

on comparative human development could help provide the groundwork for such a foundation, and at the same time weigh the impact of various environmental-development interaction systems in the transmission of culture to and through the human organism.

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Preceramic Maize in Central Panama: Phytolith and Pollen Evidence

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The cultivation of maize in its presumed genetic heartland, Mexico, is at least 7,000 years old (Beadle 1977; Mangelsdorf, MacNeish, and Galinat 1967) and probably older (Beadle 1980). In northern South America its arrival is

thought to have occurred as early as 5000 B.C. (Lathrap 1975; Pearsall 1977-78; Piperno 1985), and more conservatively by 2500 B.C. (Bird 1982). In lower Central America, the obligate overland dispersal route, however, there is no macrobotanical evidence for the presence of maize before the last half of the 1st millennium B.C. (Cooke 1984; Galinat 1980; Linares, Sheets, and Rosenthal 1975; Snarskis 1984). In fact, the available data suggest not only that maize farming was a late introduction in this region, but that its apparently sudden appearance was related to (1) population increase and nucleation, (2) sedentary villages, (3) the colonization of pluvial and montane forests, and (4) widespread environmental degradation. A similar pattern of interactions has been proposed for the Orinoco (Roosevelt 1980).

Despite the available archeological data, some botanists have reasonably argued that *Zea mays* should be present in lower Central American sites long before 500 B.C. (Galinat 1980; Pickersgill and Heiser 1977). Even if a late date of 2500 B.C. is taken as the *terminus post quem* for maize in northern South America, its cultivation in Central America must have been at least as early as this date. Yet, even though fine screening and water separation techniques have yielded large samples of carbonized plant remains from pre-1st-millennium B.C. deposits in Panama, none of the plant remains have been identified as maize (Smith 1980; Ranere and Hansell 1978).

Archeologists working in the humid tropics are coming to realize that the presence of early maize is not going to be documented merely by applying increasingly careful recovery techniques for carbonized macrofossils. Neither is its presence to be inferred only when manos and metates are included in the stone tool inventory. If, during the early stages of its cultivation, maize was not a staple, but rather one of several minor crops grown in a more generalized food producing economy, the absence of manos, metates, and carbonized materials in the archeological record becomes less enigmatic (Piperno 1983; Ranere 1980). Phytolith and

pollen data from two rock shelters in central Pacific Panama indicate that indeed maize is older here than 500 B.C. It may well have been brought under cultivation by early in the 5th millennium B.C.

The Aguadulce shelter (henceforth, Aguadulce) was excavated by author A. J. R. and R. McCarty in 1973 and 1975 (Ranere and Hansell 1978). It is a small (16 × 4 m) overhang located on the coastal plain at 40 m above sea level, 17 km from the present-day shoreline of Parita Bay. The Cueva de los Ladrones (henceforth, Ladrones) is a much larger shelter, having a dry floor space of about 30 × 12 m. It was excavated in 1974 by Junius B. Bird and author R. G. C. (Bird and Cooke 1978). It is located on the southern slopes of Cerro Guacamayo, a Pliocene volcano at about 300 m above sea level, and at the seaward edge of the foothills of the Cordillera Central. Today it is about 25 km from the coast.

At both sites, preceramic deposits are overlain by layers that contain ceramics. Most of these are classifiable as 2nd- and 3rd-millennium B.C. Monagrillo types, originally described at the Monagrillo shell mound (Bird and Cooke 1978; Wille and McGimsey 1954). The uppermost layers do contain, however, some sherds typical of Period IV of the Central Region Sequence (300 B.C.-A.D. 500; Cooke 1984) and of very late pre-Columbian or historic times (Bird and Cooke 1978). (See Figure 1 for the quantity and position of post-Monagrillo sherds at Ladrones.)

