Economic Plant Species Associated with Prehistoric Agriculture in the Maya Lowlands[1]

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The issue of plant species used by the ancient Maya of the Yucatan region previous to A.D. 900–1,000 has involved a number of types of arguments, 5 of which are identified: ecological speculation, ethnobotany, plant relicts, linguistics/iconography, and plant remains/fossils. Recent emphasis on uncovering and analyzing plant remains from Maya occupational and agricultural relics demonstrates that direct evidence from archaeological contexts can be obtained. This evidence, including fossil pollen, seeds, and stem and wood fragments, is used to evaluate various issues involving those species proposed to have been used by the Maya. The results support views dealing with the dominance of maize as a staple and the use of squash, agave, cotton, and tree species. Propositions concerning significance of ramón, *cacao, root crops, and amaranth are not yet supported by direct evidence.*

The study of ancient Maya agriculture in the lowlands of the Yucatan peninsular region has flourished during the last decade (e.g., Harrison and Turner, 1978; Flannery, 1981; Wiseman, 1983a). Emphasis has been placed on the study of relic agricultural features, such as terraces, raised fields, and irrigation canals, in order to establish direct evidence of the types of agrotechnologies employed by the Maya and the areal extent of their use (Adams, 1980; Adams et al., 1981; Bloom et al., 1983; Eaton, 1975; Friedel and Scarborough, 1981; Gliessman et al., n.d.; Harrison, 1977; Healy, 1983; Healy et al., 1980; Kirke, 1980; Matheny, 1976; Puleston, 1977; Siemens, 1981, 1983a,b; Siemens and Puleston, 1972; Turner, 1974, 1983; Turner and Harrison, 1981, 1983; Turner and Johnson, 1979). Emphasis has also been placed on agriculture leading up to and sustaining the Classic period culture (before A.D. 900–1,000). A second phase of the agricultural studies has attempted to establish the types and production significance of the plants used by the Maya during this time. This paper offers a brief overview of the 5 types of arguments that have been used to address this second phase of study. It is suggested that direct evidence for the economic species used by the Maya is retrievable and that this evidence must take precedence over other assessments, especially in dealing with the Classic culture.

TYPES OF ARGUMENTS

Arguments concerning the use and agronomic significance of plant species among the ancient Maya are numerous and varied. However, at least 5 categories or types of arguments can be identified: 1) ecological speculation; 2) ethnobotany; 3) plant relicts; 4) linguistics/iconography; and 5) plant remains/fossils.

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Ecological speculation

This form of speculation is based on the identification of likely plant species that could have been available to the Maya and were ecologically suited for cultivation or use within the Maya lowlands (Drucker and Fox, 1982). Unfortunately, such speculation has, in the past, gained unwarranted measures of acceptance among some students of the Maya. The "artificial rainforest" and root-crop arguments are cases in point.

Artificial rainforest refers to the selective clearing of the forest so that useful species are retained for food and fiber and for shade and other support of annual cultigens. The result is not a cleared landscape per se but a "used forest." Gordon (1969) originally suggested the idea, and Wiseman (1978) has produced models suggesting the long-term productivity of an artificial rainforest system. However, direct evidence for this system or for the species specific to it has not been found.

As formalized by Bronson (1966), the root-crop argument asserts that manioc or cassava (*Manihot esculenta* Crantz), *yautia* or cocoyam (*Xanthosoma* spp.), sweet potato [*Ipomoea batatas* (L.) Lam.], and *jicama* [*Pachyrhizus erosus* (L.) Urb.] composed a significant, if not predominant, portion of the diet of the Classic Maya. Bronson marshalls ethnobotanical, lexical, and other types of evidence to support his position that these crops were used by the Classic Maya—a point of minimal dispute. However, support for the argument that these root crops were dominant staples relies largely on the proposition that root-crop productivity in the lowland tropics is superior to that of maize (*Zea mays* L.) and that population pressures associated with the Classic Maya would have necessitated the use of the more productive (ecologically efficient) species. To date, direct evidence of the significance of root crops to the Classic Maya has not been forthcoming.

