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SAPOTACEAE TREE DOMESTICATION IN THE CARIBBEAN

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ABSTRACT

Sapotaceae seeds are often found well preserved in the archaeological records of the Caribbean (Newsom and Wing 2004). However, little research on the possible cultivation and domestication of the trees in the region, including between sites has been completed. Visual examination and numerical analysis of these seeds from two Caribbean sites compared with seeds from Honduras and Florida do not suggest any form of domestication but there may be possible common genera between sites.

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Chapter 1

Introduction

The study of humanity's past through the physical material left behind is not just about the cities built or the documents written that have survived to modern times. In order to fully understand how humans lived, every part of their lives must be studied. This includes the botanical remains preserved in the hearths and middens excavated at archaeological sites that were part of their diets. This type of study is called archaeobiology, and is defined as 'the analysis and interpretation of biological remains from archaeological sites…refers to the remains of anything that was once living" (Sobolik 2003: 1). It can be limited to just plant and animal remains; the former are the subject of the sub-discipline known as paleoethnobotany. Archaeobotany is also another term used for botanical remains recovered at archaeological sites but is not as commonly used as paleoethnobotany (Sobolik 2003: 1-2). There are two goals of archeobiological research: the first is to analyze the relationship between humans and plants/animals and their effect on each other. The second goal is to place the archaeological data in its anthropological context. The information recovered by archaeobiology is useless unless it is applied to interpret human activity at a site or the environment that the humans lived in (Sobolik 2003: 2-3).

Paleoethnobotany emerged in the early 1900s as American ethnologists worked with Native Americans and their relationship to and use of certain plants. Ethnobotany programs began to develop in the 1930s as its importance began to be seen in ethnography, medicine, and at archaeological sites. The main questions developed then and still being analyzed today are the origins of agriculture, plant domestication, paleoenvironment characteristics, and landscape use by humans. The term archaeobiology was developed in the 1960s alongside the New Archaeology in order to answer questions about diet, environment, and ecology. The biggest issues being addressed are technical aspects of recovery and identification, interpretation of plant remains, and the importance of plant remains to more broad-scale questions (Sobolik 2003: 7-9).

While these questions and inquiries are most often applied to the biological remains found at Old World sites, they are just as important to the study of New World material as well. The remains most often persevered in the Caribbean and in Mesoamerica are tree fruit seeds and pits. The exact opposite is expected here because of the ethnohistorical records of the Europeans who encountered the native populations, but what has been uncovered in the archaeological record vastly contradicts the writings of the Spanish explorers (Newsom, 2008: 179-181) (See Figure 1.1).

The domestication of tree crops in the Caribbean and Mesoamerica is not a subject commonly studied. Despite the abundance of such archaeological material from this region, few studies have been conducted on the many samples and species that have been collected. Similar studies have been conducted on olive stone samples in the Mediterranean region (Terral et. al, 2004: 63-77), cultivated fruits and nuts in Melanesia (Lepofsky et al, 1998: 1001-1014), and on squash seeds from Florida (Decker and Newsom 1988: 35-44). Sapotaceae fruit seeds from the archaeological sites of Grand Bay, Carriacou ; María de la Cruz, Puerto Rico; Grenada; El Gigante Rock Shelter, Honduras; and Pine Island, Florida were found in different contexts but are similar in appearance, especially in color, size, and shape. The rarity of such samples, especially in pristine condition, makes them prime candidates for domestication and genus analysis. In this study, the sample seeds will be measured and numerically analyzed to determine their domestication status as compared to modern specimens collected from Puerto Rico, and databases of Sapotaceae seeds from each location will be analyzed to determine if the collected samples are of the same or different genus.

Chapter 2

Domestication Background

For domestication to have occurred in human prehistory, there must have been either intentional or unintentional human selection and circulation. Most domestication events were likely unconscious, and tree domestication was most likely the product of humans learning which trees produced the best fruit and then harvested them, regardless of Old or New World origins. These fruits would have been brought back to their base camp, and the seeds discarded nearby. The discarded seeds would germinate and grow to reproduce; "if they germinated and grew in dump heaps they would even be less dependent on environmental conditions because of extra nutrients and light. These new populations around camps would be more homogeneous than the source populations, but would certainly contain progenies from numerous seed trees, allowing for crossing among selected types, which in turn would yield sweeter and juicier pulps in the next generation" (Clement et al, 2010 :80).

The degree of modification during domestication can be dramatic in many crops, including some tree crops. Given the long generations and typically outcrossing reproductive systems, these degrees of change suggest that domestication in Amazonia started quite early, at the beginning of the Holocene, rather than during 3,000-4,000 BP at the prominence of production systems. The archaeological record at present does not have any early records of Amazonian tree crops., however, does not contain early records of Amazonian tree crops. Guava, the earliest lowland tree crop, was present before or around 5,000 BP (Clement et al, 2010 :74).

Originally, it was thought that ceramic-making people migrated from North and South America to the Lesser Antilles around 500-400 BC island-hopping from Puerto Rico east and south (Fitzpatrick et al 2010: 163). There are thought to be at least 3 major migrations from South America, starting as far back as 5000 BC. The Lesser Antilles are thought to have been initially reached around 3500 BC, and Puerto Rico around 500/400 BC. This is thought to have been done in a "stepping-stone" pattern, where people traveled north from South America through the Antillean chain (with its closely set islands) and going east to Puerto Rico. Early Sabadoid (ceramic-making horticulturalists) pottery from Puerto Rico and the Lesser Antilles suggest that this last migratory group settled the islands rather quickly. These observations were made on similar artifacts between islands that were dated loosely, overlooking the fact that pottery can persist for hundreds of years, that people come and go at different times on the islands, and that some islands could have been initially bypassed. This hypothesis was relatively accepted until radiocarbon chronologies and computer seafaring simulations began to contradict it (Fitzpatrick et al 2010: 164-5).

