AT THE CROSSROADS: STARCH GRAIN AND PHYTOLITH ANALYSES IN LUCAYAN PREHISTORY

Mary Jane Berman and Deborah M. Pearsall

Starch and phytolith analyses of an assemblage of chert microliths from the Three Dog site, an early Lucayan settlement on San Salvador, Bahamas, yielded Zea mays, Capsicum, *and possible manioc indicating that these domesticates were present by at least A.D. 800 or earlier in Cuba or Hispaniola and brought to the central Bahamas during its early peopling. The presence of corn at this site contradicts previously held ideas that it did not appear in the Bahamas until the A.D. 1200s. Starch granules tentatively identified as root/tuber starch were also found on the microliths, although we were unable to discern if these represent wild species and/or culturally transported wild or domesticated species. The presence of more than one species on the microliths, initially believed to have been manioc grater chips similar to those documented ethnographically, demonstrates multifunctional use. A broad-based plant diet that included maize and root/tuber crops was in place at least by the Archaic age in parts of the Greater Antilles and brought to the Bahamas, along with chilis, during its colonization by Ceramic age peoples.*

El análisis de almidón y fitolitos realizado en un conjunto de microlítos de chert procedentes del sitio lucayo temprano de Three Dog, San Salvador, Bahamas evidencia restos de Zea mays, Capsicum, *y una posible célula secretora de yuca, indicando su presencia ya domesticada en Cuba o La Hispaniola desde el 800 d.C. o antes; y que fueron transportados al centro de las Bahamas durante su poblamiento temprano. La presencia de maíz contradice ideas previas de que su aparición en Bahamas no sucede hasta el 1200 d.C. Evidencia provisional de granos de almidón—quizás raíz o tubérculo—también fue encontrada en los microlitos. Desafortunadamente no es posible discernir si representan especies salvajes endémicas y/o salvajes o domesticadas transportadas culturalmente. La presencia de más de una especie en estas microlascas tradicionalmente asociadas a ralladores a rayadores de yuca, demuestra su uso multifuncional. Una dieta en base al uso vegetales más amplia que incluye el maíz y raíces/tubérculos ya se encontraba en el Arcaico en partes de las Antillas Mayores y llegó a Bahamas, junto con los pimientos con la colonización efectuadas por poblaciones en momentos cerámicos.*

The importation of objects, plants, and animals; the transference of routinized daily practices (*sensu* Bourdieu 1977); and the application of traditional knowledge help to assure the continuity of experiences that bridge the known with the unknown, reducing the uncertainty that moving to a new land brings. The re-creation of homeland environments through the propagation of familiar biota in new habitats is one means by which people attempt to produce predictability, insure comfort, and provide a preferred diet in their new surroundings. The transfer of plants and animals is known as "transported" landscapes, a notion developed by Edgar Anderson (1967) to describe the flora and fauna that migrating people introduce intentionally and accidentally when they settle new areas. Crosby (1986:89) used the term "portmanteau biota" to describe the plants, animals, and organisms that accompanied European colonization of the Americas; these helped to create what he called "versions of Europe." The concept of the "transported landscape" and that of "portmanteau biota" have been applied to the peopling of the Pacific where, according to Kirch (2000:109), the Lapita "transported and established the biotic and cultural components necessary to recreate in each new island precisely the kind of managed landscape they had left behind."

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In this study we extend the model to the central Bahamas, as part of our long-term investigations of how its early colonizers transferred cultural practices, including plant knowledge, food preparation techniques, and cuisine, from ancestral homelands in northern Cuba and/or northern Hispaniola (Berman and Gnivecki 1995; Keegan 1992) and applied them to new settings. The Bahamas is an ideal area to explore these questions because there are numerous environmental dissimilarities between the Bahamas archipelago and Cuba and Hispaniola that would have posed significant challenges to the colonization and management of a new physical and biotic landscape (Berman et al. 1999; Newsom and Wing 2004). These differences include the lack of naturally occurring freshwater sources such as springs, streams, or rivers; less annual rainfall; a carbonate geological environment; little topographic relief; inadequately developed, nutritionally deficient carbonate soils; small island size; depauperate terrestrial fauna; and the absence of naturally occurring high-quality lithic materials (Sealey 1994). This contrasts with the varied and complex geology and environment of Cuba and Hispaniola and makes the current potential productivity of the Bahamas poorer (Newsom and Wing 2004:172), which we suspect was the case prehistorically. Because the paleoethnobotanical and zooarchaeological records of Cuba and Hispaniola are insufficiently known, research in the Bahamas can also help us infer which resources must have been present and exploited by the prehistoric inhabitants of these larger islands during this period. Furthermore, the picture of plant introductions is vaguely known for the Bahamas because macrobotanical and microbotanical remains have failed, prior to the research reported here, to yield unequivocal evidence of domesticated plants (Berman and Pearsall 2000). Through the study of artifacts, paleoethnobotanical, and zooarchaeological remains (Berman et al. 1999; Berman 1992, 1994; Berman and Pearsall 2000), we are researching the ways in which the people who established permanent settlements in the central Bahamas applied environmental and technological knowledge and social and cultural practices (Bourdieu 1977) from their homelands to construct familiar natural (i.e., biological) and cultural environments. We are also examining how, in attempting to reproduce the lifeways of the motherland, prehistoric occupants created technological innovations designed to respond to their new physical, biological, and social contexts (Berman 2005; Hoffman 1970). Finally, we hope to contribute to a growing body of knowledge constituting island archaeology (e.g., Broodbank 2000; Fitzpatrick 2004).

By the time of European contact, the people of the Antilles cultivated plants that included root and tuber, seed, and fruit and vegetable domesticates whose origins lay in Mexico, Central America, and South America (Cooke and Piperno 1993; Newsom 1993; Newsom and Pearsall 2003; Newsom and Wing 2004; Sauer 1966; Sturtevant 1969). These plants consisted of manioc (*Manihot esculenta*), sweet potatoes (*Ipomoea batatas*), yautía (*Xanthosoma* sp.), arrowroot (*Maranta arundinacea*), llerén (*Calathea allouia*), corn (*Zea mays*), varieties of peppers (*Capsicum* spp.), avocado (*Persea americana*), guava (*Psidium guajava*), papaya (*Carica papaya*), soursop (*Annona* spp.), jack bean (*Canavalia* sp.), peanut (*Arachis hypogaea*), squash (*Cucurbita* spp.), pineapple (*Ananas comosus*), and common and lima beans (*Phaseolus vulgaria, P. lunatus*). Most of these plants have been recovered archaeologically (Newsom 1993, 2008; Pagán Jiménez et al. 2005; Pagán Jiménez and Oliver 2008; Rodríguez Suárez and Pagán Jiménez 2008), but questions related to their full geographic distribution, dates of entry, routes of entry, orders of entry, and whether they were brought singly or as parts of "packages" (*sensu* Broodbank 2000) into the islands remain poorly understood. Newsom and Pearsall (2003:401) suggest these crops were not "transported wholesale" and that migrating populations selected only certain plants to propagate in new settings. Evidence for the exploration and limited use of the Turks and Caicos before the establishment of permanent settlements (Berman and Gnivecki 1995; Carlson 1999; Keegan 2007; Sears and Sullivan 1978; Sinelli 2001) suggests the people who colonized the southern islands were familiar with their unique, arid environments before permanently settling there. Similarly, the islands of the central Bahamas may have been explored before their permanent settlement (Berman and Gnivecki 1995). The prior knowledge of the growing conditions, which differed from the colonizers' points of origin, may have conditioned what they brought to their new homes. Thus, early coloniz-

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ers may have brought only certain crops and crop dispersal may have occurred selectively and not in "packages" as people expanded into different islands. This offers a contrasting scenario with the eastern Pacific, where the early colonization of the Fiji, Samoa, and Tonga group was not preceded by exploratory visits, due to the vast distance of the Vanuatu-Fiji water gap (Kirch 1988). Because the resource base of these islands was unknown, it is believed that people brought a large repertoire of plants and animals as a form of "insurance" guaranteeing that they would be able to support themselves in their new environment.

For almost 20 years archaeologists have hypothesized that Caribbean Archaic societies grew domesticates (Davis 1988), but macrobotanical evidence has failed to substantiate this claim. Recent discoveries, made possible through starch grain analysis of ground stone artifacts from two sites in Puerto Rico, Maruca (1295–395 B.C.) and Puerto Ferro (700 B.C.), have provided evidence for domesticated maize, manioc, beans, sweet potato, and yautía (Pagán Jiménez 2005; Pagán Jiménez et al. 2005). These and other studies now affirm the potential of starch grain analysis for Caribbean studies suggested earlier by the work of Berman and Pearsall (2000). The Bahamas were the last Caribbean islands to be colonized by humans and it is expected that domesticates would have been brought by the people who settled them. Previous research, focused on macrobotanical recovery, failed to find evidence for domesticated plants at sites in the Turks and Caicos (Newsom and Pearsall 2003; Newsom and Wing 2004) or at the Three Dog site, San Salvador island in the central Bahamas (Berman and Pearsall 2000). We therefore turned to starch grain and phytolith analyses to obtain these remains, because microfossil recovery has proved to be a useful means of establishing plant use in Neotropical contexts in Central America (Dickau 2005; Piperno and Holst 1998; Piperno et al. 2000), South America (Chandler-Ezell et al. 2006; Pearsall et al. 2004; Perry 2001, 2002, 2004, 2005; Perry et al. 2007), and other portions of the Caribbean (Cuba and Puerto Rico) (Pagán Jiménez 2005; Pagán Jiménez and Oliver 2008; Pagán Jiménez et al. 2005; Rodríguez Suárez and Pagán Jiménez 2006, 2008; Siegel et al. 2005).

