MAGUEY (*AGAVE* spp.) UTILIZATION IN MESOAMERICAN CIVILIZATION: A CASE FOR PRECOLUMBIAN "PASTORALISM"

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Abstract. Archaeologists have generally neglected the implications of maguey cultivation in their assessments of prehispanic Mesoamerican cultural development in the highlands of central and north-central Mexico. Recent ethnographic, ethnohistoric, and archaeological studies provide the basis for the formulation of new hypotheses about the importance of the complementarity of maguey and seed-based cultivation in ancient Mesoamerica. We see cultivated maguey as functionally analogous in Mesoamerica to the role of pastoralism in the development of archaic civilizations in the Andes, Asia, Africa, and Europe. Future archaeological and ethnobotanical research should provide key new information for refining and testing these hypotheses.

Key words: *Agave*, archaeology, ethnobotany, maguey, mesoamerica.

Resumen. Los arqueólogos generalmente han descuidado la importancia del cultivo del maguey (*Agave* spp.) en sus apreciaciones del desarrollo cultural prehispánico en las tierras altas del centro y norte-centro de México. Estudios etnográficos, etnohistóricos, y arqueológicos recientes han sido la base para la formación de nuevas hipótesis sobre la importancia de la complementariedad de los sistemas agrícolas, basados tanto en la producción anual de semillas como en la producción vegetativa y continua del maguey. Consideramos el cultivo del maguey en las tierras altas de la Mesoamérica prehispánica como análogo del pastoreo en el desarrollo de civilizaciones antiguas en los Andes, Asia, África, y Europa. Futuras investigaciones arqueológicas y etnobotánicas deben proveer nuevos datos para refinar y probar estas hipótesis.

Palabras clave: *Agave*, arqueología, etnobotánica, maguey, mesoamérica.

Prehispanic Mesoamerica was the only one of the world's ancient primary civilizations which lacked a domestic herbivore. With domestic camelids in the Central Andes, and sheep and goats in much of the Old World, food producers in virtually all other regions where Archaic States existed were able to significantly extend their productive landscapes into drier and colder zones and over a full annual cycle i.e., some of them became full- or part-time herders, and herder-cultivator relationships became important in the long-term development of socio-political complexity. How could ancient Mesoamericans —particularly in the highlands (tierras altas) of central and north-central Mexico, where severe winter frosts and highly seasonal rainfall limited seed-based agriculture to one growing season per year (figure 1)—, have attained such a comparably high level of organizational complexity?

Most archaeologists have overlooked the full significance of cultivated maguey, *Agave salmiana* Otto ex Salm-Dyck, *Agave mapisaga* Trel., *Agave atrovirens* Karw. ex Salm-Dyck, *Agave ferox* K. Koch, *Agave hookeri* Jacobi, and *Agave americana* L. (Gentry, 1982) in the prehispanic economy of highland central and north-central Mexico. An extreme expression of this viewpoint is the assertion by Blanton *et al.* (1981:174) that "in the highland valleys [of Mesoamerica] the surest way of producing a large surplus was to plant maize everywhere."

In this paper we argue that cultivated maguey (which reproduces vegetatively and matures over a 7-25 year cycle) and annual seed crops were fully complementary in the Mesoamerican tierras altas. Furthermore, we suggest that maguey made available in prehispanic Mesoamerica some of the same kinds of

adaptive strategies complementary to annual seed-based agriculture as did domestic camelids in the Central Andes and sheep and goats in Asia, Africa, and Europe. We attempt to develop the following inter-related hypotheses:

1. In the Mesoamerican *tierras altas* the development of complex society during the Middle and Late Formative (table 1) depended upon the domestication of maguey as a primary complement to seed crops for the production of food and fiber (Sauer, 1941).
2. The expansion of ancient Mesoamerican civilization into the drier highland regions of central and north-central Mexico depended upon the full integration of seed-based and maguey-based agricultural production.
3. Prehispanic agricultural production in the drier highland regions of central and (especially) north-central Mexico was based upon generalized pro-

Table 1. Valley of Mexico, Prehispanic Chronology (adapted from Sanders, Parsons, and Santley 1979).