Ethnobotany

Some identifications of cultivars used by the Maya rest largely upon information gathered subsequent to the Spanish Conquest, but also include information taken from Postclassic documents (codices, murals, and so forth). The traditional species complex of maize, beans (*Phaseolus* spp.), and squash [*Cucurbita moschata* (Duch.) Duch. ex Poir. and *C. pepo* L.] as ascribed to the Classic Maya and other Mesoamerican peoples drew its early support from this type of evidence as found in such sources as Tozzer (1941), Roys (1931), Lundell (1933, 1938), and Steggerda (1941). Although maize, beans, and squash have received more recognition than other domesticates, these studies also demonstrated that a large variety of other species were either cultivated or collected by the Maya. The diversity of the Maya diet has been elaborated more recently in works taken from archival materials (Hellmuth, 1974; Reina and Hill, 1980) and in studies of contemporary, traditional lowland Maya (Nations and Nigh, 1980).

One of the more interesting arguments is that involving the raised and channelized fields of the wetlands of northern Belize as relics of Classic Maya cacao (*Theobroma* spp.) plantations (Hammond, 1977; Dahlin, 1979). Part of this argument is based on ecological speculation. But part is also based on historic accounts of the northern Belize-southern Quintana Roo border zone as a major source of cacao. Unfortunately, direct evidence of large-scale cacao production in that area during Classic times or earlier is unavailable, despite searches for its

presence through the retrieval of plant remains from wetland fields and associated settlements (Turner and Harrison, 1981; Miksicek, 1983; Bloom et al., 1983).

Plant relicts

For lack of a better word, the term "relict" is used to designate a plant species whose distribution and density at the present time has resulted from some past activity of the inhabitants of the region concerned. For example, Lundell (1933, 1938) observed the high density of *ramón* (*Brosimum alicastrum* Sw.) within and among Maya ruins and suggested that this spatial pattern may have resulted from ancient Maya semidomestication of the species, its persistence having more to do with ancient Maya use than with soil conditions subsequent to the abandonment of Maya sites. Puleston (1968) formalized the argument, utilizing a set of assumptions concerning the storage capabilities of *chultunes* or underground chambers for *ramón*, but he also relied heavily on the current distribution and population of the species. He argued that the species was a major staple in the Peten area, especially at Tikal, during Classic times (Puleston, 1968, 1971, 1978, 1982; Puleston and Puleston, 1971).

The problems with the *ramón* argument have been well articulated (Sanders, 1973; Turner and Harrison, 1978: 348–349; Miksicek et al., 1981b), although speculation about the importance of *ramón* to prehispanic Mesoamericans continues to be raised at various conferences, including botanical ones. Much of the evidence countering the *ramón* argument is recent and is briefly summarized here. Lambert and Arnason (1978, 1982) demonstrate that the present distribution of the species near the ruins of Lamanai, Belize, can be explained by edaphic considerations. Similar conclusions have been reached by 2 ecologists, Frederick Wiseman (1983a: 163–164) and Charles Peters (pers. comm.) working in Petén, Guatemala, and Vera Cruz, Mexico, respectively. A recent study of plant remains from a *chultun* at Cuello, Belize (Miksicek et al., 1981b), found no *ramón*. Finally, Reina and Hill (1980) have produced archival documentation that *chultunes* in Alta Vera Paz, Guatemala, were used by Postclassic Maya to store smoked or cured maize.