The alternative hypothesis is that the Saladoid colonizers went from the northern coast of South America to Puerto Rico and the Lesser Antilles, then worked southward through the Leeward and Windward islands, bypassing some in between, keeping with the distribution of early Sabadoid sites concentrated in the north. Voyaging simulations that indicate current patterns and winds in the West Indies favored this route. However, this hypothesis remains unassessed (Fitzpatrick et al 2010: 166).

Regardless of whom the first people were, where they came from, and when they came to the Caribbean, they would have either brought these seeds with them or exploited the wild ancestors. The earliest seeds possibly utilized by humans have been carbon-dated to 3070 +/- BP from the Rio Chico, Cuba site. A similar Sapotaceae study was done by Berman and Pearsall in 2000 at the Lucayan site of Three Dogs, San Salvador, Bahamas, looking at charred robust seeds of either *Manilkara* or *Mastichodendron* (syn. *Sideroxylon)* genera. Early evidence for the consumption of the fruit that surrounded these seeds suggests that these were brought from South America and migrated up the Antillean chain. The forested area would have been cleared to create an open habitat suitable for planting seeds, such as Neo-tropic tree crops that are adapted to this environment. According to the ethnohistorical record, their crops were grown not just in these specially prepared fields but also in house gardens, though by which sex and which age group has yet to be determined (Berman and Pearsall 2000: 219, 232-3, 235; Newsom 2010: 174-9).

When looking for signs of domestication in wild plant species, one of the most common signs of “domestication syndrome” is the enlargement of the reproductive organs -- the fruit or seed. Genes targeted for improvement during domestication have been identified in many crops, including fruit size and shape as well as seed color (Tang et al 2010:160-1). These physical characteristics were taken into account during the metric analysis of the four charred seed samples from María de la Cruz, one-hundred and ninety-two charred samples from Grand Bay, thirty-one uncharred from El Gigante, five uncharred seeds from South Florida, and the twenty six uncharred modern samples from Florida.

Chapter 3

Seed Background

Grand Bay, Carriacou, Grenada

Carriacou is the largest island in the Grenadines chain with archaeological investigations that have well-stratified anthropogenic deposits at several sites that can be easily examined for colonization strategies and settlement patterns for the island and the region. Grand Bay is the largest site on the island at 6000 square meters in area) and has also provided radiocarbon dates. These have been used for the analysis of migration from South America out into the Caribbean. The calibrated dates range from 390-1410AD, indicating that the island was settled in the later part of the Saladoid period, contradicting some of the ceramic finds (but these were not carbon-dated) (Fitzpatrick et al 2010: 166-174).

This study examined burned whole and fragmented seeds from Trench 466 collected in 2005 and 2008. Lab 54 had fifteen seeds from Feature L6; Lab 56 had the fifteen seeds from Feature L6; Labs 66 and 68 had sixty seeds and twenty-four seeds respectfully from Feature L5; and Lab 78 had two sets of seeds (sixty-five seed samples in totally) from Feature L3.

María de la Cruz, Puerto Rico

María de la Cruz Cave is one of several caves in the limestone rock hills of Barrio Cuevas, Loiza, Puerto Rico. It is the largest, most habitable cave with dimensions of 50 meters wide by 25 meters deep by 30 meters high. The main entrance lies at ground level with 2 back entrances. The roof of the cave is cracked due to tree roots, causing much of the floor to be covered with large rocks and boulders on top of the sandy soil and human refuse. It is situated in the hills by Puerto Rico's largest river, the Río Grande de Loiza. The hills shelter the locality, with its flood plains and coral reefs, making the cave a perfect shelter for humans since Archaic times. Most of the refuse dates to the Archaic period when natives would have been gathering food. The Ceramic-age people left some artifacts and food remains in the cave, but occupied the open air site of Hacienda Grande (Alegría et al 1990: 1; 13).

María de la Cruz has a long sequence of occupation that runs from Archaic times to the present day except for the Lithic age. It shows long-term cultural development and adaptation, especially with the Archaic refuse underneath ceramic remains. This helps to clarify about the arrival of natives with ceramics, their contacts with other Archaic populations in Puerto Rico, and the introduction of agriculture. The earliest publications on the site date to 1941, and the last was in 1990 (Alegría et al 1990: vii; Newsom 2008).

The cave was initially surveyed in 1914-1915 by Mason, who reported that there was "little of value to the archaeologist" at the site as well as at Hacienda Grande. It was later excavated by Alegría in 1940s and 1950s, with the findings deposited at the Peabody Museum of Archaeology and Ethnology at Harvard, the Peabody Museum of Natural History at Yale, and at the University of Puerto Rico's museum. Most of the material had field numbers and was catalogued, retaining its scientific value (Alegría et al 1990: 6). The exact provenances of unmarked specimens is not completely reliable because the containers were changed from time to time, had loose labeled slips, and specimens were removed for further study (Alegría et al 1990: 8).

