BLACKWELL STUDIES IN GLOBAL ARCHAEOLOGY

Series Editors: Lynn Meskell and Rosemary A. Joyce

Blackwell Studies in Global Archaeology is a series of contemporary texts, each carefully designed to meet the needs of archaeology instructors and students seeking volumes that treat key regional and thematic areas of archaeological study. Each volume in the series, compiled by its own editor, includes 12–15 newly commissioned articles by top scholars within the volume's thematic, regional, or temporal area of focus.

What sets the *Blackwell Studies in Global Archaeology* apart from other available texts is that their approach is accessible, yet does not sacrifice theoretical sophistication. The series editors are committed to the idea that usable teaching texts need not lack ambition. To the contrary, the *Blackwell Studies in Global Archaeology* aim to immerse readers in fundamental archaeological ideas and concepts, but also to illuminate more advanced concepts, thereby exposing readers to some of the most exciting contemporary developments in the field. Inasmuch, these volumes are designed not only as classic texts, but as guides to the vital and exciting nature of archaeology as a discipline.

1. Mesoamerican Archaeology: Theory and Practice
   Edited by Julia A. Hendon and Rosemary A. Joyce
2. Andean Archaeology
   Edited by Helaine Silverman
3. African Archaeology: A Critical Introduction
   Edited by Ann Brower Stahl
4. Archaeologies of the Middle East: Critical Perspectives
   Edited by Susan Pollock and Reinhard Bernbeck
5. North American Archaeology
   Edited by Timothy R. Pauketat and Diana DiPaolo Loren
6. The Archaeology of Mediterranean Prehistory
   Edited by Emma Blake and A. Bernard Knapp
7. Archaeology of Asia
   Edited by Miriam T. Stark

Forthcoming:

Archaeology of Oceania: Australia and the Pacific Islands
Edited by Ian Lilley

Historical Archaeology
Edited by Martin Hall and Stephen Silliman

Classical Archaeology
Edited by Susan E. Alcock and Robin G. Osborne

Archaeology of Asia

Edited by

Miriam T. Stark

Blackwell Publishing

5

East Asian Plant Domestication

Gary W. Crawford

The oldest substantial record of potential agriculture in East Asia is in both North and South China from 7000 to 6000 B.C., and an understanding of the relationship between people and their environs during and preceding this period is a priority for current research. For now, such research is only beginning. The traditional link between archaeology, history, and art in East Asia has deprived the field of important interdisciplinary scientific research. There are, of course, exceptions to this generalization but it is important to keep it in mind when assessing research, or lack of it, on domestication and agricultural origins in East Asia.

Considering that the number of plants cultivated in East Asia (China, Korea, Japan, and Russian Far East) ranks second only to Southeast Asia (Zeven and Zhukovskiæi 1975), investigating the origin of these crops and their agricultural context is a complex matter. A significant number of these plants, including some of the world's most important crops (e.g. rice and soybean) (Table 5.1), were domesticated in this vast region, yet we know little of their history. Domestication is, of course, fundamental to agricultural origins but it is also a "clear and dominant feature of the conceptual landscape between hunting-gathering and agriculture" (Smith 2001:27). This chapter, then, is about the evidence for domestication, including its context, rather than agricultural origins specifically. It complements more detailed discussions of East Asian cultigen history (Chang 1983; Crawford 1992; Ho 1977; Li 1983). Despite intensive archaeological research exploring the complex cultural history of East Asia, archaeologists are still delineating the appropriate questions concerning domestication and early food–resource production in East Asia. Current issues include the domestication and evolution of indigenous crops, early post-Pleistocene events, the role of low-level food production, and agricultural intensification. Korea and Japan in the Early and Middle Holocene are important to investigate in their own right and are discussed here from the perspective of low-level resource–food production and expansion of intensive agriculture.

The Crops

East Asia is a center of diversity for most crops grown there (Table 5.1). Such centers indicate that a crop has a long history in a region, but not necessarily that its origins can be found there. The concept of a "center" can be misleading though. Most crops in Table 5.1 are either "oligocentric," that is, with "a definable center of origin, wide dispersal, and one or more secondary centers of diversity," or non-centric, suggesting "domestication over a wide area" (Harlan 1992:139). Many of the wild counterparts of plants in Table 5.1 are so widespread that the present distribution of these plants does not help delineate the location of their early management and domestication. Furthermore, each crop has an independent history and may have had multiple origins (Harlan 1992:155).

Research on plant domestication in East Asia has emphasized rice, consequently reinforcing a stereotype that rice is central to East Asian agriculture (Figure 5.1). Rice is one of many grains important in the region, and for a variety of reasons rice has become culturally significant in East Asia despite its temporal and regional economic variance. Domesticated rice belongs predominantly to two subspecies (Table 5.1). They are distinct to the extent that they do not readily hybridize. Japonica rice is East Asian, and DNA analysis of 28 archaeological rice specimens in China links them all to japonica (Sato 2002). Little is known about the original distribution of indica rice (see Crawford and Shen 1998 for a detailed discussion), however historic references to indica rice in China indicate it was not significant until about A.D. 1000 (Ho 1977:446). The Yangzi River basin has gained acceptance in recent years as the region where people domesticated rice (Crawford and Shen 1998). Rice is unique among the world's primary food grains because of its wetland adaptation. Paddy fields are complex structures designed to direct and control the flow of water through the paddies, mimicking rice's natural habitat. Rice is still grown in natural, seasonally inundated wetlands in parts of Asia today, so paddy fields are not essential for rice production (White 1989). In fact, in flood-prone areas rice is the *only* crop that can be grown. Rice can be grown in dry fields and, although its productivity in such fields is relatively low, this may well have been an important strategy in some areas. Annual wild rice is well adapted to the annual monsoon-influenced rise and fall of water levels at the edges of rivers, lakes, and marshes in the Yangzi River. Abundant natural stands can still be found in these settings but, unlike domesticated rice, the seeds do not ripen synchronously and when they do ripen, they disarticulate almost immediately (White 1989).

Two other prominent crops in East Asia, six-row barley and bread wheat (Table 5.1), were introduced from the Near East. Barley has not been confirmed in the early archaeological record in eastern China. Research at the Fengtai and Arhetela sites document barley becoming significant in western China during the Bronze Age some time between 2000 and 800 B.C. (Zhao 2004). In China today barley is primarily a fodder crop, with wheat being the second most significant crop, important even in rice growing areas. The rice–wheat combination has become critical to the Chinese agricultural economy. Bread wheat, but not barley, appears in eastern

