THE ORIGINS OF *Agriculture*

An International Perspective

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The Origins of Plant Cultivation in the Near East

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Between about 11,000 and 6000 B.C. a series of irrevocable changes took place in the societies of the ancient Near East. Before this period, groups of mobile foragers lived by hunting and gathering. By the end of it, much of the region was inhabited by settled villagers who relied primarily on farming and stock-raising for their livelihood. The cultivation and eventual domestication of plants played a major role in this process.

One can think of plant cultivation as a single point along a continuum of human/plant interaction. At the least intrusive end is the simple harvesting of crops, which can have an effect on a wild plant population; the use of fire and other simple techniques also encourage particular wild plants. At a greater degree of interference is cultivation, in which a crop is intentionally planted. At the most intrusive end is domestication, in which a plant has evolved into a new form under continued manipulation by humans so that it may have lost the ability to reproduce itself (Helbaek 1969:403).

In the Near East, two aspects of human plant exploitation were distinctive. First, the native grasses were highly productive. Wild wheat and barley grew in dense stands and served as a valuable food source even before cultivation had begun. It was this use of wild grasses for *food* that probably led to their early domestication. Second, early reliance on domesticated grasses was facilitated by the adoption of complementary sources of protein, namely, leguminous crops, such as pea and lentil, and domesticated animals. Domestication followed increased wild plant use by sedentary human populations by several thousand years. The beginning of plant cultivation prior to domestication, and the association between plant cultivation and changing patterns of human/plant interaction can, however, be approached only indirectly.

In this chapter I review the geographical, archaeological, and botanical background of plant cultivation, note some of the more recent archaeobotanical research on the origins of plant cultivation, and discuss certain aspects of the theories of agricultural origins that were developed during the 1960s, 1970s, and 1980s. Finally, I offer a critique of the use of archaeological plant remains as evidence for those theories.

Geography

This chapter focuses on those parts of Iran, Iraq, Turkey, Syria, Jordan, Lebanon, and Israel where the early development of food production took place

(Fig. 3.1). The region is characterized by several major land forms (M. Zohary 1973; Fisher 1978). The Afro-Arabian tableland borders the area to the south and is today largely desert. The Irano-Anatolian folded zone, which includes the Zagros, Taurus, and Syro-Palestine ranges, forms a mountainous arc where most of the arboreal vegetation now grows. Between these two zones is a region of rolling terrain and alluvial plains. A portion of this region in Turkey, Iraq, and Iranian Kurdistan is sometimes referred to as the "hilly flanks of the Fertile Crescent" (Braidwood and Howe 1960:3). The two major rivers of Mesopotamia, the Tigris and the Euphrates, have their origins in the mountainous regions and flow in a generally southeasterly direction through the Syrian steppe and the Mesopotamian lowland.

The tremendous variability in topography has a strong influence on climate and vegetation. The coastal regions in the west are characterized by a Mediterranean regime of hot, dry summers and cool, wet winters. A lowland area known as the "Syrian Saddle," which separates the Anti-Taurus from the Syro-Palestine ranges, allows the Mediterranean influence to extend inland. The inland regions, however, have a more continental climate.

Generally, there are altitude and latitude clines in temperature and available moisture. This variability is reflected in the distribution of the natural vegetation. Following M. Zohary (1973), one can define several different types of vegetation. Because of severe deforestation and degradation of the landscape, such reconstruction of the natural flora is based on discontinuous patches of relatively undisturbed vegetation that still exist today.

Oaks (*Quercus calliprinos* Webb, among others) and Aleppo pine (*Pinus halepensis* Mill.) predominate in

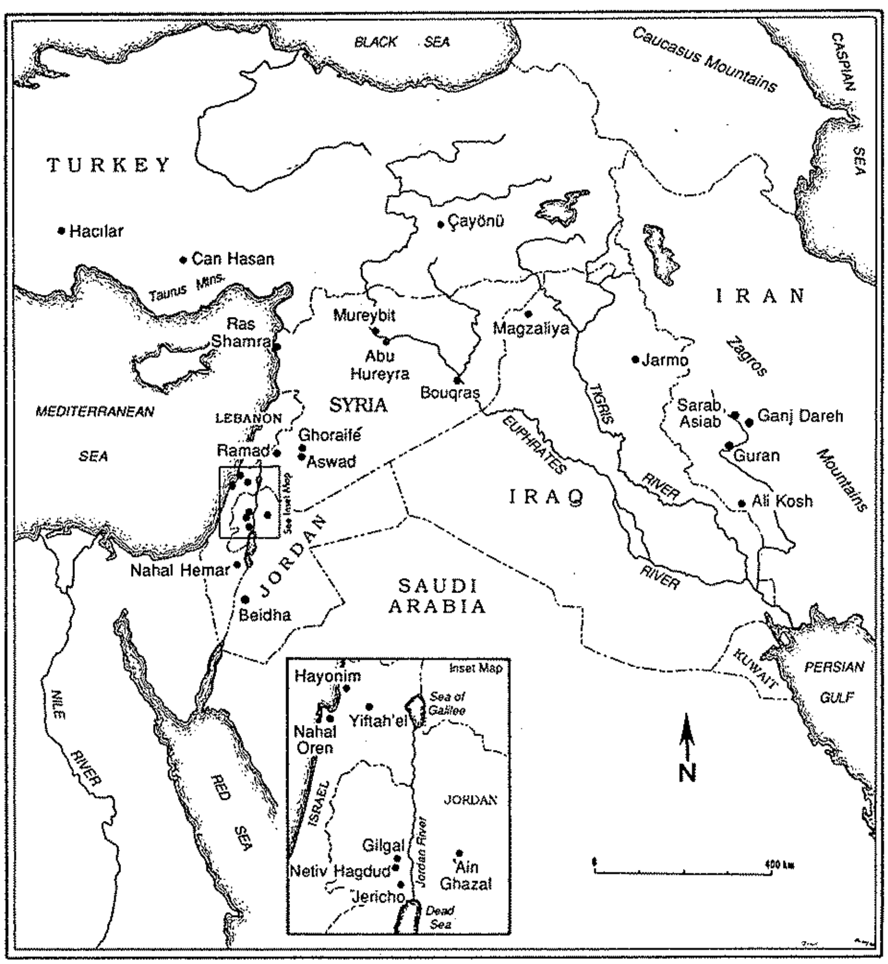

Fig. 3.1. The Near East and archeological sites mentioned in the text.

the Mediterranean coastal forest west of the great bend in the Euphrates. In addition to oak, pistachio (*Pistacia* spp.) and carob (*Ceratonia siliqua* L.) are important trees that have edible fruit and nuts. Lebanon cedar (*Cedrus libani* A. Rich.) is found only at higher elevations. The drier inland regions of the folded zone are dominated by oak (*Quercus brantii* Lindl.), but pistachio continues to be an important component. In the more arid regions of southern Iran where it is too dry for oak, pistachio-almond steppe forest predominates. The forest grades successively into steppe forest, steppe, and desert in northern Syria and Iraq. Riverine associations characterized by willow (*Salix* sp.), poplar (*Populus* sp.), and tamarisk (*Tamarix* sp.) cut across environmental zones. The wild cereal grasses and legumes are at home in the open oak forest and steppe forest regions (Harlan and Zohary 1966; Zohary 1989; Zohary and Hopf 1973).

