on the same cob, including one postbomb date, suggesting that the harder, more durable (husk, shank) and charred plant parts yield more reliable measures than others.

v) With regard to the discrepancy just described between the 2 sigma age of 6775–6504 cal BP determined from a fragment of husk attached to its charred shank from floor 18, unit 22, at Paredones and the four aberrant dates thousands of years younger (including the postbomb age) determined from the cob attached to this same dated husk/shank, a younger carbon-bearing element must have penetrated the fossil cob structure and contaminated it. Contaminants can also have $\delta^{13}C$ readings that can mimic maize. Underlying these dates is a valid date of 6640–6319 cal BP (AA83260) on wood charcoal from floor 24, unit 22, at Paredones. In sum, the dates on wood charcoal, husk/shank, and charred cobs from unit 22 are in complete stratigraphic agreement, showing that the four anomalous assays on the one cob in floor 18 are in error. Maize phytoliths were also identified in strata 18 and 23 of unit TP-18 at Paredones. A single chunk of wood charcoal from stratum 23 in this unit dated to 5535–5297 cal BP (AA86959, $^{13}C=-23.5$; conventional age is 4740 ± 35 y BP).

vi) In unit 16, a small domestic site near Huaca Prieta, a cob fragment from stratum 3 at a depth of 90 cm, located below two intact preceramic stone architectural structures, was dated at 767–664 cal BP (Beta263319). This date is also anomalous. A partially charred cob recovered from stratum 28 (substratum 33) at a depth of 4.2 m in Bird's HP-3 trench on the mound at Huaca Prieta dated to 4149–3839 cal BP (Beta278050). A date on another charred cob fragment from floor 2 at a depth of 1.5 m in unit 15/21, also on the mound, was dated to 3956–3704 cal BP (AA86941). Both of these cob dates are valid and in agreement with directly associated wood charcoal. Wood charcoal from floor 3 just below floor 2 in unit 15/21 was dated at 3982–3728 cal BP (AA86931), which agrees with the above cob date. Another charred cob fragment from floor 9 at a depth of 2.8 m in unit 15/21 was assayed at 4235–3928 cal BP (AA86946), another stratigraphically valid date. Both cobs dated in unit 15/21 were recovered underneath intact floor and floor features.

vii) An unburned cob sample from floor 3 at a depth of 2.1 m in unit 3 assayed at 1052–809 cal BP (Beta233649). This date is anomalous, as indicated by a series of valid dates on wood charcoal specimens ranging from 3849 to 3636 cal BP (AA76977) for floor 2 above it to 4520–3643 cal BP (Beta247695) for the floors below it. The cobs with unacceptable dates might have been contaminated by mold, fungus, heavy salt saturation from the local seashore environment, or some other element that might have affected them. We performed limited SEM analyses of the microscopic cellular structure of a few unburned cobs, stalks, husk, and shanks, as well as of wood charcoal. Some fungal activity was identified in the cellular structure of two unburned cobs. No fungal activity was observed in the cells of wood charcoal and of husks, shanks, and stalks. With regard to possible contamination effects including from fungi, Darden Hood (Beta Analytic Inc., Miami, FL) in a personal communication to T. D. Dillehay in 2011 proposes some reasonable causes to consider: "...uncharred corn acts like a sponge and its integrity is too weak to withstand the pretreatments prior to removing organic contaminants. Thus, the radiocarbon (RC) pretreatments are dissolving the sample just as fast as contamination, resulting simply in reduction in sample size rather than de-contamination" and "...if the corn was being preferentially removed with the alkali, thereby increasing the concentration of the fungus, the date would come out younger with a higher fungus to corn ratio. As you go deeper, the corn is more weathered, and more susceptible to removal with the alkali...whereas the fungus is fresh-and-resistant." The husk sample from unit 20 at Paredones (AA86932) yielded a radiocarbon date in agreement with its stratigraphic position and also rendered an aberrant $\delta^{13}C$ assay, suggesting the presence of a contaminant. Regardless of our suspicions of what might have contaminated some maize cobs, the archaeological contexts of the deeply buried and culturally intact stratigraphic deposits, where all maize remains and acceptable maize and wood dates were recovered, take precedent over the unexplained younger cob dates.