Table 5.1. Examples of managed and domesticated plants in East Asia

Use	*Common Name*	*Scientific Name*	*Native Distribution*
Tree fruit	chestnut	*Castanea crenata*	Japan
		C. motissima	China
	Chinese bayberry	*Myrica rubra*	S. China
	hawthorn	*Crataegus*	China
	hazelnut	*Corylus* (4 species)	E. Asia
	jujube	*Ziziphus jujuba*	China
	litchi	*Litchi chinensis*	China
	mandarin orange	*Citrus reticulata*	China
	paper mulberry	*Broussonetia payrifera*	China
	peach	*Prunus persica*	China
	persimmon	*Diosporus kaki*	E. Asia
Grains	barley (six-row)	*Hordeum vulgare*	Near East
	barnyard millet	*Echinochloa crus-galli*	China, Korea, Japan
	broomcorn millet	*Panicum miliaceum*	China
	buckwheat	*Fagopyrum esculentum*	S. China
	chenopod	*Chenopodium* spp.	China, S. China
	foxtail millet	*Setaria italica*	China
	Job's tears	*Coix lacryma-jobi*	SE Asia
	rice	*Oryza sativa* spp. *japonica*	Yangzi River Basin
	rice	*O. sativa* spp. *indica*	S. China, S. Asia
	wheat (bread)	*Triticum aestivum*	Near East
	wild rice	*Zizania latifolia*	N. China
Legumes	azuki	*Vigna angularis*	E. Asia
	mungbean	*Vigna radiata*	S. Asia
	soybean	*Glycine max*	E. Asia
Roots, tubers	burdock	*Arctium major*	Japan/China?
	Ginseng	*Panax quinquefolia*	China
	lotus root	*Nelumbo nucifera*	E. Asia/Japan
	turnip	*Brassica rapa*	N. China
	radish	*Raphanus sativus*	E. Asia
	prickly water lily	*Euryale ferox*	E. Asia
	yam	*Dioscorea japonica*	Japan
	yam	*D. opposita*	S. China
Greens, bulbs	beefsteak plant	*Perilla frutescens*	E. Asia
	Chinese cabbage	*Brassica chinensis*	N. China
	knotweeds	*Polygonum* spp.	E. Asia
	onion	*Allium* (9 species)	E. Asia
Beverage	broomcorn millet	*Panicum miliaceum*	China
	foxtail millet	*Setaria italica*	China
	rice	*Oryza sativa* spp. *japonica*	Yangzi River Basin
	tea	*Camellia sinensis*	S. China
Oil	beefsteak plant	*Perilla frutescens*	E. Asia
	hemp	*Cannibis sativa*	Asia
	rapeseed (canola)	*Brassica campestris*	N. China
	sesame	*Sesamum indicum*	Africa/S. Asia?
	soybean	see legumes	
Technology	lacquer tree	*Rhus verniciflua*	E. Asia
	paper mulberry	*Broussonetia payrifera*	E. Asia
	hemp	*Cannibis sativa*	Asia
	bottle gourd	*Lagenaria siceraria*	Africa, Asia
Other	hops	*Humulus lupulus*	E. Asia
	water chestnut	*Trapa natans*	E. Asia

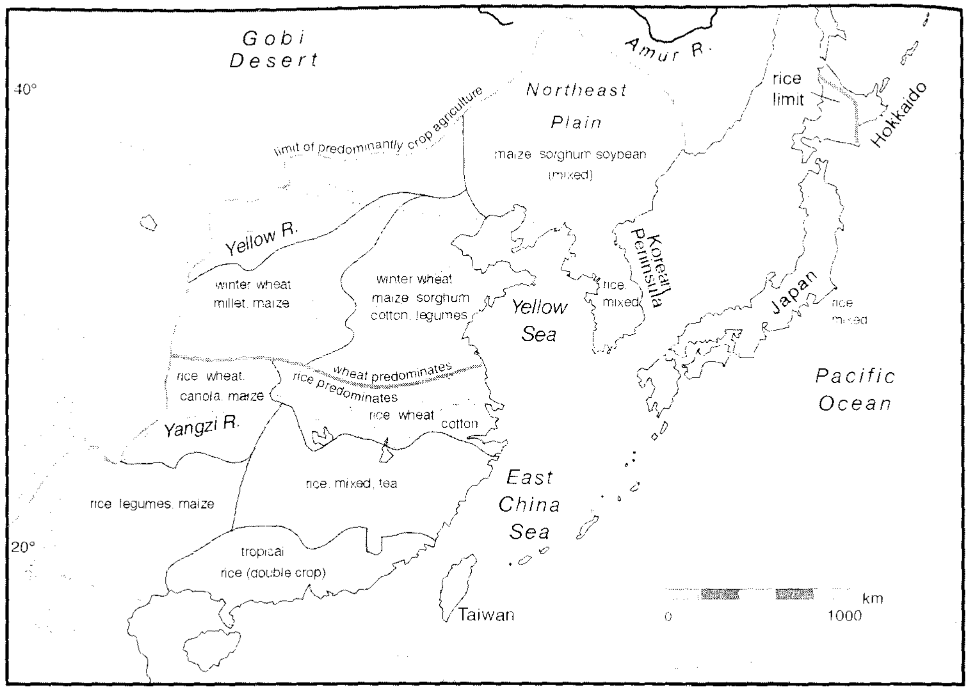

Figure 5.1 Agriculture in East Asia

China by the Late Neolithic dating to between 2600 and 1900 B.C. (Crawford, et al. n.d.). All the bread wheat recovered from contexts before A.D. 1500 in East Asia is small-seeded, possibly derived from small shot-wheat in Pakistan. Small-seeded varieties are also short, so the plants are adapted to the monsoonal climate of much of East Asia. Under high winds and heavy rain, short wheat will not tangle and therefore remains easy to harvest. Two genotypes of barley are present in East Asia indicating at least two separate introductions from the West (Takahashi 1955).

Barnyard millet (Table 5.1) is the only crop in northeast Asia for which flotation sampling has produced a record of evolution from a wild to a cultigen phenotype (Crawford 1983, 1997). Barnyard grass (wild barnyard millet) seeds are common in late Early Jomon deposits (4000–3500 B.C.) at the Hamanasuno site, Hokkaido. Seeds indistinguishable from the larger-seeded barnyard millet, a cultigen, are evident by the end of the Middle Jomon (about 2500 B.C.) at the nearby Usujiri B site. Broomcorn and foxtail millet are the two most significant grains in the early history of northern China yet no sequence evidencing their domestication has been found yet. Archaeologists have just begun looking for plant remains at sites in China where the crops may have been undergoing domestication. Missing from the earliest reports of domesticated millet in China are the criteria for their identification as millet as well as their domesticated status. Until these criteria are reported, we

need to be cautious about subsistence interpretations. The ancestor of foxtail millet is green foxtail grass (*Setaria italica* subsp. *viridis*). The ancestor of broomcorn millet is not known; however, a weedy form (*Panicum miliaceum* subsp. *ruderale*) grows throughout Eurasia (Sakamoto 1987). Its possible role in broomcorn millet's lineage still needs to be explored.

Five grains have glutinous (sticky) varieties in East Asia and nowhere else: barley, broomcorn and foxtail millet, Job's tears, and rice (Sakamoto 1996). Dietary preferences are likely responsible for the selection of sticky or glutinous grains (Sakamoto 1996), and a single recessive gene is responsible for the glutinous starch in these grains. Glutinous foxtail millet is used for making wine and millet cakes in central Taiwan (Fogg 1983). The recognition of glutinous grains in the archaeological record is problematic, but would be useful in discerning when such customs as wine and cake making developed.

