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Domestication and Significance of *Persea americana*, the Avocado, in Mesoamerica

Amanda J. Landon

Abstract: The avocado (Persea americana) is grown all over the modern world in tropical and subtropical climates for food and cosmetics (Humani 1987). In antiquity, the avocado was important to the Ancient Maya not only for food but also as a part of their mythology. Avocados were grown in sacred gardens, and important ancestors were thought to become reborn through fruit trees, including the avocado. Here, I examine the cultural context of the avocado and the issues related to understanding the domestication of the avocado and other tropical fruit trees. I discuss archaeological and molecular evidence, and offer direction for future research.

The Avocado and its Cultural Context

Avocado usage has been documented archaeologically and historically in Mesoamerica and Northern South America. The tree acquired spiritual significance to the peoples who used the plant. European documentation of the avocado occurred in the 1500s, as indigenous peoples in Mesoamerica and Northern South America, especially the Andes, encountered these explorers. Spanish conquistadors recorded avocado growing from Mexico to Perú, describing the fruit itself and the various names by which the tree went, as well as the different varieties of avocado that differed in shape, color, and texture (Galindo-Tovar et al. 2008, Popenoe 1934). The first European chroniclers and explorers also documented the avocado in Mesoamerican home gardens, a practice that continues today (Gama-Campillo and Gomez-Pompa 1992).

Avocado also appears in Mayan iconography in different periods. The chronology of the Maya world is split into periods that serve as both blocks of time and rough “stages” of development. More recent evidence, such as radiocarbon dating and more detailed archaeological data on ceramics, have rendered the “stages” problematic because different developments, such as the use of a new ceramic type or the formation of more complex societies, no longer fall within the boundaries of the period in which they had been assigned.

Now, these periods are viewed more as arbitrary than as defining clear-cut stages (Demarest 2004:12).

The periods are as follows: Archaic (7000 B.C. – 2000 B.C.), Early Preclassic (2000 B.C. – 1000 B.C.), Middle Preclassic (1000 B.C. – 400 B. C.), Late Preclassic (400 B.C. – 300 A.D.), Classic (300 A.D. – 900 A.D.), Terminal Classic (800 A.D. – 1000 A.D.), and Postclassic (1000 A.D. – 1542 A.D.). The Archaic Period is characterized by megafaunal extinctions, foraging, the beginnings of agriculture, and a movement toward larger populations. In the later archaic, people began settling in semisedentary villages, and settled farming villages by 2000 B.C. (Demarest 2004:14).

Complex societies emerged during the Preclassic Period. The Olmec civilization developed along the gulf coast during this period and influenced the Maya. The first major Maya cities appeared by 500 B.C. (Martin and Grube 2008:8). The Early Preclassic is characterized by the emergence of religious and political leadership, long distance trade, some social stratification, and the beginnings of monumental art, iconography, and the calendric system (Demarest 2004:14). The Middle Preclassic brought the emergence of archaic states with centralized authority, more economic complexity, more social stratification, and the development of a pan-Mesoamerican complex of iconography, writing, and calendars. There was also more interregional interaction between the elites (Demarest 2004:14). The Late Preclassic is characterized by regional variants on Mesoamerican culture. Teotihuacan rose as a major urban center in what is now Mexico City. Monte Albán rose as another urban center on what is now Oaxaca. The period is characterized by large populations and complex social organization with high levels of social stratification (Demarest 2004:15).

During the Classic Period, the major urban centers influenced each other heavily, and Teotihuacan emerged as a major power (Martin and Grube 2008:8). The period is associated with a set of traits including ancient Maya writing systems in stone texts, polychrome ceramics, vaulted stone architecture, and a stelae-alter monument complex. It is divided into the Early and Late periods based on ceramic style changes and economic and political trends (Demarest 2004:15). The Terminal Classic was a period of change in the Maya Lowlands including major population changes, migrations, and more interregional contact (Demarest 2004:16). Populations were concentrated in the North and the South, and the central area remained sparsely populated (Martin and Grube 2008:9). The Postclassic was similar to the Classic Period, but brought with it an expansion of the alliances between sociopolitical groups. This period ended with the Spanish Conquest beginning in 1542 (Demarest 2004:16). Most of the iconography discussed in this section dates to the Classic Period.

