Linking Past and Present: A preliminary paleoethnobotanical study of Maya nutritional and medicinal plant use and sustainable cultivation in the Southern Maya Mountains, Belize

Research

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Abstract

Paleoethnobotanical analysis of anthropogenic soils sampled from archaeological features dating to the Classic Maya Period (A.D. 250-900) reveal diagnostic phytoliths that help the authors bring to light evidence of a novel sustainable agricultural strategy and a variety of nutritional and medicinal plants that were utilized by the Classic Maya of the Maya Mountains, Belize, Central America. Given the archaeological context of these phytoliths, the authors infer that the plants from which they were derived were exploited by the Classic Maya of the region. These discoveries have the potential for improving health and wellness regionally in the present since the agricultural strategy that is reconstructed demonstrates an intensive means of cultivation that has the potential of sustaining large, dense populations. The nutritional and medicinal plants alluded to, in turn, provide further evidence in support of the utilization of traditional knowledge in sustaining community health and wellness.

Introduction

In recent years, the view of the ancient Maya, as imprudent exploiters of their environment with little regard for sustainability (e.g., Diamond 2005), has begun to change (Ford & Nigh 2009). Research has shown that the Maya lowlands during the Classic period (A.D. 250-900) were one of the most densely populated areas in the world (Fagan 2004:284). In some regions in the Maya lowlands, such as the southern Maya Mountains, population density estimates near 300 persons per squared kilometer (Abramiuk 1998). This estimate is quite staggering, especially if we consider that the people of this particular region had no efficient means for importing foodstuffs and therefore probably had little sustentive support from outside their vicinity.

Lack of habitable, arable land except for the relatively few alluvial pockets circumscribed by high karstic cliff faces forced the people of the southern Maya Mountains to settle on and between areas used for agricultural purposes. Here, the ancient Maya had to maintain a lifestyle in which the available arable land was used frugally and efficiently. To maintain this lifestyle for any length of time is something that we argue required a quite sophisticated understanding of sustainability and it is the techniques implemented by these people in pursuit of sustaining their high populations that we argue can and should be learned from. Indeed, a reimplementation of these ancient techniques in today's highly populated conditions, which in many ways resemble those we are investigating, may, in fact, be beneficial.

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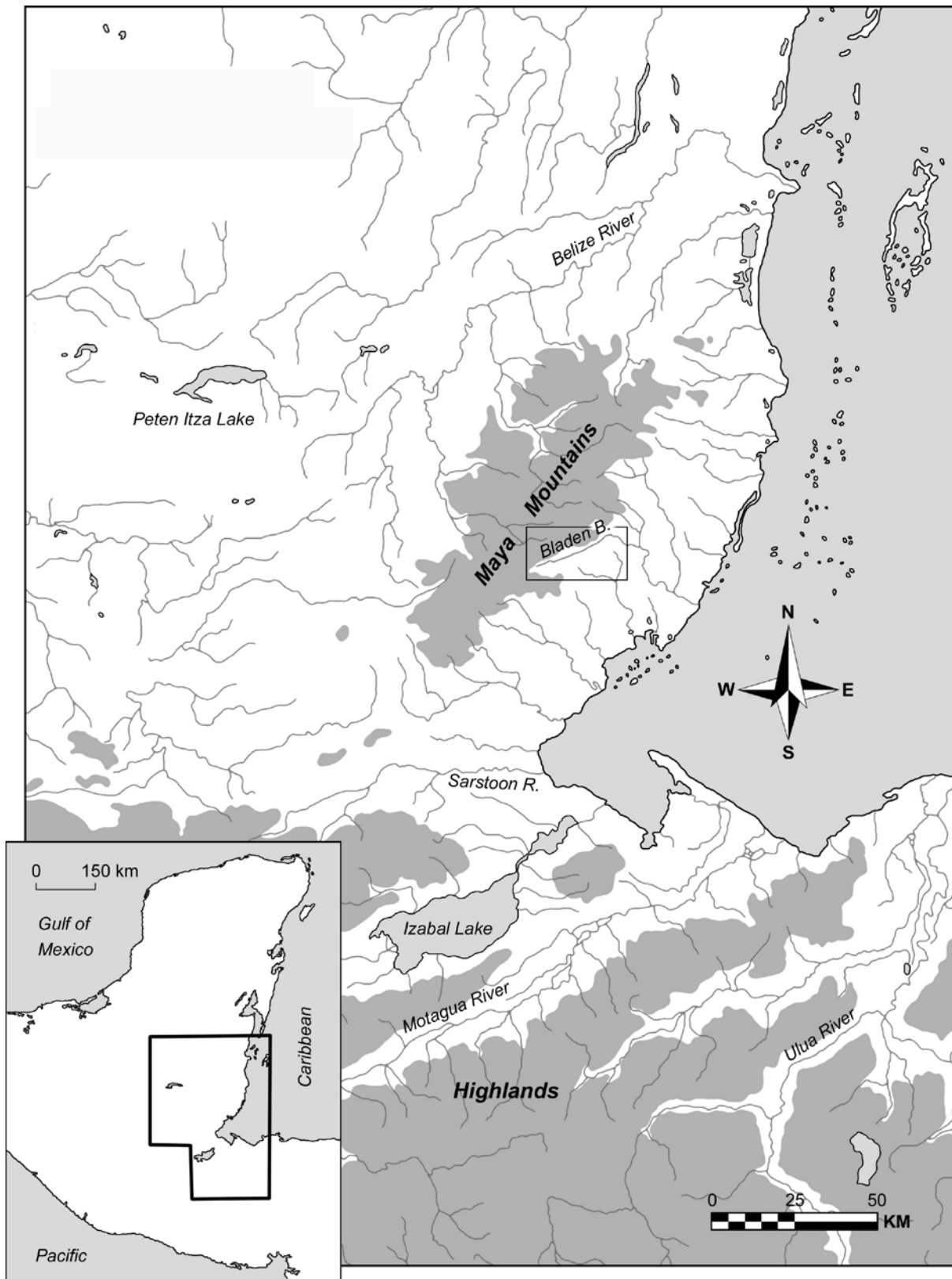t.pesek@csuohio.edu

Figure 1. Central America with focus on the Southeastern Maya area and location of a geologically distinct region in the Maya Mountains known as the Bladen Branch. Map by C. Helmke & M. Abramiuk.

We propose two potential directions that might be explored for learning more about how the ancient Maya sustained themselves in the southern Maya Mountains and which we suggest might be reimplemented to improve environmental and human health conditions today. One is to look at the kinds of plants that the Classic Maya in this region used for nutritional and medicinal purposes. The second is to examine how they sustainably cultivated their plants. We rely primarily on ethnographic analogies, particularly with contemporary Maya groups, as a means of interpreting many of our findings.

Background

The Maya Mountains run along a southwest-northeast axis in the interior of Belize (Figure 1). The northeast end of the range is located in the present day Stann Creek District of Belize while the southwest end of the chain extends into neighboring Guatemala. The entire massif is some 150 kilometers in length and 75 kilometers in width. Although considered to be a relatively low mountain range (the

highest point, Doyle's Delight, is 1,200 meters above sea level), this is the only mountain range in the entire Maya lowlands (West 1964, Wright *et al*. 1959). What the Maya Mountains lack in height, they make up for in ruggedness and they constitute a formidable area to penetrate. It is for this reason, as well as the perceived facts that the Maya Mountains exhibit little value in terms of modern mineral resources (Dixon 1956, Graham 1994) or extensive cultivable land (Wright *et al*. 1959), that the mountains are uninhabited and commercially unexploited today. Although lacking in commercially valuable mineral resources today, the Maya Mountains zone comprises a wide range of mineral and biotic resources that provided attractive opportunities for resource exploitation for the Maya during the Classic Period (Abramiuk & Meurer 2006, Dunham 1996, Graham 1987).