At Aguadulce, where floor deposits are shallower than 50 cm, eight radiocarbon dates (all but one on shell) range from 3890 ± 95 B.C. to 590 ± 70 B.C. A shell date of 1680 ± 95 B.C. marks the end of the preceramic occupation. Although isotopic fraction corrections are not available for the Aguadulce shell samples, 13C/12C ratios for recently submitted shell (*Crassostrea* sp. and *Protothaca* sp.) from three sites in the region (Monagrillo, Cerro Mangote, and La Mula-Sarigua) indicate that the radiocarbon ages for all shell are 400 years too young. Consequently, the excavator (A.J.R.) places the

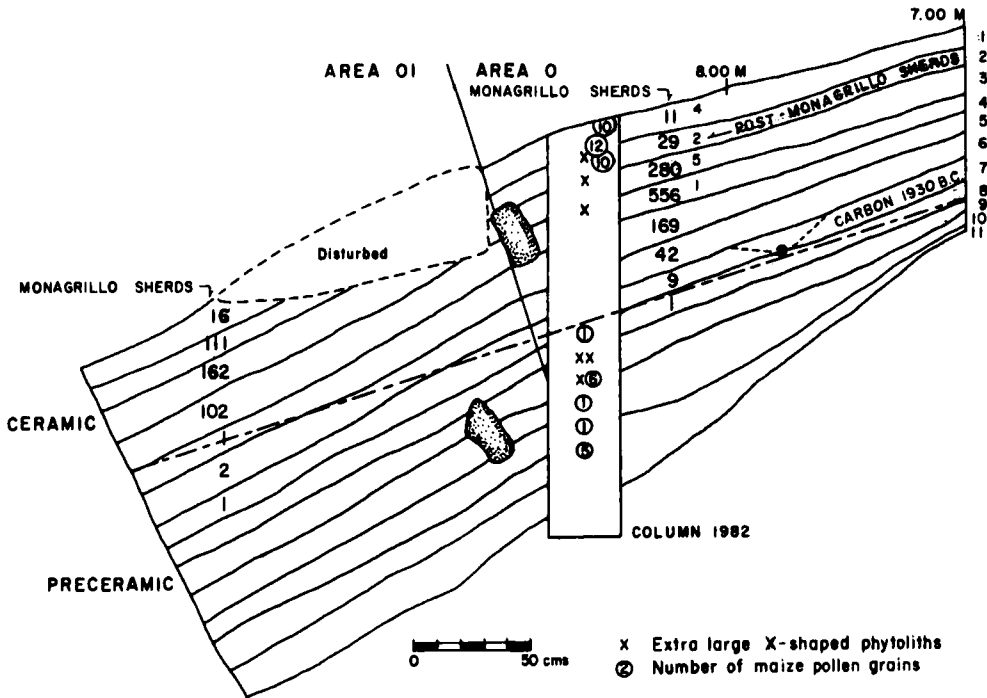


Figure 1
Cueva de los Ladrones: Location of maize pollen and phytoliths.

preceramic/ceramic boundary at Agua-dulce late in the 3rd millennium B.C.

At Ladrones, floor deposits underneath the overhang are only 10–25 cm deep. On the talus, however, the depth of the midden exceeds 140 cm, two thirds of which is preceramic. There is one date for the preceramic (4910 ± 90 B.C.), and five for contexts that contain only Monagrillo sherds (range: 2850 ± 100 B.C. to 1820 ± 80 B.C.). The excavator (R.G.C.) therefore believes that the ceramic period occupation had begun at Ladrones by the beginning of the 3rd millennium B.C. At the Monagrillo shell mound, Monagrillo ceramics are radiocarbon-dated from 2500 B.C. to 1200 B.C. (Ranere and Hansell 1978). It is clear, then, that simple ceramics were being manufactured in central Panama by the middle of the 3rd millennium B.C.

The soil samples from Ladrones used for phytolith and pollen analysis were recovered by A. J. R. and R. G. C. in 1981 and 1982 as two 30 × 30 cm columns taken at 8.44 m southwest along Bird and

Cooke's original baseline (see Bird and Cooke 1978; Fig. 3). In Figure 1, we have plotted the division between the preceramic and ceramic levels. The ten small Monagrillo sherds recovered from layers 7 and 8 were all found near the 7-m mark. In the columns, these two layers were devoid of sherds. The 1920 B.C. carbon date, shown in the figure as being just above the ceramic/preceramic boundary, was recovered at the base of a small depression whose edges could not be discerned. Its correct stratigraphic position is probably higher than its recorded depth.