viii) Certain conclusions can be drawn from the anomalous dates on the cob macroremains. There is no evidence of postdepositional disturbance at any of the three excavated sites. Thus, there is very little possibility that the younger dated samples are intrusive. All of the dates considered reliable are entirely coherent within the radiocarbon-dated stratigraphic sequences at Huaca Prieta and Paredones and with directly associated wood charcoal dates from the same feature and floor contexts yielding the maize remains. The most reliable dates are on maize husks and charred shanks and cobs, which have a more rigid, impenetrable plant structure. This suggests the possibility that the other, more porous tissues of uncharred cobs can absorb some contaminating substance that does not affect the harder tissues of the charred tissue and husks of the maize. Finally, to be clear, we are not implying that all uncarbonized maize remains yield anonymously young dates in all environmental contexts, but this appears to be the case in this region of Peru.

ix) Presented in Table 1 and in Dillehay et al. (5) are the majority of radiocarbon dates processed for Junius Bird by Libby's laboratory in the 1950s and for our project by the AMS laboratories at the University of Arizona, Beta Analytic Inc., and the Woods Hole Oceanographic Institute. More comparative research is needed to detail the precise contexts (e.g., features, floors, fills), dated materials (e.g., wood species), and stratigraphic relationships for all radiocarbon dates from Huaca Prieta, Paredones, Unit 16, and off-site geological areas.

Prismatic Stone Tool Used to Process Maize and Possibly Other Plants. The blade is atypical of the unifacial, edge-trimmed pebble tools that primarily characterized the stone tool technology at Huaca Prieta and Paredones and possibly represents a special type of blade technology developed to process plants. Approximately 4,500 lithic specimens were recovered from our excavations at Huaca Prieta and Paredones and another 15,000 or more were observed on the surface of these sites. The blade shown here and one other are the only ones recorded by our work in the area.

The worked lateral edges in Fig. S5 show minimum grain loss, randomly scattered striations, which are perpendicular, parallel and diagonal to the edge, and other linear features indicative of use. A few semibright-to-dull polish areas and streaks, with occasional micropitting, are visible on elevated surfaces, suggesting contact with a wet, soft-to-medium hard plant material, probably maize grains and cobs, given the recovery of corn starch grains from this worked edge (Fig. S4). This specimen also shows edge attrition, nicking, and small scalar fractures and half-moons, probably resulting from light-to-moderate contact with harder material, perhaps maize stalks. Most of these traits are reminiscent of the wear patterning seen on the edges of experimental tools used to cut, slice, and scrape fresh plants. The minimal use and wear and edge attrition suggest expedient use and discard of this tool.

1. Bird JB, Hyslop J, Skinner MD (1985) *Huaca Prieta: A Preceramic Site in Northern Peru* (Anthropological Papers of the American Museum of Natural History, New York).
2. Bird RM (1978) Archaeological maize from Peru. *Maize Genetics Coop News* 52:90–92.
3. Grobman A, Salhuana W, Sevilla R, Mangelsdorf PC (1961) *Races of Maize in Peru.* (National Academy of Sciences and National Research Council, Pub. 915, Washington, DC).
4. Grobman A (1982) Mays (Zea mays). *Precerámico Peruano, Los Gavilanes: Mar, Desierto y Oasis en la Historia del Hombre*, ed Bonavia D (Corp. Finan. Desarrollo S.A. COFIDE, Instituto Arqueológico Alemán, Lima, Peru), pp 157–180.
5. Dillehay TD, et al. (2012) Chronology, mound-building, and environment at Huaca Prieta, coastal Peru, from 13,700 to 4,000 years ago. *Antiquity*, in press.