Moisture is the limiting factor for agriculture over much of the region. The minimum rainfall needed for winter crops is approximately 250 mm. Fields may be planted in locally moist plots to improve harvest security.

Ancient Climate

Reconstructions of climate and vegetation for the period of the earliest cultivation and adoption of agriculture are critical elements for models of agricultural origins in the Near East. Several recent syntheses have described the climate of the Near East at the end of the Pleistocene and in the early Recent period (Bottema and van Zeist 1981; Wright 1977, 1980, 1983; van Zeist and Bottema 1982). Much of the Near East had little or no forest cover during the glacial period, probably because of higher aridity and/or lower temperatures than today. Although treeless steppe characterized the Zagros Mountains, the Levant remained forested, and the amount of forest cover in Syria and Turkey fluctuated (Bottema and van Zeist 1981). Pollen evidence suggests that the forest (primarily oak) gradually expanded from refugia in the west and eventually reached the Zagros Mountains. Modern analogues to this type of forest cover contain wild cereal grasses, so it is likely that the grass habitat expanded as well (Wright 1983). Of special interest is the situation in northwest Syria where the climate from about 10,000 to 7000 B.C. was apparently moister than at present and the vegetation was dominated by deciduous oak (van Zeist and Woldring 1980).

History of Investigations

The first systematic attempt to recover empirical evidence for the transition to food production was Robert Braidwood's Iraq-Jarmo Project (Braidwood and Howe 1960; Braidwood et al. 1983). The project included specialists in geology, botany, and zoology. Hans Helbaek, the project's botanist, wrote an important early survey of the botanical evidence for domestication (Helbaek 1960). Although some of the results of the project have been superseded by the discovery of earlier agricultural settlements, the Jarmo project was a model of interdisciplinary research; all subsequent work on agricultural origins in the Near East can trace an intellectual descent from it.

Important work on early agriculture continued during the 1960s. In Iran, Hans Helbaek (1969) analyzed painstakingly collected plant remains from the Deh Luran Plain (Hole et al. 1969). Braidwood and his colleagues transferred their operations to Çayönü in southeastern Turkey (van Zeist 1972). Several projects were carried out under the inspiration of Eric Higgs and the auspices of the British Academy Major Research Project in the Early History of Agriculture (French et al. 1973; Moore et al. 1975; Noy et al. 1973). The Tabqa Dam Project of the 1970s yielded a wealth of archaeobotanical material from sites in northwestern Syria (Cauvin 1977; Moore et al. 1975). Much of this work has only recently been completed. Although some archaeologists are concerned primarily with the origins and development of early village life (e.g., Cauvin 1978), the archaeobotanical study of early agriculture can easily be accommodated within such research projects since farming in the Near East seems to have been associated with sedentism from the beginning. A summary of work through the 1960s is available in Renfrew (1969) and Flannery (1973). Henry (1989) and Moore (1985) have recently written archaeological reviews of the Natufian and Neolithic periods. Botanical reports or notes are available for the early village sites listed in Table 3.1.

Archaeological Background

The earliest evidence of morphologically new plants occurs in the archaeological record at about 9000 B.C.

Table 3.1. Botanical Reports from Epipaleolithic and Aceramic Sites

Site	Period	Reference
Levant		
Nahal Oren	Kebaran, Natufian, PPNA, PPNB	Noy et al. 1973
Hayonim	Natufian	Hopf and Bar-Yosef 1987
Wadi Hammeh 27	Natufian	Edwards et al. 1988
Netiv Hagdud	PPNA	Kislev et al. 1986
Gilgal	PPNA	Noy 1988
Jericho	PPNA, PPNB, Neolithic	Hopf 1983, Western 1971
Nahal Hemar	PPNB	Kislev 1988
Yiftah'el	PPNB	Kislev 1985
'Ain Ghazal	PPNB	Rollefson et al. 1985
Beidha	PPNB	Helbaek 1966
Syria		
Abu Hureyra	Late Epipaleolithic, Aceramic Neolithic	Moore et al. 1975, Hillman et al. 1989
Mureybit	Late Epipaleolithic	van Zeist and Bakker-Heeres 1986b
Aswad	Aceramic Neolithic	van Zeist and Bakker-Heeres 1985
Ramad	Aceramic Neolithic	van Zeist and Bakker-Heeres 1985
Ghoraifé	Aceramic Neolithic	van Zeist and Bakker-Heeres 1985
Ras Shamra	Aceramic Neolithic, Neolithic	van Zeist and Bakker-Heeres 1986a
Bouqras	Neolithic	van Zeist and Waterbolk-van Rooijen 1985
Turkey		
Çayönü	Aceramic Neolithic	van Zeist 1972, Stewart 1976
Hacılar	Aceramic Neolithic, Neolithic	Helbaek 1970
Can Hasan III	Aceramic Neolithic	French et al. 1972, Hillman 1978
Iraq		
Jarmo	Aceramic Neolithic	Helbaek 1960, Watson 1983, L.S. Braidwood et al. 1983:541
Magzaliya	PPNB	Lisicyna 1983
Iran		
Ganj Dareh	Aceramic Neolithic	van Zeist et al. 1986
Ali Kosh	Aceramic Neolithic, Neolithic	Helbaek 1969

Domesticated barley has been reported from the Levant at two Pre-Pottery Neolithic A (PPNA) sites, Netiv Hagdud (Kislev et al. 1986) and Gilgal (Noy 1988), and from Iran in the earliest levels at Ganj Dareh (van Zeist et al. 1986), although these early specimens may be morphologically indistinguishable from the wild type (Kislev 1989). Domesticated einkorn and emmer wheat have been found in Syria and Turkey at Aswad, Çayönü, and Neolithic Abu Hureyra. Emmer wheat gave rise to durum wheat by the eighth millennium B.C., and bread wheat appeared in the seventh millennium B.C. (van Zeist 1986a). Since plant domestication represents the culmination of a long process of human/plant interaction, we know that important changes in plant use had already taken place during the preagricultural period, sometimes called the Epipaleolithic. During that time, people in the Near East began to occupy permanent or semipermanent villages. Subsistence strategies apparently changed as well, with increased consumption of plants and mollusks. Kent Flannery (1969) calls this change in the prehistoric menu the "broad spectrum revolution," although recent studies have questioned this characterization of the preagricultural diet (Edwards 1989; Henry 1989).

The Epipaleolithic refers to the (presumed) foraging cultures of the Late Glacial and Early Holocene periods. Local sequence names in the Levant include the Kebaran (to ca. 11,000 B.C.) and Natufian (ca. 11,000–9400 B.C.) and in the Zagros the Zarzian and Karim Shahirian, which are roughly contemporary with the Levantine sequence. Early farming societies are referred to as "Neolithic." The earliest Neolithic societies that did not use ceramic vessels, although many had some knowledge of the properties of clay, are called Pre-Pottery Neolithic in the Levant (PPNA, ca. 9400–8500 B.C.; PPNB, ca. 8500–6700 B.C.) and simply the Aceramic Neolithic elsewhere. An extended discussion of local sequences and chronological problems is beyond the scope of this chapter, but they have been discussed by others (Aurenche et al. 1987; Bar-Yosef and Vogel 1987; Braidwood and Howe 1960; Henry 1989). The early farming societies adopted various combinations of crops and animals in different parts of the Near East. Village life based on the complete Near Eastern complex of wheat, barley, pulses, sheep, goat, pig, and cattle took several thousand years to develop (Table 3.2).