Plant relicts have also been used as evidence for the argument that the ancient Maya at Coba, Mexico, maintained orchards within the central portion of the site (Folan et al., 1979). This argument is consistent with Spanish accounts of Postclassic Maya orchards near settlements (locations unspecified). However, the Coba study should be viewed cautiously for several reasons. Of the 15 economic species identified at Coba, only *ramón* and *guaya* [*Talisia oliviformis* (H.B.K.) Radlk.] show a strong statistical correlation with elite residences (Folan et al., 1979: Tables 1–4), probably reflecting the edaphic factors described by Lambert and Arnason (1982) at Lamanai. Moreover, the Coba study fails to account for the intensity of burning, culling, and planting done by modern farmers at the site. The distribution of *limón* [*Citrus aurantiifolia* (Christm.) Swingle] trees, an historic period introduction at the site, attests to the impact of these activities on the local flora. Farmers have not cleared around large platforms and other relic Maya structures where it would be difficult to cultivate, allowing *ramón*, *guaya*, and other large trees to grow. Many of the other "economic" species discussed in the Coba study are secondary successional species characteristic of plots in long fallow.

Linguistics and iconography

Various Postclassic (after A.D. 900–1,000) Maya murals have been described as illustrating maize (Lothrop, 1924: 57) and several Maya codices depict hunted animals (Villacorta and Villacorta, 1930). For the most part, however, minimal attention has been given to the study of Maya linguistics and iconography to produce direct evidence of economic species used in Classic times. McQuowan (1964: 80), arguing for a glottochronological dating scheme, hypothesized that a proto-Maya linguistic group (ca. 2,600 B.C.) was using words for avocado (*Persea americana* Mill.), cacao, maize, manioc, sweet potato, agave (*Agave* spp.), chile (*Capsicum* spp.), and squash. The proposed antiquity of these proto-Maya words is not important here, as noted by Bronson (1966: 263). Rather, the fact that proto-Maya words can be traced from the 4 main branches of Maya linguistic stock is suggestive that these species were recognized and/or used by the Maya previous to Postclassic times. Miksicek's perusal of the linguistic evidence has led him to concur with most of McQuowan's identifications. He questions the proto-Maya words for agave and possibly manioc, and adds cotton (*Gossypium hirsutum* L.) and copal [*Protium copal* (Schlect. and Cham.) Engl.] to the proto-Maya list.

Puleston (1977) attempted to use Maya iconography to assess the significance of wetlands to the Classic period culture. The potential for species identification in Maya iconography may exist. Schele (1978) has tentatively identified avocado, *nanze* [*Byrsonima crassifolia* (L.) H.B.K.], guava (*Psidium guajava* L.) and *sapodilla* [*Manilkara zapota* (L.) van Royan], and Thompson (1981) may have identified a species of *Xanthosoma*.

Plant remains and fossils

The most convincing evidence for the identification of species used by the Classic Maya is the recovery of plant remains from datable Maya features or in relative chronological contexts provided by natural stratigraphy. In the past, the potential for recovery of such remains from wet-dry tropical habitats was thought to be limited. However, recent work has demonstrated the presence of fossil pollen and other plant remains in a variety of contexts in the Maya area (Tsukada, 1966; Wiseman, 1978; Miksicek et al., 1981a; Fish, 1978). Moving from the general to the specific, these remains have been found in lake cores, ancient occupational structures, and ancient agricultural features.

Lake cores have produced evidence of maize in Petén, Guatemala (Tsukada, 1966; Tsukada and Deevey, 1967; Deevey et al., 1979; Wiseman, 1978), and in northern Belize (Bradbury and Puleston, 1974). Maize pollen is usually transported only short distances by wind, so that the presence of this pollen in the lake cores indicates that the species was grown or used in the immediate vicinity. Most of the lakes in question do not have major streams entering them, such that long distance water transport of the pollen is not an issue. Contamination hinders the use of radiocarbon dating of the cores from many lakes in the lowlands (unless wood is encountered), but the depths of the finds leave little doubt of the antiquity of the maize pollen.

Recovering fossil pollen from occupational context has increased during the past few years. Wiseman (Turner et al., n.d.) found maize pollen associated with

a Classic period *metate* (grinding stone) at Copán, Honduras. Pollen of maize, squash, agave, and possibly cotton have been found in various habitation structures at Edzna, Campeche (Fish, 1978). Other suggested economic species from Edzna are prickly pear (*Opuntia* sp.), cattail (*Typha* sp.), hackberry (*Celtis* spp.) and amaranth (*Amaranthus* spp.). Pollen of maize and agave have also been recovered from a Postclassic (after A.D. 850–1,000) barkbeater from Nohmul, Belize (Susan Fish, pers. comm.).