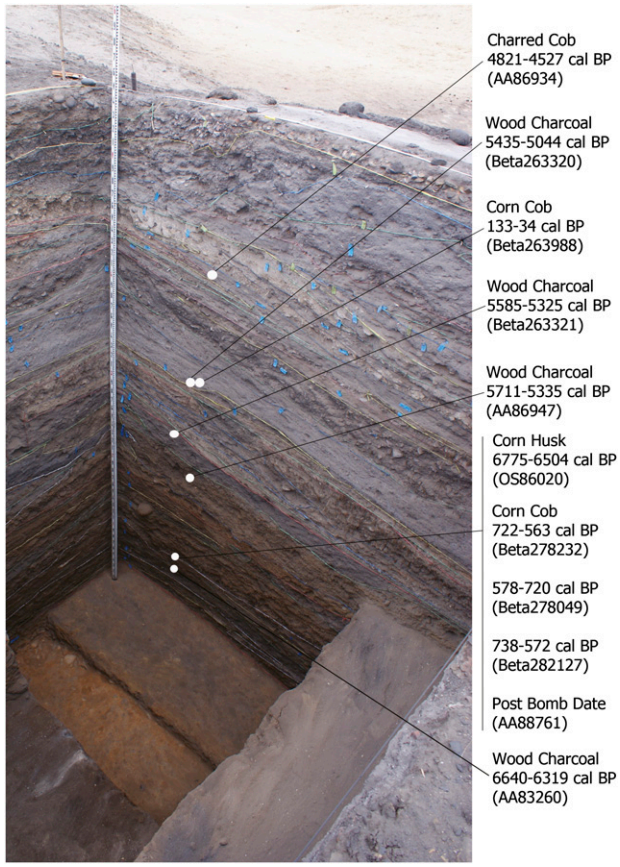

Fig. S1. Intact stratigraphy in unit 22 at Paredones showing stratigraphic location of radiocarbon dates on corn remains and wood charcoal.

Fig. S2. Corn cob of Proto-Confite Morocho embedded in floor 15, unit 22, Paredones.

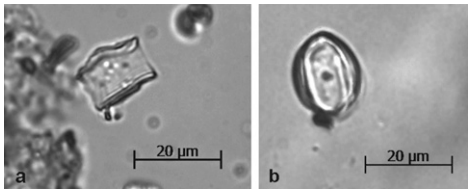

Fig. S3. Characteristic phytoliths of corn from Paredones. (*A*) Top view of *Zea mays* cob wavy-top rondel (Paredones, TP-18, Capa 13). (*B*) Side view of the *Z. mays* cob wavy-top rondel shown in A.

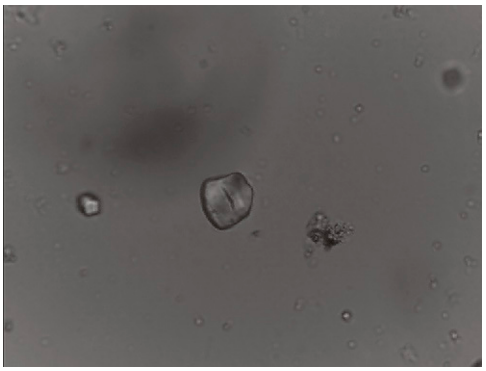

Fig. S4. Characteristic starch grain of maize from the stone tool shown in Fig. S5 from floor 18, unit 22, at Paredones. The grain is 20 μm long by wide.

Fig. S5. Prismatic blade of andesite floor 18, unit 22, at Paredones used to process corn plants.

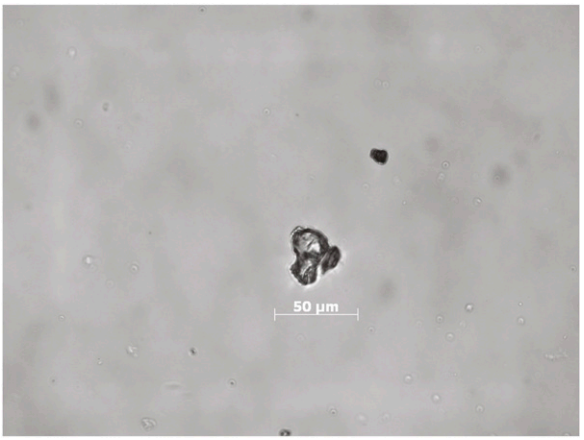

Fig. S6. Starch grains recovered from the maize kernel (Fig. 2C).

Table S1. Frequency by cultural periods of Peruvian maize races recovered from the Paredones and Huaca Prieta sites

	Middle preceramic		Late preceramic		Cupisnique		Gallinazo	
Races and hybrid interacials*	Complete cobs	Incomplete cobs	Complete cobs	Incomplete cobs	Complete cobs	Incomplete cobs	Complete cobs	Incomplete cobs
Proto-Confite Morocho	2	8	5	66		10		4
Confite Chavinense		5	12	89	1	6		1
Proto-Kculli			1	1				
Proto-Confite Morocho/Confite Chavinense		2	3	17				2
Proto-Alazan			2	3		5		
Total	2	15	23	176	1	21		7

*Forty-three unidentifiable fragments and two Moche cobs are not included.