Alegría tested the site in 1948 with 2 test pits by the main entrance, finding a large amount of potsherds, shells, animal and fish bones, rock fragments, and some human remains on the first level. Ash was found in the 4th level along with some burned seeds. The charred seeds were analyzed by Hugh Cutter, the Director of the Missouri Botanical Garden for identification. He determined that they were wild avocado seeds and yellow sapote (*Lucuma salicifolia*, now known as *Pouteria campechiana*) as well as 2 other unidentified species (Alegría et al 1990: 22-23; Newsom 2008: 180).

Eight pits were dug in 1954 by Alegría and Nicholson on the other side of the cave. Ash was found in Pits 1, 1A, with food remains in Pit D. Ecofacts from this time were counted and then analyzed with lithic materials and food remains by Walker and Rodríguez at Hacienda Grande (Alegría et al 1990: 20).

In 1962, Alegría and Rouse found charcoal beneath a boulder in Pit A, Levels 2-5, with some seeds found in Level 3 as well. The radiocarbon dates of this charcoal puts the site at 30-40AD. Earlier dates of charcoal from other sites in Puerto Rico date occupation to the first millennium BC (Alegría et al 1990: 24-25).

An excavation in 1991 uncovered four burned Sapotaceae seeds from Unit A, Level 70-80. No whole seeds were found, one half seed and three seed fragments. These were used in the study, but the radiocarbon dating done previously is important for comparative purposes with the other sites.

El Gigante Rock Shelter, Honduras

The El Gigante rock shelter is in the south-western part of Honduras near the border with El Salvador. The site is at approximately 1300 meters above sea level. It lies on top of the continental divide, which is a volcanic plateau with narrow, steep valley topography (Scheffler 2002: 4).

The strata from the 2000 excavation can be described as nine lithostratigraphic units (I-IX). Each of these units is divided into several sub-strata and described individually. In 2001 a series of six radiocarbon assays were performed on material from the 2000 excavation, with the 2-sigma calibrated results dating the site as far back as 9900 BC to about 160 BC (Scheffler 2002: 11).

A large amount of preserved macro-floral remains were preserved in all cultural strata, decreasing in number as the strata went down. In almost all cultural strata, some amount of preserved macro-floral material was present, with 29,096 specimens in all. A maize sequence was found as well as "a predominance of *ciruela* (Sponidas sp.) and avocado (*Persea americana*) rinds and pits, maguey quids and fibers (*Agave spp*.) as well as many unidentified seeds (Sapotaceae?). In addition, unidentified beans (Leguminosae spp.), squash and gourd (*Curcurbitaceae*) remnants and grasses (*Poaceae*) and leaves (mostly Quercus spp.)…" (Scheffler 2002: 14).

Given the large amount of botanical data, it is easy to see why the floral findings have not been completely analyzed even over a decade later. The previously unidentified, unburned Sapotaceae seeds were analyzed and sorted through for this study, pulling thirty-one Sapotaceae seeds from nineteen of EGO1's floral remains collection. The other seeds stored with the thirty-one pulled varied so greatly that they are considered to be of another genus, maybe even another species, of fruit seed, so they were not used for this study.

Pine Island, Florida

The twenty-six samples that came from Pine Island are the modern, comparative Sapotaceae seeds. There are also 5 seeds from South Florida that were measured, but their age has not yet been determined.

Chapter 4

Methods and Materials

Sapotaceae are a family of angiosperms, also known as flowering, seed-bearing vascular plants. They reproduce with flowers where an ovule is situated inside of an ovary. They are found in every habitat and in a large variety of life forms. Sapotaceae are often trees or shrubs, and their fruit pits have a hard, woody layer called an endocarp protecting the seed kernel. The endocarp often has a hilum mark or scar, which is where the pit/seed attached to the fruit (Armstrong: 2002; Carr: N.d.; Plant List, The: 2010). The Sapotaceae being analyzed in this study have endocarps that are thick, brown, and tear-shaped with a large, angled hilum toward the pointed top of the pit/seed.

Measurement Methods

Measurements were taken of the sample seed's endocarp length, width, and thickness; the hilum length and width; and the seed kernel length, width, and thickness. The measurements of the endocarp length and width were taken by identifying where the hilum was and orienting the scar to the left. The endocarp thickness was taken by rotating the seed 90 degrees to the left or right and taking the measurement from there. The hilum measurements were taken by holding the seed at its thickness and having the scar face up.

These measurements depended upon the preservation of the sample. Some samples were either too damaged or too fragile to take all of the measurements listed above.

In order to analyze the modern samples with the archaeological, the measurements were compared by looking at the average, the standard deviation, the minimum, the maximum, and the coefficient of variation of each measurement taken from each site. The measurements were put into a Microsoft Excel spreadsheet and analyzed using the "Average", "StDev," "Min," " Max," and "CoVar" formulas. Tight standard deviation values would indicate homogenous population, while loose values would indicate too much variation in population. Values around 10 for coefficients of variation suggest a fairly homogenous population, but ones ranging higher (20s and 30s) may indicate variation under cultivation or the presence of more than one cultivar (Newsom, personal communication).

The lengths and widths of the endocarp, hilum, and kernel were then divided by each other (Width to Length, W/L) to create a ratio that determined the roundness of the samples. The closer to 1.0 each measurement was, the rounder the specimen was.

Each sample (6 for Grand Bay, 1 each for Maria de la Cruz, El Gigante, South Florida, and the Modern Samples) was measured along these parameters, and then the samples were further compared by taking the Whole Seed Coats, Partial Seed Coats, Whole Seed Kernels, Half Seed Kernels, Hilum, and Hilum Hole and statistically analyzing the samples of each area for an overall measurement.