Recent work in the Middle Orinoco region of Venezuela (Perry 2001, 2002, 2004, 2005) has revealed the presence of starch grains in the fissures, crevices, and holes of stone tools resembling ethnographically documented manioc grater chips. In this study, we examine the bipolar flakes and shatter that constitute the Three Dog site microlith assemblage for both starch grains and phytoliths. These flakes, which also resemble ethnographically recorded manioc grater board chips (Berman et al. 1999), are manufactured from a white fossiliferous chert whose nearest source is located over 300 km away in Cuba and Hispaniola (Berman et al. 1999). In our earlier study (Berman et al. 1999; Berman and Pearsall 2000), we found starch grain evidence of cf. *Xanthosoma* sp. (yautía) or cf. *Zamia* sp. on two microliths. We hypothesized that *Zamia* sp., which Newsom and Wing (2004:183) suggest may have been the primary source of starch in the Bahamas, would be confirmed on more microliths. Similarly we expected to find other instances of *Xanthosoma* sp. and possibly other root crops known to be prepared by grating. Because manioc is believed to have been a ubiquitous dietary mainstay of island Caribbean populations (Sturtevant 1969), the staple of post-Saladoid populations (Rouse 1992), and because of its great antiquity (starch grains have been found on Archaic period artifacts from Puerto Rico [Pagán Jiménez et al. 2005]), we anticipated that manioc would be recovered from the microlith assemblage. Finally, we expected to observe palm or grass residue. Palms and grasses have been reported widely from Caribbean paleoethnobotanical assemblages (Newsom 1993; Newsom and Pearsall 2003; Newsom and Wing 2004) and have been found on the microliths from Barrancoid and Arauquinoid sites in the Orinoco region (Perry 2001, 2002, 2004, 2005) and on stone tools from Panama (Dickau 2005).

Bamforth (1986) and Morrow and Jefferies (1989) have shown that tools made from nonlocal materials tend to be used for a wider range of functions than those manufactured from local materials. In a previous study, Berman et al. (1999) hypothesized that the tools from the Three Dog site, made from scarce, nonlocal materials, were used for multiple purposes. Here, we extend the argument to infer that the microliths would have been used to process a variety of plants. We suggest that the use of one tool to process numerous plants is a form of "scarcity-induced economizing behavior," a term coined by Odell (1996:75) to describe the multiple uses of stone tools in situations of raw material scarcity. We believe that the site's prehistoric occupants, faced with a lack of high-quality materials for their grater chips, made maximal use through the processing of a range of plants. Colonization of a new land may have required different strategies of tool use, including the conservation of rare materials, in the attempt to continue and reproduce homeland plant processing and consumption practices.

The Three Dog Site

The colonization of the Bahamas archipelago was part of a generalized fast-paced, near-simultaneous movement of peoples from Hispaniola and Cuba into the Bahamas in the A.D. 700s. The Turks and Caicos, in the dry tropical zone of the southern part of the Bahamas archipelago, were first settled ca. A.D. 750 by Ostionoid peoples who originated in northern Hispaniola (Carlson 1999; Carlson and Keegan 2004). A second wave of people, who also established outpost colonies in the Turks and Caicos during the eleventh and twelfth centuries, is attributed to an influx of Meillacan Ostionoid/Meillacoid (*sensu* Keegan 2004) peoples from northern Hispaniola (Carlson and Keegan 2004; Sinelli 2001:142–143). The moist tropical zone of the central Bahamas was settled permanently during the A.D. 700–800s from northern Cuba or northern Hispaniola (Berman and Gnivecki 1995; Carr et al. 2006:55, 81; Keegan 1992; Sinelli 2001:142); colonizers made their way up the island chain as part of a rapid expansion. By A.D. 900, New Providence, occupying the moist subtropical zone of the northern Bahamas, was settled (Bohon 1999).

The Three Dog site (Figure 1) is the earliest systematically excavated open air site in the Commonwealth of the Bahamas. Its radiocarbon dates, which range from the late cal A.D. 600s/700–900 (Berman and Gnivecki 1995:430), overlap with a well-dated human skeleton from Preacher's Cave, Eleuthera, a burial cave site that dates to A.D. 700–980 (Carr et al. 2006). Sitting atop a dune ridge adjoining Sugar Loaf Bay on the western side of San Salvador Island, the Three Dog site consists of a midden, two activity areas, and a low density (well-swept) area. Local and nonlocal ceramics, shell beads and bead debitage, chert microliths, a grinding stone fragment, coral artifacts and debitage, shell hammers, scrapers, adzes, picks, and waste, a limestone hoe, limestone flakes, shell and stone pendants and an associated toolkit, paleoethnobotanical, and zooarchaeological remains have been recovered. Bead and ceramic vessel production, the manufacture of stone and shell figurines, food preparation, cooking, meal consumption, sweeping, possible woodworking, and waste disposal took place here. Evidence of off-site activities such as field preparation (hoeing and tree-cutting), fishing, and shellfish collection was present as well. The site appears to represent the material remains of one household, probably composed of an extended or joint family. There is no material evidence of social differentiation other than gender and age, although the latter is not readily discernible.

The Microlith Assemblage

The chert assemblage, which consists of 58 microliths manufactured through bipolar production, was distributed throughout the site with nearly equal concentrations in the midden in the northernmost portion and in a food preparation area in the southernmost part. The microliths range from 4.04 to 37.79 mm long (mean of 11 mm), 3.56 to 18.77 mm wide (mean of 6.98 mm) and 1.45 to 10.54 mm thick (mean of 3.52 mm) and resemble grater chips from ethnographically observed manioc grater boards (Berman et al. 1999). Traces of a dark, sticky adhesive suggest the microliths were inserted into a grater board (Berman et al. 1999; Rostain 1997; Roth 1924; Sievert 1992a, 1992b; Yde 1965). Furthermore, 43 percent of the assemblage ($N = 25$) exhibited crushing, which experimental studies have attributed to bipolar manufacture or insertion into a grater board, not use (Berman et al. 1999; Sievert 1992a; Walker 1980). High-power (50×–200×) microwear analysis provided little or no evidence of function due to the degraded nature of the chert, so we examined a small sample with a scanning electronic microscope for phytoliths to determine if the artifacts were used for plant processing (Berman et al. 1999; Berman and Pearsall 2000). No identifiable phytoliths were detected, but two small spheroidal bodies, identified as possible *Xanthosoma* sp. or *Zamia* sp. starch grains, were observed on the working edges and crevices of two of the tools.

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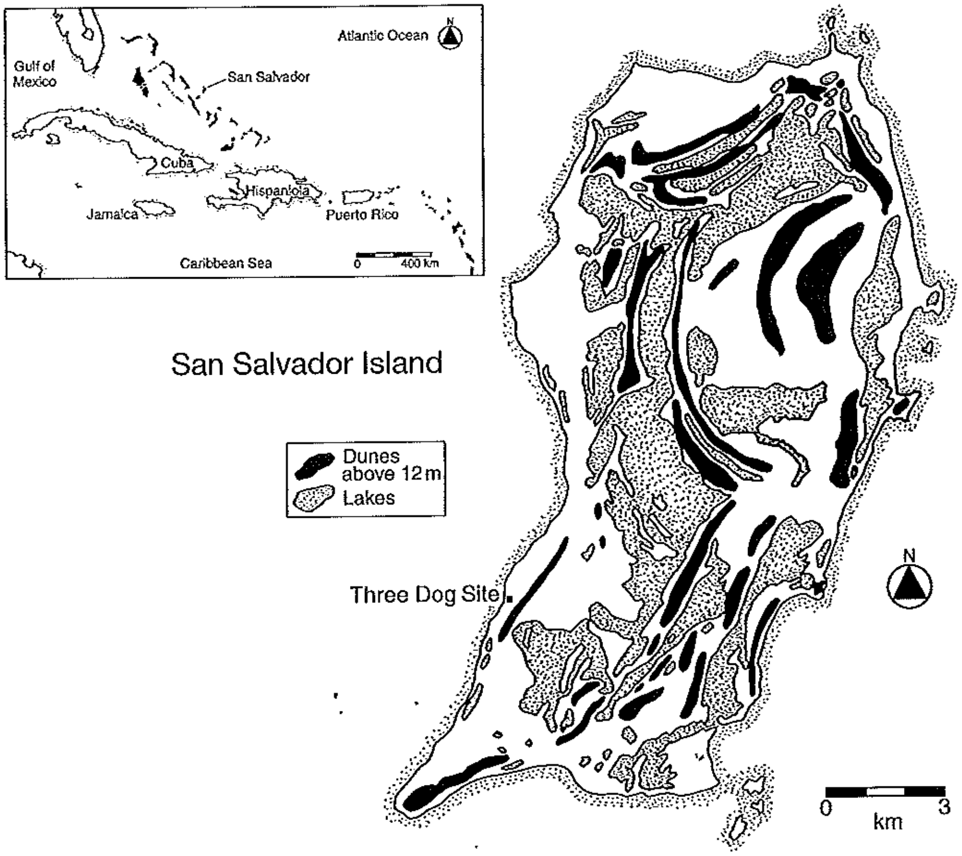

Figure 1. Map of the Bahamas and San Salvador Island.

Because of the discovery of starch residues on the microliths during the SEM analysis, we decided to conduct a larger, systematic examination of a sample of the assemblage to search for identifiable phytoliths and starch grains. This was carried out by project paleoethnobotanist Deborah M. Pearsall. The study goal was to identify if there was greater evidence for plant use, and if so, which species were present, and whether they were part of "transported" landscapes or represented localized adaptations to the Bahamian environment. Furthermore, we wanted to see if the artifacts believed to be manioc grater chips were really used prehistorically to process manioc.