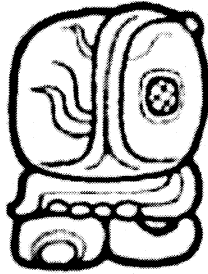


Figure 1: K'ank'in, the fourteenth month in the Classic Maya Calendar (Kettunen and Helmke 2005:48).

The fourteenth Classic Maya Month is represented by the glyph for the avocado, pronounced as “*K'ank'in*” (Galindo-Tovar et al. 2007) (see Figure 1). The same glyph, translated as “*un*” in this context, appears in the sign at the Classic Maya city Pusilhá, the site of a complex society in present-day Belize. Pusilhá is known as the Kingdom of the Avocado due to the main sign on the city’s emblem being the glyph for the avocado, and its rulers would have been the “lords of the avocado.” The sign at Pusilhá is very similar to that at Quirigua, leading archaeologists to hypothesize that they belonged to the same polity, but others have pointed to major differences that suggest otherwise (Braswell et al. 2005; Braswell et al. 2004).

Maya ancestors are reborn as trees, and people would surround their houses with fruit trees, sometimes over the graves of relatives. The Ancestral Orchard shows the rebirth of ancestors as trees in the Maya cosmological landscape, as manifested on King Janaab-Pacal’s sarcophagus at Palenque, a Classic urban center. The lid of the sarcophagus features the King himself, and along the sides are ancestors. Lady Kanal-Ikal is emerging with an avocado tree (Figure 2). These trees that “grow” around the coffin of the king are not a wild forest, but a tended garden (Galindo-Tovar et al. 2008). The distinct characteristics of each figure suggest that these ancestors represent real people (Schele 1974).



Figure 2: Lady Kanal-Ikal emerging with an avocado tree on the side of Janaab-Pacal's sarcophagus (Martin 2006:162).

The avocado has also appeared in the iconography in the Mexica (Aztec) world, which lies to the North of the Maya area. The Nahuatl word for avocado is *ahuacatl*, or testicle in English. This was mentioned first in 1519 by Spanish chroniclers (Gutierrez and Villanueva 2007). According to Mexica myth, the avocado fruit gives strength. A fruit's form contributes to its properties: the outer form is a result of inner forces. The avocado is shaped like a testicle, and it can therefore transfer that strength to whoever eats it (Gutierrez and Villanueva 2007). Ahuacatlan, a Mexica city, was named after the avocado ("place where the avocado abounds"), according to its glyph: a tree with a set of teeth plus the glyph for "place" (Galindo-Tovar et al. 2007; Gutierrez and Villanueva 2007) (see Figure 3).



Figure 3: Mexica glyphs representing the city Ahuacatlan and ahuacatl, respectively (Gutierrez and Villanueva 2007:6).

The avocado has been important to indigenous populations in Mesoamerica for food and mythology, as suggested by iconography and European journals, for hundreds of years. It has been documented iconographically all over Mesoamerica. In order to better understand the relationship between indigenous peoples and the avocado, it is important to understand its domestication history and how the avocado and other tropical trees are represented in the archaeological record.

Domestication and agriculture

A clear understanding of the definitions of terms used for different kinds of plant-human interactions is necessary in order to discuss the domestication status of the avocado. Additionally, the ways in which archaeologists define and study agriculture and domestication have changed over time. I begin with a general discussion of the definitions of important terms, including cultivation, domestication, low-level food production, tree cropping, and agroforestry to provide a base for the subsequent discussion on definitions of agriculture over time and the problematic status of tropical trees.

The term cultivation is commonly used to refer to caring for either wild or domesticated plants (Smith 2001). Domestication, in contrast, is the product of the way in which humans and plants interact. The process of domestication can lead to major genetic and morphological changes in plants that usually render them more useful to humans. Humans select the best plants for the activities for which they are needed (Pearsall 1995).

Smith (2001) uses the term “low-level food production” to describe the varied ways in which people who are neither strictly hunter-gatherers nor strictly agriculturalists acquire food. For example, this term can refer to people who primarily hunt and gather food, but also cultivate plants. The term is intended to avoid suggesting that there is a clear-cut separation between agriculture and hunting and gathering as food procurement strategies, and that there is not necessarily a linear progression from hunting and gathering to

agriculture (Smith 2001:4, 33). Agriculture differs from low-level food production in that agricultural activities require a substantial amount of time each day and that foraging activities become rare and possibly unnecessary (Winterhalder and Kennet 2006).