Date	Period	Phase
1520 A.D.		
	Late Postclassic	Aztec III
1350 A.D.		
	Middle Postclassic	Aztec I-II
1150 A.D.		
	Early Postclassic	Mazapan Coyotlatelco
950 A.D.		
	Epiclassic	Metepec Xolalpan
750 A.D.		
	Classic	Tlamimilolpa Miccaotli Tzacualli
150 A.D.		
50 B.C.	Terminal Formative	Patlachique
250 B.C.		
	Late Formative	Ticomán
500 B.C.		
	Middle Formative	La Pastora El Arbolillo
900 B.C.		
	Early Formative	Bomba Ixtapaluca
1200 B.C.

Figure 1. Middle America, showing the approximate extent of the *tierras altas* (shaded).

duction of both seed crops and maguey in comparatively well-watered core areas (the irrigable river valleys) and more specialized agave (and probably nopal [*Opuntia* sp.]) production in the drier peripheral zones beyond the reach of effective irrigation.

4. The archaeological record hints at a major change in the technology of prehispanic maguey production after the Classic period. This technological change is suggestive of basic differences in Classic and Postclassic political economy.

Materials and Methods

It has long been known that maguey was an important prehispanic source of food and fiber in highland Mexico. Nevertheless, the plants themselves are often poorly preserved in archaeological contexts, and the technology and organization of prehispanic maguey exploitation have remained poorly understood. Recent ethnographic research (Sánchez, 1980; Ruvalcaba, 1983; Salinas and Bernard, 1983; Patrick, 1985; Rangel, 1987; Parsons and Parsons, 1990) has provided some new insights.

Maguey sap and flesh. The maguey plant provides a rich store of both sap and edible flesh. Today, throughout the highlands of southern, central and north-central Mexico, maguey sap (aguamiel) is acquired for human use by means of procedures which interrupt the final stage of a plant's normal 7-25 year maturation process in order to extract the sap through twice-daily scraping and sucking operations over a period of 3-6 months. Individual plants in cultivated fields typically approach maturity continuously throughout the year: the timing of their planting and

replacement is explicitly managed so as to insure continuous productivity when usually no more than 5-10% of a field's maguey plants are producing sap at any particular point in time (Parsons and Parsons 1990:336).

Over its 3-6 month production period, a single plant typically yields several hundred liters of sap, and a hectare of land planted in maguey typically yields 5000-9000 liters of sap per year (Parsons and Parsons 1990:338). The sap may be allowed to ferment to form pulque (as it usually is today), or it may be consumed in its unfermented liquid form, or it may be boiled down to form thick syrup or solid sugar. *Aguamiel* and *pulque* are quite unstable, and cannot remain unused for more than about a week. As syrup or sugar, however, maguey sap is much more durable, and in these forms sap surpluses can readily be stored and redistributed over a period of months, or even longer.

The modern Tarahumara of northern Mexico extract agave sap by simply mashing up the plant's leaves and squeezing out the liquid in a single operation (Bye *et al.*, 1975). The leaves, heart, and stalk of the maguey plant can also be eaten. The Tarahumara, for example, prepare cakes of baked agave flesh which can be stored up to six months (Bye *et al.*, 1975).

Maguey sap and flesh are rich in both nutrients and calories. Ruvalcaba (1983:89) cites analyses showing that one liter of pulque contains 574 calories. Davidson and Ortiz de Montellano (1983:155) report that one tablespoon of maguey sap contains significant

quantities of protein, carbohydrates, Vitamin C, calcium, phosphorous, potassium, iron, magnesium, selenium, chromium, and zinc. Anderson *et al.* (1946:888) found that in the diets of their study group of rural Otomí villagers *pulque* supplied 12% of total calories, 6% of total protein, 10% of total thiamine, 24% of total riboflavin, 23% of total niacin, 48% of total Vitamin C, 8% of total calcium, and 20% of total iron. Ross (1944, cited in Fish *et al.*, 1986) found that 100 grams of cooked agave flesh contains 347 calories and 4.5 gms of protein.

