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Prehistoric Plant Domestication in East Asia

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Introduction

In earlier syntheses on the origins of agriculture, China was a necessary subject of some deliberation, but Korean and Japanese agricultural origins were largely ignored (e.g., Harris 1977; Ho 1969, 1977). Discussions on Korea and Japan were of interest only to small circles of local archaeologists; few others seemed to think it worthwhile to pay attention to these two subareas of East Asia. After all, in neither Korea nor Japan were there apparent indigenous agricultural origins. At present, archaeologists are still debating the existence of food production in pre-Bronze and Iron Age Korea and Japan. The prevailing view is that agriculture began in Korea and Japan in the third millennium B.P. with the initiation of rice-based agrarian societies by both the diffusion of crops and ideas and the migration of people. Evidence is mounting, however, for earlier agricultural origins in these two areas.

By 1977 North China had been established as an independent center of agricultural origins (Ho 1977). Yet, at that time, there were only six radiocarbon dated sites with domesticated remains (Kabaker 1977:968–69). Chinese agricultural beginnings, then dated to about 7000 B.P., seemed to be later than their initiation in Southwest Asia. Both Southwest Asian and Chinese agriculture appeared to have begun in an *Artemisia* steppe, yet the immediate predecessors of Chinese agricultural complexes were unknown (Reed 1977:903–4). No early Holocene cultures comparable to the Natufian (Miller, this volume), for example, had been reported in China, although a long, rich archaeological record of early Holocene cultures was known for Japan. Data on the origins of rice agriculture in China were not available in 1977, although the minimal available data led Ho (1977) to suggest that a South China rice domestication center was likely.

Some questions posed more than a decade ago remain unanswered. Evidence of an early Holocene population from which agrarian society arose in North China is still inadequately documented (Chang 1986). In the last decade a number of phases immediately predating the Yangshao have been uncovered but they are substantially involved with food production (An 1989; Chang 1986; Yan 1989). The onset of food production in Southwest and East Asia is likely to have occurred in similar periods, sometime before 9000 B.P. The origins of rice husbandry are better known today, and Ho's (1977) suggestion of a South China center of rice domestication appears more likely. Many more sites—close to 30—with domesticated plant remains are known in Neolithic China. In Japan, the introduction, development, and spread of agriculture is an active area of research, as is the search for a mid-Holocene record of cultigens. In Korea, the archaeology of agricultural origins is probably the least developed of North Asia, although Korea's role in understanding crop dispersals to the east from China cannot be underestimated.

Northern China, Korea, and Japan are centers of diversity and potential sources of many cultigens.[1] Zeven and Zhukovsky (1975) compiled a list of 284 taxa of cultigens and managed plants in this part of Asia (Table 2.1). Not all are native to northeastern Asia, of course, and the relative economic importance of these plants has varied over time. Rice (*Oryza sativa*), an important food plant throughout much of the present world, became economically significant in northern China, Korea, and Japan only recently. Rice is not native to any of these regions either. Indigenous cultigens include broomcorn millet (*Panicum miliaceum*), barnyard millet (*Echinochloa utilis*), foxtail millet (*Setaria italica* ssp. *italica*), Chinese cabbage (*Brassica campestris*), *adzuki* bean (*Vigna angularis*), soybean (*Glycine max*), hemp (*Cannabis sativum*), great burdock (*Arctium lapa*), and buckwheat (*Fagopyrum esculentum*). Tree crops, such as peach (*Prunus persica*) and persimmon (*Diospyros kaki*), also attained cultigen status in this area. Barley (*Hordeum vulgare*) and bread wheat (*Triticum aestivum*) probably arrived from southwestern Asia by the third millennium B.P. Introduced cultigens were isolated from their parent gene pools and local forms and varieties eventually evolved. Much of the basic archaeological data on these plants is lacking, but the region is not completely without an archaeological record for domestication. Ho (1977), for example, relied almost entirely on ethnohistory for his discussions on early Chinese agriculture. He had little choice, but today more archaeological data are available. In this paper I review what *is* currently known about plant domestication in northern China, Korea, and Japan, with an emphasis on Japan.

