THE MESOAMERICAN CENTER OF DOMESTICATION

A. DELGADO-SALINAS¹, J. CABALLERO², AND A. CASAS³

¹Departamento de Botánica, Instituto de Biología, UNAM, Apartado Postal 70-233, C. P. 04510, México, D. F.

²Jardín Botánico, Instituto de Biología, UNAM, Apartado Postal 70-614, C. P. 04510, México, D. F.

³Departamento de Ecología de los Recursos Nacionales, Instituto de Ecología, UNAM, Apartado Postal 27-3, C. P. 50089, Morelia, Michoacán, México.

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INTRODUCTION

Mesoamerica is the cultural area that extends from northern Mexico (except for the northwestern states) south to Costa Rica (32). This region has been the origin of numerous domesticated plants, many of which are important sources of food and other needs for human populations all over the world. With a vast biodiversity established in arid, temperate, and tropical ecosystems, Mesoamerican human populations diversified into a broad array of cultural groups that have explored, experimented, and modified through selection a great number of plant resources. Mesoamerican peoples have depended on the continued output of food, fiber, medicine, and other essentials derived from wild, weedy, and domesticated plants. Their agricultural landscape has been characterized since early days by irregular patterns of multiple cropping agroecosystems, home gardens, and nearby
human-modified vegetation areas (transformed habitats that hold mixed stands of prominent species that provide families with food security and nutritional balance).

ARCHEOBOTANICAL EVIDENCE

Archeological research in Mesoamerica has been conducted in regions of Mexico and Central America and provides a glimpse of some of the considerable diversity of both wild and domesticated plants throughout human history. In the highland sites of Mexico (Oaxaca, Tamaulipas, and Tehuacán), changes in major and minor crops, as well as wild and manipulated plants, are represented through different chronological ages. Evidence shows plants imported over great distances or in different stages of domestication. The archeobotanical record from the highland sites include remains of maize (*Zea mays*), wild and cultivated beans (*Phaseolus acutifolius*, *P. coccineus*, *P. vulgaris*), squash and gourds (*Cucurbita argyrosperma*, *C. moschata*, *C. pepo*, and *Lagenaria siceraria*), chili peppers (*Capsicum annum*), husk tomato (*Physalis* sp.), foxtail grass (*Setaria* sp.), chenopods and amaranths (*Chenopodium* sp.; *Amaranthus cruentus*, *A. hypochondriacus*), chayote (*Sechium edule*), cotton (*Gossypium* sp.), avocado (*Persea americana*), zapote blanco (*Casimiroa edulis*), zapote negro (*Diospyros digyna*), and guajes (*Leucaena esculenta* and *L. leucocephala*) (17;32; 39; 42). Evidence from lowland sites (Tabasco, Mexico, Guatemala, El Salvador, Honduras, Costa Rica and Panama) represents later stages in the archeobotanical record, and partially documents the innovative work of early agriculturalists that locally domesticated cotton (*Gossypium hirsutum*), jícama (*Pachyrhizus erosus*), chayotes (*Sechium edule*), arrowhead (*Maranta arundinacea*), and other crops, in addition to vegetatively propagating vanilla (*Vanilla planifolia*) and henequén (*Agave fourcroyoides*). Remains from ca. 6000 B.P. also document the occurrence of maize (pollen),
beans, squash, chili peppers, sunflowers, avocado, plums (*Spondias* sp.), and palms (such as fruits of *Acrocomia* sp.) (29; 32; 36).

Recently, age dating of some of these plant remains has been modified by the use of accelerator mass spectrometry (AMS), which has provided new and unexpected information on the history of domesticated plants. Archeological remains from Guilá Naquitze in Oaxaca, México, indicate that ancient populations of domesticated squash (*Cucurbita pepo*) are represented as far back as 10,000 years B.P. (39). Surprisingly, what had been considered the earliest beans records, from Tehuacán, Mexico, have recently been dated as later than thought, at 2300 years B.P. (28). Furthermore, a domesticated sunflower seed (*Helianthus annuus*) dated ca. 4000 years B.P. has been discovered in Tabasco, Mexico (29). This discovery challenges the hypothesis that sunflower domestication originated in eastern United States, and has resulted in immediate controversy (24). In addition, chemical evidence based on chromatography and mass spectrometry of Mayan ceramic vessels from northern Belize has moved back the earliest recorded use of chocolate (*Theobroma cacao*) as a beverage to as early as 2600 B.P. (27) (Figure 1).

Some plants gradually faded from the archeological record (such as *Canavalia* and *Helianthus* in Mexico, and *Setaria*), possibly because of ecological changes or different agronomic practices. The latter explanation was suggested for *Setaria*, which was replaced by maize (16).

**SYSTEMATICS AND MOLECULAR EVIDENCE**

Within the last twenty years, molecular systematists and geneticists, based on morphological and molecular evidence, have shed light on the systematics, genetic structure, and evolution of several crops (19; 41). These studies have determined relationships between wild and cultivated species of the genus *Phaseolus* (12) and
populations of *Lagenaria siceraria* (10). Other studies have assessed genetic variation between wild and domesticated species of agave henequén (7) and chili pepper (25). Research has also determined centers of origin for some species, such as maize (southern Mexico: 31) and domesticated cotton (Yucatan peninsula: 1). Natural and artificial hybridization and introgression have been demonstrated in *Leucaena leucocephala* (26). Gene pools at centers of genetic diversity have been studied from various species (e.g., *Phaseolus vulgaris*; 20). Also, indirect and direct estimates of gene flow between cultivars and wild counterparts have been done for several crops (see review by 15;and,33; 22).