Two legumes, soybean and azuki (red) bean, figure prominently in East Asian history and cuisine. Wild soybean grows throughout East Asia (Hymowitz and Singh 1987; Yamaguchi 1992). Cultigen soybean seed size and shape are extremely variable but seeds of all landraces are larger than their wild counterpart, *Glycine soja*. Modern domesticated azuki beans are also larger than the seeds of their wild relative (*Vigna angularis* ssp. *nipponensis*). The main distinctions between wild and cultigen azuki and soybean is that cultigen pods are indehiscent and do not release their seeds naturally. Wild pods spring apart and distribute their seeds some distance from the plant; wild soybean is a vine while domesticated soybean is not. Both traits will be difficult to recognize in the archaeological record. The oldest archaeological examples of cultigen-size soybean date to about 1000 B.C. and are from the Daundong site, South Korea (Crawford and Lee 2003). They are associated with intermediate-size azuki beans. So far only wild size soybean has been found in the Yellow River basin archaeological record (Crawford, et al. n.d.). In China, only a few azuki beans have been found at one site – the Late Neolithic Liangchengzhen site – and they are similar to the examples from Korea (Crawford et al. n.d.); many archaeological examples are reported from Korea and Japan (Crawford 1992; Crawford and Lee 2003).

Other cultigens in the local archaeological record are hemp, beefsteak plant, and bottle gourd. Hemp has been identified in archaeological contexts in East Asia, and it has many uses including fiber, drug, oil, and food. Beefsteak plant is known mainly from Japanese and Korean archaeological contexts, but at least one example, from the Erlitou period (ca. 1900–1500 B.C.) Zaojiaoshu site, is from China. Its ancestor is also found throughout East Asia. It is an oil and medicinal plant whose leaves are used for food. Bottle gourd was a crop in the later prehistory of East Asia and has an early association with people there, seeds having been recovered from Middle Holocene sites in Japan and China (Crawford 1992). Wild bottle gourd seems to be extinct but it likely originated in Africa and found its way naturally to Asia following ocean currents (Heiser 1989). How and when it was domesticated in Asia is still unknown.

Root crops are also important in East Asia (Table 5.1) but so far no archaeological examples have been identified. Wild yams are distributed widely and at least two species were domesticated, one in China and one in Japan. Domesticated yam tubers grow shallower and are thicker than wild tubers (White 1989).

Tree fruit production is an important characteristic of East Asian agriculture (Table 5.1). The lifespan of nut trees and their ease of harvesting may mitigate against their domestication (Harris 1977) but the fact remains that many trees were effectively domesticated. They were likely domesticated after agriculture began. In the Near East domesticated tree fruit appears after other crops were domesticated (Spiegel-Roy 1986). Trees that respond well to vegetative reproduction (grafting), such as hazel, are quicker to domesticate than are others (Spiegel-Roy 1986). Dioecious species, with separate male and female plants, can be bred to reduce the number of male plants; thorniness is reduced; bitterness is eliminated; and self-fertility can develop (Spiegel-Roy 1986).

The Early Evidence

The Early Neolithic in North China is simply the time when the first substantial communities with pottery are visible in the archaeological record (see Underhill and Habu, this volume). Chinese archaeology tends to assume Early Neolithic communities are on the path to agriculture, and may even be called agricultural, with no supporting evidence. The traditional approach in Japan and Korea is to assume that substantial communities with pottery are, to the contrary, *not* nascent agricultural communities despite evidence, discussed later in this chapter, that this, too, is a significant oversimplification. Villages developed and expanded, apparently independently, on the central loess plateau and in northeast China. Clusters of pit houses are the first evidence for these communities (Chang 1986). Pit houses do not necessarily mean settlements are year-round, although they indicate substantial sedentism. The pit houses of the Nivkh in the lower Amur River and northern Sakhalin, for example, were only winter residences (Black 1973), so pit houses provided a number of options, including year-round residences. The Peiligang and Cishan sites along the Yellow and Wei Rivers and the Xinglongwa and Zhaobaogou sites near Inner Mongolia characterize the Early Neolithic in the north (Figure 5.2). Xinglongwa is partially surrounded by a ditch, the earliest known in China. Pit house construction and the ditch mean that anthropogenic habitats ideal for pioneering weeds were developing. Old pit house sites were used as gardens by native people in the U.S. Southeast (Waslekov 1997). We have no idea yet whether people who lived in early pit house communities in Asia were taking advantage of such habitats but it would be surprising if they were not. Millet remains have been recovered from the loess plateau sites but not yet from the northeast China Early Neolithic. Only nut remains have been found at Xinglongwa (Shelach 2000). Locality 1 (ca. 8000–7000 B.P.) at another Xinglongwa culture site, Xinglonggou, has produced a high density of broomcorn and foxtail millet with smaller relatively elongate grains compared to those from Locality 2, a 4000 B.P. Xiajiadian culture occupation. Locality 1 remains may represent an early domesticated form (Zhao 2004). Recently, Zhao Zhijun has collected flotation samples from another Xinglongwa culture site so we will soon be able to evaluate the paleoethnobotany of this culture.

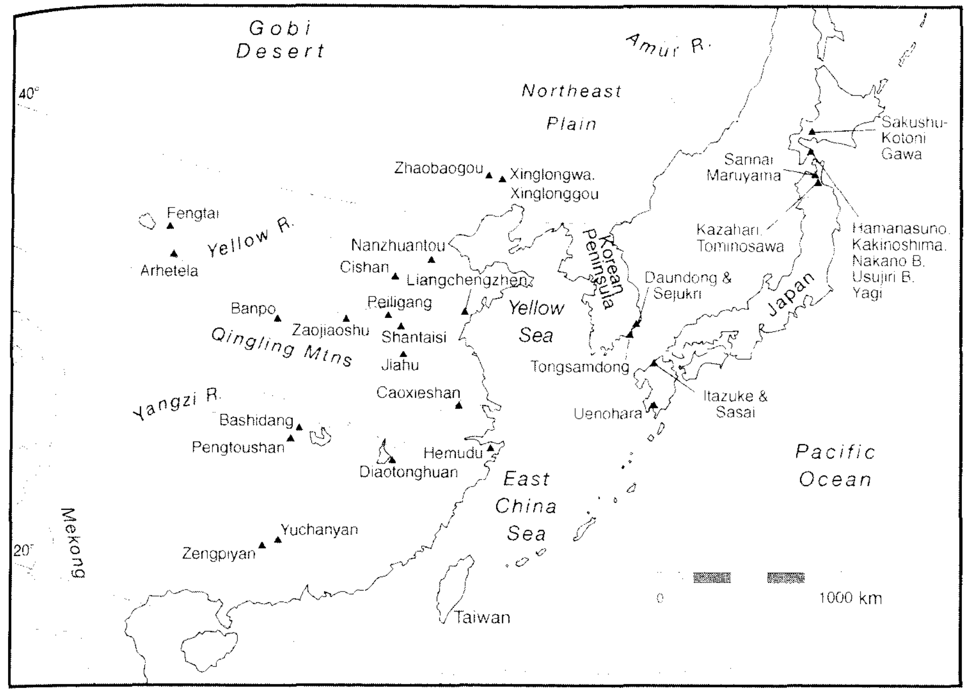

Figure 5.2 Map of East Asia with sites mentioned in the text

Changing relationships between plants and people hypothesized for the Early Neolithic are easier to discern at sites such as Banpo, characteristic of the North China Middle Neolithic. The millets here are domesticated rather than undergoing domestication. The perimeter of Banpo was surrounded by a ditch even larger than the one at Xinglongwa, perhaps 5 to 6 meters wide and about as deep. Food reserves were stored in large pits sometimes up to two meters deep. Some structures appear to be animal pens; people raised dogs and pigs. Plant remains include broomcorn and foxtail millet, hemp, and jujube. Exchange and alliances probably played an important role in providing access to regionally variable resources. Many landraces of the Yangshao crops likely developed and valued seeds of special landraces may have been important exchange items. Special types of foxtail millet were exchanged among groups in central Taiwan in the 1970s as part of rituals or peaceful meetings (Fogg 1983:106).