The transition to food production in East Asia involves not only indigenous domestication and evolution of agricultural systems, but also the diffusion of cultigens within this geographical area and the introduction of cultigens from the west. Recent summaries of these processes can be found in Chang (1983), Ho (1977), and Li (1983) for China; Kim (1978), Nelson (1982), Pearson (1974), and Rowley-Conwy (1984) for Korea; and Crawford (1983, 1992), Crawford and Takamiya (1990), Esaka (1977), Kasahara (1984), Kotani (1981), Pearson and Pearson (1978), Rowley-Conwy (1984), and Tozawa (1982) for Japan.

Research is active in all three areas, but Japan, with a tradition of extensive salvage archaeology and rapid reporting of data, continues to be a window on Asia for western archaeologists seeking to understand Asian prehistory in general. In addition, recently collected data on cultigen prehistory in Japan are now providing a provocative view of the Asian Neolithic. The Jōmon of Japan is also proving to be of comparative importance in the study of the European Mesolithic (Dennell, this volume; Rowley-Conwy 1984) and the eastern North American Archaic and Woodland (Aikens 1981; Crawford 1983; Smith, this volume). Finally, populations of carbonized cultigens from Hokkaidō are being studied (Crawford 1986; Crawford and Yoshizaki 1987) and seem to provide the best comparative data on the taxonomy and evolution of East Asian cultigens available to western scientists at this time. Because few plant remains have been reported from northern China and Korea, this chapter focuses on recent developments in Japan and the relevance of the current data to problems elsewhere in eastern Asia.

Until the early 1970s few empirical data on Jōmon agriculture were available. Since then, considerable quantities of plant remains have been recovered from Jōmon and later occupations. After a brief discussion of East Asian Neolithic chronologies and a review of the early hypotheses, I explore revised concepts of Jōmon subsistence in light of the new data. In addition, I examine the first millennium A.D. complement of northern temperate Asian cultigens in order to shed light on the history of plant domestication in East Asia. The principal archaeologically visible cultigens are reviewed in terms of their botany, context, and the Asian Neolithic in general. Current perspectives are based mainly on my own research in Hokkaidō (Crawford 1983, 1992; Crawford and Takamiya 1990; Crawford et al. 1978), on the work of the Kōbunkazai Henshū Iinkai (Antiquities Editorial Committee), and on a project involving a ninth-century A.D. agricultural complex in Hokkaidō (Crawford and Takamiya 1990; Crawford and Yoshizaki 1987; Yoshizaki 1984). The latter project serves as a focus for the cultigen prehistory and botanical discussions to follow. Wherever possible, I have included references in English, and when an article is available in both Jap-

Table 2.1. Domesticated Plants and their Relatives in East Asia

English Common Name	Japanese Common Name	Latin Name
apricot	anzu	*Prunus armeniaca*
barley	ō-mugi	*Hordeum vulgare*
bean: adzuki (red)	azuki	*Vigna angularis* var. *angularis*
black gram or urd	ketsuru-azuki	*V. mungo*
mung	ryokuto	*V. radiatus* var. *radiatus*
soy bean	daizu	*Glycine max*
beefsteak plant	shiso	*Perilla frutescens* var. *crispa*
	egoma	*P. frutescens* var. *japonica*
bottle gourd	hyōtan	*Lagenaria siceraria*
buckwheat	soba	*Fagopyrum esculentum*
wild buckwheat		*F. cymosum*
giant radish	daikon	*Raphanus sativus*
great burdock	gobō	*Arctium lappa*
hemp	asa	*Cannabis sativa*
hops	karahanasō	*Humulus lupulus*
Job's tears	jyuzu dama	*Coix lachryma-jobi*
lacquer tree	urushi	*Rhus vernicifera*
melon	uri, makuwa-uri	*Cucumis melo*
millet:		
barnyard grass	ta-inubie, inubie	*Echinochloa crusgalli*
barnyard millet	hie	*E. utilis*
broomcorn proso	kibi	*Panicum miliaceum*
foxtail	awa	*Setaria italica* ssp. *italica*
mustard family	aburana-ka	Brassicaceae
Chinese cabbage	chūgoku kyabichi	*Brassica campestris*
		ssp. *chinensis*
Indian mustard	kyona/mibuna	ssp. *nipposinica*
Chinese cabbage	hakusai	ssp. *pekinensis*
rape, canola	natane	*B. napus*
paper mulberry	kaji-no-ki	*Broussonetia papyrifera*
pea	endō	*Pisum sativum*
peach	momo	*Prunus persica*
pear	seiyō-nashi	*Pyrus communis*
persimmon	kaki	*Diospyros kaki*
plum	sumomo	*Prunus salicina*
rice	kome	*Oryza sativa* ssp. *japonicum (sinica)*
		O. sativa ssp. *indica*
safflower	benibana	*Carthamus tinctorius*
sorghum	morokoshi	*Sorghum bicolor*
soybean	daizu	*Glycine max*
wheat, bread	ko-mugi	*Triticum aestivum*

