Sunflower (*Helianthus annuus* L.) as a pre-Columbian domesticate in Mexico

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Edited by Michael D. Coe, Yale University, New Haven, CT, and approved March 10, 2008 (received for review December 14, 2007)

Mexico has long been recognized as one of the world's cradles of domestication with evidence for squash (*Cucurbita pepo*) cultivation appearing as early as 8,000 cal B.C. followed by many other plants, such as maize (*Zea mays*), peppers (*Capsicum annuum*), common beans (*Phaseolus vulgaris*), and cotton (*Gossypium hirsutum*). We present archaeological, linguistic, ethnographic, and ethnohistoric data demonstrating that sunflower (*Helianthus annuus*) had entered the repertoire of Mexican domesticates by *ca.* 2600 cal B.C., that its cultivation was widespread in Mexico and extended as far south as El Salvador by the first millennium B.C., that it was well known to the Aztecs, and that it is still in use by traditional Mesoamerican cultures today. The sunflower's association with indigenous solar religion and warfare in Mexico may have led to its suppression after the Spanish Conquest. The discovery of ancient sunflower in Mexico refines our knowledge of domesticated Mesoamerican plants and adds complexity to our understanding of cultural evolution.

Asteraceae | Aztec | domestication | eastern North America | Mesoamerica

Evidence for early (*ca.* 2600 cal B.C.) domesticated sunflower (*Helianthus annuus*) at the San Andrés site in Tabasco, Mexico (1, 2), has reopened discussions about the array of domesticated plants in Mesoamerica. This discovery generated controversy because the domesticated sunflower has previously been accepted as a domesticate originating in eastern North America. One scholar suggested that sunflower was unknown in pre-Columbian Mexico and it was introduced from North America by the Spaniards in the sixteenth century, perhaps by the Hernándo de Soto expedition of 1539–1543 (3). In this article we present archaeological, linguistic, ethnographic, and ethnohistorical data that demonstrate a considerable antiquity for the domesticated sunflower in Mexico.

Sunflower is a member of the Asteraceae family, often referred to as the Compositae in earlier texts. (Although there are many species referred to as "sunflowers," for the purposes of this article, sunflower refers to *H. annuus*.) Plants in the genus *Helianthus*, a relatively primitive Asteraceae group, arose in the southwestern United States during the Cretaceous period ≈50 million years ago (4). The wild diploid annual *H. annuus* has been flowering and setting seed for the past 500,000 to one million years (5), and during that time it has dispersed broadly across temperate North America. Today, wild sunflowers grow throughout most of the United States (6) and range as far north as southern Canada and as far south as the Transmexican Volcanic Belt in central Mexico (7). Although populations of wild sunflower are limited to habitats north of the Transmexican Volcanic Belt, domesticated sunflowers are cultivated in many areas throughout southern Mexico and other Neotropical regions (7).

Sunflower is well known as an ornamental plant, and the seeds are widely relished as a foodstuff. Most significantly, sunflower is one of the world's major oil seed crops (8–10). An understanding of the origin and distribution of *H. annuus* is important because it is now technically possible to extract genetic material from both wild and domestic plants to improve future generations of domesticated sunflower (11). Because marginal populations of a species often have different gene arrangements than more centrally located populations (12–14), Mexican sunflower populations, at the south end of the plant's native range, may serve as a valuable genetic resource for future breeding experiments.

Archaeological Data. Archaeological evidence for sunflower has been rare in Mexico for three reasons: (*i*) pre-Columbian people may have used sunflower in ways that would have made carbonization unlikely, (*ii*) regional climatic conditions, especially in Neotropical areas, have not been favorable for the preservation of uncarbonized plant remains, and (*iii*) many archaeological research strategies have, until recently, focused more on monumental architecture than on the recovery of archaeological plant materials. In recent years, new evidence for Mesoamerican plant use has come to light as advanced paleoethnobotanical recovery techniques have become more commonplace.