Measurement Materials

The main tool used to measure the seeds was a Fowler Sylvac Ultracal II Digital Caliper. For cleaning soil remnants off of the seeds during analysis, a Robert Simmons Short Handle Sapphire Round S85 Series with red Kolinsky hair and synthetic filaments was also used. For handling the specimens, a large Petri dish and tweezers were used. For the metric analysis, Microsoft Excel 2007 was used. In order to determine the most likely genus of *Sapotaceae* for each area studied, the plant databases 'Tropicos," "The Plant List," and "The Royal Botanic Gardens, Kew" were searched through for the common Sapotaceae family between the areas.

On “Tropicos”, the family Sapotaceae was searched for over the entire world, and then narrowed down to each country. Each individual find was catalogued, and then repetitions were erased (Missouri Botanical Garden: 2013).

With “The Plant List,” each country was searched for all genera in the family Sapotaceae, and then compared to each other for similarities and differences (Plant List, The: 2013).

For “The Royal Botanic Gardens, Kew”, the similar genera found using “Tropicos” and “The Plant List” were searched for by country and compared to the previous findings for correctness (Royal Botanic Gardens: Kew, The: 2013).

Chapter 5

Results

After the statistical analyses were done for each seed type per site, the seed type measurements were statistically analyzed and compared to the modern samples. Overall, there were no statistically significant differences found when comparing the modern samples' seed coats, fragment and kernel to the archaeological seed coats, fragments, and kernels. When the databases were analyzed and compared against each other, there was no single genus that was found at all four sites.

Statistical Measurements

Modern Samples

The modern samples had low standard deviations and coefficients of variation for their whole seeds. Their seed coat fragment with a hilum was relatively oval in shape, as well as the seed kernel measured (see Table 5.1 in Appendix B). The roundness of the seed was determined to be oval in shape due to the small W/L ratios (see Table 5.2 in Appendix B).

Grand Bay

The overall Grand Bay measurements (see Table 5.3 in Appendix B) had high standard deviations (varying from 2.040728 to 1.130146) as well as coefficients of variation (10.13913 to 25.84592), especially in the "Whole Seed Coat" measurements. The lowest measurements were found in "Seed Fragments" for the standard deviation of the Hilum width (0.665669) and the standard deviation of the "Whole Seed Kernel" length (0.715769). The L/W measurements were all over 1.0, and the W/L measurements were mostly under 1.0 for "Seed Coat," "Hilum," and "Seed Kernel" (see Table 5.4 in Appendix B).

María de la Cruz

María de la Cruz's measurements were low, most likely because of the small sample size. The standard deviations were under 1.0 and the coefficients of variation were under 10.0. The roundness of the seeds could not be determined due to the lack of sample measurements available, but the one hilum was almost perfectly round (see Table 5.5 in Appendix B).

El Gigante

El Gigante's whole seeds had high standard deviations (0.82 to 3.1) as well as high coefficients of variation (12.5-19.2) (see Table 5.6 in Appendix B). The W/Ls were all below 1.0 but above 0.5, indicating oval seed shape (see Table 5.7 in Appendix B).

Florida

South Florida's samples had standard deviations below 1.0 and all but one coefficient of variation below 10.0 for seed fragments "Without Hilum" and "Seed Coat with no intact Hilum" (see table 5.8 in Appendix B). The W/Ls were between 0.5 and 1.0, once again indicating oval seeds (see Table 5.9 in Appendix B).

Database Measurements

When looking at the databases, there was not a single Sapotaceae genus that was consistently found at all four sites. Honduras had six different genera; Grenada had two; Puerto Rico had seventeen; and Florida had eleven. Two Sapotaceae were found at 3 of the 4 sites: *Manilkara zapota* and *Pouteria sapote*. *Manilkara zapota* and *Pouteria sapote* have been documented in Honduras, Grenada, and Florida. Puerto Rico shared two genera with Florida, *Sideroxylon foetidissimum* and *Chrysophyllum oliviforme.*

Grenada

This country had zero samples appear on the Tropicos site (see Figure 5.1 in Appendix A). However, Kew had two genera catalogued on their database (see Table 5.10 in Appendix B).

Puerto Rico

This country had 40 samples consisting of seventeen genera (see Figure 5.2 in Appendix A).

Honduras

This country had thirty samples recorded on the database and plotted on a map (see Figure 5. 3 in Appendix A). These consisted of six different genera of *Sapotaceae*.

Florida

This state had twenty-two samples consisting of 11 genera (see Figure 5.4 in Appendix A).

Chapter 6

Discussion, Conclusion, and Future Research

The statistical variation that did exist in this study was within samples, and that is worthy of further explanation and research. On an individual sample bases, there is not a strong indication of variability. However, variation at Grand Bay and El Gigante may suggest more variation in the assemblage due to human management, exceeding what would be found in a strictly wild population.

For this study, the question must be asked: why were no statistical differences found in this metric analysis? It could be that the sample size was not even enough between sites; that all sites had different genera of Sapotaceae; this study was pressed for time and resources; or that these archaeological seeds do not show any signs of domestication when compared to the modern samples. In this study, the information collected off of the databases may hold part of the answer: that all four sites do not share a common genus of Sapotaceae.

For the purpose of determining taxon, the current floral environment of these regions must be as fully researched as possible in order to determine what species of plants are currently growing there; the collection of archaeological floral data must go beyond the macroscopic and more into the microscopic to look for pollen remains in order to compare the modern with the ancient as well as possible. Genetic testing on samples could also be done in order to narrow down the species, families, and genera further.