Fossil pollen has also been retrieved from agricultural or related features. Maize and possibly cotton and amaranth were reported from a canal at Albion Island (in the Hondo River), northern Belize (Bradbury and Puleston, 1974). More recent studies of pollen from the wetland fields at Albion Island revealed up to 2% maize (Bloom et al., 1983). Pollen of maize, and possibly cotton and amaranth, have also been retrieved from the wetland fields at Pulltrouser Swamp, northern Belize (Turner and Harrison, 1981; Wiseman, 1983b).

Of these finds there is little doubt that the pollen of maize and squash are those of cultigens. And, the pollen of agave is presumed to be that of cultigens because the species were cultivated by the Maya at the time of Spanish contact, they are poor producers of pollen, and no species of agave is native to the forest areas of Belize or southeast Mexico. The verification of other cultigens must be taken cautiously either because of identification problems or because they may represent collected, not domesticated, species. The identification problem is particularly acute for the pollen of cotton and amaranth. The pollen of domesticated amaranth, for example, is indistinguishable from that of many other species of *Amaranthus* and *Chenopodium*, a number of which are disturbance weeds. And, cotton is only minutely different in size, sculpturing, and pore structure from its weedy relatives.

One of the most promising approaches being utilized in the Maya area is the recovery, usually by flotation procedures, and analysis of plant remains other than that of pollen (and phytoliths), including seeds, and wood or stem fragments (Table 1). First used in a major way in the Maya area at Cuello, Belize (Hammond and Miksicek, 1981; Miksicek et al., 1981a,b), and utilized significantly at Colha (Miksicek, 1979), and Pulltrouser Swamp (Miksicek, 1983), the procedure to date has recovered and identified 18 economic species from the lowlands, mostly from the constructional fill of ruins (Table 1). These finds include maize, squash, avocado, cacao, *nanze*, hogplum (*Spondias* spp.), allspice [*Pimenta dioica* (L.) Merr.], hackberry, guava, sapodilla, calabash (*Crescentia* spp.), *siricote* (*Cordia dodecandra* DC.), cotton, copal, indigo (*Indigofera suffruticosa* Mill.), and logwood (*Haematoxylon* spp.). Use of this technique in context with the relic wetland fields at Pulltrouser Swamp and at Albion Island yielded fragments of carbonized maize stems (Miksicek, 1983; Bloom et al., 1983). Also, maize charcoal, presumably from below a wetland canal at Albion Island, has produced an uncorrected radiocarbon date of 670 B.C. (Bloom et al., 1983).

Of these finds it can be stated with certainty that the remains of maize, squash, cotton, avocado, and possibly cacao are those of domesticated crops dating to Classic times or earlier. Whether some of the fruits are true cultivars or semidomesticates, as opposed to collected species, is uncertain. Most of the species identified are remains of food crops, although some fiber and dye plants and species used for wood are included. For discussions of plant usage, the reader is directed to Lundell (1938).

Another issue is that of the proper interpretation to be given to the plant remains based on their "provenience" (location within an excavation unit). Plant remains can be transported by wind and water and can be moved vertically within soil by bioturbation. Hence, discovery of these remains in a Maya habitation structure or agricultural feature does not necessarily imply cultivation or use at that locale.

The pollen of maize, squash, and cotton, the principal species at issue (Table 2), are presumed not to be carried long distances in large quantities by natural agents. Therefore, if the species are present and associated with a suppression of the pollen of the native flora, cultivation in the area of the find may be implied. Based on comparisons with pollen collected from various types of contemporary plant communities in the lowlands, Wiseman (pers. comm.; Bloom et al., 1983) concludes that when maize pollen constitutes 2% or more of the total pollen count, cultivation of the species in the immediate area (of the source of the material in which the pollen was found) is indicated. Little is known about the effect of water transport and bioturbation on all types of plant remains in the Maya area. With the exception of a few rivers on the eastern and western sections of the lowlands that empty into the sea, most surface water courses in the Maya area extend only short distances, leading into swamps or other low areas (*bajos*). However, studies of plant remains in agricultural features in the lowlands have focused on northern Belize, an area with several major waterways.