Research in South China emphasizes rice. Unfortunately, the literature is rife with unsubstantiated claims of early domestication. Zengpiyan cave (11,000 B.P.) has been assumed to have evidence of pig domestication and rice agriculture but recent research indicates that the occupants had no domesticated plants or animals. In particular, flotation samples document the collection of a range of wild plants, none of them small grain plants (Zhao 2003). The oldest directly-dated rice grains have been found in two areas: the Yangzi River drainage basin (6500 B.C.); and to the north in Henan at Jiahu (6000–7000 B.C.) (Crawford and Shen 1998). Some of the best evidence for early rice is from the Pengtoushan and Bashidang sites on the Liyang Plain near Dongting Lake. Both sites belong to the Pengtoushan culture (7500 to 6100 B.C.). Village life was well established at the time. Bashidang is surrounded by the earliest combination of defensive walls and ditches in China. Nearly 15,000 rice grains were recovered from a 100 square meter area of waterlogged deposits. The rice from Bashidang has considerable variation so cannot be assigned to a rice subspecies (Zhang and Pei 1996), and the grains are slightly smaller than modern domesticated rice. Wild rice grains disarticulate freely and have prominent awns, and both these characteristics help in the natural dispersal of the grains. So far, no description of rachis remains or awns from Bashidang and Pengtoushan is available. Three other wetland plants – water chestnut, lotus root, and prickly water lily – may have been used by the Bashidang residents and all are economically important in the area today. Water chestnut (water caltrop) fruits are reported at Bashidang and some pottery bowls are shaped like lotus leaves, although no lotus remains have been found.

How people domesticated rice and first came to develop paddy fields are still problems to be resolved by interdisciplinary research. We don't know whether rice was grown in managed habitats or harvested from natural wetlands by the Pengtoushan residents. Sickle harvesting would help select for non-brittle rachis rice plants, whatever the habitat. Once water flow and containment systems were developed, rice selection could be particularly rapid. The history of these techniques is poorly known. The first written reference to paddy fields is relatively late (Ho 1977). However, rice paddies date to as early as 2500 B.C. at the Caoxieshan site where numerous paddies and an irrigation system have been uncovered (Liu 2000). Paddy fields and water management systems are evident in Korea during the Early and Middle Mumun periods (Kwak 2000; Lee and Lee 2001), ca. 3500–2000 B.C., so rice paddy fields seem to have a much longer history than written records suggest.

While the domesticated status of rice from the Pengtoushan culture is open to question, the best example of an early group reliant upon domesticated rice is represented by the Hemudu site, part of a culture thriving near the mouth of the Yangzi River. The earliest rice-growing group there dates to 5000–4500 B.C. (Zhejian Provincial Museum 1978). The site is located in a wetland on the south side of Hangchou Bay not far from Shanghai (Chang 1986). During the excavation, a thick layer of complete rice plants was discovered in the waterlogged soils near the houses. Once exposed to air, the plant remains were impossible to preserve but many grains were recovered. Some of the rice glumes have awns so have a wild trait, but most glumes have no awns indicating that they are from cultigen rice. Dogs, pigs, water buffalo, bottle gourd, water chestnut, and rice are all evidenced here.

Low-Level Food–Resource Producers

The sparse data related to the subsistence-economy during the shift from the Upper Palaeolithic to Neolithic agriculture in China currently frustrates efforts to understand how agriculture began there. What we do know about the shift elsewhere may inform our hypothesis building. The archaeological record immediately after the Palaeolithic in the Near East, the Epi-Palaeolithic, is characterized by intensification of animal and plant use and the first pit house communities. The material culture excludes pottery. The earliest domesticated plants appear at the end of this period but several thousand years passed before the emergence of balanced agricultural societies (Smith 1998, 2001). In Mexico, the earliest domesticated cucurbit appears by 9000–8000 B.C. in a seasonal encampment, but village agricultural people are not evident until about 2500 B.C. (Smith 2001:19). In eastern North America the relatively mobile Paleo-Indian culture was eventually superseded by Archaic cultures who, west of the Appalachians, settled into river valleys and highlands alike, exploiting a variety of resources from smaller territories than their predecessors had. Several local plants were being domesticated by 3000 B.C., long before pottery and the widespread adoption of village life. Three to four millennia later, agricultural communities were widespread (Fritz 1990; Smith 2001). Low-level food–resource-producing societies appear to be common, and are so long lasting that they ought to be considered stable adaptations and should be studied in their own right rather than being considered on the way *to* agriculture or *from* hunting and gathering (Smith 2001).

Precious little is known about adaptations in North China and Korea immediately after the Palaeolithic. Pottery is becoming increasingly evident in the archaeological record at the end of the Pleistocene in Japan, China, and the Russian Far East (Yasuda 2002). Little is known about human and environmental relationships or subsistence at the time. Virtually no archaeological data of any sort have yet to be recovered from the period from about 10000 B.C. to 7000 B.C. in Korea and North China. One exception appears to be the Nanzhuangtou site, an occupation near Baiyangdian Lake in North China (Wang 1999:96). The site has the oldest pottery in North China, dating to 9000–8000 B.C. None of the plant remains from Nanzhuangtou has been identified.

One site in South China – the Diaotonghuan site near Dongting Lake – has substantial evidence that rice exploitation was underway by 10000 B.C. (see Underhill and Habu, this volume), although the rice was not domesticated (Zhao 1998). Diaotonghuan differs from floodplain sites such as Pengtoushan and Bashidang in being a small shelter under an arch of rock 60 meters above the Dayuan Basin. The bottomlands of Dayuan Basin would have been wetlands during the Early Holocene, providing an appropriate habitat for wild rice. Small silica bodies (phytoliths) that develop in structural support cells of the rice plant are found in the soils at Diaotonghuan (Zhao 1998). Rice phytoliths have distinct shapes that can be linked to specific parts of the rice plant and rice chaff phytoliths are common in the Diaotonghuan sediments. Rice would not grow at the site because of its elevation unless people were trying to grow it as a dry crop; people probably brought the rice grains to the site from the lowland. Rice phytoliths occur in deposits that are older than 10000 B.C. and their morphology is identical to that of wild rice. Phytoliths resembling those from domesticated rice are common after 8000–7000 B.C. At the onset of rice domestication then, Diaotonghuan was used by a small group of people with little opportunity to produce anthropogenic communities. A similar site is Yuchanyan, where a few undated rice husks and some phytoliths have been recovered and are associated with an Upper Palaeolithic assemblage typical of the region. The rice appears to be wild except for missing awns (Yuan 2002). The sample is undated and too small to provide much insight on rice domestication, but the potential for learning more about early rice exploitation at these sites is tantalizing.

Pit house communities appear by 10000 B.C. in southwestern Japan as part of a long unbroken archaeological sequence starting at the beginning of the Upper Palaeolithic (Imamura 1996). One of the earliest villages so far discovered anywhere in East Asia is the Uenohara site in Kyushu, an Initial Jomon pit house community dating to 10000–7500 B.C. By 6500 B.C., villages were common throughout Japan as they were in north and central China; however, nothing yet suggests these early village residents of the Japanese islands were developing crops. Relatively intensive agriculture is not known in Japan before roughly 400 B.C. at the earliest (Crawford 1992). Japan, therefore provides an important comparative counterpoint to China.