Understanding the phylogeny and genomic evolution of crops has also made possible (albeit not without some problems of calibration) the calculation of rates of evolution of crop lineages, such as beans (21) and cotton (8).

**SINGLE AND MULTIPLE DOMESTICATION EVENTS**

Early Mesoamerican agriculturalists, and those from other regions, have converged in their selection of the same widespread genera and consequently, have often domesticated multiple congeneric species. For example, separate domestications have been proposed for different species of *Gossypium* in both Old and New Worlds (8). Also, among others, different species of *Amaranthus, Annona, Chenopodium, and Pachyrhizus* were domesticated in both the northern and southern hemispheres of the New World (38). In addition, throughout their distributional ranges, some species have been domesticated more than once. Morphological and molecular evidence has confirmed independent domestication events in *Cucurbita moschata, Phaseolus lunatus, and P. vulgaris* in both Mesoamerican and Andean regions (14; 20). *Cucurbita pepo* was domesticated in both southern Mexico and eastern United States (11). Within the Mesoamerican center,
*Capsicum annum* was domesticated in Mexico in two different regions, in the eastern/northeastern states, and in the western state of Nayarit (30). Often these vicarious domestications have accentuated population differences within species, such as in *Phaseolus vulgaris* and *P. lunatus*, where Mesoamerican and South American gene pools are molecularly distinguishable (20; 23).

However, many species have been domesticated only once in their history. A single domestication of maize is proposed from southern Mexico ca. 9000 years ago (31). The wild progenitor of tomato (*Solanum lycopersicum* var. *cerasiforme*) was apparently domesticated once, in Mesoamerica, even though the genus is highly diversified in South America (37). Molecular evidence has shown that the domestication region of cassava (*Manihot esculenta*) and cocoa (*Theobroma cacao*) was in fact the Amazon basin, and not in southern Mesoamerica as was earlier thought (34; 13).

**IN SITU DOMESTICATION BY SELECTIVE TOLERANCE**

Manipulation of plant resources by local peoples has influenced plant evolution in various ways, and continues to operate in Mesoamerica (2). At present, indigenous peoples in Mesoamerica utilize more than 6,000 plant species for food, medicine, and a great variety of other purposes (3). Management of plant resources involves different forms of manipulation which increase the availability of plants in space and time and provide a glimpse of different stages of domestication (5). Most plant species are harvested from the natural vegetation, but some plant resources, mainly trees and other perennials, are selectively spared when cutting down the forest to establish maize fields or settlements. In some cases, plant individuals or their populations are protected by controlling or eliminating their competitors and predators. The conscious dispersal of sexual and vegetative propagules of plants is another way in which selection may be imposed.
Cultivation of wild plants in home gardens and croplands is also a common practice that maximizes reproduction and productivity of plant resources. Many species are managed simultaneously in two or more ways in different regions, and even within a single region or locality, by the same people. Studies on morphological variation of some species of central Mexico show that selective tolerance and other forms of plant management constitute active processes of in situ domestication. It is known that when gathering plants in the wild, people frequently harvest only those individuals that they recognize as more desirable, because they have better flavor, texture, color, shape, disease- or insect-resistance qualities, etc. For example, the Mixtec and the Nahua of central Mexico recognize differences in the quality of edible fruits such as guayaba (Psidium guajava), guamuchil (Pithecellobium dulce), nance (Byrsonima crassifolia), and ciruela (Spondias purpurea) (5). The recognition of variation in wild plants by indigenous peoples may be the first step in the process of conscious selection of the most desired phenotype.

In situ domestication by selective tolerance seems to be a common and current process in Mesoamerica. Selective tolerance has been described for Leucaena esculenta ssp. esculenta, Opuntia spp. and several species of columnar cacti such as Stenocereus stellatus, Escontria chiotilla, Polaskia chichipe, and P. chende (6; 35). In all these cases, selection has favored phenotypes with larger, more flavorful seeds, although they are more susceptible to predation, in the case of L. esculenta, and fruits that are larger, sweeter, thinner skinned, and less spiny, in the case of cacti. In the case of Polaskia chichipe, selection has also favored individuals that self pollinate and germinate more rapidly (35). This form of management allows local people to modify the genetic structure of a population by increasing the frequency of the most desired phenotypes while eliminate those that are not desirable. At least 37 other wild species have been reported as selectively
tolerated and sometimes promoted by local people. This number could be much higher given the relatively scant attention that ethnobotanists have paid to the study of this kind of plant management.

Moreover, in situ domestication has favored the maintenance of vital coevolutionary processes of long-term ecological associations between crop plants and their wild pathogens and symbionts (18; 40).

CONCLUSIONS

Since most plants subject to in situ domestication are common elements of the landscape of the indigenous regions of Mesoamerica, the crops, pasturelands, and fallow fields of the region can be seen as complex agrosilvicultural systems. All elements of these systems, including the apparently wild plants, have a role in the local economy and are the result of some degree of selection and manipulation by local people. Cutting down the natural vegetation for agricultural purposes involves a significant loss of biodiversity; conversely, domestication processes add an important amount of human-created biodiversity to nature. The important ecological and evolutionary role that skilled indigenous Mesoamerican peoples have played and continue to play is undeniable. Their activities result in the creation, maintenance, and enhancement of plant genetic resources, which results in worldwide contributions to food support and other human needs.

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REFERENCES