The Classic Maya sites we consider in this study occupy a geologically distinct region in the Maya Mountains known as the Bladen Branch region (Figure 2). The Bladen Branch region consists of the only known exposed vol-
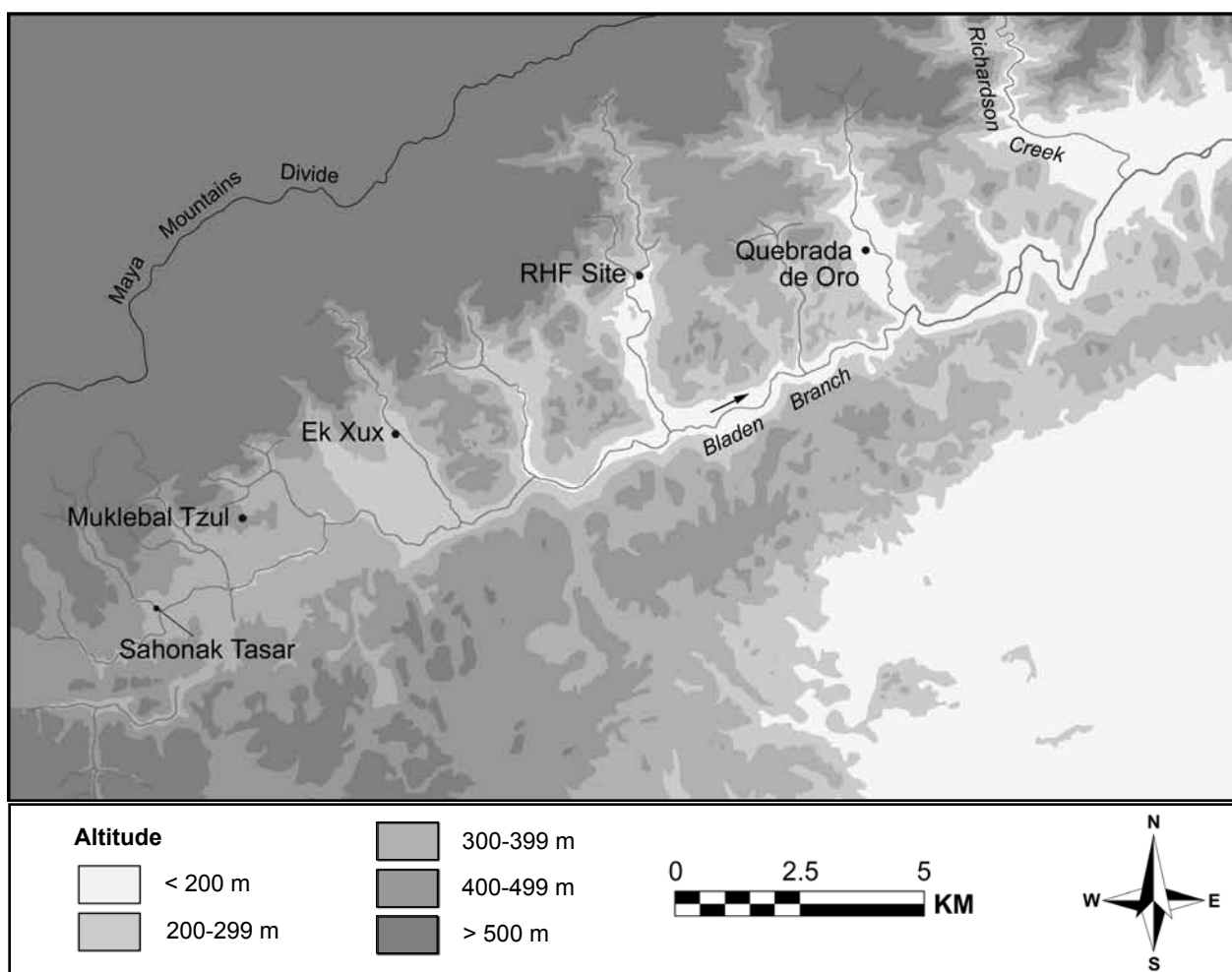

Figure 2. Study area with locations of sites studied in the Bladen Branch, Southern Maya Mountains, Belize. Map aligned to UTM grid north. Map by M. Abramiuk & C. Helmke.

canics and volcaniclastics in the Maya Lowlands, referred to as the Bladen Group of the Santa Rosa Formation (Bateson & Hall 1977). The volcanics and volcaniclastics have been exposed due to the long-term coursing of the Bladen Branch and its associated tributaries which have cut through an onlap of late Cretaceous and early Tertiary limestone covering the Bladen Group. Alluvial erosion of the Bladen Group has resulted not only in areas flat enough to accommodate settlement, but has produced distinctively acidic soils that exhibit excellent conditions for preserving paleobotanicals, and, in particular phytoliths.

Previous Research on Classic Maya Cultivation Methods

Traditionally, Mayanists have delineated four main cultivation techniques that the Classic Maya utilized to sustain their well-established dense populations: swidden agriculture (Culbert 1988, Nye & Greenland 1965), raised fields (Puleston 1977, Siemens & Puleston 1972, Turner 1974), irrigation (Turner 1974), and terracing (Flannery 1982, Turner 1974), which was sometimes facilitated by fertilization (Demarest 1996). Depending on the method implemented, cultivation would have yielded different results, which, in turn, would have affected the carrying capacities of Classic Maya settlements. Clearly, some methods would have been more efficient than others thereby increasing the carrying capacities in the areas in which the methods were implemented. Each method is advantageous depending on the environment, and humans will often resort to the method that produces the highest yields for their settlement. With the exception of irrigation and raised fields, which can be combined to form **tablónes** (Mathewson 1984), swidden, raised fields, irrigation, and terracing were typically seen by archaeologists as exclusive techniques (e.g., Flannery 1982). That is, in any given region, one of the four methods discussed constituted the dominant strategy, and while different techniques might be found within a short distance of each other, they tended not to be combined on the same plot of land.

In addition to the four methods of agriculture mentioned above, it is has been proposed that the Classic Maya engaged in agro-forestry (Atran 1993, Gomez-Pompa & Kaus 1990). Rather than cut down extensive tracts of land to build their cities, the Maya maintained a constant supply of trees within their city limits. These trees would have provided shade from the tropical sun as they do today, and they would have provided food. The notion that Maya cities were "green" cities seems supported by patterns in the vegetation around Maya ruins.

For instance, several sorts of trees shown to have a strong association with Maya ruins are **ramón** (*Brosimum alicastrum* Sw.), cacao (*Theobroma cacao* L.), and **coyol** (*Acrocomia aculeata* (Jacq.) Lodd. ex Mart.). Puleston (1982) was one of the first to advocate the notion that the

Maya were growing **ramón** as an additional starch staple to maize. Unfortunately, it is still unclear how significant **ramón** was to the Classic Maya diet. Although it is grown and eaten today among the Yucatec Maya, the fact that **ramón** seems to cluster around Maya ruins could be due to the fact that they prefer to grow on or near limestone, precisely the kind of rock that was used to construct Classic Maya buildings (Lambert & Arnason 1982). Future research will seek an explanation for this **ramón** / ruin relationship. More clear is the evidence of agro-foresty practices discussed by Lentz (1991). The data collected by Lentz (1991) indicates that **coyol** (*A. aculeata*), which grows around the ancient Maya site of Copan, was introduced into the Copan valley by the Maya when they settled the valley. Finally, the most clear evidence of a tree variety that is found around ancient Maya sites and which likely was the result of ancient Maya agro-forestry practices is **cacao** (see Gomez-Pompa & Kaus 1990). The fact that **cacao** is found associated with ancient Maya archaeological sites in the northern and central Yucatan, where the most of the natural habitat has been ill suited for **cacao** since at least the dawn of the Holocene, is a testament to the economic value that this tree held for the Maya and the desire to have these trees growing near their settlements (Whitkus *et al*. 1998). Cacao has even been observed to grow in high concentration and in plots around the ancient Maya settlements of the southern Maya Mountains sites (Dunham & Pesek 2000).

In addition to the archaeological evidence for agro-forestry, it seems likely from ethnographic and ethnohistoric accounts that some form of agro-forestry was being conducted. Atran (1993), for example, argues strongly that the Itza Maya of Peten practice a form of agro-forestry, which was passed down to them from earlier times. Atran argues that knowledge of this agricultural method was preserved in the social memory of the Maya from Early Classic times. Indeed, Atran goes so far to say that the Classic Maya collapse was in part due to a shift from agro-forestry techniques to mono-cropping and more wasteful methods such as slash-and-burn agriculture.

Although much attention on ancient Maya agriculture has tended to center around one particular subsistence plant, namely maize, and the monocropping thereof using a well understood cultivation strategy, studies such as Atran's (1993) have been reporting more complex methods. One such instance of complex strategy that has been observed is the use of housegardens for growing not only subsistence plants, but also certain medicinal plants as well (Anderson 2003, Kashanipour & McGee 2004).

Kashanipour and McGee (2004), for example, observe that the Lacandon are adept not only at identifying and using medicinal plants in the wild, but often grow them in their housegardens. This is similarly observed among the Q'eqchi' Maya of southern Belize. Q'eqchi' Maya healers not only grow medicinal plants at their housegardens,

but team together to grow medicinal plants in a communal venue, one of which, in southern Belize, goes by the name of Itzama (Otarola Rojas *et al*. 2010, Pesek *et al*. 2007). The Q'eqchi' Maya healers associated with this garden are actively involved in importing medicinal plants from the wild and cultivating them so that they may have easy access to a variety of medicinal plants for their patients and communities. These healers offer their services as primary healthcare providers to over 30 different villages throughout the Toledo District of Belize.