The Nature of the Evidence

Several lines of evidence contribute to the study of agricultural origins. Prehistoric tools and facilities provide indirect evidence of plant use, human skeletal remains are used in dietary reconstructions of the Epipaleolithic, and ecological and botanical studies of plant remains found on archaeological sites shed light on the transition to food production. Finally, the archaeological context in which plant remains are found must also be considered.

Plant processing equipment and facilities became important elements of Epipaleolithic material culture. Grinding stones, some of which were used for pigments (Moore et al. 1975:58), could also have been used for grain or acorn processing, and flint sickle blades were used for cutting grasses. Roasting pits, which are present on some sites, could have been used to process grain. Storage technology developed as well. Although pottery had not yet been invented, underground pits were used to solve the problem of preserving seasonally abundant, storable plant resources, particularly wild cereals.

Flannery used the term "preadaptation" for the technological changes that preceded and permitted reliance on agricultural production. Until recently, the association between increasing dependence on plant foods and the development of new food processing technologies has been somewhat conjectural. Now, however, it has been borne out by several studies showing that human skeletal remains bear traces of an individual's dietary history. For example, the consumption of stone-ground foods has been shown to lead to a rapid wearing down of teeth. While this pattern is typical of later agricultural villagers of the Near East, it first appears in the skeletons of the late Epipaleolithic (P. Smith 1972). Bone strontium analysis provides additional, although somewhat contro-

Table 3.2. Simplified Chronology for the Epipaleolithic and Neolithic in the Near East

Calibrated Date[a] B.C.	Levant	Syria/Anatolia	Zagros	Uncalibrated Date[b] (B.C.)
		Pottery Neolithic		
6700				6000
8000	PPNB		Aceramic Neolithic	7000
		Aceramic Neolithic		
8500				7600
9000	PPNA		(Proto-Neolithic)	8000
9400				8300
11,000				9000
	Natufian		Karim Shahirian	
12,000				10,000
	Geometric Kebaran			
		Epipaleolithic	Zarzian	11,000
				12,000
	Kebaran			13,000
				14,000
				15,000

Source: The information on local sequences was compiled from Aurenche, Évin, and Gascó (1987) and Bar-Yosef and Vogel (1987).
[a]Calibrated radiocarbon dates are interpreted from Stuiver et al. (1986, fig. 7).
[b]Uncalibrated dates are based on Libby half-life (5568 years).

versial, evidence for dietary change. Since plants and mollusks both have higher proportions of strontium relative to calcium, herbivores and shellfish eaters exhibit higher bone strontium than carnivores. An analysis of a small series of Levantine Epipaleolithic skeletal remains suggests that the individuals had consumed more plants compared with others from earlier periods (Schoeninger 1981, 1982; also compare with Sillen 1981). This finding is further substantiated by the presence of grinding and storage facilities at the sites. For reviews of the Near Eastern skeletal evidence, see P. Smith et al. (1984) and Rathbun (1984).

The archaeobotanical evidence for early plant domestication in the Near East (Table 3.3), although incomplete, is fairly clear (van Zeist 1986; Zohary and Hopf 1988). The wild ancestors of early domesticated cereals are inferred on genetic, morphological, and phytogeographical grounds (Harlan and Zohary 1966; Zohary 1989; Zohary and Hopf 1988) (see Figs. 3.2–3.4). Rapid evolution toward morphologically domesticated types may explain why intermediate forms are rarely encountered in the archaeobotanical record (Hillman and Davies 1990). Two-row barley (*Hordeum distichum* L. emend. Lam.) evolved from the two-row wild form (*H. spontaneum* C. Koch), which grows today in an arc stretching from the Levant to western Iran. The most primitive domesticated wheat, einkorn (*Triticum monococcum* L.), evolved from a wild form (*T. boeoticum* Boiss. emend. Schiem.) whose native habitat extends from southeastern Turkey to western Iran. Both wild and cultivated types of einkorn are genetically diploid. The origin of the tetraploid emmer wheats is still problematic. Wild emmer (*T. dicoccoides* Korn), the closest relative of the domesticated variety (*T. dicoccum* Schubl.), grows in the Levant. Some consider it to be a weedy form that is derived from domesticated emmer, but others believe it is the wild ancestor. Both wild and domestic emmer have two genomes, A and B. The A genome is derived from einkorn, but the source of the other is uncertain (Feldman 1976). In contrast to einkorn and emmer, which are both hulled wheats, durum, or hard wheat (*T. durum* Desf.), is a free-threshing tetraploid that is closely related to emmer. A later hybridization between cultivated emmer and a wild, goat-face grass, *Aegilops squarrosa* L. (= *T. tauschii* [Coss.] Schmalh), gave rise to the free-threshing hexaploid bread wheat (*T. aestivum* L.; see also Kislev 1984). A third cereal, rye (*Secale cereale* L.), may also have originated in the Near East (Hillman 1978), but it was established as a crop relatively late.

Fortunately for the archaeobotanist, the forms of domesticated cereals are distinct from those of wild types. The cultigens have larger and plumper grains than their wild counterparts. In addition, the wild forms have brittle stalks, or rachises, which shatter into individual internodes when they are ripe, allowing the plants to propagate themselves in the wild. Human harvesting practices may have selected for a tougher rachis, so that the domesticates should be recognizable by the presence of intact rachis segments. Unfortunately, the rachises of the more primitive domestic wheats—einkorn and emmer—have a tendency to break up with threshing, and those of some wild barleys may not shatter at all (Kislev 1989). Therefore, although domestication involved morphological changes to both fruit and stalk, many of the reported examples of domesticated cereals from early sites can be identified only on the basis of grain size and shape (e.g., van Zeist 1972; van Zeist and Bakker-Heeres 1985). Several researchers are trying to refine the criteria for identifying archaeobotanical specimens (Kislev 1989; Körber-Grohne 1981).

Legumes also appear early in the archaeobotanical record, sometimes in greater quantity than the cereals. This is true of both small-seeded legumes, such as clover (*Trifolium*) and medick (*Medicago*), and pulses, such as lentil (*Lens culinaris* Med.), pea (*Pisum sativum* L.), chickpea (*Cicer arietinum* L.), and vetches *Vicia sativa* L., *V. ervilia* (L.) Willd., and *V. faba* L.). The cultivated legumes are generally not readily distinguishable from their wild counterparts, since many characteristics, such as size and surface texture, overlap. For example, while domesticated lentil tends to be larger than the wild type, this is not always the case. Further complicating matters, the rigors of ancient processing and archaeological recovery may destroy distinctive characteristics, such as the surface texture of the seed coat of pea. Regardless of present-day differences, therefore, the earliest cultivated legumes would not be morphologically distinct from the wild forms (Zohary and Hopf 1973). Lentil, pea, and chickpea occur at early agricultural sites. The vetches, most of which are grown today for fodder, are relatively common at Epipaleolithic sites. A fava-like vetch occurs in PPNA levels at Jericho (Hopf 1983), and a large quantity of domesticated fava bean (*V. faba*) dating to the sixth millennium B.C. has been reported from Yiftah'el in Israel (Kislev 1985).