During the Early Jomon period beginning about 4500 B.C., villages were common and often large, particularly in northeastern Japan. Stone tool technology included flaked stone, as well as grinding and polishing, to make a variety of tools. Material culture in general is not particularly different from that of North China. Over the ensuing millennia, Jomon material culture became more elaborate. Middle Jomon pottery in the north included the tall cylindrical pots of their predecessors, but people were making use of a broad range of pottery forms. Population density was relatively high and probably within the range of what we might expect for agricultural populations. By 2500 B.C., Jomon peoples had sizeable, complex villages and large communal buildings are found at some sites. An example is the Sannai Maruyama site in Aomori Prefecture. Distinct activity precincts include dwelling areas and a cemetery, as well as a communal structure. Missing is extensive evidence of obvious crops, although plants such as bottle gourd are present. Azuki is also reported and it is well north of its modern range. Walnut dominates the pollen assemblage.

For many decades, scholars have debated whether Jomon people were agricultural (Crawford 1992). In fact, the debate is so explicit that the phrase "Jomon hunter-gatherers" is used by some rather than simply "the Jomon" (see Underhill and Habu, this volume). This forces the view that the Jomon must be categorized as either agricultural or hunter-gatherer and furthermore, that researchers must make a choice. However, another theoretical view holds that economies lie along a continuum from hunting and gathering to intensive agriculture and that a binary opposition is untenable (Smith 2001). More to the point, then, is where along the continuum from hunting and gathering to agricultural intensification are Jomon cultures? Research in Hokkaido helps clarify the issue of northeastern Jomon subsistence (Crawford 1983, 1997, 2000; Crawford and Bleed 1998; Crawford et al. 1978). This investigation also suggests what may await investigators when early sites in China such as Nanzhuangtou are extensively sampled for plant remains. The research explores what we now know is one of the longest-lasting, low-level food-producing adaptations in the world. For several years, our team carried out flotation at the Hamanasuno, Usujiri B, Hakodate Airport, Nakano B, and Yagi sites in southwestern Hokkaido (Crawford 1983). The sites are Initial through Middle

Jomon (ca. 7000–2500 B.C.). Similar extensive sampling of the Middle Jomon Tominosawa and Late Jomon Kazahari occupations in Aomori Prefecture provides insight from northern Honshu (D'Andrea 1992; D'Andrea et al. 1995).

Walnut remains are common in the Initial and early phases of the Early Jomon in southwestern Hokkaido (6700–4000 B.C.). Nuts are often assumed to have been the most important food source of the Jomon; many archaeologists feel that nuts were a staple food while others believe that nut domestication was taking place (Hudson 1999; Nishida 1983). Nut exploitation strategies can be conducive to agricultural origins (Gardner 1997), and nuts, without doubt, are nutritious and can be harvested in large quantities. They are particularly high in fat for example, and fat is a precious resource in late winter and early spring in regions with long winters. Successful, long-term use of nuts is constrained by a number of factors (Gardner 1997:173). Nut trees do not produce the same quantities of nuts (masts) year after year; they require plenty of work to process; and nut mast is also sensitive to weather conditions. Nut trees do not need to be genetically altered to change their productivity: people can clear vegetation around the nut trees; with more sunlight, more nuts are produced. People were probably well aware that nut trees are more productive on forest edges and in clearings than in the shaded forest. Once people began to reproduce some tree species vegetatively, their fruit production would have been more predictable and productive.

By the end of the Early Jomon in southwestern Hokkaido nearly all the plants represented at these sites flourished in disturbed habitats. Nuts become rare in the record indicating that alternate resources were available. Nearly 200 kinds of plants are represented in flotation samples from the Hokkaido and Aomori Early and Middle Jomon. However, only 15 kinds of plants dominate the carbonized seed assemblages. People were primarily interested in collecting small grains and leafy greens of barnyard grass, chenopod, dock (*Rumex* sp.), and knotweed. Fleshy fruits include elderberry (*Sambucus*), grape (*Vitis*), a wild kiwi (*Actinidia*), and *udo* (*Aralia cordata*). Sumac (*Rhus*) seeds also appear in a variety of contexts in these archaeological sites. In some parts of the world sumac is used as a spice or beverage, and lacquer is made from the sap of a sumac, *Rhus vernicifera*. The earliest lacquer in the world comes from the town of Minamikayabe in southwestern Hokkaido where six red lacquer items from the Kakinoshima site have been AMS dated to 9000 B.C. The evidence of sumac in the archaeological record in Minamikayabe could reflect lacquer production in the area, although the seeds are not part of the lacquer production process. Sumac, a perennial, flourishes in disturbed, sunny locations. One small pit structure, H. 74 at Hamanasuno, had a high concentration of sumac seeds in a fill deposit near the floor.

Disturbed habitats are precisely what we would expect to find in and around large villages. Tree removal, house construction, and similar activities all have important impacts on the local ecology. These impacts are referred to as anthropogenic, some of which may be intentional while others not. Such impacts are often beneficial to people, primarily by enhancing spatial heterogeneity, biodiversity, and productivity (Crawford 1997; Smith and Wishnie 2000). From intentional burning to large-scale construction, such ecosystem engineering is an important aspect of human adaptation, even in small-scale communities (Smith and Wishnie 2000). Weedy plants, for example, are extremely productive in open, sunny areas. Jomon peoples took advantage of the plants and animals in these anthropogenic habitats, and they therefore had an impact on the local environment and in turn, took advantage of the impacts. This kind of reciprocity between people and their environment was probably common long before the shift to low-level food production. We cannot rule out the purposeful choice people may have made in order to increase the local environmental productivity. This may have been an important step in the evolution of domesticated organisms in East Asia. At least one grass, barnyard millet, shows evidence of having been domesticated in this setting in northern Japan. A variety of grasses other than barnyard grass is common in nearly all the sites, including a few examples of wild foxtail grass. Barnyard grass seeds increase in size by about 20 percent over the 1,500 year period between the Early and Middle Jomon (Crawford 1983, 1997). By the end of the Middle Jomon barnyard grass seeds are indistinguishable from barnyard millet, an important economic plant in Medieval Japan. Buckwheat, indigenous to southern China (Ohnishi 1995), may also be present during the Early Jomon in Hokkaido. However, only one buckwheat grain may date that early. It may have been traded from southwestern Japan where pollen evidence suggests the crop was grown. Similar research needs to be undertaken in the Chinese early Neolithic.

A project similar to the one in northeastern Japan is investigating the paleoethnobotany of early South Korea (Crawford and Lee 2003). The Chulmun culture flourished in the Korean Peninsula from at least 6000 B.C. to 1500 B.C. Chulmun people lived in pit house villages and their economy was based largely on hunting, gathering, and fishing. Shell mounds are common along the coast. So far, little evidence for high population densities and social complexity has been found in the Korean Chulmun, suggesting Chulmun subsistence was not as productive as that of the Jomon. Research in the early Korean sequence is just beginning but preliminary data indicate that subsistence in the early Chulmun had some similarities to that of the Early Jomon. At the 5000 B.C. Sejukri shell midden researchers have recovered quantities of charred nuts as well as small seeds (Crawford and Lee 2003).