Specialized healers are not the only individuals who prepare medicines—although they are the most knowledgeable about preparation—but common folk do as well. Widespread knowledge of medicinal plant preparation is not only observed among the Q'eqchi' of southern Belize, but also among the Lacandon (Kashanipour & McGee 2004). The Lacandon are predominantly self-healing and a major source of medicinal plant knowledge is acquired from the family. It is therefore in the household that concoctions and decoctions are prepared, the remains of which are commonly disposed in the garbage or compost pile.

The ancient Maya, because of their shared notions toward field and forest, were also likely very adept at cultivating medicinal plants as well as nutritional plants in their gardens and concocting and decocting medicines at home. This claim is supported by the divisive manner in which Classic Maya urban / residential areas were segregated from forests (Christophe Helmke 2006, personal communication, Taube 2003) and the logical need for resources of the forest such as medicinal plants and their derivatives to be kept close to home.

Methodology

We concentrate our efforts particularly around the Classic Maya sites of Quebrada de Oro, Ek Xux, and Muklebal Tzul (Figure 2). Our study methodologies were approved by the Institutional Review Board of Cleveland State University, Cleveland, Ohio, U.S.A. Using minimally invasive techniques, and with the support of the Government of Belize, via permits issued through Forest Department and the Institute of Archaeology, we conducted select excavations in the Bladen Branch region to seek out evidence of plant utilization and cultivation. Our excavations and field investigations were conducted by a transdisciplinary team comprised of archaeologist, ethnobotanist, three Q'eqchi Maya bushmasters, and two Q'eqchi Maya traditional healers. The contemporary Maya served as cultural brokers to their ancient past. The features we selected to excavate were homed in on during prior exploratory research phases over the past 10 years.

Field Methodology

Based on contemporary ethnobotanical and ethnographic observations of local Maya plant cultivation and use, there were several archaeological contexts that could potentially have been examined for evidence of nutritional and medicinal plants. The contexts that were selected were regions where these plants were likely to have been 1) grown, and, 2) prepared.

In selecting a context where such plants would have likely been grown, we examined the soils of a most conspicuous feature called Sahonak Tasar, which is a series of stone-walled terraces on a hillside near the Classic Maya site of Muklebal Tzul. Because of Sahonak Tasar's proximity to the site of Muklebal Tzul, it appears to have supplied the growing population at that community with agricultural products, but its produce is representative of what was likely grown at all the Bladen communities, based on the evidence that we have for the material cultural interconnectedness among the Bladen communities (Abramiuk & Meurer 2006).

At Sahonak Tasar, we began by excavating an exposed portion of the terraces. Due to erosion, a portion of the terraces had collapsed revealing a stratigraphic record of the episodes documenting Sahonak Tasar's formation (Figure 3). Using standard excavation procedures, the exposed wall recording the stratigraphy was straightened and cleaned using a trowel and the stratigraphy was drawn and photographed. A two-kilogram soil sample was taken from every stratum from within the strata (to avoid contamination), and two samples were selected for analysis. The two samples selected for analysis were taken from adjacent strata and they represented each of the different soil types observed: sandy loam and sandy clay loam.

In selecting a preparatory context, we looked at several residential middens where overflow from preparation of food and medicines would likely be found. Middens are ancient refuse heaps, and it was reasoned that if food and medicines were being prepared in the same manner that Maya today prepare their food and medicines, namely at their homes, that the evidence for medicinal and nutritional plant preparation could be found in their compost piles or garbage.

To collect the soils from the residential middens, six test pits, 1x1 meters in area and of varying depths, were inserted in regions where middens were most likely to be found, namely regions adjacent to residential structures. These pits were excavated in arbitrary 20 cm intervals to a maximum depth of one meter or until we reached the bottom of middens. Of the six test pits, five pits were confirmed to have intersected middens. These five middens were identified based on soil color and contents (i.e., presence of artifacts and ecofacts), differing significantly

from the soils extracted from two 1x1 meter control test pits dug at least 250 meters away from the nearest evidence of human habitation. Soil color was recorded using a Munsell soil color chart and the midden contents were bagged separately for each arbitrary level. No arti-

facts or ecofacts were observed in the surrounding soils or controls. Two-kilogram soil samples were also taken from each arbitrary level within the middens and the soils surrounding the middens.
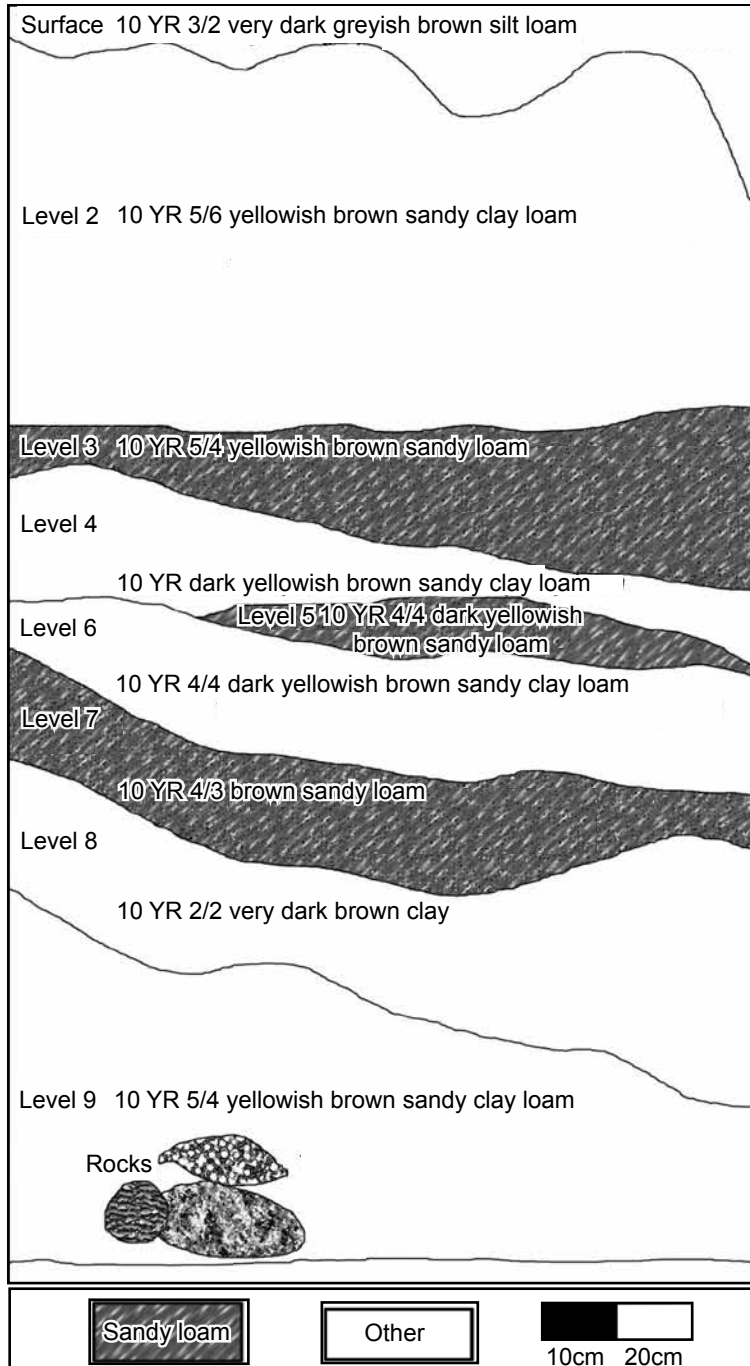

Figure 3. East profile of terrace with colors and textures of soils of a most conspicuous feature called Sahonak Tasar, which is a series of stone-walled terraces on a hillside near the Classic Maya site of Muklebal Tzul, Bladen Branch, Southern Maya Mountains, Belize. See Dunham *et al*. 2009 for original and discussion.

Illustrations were made of the wall profiles of all six test pits; the wall profiles of the test pits that intersected the two largest and most clearly delineated middens are shown in Figures 4 and 5). It was the soils from these middens that were selected for paleo-ethnobotanical analysis and upon which we report below. Both midden features consisted of light olive brown soils containing charcoal, limestone fragments, hematite, ceramic sherds, chert blade fragments, and most importantly for the present study, paleoethnobotanical remains. The first of these two middens was located on the outskirts of the Quebrada de Oro proper at the southern base of a residential structure, approximately 600 meters north of the site core. The other midden was located near the southern base of a residential complex within the Ek Xux site core.

Laboratory Methodology

Four soil samples were selected for preliminary pollen and phytolith analysis (Figures 6 and 7). Sample M2 was taken from a midden adjacent to a residential structure in the Quebrada de Oro valley. Sample X3 was taken from a midden adjacent to a settlement structure located in the Ek Xux valley. Samples TL-6 and TL-7 were taken from two exposed adjacent strata at Sahonak Tasar.