Pollen of economic species has been found on ancient *metates*, and pollen and other plant remains have been recovered in ancient structural fill and agricultural features. Pollen from lake cores has been discussed above. It is safe to conclude that, barring contamination, the maize pollen taken from a grinding stone found buried in a habitation structure represents the use of that species in or near the location of the structure. No one has yet determined that the Maya hauled structural fill long distances, so that barring contamination or bioturbation, all plant remains taken from such fill reflects the presence of the species in the general vicinity of the structure in question. Furthermore, when that fill is sealed by stone or plaster, the latest possible date that the remains were deposited can usually be estimated with a high degree of confidence.

Interpretations of plant remains from canal fill are problematic because their presence in canal sediments may have resulted from water transport at some distance from their point of origin, especially in riverine contexts. Moreover, if it is assumed that canals were periodically cleared until abandoned, then the remains found in the sediments could date to any time after the feature was abandoned. In contrast, plant remains found in the old cultivated zone or in the artificially created portions of wetland fields reflect the presence of that species in the vicinity of the field or of the source of the materials used to construct the fields. In either case, the plant remains were deposited during construction and maintenance of the fields or were cultivated on them.

INTERPRETATIONS

Direct evidence of Classic Maya domesticates includes maize, squash, manioc, cotton, avocado, sweet potato, and agave and probably includes cacao and chile (Table 2). Plant remains found in archaeological context and linguistic evidence support the validity of this list. No remains of domesticated manioc, sweet potato,

TABLE 1. PLANT REMAINS (OTHER THAN POLLEN AND PHYTOLITHS) FROM SOUTHERN

		Cuello[a] (northern Belize) 2,000–1,000 B.C.	Cuello 1,000–400 B.C.	Cuello 400 B.C.–A.D. 250	Pulltrouser Swamp[b] (northern Belize) before A.D. 850		Copán[c] (Honduras) before A.D. 850	Colha[d] (northern Belize) early historic	Albion Is.[e] (northern Belize) before A.D. 850		Tikal[f] (Petén, Guatemala) before A.D. 850
					Kokeal & K'aseb	Raised field			Wetland field	Below canal	
Field crops											
Maize	*Zea mays*	c, s	c, s	c, s	c	w		c, s	w	w	c, s
Squash	*Cucurbita moschata*	r	r	r	r			r			s
Wild chile	*Capsicum* spp.		s								
Fruit trees											
Avocado	*Persea americana*	w	w	w	w		s				s
Nance	*Byrsonima crassifolia*	s, w	s	s			w				?
Hogplum	*Spondias* spp.	w		w	w						s
Cacao	*Theobroma cacao*			w	w		w				
Mamey zapote	*Calocarpum mammosum*		s, w	s, w	w			w			
Huiscoyol	*Bactris* spp.			s							
Allspice	*Pimenta dioica*	w		w	w?						
Hackberry	*Celtis* spp.	s*	s*	s*							
Guava	*Psidium guajava*			w			w				
Coyal palm	*Acrocomia* spp.										s
Sapodilla	*Manilkara zapota*			w	w						s
Calabash	*Crescentia* spp.				w						
Fiber plants											
Cotton	*Gossypium hirsutum*		s	s				s			
Resin											
Copal	*Protium copal*				w		w				
Dye plants											
Indigo	*Indigofera suffruticosa*			w							
Logwood	*Haematoxylon* spp.			w							

Key to symbols: c—cob fragment, carbonized; s—seed, carbonized; s*—seed, mineralized; r—rind fragment, carbonized; w—wood charcoal or stem fragment; ?—seed, uncarbonized.