Ecological niche construction theory, featured in ecology, posits that organisms both choose and modify their environments. These constructed environments in turn affect the selection pressures that act upon the offspring of the organism. Multiple populations can modify overlapping environments, affecting other populations, as well (Day et al. 2003:81). The theory predicts that agriculture is an evolutionary adaptation in which humans invited attractive plants into the human niche. Humans involved in plant domestication were modifying their environments, and the subsequent environmental impact had an impact on local taxa (Smith 2007:192). Bleed (2006) and Smith (2007:193) view these ecological modifications as an “invitation” to plants and animals to live in the human ecological niche. Some of these organisms “accepted” the invitation, while others did not (Blead 2006; Smith 2007). Some of the local taxa adapted to this environment more readily than other taxa. For example, dogs came under domestication in Asia thousands of years before the reindeer in Northern Europe. The best ecological conditions for dogs to move into the anthropogenic environment existed before the proper ecological conditions for reindeer. Dogs entering the human ecological niche would have resulted in alterations to the niche. Over time as more organisms entered and altered the niche, reindeer, a more complex species to utilize, could be extended an invitation and accept it. (Blead 2006).

Due to the way in which people manage plants, additional definitions are necessary when discussing tree exploitation, especially in tropical forest contexts. Tree cropping is used to refer to the use of resources from trees, whether they be wild or domesticated (McKillop 1994). The term agroforestry is used to refer to harvesting or removing wild species, or mixing wild and domesticated species under a management system (McKillop 1994). These definitions include wild trees because even when indigenous people appear merely to be gathering forest products, they are usually actively managing forest plots in such a way that encourages useful trees to thrive, regardless of domestication status. These activities do occasionally present themselves in a recognizable way in the archaeological record. For example, paleoethnobotanical data from New Guinea reveals that even 30,000-40,000 years ago, people were trimming and thinning natural taro, banana, and yam stands (Weirsum 1997a). This sort of cultivation likely marks the beginnings of the domestication process for trees, which led to impacts both on the surrounding environment and the trees themselves directly. Both unconscious and conscious manipulation on

the part of people would have furthered this relationship (Weirsum 1997a).

These theories address the possible ways in which plants and animals can come under domestication very well. They do not, however, address a problem that archaeologists encounter in tropical settings regarding how to identify “agriculture” and “domesticated” plant species in the absence of evidence for obvious morphological or ecological change. Agriculture is usually identified in the archaeological record by way of morphogenetic change and environmental transformation, but, in the absence of clear signals in some tropical plants, especially trees, Denham (2007) argues that a new framework based on the archaeological record and past cultivation techniques is needed in order to properly identify agriculture and domestication in these tropical contexts.

Denham (2007) looked for evidence in New Guinea for paleosurface disruption, phytoliths, pollen, macrobotanical remains, and a few other lines of evidence in order to test how accurately such data could identify agricultural practices in the region. Of the “potential markers of agriculture” (Denham 2007:91), which include morphological changes, not one provided clear evidence of domestication. Denham concludes that agriculture in the humid tropics cannot always be identified in the archaeological record through morphogenetic or paleoecological changes as one would use for, for example, grain crops in Asia. Instead, one must employ a multidisciplinary approach to detecting agriculture that incorporates paleoecological and paleosurficial evidence. Denham (2007) found evidence of prolonged forest disturbance, which indicates that people were clearing swaths of land, likely for swidden cultivation. Denham also uncovered evidence of paleochannels, pits, and mounds that together suggest agricultural activities. Denham (2007) argues that agricultural practices in New Guinea should be thought of as broad, including reliance on wild species and species that, while domesticated, showed no morphological change, such as the yam. He suggests that archaeologists must recognize that there is variability in agricultural practices, and that evidence of such activities in different areas is likely to be quite different. Archaeologists can look for contextual evidence, such as that found in features, artifacts, and so on in order to link what people were doing to interactions with plants, but can only treat modern practices as analogues or hypotheses (Denham 2007).