Because pollen preservation is less than ideal in these soils, and pollen density much lower than that observed from peat and lake sediment samples, a large volume, chemical extraction of pollen, based on heavy liquid flotation was used. Each 65 ml sample was tested for carbonates, then screened through 250 μm mesh using reverse osmosis deionized (RODI) water. Clays were removed using sodium hexametaphosphate and gravity settling, followed by rinsing with ethylenediaminetetraacetic acid (EDTA), which also removes trace metals and humic substances. Heavy liquid separation, using sodium polytungstate (SPT), with a density 1.8 g/ml, separated pollen from inorganics. The light fraction was retained, concentrated through centrifugation, and treated with a short (20-30 minute) treatment in hot hydrofluoric acid to remove any remaining inor-
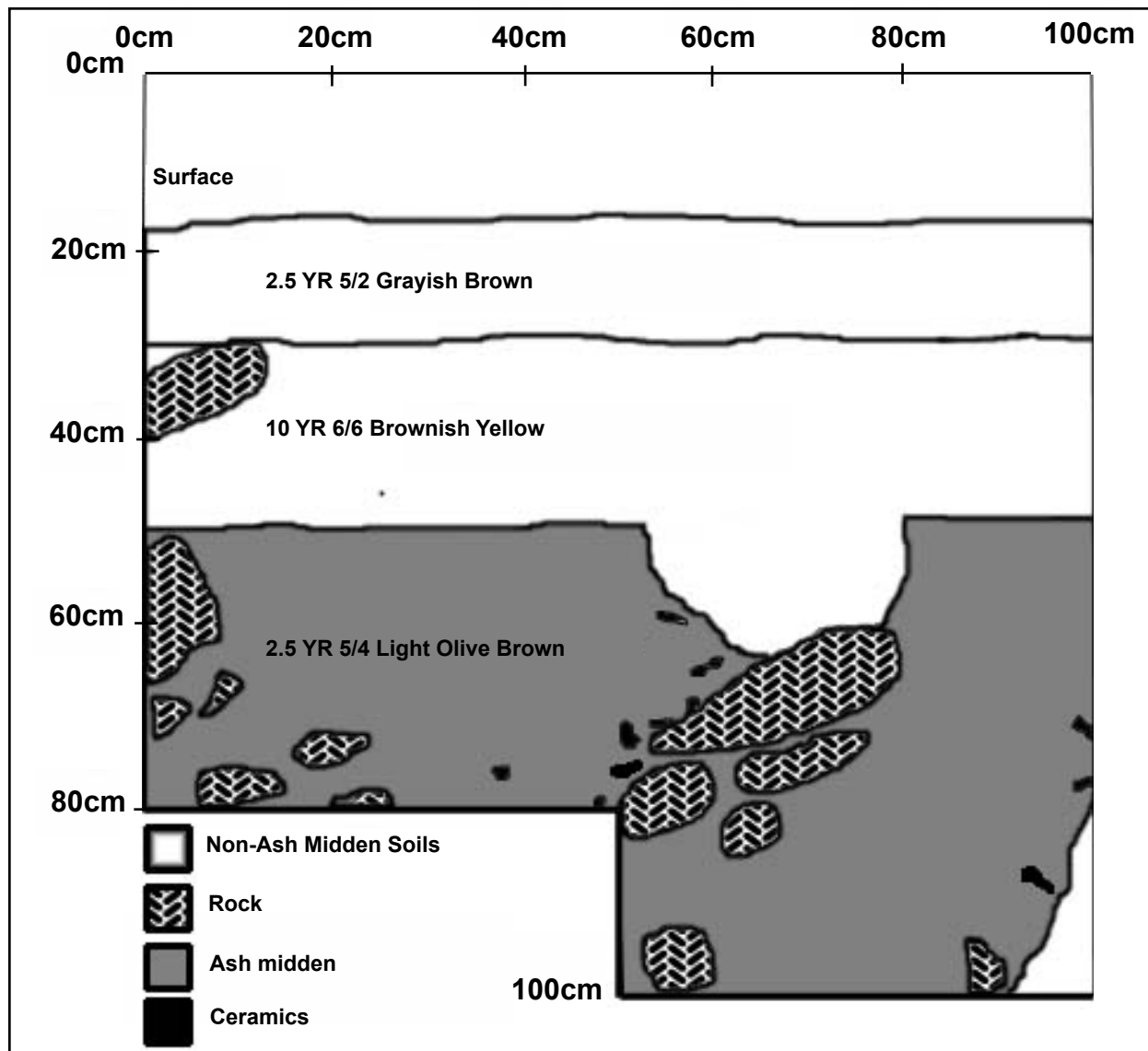
Figure 4. Northeast wall profile of excavation unit showing ash midden from which phytoliths were extracted. This unit was inserted at the southwestern base of a housemound in the Ek Xux valley, Bladen Branch, Southern Maya Mountains, Belize.

ganic particles. The samples were then acetolated for 3-5 minutes to remove any extraneous organic matter.

A light microscope was used to count pollen grains at a magnification of 500x. Pollen preservation in these samples varied from good to poor. Total pollen concentrations are calculated in Tilia©, the pollen diagramming program (Grimm n.d.), using quantity of sample, quantity of exotics (spores added to each sample), quantity of exotics counted, and quantity of pollen counted. Indeterminate pollen included pollen grains that are folded, mutilated, and otherwise distorted beyond recognition. These grains are included in the total pollen count since they are part of the pollen record.