anese and English, both are cited. This should make the available complex literature somewhat more useful to western students and researchers than otherwise might be the case. English common, scientific, and Japanese common names are given for plants discussed in the text. This should allow for clearer understanding for most readers, including Japanese readers who are more accustomed to using common rather than scientific names.

Environment

China, Japan, and Korea span a range of latitudes from tropical or subtropical to temperate, have a range of floral and faunal associations, and have climates controlled in part by the East Asian monsoon (Hsieh 1973; Liu 1988; Ren et al. 1985). China has the greatest extent of riverine and plain development of the three regions. East Asia tends to be isolated from

Central and South Asia by desert, steppe, and mountains. Korea and Manchuria are somewhat separated by the Changhai Mountains while Japan has the highest degree of isolation, separated from the mainland by the Japan Sea. North China and South China are distinctive in that the former is temperate while the latter is subtropical to tropical. In the interior, the Qin Mountains at about 30° north latitude create a topographical division between North and South China, forming a barrier to an easy north-south movement of people. In the lower Huai River, no such barrier to movement exists.

The potential vegetation of China (Fig. 2.1) is open to interpretation based on climatic and historic records. Human impact on habitats has been extensive so little natural vegetation remains. The discrepancies between two commonly cited vegetation maps of China illustrate problems with the reconstruction of potential vegetation. One map used by Hsieh (1973) and Kolb (1971) and another cited by Liu (1988) disagree on the location of the mixed-forest zone that lies between the deciduous forest and the broadleaf-evergreen forest zones, as well as on details of the boundaries of other zones. Figure 2.1 is based on Liu's (1988) depiction of Wu (1980) and on Ren et al. (1985), the latter of which includes a temperate-forest grassland between the steppe and deciduous-forest zone (Fig. 2.1, Zone 4).

China is unique among the three areas in having a well-developed steppe (Fig. 2.1) whose existence is due to a steep northeast-southwest moisture gradient, which results in a dry, continental climate in the interior (Liu 1988:1). The steppe-forest ecotone (Zone 4) crosses through the Wei River basin today, where some of the earliest evidence for plant and animal domestication is found in China. Ho (1977:426) argues that the semiarid steppe was the zone in which the earliest agriculture in North China arose. His evidence is in two forms: palynological and ethnohistoric. Unfortunately, at the time of Ho's synthesis, a dated pollen sequence was apparently not available. In fact, among 80 pollen records published for North China, few are radiocarbon dated (Liu 1988:5). The only data that Ho could use for his interpretation was the upper 20 meters of a loess profile in Wucheng County near the modern steppe-forest boundary (Ho 1977:421–23). The ethnohistoric data are late first millennium B.C. odes and songs whose contents include the names of plants and their habitats. Ho concluded that because trees and shrubs were confined to mountains, hills, slopes, and places near watercourses, North Chinese food production evolved in a steppe environment, making this area the only exception to the generalization that agriculture did not, and could not, first appear in a grassland area (Ho 1977:424, 426). This interpretation oversimplifies our understanding of the Holocene Loess Plateau vegetation and the context of the first plant husbandry in North China. There is simply not enough evidence to determine under what environ-