These observations apply to tree-human interactions in Mesoamerica, as well. In a chapter on pre-Hispanic Maya agriculture, Wiseman (1978) discusses artificial rainforests, or rainforest areas under human influence. These zones include seed crops, root crops, vine crops, and tree crops grown together in such a way that minimally impacts the parent forest, at least in terms of nutrients. For example,

today in the Petén region in Guatemala, people practice a form of agriculture in the rainforest that does not involve clear cutting, but rather selecting for certain trees to keep and certain trees to remove, depending on each tree type's usefulness (Wiseman 1978). Once these fields go fallow, the previously cleared tree species return to the plot. Trees deemed useful have included the avocado and several other fruit trees, as well as some vines, herbs, and root plants found in the rainforest. These practices might not manifest themselves in an identifiable way in the archaeological record.

Forest gardens are another form of agriculture that might be difficult to identify in the archaeological record. Weirsum (2004) defines these as intermediate between natural forests and tree-crop plantations because of the structure and composition of these plots. They consist of a "natural forest" area that has adapted to suit human needs, and is exploited more intensively than a natural forest and less intensively than a tree-crop plantation.

Tree crop selection is a very slow process. Open pollination increases chances of cross-pollination with wild, non-cultivated varieties. Around seven years can pass before selected trees reach fruit-bearing age, and another few years to grow large enough to produce maximum-sized fruit. Additionally, in dry areas or those that experience long dry seasons, tropical fruit trees require complex irrigation systems. They may not disperse into these areas until the necessary water sources are created (Smith 1967). For these reasons, tropical tree crops often do not exhibit morphological differences from wild varieties.

Both natural and cultural selection act on trees, and these plants appear to have coevolved with human beings in Mesoamerica to live in these areas and make up the portion of the human diet that they do today. Tree management techniques, however, have evolved along with the environment and are a result of ecological, cultural, and socioeconomic conditions (Weirsum 1997a). The intensity with which humans exploit tree resources varies over not only time but also space, further complicating the definitions of agriculture and domestication as they apply to tropical trees (Weirsum 1997a, 1997b). In addition, tree crops tend to be managed in-situ in intermediate phases, while field crops are brought into fields during the intermediate phases (Weirsum 1997b).

This general discussion on the definitions of terms related to agriculture and domestication is useful when considering the lack of morphological and genetic evidence for avocado domestication in spite of clear evidence, discussed in the section regarding its cultural context, of its importance to the peoples of Mesoamerica. The avocado tree presents its own issues in terms of identifying wild versus domestic paleoethnobotanical remains. The family, *Lauraceae*, is complicated

taxonomically, and even the avocado itself is complicated within its own species, though genetic studies have shed some light on how avocado varieties are related to one another (Ashworth and Clegg 2003; Chen et al. 2008). Additionally, the avocado seed varies greatly in both domestic and wild varieties, further complicating studies of its domestication (Gama-Campillo and Gomez-Pompa 1992).

The avocado and its domestication

In order to better understand the importance of the avocado to the peoples of Mesoamerica, it is necessary to understand its taxonomy and domestication history. The large size of the avocado fruit appears to have developed before humans arrived in Mesoamerica (Barlow 2002), and then changed little in shape or size under human influence (Ashworth and Clegg 2003; Gama-Campillo and Gomez-Pompa 1992). It is therefore difficult to point to a specific point in time when the avocado began the domestication process, or to differentiate between domestic and wild remains in the archaeological record. I discuss these issues within the context of the paleoethnobotanical evidence, and then offer suggestions for improving our understanding of avocado domestication.

Avocados belong to the family *Lauraceae*, most members of which thrive in tropical or subtropical climates. Carolus Linnaeus placed avocados in the genus *Laurus*, but in 1754, P. Miller reassigned it to the genus *Persea*. At this time, he provided a description of the plant and an explanation that the name *Persea* had already been used for some time, and was more accurate than *Laurus*. Under the genus *Persea* there are two subgenera of sharply distinct plants, *Persea* and *Eriodaphne*. The avocado belongs to the former, and goes by the scientific name *Persea americana* Mill. (Bergh and Ellstrand 1986; Williams 1976). There are 12 species of *Persea* in Mexico, but most produce inedible fruits. The most commonly cultivated species is *P. americana* (McClung de Tapia 1979).