Archaeologists should base their models of plant use on systematically collected plant remains. Unfortunately, all too often such reconstructions are speculative or informed by indirect evidence. A good example is the Tongsamdong site, South Korea, where a coastal, maritime adaptation during the middle Holocene has been modeled from data collected in the 1960s. The animal remains are primarily maritime, dominated by sea bream (Sample 1974:93). Although innovations in stone technology partway through the sequence suggested an economic shift, that may have included crops, subsistence interpretations ignored plants completely. Gyoung-Ah Lee returned to Tongsamdong in 2000 when the site was once again being excavated. A soil sample she took from the floor of a Middle Chulmun pit house contained a high density of both broomcorn and foxtail millet. Specimens have been directly AMS dated to 3400 B.C. and confirm the association of crops with the Middle Chulmun (Crawford and Lee 2003). Low-level food production at Tongsamdong therefore involved at least two millets.

Intensification

The initial development of agriculture may be followed by a significant commitment to the new ecology. Social change may be rapid: community structures change; social hierarchies develop; population growth increases; and warfare becomes common. Health may actually decline. Resource output increases and risk reduction may also result (Fritz 1992; Gallagher and Arzigian 1994). Resources may change because of exchange and procurement of resources from outside the region. Migration may also be a factor. In the Near East, agriculture initially developed along at least two trajectories (Smith 1998). Eventually, the two systems blended. The resulting system was more productive and probably more resilient, at least initially, than either ancestral system on its own. In other areas, a productive crop evolved after other crops were domesticated. In the New World, corn evolved later than many of the earliest crops. In East Asia, agricultural intensification occurs but the mechanisms for this process are not well understood. In China, substantial changes begin at least by the third millennium B.C., in Korea 1,500 years later, and in Japan 1,200 years after that. China is the least well known of the three.

In North China, the material cultural diversity of the Yangshao and Dawenkou is superseded by the Late Neolithic Longshan culture ca. 2500 B.C. Longshan is generally viewed as ancestral to state societies in North China and was well on the way to having a form of centralized authority. Earthen walls surround a few Longshan sites; cemeteries contain clusters of burials probably representing differential power; and craft specialization is evident. Population growth increased (Liu 1996:267). Rapid settlement nucleation during the subsequent Erlitou period appears to correlate with changes in resource procurement and craft specialization (Liu 1996; Underhill 2002). Intensified agriculture was one important factor enabling these developments (Chang 1986:250), but in reality we actually know very little about Longshan subsistence. Several archaeological projects are addressing the issue. Excavations at Liangchengzhen and Shantaisi involve substantial soil flotation programs (Crawford et al. 2001; Crawford et al. 2005). Millet appears to be the primary grain of the preceding Yangshao and Dawenkou. Our preliminary results indicate rice was becoming significant, particularly to eastern Longshan people. Wheat is probably an addition to the crop complex (Crawford et al. 2001; Crawford et al. n.d.), and the new combination of crops likely played a role in agricultural intensification. Domestic animals are an unknown aspect of intensification because of their long-time presence in the Neolithic economy; fodder production and availability may also be a factor. Through the Shang and Zhou periods agriculture continued to develop. By 1000–500 B.C. barley, wheat, rice, soybean, beefsteak plant, melon, and gourd were all common. None were domesticated in the Yellow River basin.

In Korea, a sequence of crop introductions with intervening periods of little change is being documented (Crawford and Lee 2003). People in the Korean Peninsula and Japan eventually adopted agriculture largely based on Chinese systems, although potentially local azuki, barnyard millet, and soybean were grown along with Chinese crops. By 2000 B.C., rice appears to have been added to the suite of crops (Crawford and Lee 2003). Intensive agriculture did not develop until the beginning of the Bronze Age Mumun period between 1500 and 1000 B.C.; Mumun people made a significant investment in rice, bread wheat, soybean, azuki, and hemp production. Soybean and azuki bean origins are still unclear. Early Chinese records mention that soybean was a gift from the northeast China–Korean Peninsula region (Ho 1977). The Korean soybeans dating to about 1000 B.C. are the oldest yet discovered. Mumun ridged, dry fields, and paddy fields have been excavated in the southern Korean Peninsula. Intensification in Korea involved new crops, new production strategies, and significant technological and cultural change underlying the eventual development of state society there.

Intensified agriculture in southwestern Japan was not a unilineal development from local agriculture. Changes seen almost a millennium earlier in Korea were impacting the southern Japanese archipelago by 400–300 B.C. The Yayoi culture – known for its metallurgy, intensive agriculture, and more centralized sociopolitical organization – began replacing the Jomon in Kyushu. Cultigens were not new to Kyushu where rice is AMS dated to 900–800 B.C. and soybean to 760–550 B.C. at the Sasai site (Takano and Komoto 2004), but the Yayoi signaled a new era of balanced agriculture. The Itazuke site has evidence of well-engineered drainage systems that maintained paddy fields. Ditches and earthworks served as defensive structures around these densely populated communities. Crops included rice, millet, wheat, barley, soybean, azuki bean, hops, bottle gourd, peaches, and persimmons.

The Yayoi transformation moved northeastward until all but Hokkaido, the northernmost prefecture, was part of the Yayoi world by 100 B.C. In southwestern Japan, the Yayoi developed mainly through migration but northeastern Jomon people appear to have adopted aspects of Yayoi life including intensive agriculture. As in Kyushu, crops were not entirely new to northeastern Japan because the oldest directly dated rice, foxtail millet, and broomcorn millet in Japan are from Late Jomon contexts (900 B.C.) at the Kazahari site in Aomori Prefecture. On the northern frontier, people experimented with paddy field agriculture but any success they had was short-lived. Dry field production was eventually the system of choice. This form of agriculture continued into recent centuries in Hokkaido where the Ainu practiced a mixed economy of agriculture, hunting, fishing, and gathering. Soil samples from the Sakushu-Kotoni-Gawa site in Sapporo dating to A.D. 700 to 900 contain the largest collection of cultigen remains yet documented in any detail in East Asia. By A.D. 700, millets, beans, hemp, barley, and wheat were grown in northern Honshu and Hokkaido. A small number of rice, melon, and safflower seeds suggest these resources were imported. The wheat grown in Japan until at least the 16th century was all the small-grained type.

Discussion

Over many millennia in East Asia, several hundred plants were domesticated. Grains, "root" crops, tree fruit, and legumes are among the significant resource categories, each requiring somewhat different interactions with people to be domesticated. Little is known about the archaeological record in China and the Korean Peninsula between the end of the Palaeolithic and 6500 B.C. when significant developments in the relationships between plants and people must have been taking place. So far, it appears that at least rice was being used in China before incontrovertible evidence of its domestication appears. The same is probably true for millet in China. Between 6500 and 6000 B.C., millet and rice had become significant resources and mixed procurement strategies (hunting, gathering, fishing, agriculture) were on the way to being well established in several regions in China. Anthropogenic habitats are prominent by then, given the structure of Neolithic sites.

Nothing is known about the early stages of foxtail and broomcorn millet domestication. In fact, southwestern Hokkaido, Japan is the only locale where wild millet is superseded by domesticated millet. Paleoethnobotany in Japan and Korea exemplifies the potential for research in China. Much more is known about low-level food–resource production during the Jomon than anywhere else in East Asia. Not only do we need comprehensive paleoethnobotanical research on occupations in China pre-dating 6500 B.C., but intensive research on resource exploitation and habitat reconstruction will be required to assess issues around agricultural origins.