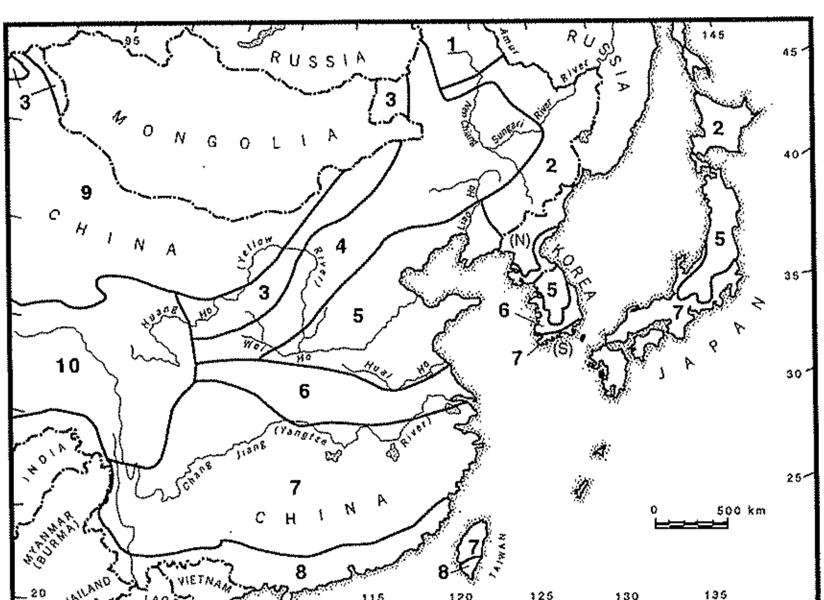

Fig. 2.1. Vegetation zones of East Asia. 1, boreal; 2, mixed conifer-deciduous; 3, steppe; 4, forest-steppe; 5, deciduous broadleaf; 6, mixed deciduous and broadleaf evergreen; 7, subtropical broadleaf evergreen; 8, tropical monsoonal rainforest; 9, desert; 10, highland.

mental conditions domestication began in North China. The steppe-forest ecotone location varied throughout the Holocene, as recent dated pollen sequences and archaeological data indicate. It would be safe to say that the location of the steppe-forest ecotone in China during the early and mid-Holocene is not known with any accuracy. Furthermore, an archaeological record for cultures immediately preceding the earliest known settlements on the Loess Plateau is poorly known and the earliest food producing communities on the plateau so far show little or no use of steppe resources.

An early Holocene mixed forest, which apparently dominated at Beizhuangcun in the Wei River basin until about 9000 B.P., was followed by a steppe dominated by *Artemisia* and Compositae (Liu 1988:13–14). The date for the beginning of the steppe at Beizhuangcun is only an estimate and the upper part of the pollen sequence is missing. At Xinlitun, near Beijing, increasing *Artemisia* and grass pollen seem to confirm increasing aridity in the latter mid-Holocene of North China (Liu 1988:15). Hardwood pollen dominated by oak is most common in the mid-Holocene at Xinlitun as well, indicating an expansion of the deciduous forest. In general, the steppe seems to have expanded to the southeast into the present forest zones of North China in the last glacial period. There is some question as to whether this expansion occurred during, or near the end of, the last glacial period (Liu 1988:17). A northwestern retreat of the steppe appears to have occurred in the mid-Holocene, followed by a return of the steppe sometime after 5000 B.P. The Xinlitun pollen diagram indicates that, although the deciduous forest expanded in the mid-Holocene, the steppe was probably an important component of local habitats. At the Fuhokoumen site in Hopei, now in the temperate forest-steppe zone (Zone 4), only deciduous forest zone animal remains were found (Chang 1986:191). Details of the chronology of the southeastern steppe boundary are still not well known.