Table 3.3. Seeds of Likely Crops from Epipaleolithic and Early Farming Sites

	Cereal					Pulse						Other
	Wheat			Barley								
	Einkorn	Emmer	Bread/Hard	2-row	6-row	Lentil	Pea	Vetch	Fava bean	Chick-pea	Lupine	Flax
Epipaleolithic												
Hayonim	.	.	.	.	.	.	.	.	.	.	•	.
Nahal Oren	.	.	.	w	.	.	.	•	.	.	.	.
Abu Hureyra	w	.	.	w	.	+	.	•	.	.	.	.
Mureybit	w	.	.	w	.	+	cf	+	.	.	.	•
PPNA												
Netiv Hagdud	.	.	.	w/c	.	.	.	.	.	.	.	.
Jericho	+	+	.	+	.	+	.	.	.	cf	.	.
PPNB												
Jericho	•	•	.	•	+	•	•	.	+	+	.	•
Nahal Hemar	.	•	.	•	.	•	.	.	.	.	.	.
'Ain Ghazal	.	•	.	•	.	•	•	.	.	•	.	•
Beidha	.	•	.	w/c	.	.	.	.	.	.	.	.
Magzaliya	+	+	cf	+	.	+	.	+	.	.	.	w?
Other Aceramic												
Aswad	+	•	•	w/c	.	+	•	+	.	.	.	.
Çayönü	•	•	.	.	.	•	•	•	.	+	.	w
Ganj Dareh	.	.	.	•	.	+	.	.	.	.	.	.
Ali Kosh	+	•	.	•	.	+	.	.	.	.	.	+
Jarmo	+	+	.	+	.	+	+	.	.	.	.	.
Hacılar	w?	•	.	w	+	+	.	.	.	.	.	.
Can Hasan III	•	•	•	•	.	•	.	•	.	.	.	.
Abu Hureyra	•	•	.	.	•	•	.	.	+	+	.	.
Ghoraifé	+	•	•	w/c	+	+	+	.	.	+	.	+
Ramad	.	•	+	+	+	•	•	+	.	.	.	+
Ras Shamra	.	+	.	+	.	•	•	.	.	.	.	+
Neolithic												
Jericho	•	•	.	•	+	•	.	.	.	.	.	.
Ras Shamra	.	.	.	+	.	•	+	.	.	.	.	+
Ramad	+	•	•	+	+	+	+	.	.	+	.	•
Bouqras	•	•	•	+	•	+	+	.	.	.	.	.
Hacılar	•	•	•	•	•	•	•	+	.	.	.	.
Ali Kosh	+	•	.	•	+	+	.	.	.	.	.	+

w = wild; • = numerous; w/c = wild or cultivated; + = present or quantity not reported; cf = tentative identification.

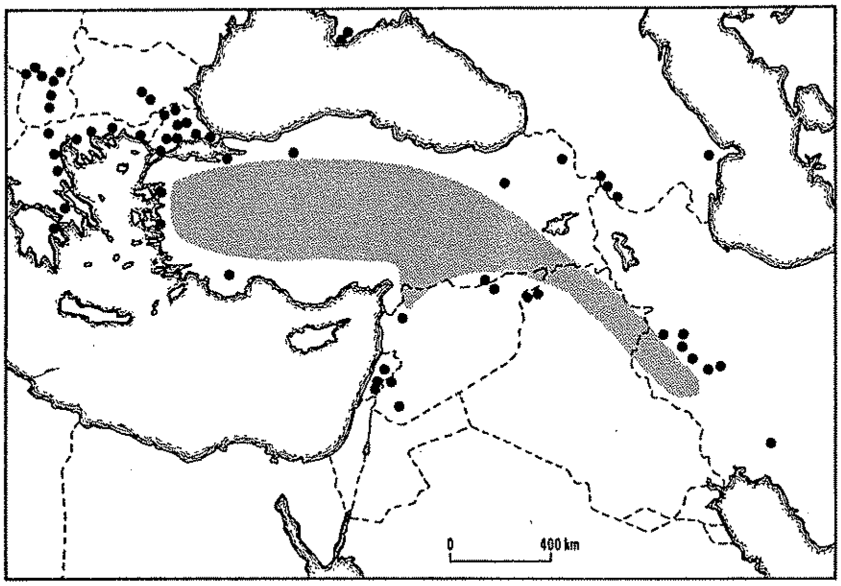

Fig. 3.2. Present-day distribution of wild einkorn wheat, *Triticum boeoticum*. Dots represent places where weedy forms have been seen. (After Harlan and Zohary 1966; Zohary 1989)

While researchers learn a great deal about crop evolution from a study of the plants themselves, they assess the role of plants in the ancient economy through a combination of botanical and archaeological analyses. The remains of plants, whether they are domesticated or not, have a cultural context if they are found on an archaeological site. Their cultural significance depends on how they were used and how they came to be preserved in the archaeological record. In the 1960s, researchers explicitly considered the possibility that at least some weed seeds were eaten, and generally assumed that the seeds of cultivated plants represented accidentally charred food remains. During the 1970s, studies demonstrated that residues from different stages of crop processing could leave an assortment of weed and cultigen seeds (Dennell 1974; Hillman 1981). More recently, I have suggested that some seeds from later agricultural sites came from burning dung as fuel (Miller 1984; Miller and Smart 1984), and this interpretation may be applicable to earlier remains as well. As I will discuss below, these considerations have important implications for theories of agricultural origins.

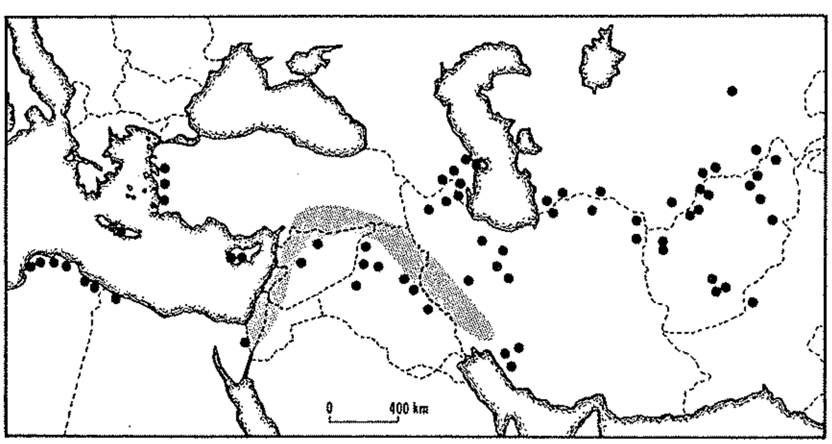

Fig. 3.3. Present-day distribution of wild barley, *Hordeum spontaneum*. (After Harlan and Zohary 1966; Zohary 1989)