The phytoliths extracted from the columns have been analyzed by author D. P. Grass phytoliths were identified by reference to Pearsall's (1978) criteria for cross-shaped phytolith size, and to Piperno's newly established criteria for cross-shaped three-dimensional structure. Cross-shaped phytoliths are limited in occurrence to the Panicoid subfamily of grasses, of which maize is a member, and bamboos, and they occur much more fre-

quently in maize than in wild grasses (Pearsall 1978; Piperno 1984). The cross-shaped type was studied in the following groups of modern grasses: 20 races of maize, 4 races of annual teosinte, the presumed wild ancestor of maize (Beadle 1977), and 40 species of wild Panicoid and Bambusoid grasses from Panama. The results of the size comparisons, using Pearsall's criteria, indicated that two of the wild grasses, *Oplismenus hirtellus* and an unidentified bamboo (Bambusoid grass No. 1), have cross-shaped phytoliths as large as those from maize (Table 1). However, these grasses (as well as many others, including Guatemala, Balsas, and Nobogame teosinte) have cross-shaped phytoliths with three-dimensional structures that are quite different from those found in maize.

A total of eight different cross-shaped three-dimensional forms, which we have termed Variants, were isolated from the grasses (Table 1). Maize was characterized by high numbers of Variant 1 cross-shapes, in which both sides of the phytolith are cross-shaped in structure. Wild grasses, in contrast, generally have high numbers of Variant 2 cross-shapes, which have one tent-shaped side, and/or Variant 6 cross-shapes, which have one trapezoidal/rectangular-shaped side. None of the wild grasses studied had the combination of high percentages of large cross-shaped phytoliths and cross-shaped three-dimensional proportions found in maize. Furthermore, no extra-large Variant 1 cross-shaped phytoliths occurred in wild grasses, and large Variant 1 types occurred rarely. In maize, all of the extra-large and many of the large-sized cross-shapes were Variant 1 in three-dimensional structure. Therefore, when cross-shaped phytolith size and three-dimensional criteria are applied in combination, maize phytoliths can be clearly distinguished from those of other grasses in archeological soils from Panama.

Both the phytolith and pollen data from Ladronez indicate that maize was being cultivated in the foothills of Central Panama from the early 5th millennium B.C. onward. In column samples from the preceramic and ceramic levels, both

size ratios and three-dimensional proportions of cross-shaped phytoliths indicate the presence of maize (Table 2). The phytolith spectra contained extra-large Variant 1 cross-shapes, which have not been found in wild grasses, and high numbers of large Variant 1 cross-shapes, which occur rarely in wild grasses. They were present from the lowest to the uppermost levels of the deposits, making the phytolith pattern throughout entirely consistent with the presence of maize (Figure 1).

Maize pollen was likewise recovered from the bottom to the top of the columns. Thirty-two well-preserved maize pollen grains were recovered by author K. C. from the ceramic levels. Their diameters averaged 89 microns (range: 80–100 microns). Fourteen complete maize pollen grains were recovered from preceramic layers. These are noticeably more weathered, torn, and fragmented than the ceramic-period grains. Their diameters averaged 83 microns (range: 63—from a folded grain—to 108 microns). Many of the grains were crumpled or folded to some extent: their diameters were measured from the longest, least folded dimension. Fully expanded, they would be larger. Contemporary maize pollen from Central America generally ranges in size from about 80 to 120 microns (Barghoorn, Wolfe, and Clisby 1954). Under phase microscopy, the spinules of the fossil exines are located regularly, as in maize.

Teosinte alone among wild grasses has pollen whose size overlaps some of the archeological grains. The average size of teosinte pollen is from about 65 to 86 microns, with an upper extreme of 102 microns (Barghoorn, Wolfe, and Clisby 1954; Wilkes 1967). Not only is one of the preceramic grains larger than the upper extreme of teosinte, but there is also no evidence that teosinte ever grew south of Mesoamerica. Moreover, the cross-shaped phytolith sizes and three-dimensional proportions rule out the presence of four races of teosinte: Balsas, Nobogame, Chalco, and Guatemala. The preceramic and ceramic pollen grains, therefore, are those of maize.