A standard or average size and measurement database would be helpful for this type of research in order to compare what has already been analyzed with what must be analyzed. Preservation of archaeological samples must become more standardized and more highly-focused in order to safeguard the fragile material currently in collections and museums for these comparative studies.

Given the importance of tree crops in the Caribbean, more studies on this specific material need to be done to answer more of the pressing questions of human migration and plant domestication in the Caribbean that still plague the archaeologists of the Caribbean region to this day. Lab work in archaeology should be pushed more in undergraduate studies to help gather like-minded and genuinely-interested researchers together for this type of study. Hopefully, studies like this will grab the attention of the younger generation and make them think beyond the treasure-hunting aspects of archaeology and more into the lab side of this field so that the more basic details of human life can be uncovered.

Appendix A

Figures

Figure 1.1 Ethnohistorical versus Archaeobotanical Records (From Newsom 2008: 180)

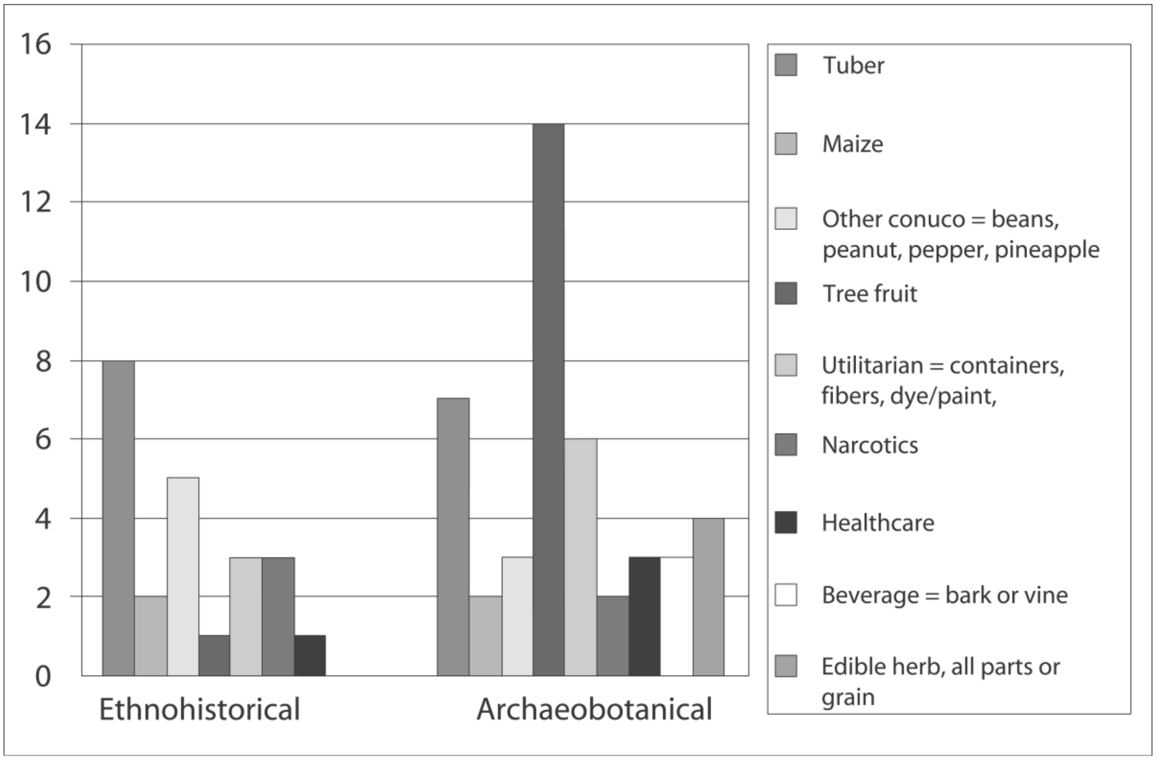


Figure 5.1 Tropicos Map of Grenada Sapotaceae

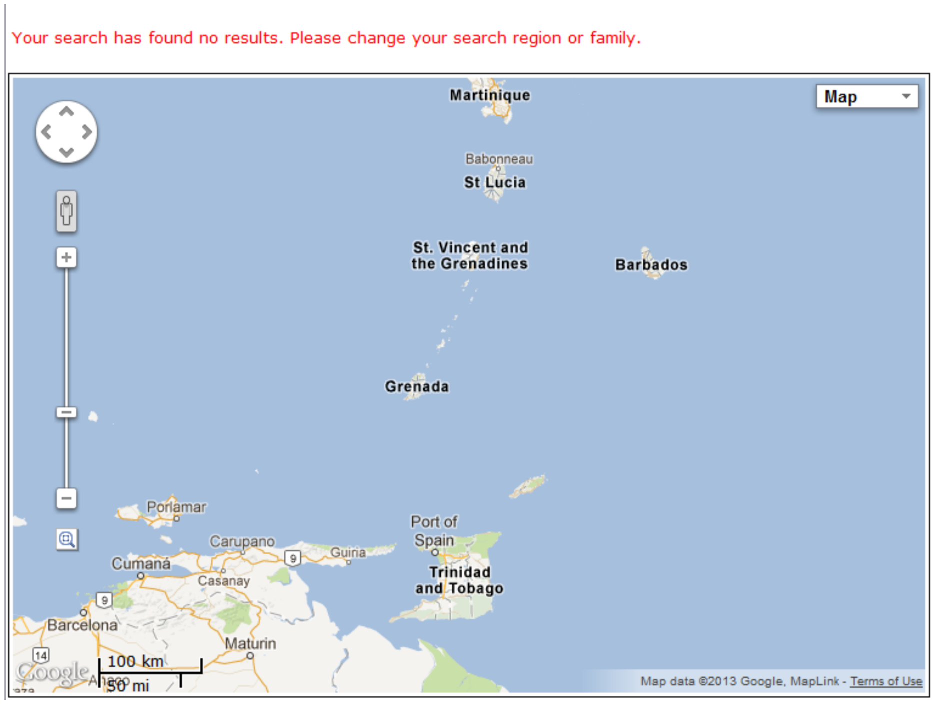


Figure 5.2 Tropicos Map of Puerto Rico Sapotaceae

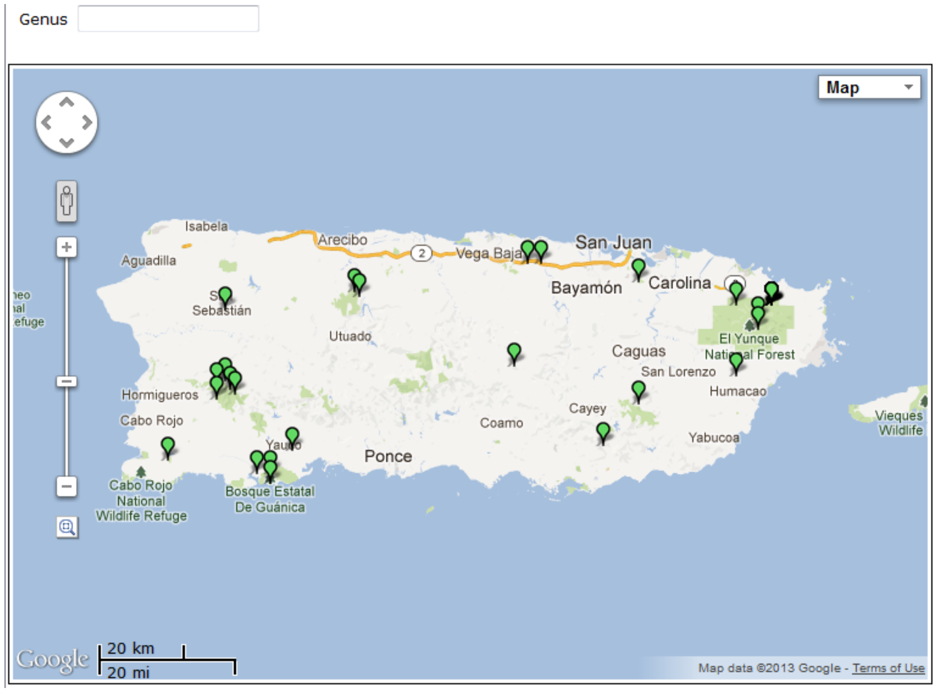


Figure 5.3 Tropicos Map of Honduras Sapotaceae

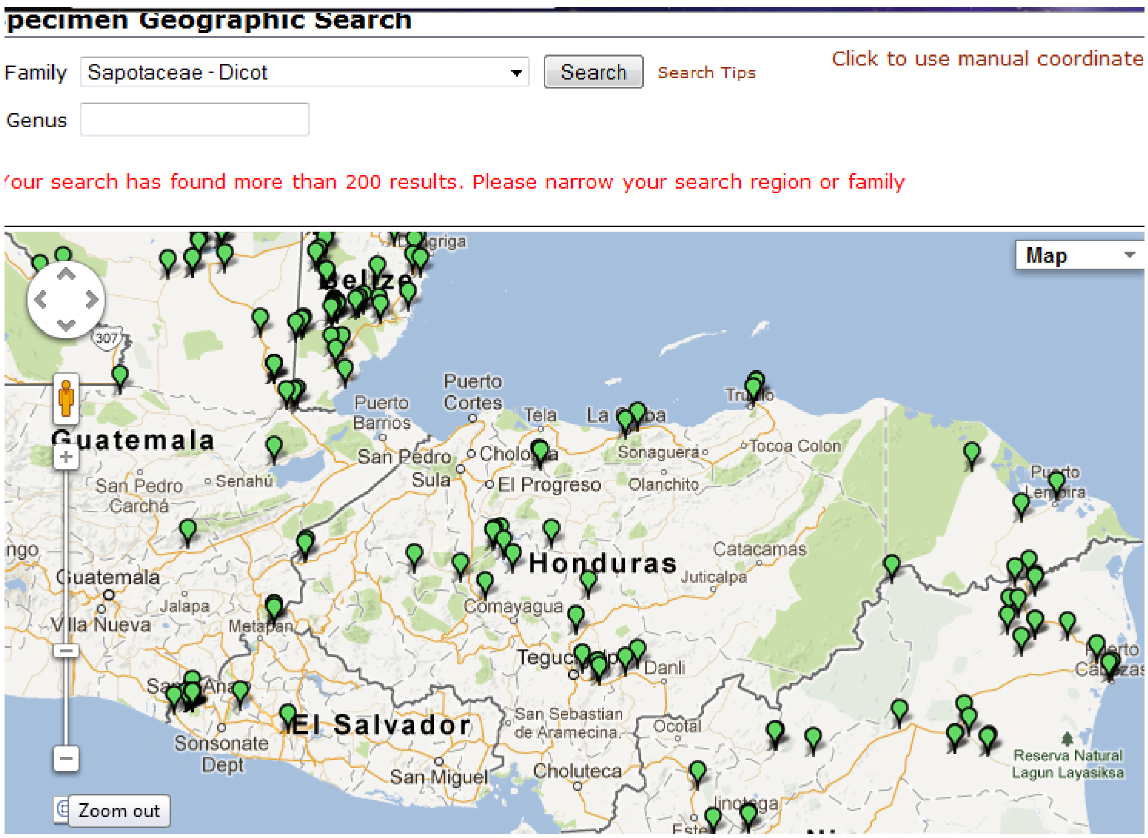
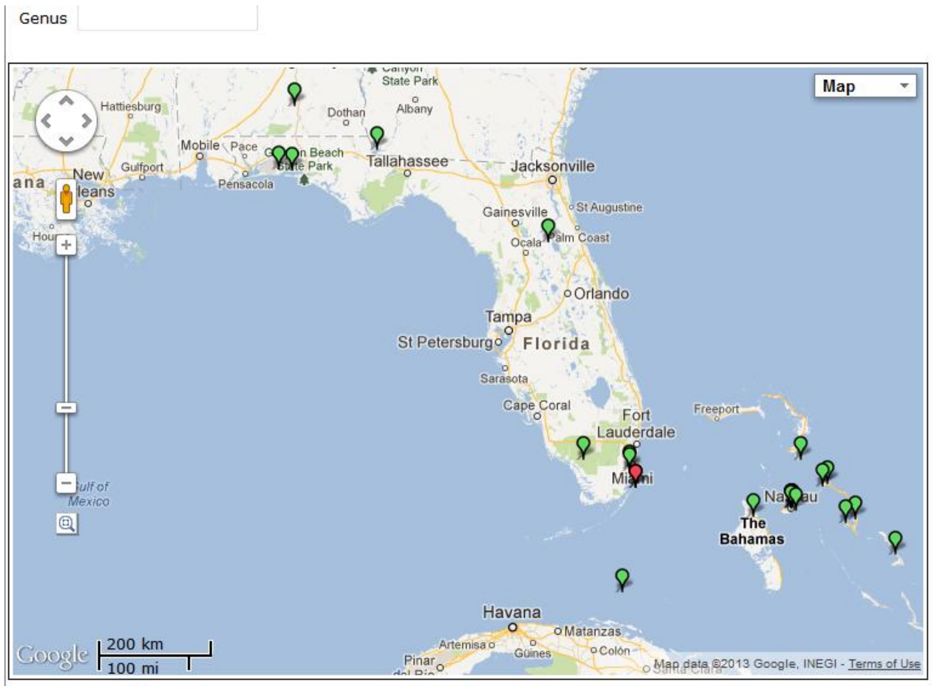


Figure 5.4 Tropicos Map of Florida



Appendix B

Tables

Table 5.1 Modern Samples Statistics

Whole Seed Coat with Kernal Inside					
	Average/mean	STDev	Min	Max	CoVar
L	15.6408	0.594439	14.3	16.87	3.8005665
W	12.4068	0.4376425	11.55	13.16	3.5274446
T	10.9868	0.4635706	9.88	11.78	4.219345
HL	4.372	0.386857	3.4	5.16	8.8485133
HW	3.46	0.3565576	2.78	4.21	10.305145
Seed Coat Fragment with Hilum					
W/L					
0.7813163					
Seed Kernal					
W/L					
0.6418338					

Table 5.2 Modern Sample Roundness

Seed Coat		Hilum
W/L		W/L
0.77899211		0.80841122
0.77979275		0.92978208
0.76187335		0.85111663
0.77097792		0.75321337
0.78453404		0.56275304
0.79602309		0.8221709
0.75815056		0.66083151
0.77919592		0.72687225
0.8221519		0.88106796
0.82942708		0.67386609
0.8373612		0.85023042