It appears that in many highland agricultural contexts maguey can produce approximately as many calories and essential nutrients per hectare as the standard seed crops; when the plant's flesh and sap are both consumed, maguey can potentially produce more calories than seed crops on a given unit of land (Parsons and Parsons, 1990:337-338, 345). Most important of all, maguey can be interplanted with seed crops in virtually all agricultural settings, and when this is done the overall nutritional and energetic output on a given unit of land is potentially doubled.

It is important to emphasize that this potential doubling of agricultural productivity in the *tierras altas* applies to both prime, highly fertile land as well as to more marginal terrain. Modern scholars have usually associated maguey production with marginal land (e.g., Simpson 1952; Sanders *et al.*, 1979), but this viewpoint is simply inaccurate: the ethnographic and

Figure 2. Prehispanic spindle whorls for maguey fiber, showing diversity in size.

historic literature is filled with clear evidence that maguey has been a key, primary component of agricultural productivity in virtually all types of agricultural land in the tierras altas, including productive zones of deep soil and adequate humidity (Parsons and Parsons, 1990). Cultivated maguey will also flourish on dry, infertile land where no other cultigens will grow: consequently, there are large areas of poor agricultural land in central and north-central Mexico today where maguey is the dominant or exclusive cultigen.

Combining maguey and seed crops would have maximized subsistence security for prehispanic agriculturalists in the tierras altas: annual energy productivity on many kinds of cultivated land could be doubled; agricultural productivity could be extended over a full annual cycle; agricultural productivity could be extended into nearby drier, colder, and less fertile areas; maguey is resistant to drought, frost, and hail, all common causes of seed-crop failure in the tierras altas; the year-round productivity of maguey could be combined with the long-term storability of seed crops; and most maguey-sap exploitation could easily be deferred to the winter agricultural off-season (because after the initial "castration" operation, when the first stages of a plant's nascent central stalk are removed, the collection of the plant's sap can be postponed for up to six months, without any apparent loss in productivity) (Macedo, 1950).

Because maguey is an ideal famine food in highland Mexico, stands of wild or feral maguey may have been deliberately extended in prehispanic times so as to provide food for sedentary cultivators during times of serious crop scarcity, as was commonly done by prehistoric colonists with certain types of introduced wild or semi-wild plants in ancient Polynesia (Kirch, 1984:131-132). The extensive stands of wild maguey and nopal which today occur throughout the most marginal highland zones in central and north-central Mexico might be relicts of such prehispanic practices. The relationship over time between cultivated and feral/wild maguey is a key problem, still little studied by either archaeologists or botanists (Rzedowski, 1986).

Maguey fiber. In prehispanic Mesoamerica there were only two major fibers suitable for making textiles: cotton and maguey (*ixtle* fiber). Cotton could not be grown at elevations above c. 1800 m asl in the tierras altas, so there would have been a great need for large quantities of locally produced maguey-fiber textiles in highland Mexico.

An average maguey leaf produces roughly 75 gm of dried fiber (Parsons and Parsons, 1990:157). A typical maguey plant has 20-30 leaves, and thus provides some 2000 grams of *ixtle*. A modern carrying cloth (*ayate*) made of woven maguey thread measures about one meter square and weighs about 200 grams.

Figure 3. Modern iron maguey scraper mounted in wooden handle.

Figure 4. Examples of prehispanic trapezoidal tabular basalt scrapers.

Thus, one maguey plant provides enough fiber for about 10 square meters of cloth. More precise calculations would have to make allowance for variable thread thickness, thread spacing, fiber quality, and type of costume, etc. Nevertheless, these rough estimates suggest that one maguey plant would have provided enough fiber for outfitting an average precolumbian person in highland Mexico with most of the maguey-fiber textile required for clothing over a period of a few years.