Starch Grain and Phytolith Study

Starch Grain and Phytolith Recovery

Pearsall analyzed 28 microliths; 15 produced evidence of residues. Nine microliths with residues are pictured in Figure 2. The starch grains and phytoliths were recovered and identified using methods developed during the Real Alto site, Ecuador, tool residue study (Chandler-Ezell and Pearsall 2003; Chandler-Ezell et al. 2006; Pearsall et al. 2004). This approach, known as "piggyback" microfossil processing, allows for both starch and phytolith sampling from stone tools, while minimizing potential damage to more delicate starch remains. Briefly, each tool was scrubbed with cool distilled water and a new toothbrush. The aqueous sediment, referred to as Sediment 2 (wet brushed sediment), was retained. (If the tools had been unwashed, they would have been dry-brushed as a first step and referred to as Sediment 1.) The tool was then placed in a disposable plastic container. Cool distilled water was added to cover the artifact. The container was placed in an ultrasonic bath for five minutes; upon removal, the aqueous sediment, known as Sediment 3, sonicated sediment, was retained. For the first 11 tools, Sediments 2 and

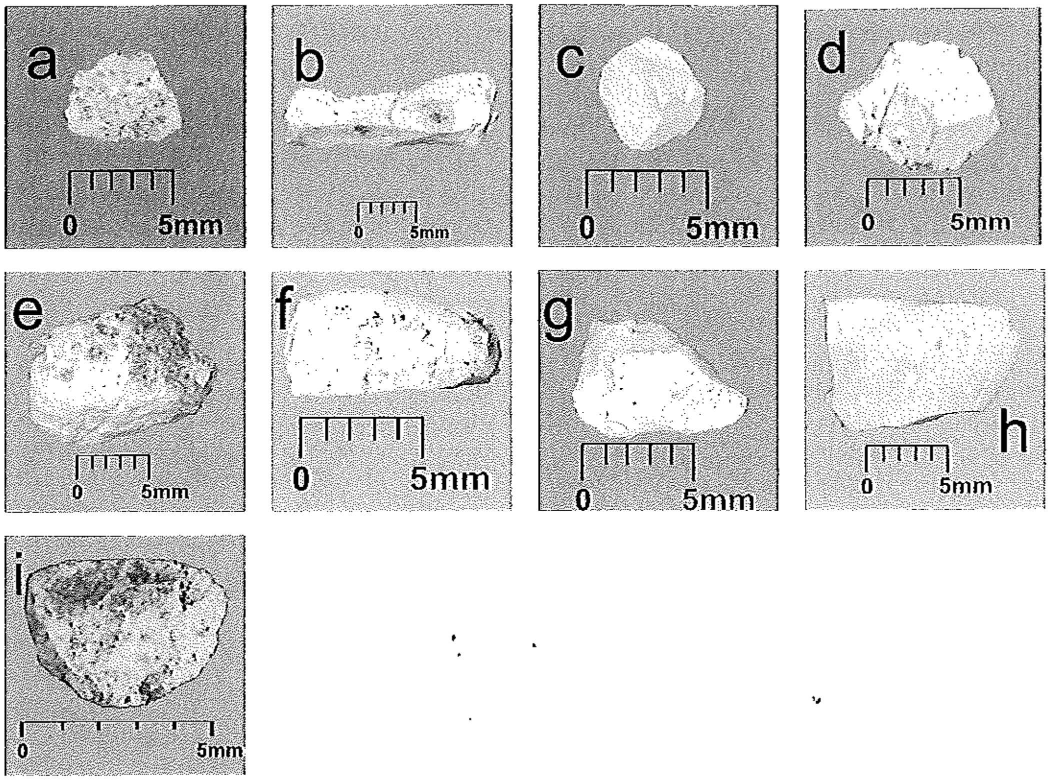

Figure 2. Selected sample of microliths with starch grains and starch grains and phytoliths. (a) 8289, shatter (cf. 1 *Zea mays*, 1 *Capsicum* sp., 2 undulating fruity transport tissue); (b) 9908, compression flake (1 cf. *Zea mays*); (c) 12883, compression flake (cf. 1 *Zea mays*); (d) 16513, compression flake (cf. 1 *Zea mays*); (e) 16745, shatter (1 *Zea mays*); (f) 16838, compression flake (1 *Zea mays*); (g) 16841, shatter with retouch (2 *Zea mays*, 1 large root/tuber, 1 small root/tuber); (h) 16847b, distal flake (2 small root/tuber, 1 possible manioc phytolith secretory cell); (i) 17127, compression flake (1 *Zea mays*, 1 *Capsicum* sp., 2 undulating fruity transport tissue)

3 were processed separately, as described below. When initial scanning revealed scant residues, wet brushed and sonicated sediments from subsequent tools were combined into a single sample for processing and scanning. Samples were dispersed and deflocculated by shaking in water and .1 percent NaEDTA, then each was split into a starch and phytolith subsample. Starch subsamples were quite clean and not processed further. Starch residues were stored in distilled water. Phytolith subsamples were processed to remove carbonates and organic matter; then phytoliths were floated from the sample using Zinc iodide heavy liquid. Phytolith extracts were stored dry.

Starch extracts were slide-mounted in glycerol and distilled water and examined using a Zeiss research microscope at 250×–400× magnification. Starch was identified by the distinctive extinction cross produced under cross-polar light. Each starch granule was described and photographed. Identifications were made using the University of Missouri lab comparative collection, published sources (e.g., Dickau 2005; Pagán Jiménez et al. 2005; Perry 2001; Piperno and Holst 1998; Riechert 1913), and consultation with colleagues. Phytolith extracts were slide mounted in Canada balsam and examined using a Nikon research microscope at 400× magnification. Phytoliths were identified using the University of Missouri comparative collection.

Starch and Phytolith Results

Results are summarized in Tables 1, 2, and 3. This investigation, including the previous one (Berman and Pearsall 2000), revealed that starch granules were present on 14 artifacts: seven from the midden, two from the multipurpose activity area, one from a low density area, and four from an area in the southern part of the site that contained a high density of microliths (Table 4). Five *Zea mays*

Table 1. Results of Starch and Phytolith Analyses, Microliths With Starch Grains and Phytoliths.

Tool No.	MU SS No.	MU PS No.	Maize starch	Possible maize[a]	Maize granule size[b]	Outline	Milling damage	*Capsicum sp.* Starch flat granule	Unknown small granule	Unknown large granule	Possible damaged starch	Possible manioc secretory cell	Undulating (fruity) transport tissue
7426	376	2373	-	-	-	-	-	-	-	-	1	-	1
8289	353	2350	-	1	7 x 7	rounded	-	1	-	-	-	-	2
16847-B	344	-	-	-	-	-	-	-	2	-	-	1	-
17127	352	2349	1	-	11 x 11	rounded	-	1	-	-	-	-	2
17128	375	2372	-	-	-	-	-	-	-	-	1	-	1

[a]Grains will not roll.
[b]Size in microns.

Table 2. Results of Starch and Phytolith Analyses, Microliths With Starch Grains Only.

Tool No.	MU SS No.	MU PS No.	Maize starch	Possible maize[a]	Maize granule size[b]	Outline	Milling damage	*Capsicum sp.* Starch flat granule	Unknown small granule	Unknown large granule	Possible damaged starch	Possible manioc secretory cell	Undulating (fruity) transport tissue
9908	338	-	-	1	14 x 16	angled	slight	-	-	-	-	-	-
12883	374	-	-	1	10 x 12	rounded	-	-	-	-	-	-	-
16513	348	-	-	1	8 x 9	rounded	-	-	-	-	-	-	-
16745	355	-	1	-	7 x 8	rounded	-	-	-	-	-	-	-
16838	346	-	1	-	9 x 9	rounded	-	-	-	-	-	-	-
16841	61	-	2	-	14 x 20; 18 x 20	angled	slight (1)	-	1	1	-	-	-
16850	347	-	-	-	-	-	-	-	-	-	3	-	-

[a]Grains will not roll.
[b]Size in microns.

Table 3. Results of Starch and Phytolith Analyses, Microliths With Phytoliths Only.

Tool No.	MU SS No.	MU PS No.	Maize starch	Possible maize[a]	Maize granule size[b]	Outline	Milling damage	*Capsicum sp.* Starch flat granule	Unknown small granule	Unknown large granule	Possible damaged starch	Possible manioc secretory cell	Undulating (fruity) transport tissue
11092	349	2346	-	-	-	-	-	-	-	-	-	-	2
12885	-	2348	-	-	-	-	-	-	-	-	-	-	3
16851	-	2342	-	-	-	-	-	-	-	-	-	-	1

[a]Grains will not roll.
[b]Size in microns.

Table 4. Spatial Distribution of Microliths With Starch Grains, Phytoliths, and Starch Grains and Phytoliths.