Jomon plant resource procurement was based on a relatively stable agricultural ecology with anthropogenic resources and a few crops. The Initial and Early Jomon, with their narrowing exploitation territories, use of anthropogenic and aquatic resources, degree of sedentism, and substantial non-portable technology including pottery and grinding stones, are similar to cultures at the dawn of agriculture in North China. However, subsistence evolution diverged significantly from the trajectory taken in China where agriculture blossomed in the Middle Holocene. Instead, Jomon economies persisted in an "in between" state (Smith 2001). This was due to the success of Jomon strategies rather than to any failure to intensify food production. Korea is another case where hints of evidence for anthropogenesis during the Early Chulmun have been found and where two Chinese millets appear by 3600 B.C. The Chulmun adaptation was relatively stable until 1500 B.C. when agricultural intensification began.

Several features appear to be common to domestication around the world (Cowan and Watson 1992; Smith 1998). Seed plants were the first to be domesticated, the ancestors of these plants having been resources before they were domesticated, and affluent people in large, permanent communities near rivers and lakes were the first to domesticate plants. Another factor is lack of security in the environment, especially marked seasonality. Most of these characteristics should apply to the 10000 and 7000 B.C. period in much of China and Korea. Insecurity is likely due to marked seasonality in East Asia. In the north, the lean times were the winters; in the south, regular, severe flooding along the Yangzi would have brought about lean times as it does today in parts of Southeast Asia. Storable, productive resources such as rice and millet would have brought added security.

Until comprehensive, interdisciplinary archaeological research results in systematically collected, accurately dated assemblages of plant remains from the Early Neolithic in China, we will know little about the first stages of domestication there.

For now, we can only speculate about the initial processes of domestication, the sequence of plants to be domesticated, how they were domesticated, if there were crops that were domesticated and failed to have any longevity, and what the spatial variation of domestication was. We are only now beginning to study the intensification of agriculture in East Asia.

REFERENCES

Black, Lydia 1973 The Nivkh (Gilyak) of Sakhalin and the Lower Amur. Arctic Anthropology X(1):1-110.

Chang, Kwang-Chih 1986 The Archaeology of Ancient China, 4th edition. New Haven: Yale University Press.

Chang, Te-Tzu 1983 The Origins and Early Cultures of the Cereal Grains and Food Legumes. *In* The Origins of Chinese Civilization. David N. Keightley, ed. Pp. 65–94. Berkeley CA: University of California Press.

Cowan, C. Wesley, and Patty Jo Watson 1992 Some Concluding Remarks. *In* The Origins of Agriculture: An International Perspective. C. Wesley Cowan and Patty Jo Watson, eds. Pp. 207–12. Washington and London: Smithsonian Institution Press.

Crawford, Gary W. 1983 Paleoethnobotany of the Kameda Peninsula Jomon. Volume 73. Ann Arbor, Michigan: Museum of Anthropology, University of Michigan.

—— 1992 Prehistoric Plant Domestication in East Asia. *In* The Origins of Agriculture: An International Perspective. C. Wesley Cowan and Patty Jo Watson, eds. Pp. 7–38. Washington and London: Smithsonian Institution Press.

—— 1997 Anthropogenesis in Prehistoric Northeastern Japan. *In* People, Plants, and Landscapes: Studies in Paleoethnobotany. Kristen Gremillion, ed. Pp. 86–103. Tuscaloosa: University of Alabama Press.

—— 2000 43rd Parallels. Rotunda 33(2):30–7.

Crawford, Gary W., and Peter Bleed 1998 Scheduling and Sedentism in the Prehistory of Northern Japan. *In* Identifying Seasonality and Sedentism in Archaeological Sites: Old and New World Perspectives. Thomas Rocek and Ofar Bar-Yosef, eds. Boston: Peabody Museum, Harvard University.

Crawford, Gary W., and Gyoung-Ah Lee 2003 Agricultural Origins in the Korean Peninsula. Antiquity 77(295).

Crawford, Gary W., and Chen Shen 1998 The Origins of Rice Agriculture: Recent Progress in East Asia. Antiquity 72(278):858–66.

Crawford, Gary W., William H. Hurley, and Masakazu Yoshizaki 1978 Implications of Plant Remains from the Early Jomon, Hamanasuno Site. Asian Perspectives 19(1):145–55.

Crawford, Gary W., Jian Leng, and Gyoung-Ah Lee 2001 Paleoethnobotany in Northern China and Southern Korea During the Neolithic/Bronze Periods. Society for American Archaeology, New Orleans LA, 2001. Unpublished MS.

Crawford, Gary W., Anne Underhill, Zhijun Zhao, Gyoung-Ah Lee, Gary Feinman, Linda Nicholas, Fengshi Luan, Haiguang Yu, Hui Fang, and Fengshu Cai In press Late Neolithic Plant Remains from Northern China: Preliminary Results from Liangchengzhen, Shandong. Current Anthropology 46.

D'Andrea, A. Catherine 1992 Paleaeoethnobotany of Later Jomon and Yayoi Cultures of Northeastern Aomori and Southwestern Hokkaido. Ph.D. Dissertation, University of Toronto.

D'Andrea, A. Catherine, Gary W. Crawford, Masakazu Yoshizaki, and T. Kudo 1995 Late Jomon Cultigens in Northeastern Japan. Antiquity 69(262):146–52.

Fogg, Wayne 1983 Swidden Cultivation of Foxtail Millet by Taiwan Aborigines: A Cultural Analog of the Domestication of *Setaria italica* in China. *In* The Origins of Chinese Civilization. David N. Keightley, ed. Pp. 95–115. Berkeley CA: University of California Press.

Fritz, Gayle J. 1990 Multiple Pathways to Farming in Precontact Eastern North America. Journal of World Prehistory 4(4):387–435.

—— 1992 "Newer," "Better" Maize and the Mississippian Emergence: A Critique of Prime Mover Explanations. *In* Late Prehistoric Agriculture: Observations from the Midwest. William I. Woods, ed. Pp. 19–43. Springfield: Studies in Illinois Archaeology No. 8. Illinois Historic Preservation Agency.

Gallagher, James P., and Constance Arzigian 1994 A New Perspective on Late Prehistoric Agricultural Intensification in the Upper Mississippi River Valley. *In* Agricultural Origins and Development in the Midcontinent. William Green, ed. Pp. 171–88. Iowa City: Report 19, Office of the State Archaeologist, The University of Iowa.

Gardner, Paul 1997 The Ecological Structure and Behavioral Implications of Mast Exploitation Strategies. *In* People, Plants, and Landscapes: Studies in Paleoethnobotany. Kristen J. Gremillion, ed. Pp. 161–78. Tuscaloosa: University of Alabama Press.

Harlan, Jack R. 1992 Crops and Man. Madison: American Society of Agronomy.

Harris, David R. 1977 Alternative Pathways Toward Agriculture. *In* Origins of Agriculture. Charles A. Reed, ed. Pp. 179–243. The Hague: Mouton.

Heiser, Charles 1989 Domestication of Cucurbitaceae: *Cucurbita* and *Lagenaria*. *In* Foraging and Farming. David R. Harris and Gordon C. Hillman, eds. Pp. 471–80. London: Unwin Hyman.