[a] Miksicek et al., 1981a; Hammond and Miksicek, 1981.

[b] Miksicek, 1985.

[c] Miksicek, unpublished data.

[d] Miksicek, 1979.

[e] Bloom et al., 1985.

[f] C. E. Smith, pers. comm. with permission of W. Coe.

TABLE 2. TYPE OF DIRECT EVIDENCE OF ECONOMIC SPECIES USED BY THE CLASSIC (OR EARLIER) MAYA.

Domesticated species	Location	Context	Evidence
Maize, *Zea mays*	Lowlands	—	linguistic
	Central Petén (lakes)	lake core	pollen
	Tikal	structural fill (o)	cob fragment, seed
	Southern Petén (Lago Izabal)	lake core	pollen
	Northern Belize		
	Albion Is. (Laguna de Cocos)	lake core	pollen
	Albion Is. (San Antonio)	canal	pollen
		below canal	stem fragments
		channelized field	stem fragments
	Cuello	structural fill (o, m)	cob fragments, seeds
		chultun	cob fragments, seeds
	Kokeal (Pulltrouser Swamp)	structural fill (o)	cob fragments
	K'axob (Pulltrouser Swamp)	structural fill (m)	pollen, cob fragments
	Pulltrouser Swamp	channelized field	stem fragments
		raised field	pollen
	Central Campeche		
	Edzna	structural fill (o, m)	pollen
Agave, *Agave* spp.	Lowlands	—	linguistic
	Central Campeche		
	Edzna	structural fill (o, m)	pollen
Avocado, *Persea americana*	Lowlands	—	linguistic
	Honduras		
	Copán	structural fill (o)	seeds
	Northern Belize		
	Cuello	structural fill (o, m)	wood charcoal
	Kokeal	structural fill (o, m)	wood charcoal
	Petén, Guatemala		
	Tikal	structural fill (o, m)	seeds
Cacao, *Theobroma* spp.	Lowlands	—	linguistic
	Northern Belize		
	Cuello	structural fill (o, m)	wood charcoal
Nance, *Byrsonima*	Northern Belize		
	Cuello	structural fill (o, m)	seeds, wood charcoal

TABLE 2. CONTINUED.

Domesticated species	Location	Context[a]	Evidence
	Petén, Guatemala[b]		
	Tikal	structural fill (o, m)	seeds (?)
Allspice, *Pimenta dioica*	Northern Belize		
	Cuello	structural fill (o, m)	wood charcoal
	Kokcal	structural fill (o)	wood charcoal (intrusive?)
Hackberry, *Celtis* spp.	Central Campeche		
	Edzna	structural fill (o, m)	pollen
	Northern Belize		
	Cuello	structural fill (o, m)	seeds
Guava, *Psidium guajava*	Honduras		
	Copán	structural fill (o)	wood charcoal
	Northern Belize		
	Cuello	structural fill (o, m)	wood charcoal
Sapodilla, *Manilkara zapota*	Northern Belize		
	Cuello	structural fill (o, m)	wood charcoal
	Kokcal	structural fill (o)	wood charcoal
	Petén, Guatemala[b]		
	Tikal	structural fill (o, m)	seeds
Calabash, *Crescentia* spp.	Northern Belize		
	Kokcal	structural fill (o)	wood charcoal
Squash, *Cucurbita* spp.	Lowlands	—	linguistic
C. moschata and	Northern Belize		
C. ficifolia (?)	Cuello	structural fill (o, m)	rind fragments
	Colha	structural fill (o)	rind fragments
	K'axob	structural fill (o, m)	rind fragments
	Petén, Guatemala[b]		
	Tikal	structural fill (o, m)	seed
C. pepo	Central Campeche		
	Edzna	structural fill (o, m)	pollen
Cotton, *Gossypium hirsutum*	Northern Belize		
	Cuello	structural fill (o, m)	seeds

TABLE 2. CONTINUED.