Pre-Columbian archaeological remains of wild sunflower in Mexico cover a long time span, from Late Archaic to post-Classic periods. Wild sunflower, native to northern Mexico, occurred in coprolites in Flacco phase (2900–2200 cal B.C.) deposits at Ocampo Cave, Tamaulipas, Mexico (15), demonstrating that humans were consuming sunflower fruits (achenes) in that region at an early time. At the other end of the pre-Columbian time scale, at least 10 wild *H. annuus* achenes (16) were found as part of a Late post-Classic offering in the Aztec paramount temple, the Templo Mayor, at Tenochtitlan (A. Montúfar López, personal communication, 2007). These achenes connect sunflower with the most sacred Aztec ceremonial activities.

Early domesticated sunflower remains from Mexico were excavated by M.D.P. and Kevin O. Pope at the San Andrés site in Tabasco, Mexico, where waterlogged conditions resulted in unusually good plant preservation (1, 2). A sunflower seed and an achene were found in Late Archaic deposits and were accelerator mass spectrometry (AMS) dated to 2875–2575 cal B.C. and 2867–2482 cal B.C, respectively. [See supporting information (SI) Figs. S1–S6.] Smith (17) questioned the identification of the sunflower achene from San Andrés, stating that it lacked prominent bundles of sclerenchyma fibers. In response, we note that the fiber bundles Smith

Author contributions: D.L.L., M.D.P., and R.B. designed research; D.L.L., M.D.P., and R.B. performed research; D.L.L., M.D.P., J.L.A., S.T., and R.B. analyzed data; and D.L.L., M.D.P., and R.B. wrote the paper.

The authors declare no conflict of interest.

This article is a PNAS Direct Submission.

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This article contains supporting information online at www.pnas.org/cgi/content/full/0711760105/DCSupplemental.

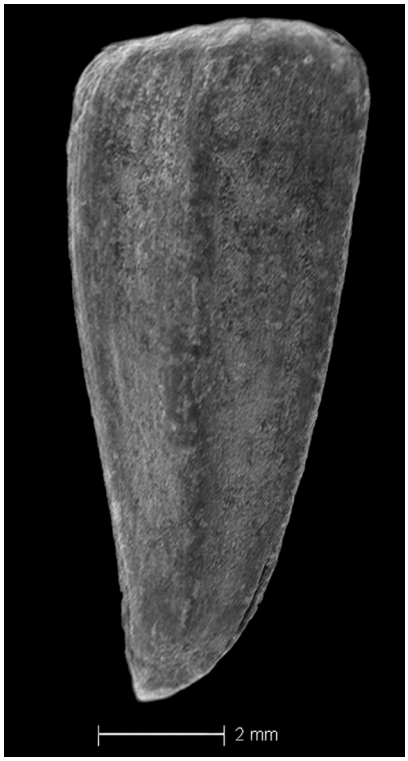

Fig. 1. Electron micrograph of a sunflower (*H. annuus*) achene from the Cueva del Gallo site in Mexico.

discusses (illustrated by using an achene from Newt Kash Hollow, Kentucky) are highly variable in their prominence, and the trait is not present in all varieties of domesticated sunflower. Furthermore, the achene from San Andrés was buried in marsh sediment for >4 millennia. We minimized our handling and cleaning of the mud-coated specimen to prevent modern contamination, and thus the surface features are less clear than the more recent sample from Newt Kash Hollow, which was well preserved in a dry cave. The San Andrés achene did have the diamond shape in cross-section and sutures around the perimeter that are characteristic of domesticated sunflower. In regard to the sunflower seed from San Andrés, Smith discounts this specimen as having "... evidence of edge damage (17)," but he fails to articulate the meaning of this observation. The carbonized San Andrés seed has the distinctive taper formed by the embryonic radicle at the proximal end and the broadened, truncated cotyledons at the distal end that are unmistakably sunflower. Before radiocarbon dating, identifications of the San Andrés sunflower finds were verified by botanical specialists with extensive knowledge of the Asteraceae. The San Andrés discovery is backed up by Miksicek's (18) previous identification of a Late Formative (400 B.C. to A.D. 250) domesticated sunflower achene from the Santa Leticia site in western El Salvador.