0.79147837		0.94244604
0.8587385		0.76086957
0.85524476		0.69141531
0.78274559		0.80982906
0.77164366		0.75
0.79847425		0.8995098
0.78473465		0.81589147
0.82084691		0.82494005
0.80548469		0.74029126
0.77911647		0.75845411
0.7790404		0.8326087
0.75824835		0.7519685
0.77711244		0.82366589
0.78300064		0.97647059

Table 5.3 Grand Bay Statistics

Whole Seed Coat					
	Average/mean	STDev	Min	Max	CoVar
L	17.351818	2.0407483	12.48	20.8	11.76
W	13.965714	1.5433067	8.66	15.7	11.051
T	12.908095	1.308769	8.74	15.55	10.13913
HL	6.3578947	1.4678199	3.69	8.8	23.08657
HW	4.3726316	1.1301467	2.55	6.42	25.84592
Seed Fragments					
HL	7.49	0.9353762	5.73	9.38	12.4883
HW	5.4027778	0.6656691	3.87	6.59	12.2653
Partial Seed Coat					
L	17.142222	2.718836	12.48	20.17	15.86
W	13.8925	2.1556487	8.66	15.2	15.517
T	12.482857	1.7290914	8.74	13.72	13.8517
HL	7.18	0.940234	6.1	8.49	13.095
HW	4.465	0.9724557	2.55	5.15	21.77953
Whole Seed Kernel					
L	12.72	0.7157688	11.04	13.81	5.6271148
W	9.2036	0.8031702	7.35	10.84	8.726693
T	8.8764	0.8484342	6.36	10.9	9.5583119
Seed Kernel Halves					
L	12.308485	1.0178578	10.21	14.46	8.26957
T	8.9111392	0.8454296	7.54	11.09	9.4873