There is a taxonomic issue regarding how to address the landraces within *P. americana*. The three recognized landraces, or varieties, of avocado are the Mexican, Guatemalan, and West Indian. They are differentiated based on factors such as skin texture and fruit texture. Fruit size does not help differentiate between domesticated and wild avocados due to the variation in fruit size caused by environmental factors and individual tree traits (Gama-Campillo and Gomez-Pompa 1992). Some people argue for splitting them various ways into species or subspecies, and others argue for lumping them into one, all based on the differences between the landraces. Bergh and Ellstrand (1986), on the other hand, argue for considering the three landraces “varieties.” Genetic and isozyme data, however, suggest that the landraces are

closely related and do not support splitting *P. americana* into separate species (Gergh and Ellstrand 1986).

Ashworth and Clegg (2003) studied microsatellite markers in *P. americana* in order to better understand how avocado varieties are related. These genetic markers prove useful for tracking tree relationships because they reveal paternity and pollen movement between populations. Additionally, these markers are highly variable, and the results of such studies tend to be reproducible. Samples tested came from each of the three varieties and their hybrids. The authors identified 25 microsatellite loci, which revealed 37 genotypes. Many of the samples ended up being hybrids, and the three landraces, even when hybrids were removed from the statistical analysis, ended up exhibiting low genetic distance, indicating that hybridization may have occurred, or that the landraces are a fairly recent phenomenon.

More recent genetic research on *P. americana* has revealed subpopulations within wild avocados, and that domesticated avocado varieties have between 80% and 90% of the nucleotide sequence diversity presented in wild populations. Domesticated avocados do not show evidence of a major genetic bottleneck, as is presented in many other domesticated plants, due to multiple domestication events followed by hybridization, based on statistical analysis of the genetic test results (Chen et al. 2008).

Gama-Campillo and Gomez-Pompa (1992), on the other hand, argue that it would be most accurate to consider the avocado a semi-domesticated tree due to the amount of back-crossing the domesticated trees do with wild populations, and the trees tend to be documented in home gardens or stands in chroniclers' accounts. Additionally, the tree is still under the process of being domesticated, with wild trees being brought into garden plots and domestic tree seeds being transported out into the wild. The same pattern can be seen in other tropical trees, as well.

The form of the avocado fruit today may be more a result of a past ecological relationship with megafauna than the current relationship with humans, monkeys, and other extant animals. Barlow (2002) posits that the avocado is "haunted" by the "ghosts" of glyptodonts, toxodons, gompothers, and ground sloths. The *Persea* species that live along the Gulf Coast have fruit that are about the size of blueberries, small in comparison to the avocado. Avocado pits are soft and unprotected, unlike other fruit tree seeds such as canistel (*Pouteria campechiara*), which has a mild-flavored seed with a tough protective coating. Instead, the avocado relies on bitter toxins to deter damaging the seed through digestion. The avocado pulp also contains laxatives, which quicken the seed's trip through the animal's digestive system, reducing the chances of damage by digestive juices. Only megafauna would have been large enough to swallow the fruit and pit

whole, which would have helped the avocado disperse its seeds. The seeds pass through in a “fertilizer” of feces. Today, elephants in Africa disperse fruit tree seeds through their feces, including the non-native avocado and American papaya (*Carica papaya*) (Barlow 2002).

The avocado fruit is edible for humans, and the seeds, leaves, and bark are considered medicinal (McClung de Tapia 1979). The high oil content is useful and likely increased the fruit’s desirability to humans and prompted initial transplants closer to dwelling sites (Smith 1967). In addition to the previously discussed cultural contexts of the avocado, the present-day Maya manage home gardens in San Jose that cover about 0.65 ha, with an average of 240 individual plants belonging to 30 species. The majority of these plants are food crops, such as the avocado, guava (*Psidium guajava*), various *Citrus spp.*, and pimento (*Capsicum frutescens*). These gardens are important for diversifying the diet, and are one of the results of the ecological relationship that humans and avocados share (Levasseur and Olivier 2000).