Domesticated species	Location	Context[a]	Evidence
Gossypium spp.	Albion Is. (San Antonio)	canal	pollen (?)
	Pulltrouser Swamp	raised field	pollen (?)
Manioc, *Manihot* spp.	Lowlands	—	linguistic
Sweet potato, *Ipomoea batatas*	Lowlands	—	linguistic
Chile, *Capsicum* spp.	Lowlands	—	linguistic
	Honduras		
	Copán	structural fill (o)	wood charcoal
Hogplum, *Spondias* spp.	Northern Belize		
	Cuello	structural fill (o, m)	wood charcoal
	Kokeal	structural fill (o)	wood charcoal
	Honduras		
	Copán	structural fill (o)	wood charcoal
	Petén, Guatemala[c]		
	Tikal	structural fill (o, m)	seeds
Mamey zapote, *Calocarpum mammosum*	Northern Belize		
	Cuello	structural fill (o, m)	seeds, wood charcoal
	K'axob	structural fill (o, m)	wood charcoal
	Colha[c]	structural fill (o)	wood charcoal
Huiscoyol, *Bactris* spp.	Lowlands	—	linguistic
	Northern Belize		
	Cuello	structural fill (o, m)	seeds
Copal, *Protium copal*	Honduras		
	Copán	structural fill (o)	wood charcoal
Indigo, *Indigofera suffruticosa*	Northern Belize		
	Cuello	structural fill (o, m)	wood charcoal
Logwood, *Haematoxylon* spp.	Northern Belize		
	Kokeal	structural fill (o)	wood charcoal

[a] o = occupational structure; m = ornamental structure.

Xanthosoma, or chile have yet been reported, although the linguistic evidence indicates their use.

Despite the various data and interpretive problems noted above, several patterns related to the ancient Maya use of economic species prior to Postclassic times are emerging:

(1) The cultivation of maize during most, if not all, of Maya tenure in the lowlands is unquestionably supported by all lines of evidence. Remains of maize are confirmed at Cuello as early as 2,000–1,000 B.C. and at K'axob (Pulltrouser Swamp) in context with ceramics similar to those at Cuello. Environmental conditions throughout much of the Maya lowlands are suitable for maize cultivation, and the Spanish document its use as a major food source among the 16th century Maya. Hence, it is difficult not to speculate that maize was cultivated throughout the lowland Maya domain in Classic times and that the scale of production was significant.

(2) The presumed complementary domesticate to maize, squash (*Cucurbita moschata, C. pepo* and possibly *C. ficifolia* Bouché), is confirmed by both pollen and other plant remains. Interestingly, the third complementary crop, beans (*Phaseolus* spp.), has not been confirmed in lowlands.

(3) The evidence for fiber crops is increasing. *Agave* spp. has been identified at Edzna. Cotton appears between 1,000–400 B.C. at Cuello. Possible fossil pollen of cotton has been reported in context with relic raised fields and canals in northern Belize.

(4) The Maya utilized a large number of tree fruits, both domesticated and wild. At least 12 species have been identified by seed, stems, or wood fragments. Interestingly, combined with the pollen data the picture that emerges is that of the use of orchard-gardens, not unlike those that can be found throughout the lowlands today (Netting, 1977). Whether orchard-gardens were located at the center of sites (nucleated settlements), associated with elites or commoners, or grown in special locations around sites, is not known. Our hunch is that the central segments of nucleated settlements were not zones of orchard-gardens, particularly in that many of the central plazas were paved. Rather, orchard-gardens were probably associated with residence structures away from the central plazas and with farming abodes. Indeed, orchard-gardens situated between farm houses or houses at the edges of "urban" areas may partially explain the dispersed pattern of Maya settlement, as implied by Folan and colleagues (1979). Regardless of the precise situation, orchard-gardens probably did not take up too much of the landscape, as studies of regional pollen suggest an open vegetation throughout much of the lowlands during Classic times.