Table 5.4 Grand Bay Roundness

Hilum		Seed Coat		Seed Kernel
W/L		W/L		W/L
0.98787879		0.77467199		0.66901961
0.93839836		0.86358636		0.73349835
0.6893733		0.82843984		0.6145485
0.68803419		0.78016086		0.72192029
0.55523673		0.78136986		0.7269962
0.56590085		0.73173077		0.65512159
0.95287958		0.8336887		0.76910299
0.71907217		0.78674203		0.76749611
0.70149254		0.7901166		0.78342904
0.72351421		0.77566321		0.79150579
0.74355301		0.83025027		0.79000847
0.61210762		0.79388856		0.78973105
0.72540382		0.80068729		0.76322213
0.78582202		0.80295287		0.6681191
0.70744681		0.82199546		0.76475038
0.61778846		0.81718346		0.67936508
0.80958386		0.82196339		0.68164794
0.62548765		1.13060897		0.65727342
0.68371467		0.66564181		0.65583456
0.72900763		0.85207756		0.74874791
0.64318182		0.82611241		0.61787365
0.66882068		1.37686939		0.7262853
0.60283688				
0.77327935				
0.48521739				
0.89018692				
0.75338753				
1.20652174				
0.76461039				
0.85446985				
0.41463415				
0.7005571				
0.79782082				
0.46989967				
0.42301184				
0.51219512				
0.42176871				
0.71428571				
0.52741021				
0.57768362				
0.50923077				

0.45098039				
0.40874811				
0.52298851				
0.61978362				
0.48909091				

Table 5.5 María de la Cruz Statistics and Roundness

Hilum Only					
W/L					
0.9173333					
Seed Fragments					
	Average/mean	STDev	Min	Max	CoVar
L	9.745	0.9263099	9.09	10.4	9.50549
L	7.15	0.6363961	6.7	7.6	8.9006434

Table 5.6 El Gigante Statistics

Whole Seed Coats					
	Average/mean	STDev	Min	Max	CoVar
L	18.225357	3.135651	12.25	24.13	17.204878
W	15.016154	1.8786124	9.65	18.2	12.51061
T	13.535484	1.7446315	9.46	16.34	12.889318
HL	6.3965385	1.1758093	4.95	10.28	18.381959
HW	4.2861538	0.824408	2.58	6.47	19.234213

Table 5.7 El Gigante Roundness

Seed		Hilum
W/L		W/L
0.82615987		0.75255973
0.77898551		0.76629571
0.91958496		0.59744409
0.80485612		0.54325956
0.73288382		0.73044925
0.80671007		0.76384365
0.78564772		0.59165425
0.87458963		0.65674256
0.88437715		0.78598485
0.95991561		0.74949495
0.7877551		0.50887574
0.74465692		0.61956522
0.78079044		0.70451237
0.9470405		0.52336449
0.95915679		0.67811159
0.84111169		0.62044653
0.79524503		0.76079734
0.78245916		0.759375
0.73265495		0.61917098
0.80867747		0.6885759
0.86047692		0.62937743
0.71322006		0.73481482
0.89235474		0.69774011
0.68255481		0.5730897
0.77371833		0.64990689
0.93941457		0.77876106

Table 5.8 South Florida Statistics

Without Hilum					
	Average/mean	STDev	Min	Max	CoVar
L	12.77	0.1131371	12.69	12.85	0.8859593
W	9.71	0.6646804	9.24	10.18	6.8453141
T	9.365	0.3889087	9.09	9.64	4.1527923
HL	8.67	0.6081118	8.24	9.1	7.0139792
HW	5.185	0.6010408	4.76	5.61	11.591919

Table 5.9 South Florida Roundness

Without Hilum			
Seed Coat			Hilum Hole
W/L			W/L
0.71906615			0.68082524
0.80220646			0.52307692
Seed Coat with no intact hilum			
Seed			Hilum
W/L			W/L
0.79265494			0.60848126
			0.63932898
Seed Coat with Intact Hilum			
Seed			Hilum
W/L			W/L
0.9100346			0.50058617

Table 5.10 Genera of Grenada

50879		SAPOTACEAE Manilkara zapota	Fruit	Grenada	Fruit	
51061		SAPOTACEAE Pouteria sapota (Jacq.) H.E. Moore & Stearn	Seeds	Grenada	Seed	Gillespie Bros.

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  - Deans List, College of the Liberal Arts, Summer 2010; Spring 2011; Summer 2011; Spring 2012; Summer 2012; Fall 2012
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  - Paterno Fellows Program, College of the Liberal Arts, 2011-2013
  - Schreyer Honors College, the Pennsylvania State University, 2011-2013
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  - Weiss Breakthrough Scholarship, College of the Liberal Arts, 2009-2012.
  - Liberal Arts Enrichment Fund, College of the Liberal Arts, 2010-2012.
  - Rein Trustee Scholarship, College of the Liberal Arts, 2011-2012
  - Mitrovic Scholarship, College of the Liberal Arts, 2011-2012
  - Hatch Fund Scholarship, Penn State, 2011-2012.
  - Craig Scholarship, College of the Liberal Arts, 2012-2013.
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Association Memberships/Activities

In this section, list all memberships in:

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Research Interests

I have broad interests in mortuary analysis and site conservation, particularly in the Middle East and North America. Specifically, I am interested in cave mortuary practices, mortuary botanical remains, and the conservation of mortuary sites.