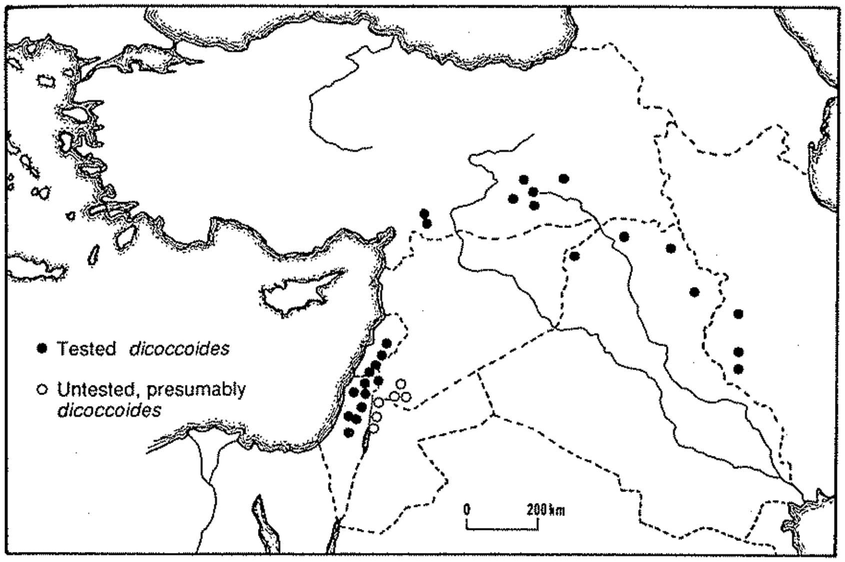

Fig. 3.4. Present-day distribution of wild emmer wheat, *Triticum dicoccoides*. (After Harlan and Zohary 1966; Zohary 1989)

Previous Archaeobotanical Work

Epipaleolithic Near Easterners apparently began eating the wild ancestors of plants that their descendants ultimately domesticated. Any discussion of domestication, therefore, must start with the botanical evidence for plant use.

In addition to gaps in the archaeobotanical record resulting from the relatively small number of excavated archaeological sites, archaeobotany suffers from several other disadvantages. First, because systematic archaeobotanical studies did not begin until the 1950s, few incipient or early agricultural sites excavated have been tested for plant remains. Second, because so much work is recent, relatively few final archaeobotanical reports have been published. Third, even when great care has been taken to recover charred seeds, many ancient sites have yielded low densities of carbonized plant remains (e.g., Noy et al. 1973).

Prior to 1970, the most complete paleoethnobotanical study of an early agricultural community was done by Hans Helbaek (1969) for Ali Kosh in southwestern Iran. The study provided the botanical basis for much of the subsequent discussion about agricultural origins and development in the Near East, especially Flannery's work (1969). Domesticated plants and husbanded animals occurred in the earliest levels. Most of the plant remains were recovered from ash lenses and midden (Hole et al. 1969). Extraordinary quantities of small-seeded legumes (94 percent of the seeds, about 29,000 seeds) occurred in samples from the Bus Mordeh phase (beginning of the eighth millennium B.C.). In the subsequent Ali Kosh phase (end of the eighth millennium B.C.), cultigens, primarily emmer, comprised 40 percent of the seed remains, and small-seeded legumes dropped to 19 percent. In the final Mohammad Jaffar phase, small-seeded legumes once again made up a substantial portion of the remains (59 percent, about 5,000 seeds). Hole, Flannery, and Neely's (1969:342–54) interpretation of the Ali Kosh remains emphasized aspects of the seed assemblage that favored progressive agricultural development. As these figures suggest, however, the assemblage does not necessarily exhibit straight-line development.

A summary and discussion of plant remains from other early sites up to the early 1970s appears in Renfrew (1969, 1973) and Flannery (1973). Therefore, I confine the remainder of my discussion to sites with botanical remains reported in the last twenty years.

Among the earliest macroscopic plant remains recovered to date from the Near East are those from Nahal Oren in Israel (Noy et al. 1973). The site is located in the Wadi Fellah at an elevation of about 100 m between the uplands and the Mediterranean coast. The earliest levels at Nahal Oren, which date to the Kebaran period, had very low seed densities. The single largest category was vetch, which comprised 27 out of a total of 64 seeds. Three wheat grains identified as *Triticum dicoccum*, the domestic type, were reported, but they are now known to be intrusive (Gowlett and Hedges 1987). The Natufian levels yielded 25 seeds, including 11 vetch remains, but no emmer. PPNA and PPNB levels produced similar low densities of seeds, including vetch and emmer. The PPNB levels are distinguished by a comparatively large number of plant types, including several nuts and fruits. Another Natufian site, Hayonim, which is 13 km east of the Mediterranean coast and about 250 m above sea level, revealed the predominance of a large-seeded legume, lupine (*Lupinus pilosus* L.).

Mureybit (van Zeist and Bakker-Heeres 1986b) and early Epipaleolithic Abu Hureyra (Hillman et al. 1989), which date to between the ninth and eleventh millennia B.C., are located about 30 km apart on the Euphrates river in northwestern Syria at an elevation of about 300 m. Both have evidence for the ancient use of wild einkorn about 100 km from its present habitat. The middle levels of Mureybit are characterized by the presence of "fire pits," which may well represent grain roasting facilities. Two of the samples from these levels show high concentrations of nearly pure wild einkorn. The archaeological context and the purity of these samples together support the conclusion that einkorn was intentionally harvested for food. A slightly later sample consists primarily of *Polygonum,* a plant that never became a Near Eastern cultigen but appears to have been collected for food at Mureybit. The remaining samples are mixed assemblages of weedy types. Abu Hureyra exhibits a slightly wider range of materials from this time period. Although wild-type einkorn is quite common, the assemblage includes mixed samples of seeds from many wild plant types, most of which were never domesticated (Hillman et al. 1989). Hillman et al. (1989) suggest that the weed seeds are most likely food remains, although they could easily be interpreted as the remains of burned trash, fuel, or contaminants of harvested cereals (see below). Both sites have some tree fruits (pistachio and hackberry), which is consistent with the recent interpretation that the climate of northwestern Syria was relatively moist during the Epipaleolithic (van Zeist and Woldring 1980).

Aswad (van Zeist and Bakker-Heeres 1985), another ninth millennium B.C. site, is located near a former lake in the steppe region of Syria. It has yielded the earliest domesticated emmer found to date (van Zeist and Bakker-Heeres 1985; see Kislev 1989 for an alternative view), as well as probably cultivated pea and lentil. Farming, however, seems to have begun in the Levant, and only later spread beyond the Jordan Valley to such sites as Aswad (van Zeist 1986; Bar-Yosef and Kislev 1989). Of all the sites considered here, Aswad most closely resembles the Bus Mordeh phase at Ali Kosh in that small-seeded legumes represent a disproportionately large component of the total seed assemblage (55 percent for Phase I at Aswad versus 94 percent for the Bus Mordeh phase at Ali Kosh; at Çayönü they are well under 1 percent; and at Mureybit they represent less than 2 percent). Later "Neolithic" Abu Hureyra, which is roughly contemporary with Aswad, also has domesticated plants, including einkorn, emmer, hulled and naked six-row barley, chickpea, and lentil. Plant assemblages from sites in the steppe region (Aswad, Abu Hureyra, and Ali Kosh) are similar to one another in that they contain a variety of weedy types.