Extraction of phytoliths from each sediment sample was based on the oxidation of organic matter, followed by heavy liquid floatation. Sodium hypochlorite was first used to oxidize part of the organic fraction from each 15 ml sediment sample, followed by rinse cycles to neutral, then the addition of hydrogen peroxide to remove any remaining organics. Samples were transferred to 250 ml beakers, and a 5% sodium hexametaphosphate solution was then added to deflocculate and suspend clay particles. Each sample was stirred and allowed to settle by gravity for 2 hours, then decanted to remove the clays. Gravity settling and decantation was repeated 5 times until the supernatant was clear. The remaining silt and sand-size fractions were transferred to 50 ml centrifuge tubes, fro-
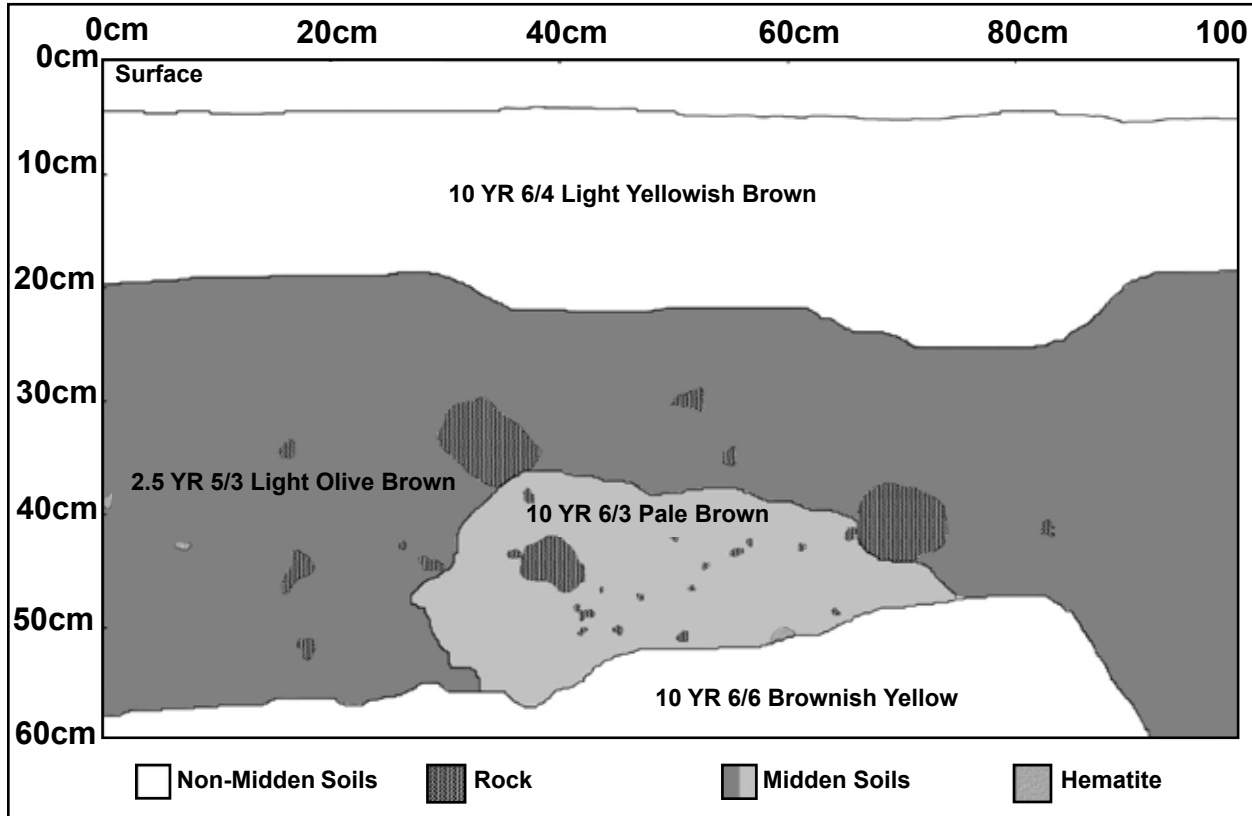
Figure 5. North wall profile of excavation unit showing midden from which phytoliths were extracted. This unit was inserted at the southern base of a house mound in the Quebrada de Oro valley, Bladen Branch, Southern Maya Mountains, Belize.
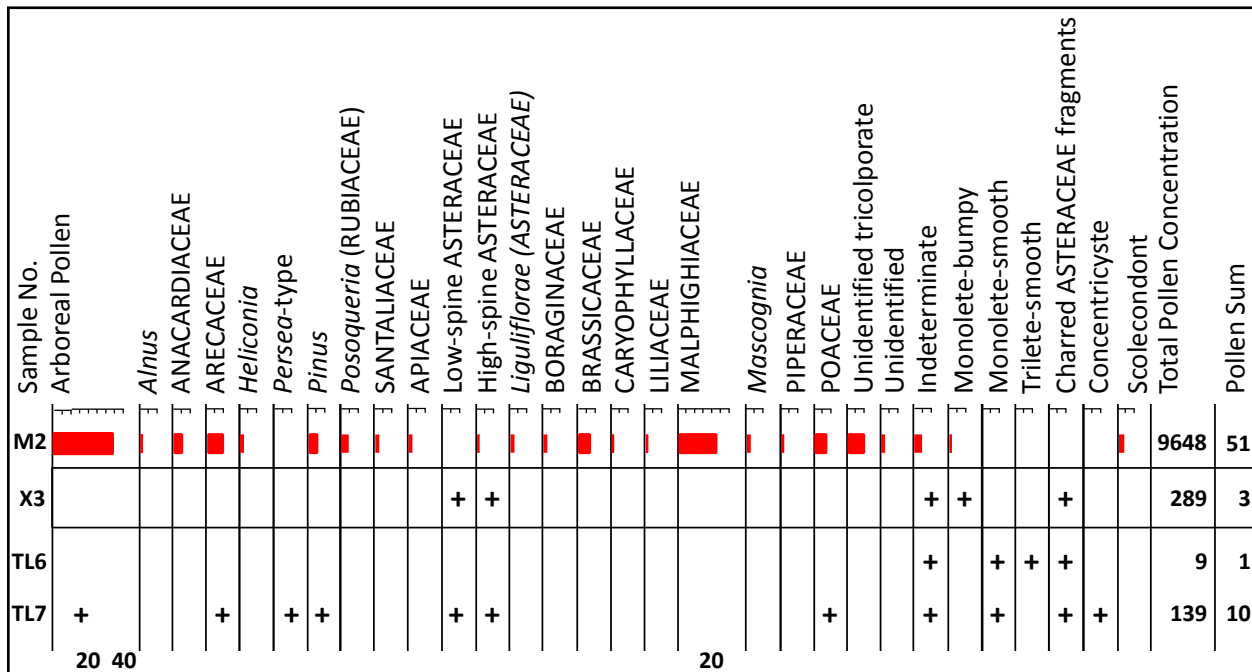

Figure 6. Preliminary percentage pollen diagram (Concentration in pollen per cc of sediment) for the samples collected in the Bladen Branch region, Southern Maya Mountains, Belize. Sample M2 taken from a midden adjacent to a residential structure in the Quebrada de Oro valley. Sample X3 taken from a midden adjacent to a settlement structure located in the Ek Xux valley. Samples TL-6 and TL-7 taken from two exposed adjacent strata at Sahonak Tasar.

Figure 7. Preliminary percentage phytoliths for samples collected in the Bladen Branch region, Southern Maya Mountains, Belize. Sample M2 taken from a midden adjacent to a residential structure in the Quebrada de Oro valley. Sample X3 taken from a midden adjacent to a settlement structure located in the Ek Xux valley. Samples TL-6 and TL-7 taken from two exposed adjacent strata at Sahonak Tasar.
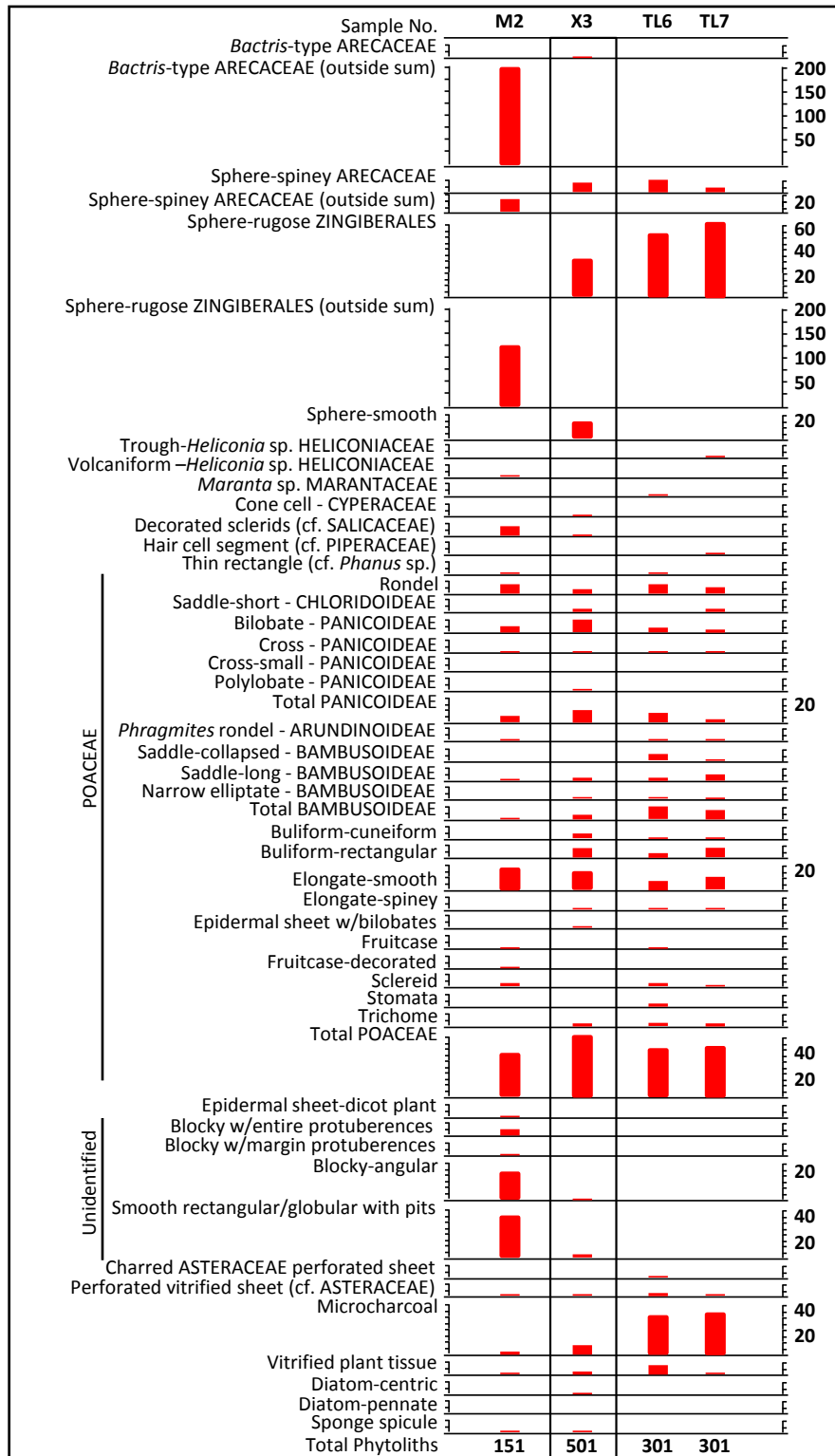
zen, and dried under vacuum. The dried samples were then mixed with a heavy liquid solution of potassium/cadmium iodide (KI/CdI$_2$) prepared to a density of 2.3 g/ml, centrifuged (10 min, 1500 rpm) and then decanted to separate the lighter biogenic opal silica phytoliths, as well as diatoms and sponge spicules, from the remaining material. Samples were then rinsed with distilled water, followed by isopropyl alcohol. A small subsample was mounted in optical immersion oil for counting with a light microscope at a magnification of 400x. Phytolith micrographs were taken using a Nikon Coolpix 4500 microscope phototube mount (Figure 8).