On an average hectare of cultivated land in highland Mexico today, about 30 maguey plants can be exploited each year for both sap and fiber (Parsons and Parsons, 1990:336, 338). Thus, one hectare of cultivated maguey could potentially outfit approximately 30 people with the maguey cloth they need for a few (say three) years. Or, assuming each average person requires one-third of his/her wardrobe to be replaced each year, then one hectare of cultivated maguey would provide the annual maguey cloth needs for some 90 people (once again, let's simplify our calculations by calling it an even 100). On this basis, 1,000,000 people (approximately the number of peo-

ple living in the Valley of Mexico in A.D. 1500) would annually require the fiber production (c. 600,000 kilos) from some 10,000 hectares (roughly 5% of the total potentially arable landscape in the Valley of Mexico) of cultivated maguey. This same amount of land could potentially, at the same time, have produced large amounts of aguamiel, cooked maguey flesh, interplanted maize or beans, and dried maguey stumps for use as household fuel (Parsons and Parsons, 1990:337-338; Evans, 1990).

The sub-specific variability of maguey is impressive. Today, for example, there are at least a dozen named varieties of cultivated maguey in the eastern Mezquital (Salinas and Bernard, 1983), and in the late nineteenth century there were more than two dozen different named varieties on the large pulque haciendas in nearby Tlaxcala and Puebla (Blásquez and Blásquez, 1897). Different varieties have different properties and characteristics: some are recognized as better sap producers, others are better for fiber, while others perform better on certain types of land, etc. The origins of this botanical diversity remain poorly understood, but we suspect that some of it ultimately

Figure 5. Experimental use of a trapezoidal tabular basalt scraper.

derives from deliberate prehistoric human selection for specific qualities in an increasingly specialized and diversified maguey productive system. These key issues can only be illuminated with more ethnobotanical and paleo-ethnobotanical investigation.

Results

Ethnographic and archaeological studies indicate that several categories of stone and ceramic tools can be associated with some aspects of prehispanic maguey processing.

Spinning. In central Mexico mold-made Postclassic ceramic spindle whorls are common, and archaeologists can distinguish between small whorls (almost always weighing less than c. 7 grams) used for spinning cotton fiber and large whorls (almost always weighing more than c. 11 grams) used for maguey fiber (e.g., Parsons, 1972; Smith and Hirth, 1988) (figure 2). Furthermore, we now know that those whorls which weigh between 20-30 gm can be used to produce a wide range of fine to coarse maguey thread, whereas lighter (c. 11-15 gm) and heavier (c. 35-140 gm) whorls could only have been used to produce a much narrower range of fine or coarse maguey thread, respectively (Parsons and Parsons, 1990:329, 331).

Once we know more about spindle whorl weights at specific workshops we should be in a much better

position to infer the extent to which different workshops were involved in specialized vs. generalized spinning, in the production of cotton vs. maguey thread, and in tributary vs. market vs. domestic modes of production. We also suspect that the elaborate stamped, molded, and incised designs so characteristic of Postclassic spindle whorls may relate to specific social units (e.g., *calpulli*, *altepetl*, etc.) associated with particular kinds of whorl, thread, and textile production (Carrasco, 1976; Parsons, 1975).

Ceramic spindle whorls were extremely scarce in highland central Mexico before the Postclassic. Several possible factors might explain this (e.g., spinning without whorls; the use of perishable wooden whorls; the use of simple perforated circular fragments of broken pottery (sherd disks) that are not always recognizable as spindle whorls). However, the difference between Classic and Postclassic in this regard is so dramatic as to suggest a major reorganization of spinning after Classic times. We suspect that spinning (and possibly weaving as well) became more specialized and more efficient during the Postclassic than it had been earlier.

Scraping maguey fiber. Today maguey fibers are usually detached from the encasing flesh with an iron scraper mounted in a wooden handle (figure 3). These scrapers are dull, even-edged tools designed to scrape away the flesh without cutting or shredding the fiber.