Artemisia steppe likely existed in southwestern Japan from about 10,000–8,500 B.P. (Yasuda 1978:254). This period in southwestern Japan also characteristically has relatively high proportions of Compositae, grass, *Persicaria,* and *Lythrum* pollen (Zone RI). Oak pollen indicates the presence of woodlands of some form. Absolute pollen frequencies are relatively low as well (Yasuda 1978:172). Yasuda (1978:172) suggests that this vegetation is due to a sudden climatic warming that resulted in the formation of a grassland during the transition from a late Pleistocene mixed forest to an early Holocene deciduous hardwood forest.

A mixed conifer-hardwood forest dominates eastern Manchuria, northern North Korea, and Hokkaidō, Japan (Fig. 2.1). Pine, fir, and spruce are prevalent conifers in each region while beech and oak are the common deciduous trees in Japan and Korea. Oak (*Quercus mongolica*) is the dominant deciduous tree in Manchuria. Deciduous broadleaf forests dominate the North China Plain, the central Korean Peninsula, and northern Honshū, Japan (Fig. 2.1). In China and Korea, oak predominates while in Japan the forest is mainly beech and oak. Some pine is present, along with a range of hardwoods.

A transitional zone (Zone 6) of deciduous and broadleaf evergreen trees lies between the Huai and Yangtze river basins, as well as in South Korea (Fig. 2.1). This zone is not usually portrayed on vegetation maps of Japan; it is usually subsumed within the broadleaf evergreen forest zone (Yasuda 1978). Yasuda (1978:138) believes that it is a separate element of the Japanese vegetation and that it was more extensive between 8500 and 6500 B.P. than at present. The broadleaf evergreen forest covers southwestern Japan, the southern tip of the Korean Peninsula, and most of South China. In Japan, several species of oak are common to coastal areas, while *Machilus* and *Castanopsis* species are the major tree taxa in interior regions. A tropical monsoonal forest is found in China, but not in Korea and Japan.

The modern potential vegetation of northeast Asia is obscured by agriculture and urbanization. The role of anthropogenic influences on Holocene vegetation is not documented well for China and Korea (Liu 1988; Pearson 1974), but Yasuda (1978) and Tsukada (1986) have examined both climatic and anthropogenic influences on vegetation in Japan. Evidence for swidden agriculture may occur as early as 7700 B.P. in Japan (Tsukada 1986; Tsukada et al. 1986). Human-caused changes linked to agriculture in Japan, however, are continuous only after 3200 B.P. By 1600 B.P., climate cannot be inferred from the pollen record due to extensive landscape modification by people (Yasuda:242, 250). By 3200 B.P. in southwestern Japan, rice pollen appears, signaling the development of intensified food production that spread rapidly to central Honshū by 2100 B.P. The area of the initial spread of rice agriculture in Japan coincides with the broadleaf evergreen forest zone (Yasuda 1978:257). With the spread of agriculture came the destruction of floodplain and hillside forests. At the same time, pine pollen increases (Yasuda 1978:242). At only one site, Torihama, is there evidence for extensive forest destruction any earlier (Yasuda 1978). Anthropogenic vegetation was, however, a localized but significant component of the environment surrounding and within mid-Holocene communities in Japan (Crawford 1983).

Throughout East Asia there is evidence for a warmer mid-Holocene. Seven of 80 pollen studies in North China span the Holocene, or much of it (Liu 1988). In these sequences Zone III, which is interpreted to be a warmer and probably more humid period, is characterized by maximum deciduous tree pollen frequencies. This zone has an upper boundary of about 5000–4300 B.P. in northeastern China and a lower boundary dating to about 8000 B.P. (Liu 1988:7, 15). Archaeological data further support the contention of a warmer mid-Holocene in China. Fauna, which are limited today to South China, are found in mid-Holocene sites in the north. Bamboo rat, water deer, and elaphure are identified at Yangshao sites (Chang 1986:79; Archaeological Institute, Chinese Academy of Science 1963:319). Chang (1986) also notes that water buffalo, elephant, rhinoceros, and tapir at some sites were north of their potential ranges today. At San-li-ho on the Shandong Peninsula the local environment was considerably wetter, with the remains of at least 20 alligators recovered (Chang 1986:162).