Artifact Number	Location	Activity	Species (starch)	Taxon (phytoliths)
17127	S01E02	Midden	1 *Zea mays*, 1 *Capsicum sp.*	2 undulating fruity transport tissue
17128	S01E02	Midden	1 unknown, but damaged	1 undulating fruity transport tissue
9908	S03E02	Midden	cf. 1 *Zea mays*	
7426	S05E02	Midden	1 unknown, but damaged	1 undulating fruity transport tissue
8289	S06E01	Midden	1 cf. *Zea mays*, 1 *Capsicum sp.*	2 undulating fruity transport tissue
16513	S06E07	Midden	1 cf. *Zea mays*	
6225	S07W01	Midden	1 cf. *Xanthosoma* sp. or cf. *Zamia sp.*	
16745	S15E03	Multipurpose area	1 *Zea mays*	
12883	S17E00	Multipurpose area	1 cf. *Zea mays*	
12885	S17E00	Multipurpose area	—	3 undulating fruity transport tissue
11092	S17E01	Multipurpose area	—	2 undulating fruity transport tissue
3207	S28E02	Low density area	1 cf. *Xanthosoma* sp. or cf. *Zamia sp.*	
16841	S41W01	Plant processing	2 *Zea mays* 1 large root/tuber 1 small root/tuber	
16847b	S41W01	Plant processing	2 small root/tuber	1 possible *Manihot* secretory cell
16850	S41E00	Plant processing	3 unknown, but damaged	
16838	S42W01	Plant processing	1 *Zea mays*	
16851	S42E00	Plant processing	—	1 undulating fruity transport tissue

starch grains were identified on four microliths; two were present on one tool (Figure 3a, b, d, f, i). Four starch grains, tentatively identified as maize (the grains could not be rolled), were observed on four microliths (Figure 3c, e, g, h). A large granule resembling root/tuber starch was found on one stone tool (Figure 4e, f), and three smaller granules that may also be root/tuber starch were observed on two microliths (Figure 4a–d). Two grains identified as domesticated chile, *Capsicum* spp. were also recovered (Figure 5a–d). Finally, three tools preserved possible damaged starch that cannot be identified further.

A number of investigators (Pearsall et al. 2004; Perry 2001; Piperno 2006; Piperno and Holst 1998; Piperno et al. 2000; Reichert 1913) have described starch produced in the kernels (seeds) of maize. Maize granules were identified using these sources, as well as the University of Missouri starch grain collection. Identifications were confirmed by Dolores Piperno and Linda Perry (personal communication to Pearsall, April 2005). The tentatively identified maize grains (cf. *Zea mays)* possess the diagnostic characteristics of maize, but could not be rotated on the slide to confirm their three-dimensional morphology.

At least two maize races, a popcorn and a floury-endosperm grain, dating to A.D. 1350 ± 70, were found at En Bas Saline in Haiti (Newsom 1993, 2008; Newsom and Deagan 1994), indicating that by the mid-fourteenth century, these and possibly other varieties of maize were grown in the Caribbean. Oviedo noted two types of maize, one that matured at three months, another at four (Newsom 2008:176). Morphological features required to make definitive statements about the kinds of maize at the Three Dog site are lacking, however. Both smooth grains, common in soft endosperm maize varieties (flour, sweet corn), and grains showing compression facets (angled grains), common in hard endosperm varieties (popcorn, flint corn) (Perry 2001), are present. No large smooth grains or "bumpy" grains typical of some flour varieties were recovered, however. Grain size varies from 7–20 μm, with an average of 12.4 μm ($n = 9$). This falls in the range of other published reports of maize (Pearsall et al. 2004; Piperno and Holst 1998). While the smallest granules (7–8 μm) overlap in size with some wild grass starch, all show the distinctive smooth surfaces, open centric hilum, and crisp double-outline edges of maize.

Domesticated chile species fruits produce large, flattened lenticular starch grains with a shallow central depression (Perry et al. 2007). When rotated on the side, a central linear feature is visible that runs parallel to the long axis of the grain. All five domesticated species of chile produce starch grains of this type; starch produced by wild species is distinctively different. The two chile grains recovered from the Three Dog site measure 19 and 21 μm in

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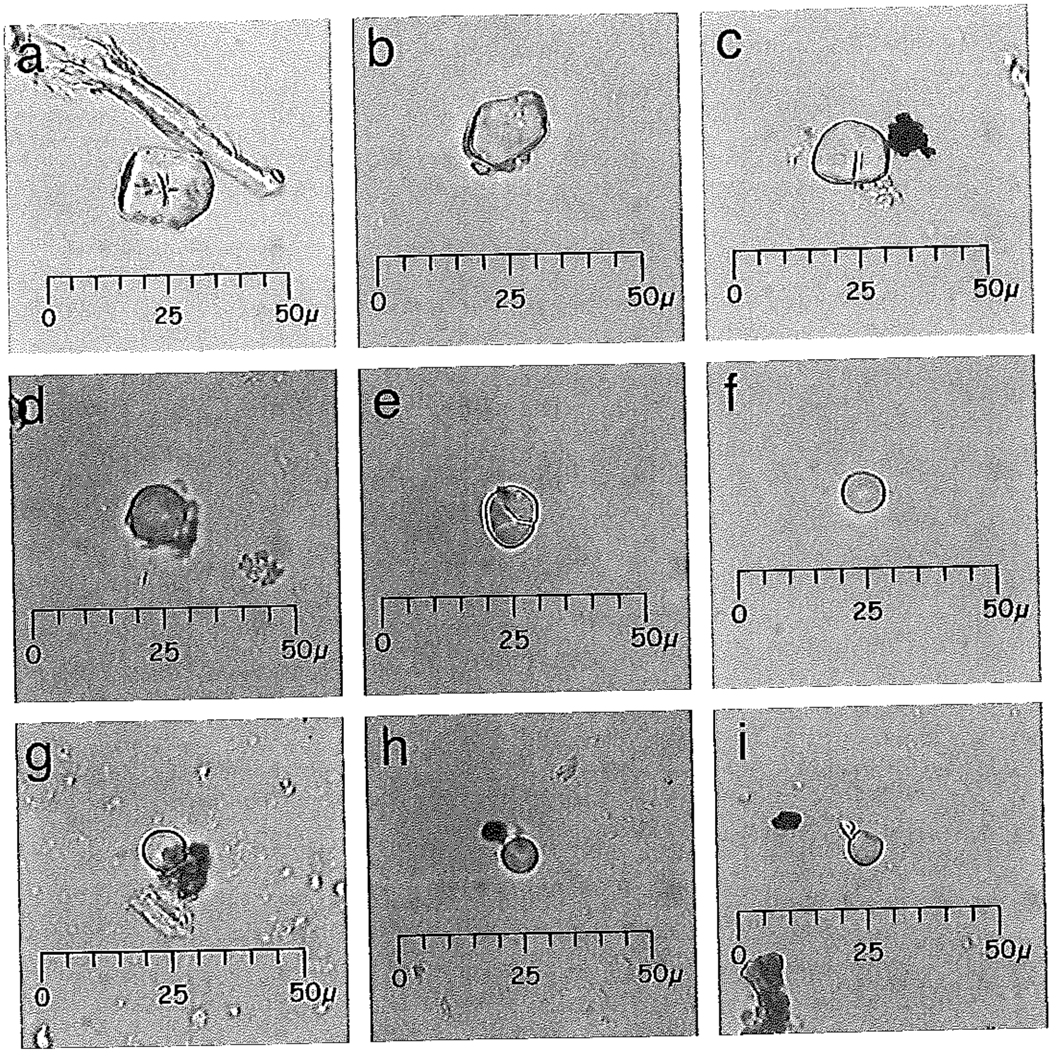


Figure 3. *Zea mays* starch grains. (a) Z1123.SS61.Granule4-TL; (b) Z959.SS61.Granule1-TL; (c) Z1120.SS338.Granule1-TL; (d) Z1212.SS352.Granule2-TL (e) Z1275.SS374.Granule1-TL; (f) Z1153.SS346.Granule1-TL; (g) Z1156.SS348.Granule1-TL; (h) Z1215.SS353.Granule1-TL; (i) Z1267.SS355.Granule1-TL. *Note*: Figures 3–5 use a specific labeling system. For example, Z1212: Zeiss microscope catalog number; SS352: starch sediment number (corresponding to Tables 1–3); Granule 2: starch granule number;TL: transmitted light, PL: polarized light.

length, well within the size range of starches of domesticated chiles (13–45 μm) (Perry et al. 2007), and show the distinctive morphology of domesticated chile starch.

The large root/tuber-type granule (Figure 4e, f) falls into Reichert's Type 8: grains simple, eccentric, cuneiform, or flattened. However, unlike most grains in this category, this flattened granule is broader than long (length = 36 μm, width = 46 μm, thickness = 30 μm, tapering at the edges to 5–10 μm). The granule is oriented in terms of the location of the hilum (accretion center). Faint lamellae are present. The large unknown is not any of the domesticated lowland root or tuber taxa and does not match any species illustrated in Reichert (1913). However, there are some similarities to taxa described by Reichert in the Amaryllidaceae, Cycadaceae, Liliaceae, Dioscoreaceae, Marantaceae, and Zingiberaceae, as well as taxa in the Iridaceae (Pearsall, laboratory documents); study of starch from wild utilized plants in these groups may allow eventual identification of this granule. Pearsall checked stem tissues of two species of *Heliconia* and one *Costus*, plants that produce useful fibers, but these are not the source of the large unknown.