Direct evidence is also helpful in evaluating several of the arguments developed by other means:

(1) *Ramón. Brosimum alicastrum* was probably utilized by the Classic Maya. However, it is doubtful that it was a major dietary staple for the reasons discussed previously. It seems unlikely that *ramón* could have been used extensively by the Maya and yet evade detection by techniques used to recover its remains, although it should be noted that Tikal—the presumed center of *ramón* use in Classic times—has not been examined through the extensive use of flotation techniques.

(2) *Cacao.* The direct evidence indicates the use of cacao in Classic or earlier times. The existence of cacao plantations on wetland fields in the Maya area is

not supported by the evidence. Plant remains of cacao have not been found in the wetland fields at Pulltrouser Swamp, and only a few fragments of charcoal have been found in the structural fill at the adjacent occupation sites. It is doubtful that the Maya were so efficient in their use of cacao that vestiges of its large-scale production would escape the intensive search conducted there.

(3) *Root crops.* Linguistic evidence supports the use of root crops, especially manioc and sweet potato. Furthermore, wild *Xanthosoma* and manioc occur throughout the lowlands. The significance of these cultivars to the Classic Maya is not known however. There are no published reports of pollen or other remains of the species, although evidence of *Xanthosoma* was apparently found at Tikal (Mary Pohl, pers. comm.). Root crops produce very little pollen, and a strong argument can be made that preservation problems hinder detection of such pollen. Determination of the significance of root crops may await more detailed studies or the use of recovery techniques and methods of analysis that have yet to be employed in Maya studies in a major way. Improvement of phytolith analysis or examination of other intracellular plant crystals, such as calcium oxalate, may prove useful here.

(4) *Amaranth.* The use of *Amaranthus* in the lowlands has been suggested (Puleston, 1977; Fish, 1978). Unfortunately, the evidence is slim, consisting of the palynological identification of the genus, which includes a variety of weeds common throughout the Maya lowlands. Furthermore, the lack of amaranth remains in lowland flotation samples casts strong doubt on the use of the species in Classic times. Miksicek has found that use of amaranth (gathered or cultivated) in other areas results in a dominance of that genus in flotation samples collected from archaeological features.

SUMMATION

A variety of arguments has been used to suggest and to demonstrate economic plant species and their importance to the Classic Maya. The arguments based on speculation and indirect evidence have been helpful in establishing possible species. The danger with them is that the interpretation of the possible may become accepted as fact. Farmers do not invariably choose to emphasize "staples" that are the most ecologically efficient for their local environments, and the degree of reliance on particular sets of species changes as socioeconomic conditions change. Interpretations focusing on efficiency-based speculation and ethnobotany must consider the socioeconomic contexts from which the argument or evidence is taken and to which they are applied (e.g., Turner, 1978).

Studies of plant remains have demonstrated that direct evidence of the species used by the Maya can be retrieved. While in their infancy in the Maya area, the techniques of retrieval and analysis of plant remains have more than demonstrated their usefulness. However, several problems exist with the data at this time. First, too much emphasis may be given to the materials that preserve. Obviously, what is found is what preserves or what can be detected, given the techniques available. This point may be particularly important with respect to the lack of remains of root crops, vegetables, such as the tomato (*Lycopersicon esculentum* Mill.), and beans in the lowland zone. Second, studies that have used techniques to extract fossil pollen from relic habitation structures or agricultural features are few in number, and spatial coverage is small, perhaps resulting in a skewed data base.

Indeed, northern Belize has received by far the most attention, while Peten and the northern and southern lowlands have been relatively ignored. Studies from different regions may well reveal the past existence of larger and more regionally specialized crop assemblages than the data presently indicate. Finally, phytolith research has only begun in the Maya lowlands (Wiseman, 1983b), and the development of this technique may allow the detection of various other species.

The next 10 yr, barring a major reduction of research, will undoubtedly expand the data pertaining to economic species utilized by the lowland Maya in Classic times and earlier. We expect that this evidence will indicate the use of a large number of plant species (Lundell, 1938) but with an emphasis on key staple and other crops, especially maize and cotton, that increased in significance up to the collapse of the Classic lowland Maya.

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