We think the prehispanic analog is a trapezoidal ground-stone tool made of tabular basalt (figure 4). This latter tool is most common in the Postclassic (Tesch and Abascal, 1974; Brumfiel, 1976; Sanders *et al.*, 1979), but it also occurs in at least one Late-Terminal Formative context (Serra, 1988). These implements have been variously called *azadas*, *felsite knives*, *hoes*, and *desfibradores*. Recent experimental work (Parsons and Parsons, 1990:175) shows that they are admirably suited for scraping maguey fiber (if the encasing flesh has been softened beforehand by heating and rotting), and we are fully convinced that this was their primary, perhaps exclusive function (figure 5).

These trapezoidal scrapers are widespread throughout the highlands of central and north-central Mexico and in the North American Southwest (Spence, 1971; Tesch and Abascal, 1974; Brumfiel, 1976; Sanders *et al.*, 1979; Sejourne, 1983:Fig. 137; S. Fish *et al.*, 1986; Trombold, 1985, 1989; Cabrero, 1989; Mastache *et al.*, 1990), especially in Postclassic times. Over time in central Mexico they tend to displace another distinctive tool: the scraper plane or "turtleback scraper" (Tolstoy, 1971) (figure 6). Experimental work with archaeological scraper-planes in the southern highlands of Mexico (Hester and Heizer, 1972) has shown that repeated downward blows with the rounded side of this tool (which typically weighs about 400 grams) are effective to mash up raw agave leaves, while the flat bottom side of the same implement can serve to scrape the mashed flesh away from the fibers.

Trapezoidal scrapers were probably used in more specialized maguey fiber production in which greater efficiency in fiber extraction was achieved by means of cooking and rotting leaves to soften the flesh. We sus-

pect that the scraper plane would have predominated in the context of earlier and/or more generalized fiber production, where high efficiency was less important. If so, then increasing specialization and efficiency of maguey fiber processing (manifested archaeologically by a progressive shift from scraper planes to trapezoidal ground-stone scrapers) appears to have paralleled increasing spinning efficiency (manifested archaeologically by a dramatic increase in quantities and variability of ceramic spindle whorls) during Postclassic times in the Mesoamerican *tierras altas*.

The extraction of maguey sap. There is a very distinctive and highly specialized modern iron tool used daily for scraping the surface of the sap-collecting cavity in the maguey plant's interior. The prehispanic analog of this elliptical or circular iron scraper appears to be a distinctive "strangulated" plano-convex stone scraper (figure 7), which has a broad distribution in the highlands of central and north-central Mexico (Gamio, 1979 [1922]:214; Dibble and Anderson, 1963:Fig. 778; Spence, 1971; Meigham, 1976; Sanders *et al.*, 1979; Michelet, 1984; Rodriguez, 1985:199; Trombold, 1985, 1989; Cabrero, 1989:234, 238-241; Mastache *et al.*, 1990:189; Parsons and Parsons, 1990). This implement seems to appear as early as Late Formative times and to increase markedly in frequency in the Postclassic. These scrapers apparently do not occur archaeologically outside the *tierra fría* lending additional support to our belief that this artifact was used exclusively in the production of maguey sap.

We infer that over time maguey sap processing in central and north-central Mexico shifted from (1) something akin to the ethnographic Tarahumara

Figure 6. Archaeological scraper plane (adapted from Hester and Heizer, 1972).

procedure (in which agave leaves are simply mashed up and the sap squeezed out in a single operation), to (2) something comparable to the historically known process in central Mexico in which both the sap and fiber of individual plants are extracted over a period of several months. This shift may have been linked to a need for greater overall efficiency of plant use in the context of increasingly specialized economies stimulated by both high population densities and increased tributary demands.

Discussion

Our present knowledge about the distribution in time and space of key archaeological materials related to prehispanic maguey use in central and north-central Mexico is still too limited to provide adequate development or tests of our hypotheses. We predict that new archeological research will show the following:

1. Since at least Middle Formative times maguey cultivation has been an equal partner with annual seed crops in agricultural production in the Mesoamerican *tierra fría*. We doubt that agriculture without domestic maguey could have sustained prehispanic state-level society in this part of Mesoamerica. Perhaps a post-Formative highland
2. Maguey production, and agricultural production in general, remained generalized throughout most of the Formative in the tierras altas, with no significant shifts toward greater specialization or efficiency until the development of increasingly complex and urbanized society in southern and central Mexico late in the first millennium B.C. With their increased overhead costs and greater spatial separation between food producers and food consumers, urbanized states of the first millennium A.D. would have faced the need to intensify and expand all types of agricultural production.
3. The northward expansion of Mesoamerican civilization into north-central Mexico in Classic times was underwritten, in large part, by the integration of specialized maguey-nopal producers (living in