Here, we report data on another Mexican domesticated sunflower find from Cueva del Gallo, Morelos, Mexico, that provides definitive evidence for the pre-Columbian presence of the cultigen in Mesoamerica. Three large achenes in excellent condition were unearthed in a dry cave believed to have been used for ritual activities and burials (19). One of the achenes (Fig. 1) was AMS dated to 290 ± 40 cal B.C., a time indicating affiliation with the Ticumán culture located south of the Basin of Mexico (20). Other contemporaneous Late Formative period domesticated plant remains found at Cueva del Gallo included maize (*Zea mays*), common beans (*Phaseolus vulgaris*), two

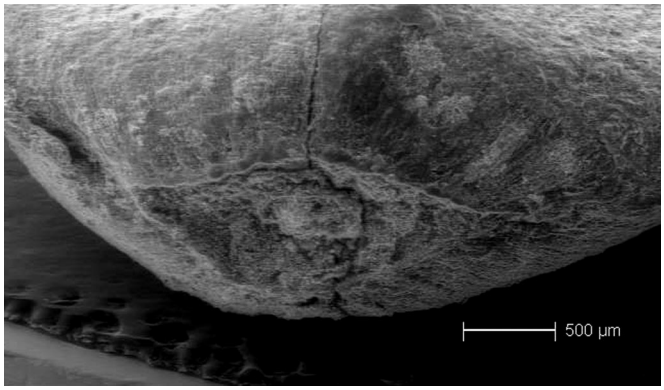

Fig. 2. Electron micrograph of the distal end of a sunflower (*H. annuus*) achene from the Cueva del Gallo site in Mexico. Note the distinctive diamond-shaped flower scar surrounding the style base.

species of squash (*Cucurbita argyrosperma* and *C. moschata*), chile peppers (*Capsicum annuum*), gourd (*Lagenaria siceraria*), avocado (*Persea americana*), chayote (*Sechium edule*), and hogplum (*Spondias purpurea*) (19).

The desiccated sunflower achenes from Cueva del Gallo show the twist in a fruit that comes from a crowded domesticated sunflower head. One of the most diagnostic features of a sunflower achene is the diamond-shaped cross-section and apical flower scar (Fig. 2). The flower scars are readily discernable on the long-tapered, triangular, and nearly glabrous Cueva del Gallo achenes. Most striking of the physical features of the Cueva del Gallo achenes is their large overall size. With an average length of 11.5 mm and width of 5.0 mm, they are 34% larger than any contemporaneous sunflower achene from eastern North America (Table 1). Note that the dimensions of all of the Mexican archeological sunflower achenes lie within the range of modern indigenous cultivated landraces from both Mexico and the United States, yet they are well outside of the maximum dimensions of wild sunflower populations (Table 2). Hence, it appears evident that the archaeological sunflower disseminules from Mexico were derived from domesticated plants.

Although the use of measurements to compare archaeological disseminules can be problematic (31), especially when the samples are carbonized (32), measurements of this type have been used historically and offer the best opportunity to make a comparison between regions. Achene size is generally considered the defining criterion of sunflower domestication. Although surface features vary considerably among eastern North American domesticated sunflowers (29), the overall dimensions of achenes from eastern North American archaeological sites during the Late Archaic to Middle Woodland periods are similar. The standard deviation for the mean index (length × width) of all North American archaeological sunflower achenes listed in the table is only 5.17 for uncorrected values, a remarkably uniform dataset.

When size indices of the eastern North American sunflower achenes are compared with the indices of Mexican achenes by using an unpaired *t* test, the results show a statistically significant difference for both corrected ($P = 0.0002$, df = 9) and uncorrected ($P = 0.0004$, df = 9) values. Although the sample size is small, the Mexican achenes that have been observed are consistently and significantly larger than contemporaneous eastern North American domesticated sunflowers, a result that is highly unlikely to be caused by chance alone.