Table 1
Examples of cross-shaped phytolith size and three-dimensional morphology in modern maize and wild grasses (from Piperno 1984).

Grass	Cross-shaped phytolith size				Three-dimensional morphology								
	Sm.	Med.	Lg.	n	Variant								n
					1	2	3	4	5	6	7	8	
<i>Zea mays</i> L. (Nal-tel)	17 34%	26 52%	7 14%*	50	25	17	-	-	-	8	-	-	50
<i>Zea mays</i> L. (Chapalote)	10 20%	38 76%	2 4%	50	33	8	-	-	-	8	1	-	50
<i>Zea mays</i> L. (Palomero Toluqueno)	7 35%	12 60%	1 5%	20	14	3	-	-	-	3	-	-	20
<i>Zea Mays</i> L. (Jalisco)	2 7%	22 73%	6 20%	30	16	4	-	-	-	7	3	-	30
<i>Zea Mays</i> L. (Maiz Dulce)	2 7%	18 60%	10 33%	30	21	5	-	-	-	4	-	-	30
<i>Zea mays</i> L. (Pardo)	1 3%	28 94%	1 3%	30	23	-	-	-	-	6	1	-	30
<i>Zea mexicana</i> (Race Balsas)	22 55%	18 45%	0 0%	40	6	29	-	-	-	5	-	-	40
<i>Zea mexicana</i> (Race Chalco)	9 23%	31 77%	0 0%	40	30	3	-	-	-	2	-	5	40
<i>Zea mexicana</i> (Race Nobo- game)	12 30%	23 58%	5 12%	40	14	16	-	-	-	10	-	-	40
<i>Zea mexicana</i> (Race Guatemala)	13 44%	16 53%	1 3%	30	-	13	-	-	-	17	-	-	30
<i>Andropogon</i> sp.	87 65%	37 28%	9 7%	133	45	3	-	-	-	2	-	-	50
<i>Axonopus compressus</i>	36	14	0	50	41	5	-	-	1	2	1	-	50
Bambusoid Grass #1	2 4%	33 66%	15 30%*	50	-	-	50	-	-	-	-	-	50
<i>Cenchrus echinatus</i>	19 23%	55 68%	7 9%	81	4	9	-	-	6	11	-	-	30
<i>Cenchrus pilosus</i>	26 58%	17 38%	2 4%	45	2	17	-	-	-	25	1	-	45
<i>Hymenache amplexicaulis</i>	23 46%	26 52%	1 2%	50	47	3	-	-	-	-	-	-	50
<i>Olyra latifolia</i>	35 62%	21 38%	0 0%	56	-	-	-	-	-	-	-	40	40
<i>Optismenus hirtellus</i>	3 15%	8 40%	9 45%*	20	-	-	-	-	-	20	-	-	20
<i>Paspalum virgatum</i>	26 60%	17 40%	0 0%	43	17	2	-	-	-	1	-	-	20
<i>Pennisetum setosum</i>	7 18%	31 77%	2 5%	40	9	6	-	-	-	25	-	-	40
<i>Setaria</i> sp.	84 67%	40 31%	2 2%	126	11	14	-	-	-	25	-	-	50
<i>Tripsacum dactyloides</i>	7 35%	13 64%	0 0%	20	1	2	-	-	-	17	-	-	20
<i>Tripsacum lanceolatum</i>	15 37%	24 60%	1 3%	40	-	7	-	-	3	30	-	-	40

The cross-shaped phytolith sizes and three-dimensional morphologies listed here are typical for the modern maize and wild grasses studied by Piperno (1984) (a total of 44 wild species and 20 races of maize). No wild grass not included in Table 1 had more than 9% large-sized cross-shaped phytoliths or had extra-large cross-shaped phytoliths.

*1 extra-large

Because both maize phytoliths and pollen occur deep within the preceramic deposits, we conclude that maize may well have been grown from the initial occupation of Ladrões, whose earliest date is 4910 B.C.