Mesoamerica without domestic maguey would have remained at an organizational level comparable to that of, for example, highland Colombia, where both maguey and domestic camelids were absent from the economic base of prehispanic chiefdoms throughout a developmental sequence of over 2000 years in which state-level organization was apparently never attained (Reichel-Dolmatoff, 1965).

Figure 7. Modern iron scraper (left) and prehispanic (two at right) obsidian scrapers used in sap collecting. The lower handles of both obsidian scrapers have been broken off.

more marginal, peripheral landscapes) and more generalized seed crop-maguey cultivators (living in restricted, more productive irrigable landscapes). The effective integration of these agriculturally-generalized cores and agriculturally-specialized peripheries would have been dependent upon the existence of redistributive networks large enough to move staples over significant distances in a regular and predictable manner. Because Formative redistributive networks were too restricted, Mesoamerican civilization was unable to expand northward into north-central Mexico until after c. A.D. 200 (Braniff, 1989; Kelley, 1990; Trombold, 1990; Darling, 1997).

4. The Classic-to-Postclassic transition in central and north-central Mexico saw the development of increasingly specialized and efficient economies. Part of this shift might relate to the changing character of urbanism and the dynamics of urbanization e.g., the development of large centers inhabited very predominantly by non-food producers. Another aspect of this change may relate to the development of new status roles and the need to distinguish them by implementing new sumptuary rules, such as regulating the production and use of pulque and certain types of clothing made of different types of fibers and finer vs. coarser thread. Most important of all might have been the changing nature of tribute, exchange, and governance, whereby, for example, different kinds of cloth and beverages assumed new functions as material symbols of new socioeconomic and socio-political relationships (Anawalt, 1980; Hicks, 1987).
5. Some techniques and procedures developed for maguey exploitation in north-central Mexico during the Classic period might have been subsequently "imported" from there back into central Mexico. If, as we have argued, it was in north-central Mexico that maguey was especially critical in the domestic and political economy, then it might be logical to expect that it was in the context of state expansion into this arid, northernmost part of ancient Mesoamerica that the most effective and efficient maguey exploitation first developed. Weintraub (1992), for example, reports the presence of maguey fiber and leaf fragments in flotation samples from Late Classic-Epiclassic contexts at La Quemada, Zacatecas—perhaps the earliest known post-Archaic examples of such material in northern Mesoamerica. Furthermore, some of the earliest well-document-

ed spindle whorls in northern Middle America derive from late first millennium and early second millennium contexts in north-central and north-western Mexico (e.g., Ekholm, 1942; Kelly, 1945, 1947, 1949; DiPeso *et al.*, 1974; Meigham, 1976; Foster, 1985), and in the adjacent Southwestern U.S. (DiPeso, 1951, 1956) although it is not yet clear whether these whorls were used for spinning cotton or maguey thread.

The largest prehispanic Mesoamerican empires were based in highland central Mexico, and most of these imperial systems date to the Postclassic. Do the changes we note in the technology of maguey production, saltmaking, and food preparation, and in the surviving impressive sub-specific variation in cultivated maguey, reflect primarily the demands of imperial administrators for greater productive efficiency and specialization in the core areas of their domains? Will we eventually discover notably less technological change or botanical diversity in areas where such imperial demands were weak or absent?

Looking further back in time, it should also be useful to think about the relationships between the competitive arena of chiefly politics (e.g., Helms, 1979) and the initial domestication and accompanying botanical diversification of maguey in the *tierra fría* during the Early and Middle Formative at a time when tribal Big Men and aspiring Chiefs in ranked societies throughout southern and central Mexico were seeking higher levels of local productivity to sustain and enhance their prestige.

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