The larger size for the Mexican sunflower disseminules at essentially the same time period argues against Smith's (33) suggestion that the domesticated sunflower populations repre-

Table 1. Size comparison of achenes (fruits) of domesticated *H. annuus* from archaeological sites in eastern North America and Mexico*

Site	Time period	No. of Achenes	Length (mean)	Width (mean)	Index (LxW)	Ref(s).
Patrick, TN, MR 40 (F75) (F25)(F154)	Early, Middle Woodland (318 cal B.C. to A.D. 287)†	3	7.3(8.1)	2.9(3.8)	21.2(30.8)	23
Rose Island, TN, MR 44 (F21)(F54)	Early, Middle Woodland (318 cal B.C. to A.D. 287)†	4	7.1(7.9)	2.5(3.2)	17.8(25.3)	23
Newt Kash Hollow, KY	Late Archaic, Early Woodland (1162–369 cal B.C.)†	14	8.6	3.8	29.2	21, 24
Marble Bluff, AR, 34–23-345	Late Archaic (1264–912 cal B.C.)	19	8(8.9)	3.4(4.4)	27.2(39.2)	25
Marble Bluff, AR, 34–23-327	Late Archaic (1032–920 cal B.C.)	14	7.9(8.8)	3.1(4.0)	24.5(35.2)	25
Eden's Bluff, AR (32–3-1712) 3BE6	Early, Middle Woodland (170 cal B.C. to A.D. 50)	4	8.1	3.2	25.9	
Salts Cave, KY (J IV: 4–11)	Early Woodland (654–416 cal B.C.)†	57	6.7(7.4)	2.6(3.3)	17.4(24.4)	26, 27
Salts Cave, KY (feces)	Early Woodland (970–660 cal B.C.)†	1,000	6.7(7.4)	2.5(3.2)	16.8(23.7)	26, 27
Mammoth Cave, KY	Early Woodland (539–239 cal B.C.)†	80	6.3(7.0)	2.4(3.1)	15.1(21.7)	24, 26
Cueva del Gallo, Mexico	Formative (330–250 cal B.C.)	3	11.5	5	57.5	
San Andrés, Mexico	Late Archaic (2875–2575 cal B.C.)	1	8.2(9.1)	4.5(5.7)	36.9(51.9)	1

*When analyzing ancient sunflower achenes, archaeologists often use conversion factors to increase length (increased by 11%) and width (increased by 27%) to correct for shrinkage caused by carbonization (21). The numbers listed in parentheses are the corrected numbers; the other numbers are the actual measurements. Note that there are no correction factors for shrinkage applied to the Eden's Bluff, Newt Cash Hollow, or the Cueva del Gallo achenes. These samples were not carbonized and therefore needed no correction factors. Remains from the Hayes site (22), a Late Archaic site in eastern North America, were omitted from this analysis because no sunflower achenes were found there, only carbonized seeds without their encasing pericarps.

†Converted from conventional radiocarbon dates to calibrated dates using the Fairbanks calibration curve (28).

sented by the archeological remains at San Andrés were derived from the more diminutive eastern North American sunflower populations. The growing season for sunflower in eastern North America is more than adequate for the plant to mature successfully in that region (34), ruling out growing conditions as an explanation for the observed size differences. The observation that the achenes from Mexico are significantly larger than contemporaneous finds from further north and the fact that they are separated by substantial geographical distances provides a strong indication that the Mexican sunflower populations represented in the archaeological record are from a separate lineage.