In the Aguadulce soils, maize phytoliths were found in the layers that contained ceramics. They were not present in the preceramic layers. The preceramic layers contained very few cross-shaped phytoliths, and they were smaller in size than those in ceramic layers (Table 2). Because of the difficulty of locating cross-shaped phytoliths in preceramic contexts, three-dimensional morphologies were not determined. The phytolith evidence suggests that maize was grown during the Monagrillo-phase occupation of Aguadulce (ca. 2500 to 1000 B.C.), but not during the preceramic occupation.

Pollen results from Aguadulce were uninformative regarding the presence of maize. Pollen preservation was very poor in the preceramic levels, and maize pollen did not occur in the ceramic levels.

Bearing in mind that Ladrões and Aguadulce are only 50 km from each other, the presence of maize in the preceramic deposits of the former and its absence at the latter until the advent of ce-

ramics invites explanation. We believe that Ladrões was a more logical location for an early horticultural settlement than Aguadulce for the following reasons: (1) it is a more attractive dwelling than Aguadulce, providing shelter for perhaps 30 people (based on a figure of 1 person per 10 m²), and is well protected from the strong dry-season winds; (2) although annual precipitation at Ladrões is probably only 300–500 mm more than at Aguadulce, there is less chance of damaging droughts because of the greater reliability of growing season rain; and (3) the pristine vegetation near Ladrões would have been easier to fell and burn than that at Aguadulce, which is located in the swampy plains and was probably surrounded by woods with larger trees. The earliest horticulturalists in Panama, therefore, may have found it more practical to cultivate the hill slopes rather than the alluvial bottoms, and only moved permanently into the latter as productivity declined in areas with thinner soils, perhaps as a result of shorter fallowing due to demographic pressures.

The discovery of preceramic maize from Panama supports the hypotheses of an early movement of primitive races of maize from their home in Mesoamerica to

Table 2
Phytolith results from the archeological sites (from Piperno 1984).

	Cross-shaped phytolith size				Three-dimensional morphology								
	Sm.	Med.	Lg.	n	Variant								
					1	2	3	4	5	6	7	8	n
<i>Cueva de los Ladrões</i>													
Monagrillo ceramic samples	36	48	11	95	61	3	-	-	-	30	-	1	95
	37%	51%	12% ^a										
Preceramic samples	81	107	29	217	148	8	-	-	-	48	4	2	210
	37%	49%	13% ^b										
<i>Aguadulce</i>													
Monagrillo ceramic samples	22	18	13	53	40	-	-	-	-	9	1	-	50
	41%	34%	25% ^c										
Preceramic samples	17	11	2	30					Not determined				
	56%	37%	7%										

^a1 extra-large

^b3 extra-large

^c2 extra-large

South America (Galinat 1980; Lathrap 1975; Pickersgill and Heiser 1977; Pearsall 1977-78). It indicates that seed cropping patterns may have been established in the Pacific watershed of lower Central America by the 5th millennium B.C. It is in this context of an early seed culture manifestation that the discrepancy between carbonized macrofossil and phytolith/pollen evidence can be explained. The absence of maize macrofossils before the 1st millennium B.C. probably reflects some or all of the following factors: the instability of primitive races under heat, as the glumes of early varieties may have been too soft to easily carbonize; differences in preparation methods and consumption; and the fact that maize may not have been a very important or widely used crop. We are reminded that at the Koster site in North America only 27 mg of 7,000-year-old squash (*Cucurbita*) was recovered out of 516 g of carbonized material (Conard et al. 1984), adequate testimony to the meager evidence left behind by primitive and incidentally used crop plants.

Finally, the presence from 5000 to 1000 B.C. of small and probably seasonally shifting settlements in central Panama (Cooke and Ranere 1984; Weiland 1984), plus the absence of carbonized maize remains, manos and metates, indeed indicate that for several millennia before it became dominant in the agricultural system, maize was a relatively minor crop.

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Running and Menstrual Dysfunction: Recent Medical Discoveries Provide New Insights into the Human Division of Labor by Sex

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In an earlier paper in *American Anthropologist*, van den Berghe and Barash (1977) argued that typical mammalian biological characteristics were sufficient to account for the human division of labor by sex. In a response to van den Berghe and Barash, I argued (Graham 1979) that some specifically human characteristics, in addition to general mammalian characteristics, were necessary to account for this division of labor. The specific characteristic offered in that response was the sexual difference in human pelvic