Jericho is located at the northern end of the Dead Sea about 300 m below sea level. The area is extremely arid today and probably was dry in the past as well. A large, freshwater spring at the base of the mound site has provided water for millennia. Although early reports (Hopf 1969) contended that farming in such an arid climate would have required at least simple irrigation techniques, recent geological work suggests that crops could have been planted to take advantage of water run-off in nearby wadi bottoms (Hopf 1983). Although a small Natufian occupation has been found at Jericho, the earliest plant remains date to PPNA and PPNB times. They were collected before flotation had become the standard procedure for recovering plant remains, so the assemblage is skewed in favor of concentrations of seed remains. Although the seeds of several crops are usually mixed, the number of weed impurities is quite low, suggesting that the seeds were cleaned crop or food remains. The presence of cultivated einkorn and emmer was documented with latex impressions of spikelets taken from mudbrick found at the site.

Several PPNB sites, including Ramad, Jericho, and Nahal Hemar, have yielded evidence of flax. Charred seeds from Ramad probably represent a domestic type of flax (*Linum usitatissimum*) (van Zeist and Bakker-Heeres 1985), as do two impressions of flax capsules (fruit cases) from Jericho (Hopf 1983). Although flax may have been domesticated for its oily seed, it may also have been the first plant in the Near East to be domesticated for non-dietary purposes. Linen textile fragments dating to PPNB were found preserved in dry deposits at Nahal Hemar cave (Schick 1986).

'Ain Ghazal is a PPNB site located at the outskirts of Amman, Jordan, on the edge of the Syrian steppe. The domesticated plants found there consist primarily of pea and lentil (Rollefson et al. 1985). A decline in the diameter of construction timbers suggests that large, old-growth trees were cut down in earlier times but that the forest did not regenerate, since, later on, only smaller, immature trees were available as construction material (Köhler-Rollefson 1988).

Ganj Dareh, an eighth- and possibly ninth-millennium B.C. site, is located in the folded mountain zone of Iran at an elevation of 1400 m. All levels contain domesticated barley (van Zeist et al. 1986). The earliest occupation, level E, is characterized by fire pits reminiscent of those found at Mureybit. Level E seems to be a temporary, perhaps seasonal, camp without permanent architecture, and is followed by four occupation levels with solid architecture.

Unlike most of the other sites, Çayönü in southeastern Turkey is located in the oak woodland zone at about 830 m. The earliest levels, which date to the early ninth millennium B.C., contain domesticated einkorn. Morphologically wild emmer and peas from the site may also represent cultivated crops (van Zeist 1972). Weed seeds are only sparsely represented, presumably because neither dung nor herbaceous plants were used for fuel. Archaeological charcoal includes pieces from trees that would have been growing nearby: oak, ash, pistachio, and almond in the forest, and tamarisk near watercourses. Although it was found in the heart of the natural habitat of wild einkorn, the one-seeded variety present at Çayönü probably originated in the west (van Zeist 1972).

These sites span the millennia during which agriculture became established. Although we have only a small sample of plant materials used by ancient peoples, it seems that the cultivation of different crops spread across a wide area in several environmental zones during the course of several thousand years. I have concentrated on the Near Eastern staple crops because of their early importance in the archaeobotanical record. By the time the Sumerian scribes began to record what they ate—after 6,000 years of agricultural endeavor—Near Easterners were growing a wide variety of cereals, pulses, fruits, and vegetables (see Sumerian Agriculture Group 1983; Zohary and Hopf 1988).

Theories of Agricultural Origins in the Near East

Modern archaeobotanical research on agricultural origins, which began with the Iraq-Jarmo Project, was designed to test several previous theories. Braidwood (Braidwood and Howe 1960) chose to work in the hilly flanks region because he assumed that the earliest farmers would have first cultivated the cereals in their natural habitat. It could not be assumed, however, that the natural habitat areas of the past were the same as those of today, since, according to some theories, there had been major post-Pleistocene climatic changes (Childe 1969[1952]:25). Therefore, one of the project's major goals was to establish an environmental baseline for the period of incipient and early farming; this research suggested that the climate was not substantially different from that of today.

A second goal was to find firm evidence for early agriculture through an archaeological survey and the excavation of Jarmo, an early village site located in the natural habitat zone of wild einkorn and barley. Dating to the seventh millennium B.C., the earliest levels at Jarmo already contained domesticated plants and animals. Therefore, questions about the *origins* of plant cultivation could not be addressed directly at the site.

According to Harlan and Zohary (1966), wild harvests are so plentiful in the natural habitat zone that one could question why people would go to the trouble of cultivating plants there at all. This issue was also addressed by Binford (1968), who agreed that people would not have begun cultivating plants in the natural habitat zone. Rather, the relatively populous plant-collecting communities living in the natural habitat zone would have expanded into areas marginally suited for wild cereals, where they would have encountered food shortages and would have been forced to take up farming to increase their food supply. Binford's population pressure model was elaborated upon by Flannery (1969), who suggested that subsistence changes that took place prior to agriculture—during the "broad spectrum revolution"—could have been a response to population growth in the marginal zone. His key argument was that, as plentiful as wild cereals were in a natural habitat zone, they were second choice foods in a marginal zone because they required more energy to find and process. The chief advantage of a plant-based diet was that it could support a higher population. As the marginal zones became more densely populated, however, people began to plant crops intentionally to ensure an adequate food supply.

If, however, the natural habitat zone was significantly larger at the end of the Pleistocene, wild cereals could well have become a *preferred* food source because of their reliability and ease of collection. In fact, "broad spectrum revolution" is a bit of a misnomer for early Holocene dietary changes. As Henry (1989) points out, the Natufian diet strongly favored just a few species, mainly the wild cereals and gazelle. Paleoenvironmental research during the past ten years suggests that during this critical time, much of the Levantine and Syrian steppe was indeed moister than it is at present (van Zeist and Woldring 1980; Henry 1989), and the boundaries of the ancient natural habitat zone are not the same as they are today. Bohrer (1972) even suggests that human disturbance of the oak forest could have encouraged the growth of wild cereals, since their present habitat is coppiced oak scrub. At the present time, the evidence is insufficient to ascertain whether wild cereals grew in vast, dense stands in the present-day marginal zone, or in favorable, but restricted microenvironments.

The concern with identifying the natural habitat and marginal zones is something of a red herring. Since population pressure is a function of the resource base and not just of absolute population density, pressures to increase food supplies could be as significant in the natural habitat zone as in the marginal zone. Although the population pressure argument is still fairly popular (Binford 1983; Cohen and Armelagos 1984; Smith and Young 1972, 1983), the extreme version based on demographic disparities between the natural habitat and marginal zones is no longer tenable.