Linguistic and Ethnographic Data. If a domesticated plant is borrowed from another culture, then a phonetic resemblance likely would be reflected in the borrower's name for the plant (35). Conversely, if an indigenous culture has a unique name for a plant, sunflower in this case, with no phonetic similarity to the Spanish terms and has distinctive traditions associated with the plant, we would expect that a long history of use is indicated. With these precepts in mind, we examined the terms used for sunflower by different Mesoamerican and North American groups. Domesticated sunflower grows well in many parts of Mexico (e.g., Chihuahua, Sinaloa, Sonora, Nueva Leon, Coahuila, and Tamaulipas) and is widely cultivated in those areas today. During our plant collection trips, we interviewed indigenous people throughout Mexico to learn about their traditional knowledge of sunflower. For each interviewee, we recorded the name, method of cultivation, and usage information. Of the 14 groups interviewed, all but three (the Mayo, the Tzotzil Maya, and the Zapotec) had unique names for sunflower. The other 11 indigenous Mexican groups, namely, the Huastec, Mixe, Nahua, Otomi, Popoluca, Raramuri (Tarahumara), Seri, Tepehuan, Totonac, Tzeltal, and Zoque, have distinctive names for sunflower that bear no phonetic resemblance to the Spanish terms ("girasol" and "mirasol") for the same species (Table 3). Nor do the Mexican indigenous sunflower names resemble any of the indigenous North American sunflower names listed in a previous study (29).

According to our informants, the most common means of consumption was to eat the seeds fresh or grind them up and mix the gruel with milk or water to make a beverage called "atole." Nahua informants, descendants of the Aztecs, most often said that the plant was used as an ornament for the church or as a funerary offering in the cemetery. The modern-day Nahua have two names for sunflower: "chimalacatl" ("shield reed"), a reference to the hollow sunflower stem, and "chimalxochitl" ("shield flower"), describing the large, disk-like head. The "shield" part of the Nahua names refers to a prominent pre-Columbian armament, one that became obsolete after the Conquest. Because of this meaning and ethno-

Table 2. Size comparisons of modern wild and domesticated sunflower (*H. annuus*) achenes from Mexico and the United States*

Sunflower population	No.	Achene length, mm				Achene width, mm				μ index, l × w
		Min.	μ	Max.	σ	Min.	μ	Max.	σ	
U.S. wild†	500	4.12	5.17	6.72	0.53	1.78	2.53	3.08	0.25	13.08
Mexican wild‡	456	3.14	4.11	4.88	0.31	1.42	1.99	2.52	0.23	8.17
U.S. commercial§	200	9.68	12.91	15.58	0.74	5.44	8.44	12.24	1.5	108.96
U.S. indigenous¶	300	7.98	11.59	15.58	1.11	4.08	7.17	11.26	1.47	83.1
Mexican indigenous‖	292	8.12	10.71	15.42	1.28	3.24	5.23	8.64	1.21	56.01

*Dimensions presented here are similar to other published datasets (29, 30) for domesticated and wild sunflower achenes.

†Wild populations collected by Lentz in Illinois, Missouri, Tennessee, and Arkansas. Kentucky populations were obtained from the U.S. Department of Agriculture (USDA).

‡Wild populations collected by Lentz and Bye in Tamaulipas, Coahuila, Veracruz, Durango, and Nuevo Leon.

§Mammoth Russian and Super Snack Hybrid cultivars purchased from Burpee & Co.

¶Hidatsa, Mandan, and Seneca domesticated landraces obtained from the USDA.

‖Raramuri (Tarahumara), Nahua, and Mixe domesticated landraces collected by Lentz and Bye.