Results

A large number of diagnostic phytoliths were isolated from the soil samples taken from Sahonak Tasar and from the middens. With the exception of the pollens found in the Quebrada de Oro midden, represented by sample M2, the pollens were less diagnostic. The reason for the poor condition of pollen at the majority of contexts explored and the good conditions observed at the Quebrada de Oro midden, may have to do with the fact that there is significantly more evidence of burning at the Ek Xux midden and at Sahonak Tasar than at the Quebrada de Oro midden, suggesting that pollen in those middens was destroyed by fire.

The pollen record represented by sample M2 (from the Quebrada de Oro midden) yielded 24 pollen types (Figure 6), only a few of which were unidentifiable. Specifically, five pollen (10% of the sample) described as unidentified tricolporate pollen on the
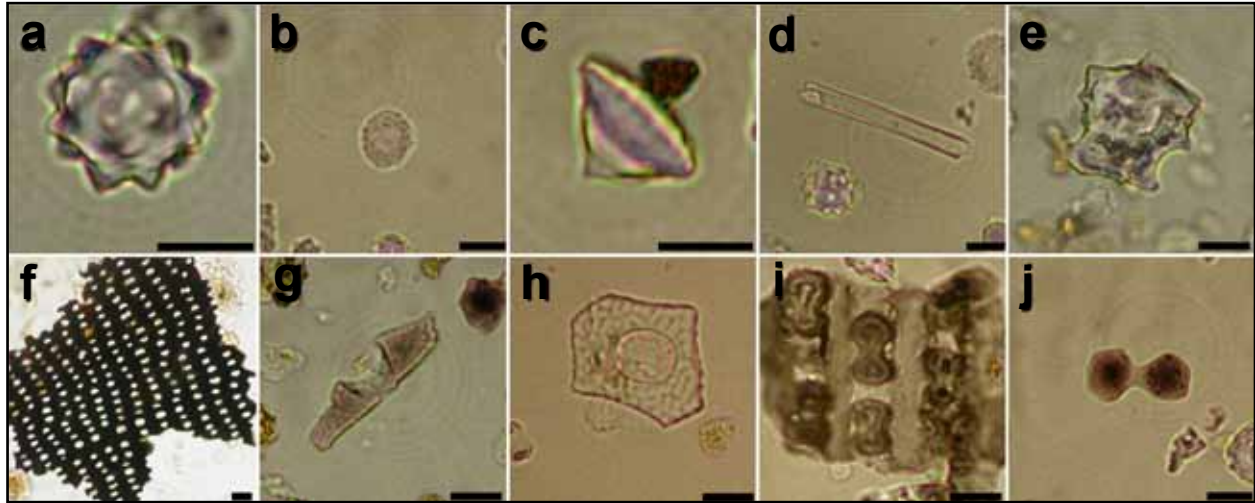
Figure 8. Selected phytoliths recovered from features and stratigraphic samples from the Bladen Branch region of the Southern Maya Mountains, Belize. Scale bar = 10µm. Phytolith micrographs **a-c** are from sample M2 taken from a midden adjacent to a residential structure in the Quebrada de Oro valley, **d-g** are from sample TL6 taken from an exposed strata at Sahonak Tasar, and **h-j** are from sample X3 taken from a midden adjacent to a settlement structure located in the Ek Xux valley. **a**. Globular echinate diagnostic of the Arecaceae. **b**. *Bactris*-type spinulose conical body diagnostic of the Arecaceae, but may be distinctive of certain palm genera such as *Bactris*, *Geonoma*, *Caryota*, and *Chamaedorea*. **c**. *Bactris*-type in side-view. **d**. Fresh-water sponge spicule fragment. **e**. Morphotype diagnostic of the Marantaceae, and likely derived from the seed of arrowroot (*Maranta arundinacea* L.). **f**. Opaque perforated platelet diagnostic of an Asteraceae inflorescence. **g**. Morphotype with trough diagnostic of the wild plantain family (Heliconiaceae). **h**. Achene phytolith highly distinctive, and possibly diagnostic of the Cyperaceae genera *Kyllinga* and *Cyperus*. **i**. Charred silicified sheet fragment of long-cells and bilobate-type short-cells diagnostic of the Poaceae subfamily Panicoideae, and likely derived from leaf material. **j**. Irregularly angled rugulose chain fragment diagnostic of the order Zingiberales, and possibly derived from *Canna*.

diagram may be identified after we collect additional reference material in the field to expand our reference collection for this purpose. Only 3 pollen (6% of the pollen in the sample) were too poorly preserved to identify. The pollen recovered in this sample indicate that that local vegetation included multiple taxa of the palm family (Arecaceae); *Heliconia* (Heliconiaceae); *Alnus* (Betulaceae); *Posoqueria* (Rubiacaceae), and a taxa of the Santalaceae. Recovery of Arecaceae pollen indicates that palms were part of the local vegetation community. Forbs growing at the site include taxa of the Apiaceae, Asteraceae (sunflower), Boraginaceae (borage), Brassicaceae (mustard), Caryophyllaceae (pink), Liliaceae (lily), and Malpighiaceae, Piperaceae (pepper), Poaceae (grass), and ferns.

The phytolith record for sample M2 (Figure 7) was overwhelmingly dominated by conical and spherical morphotypes, most of which are derived from the palm family (Arecaceae) (Figure 8a-c). Since their abundance was so great, they were counted outside the total phytolith sum, giving rare types a greater opportunity for observation. Palm family *Bactris*-type conical phytoliths were the most abundant morphotype observed; however, they are not diagnostic of the genus *Bactris*, as they have been documented in the palm genera *Geonoma* and *Chaemaedorea* as well (Piperno 2006). Local palm family reference ma-

terial (e.g., leaves and fruit) may allow for genera specific phytolith determination.

Rugose and verrucate spheres, diagnostic of the order Zingiberales (canna, ginger, arrowroot, heliconia, etc.) were almost as abundant as the *Bactris*-type spheres. Although not diagnostic, the rugose spheres observed here are very similar to those reported for the genus *Canna* (Pearsall 2008). Rugose spheres are also noted as occurring in the family Bombacaceae (now within Malvaceae). Analysis of reference plant material may help identify the origin of these rugose and verrucate spheres.

Of the "in sum" phytoliths, grass-types (Poaceae) were most common. Grass phytoliths diagnostic of the subfamily Panicoideae were abundant and may be derived from grasses such as *Ichnanthus*, *Isachne*, *Lasiacis*, *Oplismenus*, and economically important grasses *Coix* (Job's tears) and *Cymbopogon* (lemon grass). Since panicoids are abundant producers of bilobate phytoliths, a morphometric bilobate reference study of wild and cultivated grasses would likely provide increased resolution and genera determination. Other diagnostic phytoliths observed indicate the presence of wild plantain (Heliconiaceae) and sunflower family species (Asteraceae).

Although not diagnostic, decorated sclereid phytoliths common in the genus *Casearia* (Salicaceae) were also observed. It should also be noted that a few of the "unidentified" phytoliths listed in Figure 7 have a resemblance to those described from the Lauraceae and Araceae families; however, further reference material would need to be examined. Overall, the phytolith record for sample M2 was dominated by phytoliths diagnostic of the palm family (Arecaceae) and the order Zingiberales (*Canna*, ginger, etc.), with all other types occurring in low to rare frequency. This is consistent with discard of these plants in the midden, rather than identification of composition of the local plant community.

Pollen preservation in sample X3 (from the Ek Xux midden) was poor because the location had been burned, removing most of the pollen that probably existed from the extant surface. The phytolith record for sample X3 (Figure 8**h-j**) was well preserved and exhibited a high phytolith concentration in relative comparison to the others samples examined in this study. This sample was dominated by phytoliths diagnostic of grasses (Poaceae) and the order Zingiberales (*Canna*). Arboreal species such as palms (Arecaceae) were almost completely absent from the record. Palm phytoliths are typically found in all parts of the plant, including stems, leaves, and fruits. If fruits produced by Arecaceae were being utilized and discarded in the middens, their phytoliths would have been observed. Phytoliths diagnostic of the genus Heliconia, as well as the sedge (Cyperaceae) and sunflower (Asteraceae) families were observed. The grass-type phytoliths were mostly derived from the grass subfamily Panicoideae. The phytolith assemblage suggests that grasses may have been a commonly utilized resource. Examination of wild and cultivated grasses, as well as possible maize varieties, may allow for better species resolution.