Nutritional Considerations

Many theoretical models of agricultural origins focus on nutrition and sedentism because Natufian culture, with its increasingly plant-based diet and sedentary communities, was the direct precursor of later agricultural societies (e.g., Bar-Yosef and Kislev 1989; Flannery 1969; Hassan 1976; Henry 1989). Plant cultivation (at least of einkorn and emmer) seems to have originated in the Levant and spread to the Zagros (Hole 1984; van Zeist 1986).[1] Skeletal evidence also suggests that Natufian populations began to rely heavily on plants, while villagers in the Zagros continued to emphasize animal products (Schoeninger 1981). Cohen and Armelagos (1984) considered a decline in the nutritional and health status of preagricultural populations to be a test implication of population pressure theories of agricultural origins, but different subsistence strategies in the Zagros and the Levant would have had different nutritional consequences.

Two critical nutrients of any diet are carbohydrates and protein. The cereals are a good source of carbohydrates and they are also fairly high in protein. This is particularly true of einkorn, whose starchy endosperm comprises a smaller proportion of the grain than that of the plumper tetraploid and hexaploid wheats, and thus contains more protein (Akroyd 1970). Unlike animal protein, however, cereal protein is incomplete. It is low in lysine, one of the essential amino acids required by the human body to manufacture protein.

It is here that legumes come to play a role in our understanding of early Holocene subsistence. Legumes are a significant part of the archaeobotanical assemblage at both preagricultural and early agricultural sites. Although cereals are low in lysine, pulses, such as lentil, chickpea, and pea, are rich in it; in addition, at least one clover has a relatively high lysine content (FAO 1970). Although it has generally been assumed that both pulses and small-seeded legumes contributed to the Epipaleolithic diet, the archaeological context of carbonized seeds does not allow us to assume that these items were consumed by people. The pulses were eventually domesticated, but the small-seeded legumes were not. One of the ironies of the archaeobotanical record is that domesticated pulses flourish at the moment that domesticated animals, a more complete source of protein, enter the PPNB subsistence system.

Although most models assume human populations try to maintain as balanced a diet as possible, they differ in their interpretation of subsistence practices. This stems, in part, from the difficulty of reconstructing ancient diets from archaeobotanical remains (Dennell 1979). If plant remains cannot be directly translated into a dietary reconstruction, how else can one evaluate ancient eating habits? Human skeletal remains provide a complementary line of evidence. In their review of Natufian remains, P. Smith et al. (1984) conclude that nutritional and health stresses did not change very much between Natufian and early agricultural times in the Levant. In particular, they find no evidence for nutritional stress due to periodic food shortages. Rather, there is a noticeable decline in nutritional health after the PPNB, following the establishment of agriculture.

Significance of Sedentism

The presence or absence of population pressure in the marginal zone defined the terms of the debate about the origin of agriculture for many years. As early as 1973, however, Flannery (1973) stressed that in the Near East sedentism seemed to be an important precursor to domestication, and probably to cultivation as well (see also Bar-Yosef and Kislev 1989). In this view, sedentism would have been permitted by the high productivity and storability of the wild cereals.

Sedentism did not develop uniformly across the Near East. Very early sedentism with increased dependence on plants is characteristic of the late Epipaleolithic in the Levant, where evidence for domesticated animals prior to PPNB times is scanty (for alternative views, see Legge 1972 and Moore 1982). Transhumance based on pastoral production seems to have been more common in the Zagros (e.g., at Ali Kosh). The integration of pastoral and agricultural economies probably contributed to the ultimate success of the early village farming way of life in the Near East.

There are several ways to view sedentism as an impetus to plant cultivation. Sedentary peoples may cultivate food in order to ensure a *reliable* food supply or to *increase* their food supply to satisfy growing social or dietary needs.

First, even without population growth, a sedentary population will eventually deplete the densest stands of wild cereals, making it necessary to engage in supplemental seed planting to ensure locally abundant and reliable harvests (Hayden 1981; Hassan 1981). In addition, there is no way to ensure good wild harvests on the same plot of land from one year to another. Presumably, people would initially have grown whatever cereal was at hand. Only later, as population densities increased, would they have selected the most productive crops available. This behavior could account for the rapid spread of emmer from its center of origin in the southern Levant at the expense of the apparently less productive einkorn (see Gill and Vear 1980:61).[2] Einkorn may have been reliable enough for early sedentary peoples but not productive enough for later, more populous villages.

Second, sedentarization may involve social and economic changes. A sedentary lifestyle requires forms of social control and mechanisms for dispute adjudication that differ from those appropriate to a mobile lifestyle (Bender 1978). The economic advantages of sedentism based on the harvesting and storage of a year's supply of grain, for example, would be obviated if villages were chronically rent by disputes. Unlike mobile foragers, sedentary people are usually not free to pick up and move if they get into an argument with their neighbor. In addition, they must maintain ties with other villagers for trade or marriage exchanges. Group burials seem to reflect social distinctions within Natufian communities in the Levant, and special treatment accorded to some individuals within burial groups seems to reflect status differences beyond age and sex (G. Wright 1978). Bender (1978) argues that dispute adjudication, social control, and increasingly complex social networks were maintained with feasting and gift-giving, which, in turn, were supported by surplus food production provided by plant cultivation.

Finally, sedentarization may have led to a reduction of certain factors, such as miscarriage and abortion, that limited population growth. As populations grew, people would have had to find, and ultimately produce, more food. Because it promoted population increase and exhaustion of the wild food supply, sedentism is a critical element of population pressure models of agricultural origins (e.g., Smith and Young 1972, 1983).

It is not yet possible to refute any of these theoretical positions on the basis of present archeological evidence. The importance of any one factor would tend to vary in different cultural settings. It may be most accurate to integrate aspects of all three factors, although in the Near East the effects of high population densities do not become apparent until after cultivation begins. An archaeobotanical approach can help us evaluate several aspects of these models of early cultivation and agriculture.

The Role of Archaeobotanical Evidence

Archaeobotanical evidence is used in three ways in investigating agricultural origins in the Near East. First, it has been used to generate models of ancient diet. Second, it provides a means to assess the environmental conditions and effects of early agricultural practices. Third, insofar as charred plant remains originate in fodder or dung fuel, archaeobotanical evidence may tell us more about animal husbandry practices than about either human food or the environment.

Older interpretations of botanical remains suggest that subsistence activities became more broadly based and more labor intensive as traditional sources of food, primarily large game animals, became scarce. Flannery extrapolated the idea of the "broad spectrum revolution" from plant and animal remains at the early agricultural site of Ali Kosh (Flannery 1969). In his view, the enormous quantities of hard-to-process, small-seeded legumes represented an important protein source at Ali Kosh during the Bus Mordeh phase, an archaeobotanical example of a broad resource base. Even unnutritious wheat spikelet forks were believed to have been eaten (Helbaek 1969). I suggest that high numbers and high proportions of small-seeded legumes relative to cultivated pulses and cereals need not be surprising. First, the assemblage could represent the burned debris of crop processing activities; small-seeded legumes could, after all, be quite prevalent in grain fields and be removed at a settlement through winnowing (Hillman 1981). Second, many of the small-seeded legume plants produce more seeds than the large-seeded legumes and cereals (Stevens 1932). Third, dung and fodder are possible sources of legumes and other weedy plants (Miller 1984; compare Moore 1982). In all three cases, one would expect an archaeobotanical assemblage to have a relatively high proportion of weed seeds and rachis fragments relative to cultigens. In fact, Helbaek (1969) noted that small-seeded legumes and spikelet forks were more highly correlated with one another within samples than were cereals and spikelet forks, a result expected for the remains of animal fodder or food processing debris, not human food. These possibilities are all quite plausible explanations for the plant assemblage at Ali Kosh, where the inhabitants had access to domesticated wheat for carbohydrate and domesticated sheep and goats, as well as wild animals, for protein.