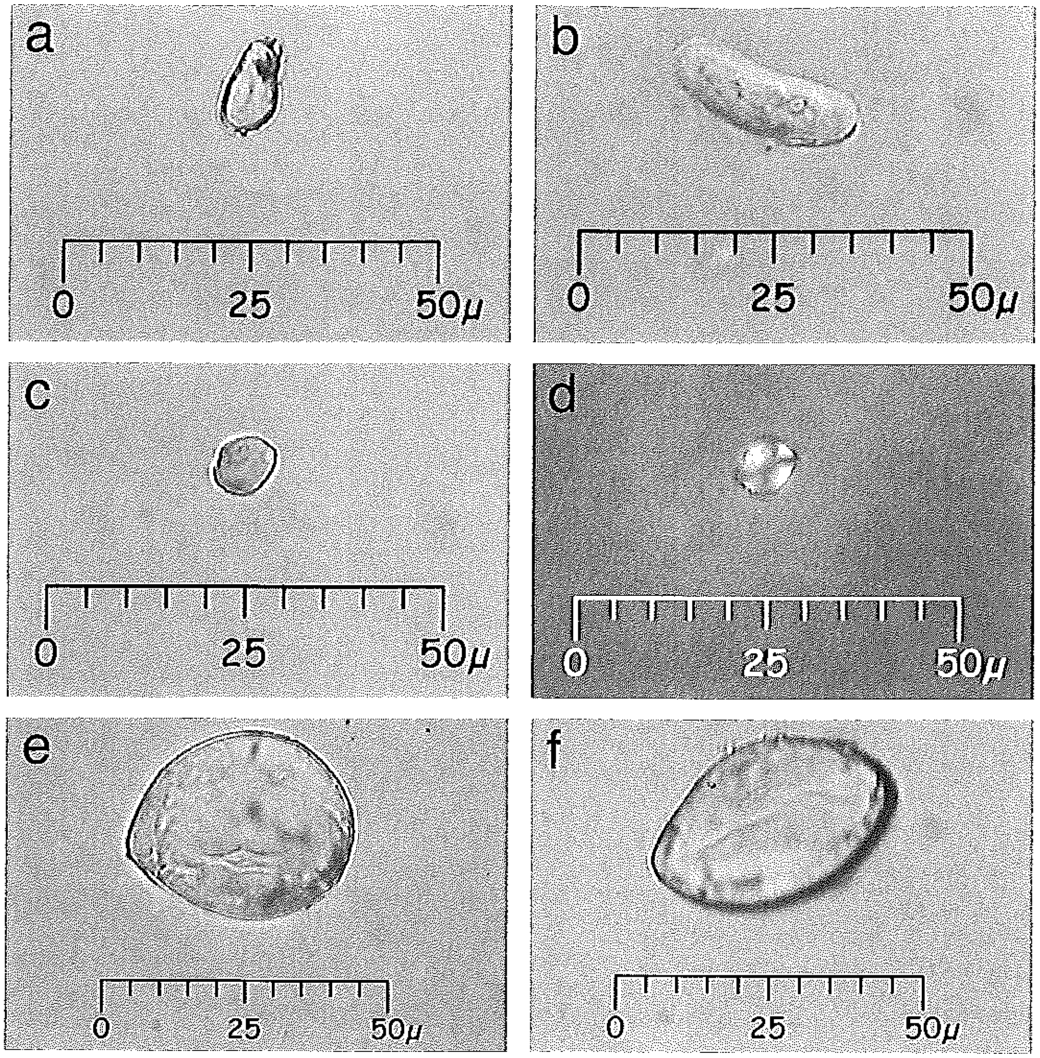
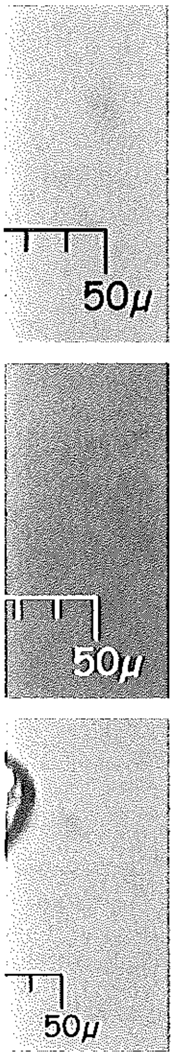


Figure 4. Root/tuber starch grains. (a) Z961.SS61.Granule2-TL; (b) Z1147.SS344.Granule2-TL; (c) Z1146.SS344.Granule1-TL; (d) same as c, PL(Z1144); (e) Z965.SS61.Granule3-TL; (f) same as e, rotated (Z1111).

The three small unknown granules (Figure 4a–d) may not be from the same plant species, as they differ somewhat in shape. SS344 Granule 1 is more spheroidal than elongated like SS344 Granule 2 and SS61 Granule 2. The three unknowns are similar, however, in possessing a slight central indentation, single outline, and closed, centric to slightly eccentric hilum. Lamellae are not visible. The central indentation is reminiscent of wild *Dioscorea* (yam genus), but the unknowns are much smaller than any illustrated species in this group or any wild *Calathea*. The shape and smooth appearance of the unknown leads us to suggest an origin in root or tuber tissue, but this is a very provisional identification.

Phytoliths proved to be extremely rare on the Three Dog site tools (compared to studies elsewhere) and were present on eight microliths. With the exception of a few grass short cells not diagnostic to genus or species (not tallied), the most common silicified tissue recovered was undulating fruity transport tissue. One to three examples of these silicified tissues were observed on seven tools. Study of phytolith production in fruits, seeds, roots, rhizomes, and tubers from a wide range of New World domesticated plants reveal that transport tissues (xylem and phloem) are sometimes silicified, and in general, are undulating in form in fruits and



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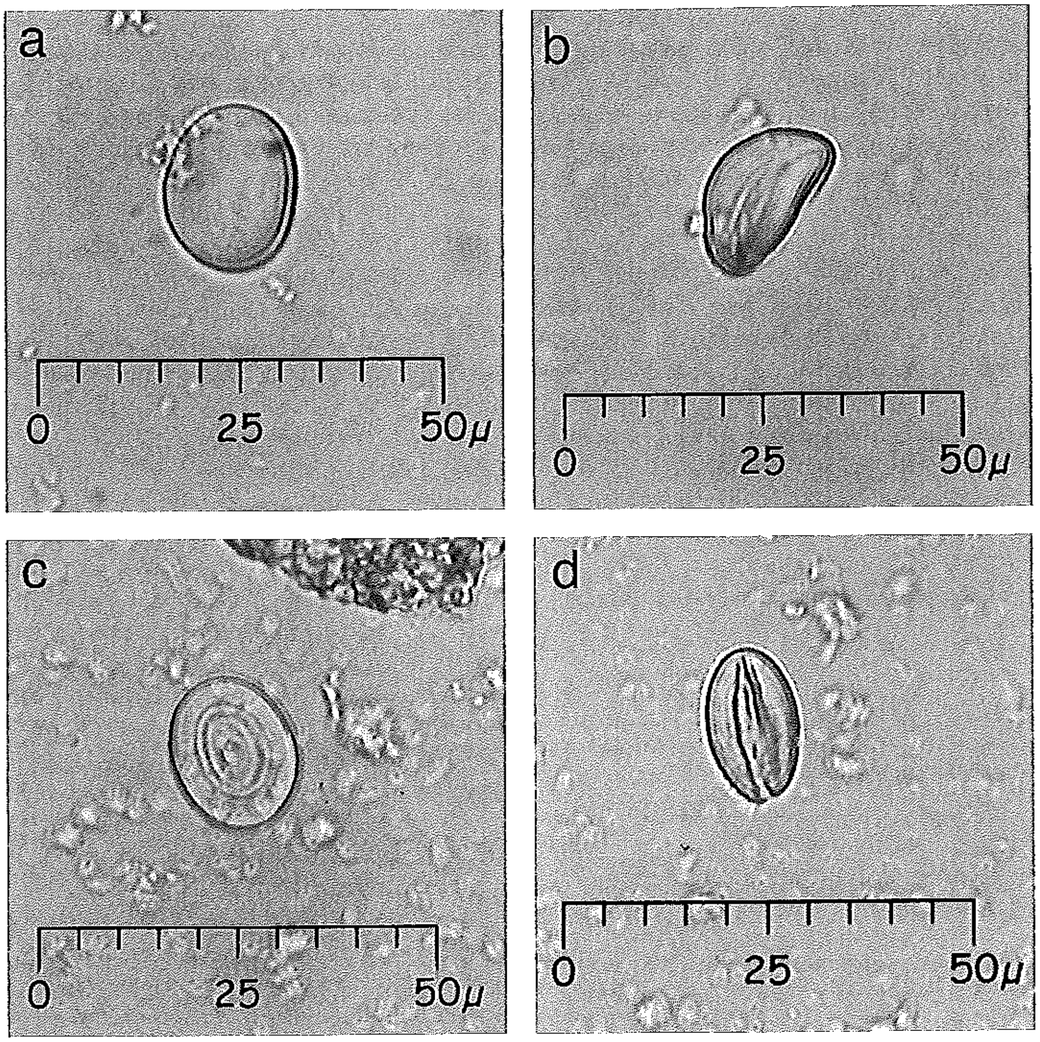

Figure 5. *Capsicum* sp. starch grains. (a) Z1207.SS352.Granule1-TL; (b) same as a, rotated (Z1208); (c) Z1219.SS353.Granule2-TL; (d) same as c, rotated (Z1220).

seeds, and straight in roots, rhizomes, and tubers (Chandler-Ezell et al. 2006). In the context of a tool surface, undulating transport tissues can be interpreted as a generalized fruit/seed indicator. While manioc infrequently produces phytoliths (Dickau 2005), they have been identified archaeologically on grinding tools at the Real Alto site, Ecuador (Chandler-Ezell et al. 2006) and thus the potential exists to find them on other tools such as microliths. We were excited, therefore, when a possible manioc secretory cell was found on 16847-B. This type of phytolith, which is produced in manioc roots and leaves, was characterized during the comparative study mentioned above. While it is assumed that grating would only be required to process manioc roots (in order to remove the toxin-bearing rind), manioc leaves can also be prepared by grating. Roth (1924:217), for example, describes how two Guyanese Amerindian groups prepared manioc leaves by mincing them on a grater. Unfortunately, example 16847-B will not roll to allow assessment of its three-dimensional form, and therefore cannot be identified conclusively.