Table 3. Sunflower names and uses by indigenous Mexican groups

Group	Language family	Sunflower term	Meaning	Uses
Nahua	Uto-Aztecan	chi:malxo:chitl, chi:mal:suchitl, chi:mala:catl	Shield flower, shield reed	Flowers used as ornaments on church altars, cemeteries, and shrines; seeds eaten fresh or toasted with salt
Raramuri (Tarahumara)	Uto-Aztecan	sewát^{s}ari (36)	Seed flower	Achenes toasted on a comal, seeds salted and eaten or ground up and mixed with water for atole; seeds fed to chickens; flowers used as ornamentation, cut flowers sold in local markets
Tepehuan	Uto-Aztecan	tásai	Sun	Seeds ground and made into atole, treatment for stomach pain; grown as ornamental plants
Seri	Hokan	za:h ko:kta	The one that watches the sun	Plant used for medicinal purposes; cough suppressant
Totonac	Totonacan	ilhalhnia xánat	Yellow flower of the sun	Seeds eaten fresh or toasted on a comal then ground to make atole
Otomi	Otopame	dä nukhä	Big flower that looks at the sun god	Seeds eaten fresh, toasted and salted then eaten; ground and mixed with hot water or milk to make atole; seed oil used for cooking; flowers used in religious ceremonies; plants used as medicine
Huastec	Mayan	met' al a k'i:icha:	Looker at the sun	Seeds toasted, ground, mixed with water to make atole; warm atole mixed with sugar as a treatment for stomach problems
Tzeltal	Mayan	pom te	Incense plant	Flowers grown as an ornament, sometimes sold in marketplaces; seeds fed to birds
Mixe	Mixe-Zoquean	äx + ta'ach tek pij	Behind urine leg/foot flower	Flowers grown as ornamentals, sold in marketplaces in arrangements; seed eaten by birds
Zoque	Mixe-Zoquean	ama gahama	Looks at the sun	Grown for commercial purposes, seeds sold in the marketplace
Popoluca	Mixe-Zoquean	mı chıjw	Big sun	Ornamental, sold in marketplaces, adornment in religious ceremonies; seeds eaten fresh; treatment for rheumatism

Note that the indigenous names are unlike the Spanish names for sunflower, i.e., "girasol" or "mirasol."

historic references that will be discussed below, the Nahua sunflower name in all likelihood is of pre-Columbian derivation.

The modern Otomi word for sunflower, "dä nukhä," means "big flower that looks at the sun god," a clear reference to pre-Columbian solar worship. In modern Otomi churches, anthropologist James Dow notes that crosses are often adorned with sunflowers, creating a decoration that ". . . symbolizes Jesus and God Sun together (37)." Dow also notes that Otomi crosses are always covered by flowers and foliage during rituals, ". . . so much so, that they look more like the pre-Columbian foliated cross than the Christian cross (37)." Thus, a connection between sunflowers and pre-Columbian symbolism is apparent among the Nahua and Otomi.

Ethnohistoric Data. Early Spanish observers document the presence of sunflower in central Mexico where it was intimately associated with the worship of the god of war, solar deity, and patron of the Aztecs, Huitzilopochtli (38, 39), who personified the elite obsession with warfare and sacrifice in Aztec society. Three late sixteenth century sources yielded the same terms for sunflower, "chimalacatl" and "chimalxochitl" (sometimes transcribed as "chimalsuchitl"), used by modern indigenous Nahua. The 1571 Molina dictionary (40) defines "chimalacatl" as "cierta yerua [= yerba] grande y redonda (certain herb big and round)." Hernández's (41) medicinal herbal provides a detailed illustration of "chimalacatl" that demonstrates his knowledge of the sunflower. He reports that the plant grew in cultivated fields and that the seeds were used to make bread by some Indians. He noted that excess consumption of the seeds brought on headaches and acted as an aphrodisiac.

Sahagún's *Florentine Codex* (42), completed in 1569, provides illustrations of the use of flowers identified as "chimalsuchitl" in the context of merchant rituals. Merchants, who saw hazardous foreign travels as analogous to the battles that made their state glorious, held military-themed banquets (42) in which warriors attended noble guests, offering first a tobacco smoking tube, signifying the spear or valor, and then a chimalsuchitl or "shield flower," representing a shield. The host later laid offerings of sunflowers and tobacco tubes at Huitzilopochtli's pyramid and conducted an all-night ceremony that culminated in the ritual burial of the sunflowers and smoking tubes at dawn.

Sahagún's illustrations (ref. 42, figures 28–31 and 33) show that the sunflower offerings were standardized symbolic presentations. The flowers were placed in holders decorated at the ends with tassels, and the offerings often consisted of both a partially open bud and a fully opened flower, possibly symbolizing the sun dawning, conquering the chaos of the night. Sahagún's link between native linguistic and pictorial documentation has allowed us to trace Aztec uses of sunflower in other contexts. For example, rulers and nobles at court carried jeweled sunflowers. In his portrait in the Codex Ixtlixochitl from the 1580s, Netzahualpilli, the Aztec ruler of Tetzcoco, holds a yellow and red sunflower bud and open sunflower in each hand (ref. 43, figure 108).