Ho, Ping-Ti 1977 The Indigenous Origins of Chinese Agriculture. *In* The Origins of Agriculture. C. A. Reed, ed. Pp. 413–84. Chicago: Mouton.

Hudson, Mark 1999 Ruins of Identity: Ethnogenesis in the Japanese Islands. Honolulu: University of Hawaii Press.

Hymowitz, T., and R. J. Singh 1987 Taxonomy and speciation. *In* Soybeans: Improvement, Production, and Uses. James R. Wilcox, ed. Pp. 23–48. Agronomy. Madison: American Society of Agronomy.

Imamura, Keiji 1996 Prehistoric Japan: New Perspectives on Insular East Asia. Honolulu: University of Hawaii Press.

Kwak, Jong-Chul 2000 Prehistoric Wet-Field Rice Agriculture in Korea. *In* Ancient Rice Agriculture in Korea (the National Museum of Korea Symposium proceedings). National Museum of Korea, ed. Pp. 69–107. Seoul: National Museum of Korea.

Lee, Sankil, and Gyoung-Ah Lee 2001 Current Research on Agricultural Sites in Korea. Pp. 1–11. Paper presented at the 2nd Meeting of the Osaka Joint Research Task Committee on Exchange Between Korean Peninsula and Japan, Osaka, Japan.

Li, Hui-Lin 1983 The Domestication of Plants in China: Ecogeographic Considerations. *In* The Origins of Chinese Civilization. David N. Keightley, ed. Pp. 21–63. Berkeley CA: University of California Press.

Liu, Li 1996 Settlement Patterns, Chiefdom Variability, and Development of Early States in Northern China. Journal of Anthropological Archaeology 15(3):237–88.

Liu, Zhiyi 2000 Thoughts about the Domestication of Rice. Agricultural Archaeology (Nongye Kaogu) 1(1):122–28.

Nishida, Masaki 1983 The Emergence of Food Production in Neolithic Japan. Journal of Anthropological Archaeology 2:305–22.

Ohnishi, Ohmi 1995 Discovery of New *Fagopyrum* Species and Its Implication for the Study of Evolution of *Fagopyrum* and of the Origin of Cultivated Buckwheat. http://soba.shinshu-u.ac.jp/contents/contents.html.

Sakamoto, Sadao 1987 Origin and Dispersal of Common Millet and Foxtail Millet. Japan Agricultural Research Quarterly 21(2):84–9.

——— 1996 Glutinous-Endosperm Starch Food Culture Specific to Eastern and Southeastern Asia. *In* Redefining Nature: Ecology, Culture, and Domestication. R. F. Ellen and Katsuyoshi Fukui, eds. Pp. 215–31. Oxford: Berg.

Sample, T. 1974 Tongsamdong: A Contribution to Korea Neolithic Culture History. Arctic Anthropology 11(2).

Sato, Yoichiro 2002 Origin of Rice Cultivation in the Yangtze River Basin. *In* The Origins of Pottery and Agriculture. Yoshinori Yasuda, ed. Pp. 143–50. New Delhi: Roli Books Pvt. Ltd.

Shelach, Gideon 2000 The Earliest Neolithic Cultures of Northeast China: Recent Discoveries and New Perspectives on the Beginning of Agriculture. Journal of World Prehistory 14(4):363–413.

Smith, Bruce D. 1998 The Emergence of Agriculture. New York: Scientific American Library.

——— 2001 Low-Level Food Production. Journal of Archaeological Research 9(1):1–43.

Smith, Eric Alden, and Mark Wishnie 2000 Conservation and Subsistence in Small-Scale Societies. Annual Reviews of Anthropology 29:493–524.

Spiegel-Roy, P. 1986 Domestication of Fruit Trees. *In* The Origin and Domestication of Cultivated Plants. Claudio Barigozzi, ed. Pp. 201–11. Developments in Agricultural and Managed-Forest Ecology 16. New York: Elsevier.

Takahashi, Ryuhei 1955 The Origin and Evolution of Cultivated Barley. Advances in Genetics 7:227–66.

Takano, Shinji, and Masayuki Komoto 2004 14C Dating Based upon Prehistoric Seeds from Kyushu. *In* Prehistoric and Ancient Botanical Remains in Kyushu and East Asia. Masayuki Komoto, ed. Pp. 145–9, vol. 2. Kumamoto: University of Kumamoto, Faculty of Letters.

Underhill, Anne P. 2002 Craft Production and Social Change in Northern China. New York: Kluwer Academic/Plenum Publishers.

Wang, Haining 1999 Early Pottery in China: A Review of Archaeological and Environmental Data from Eight Sites, Ph.D. Dissertation, Southern Illinois University at Carbondale.

Waslekov, Gregory 1997 Changing Strategies of Indian Field Location in the Early Historic Southeast. *In* People, Plants, and Landscapes: Studies in Paleoethnobotany. Kristen J. Gremillion, ed. Pp. 179–94. Tuscaloosa: University of Alabama Press.

White, Joyce C. 1989 Ethnoecological Examples on Wild and Cultivated Rice and Yams in Northeastern Thailand. *In* Foraging and Farming. David R. Harris and Gordon C. Hillman, eds. Pp. 152–8. London: Unwin Hyman.

Yamaguchi, Hirofumi 1992 Wild and Weed Azuki Beans in Japan. Economic Botany 46:384–94.

Yasuda, Yoshinori 2002 Origins of Pottery and Agriculture in East Asia. *In* The Origins of Pottery and Agriculture. Yoshinori Yasuda, ed. Pp. 119–42. New Delhi: Roli Books Pvt. Ltd.

Yuan, Jiarong 2002 Rice and Pottery 10,000 Yrs. B.P. at Yuchanyan, Dao County, Hunan Province. *In* The Origins of Pottery and Agriculture. Yoshinori Yasuda, ed. Pp. 157–66. New Delhi: Roli Books Pvt. Ltd.

Zeven, A. C., and P. M. Zhukovskiæi 1975 Dictionary of Cultivated Plants and their Centers of Diversity Excluding Ornamentals, Forest Trees, and Lower Plants. Wageningen: Center for Agricultural Publishing and Documentation.

Zhang, Wenxu, and Anping Pei 1996 Analysis of Ancient Rice from Bashidang in Mengxi, Lixian County. *In* Origin and Differentiation of Chinese Cultivated Rice. Xiangkun Wang and Chuanqing Sun, eds. Pp. 47–53. Beijing: China Agricultural University Press.

Zhao, Zhijun 1998 The Middle Yangtze in China is One Place Where Rice was Domesticated: Phytolith Evidence from Diaotunghuan Cave, Northern Jiangxi. Antiquity 278:885–97.

——— 2003 Study of Plant Remains. *In* Zengpiyan: A Prehistoric Site in Guilin. C. Institute of Archaeology, ed. Pp. 286–96, 342–4. Beijing: The Cultural Relics Publishing House.

——— 2004 Tanxun Zhongguo Beifang Han Zuo Nongye Qiyuan de Xin Xiansuo (Seeking new clues about the origins of dry farming in Northern China). Zhongguo Wenwu Bao (Cultural relics newsletter of China) November 11, 2004.

Zhejian Provincial Museum, Natural History Section, 1978 A Study of Animal and Plant Remains Unearthed at Hemudu. Archaeology (Kaogu) 1:95–111.