Discussion

Space-Time Systematics of Maize

The fifteenth- and sixteenth-century Spanish chronicles serve as a starting point to investigate the earliest European contact period geographic distribution of New World plants; the chronicles are also a source of information about how these plants were prepared and consumed. While we should not be bound exclusively to such accounts (Curet 2003; Keegan 1989), they serve as models to be tested in the earlier record. Columbus was the first European to observe the domesticates reported in this study. Lacking prior knowledge of the plants, he could only describe them in familiar terms using words of his lexicon. For example, he noted maize at least three times in his *Diario*, referring to it as *panizo*, which he likened to millet (Dunn and Kelley 1989:89), an Old World crop. Although he did not record maize for San Salvador, the first island where he made landfall, he noted it a few days later in his October 16, 1492, entry, during his circumnavigation of and short stay on another central Bahamas island, Fernandina (Long Island), Bahamas:

> I have no doubt that all year they sow millet and harvest it and likewise all other things (*...y no pongo duda q todo el año siembrà panizo y cogen y asi todas otras cosas*) [translation by Dunn and Kelley (1989:88–89)].

He mentioned millet briefly on November 6, when he saw it in Cuba (Dunn and Kelley 1989:139). Then again on December 6, while still in Cuba, he observed fields that

> looked like wheat in the month of May in the farmlands of Cordova (*o gràde parte d[e]llas y parecian las seméteras como trigo en el mes de mayo en la càpiña de cordova* [translation by Dunn and Kelley (1989:203)].

On the second voyage of Columbus to the Americas, Coma, a traveler who accompanied the expedition, wrote about a plant he observed on Guadeloupe, which we now believe to have been corn,

> it is a grain of very high yield, of the size of the lupine [referring to the cultivated white lupine of the Mediterranean], of the roundness of a chick-pea (*cicer*) and yields a meal (*farina*) ground to a very fine powder (*effracto tenuissimo polline*); it is ground as is wheat (*frumentum*) and yields a bread of very good taste; many chew the seeds when in need of nourishment [Sauer 1966:55].

On his return trip to Spain in 1493, Columbus brought corn seeds, which were planted and harvested in Europe. In Peter Martyr's Decade I, Book I, this plant is referred to as mahiz, a reference Martyr obtained from people who had made the voyage (Sauer 1966:55, 1972:155).

Currently, direct evidence for prehistoric corn in the Caribbean is known from archaeological sites in Cuba, the Dominican Republic, Puerto Rico, St. Thomas (U.S. Virgin Islands), two islands in the Bahamas archipelago, San Salvador and Eleuthera, and from cores dating to prehistoric levels from Haiti and Puerto Rico (Table 5). The earliest evidence comes from the Archaic age. Pollen from two sites in the Dominican Republic (Sanoja 1989), starch grains from the sites of Maruca and Puerto Ferro, Puerto Rico (Pagán Jiménez et al. 2005), and maize cob phytoliths in a core taken from a pond adjacent to the Maisabel site (Puerto Rico) (Siegel et al. 2005) indicate that maize was present during the Archaic age in Hispaniola and Puerto Rico and not brought by Ceramic age people from South America during the Ostionoid period as has been hypothesized (Rouse 1992:109). Findings suggest that Archaic age peoples engaged in low-level cultivation or casual horticulture (Newsom and Wing 2004) and evidence indicates that corn was part of their repertoire.

Corn has also been recovered from a variety of Ceramic age contexts including small residential sites, burial caves, a small civic-ceremonial site, and the large village of En Bas Saline, home to a *cacique*. The earliest evidence for corn from an open-air residential site from this period comes from the Three Dog site. Starch grains from Los Muertos Cave, Puerto Rico [A.D. 680–950, A.D. 1020–1190] (Pagán Jiménez and Oliver 2008), pollen from El Jobito in the Dominican Republic (A.D. 1020) (García Arévalo and Tavares 1978:36), a sediment core from Haiti's Lake Miragoane (A.D. 1000-1500) (Higuera-Gundy 1991), starch grains from Laguna de Limones and Macambo II, two sites in southeastern Cuba (A.D. 1150–1490) (Rodríguez Suárez and Pagán Jiménez 2006, 2008), starch grains from Vega de Nelo Vargas, Puerto Rico (A.D. 1280–1430) (Pagán Jiménez and Oliver 2008:140, 142, 150), and macrobotanical evidence from the Tutu site on St. Thomas (A.D. 1140–1350) (Newsom and Pearsall 2003:358; Pearsall 2002), En Bas Saline (A.D. 1350 ± 70) (Newsom 1993;

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Table 5. Caribbean Maize Occurrence.

Country	Date	Evidence	Reference
Archaic Age			
Dominican Republic			
El Curro	1450 B.C.	pollen	Sanoja 1989:532
Puerto Alejandro	similar age	pollen	Sanoja 1989:532
Puerto Rico			
Maruca	1295-890 B.C.	starch grains on one stone tool	Pagán Jiménez et al. 2005
	785-395 B.C.	starch grains on two stone tools	Pagán Jiménez et al. 2005
Puerto Ferro	700 B.C.	starch grains on one stone tool	Pagán Jiménez et al. 2005
Maisabel	785 cal B.C.	maize cob phytoliths[a]	Siegel et al. 2005
Ceramic Age			
Bahamas			
San Salvador			
Three Dog Site	calibrations at 2 sigmas cal A.D. 685; cal A.D. 600-950; cal A.D. 812, 847, 852; cal A.D. 650-1020; cal A.D. 883; cal A.D. 680-810; cal A.D. 972; cal A.D. 790- 1030; cal A.D. 991; cal A.D. 828-1157	starch grains on microliths[b]	Berman and Gnivecki 1995
Puerto Rico	calibrations at 2 sigmas		
Los Muertos Cave	cal. A.D. 680-950	starch grains on one stone tool starch grains in peripheral sediments	Pagán Jiménez and Oliver 2008
	cal. A.D. 1020-1190	starch grains on one stone tool starch grain in peripheral sediments	Pagán Jiménez and Oliver 2008
Vega de Nelo Vargas	cal. A.D. 1280-1400 cal. A.D. 1290-1400 cal. A.D. 1290-1400 cal. A.D. 1300-1430	starch grains on stone tools starch grains in peripheral sediments	Pagán Jiménez and Oliver 2008
Cuba			
Laguna de Limones	A.D. 1150-1490	starch grains on two griddles	Rodríguez Suárez and Pagán Jiménez 2006, 2008
Macambo II	A.D. 1200-1600	starch grains on one griddle	Rodríguez Suárez and Pagán Jiménez 2006, 2008
Dominican Republic			
El Jobito	A.D. 1020	pollen	Garciá Arévalo and Tavares 1978:36
Haiti			
Lake Miragoane	A.D. 1000-1500	pollen in sediment core	Higuera-Gundy 1991
En Bas Saline	A.D. 1200-1500	macroremains	Newsom and Deagan 1994
US Virgin Islands			
St. Thomas			
Tutu Site	A.D. 1140-1350	macroremains	Pearsall 2002
Bahamas			
Eleuthera			
Preacher's Cave	A.D. 1460	macroremains	Carr et al. 2006: 81

[a] Maize cob phytoliths occur down to a depth of 207 cm in the core; peats at 200-205 cm.

[b] Table 4

Newsom and Deagan 1994; Newsom and Wing 2004), and Preacher's Cave, Eleuthera (A.D. 1460) (Carr et al. 2006:81) point to the widespread use of corn throughout the Ostionoid sequence in the northern Antilles.

Dietary Contribution—Maize

The dietary contribution of maize to the Antillean diet prior to and at the time of European contact is poorly understood,[1] and most investigators believe it to have been small, never achieving the primacy of manioc or sweet potato (Newsom and Deagan 1994, Newsom and Pearsall 2003; Newsom and Wing 2004; Rouse 1992; Sauer 1966:9; Sturtevant 1969). According to Rouse (1992:12), corn was not an important food because it "played no role" in Taíno religion or mythology. Newsom and Wing (2004:202, 214) and Pearsall (1994) view maize in the Caribbean and parts of South America as an incidental, secondary, or "low-intensity" crop. The geographically broad findings of maize from sites beginning with the Archaic age now suggest that corn may have played an earlier and larger role in the Caribbean diet than believed previously. The data presented here suggest that maize was part of a broad-based diet, commonly used in concert with other plants, including chiles, and was not a supplemental or "curiosity" crop as Pearsall (1994) proposed earlier.

Maize Preparation

The Three Dog site microlith assemblage suggests that the primary means by which the inhabitants processed their corn before cooking was through grating. Other sources of information, such as the sixteenth-century ethnohistoric accounts, provide little insight into how Antillean peoples prepared maize for consumption. Peter Martyr (in Sauer 1972:155) states that the Taíno made bread from it, a practice confirmed by corn starch grains on griddles (Rodríguez Suárez and Pagán Jiménez 2008), while Oviedo's account (1959:14–15 [1526]) records that it was toasted "when the ears are tender they are eaten almost as milk." Both reports hint that corn was processed and eaten in several different ways, opening up the possibility that grating was at least one type of preparation.

Because the accounts do not mention grated corn or the grating process and because grating tools are rarely recognized or recovered archaeologically, grating has been overlooked as a possible means of maize preparation. Yet, grated corn is and was a common food or ingredient and numerous recipes call for it. During the nineteenth century, American pioneers added grated corn to thicken and sweeten dishes (Fussell 1992:187). They also made gritted meal from it and devised metal graters in a variety of shapes and forms (Douglas County Genealogical and Historical Society Journal 1986). Today as in earlier times, corn chowders and puddings call for grated corn, the major component of such dishes (Fussell 1992). Green corn tamales prepared in Nicaragua require grated corn (Honduras This Week 1997). During prehistory, grated corn was likely prepared and consumed in a number of ways. We propose that, in addition to being the primary ingredient of some dishes, it also served as a thickening and flavoring agent, along with other starch-bearing plants such as manioc, yautía, and zamia for multi-ingredient dishes prepared with pungent chiles described by the chroniclers (Sauer 1966).