The symbolic relationship between the sunflower and native elite culture including nobility, solar worship, and warfare, together with the provocative use as an aphrodisiac, suggest why the use of sunflower may have been deliberately suppressed after the Spaniards established hegemony. The Paradise Garden murals at the sixteenth century monastery of Malinalco (44) provide such an indication. Malinalco had been an Aztec tributary center significant for its ties to the mythic history of Huitzilopochtli and as the place where Jaguar and Eagle warriors

were inducted into military service. After the conquest, the Spaniards built the monastery to attract local people to the new order, and Spanish-trained native artisans painted a vision of paradise with indigenous plants and animals. Significantly, the sunflower is absent.

Discussion

Multiple lines of evidence reveal a distinct tradition of sunflower cultivation in Mexico originating before 2600 cal B.C. To explain the early presence of domesticated sunflower in Mexico, we posit the following scenario for an independent domestication in Mexico based on currently available biogeographic, archaeological, linguistic, ethnohistoric, and ethnological evidence. Wild sunflowers are common in northern Mexico today, extending as far south as the middle of Veracruz and north to the U.S. border (7). Not only was wild germplasm readily available, the Ocampo coprolites demonstrate that wild sunflowers were being consumed in northern Mexico at least 2,000 years before the time of Christ. The early sunflower achenes in eastern North American archeological deposits were significantly smaller than the Mexican domesticated sunflower remains from the same time period, making it unlikely that the latter were derived from the former. A tradition of intensive human plant use in Mexico is demonstrated by the fact that one of the earliest of the New World domesticates, squash, came from Mexico ≈8000 cal B.C. (45).

Sunflower was apparently a relatively easy crop to domesticate (11); most of the traits that distinguish the wild from the domesticated plant, such as achene size and flower head size, are polymorphic, or quantitative, traits that exist on a continuum. The major mutations required are found in two genes that exhibit dominant branching control and are both located on the same linkage group (46). Mutant alleles result in plants that produce only one stem with one flower (46). This change in branching pattern could have occurred during the domestication process or before it if ancient indigenous farmers had selected this trait from among wild populations. Sunflower domestication in Mexico would have involved selecting the largest of the wild achenes, planting them, and repeating the process over a series of years. Accordingly, the best explanation for the presence of large-seeded, early archaeological remains of sunflower in Mexico is that they were derived from an independent domestication process.

Two recent molecular genetic studies (47, 48), comparing the genetic makeup of modern-day wild and domesticated sunflower varieties, suggest that extant cultivars of sunflower, collected primarily in the United States, are most closely related to wild sunflower populations in the midwestern United States. These molecular investigations support the concept of a sunflower domestication process in eastern North America. Nevertheless, neither of these studies examined indigenous Mexican cultivars, and, therefore, they do not preclude the possibility of a separate domestication event in Mexico. Molecular studies seeking to establish the genetic relationships among indigenous Mexican landraces, wild populations, and commercial domesticates are needed.

Another question arises as to why sunflower was less significant as a household staple in pre-Columbian Mesoamerica than in eastern North America. One explanation may be associated with sunflower as a fat source. Sunflower had the highest fat content of any of the eastern North American seed crops (49) and consequently was a highly esteemed food crop in that region. The Mesoamericans, however, had many other sources of fats such as avocado (*P. americana*), zapote (*Calocarpum mammosum*), cacao (*Theobroma cacao*), amaranth (*Amaranthus* spp.), chia (*Salvia hispanica*), and numerous palm fruits (e.g., *Acrocomia aculeata*, *Attalea cohune*, and *Bactris major*) to which the farmers of eastern North America had no access. Sunflower may have been a more central element of the Mexican diet in the third millennium B.C. when maize was a less robust crop or in areas where maize was less dependable. By post-Classic Aztec times sunflower seems to have been valued less as a food source and more as an ornamental plant, as a symbolic component in ritual activities, or as medicine, all common uses among indigenous Mexican cultures today.