Table S2. Morphological traits of the various early races of maize at Paredones and Huaca Prieta in the middle preceramic phase

Races and interracial hybrids	No. of complete cobs	No. of incomplete cobs	Length of cob (cm)	Diameter of cob (cm)	Diameter of the pith (cm)	Index c/p (cob/pith)	No. of rows	Pl (color purple) (%)	Index l/w cupules (length/width)	% of fasciation of cob	Corneous glume (%)	Hairs (%)
Proto-Confite Morocho	2	8	4.7	1.025	0.35	2.928	8.2	—	0.913	0	20	—
Confite Chavinense	—	5	—	1.3	—	—	8.66	60	1.111	80	40	20
Proto-Confite Morocho/Confite Chavinense	—	2	—	1.25	0.25	5	12	50	0.666	50	50	—
Arithmetic average	—	—	4.7	1.191	0.3	3.964	9.62	55	0.896	43.3	36.666	20
Total	2	15	—	—	—	—	—	—	—	—	—	—

Table S3. Morphological traits of the various early races of maize at Paredones and Huaca Prieta in the late preceramic phase

Races and interracial hybrids	No. of complete cobs	No. of incomplete cobs	Length of cob (cm)	Diameter of cob (cm)	Diameter of the pith (cm)	Index c/p (cob/pith)	No. of complete cobs	Frequency of colors of cobs (%)		Index l/w cupules (length/width)	% of fasciation of cob	Glume (%)			Hairs (%)
								Pl (purple)	Pl/R (purple/red)			Corneous	Membranous smooth	Corneous/ membranous smooth	
Proto-Confite Morocho	5	66	2.5–6.2	1.126	0.307	3.667	8.656	54.92	—	0.758	8.45	15.492	5.633	8.45	11.267
Confite Chavinense	12	89	3.608	1.491	0.322	4.63	12.305	54.455	1.98	0.764	26.732	20.792	4.95	13.861	3.96
Proto-Kculli	1	1	2.1	1.2	—	—	10	100	—	—	50	—	—	—	—
Proto-Alazán	2	3	3.45	2.32	0.366	6.338	14.8	60	—	—	—	—	—	20	—
Proto-Confite Morocho/Confite Chavinense	3	17	4.266	1.42	0.386	3.678	10.947	45	—	0.812	40	10	5	5	5
Average	—	—	3.748	1.511	0.345	4.578	11.341	62.875	1.98	0.778	31.295	15.428	5.194	11.827	6.742
Total	23	176													

Table S4. Morphological traits of the various early races of maize at Paredones and Huaca Prieta in the Cupisnique phase

Races and interracial hybrids	No. of complete cobs	No. of nearly complete cobs	No. of incomplete cobs	Length of cob (cm)		Diameter of cob (cm)	Diameter of pith (cm)	Index c/p (cob/pith)	No. of rows	Pl (color purple) (%)	% of fasciation of cob	Corneous glume (%)	Membranous glume (%)	Corneous and membranous glume (%)	Hairs (%)
				Complete	Nearly complete										
Proto-Confite Morocho	—	—	10	—	—	1.3	0.266	4.88	8.2	50	10	10	—	40	30
Confite Chavinense	1	1	5	4.3	3.4	1.971	0.3	6.57	13.33	28.57	42.85	—	—	42.85	—
Proto-Alazan	—	2	3	—	7.1	1.9	0.333	5.7	12	40	40	40	20	—	—
Average	—	—	—	4.3	5.25	1.723	0.299	5.716	11.176	39.523	30.95	25	20	41.425	30
Total	1	3	18												

Table S5. Morphological traits of the various early races of maize at Paredones and Huaca Prieta in the Gallinazo phase

Races and interracial hybrids	No. of incomplete cobs	Diameter of cob (cm)	Diameter of pith (cm)	Index c/p (cob/pith)	No. of rows	Pl (color purple) (%)	% of fasciation of cob	Corneous glume (%)	Membranous glume (%)	Corneous and membranous glume (%)	Hairs (%)
Proto-Confite Morocho	4	1.025	0.233	4.399	8	50	—	—	25	25	25
Confite Chavinense	1	1.3	—	—	14	—	—	100	—	—	—
Proto-Confite Morocho/Confite Chavinense	2	1.35	0.35	3.857	10	100	100	100	—	—	50
Average	—	1.225	0.291	4.123	10.666	75	100	100	25	25	37.5
Total	7										