Space-Time Systematics—Chili Peppers

The first written reference to chili peppers or *ají* can be found in Columbus's diary, written on Monday, January 14, 1492, from Hispaniola:

> There is also much chili, which is their pepper, of a kind more valuable than [black] pepper, and none of the people eat without it, for they find it very healthful. Fifty caravels can be loaded with each year in Hispaniola [Dunn and Kelley 1989:341].

New evidence from starch residue analyses indicate that chiles were among the early domesticated plants of the New World, present in Ecuador by 6100 B.P. and widely cultivated during prehistory (Perry et al. 2007). Las Casas noted that the Taíno grew one wild form and two domesticated varieties, believed to be *Capsicum annum* and *C. chinensis* (Newsom 1993, 2008:178; Sauer 1996:57). The starch grain evidence from the Three Dog site pushes the date for use of domesticated chilis in the Caribbean back to A.D. 700/800. The only other Caribbean archaeological evidence for chile comes from the En Bas Saline site where Newsom identified *Capsicum* spp. The morphology of those examples overlapped that of domesticated and wild species (Newsom 1993; Newsom and Pearsall 2003).

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Capsicum domestication is a complex issue and there is considerable geographic overlap among species. Four species of chilis were brought under domestication: *Capsicum annum, C. frutescens* (includes *C. chinense*), *C. baccatum*, and *C. pubescence* (Piperno and Pearsall 1998). *Capsicum frutescens* is the most widely cultivated pepper of the Amazon Basin and Caribbean and domesticated chilis would have been widely available to the populations migrating into the Caribbean. While we cannot identify the Three Dog site domesticated chile starches to species, it is most likely that they derived from the *C. annum* and *C. frutescens* complex of lowland peppers, which emerged in the Central American to northern South American region.

Stone Tool Morphology and Use

In this study, starch grains were found on three different kinds of bipolar-produced microliths, hypothesized to have been manioc grater chips (Berman et al. 1999). Other archaeological and ethnographic data suggest that microliths, assumed to have been set in grater boards, were used to process a range of root, tuber, and seed plant materials. Grater boards are not and were not used exclusively to process only one plant, as the archaeological literature leads us to believe (*sensu* DeBoer 1975).[2] Oliver (2001:76–77) notes, for example, that Amazonian Indians use grater boards to process a variety of tubers besides manioc. Yde (1965:54, 55) reported that in addition to manioc, the Wai Wai grated sweet potatoes (*Ipomoea batatas)* and bananas on manioc graters. Walker (1980) observed that the Garifuna used grater boards to shred coconut. According to Perry (2005:423), the Makushi currently use manioc grater boards to remove maize kernels from their ears. Roth (1924:218) observed that the Indians of the Guiana Shield grated seeds from a variety of trees, including *Nectandra rodioei, Dimorphandara mora*, and *Vouacapoua americana*, as well as a local seed known as *pario*, and the sawari nut (fruit of *Caryocar tuberculosa*), but he did not indicate the kind of grating implements used. Pozo Azul Norte-1 (A.D. 400–800) and Los Mangos de Parguaza (A.D. 1000–1500), two archaeological sites in the middle Orinoco Valley, yielded microliths (assumed to have been part of manioc grater boards) that contained arrowroot, guapo (*Myrosma* cf. *cannifolia*), flint-type corn, a member of the ginger family (Zingiberaceae), and unidentified grass starches (Perry 2001, 2002, 2004, 2005). Dickau's (2005) study of residues from 15 archaeological sites in Panama also documented that more than one kind of plant was present on flaked stone tools (including microliths) indicating that they were used to process a range of plants.

Understanding Island Colonization

The establishment of permanent settlements on San Salvador most likely did not occur directly from the Greater Antilles, but was preceded by the colonization of neighboring islands (Keegan 1992). Crop dispersal may have occurred selectively among the expanding populations with certain crops having had greater chances of survival and propagation than others. We hypothesize that the resources brought to San Salvador helped reestablish at least a portion of the homeland horticultural system and a near, but not entirely, complete horticultural system from the previous island.

During the earliest exploration and settlement of the islands, the settlers may have selected specific plants to bring because of their ease of transport, high yield, quick maturation, storability, ability to grow under a range of conditions, caloric and nutritional value, desired taste, medicinal value, and religious-symbolic significance. Sites reflecting exploratory forays and sites early in the colonization process may yield a different repertoire of plants than later, permanent sites. The paleobotanical record, along with other material indices, may help us distinguish between permanent settlements and visits or stopovers. Knowledge of which plant stocks and seeds to bring may have been based on what the colonizers grew successfully on previous islands; as the migrants came to "settle in" (i.e., know and understand their local environments), they learned which endemic plants to exploit and which additional plants to secure through return visits to their homeland, long-distance trading expeditions, or gift exchanges.

Interisland voyaging distances and travel conditions also must have affected what people selected and brought with them. Some plants, such as manioc, were more difficult to propagate than seed plants, which appear to have been successful transfers. Corn and chiles, both seed plants, are easily transported, mature quickly, and produce high yields (in the case of corn). Chiles have a wide soil tolerance and thus could grow easily in the alkaline Bahamian soils. The quick, 90 day (or less) maturation rate of corn would have insured as many as four harvests a year, assuming moisture and other growing conditions were met. And, if the corn were harvested green, or if there were two types of corn, each maturing at different intervals, as Oviedo (1959) observed among the Taíno of Hispaniola, even more harvests may have been realized.

The evidence for the interisland transfer of roots and tubers is less well understood at the site. In a previous article, we noted that cf. *Xanthosoma* sp. or cf. *Zamia* sp. was present on two of the tools; these plants may have been present on the island prior to human settlement. It is possible, for example, that the yautía starch we tentatively identified came from a wild species (Berman and Pearsall 2000). Similarly, four species of *Zamia* grow wild in the Bahamas (Britton and Millspaugh 1962); our findings may be attributed to one of these. Domesticated yautía is propagated from cormels, setts cut from cormels, or stem cuttings (Onwueme 1978:208), and because harvested cormels can last 3.5 months at 7°C (Onwueme 1978:217), they could have been transported easily via canoe from nearby islands. Manioc plants, in contrast to maize, yautía, and chiles, would have been difficult to establish, as they must be propagated by stem cuttings, which are subject to deterioration within a short time of being taken out of the ground (Onwueme 1978:122). Manioc cuttings may not have easily survived the journey between islands. Manioc can be propagated by seed, although germination has a 50 percent or more failure rate (Onwueme 1978). Furthermore, manioc takes nine to 19 months to mature when grown from cuttings (Onwueme 1978; Piperno and Pearsall 1998), much longer than the other plants represented in the assemblage. The difficulties in transplanting manioc from stem cuttings or growing it from seed may explain its low incidence and may support the hypothesis that this site represents an early example of the colonization of San Salvador (Berman and Gnivecki 1995).

Raw Material Availability and Starch Grain Residues

In this study we hypothesized that the Three Dog site microliths would be used for multiple purposes due to raw material scarcity, and that numerous plant residues, representing artifact reuse, would be present. In order to see whether such a generalization can be supported, we looked at three other locales with evidence for starch grain deposition on microliths. Chert and quartz, the constituent materials for the microliths at Pozo Azul Norte 1 (Perry 2005), can be easily found near the site. The sources of the microliths from Los Mangos del Parguaza are also found in plentiful amounts in the area (Perry 2001, 2004). The raw materials that made up the stone tool assemblages from Panama studied by Dickau (2005), which include bipolar flakes, are within a few kilometers of these sources (Anthony Ranere, personal communication to Mary Jane Berman, May 2006).

The idea that microliths were used to process more than one kind of plant to maximize the utility of scarce raw materials is not upheld, as they appear to be present and abundant at the areas we queried. Perry (2002:8, 2005:422) argues that it was economical to process a variety of plants on a single grater board due to the high manufacturing costs required in its production (Roth 1924; Yde 1965). Other economic factors, such as transport costs due to interisland trade, may have contributed to their multiple uses. Grater boards are known to have been traded extensively within lowland South America and may have been traded throughout the Caribbean. Historically, numerous lowland South American groups such as the Taruma, Maiongkong, Guinau, and Wai Wai produced manioc-grater boards that were traded and exchanged great distances within Amazonia (Butt-Colson 1973; Chernela 1992; Im Thurm 1967; Lathrap 1973:172; Oliver 2001; Roth 1924:235; Yde 1965:34). Finally, grater boards were often decorated with patterned designs. Like other forms of material culture, the grater boards may have served as individual and group signifiers (*sensu* Wiessner 1983). Symbolic meanings unique to the owner or ethnic group, owner user preferences, as well as production and transport costs, rather than raw material scarcity, might have contributed to the multiple uses of grater boards.

Why No or Little Evidence for Manioc?[3]

With the exception of the possible secretory cell identified on one microlith (Figure 2h), why is manioc not present on the grater chips as expected?

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Manioc?[3]

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Perry (2001, 2002, 2004, 2005) identified starch grains on so-called manioc grater teeth from the Middle Orinoco Basin, but no manioc was evident. She suggests that the manioc starch may have been removed by washing the board to eliminate the manioc toxins. This may explain its near absence at the Three Dog site. Like Perry, though, we agree that this is an unlikely explanation because the other starch grains that were observed are found in deep fissures. Why would they have remained and manioc didn't? From ethnographic accounts, we know that manioc grater chips inserted in grater boards were made from other materials such as peach palm thorns, bone, teeth, shell, and hard woods (DeBoer 1975; Dole 1978). It is also possible that manioc grating was performed with other tools and/or other materials. Oviedo (1959) (in Keegan 2007:178) observed that Taíno used the rough skin of the stingray to grate a fine manioc flour. Such materials may not have survived the archaeological record or were not recognized as having been used to grate manioc and thus were not recovered and/or analyzed. It is also possible that manioc is not reflected significantly because a large crop was not harvested. It may be, too, that this sample of microliths was not used to process manioc or that the prehistoric occupants employed other methods such as roasting, a processing technology documented for lowland Amazonian groups (Dole 1978; Oliver 2001:76–77) or grinding or pounding, a processing technique observed in Puerto Rico (Pagán Jiménez and Oliver 2008; Pagán Jiménez et al. 2005). (A fragment of a grinding stone made from a non-local material was found.)