Eventually, the trees were managed along with other useful plants, such as in stands or home gardens (Gama-Campillo and Gomez-Pompa 1992). There is evidence of humans exploiting avocados in the Tehuacan Valley starting between 10,000 and 9,000 years ago (Galindo-Tovar et al. 2008; Smith 1967). Avocado appears in the archaeological record in the Supe Valley of Perú at sites associated with the Caral civilization at least as far back as 3200 years ago as an important staple, and is also found in the Moche Valley at Caballo Muerto starting between 4500 to 3800 years ago, and on the coast near the Gramalote site around 3500 years ago (Galindo-Tovar et al. 2007).

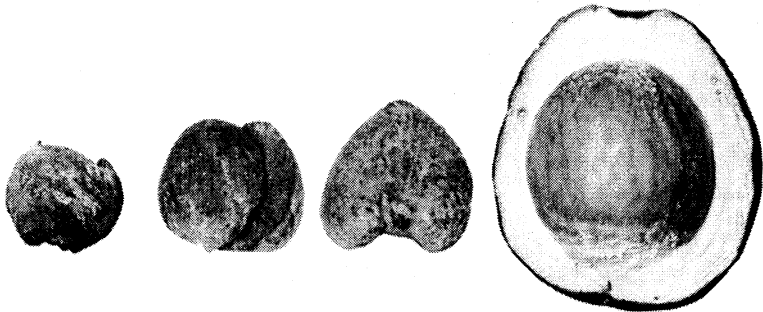


Figure 4: Avocado pits from the archaeological record and from a market (Smith 1967:239).

The avocado was, however, likely domesticated in the Tehuacan Valley. Some of the data relating this is shown in Figure 4, from Smith (1967). Consistent early appearance of larger avocado pits in the Tehuacan Valley than in surrounding areas led MacNeish (1967)

to conclude that early selection occurred in that area, followed by planting and cultivation. Subsequent research has determined that avocado pit size is not an accurate way to determine domestication status, however. As of 1967, an avocado pit from Coxcatlan Cave was the earliest known at around 9000 to 10,000 years old (Smith 1967). Avocado pits found in cultural contexts in caves in the Tehuacan Valley frequently dating back to this same time period (Smith 1966). Avocado remains typically presented themselves in the form of cotyledons, or the part of the embryo of the plant seed that typically becomes the first leaves of the plant after germination (Smith 1967) (see Figure 4).

Avocado seeds vary both in shape and size. Smith (1967:240) used an index of $l \times w$ to find the average seed sizes, and concluded that larger pits likely came from cultivated varieties, and smaller pits, some of which came from earlier levels, were likely harvested from the nearby barrancas forests. This approach is, however, problematic because of how much avocado seeds vary in shape and size. According to Tehuacan Valley paleoclimatic data, the region was too dry in antiquity to support avocado trees without irrigation. This led Smith (1967) to conclude that the presence of avocados supports arguments for use of irrigation in the area. Additionally, around 1500 CE, the water table and rainfall were higher in the Tehuacan Valley than today, so the barrancas forests were likely closer to the valley. Avocados, mangos, sapotes, papaya, and other fruit bearing trees live naturally in this biome, and these trees were also likely closer to the valley in antiquity than they are now (Byers 1967a). Smith (1967) suggests that the avocado came under domestication in the Tehuacan valley due to seed-size evidence. McClung de Tapia (1979), on the other hand, states that although avocados appear in the earliest phase of the Tehuacan Valley archaeology, the fruit must have been brought into the Tehuacan Valley after cultivation because the zone does not meet the basic temperature and humidity requirements for cultivation. Regardless, the avocado had likely undergone considerable selection in and around the Tehuacan Valley.

To resolve the question of whether avocado remains from sites in the Tehuacan Valley represent domesticated avocados in paleoethnobotanical samples, archaeologists will likely need to implement some of Denham's (2007) suggestions for detecting agriculture in humid tropical forests. In a study of the paleoclimatology and archaeology at Cobá, México, Leyden and others (1998) found that forest composition within the Cobá archaeological site includes, in comparison to surrounding forest, higher numbers of culturally important trees such as pom (*Protium copal*), nance (*Byrsonima crassifolia*), guaya (*Talisia olivaeformis*), mamey (*Calocarpum mammosum*), and the avocado (*P. americana*). This observation suggests that these trees were being cultivated in Cobá in

antiquity, and not necessarily in the surrounding forest. Detecting managed trees, and using McKillop's definitions of tree cropping and agroforestry, does in some cases require more than identifying formerly managed forest plots within archaeological sites.