This discussion underscores the idea that useful plants have complex histories and the role of a cultigen may change with time. Amaranth (*Amaranthus* spp.) is another Mexican domesticate whose usage pattern changed over time. It was once a primary tribute crop in Mesoamerica and a frequent offering to the Aztec fire god, Xiuhtecutli. The use of amaranth, however, declined rapidly during post-Conquest times because Christian clerics disapproved of its ritual associations (50). Sunflower seems to have suffered a similar fate.

In sum, the archaeological data, combined with linguistic, ethnographic, and ethnohistoric evidence, demonstrate conclusively that sunflower was cultivated in pre-Columbian Mexico, contrary to the assertions of Heiser (3, 51) and Smith (17). Strong evidence for an independent sunflower domestication in Mexico lies in the consistent morphological differences between the early Mexican cultivars and their contemporaneous eastern North American counterparts. By the time the Spaniards arrived in the sixteenth century, sunflower was used not only for food but also as a component in religious ceremonies and in the manipulation of social relations. The politically charged customs associated with sunflower likely led to its suppression after the Spanish Conquest.

Materials and Methods

The sunflower achenes, which had been unearthed in 1996 at the Cueva del Gallo site in Morelos, Mexico, were received from the Laboratório Paleobotánico del Instituto Nacionál de Antropología de Mexico. The specimens were first examined by using a conventional stereomicroscope to verify identification. One of the achenes was submitted to Beta Analytic, Inc. of Coral Gables, Florida, for radiocarbon dating using accelerator mass spectrometry. The other achene was imaged by using a Philips XL30 ESEM-FEG environmental scanning electron microscope with field emission gun housed at the Engineering Microscopy Center at the University of Cincinnati. Use of the environmental mode (set at 10 kV accelerating voltage) with its near-ambient temperature and pressure obviated the need to coat the specimen with conductive metals.

Linguistic data were obtained from informants in Mexican communities where large numbers of native speakers were known to reside. Fresh specimens of *H. annuus* and other plants were placed in a field press and then presented to informants. The names and uses were tape-recorded, with permission of the informants, then transcribed in the lab with assistance from trained linguists.

ACKNOWLEDGMENTS. We thank the Instituto Nacionál de Antropología e Historia, México, for permission to conduct excavations at San Andrés, Tabasco; Mary Suter of The University Museum of the University of Arkansas for the loan of sunflower achene specimens from the Eden's Bluff site, Arkansas; U.S. Department of Agriculture for donations of both wild and indigenous North American sunflower achenes; Lorelle Falk Lentz and Brian Lane for helping to edit this paper; Elizabeth Brumfiel, Ruth Dickau, Deborah Pearsall, Anna Roosevelt, Gerald Seiler, and Payson Sheets for reviewing and providing comments on earlier versions of this manuscript; Jonathan Amith, Roberto Alvarado, Delia Castro, César Chávez, Geoff Hall, Thomas Janota, Edelmira Linares, Chris Morehart, Oscar Farrera, and Miguel Trejo for providing field assistance and help with specimen preparation; Terry Kaufman, Jim Fox, Doris Bartholomew, Steve Marlett, Elizabeth Willett, Ronald Longacker, Katherine Voitlander, David Beck, Robert Rankin, Wes Shoemaker, and Joseph Foster for offering linguistic interpretations of indigenous terms; and Nicholas Hopkins, Eulogio Guzman, Jeanette Favrot Peterson, and Brenda Green for additional valuable contributions. Specimens collected as part of this project have been stored at Universidad Autónoma de México, University of Cincinnati, Chicago Botanic Garden, and New York Botanical Garden. This work was supported by National Science Foundation Grant BCS-0228049 and National Geographic Society Grant 7030-01.

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