It is also possible, but not demonstrated, that the lack of manioc is due to taphonomic factors. Damage to the manioc starch grains may have been incurred through grating, rendering them unidentifiable; preservation conditions may have erased the evidence; and other taphonomic variables may be responsible for their destruction or alteration. Experimental work such as cutting manioc using flakes, pounding with stone tools, fermentation, and toasting "grated" manioc on a ceramic griddle, demonstrates that manioc starch is frequently damaged by food processing (Chandler-Ezell et al. 2006; Pearsall et al. 2005). In a toasting experiment, the experimental griddle, used for 31 cooking sessions (10 hours total), preserved abundant identifiable manioc starch (granules with extinction crosses and clear diagnostic features), and an abundance of damaged (lacking extinction crosses but not gelatinized) and gelatinized starch (Pearsall et al. 2005). Many of the hundreds of identifiable manioc granules preserved on the fragments exhibited enlarged fissures in comparison to unprocessed manioc, however, the extent to which fissure enlargement reduces the likelihood of long-term preservation of manioc is unknown. Maize granules with enlarged fissures (i.e., milling damage) typically form part of archaeological maize starch assemblages as well.

Summary and Conclusion

In an earlier study of the Three Dog site, Berman and Pearsall (2000) found evidence of arboriculture from macrobotanical remains and the possible cultivation and/or use of cf. *Xanthosoma* sp. or cf. *Zamia* sp. from starch grains present on two microliths. In the findings presented here, starch and phytolith residues on additional examples of microliths revealed maize (*Zea mays*), chile (*Capsicum* sp.), two or more unidentified root/tuber resources, one possible *Manihot* secretory cell, and evidence of undulating fruity transport tissue, indicating that the site's occupants processed seed and root/tuber plants and very likely cultivated and harvested them. Maize was the most ubiquitous of the starch remains and there was no further evidence of *Xanthosoma* sp. or *Zamia* sp. Unfortunately the search for phytoliths, which may have revealed other plants, did not prove to be as telling as the starch grain analysis. As in our earlier investigation, the phytoliths yielded mainly nondiagnostic remains.

From this study, we determined that plant resources such as corn, chiles, and root and tuber plants, including manioc, were brought to San Salvador as part of a "package" or series of "packages" to help reestablish the horticultural systems practiced on the islands from where they originated. We suggest that these horticultural systems reflect those of the homeland communities of northern Cuba or northern Hispaniola. Other root and tuber plants including *Xanthosoma* sp. or *Zamia* sp. and fruit tree seeds or stocks may have been transported, too, although they may represent wild representatives of these taxa and if so, they may have been the same or similar to resources collected or cultivated in the homeland. While we hypothesized that the presence of multiple plants on the microliths may have been related to raw material scarcity, studies in other areas where raw materials were plentiful indicated that this did not play a role in the observed pattern. Our findings support the idea that grating implements assumed to have been components of the grater boards of antiquity were used to process a variety of different plants and this practice was part of routinized behavior brought by the people who colonized San Salvador.

The study of the plant remains from the Three Dog site reveals that migration to and colonization of the island from homeland areas involved the physical transfer of some domesticated plants, as well as the knowledge of how to process, grow, and harvest them. The presence of corn at this date contradicts the idea that it did not appear in the Bahamas until after A.D. 1200, as Keegan (1987:334) has suggested, while the identification of chiles pushes back the arrival of this crop into the Caribbean. The unexpected near absence of manioc starch on the microliths can be attributable to a number of explanations, none of which proves unequivocably that it wasn't cultivated. Finally, more domesticated and cultivated plants may have been brought to the island by later colonists and the plant repertoire may have been supplemented through trade, gift-giving, wife-exchange, or other means of resource-transfer.

The botanical assemblages of En Bas Saline (Newsom 1993; Newsom and Pearsall 2003; Newsom and Wing 2004) and the Tutu site (Pearsall 2002) reveal a late prehistoric horticultural system based on roots/tubers, maize, herbaceous plants (including wild or domestic *Capsicum*), and arboriculture. With the exception of chiles, this pattern was in place by the Archaic age in Puerto Rico and, as we argue, fully in place by at least A.D. 700–800 in Cuba or Hispaniola and brought to the central Bahamas. By A.D. 1150, there is evidence of maize, zamia, beans, sweet potato, maranta, yautía, Fabaceae, and Poaceae in southeastern Cuba (Rodríguez Suárez and Pagán Jiménez 2006, 2008:162); this study suggests that at least some of these plants may have been present earlier there. In spite of the differences between the larger, more environmentally complex islands of Hispaniola and Cuba, and the smaller, drier, carbonate Bahamas, these crops could be grown and were used for food. Thanks to the entries of Columbus from Long Island, Bahamas, we know that the Lucayans continued to grow maize in the central Bahamas for approximately 700 years subsequent to its introduction. While the hydrological and edaphic conditions may not have been ideal for the cultivation of corn, they were sufficient and the Lucayans may have selected certain races or developed ways of insuring successful harvests. Finally, our study substantiates other recent work in the Neotropics that indicates that an important, if not primary, means of recovering evidence for plant use is through the study of microfossils. The study should serve as one more caveat to investigators (e.g., DeBoer 1975) who infer manioc production and consumption from the presence of microliths that resemble ethnographically reported manioc grater chips and is one more example of how "a new archaeobotanical technique can produce data that fail to support a long-held inference derived originally from ethnographic observations and historical accounts" (Harris 2006:68). A close reading of the ethnographic literature indicates that Amerindians did not use manioc grater boards exclusively for manioc, but somehow, this idea has made its way into the literature and influenced the interpretations of several generations of scholars.

A persistent question in the Caribbean archaeological record is why we do not find macrobotanical evidence of maize, manioc, and other domesticates such as chiles, prior to the later parts of the Chican and Elenan Ostionoid periods and why such remains have been limited to Hispaniola, the Virgin Islands, and Nevis (in the case of manioc) (Newsom 2006). The question has become more pertinent now that starch grain and phytolith evidence indicates maize, manioc, beans, sweet potatoes, and other plants from throughout the northern Antilles and has pushed back their appearance in the archaeological record to the Archaic age. As we (Berman and Pearsall 2000) and others have argued, archaeologists working in the Caribbean should employ an inclusive approach using macrobotanical and microbotanical means of data recovery and analyses to gain a more complete and richer picture of what Newsom (1993), Newsom and Pearsall (2003:354), and Newsom and Wing (2004) describe as a "uniquely Caribbean subsistence system" and a "uniquely Caribbean approach to plant production" (Newsom 2008:181). In this study, such analyses help identify which domesticates were grown in Cuba or Hispaniola during the eighth and ninth centuries A.D., define the system of early Lucayan plant use in the central Bahamas, address questions of tool use, and contribute to the delineation of what "transported" landscapes looked like and how they took shape during this period of history in this particular island environment.

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Notes

1. Stable isotope analyses offer another means of assessing the presence of corn (and other plants) in the diet (Stokes 1998), although the explanatory potential of the method is undermined by the conflicting results offered by zooarchaeological and paleoethnobotanical analyses (deFrance et al. 1996). In the Bahamas, stable isotope determinations from bone collagen and apatite carbonate of eight Lucayan individuals from cave sites on Abaco, Crooked Island, Eleuthera, Long Island, and Rum Cay were analyzed to establish the comparative contributions of maize, manioc, and other dietary resources. The studies suggest that the Lucayan diet was composed mainly of C3 plants and marine resources, while C4 plants (including maize) were not "incorporated into the Bahamian diet in any observable quantities" (Stokes 1998:226). Because none of the sites from which these skeletons originated was dated and only two of the skeletons, which were directly dated through radiocarbon means, come from periods later than the Three Dog site [A.D. 1175–1295 (Long Island), A.D. 1375–1450 (Crooked Island)], it is difficult to infer if any dietary shifts occurred from early to late periods in these populations. Keegan's earlier study of 17 Lucayan skeletons analyzed bone collagen (Keegan and DeNiro 1988), which has since been proved to reflect the source of protein to the diet, not the correct estimates of plant foods (Stokes 1998:141). Earlier, Keegan argued that some evidence of C4 plants was present in several skeletons. His suggestion that maize was consumed seasonally is a good one, worthy of further investigation.

2. The attribution of multiple uses can be extended to the study of griddles, often used as companion indicators of manioc. As DeBoer (1975) and Rodríguez Suárez and Pagán Jiménez (2006, 2008) caution, griddles may have been used to bake manioc bread, as well as bread made from maize and other plants. Allaire (1984:127) notes that the Island Carib used griddles to crack open or dry rotting seeds of the *koua-*

heu tree, which produced oil that men used for their hair. Dole (1978:237) and Pickersgill and Heiser (1977:817) observed that Amerindians use ceramic griddles to prepare foods from a variety of plants, including manioc.

3. At least two other Caribbean starch grain studies have noted the absence of (Rodríguez Suárez and Pagán Jiménez 2008) or "lower than expected visibility" (Pagán Jiménez and Oliver 2008:153) of manioc.

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