McKillop (1994) used paleoethnobotanical remains to indirectly detect agroforestry on the islands off of the coast of what is now Belize. There was evidence of exploitation of palm trees and fruit trees for food, but few of the major staples of the mainland Maya, including maize, beans, and squash. The Maya who lived on these islands had little arable land on which to practice agriculture. They appear to have used limited crop agriculture and maritime resources along with a heavy reliance on tree crops for subsistence. These trees included three major palm trees: *Orbignya cohune*, *Acrocomia mexicana*, and *Bactris major*, as well as several wild fruit trees, including the avocado. McKillop argues on the basis of relatively abundant crop tree remains, relatively few staple crop remains, and little evidence of arable land that the people at Wild Cane Cay, one of the islands, actually focused on such tree cropping for subsistence. At Wild Cane Cay, the majority of the avocado remains consist of wood charcoal fragments, however, avocado seeds have been found at Copán, Cuello, and Tikal, and wood charcoal also from Albion Island, Colha, and Pulltrouser (McKillop 1994).

Given the botanical characteristics of the avocado and the nature of avocado remains in the archaeological record and avocado management today, it would be useful to expand the definition of agriculture, at least as it applies to tropical trees in humid environments, to include managed and exploited trees that would not traditionally be considered "domesticated" or part of an agricultural practice. While the avocado seed size has likely not changed much over the course of the archaeological record in Mesoamerica, unless in response to changing ecological conditions and individual tree traits, the tree currently lives very well in human environments, and is clearly an important tree as evidenced by iconographic examples and archaeological data.

Determining whether avocado remains in the archaeological record represent domesticated or wild plants is problematic due to the wide variation in avocado seed size, the way in which people manage trees, and a lack of clear genetic evidence for determining whether a population is wild or domestic in even modern populations. Given the characteristics of the avocado and the nature of avocado remains in the archaeological record and avocado management today, it would be useful to expand the definition of agriculture, at least as it applies to tropical trees in humid environments, to include managed and exploited trees that would not be considered "domesticated" or part of an agricultural practice. It is difficult to differentiate between managed

and unmanaged forests under this redefinition, which will also be problematic. More research needs to be done on tropical tree management techniques and the effects that those techniques have on the plants before we will be able to make a more clear distinction, if that is even possible. Unfortunately, in the absence of clear archaeological evidence for domestication, such as clear changes in seed size or morphology, we may have to rely on evidence for tree exploitation, such as the presence of avocado pits in the archaeological record, or other evidence of management, such as more economically important trees growing in a site than outside of it.

Conclusions

The story of the avocado illustrates perfectly Denham's (2007) concerns that tropical domesticates and agricultural systems might not be recognized under the current system that relies heavily on morphological change and climate shifts. Although there is a lot of evidence of avocado exploitation and management, through sacred forests planted above dead ancestors, managed forest gardens, documents produced by chroniclers, and paleoethnobotanical data from archaeological sites of widely varying ages, the avocado plant itself has changed little morphologically, and does not even show the characteristic genetic bottleneck of many other crops.

Implementing Denham's contextual approach to identifying domestication and agriculture, and using McKillop's definitions for tree cropping and agroforestry, each of which take into account the unique ecological relationship that trees and humans share in tropical Mesoamerica, we can start building a framework for recognizing domesticated trees in the archaeological record.

Archaeologists can start by working closely with iconographers, when such information is available, in order to identify potential tree crops and possible uses, and to integrate that information with paleoethnobotanical data. Ethnographic and ethnoarchaeological studies of present-day forest gardens and their impact on the environment will help to identify those impacts that would be recognizable archaeologically, such as ditches or pits, or if the tree crops stayed in place as they did at Cobá.

Most importantly, archaeologists can keep in mind that macrobotanical remains of tree crops will not necessarily show evidence of morphological change, in spite of a wide range of seed sizes for certain trees, such as the avocado. The importance of these tree crops could inadvertently be overlooked if we apply the same standards to trees as we do grains, beans, and other field crops.

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