Pollen analysis of the two adjacent strata from Sahonak Tasar (Levels 6 and 7), represented by samples TL6 and TL7, yielded an abundance of charcoal. The two samples yielded total pollen concentrations of 9 and 139 pollen per cc of sediment, respectively. Sample TL7 has potential to yield at least 50 grains for analysis. The quantity of indeterminate pollen compared with pollen that can be identified indicates that this sample is worth exploring further. On the other hand, sample TL6 taken from the uppermost stratum out of the two studied, yielded the least pollen and most charcoal, which might indicate an intensification in burning. The pollen record suggests swidden agriculture involving burning the fields, probably on a regular basis.

In general, terraces are probably more reliably examined with phytoliths than with pollens because of the reduced risk of airborne contamination although the possibility that pollen analysis will identify plants not represented in the phytolith record exists. The phytolith record for samples TL6 and TL7 was well preserved and fairly similar, although some evidence of phytolith dissolution was ob-

served on the larger morphotypes. Dissolution is usually the result of moderate to high pH (calcareous) in combination with periodically moist soil conditions. Phytoliths diagnostic of arboreal taxa were rare, but not completely absent. Rugose spheres, possibly derived from Canna (order Zingiberales) were the most dominant morphotype observed. Grass phytoliths were almost codominant and were comprised mostly of morphotypes diagnostic of bamboo species (Bambusoideae), followed by the Panicoideae species. Other diagnostic phytoliths observed indicated the presence of taxa of the Marantaceae, Asteraceae, (Figure 8**e**-**f**), and Piperaceae families, as well as a member of the genus *Heliconia* (Figure 8**g**). These samples also had a very high abundance of microcharcoal particles, as well as the highest occurrence of vitrified plant tissues, which indicates burning live or recently cut plants. Some sort of burning practice likely was employed as part of a cultivation strategy to quickly introduce nutrients to the soil, followed by a period of nutrient leaching. Siliceous diatoms (algae with silica shells) and sponge spicules (silica shells from freshwater sponges) were extracted along with the phytolith fraction during processing (Figure 8d). Diatoms were observed in sample TL6, none were observed in sample TL7.

Discussion of Results

Interpreting the Stratigraphy and Paleoethnobotanical Remains at Sahonak Tasar

Careful analysis of the character of the soils, as well as their pollen and phytolith content, suggests a sequence of intentional burning and flooding. Nine strata representing growing, burning, and flooding events have been identified. Evidence of burning can be inferred from the presence of charcoal and vitrified plant tissue throughout the adjacent soil layers studied (both Level 6 [the source of sample TL-6] and Level 7 [the source of sample TL-7]) although there appears to be an increase in the amounts of these remains in (upper) Level 6, suggesting an intensification of burning. Likewise, flooding events can be inferred from the siliceous diatoms and sponge spicules, which appear to be particularly abundant in Level 6. The notion that the phytoliths observed in this layer might have been unintentionally introduced to the soils of this layer through the flooding process is countered by the fact that adjacent Layer 7, which displays little if any evidence of flooding, contains similar phytoliths.

An observation that supports the notion of purposeful flooding is the presence of an inflow canal leading from the stream to the terraces. In this way, soil accompanying the streamwater would have been drawn into the terrace system along with the associated diatoms and fresh water sponge spicules. Thus, Level 6 might very well have been formed as part of an intentional cultivation strategy involving both flooding and burning together.

The soil from Level 6 is a dark yellowish brown sandy clay loam, whereas Level 7 is a brown sandy loam. Assuming the character of the soils is the product of a coherent cultivation strategy, taken together with the fact that the soil character in Levels 6 and 7 repeat as one ascends to the surface, suggests that a procedure existed in which the growing of plants was alternated with burning and flooding. Small interval sampling through the terrace sediments may provide a better determination of the exact sequence and periodicity of the growing and burning and flooding; however, a preliminary interpretation of the practice that produced the stratigraphic record observed at Sahonak Tasar is that burning events were supplemented by flooding.

Both burning and flooding probably helped to fertilize the soils. Soil for growing was kept fertilized by using the terraces not only as slope catchments, but also as soil traps designed to collect upland soil being transported by the nearby stream, which then was diverted into the terraces by the inflow canal. This, taken together with the burning, is indicative of a method of intensive cultivation that is quite distinct from the way in which terraces have traditionally been seen as being used.

Most relevant to our study is that a myriad of plants were being grown at Sahonak Tasar based on the phytolith remains. The most conspicuous observation was the low, but not entirely absent, remains of arboreal species and the dominance of species derived from the order Zingiberales and possibly from the genus *Canna*, the only genus in the family Cannaceae. *Canna* is grown by agricultural societies the world over for the rhizome that is rich in starch including the Maya of the Yucatan (Rico-Gray 1991).

Almost codominant with the possible *Canna* phytoliths were phytolith morphotypes diagnostic of species in the subfamily Bambusoideae (bamboos), a subfamily of the Poaceae. New World bamboos are various and those that would have been cultivated would have probably been grown for their nutritious shoots. Further reference collecting of this large subfamily needs to be conducted in order for us to narrow down the species grown. Another subfamily of Poaceae that was also abundant in the phytolith record was Panicoideae. Panicoideae contains the two popularly used economic varieties of species: *Zea mays* L. and *Setaria macrostachya* Kunth. Both of these species have been known to be grown in Mesoamerica and tend to dominate the plant varieties consumed (Smith 1965).

Another phytolith morphology observed at Sahonak Tasar is diagnostic of the family Heliconiaceae (Piperno 2006). Some of the *Heliconia* trough-types observed exhibited overall size and surface textures suggested by Piperno (2006) as being possibly diagnostic of underground organs of the genus (Figure 8**g**). Heliconiaceae, contains only one genus, namely *Heliconia* in which the Guatemalan Bird of Paradise (*Heliconia subulata* Ruiz & Pav.) is just one prominent member. In the New World, *Heliconia* is known for its beauty and odiferous tones rather than its nutritional value, but this does not discount the possibility that its shoots, fruits, rhizomes, or seeds were meant to be eaten. The Guaymi people of Costa Rica, for example, use at least three species of *Heliconia* focusing primarily on their edible shoots (Casteneda & Stepp 2007:253-254)

Most important for our purpose is our observation of morphotypes diagnostic of Piperaceae, Asteraceae, and Marantaceae. All of these families of plants contain species that are medicinal in function. Although, Piperaceae and Asteraceae are two of the most popular families of plants used for making medicines by the regional Q'eqchi' Maya (Amiguet *et al*. 2006), one phytolith identified in Sample TL-6 (Figure 8**e**) is diagnostic of *Maranta arundinacea* L., or arrowroot. (Chandler-Ezell *et al*. 2006, Piperno 1989, 2006). Arrowroot is an easily digestible starch grown and eaten as a staple throughout the Americas (Erdman & Erdman 1984), but it also has been known to be used to treat wounds and bites (Handler & Jacoby 1993, Mathew 2007).

Although terraces have been noted in the southern Maya lowlands in which the Maya Mountains chain is situated (Dunning & Beach 1994, Healy *et al*. 1983), the complex way in Sahonak Tasar was used is perhaps unique. In short, not only was a unique soil enrichment process involving slope soil catchment, burning, and flooding being utilized to maintain soil fertility but a myriad of plants were being grown on these terraces.

Interpreting the Paleoethnobotanical Remains at the Quebrada de Oro and Ek Xux Middens

Although an absolute phytolith concentration was not calculated using an exotic marker such as *Lycopodium*, both middens excavated produced proportionately similar amounts of phytoliths, based on equal sample volumes and number of transects needed to reach a count of 300 phytoliths. The Quebrada de Oro midden, however, produced a significant amount of conical and spherical morphotypes derived from the palm family (Arecaceae), which were not found in the Ek Xux midden.

Consistent with what was predominantly grown at Sahonak Tasar, the main phytolith morphotype that the test pits of these two middens produced was identified as coming from plants of the order Zingiberales. The families of plants that these morphotypes most closely resembled were Cannaceae, Heliconiaceae, Marantaceae, and Zingiberaceae. These families of plants have significant economic importance. Cannaceae, the dominant family of plants being grown at Sahonak Tasar, constitutes a family of plants that is grown for its starchy rootstock, shoots, and seeds. Its abundance in residential middens then is no great surprise, and it suggests that these plants might

not have only been cultivated, if we accept its presence at Sahonak Tasar as evidence of its cultivation, but also processed at households. Currently, we know little about the role that Heliconiaceae and Marantaceae played in the ancient Maya world, but their presence at Sahonak Tasar, as well as in the middens, suggests that they served some important function, perhaps nutritional, medicinal or otherwise. Further comparisons with contemporary species might reveal the use to which these plants were put. The final family mentioned to which the phytoliths uncovered may belong is Zingiberaceae. Zingiberaceae is a family of over a thousand flowering plant species that are aromatic and perennial with tuberous rhizomes. Commonly, medicinal plants and spices fall in the Zingibereaceae family. Some examples are ginger (*Zingiber officinale* Roscoe), galangal (*Alpinia galanga* (L.) Willd.), melegueta pepper (*Aframomum melegueta* K. Schum.), myoga (*Zingiber mioga* (Thunb.) Roscoe), and turmeric (*Curcuma longa* L.) to name a few.