One cannot explain the diverse charred seed assemblages from Epipaleolithic and Aceramic steppe sites, such as Abu Hureyra and Aswad, as the fuel residues of the dung of domesticated animals. Consequently, Flannery's model might be supported by the plant assemblage from Epipaleolithic Abu Hureyra, which Hillman et al. (1989) believe represent the remains of human food. As suggested above, however, plausible alternative explanations for such assemblages are that the seeds came from plants burned directly as fuel or were byproducts of harvested cereals (see also Hillman 1981).

A second use of archaeobotanical data has been to help characterize the environmental setting of early field systems. For example, Aswad, which is located in a region outside the present natural habitat of wild emmer, yielded evidence of very early domesticated emmer but none of its wild predecessor (van Zeist and Bakker-Heeres 1985). The presence of a wild plant outside its range would be prima facie evidence for its cultivation, if one could directly infer the ancient range of the plant. Interpretations do, however, change as new evidence refines paleoenvironmental reconstructions. Thus, the early occurrence of wild einkorn at Mureybit in northwestern Syria was used as evidence supporting the marginal zone hypothesis until a new environmental reconstruction suggested that the ancient climate was wetter at that time than it is today (van Zeist and Woldring 1980).

Another ecological approach views farming in the natural habitat zone as an attempt to reproduce the fairly pure, dense stands of wild cereals on similar terrain; in the marginal zone, cultivation would have been restricted to favorable microenvironments (Flannery 1973). Sheratt (1980) contends that early farmers would have engaged in small-field horticulture near predictable water sources rather than clear large expanses for unpredictable rainfall agriculture. He suggests that the location of many preagricultural and early agricultural settlements in areas with a high water table represents such a farming practice. The locational evidence is persuasive, although the archaeobotanical evidence used to support the argument is less so. The presence of sedge seeds mixed with grain is said to show that grain fields at Ali Kosh were located directly on the edge of marshy areas (Helbaek 1969). But there may as easily have been a fortuitous conjunction of grain and sedge in an animal's diet.

Although pollen studies are the primary source of information about ancient vegetation, complementary information can be gleaned from the archaeobotanical record. Charcoal (or lack thereof) provides important clues to the vegetation around an ancient settlement. The vegetation closest to the settlement is that most directly influenced by human activities, such as cutting wood for fuel. In more arid and/or deforested areas, one would expect to find charred remains of shrubs or riverine woods. In richer environments, one would expect to find burned evidence of climax vegetation. For example, oak charcoal seems to predominate at Çayönü in southeastern Turkey (van Zeist 1972) and at Jarmo in northeastern Iraq, both of which are located in relatively rich environments (L.S. Braidwood et al. 1983:541). By contrast, high proportions of riverine types (poplar and tamarisk), which reflect overall dry conditions, are found at sites like Jericho (Western 1971) and Mureybit (van Zeist 1970), which have highly localized sources of moisture.

The value of archaeobotanical data for assessing aspects of animal husbandry has been alluded to in this chapter, but no such studies have been conducted. A broader, related issue concerning the nature of the archaeobotanical record, however, may be addressed.

Although it was perceptive of Helbaek to suggest that even in an agricultural setting wild plants could serve as human food, it is no longer acceptable to assume automatically that seeds in preagricultural situations are either food remains or accidental inclusions in the archaeobotanical record. In order to assess the relative importance of agricultural and wild plant products in an ancient economy, one has to understand the archaeological context and preservation circumstances of the assemblage. If seeds occur in fairly pure caches, they are likely to represent intentionally harvested food, which has been accidentally burned. If, as is more generally the case, they are sparsely distributed in very mixed assemblages, they may represent the remains of fuel, fodder, refuse, or accidental inclusions. It is clear that the simple identification of a plant as wild or domestic is insufficient to determine its role in the ancient economic system. Regardless of whether or not plants served as human food, plant remains do provide valuable economic evidence. For these reasons, the usefulness of archaeobotanical data is greatly enhanced when sample-by-sample inventories of assemblages and information about the nature of the archaeological deposits are provided in final reports. An understanding of depositional circumstances is clearly critical for testing theories of agricultural origins.

Conclusions

The archaeobotanical record of early plant cultivation and domestication in the Near East is frustratingly incomplete. Much important early work concentrated on identifying the wild ancestors of the cultigens and tracing the morphological changes resulting from domestication. As excavators became more confident that plant remains could be recovered through systematic sampling and flotation, the volume of archaeobotanical remains available for study increased. Our understanding of the environmental and cultural setting of early agriculture has grown tremendously since the publication of the first Jarmo report in 1960, but there is much archaeobotanical work still to be done.

First, there is simply not enough evidence from Epipaleolithic sites to provide a detailed picture of preagricultural plant use. The low density of charred material from these early sites is a real problem, but it is still important to seek these remains.

Second, we need material from more sites in each environmental zone in order to assess the typicality of the sites already excavated. A larger number of excavated sites would allow comparisons to be made between zones as well. For example, the early appearance of domesticated animals in the Zagros area could have established conditions for the development of agriculture there that differed from those in the Levant and Syria (see Hole 1984).

Third, comparative charcoal analyses would help establish the state of the local vegetation and enable us to trace land clearance and assess the degree of environmental disturbance caused by the new, permanent settlements.

Archaeobotanical work on the origins of plant cultivation in the Near East still suffers from an inadequate database. This situation is being ameliorated by continuing fieldwork at early village sites, as well as by necessary but underfunded work in the laboratory. Archaeobotanists can take advantage of a long tradition of interdisciplinary research by archaeologists, physical anthropologists, palynologists, and others to help interpret their plant remains. In turn, archaeobotanists can help put theories of the origins of cultivation on a firmer footing.

I have chosen to end this account in the seventh millennium B.C. By that time, the economic and dietary importance of food production was firmly established. The new subsistence base led to morphological changes in the plants, the creation of a new agricultural niche for both people and plants, and higher population densities supported by agricultural production. Agricultural development did not stand still. In subsequent millennia new crops were added; some of the older ones that were not stressed in this article became more important; and new technologies, such as irrigation, took on increasing importance (Miller 1991).

Although I provide no definitive conclusions about the origins of cultivation in the Near East, it is likely that by the time plants were domesticated human populations were already dependent on cereals for a substantial portion of their diet. Human groups, increasingly dependent on agricultural production for their livelihood and on larger, denser populations to meet their social needs, could no longer easily revert to a foraging way of life.

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Notes

1. Philip Smith (personal communication 1986) points out that Ganj Dareh is a significant exception for the Zagros Mountain region. At that site, evidence for animal control appears after the earliest evidence for the use of domesticated barley.

2. Jack Harlan (personal communication 1985) points out that growing conditions, chaff weight, and wide yearly fluctuations in yield of both wild and domesticated einkorn and emmer make generalizations difficult.

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