Both middens produced a myriad of phytoliths belonging to the family Asteraceae. Plants from Asteraceae interact with the human organism in complex ways that we are only beginning to understand. Indeed, they are commonly featured in the medical and phytochemical literature given their complex phytochemical arrays, including sesquiterpene lactones and other compounds with physiologic effects (Odom *et al*. 2000) (e.g.,, the immunomodulatory effects of *Echinacea* spp. or pollen from ragweed, *Ambrosia* spp., which is among the main causes of hay fever in the United States).

Among the Q'eqchi' of Belize, Asteraceae is the third most commonly used plant family for making medicines (Amiguet *et al*. 2006), and it is one of the most commonly used families of plants for manufacturing medicines worldwide. In particular, Asteraceae ranks first among the plant families used in the pharmacopoeias of indigenous peoples in Veracruz, Chiapas, certain parts of North America, and Korea (Leonti *et al*. 2003, Moerman *et al*. 1999).

Plants from Asteraceae, when used medicinally, are typically administered in the form of beverages, such as herbal teas (Heinrich *et al*. 1998). A familiar example is chamomile, which comes from two different species, the annual *Matricaria chamomilla* var. *recutita* (L.) Fiori or German chamomile, and the perennial *Chamaemelum nobile* (L.) All., also called Roman chamomile. A more relevant herb for our discussion is winter tarragon, also called Mexican mint marigold (*Tagetes lucida* Cav.). This plant is commonly grown throughout Guatemala and parts of Mexico and used as a spice, but it is also known for its medicinal value (Heinrich *et al*. 1998, Ortiz de Montellano 1990), and its medicinal properties are written about extensively by the early Spanish chroniclers, such as Fray Bernardino de Sahagún (1963).

Although we cannot say for certain that the Asteraceae pollen and phytoliths were the remains of medicinal preparation used by the ancient Maya, we can say with reasonable certainty that they were purposefully grown, as is evidenced from their presence at Sahonak Tasar, and utilized based on their presence in the middens. The handling of plants from the Asteraceae family is supported by the fact that phytoliths were used as diagnostic markers rather than pollen, which reduces the possibility that botanical remains were blown into the ancient Maya refuse heap from another location; the presence of plant phytoliths in the middens implies that the plants were actually thrown into the refuse heap. Phytoliths are transported on the wind only when the wind is strong enough to move sediments.

The presence of Asteraceae in the middens might have been the result of weeding around the residential area, but one should not discount the possibility that these plants were used medicinally based on the mass of ethnographic evidence of its use for medicinal purposes among the Q'eqchi' as well as other groups in Mesoamerica (e.g., Veracruz and Mexico). One must realize that the Q'eqchi' have a long tradition of using these same plants medicinally. This is supported by the consensus study conducted by Amiguet *et al*. (2005) that suggests that the Q'eqchi' have a very high frequency of consensus among the healers who use these plants. In other words, there is a definite longstanding tradition of medicinal plant usage that took a significant period of time to develop, possibly dating to before the Classic period.

In the residential midden at Quebrada de Oro, we also found evidence of grass phytoliths diagnostic of the subfamily Panicoideae. Although not diagnostic specifically of *Cymbopogon*, some of the panicoid bilobate phytoliths resembled those from *Cymbopogon* (lemongrass). Although Asteraceae could be obtained in the thickly forested regions just outside of the settlement area, lemongrass does not occur naturally in the forest and must be obtained even further away—namely outside of the mountains. In short, lemongrass does not grow in the Maya Mountains and if *Cymbopogon* is determined to be present at this site through future research, it would have been brought in from outside of the mountains. This means that there would have been clear handling of the plants or seeds of lemongrass and that they were imported into the Maya Mountains. What its importance would have been is not clear, but we can infer from the ethnographic evidence that it, too, might have been used medicinally, a usage that is consistent with what is observed among the Q'eqchi' of southern Belize and other peoples living in the region (Giron *et al*. 1991, Pesek *et al*. 2007).

Lemongrass has a long tradition of being utilized as a medicinal plant throughout South America and the West Indies and some parts of Central America, and its use is popular in many parts of Guatemala, especially among

Carib populations (Giron *et al*. 1991). This would seem consistent with a South American origin for lemongrass's utilization as a medicinal plant and a northerly dissemination of this knowledge attributable to a migration by either Carib or Arawakan speakers sometime around A.D. 1100 if we consider the archaeological evidence (Bullen 1964, Bullen & Bullen 1976), or just before A.D. 1100 if we accept the linguistic evidence (Davis & Goodwin 1990). Interestingly, however, the evidence we present here of its possible presence at the Classic Maya site of Quebrada de Oro could indicate a much earlier origin for its utilization, perhaps independent of its use among Caribs.

Conclusion and Future Directions

In summary, the phytolith evidence thus far collected and analyzed suggests that the ancient Maya cultivated and utilized a multitude of plants serving nutritional and likely medicinal functions. This observation is consistent with the diversity in function of plants grown by peoples throughout Mesoamerica. The Totonacan inhabitants of Plan de Hidalgo, Mexico, for example, grow an abundance of species, numbering in the hundreds, which serve a variety of purposes, nutritional as well as medicinal (Toledo *et al*. 2003). Toledo *et al*. (2003) argue that the resultant biodiversity that manifests itself in such a method of farming goes hand in hand with maintaining a resilient and sustainable system of agriculture.

We argue for the medicinal function of some of the plants identified in this study based on the evidence we have available to us, which although not enough to be conclusive, is enough to posit supportable hypotheses. The evidence comes in the form of analogous behavior observed among Maya healers today who use the same plants that we observed in the archaeological record for medicinal purposes. It also comes from the knowledge that the contemporary ethnobotanical consensus indicates heavy use of families well represented in these paleoethnobotanical remains (see Amiguet *et al*. 2005). Provided we accept these lines of evidence, a long-standing tradition of use of some of these plants by modern Maya may date to the time that the Bladen Branch region was being heavily settled in the Classic period and possibly earlier.

Although the Q'eqchi' of southern Belize are relatively recent immigrants to the region, and technically are considered highland Maya, living mainly in Alta Verapaz, their catchment area includes and undoubtedly included (in the past) the southern Peten and, therefore, the northwestern flank of the Maya Mountains. This suggests that at least some Q'eqchi' had a familiarity with the Maya Mountains region and were not ignorant of the plants that thrived there.

Indeed, it is very likely that the highland Maya healers of the past, from whom the modern Q'eqchi' Maya descend, traveled to the lowlands to collect medicinal plants. These healers would have needed to acquire many of their medicinal plants from the lowlands, especially if we consider the antiquity that some researchers have been proposing for a "Macro-Mayan" medicinal plant healing tradition in Mesoamerica (e.g., Leonti *et al*. 2003)—a region which spans the lowlands as well as the highlands. The implication of Leonti *et al*.'s proposal is that there is a core healing tradition of using certain plants for specific uses that Mixe-Zoquean, Totonacan, and all Mayan peoples have maintained for over the past 3500 years. This tradition of using medicinal plants from all over Mesoamerica would have likely continued regardless of where the healers lived. If Mayan healers did not live in regions where the plants they knew could be collected, they probably traveled to those areas to collect them or else traded for them.

More research needs to be conducted to reconstruct the precise details of the agricultural method undertaken at Sahonak Tasar. Future work will consist of deducing the time elapsed between the growing phases and the flooding and burning events, which are believed to be soil enrichment processes. Provided this fine chronology can be reconstructed, an entirely "forgotten" method by which the ancient Maya managed to harness the environment to sustain large populations may be further clarified, and perhaps applied to benefit people today, particularly the contemporary Maya, through sustainable healthful nutritional and medicinal plant growing scenarios. An important consideration given the tremendous value of indigenous knowledge is the conservation and sustainable use of medicinal species (Pesek *et al*. 2009, 2010).

In this paper, medicinal plant use detection in the archaeological record was argued using archaeological analysis in conjunction with ethnographic analogy, and biological arguments based on known phytochemical attributes of the plants identified. However, in future studies there is no reason why we may not be able to detect distinctive medicinal uses of plants for which we have no ethnographic analogical support. Such research, however, would necessarily imply that the properties of the plants from which the phytoliths are derived and the archaeological contexts in which they are found become the primary focus for arguing for medicinal plant use.

Acknowledgements

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