Zone II in North Chinese pollen sequences is presumably early Holocene and has high proportions of birch pollen, while Zone IV has high proportions of pine and low proportions of birch and other deciduous trees (Liu 1988). This is remarkably like the patterns seen in Japan with the spread of agriculture. In Japan pollen diagrams for Zones RIIa and RIIb represent a warm period that started about 8500 B.P. and lasted until about 3500 B.P. (Yasuda 1988:250), about 500 to 1,500 years later than suggested for China. Zone RIIa, the first part of a mid-Holocene warm period in Japan, consists of mainly deciduous hardwoods. The broadleaf evergreen forest was established at the beginning of Zone RIIb in southwestern Japan (Yasuda 1988:255). The RIIb period was warmer and wetter than present. By 3500 B.P. the mean annual temperature dropped while the humidity continued to rise.

Except for Japan, northeast Asian Holocene environmental history is not nearly as well documented as it is in North America, Europe, and Southwest Asia. Of particular interest is the history of the steppe-forest ecotone in Gansu, Shaanxi, Shanxi, Hopei, and Liaoning provinces. There appears to be little doubt that by the time substantial agrarian communities were well established on the North China Plain (by 8000 B.P.), a relatively warm period had begun. In Japan this warmer trend is associated with increasing humidity, which bracketed the beginning and end of the warm period by about one millennium. The role of anthropogenic influences on the desertification of North China and on the steppe-forest boundary is also in need of examination.

A variety of agricultural regions provides a rich potential for food production in East Asia. Three regions are recognized in Japan, two in Korea, and eleven in China, five of which are in the North Chinese region of concern to this paper (Kolb 1971; Tregear 1980; Trewartha 1963). In southern China temperate crops, including wheat, rapeseed, potatoes, and beans, are grown at elevations above 1600 m (Ren et al. 1985:343). The limit of rice production in the south is between 2400 and 2700 m above which oats and beans are grown on a limited scale (Ren et al. 1985:344). The agricultural regions do not correspond precisely to the East Asian vegetation zones illustrated in Figure 2.1. Factors such as technology and crop genetics, as well as growing season, rainfall, elevation, and snow cover, affect crop distributions.

In Japan north of 37° north latitude, in Manchuria, and in North Korea, dry crops predominate (Kolb 1971; Trewartha 1963). Oats, wheat, barley, millet, potatoes, soybean, and maize are the most common crops in northern Japan. Sorghum and millet are the most important crops in Manchuria. Maize and soybean production is also common. In North Korea sorghum, wheat, and soybeans are the primary crops. Rice is grown in these northern regions, but production is low.

South of 37° north latitude in Japan wheat and barley are produced, but rice, tea, and citrus fruits gain importance (Trewartha 1963). In the eastern portion of Zone 5 on the North China Plain, sorghum and wheat are the main crops (Tregear 1980). Barley, foxtail millet, corn, soybean, and cotton are produced as well. On the Loess Plateau in the western portion of Zone 4 the principal crops are winter wheat and broomcorn millet (Tregear 1980). Sorghum, sesame (*Sesamum indicum*), buckwheat, maize, and a variety of legumes are also grown. Rainfall is sparse on the Loess Plateau, coming mainly in the summer (Hsieh 1973). Rice is grown in irrigated areas that comprise less than 10 percent of the arable land on the plateau (Tregear 1980).

Immediately to the northwest of the deciduous forest zone (Zone 5) in China are two production systems: pastoralism and crop production. Crop production is limited to the area bounded by the eastern limit of Zone 9 (desert) and the northwest edge of Zone 5. Spring wheat and millet are the principal crops. Less than 10 percent of the grain crop is wheat. Other cultigens include sesame, rapeseed (*Brassica napus*), and sunflower (*Helianthus annuus*). North of this zone pastoralists raise horses, cattle, sheep, and goats.

Areas of greatest rice production are confined to Zones 6, 7, and 8 (Fig. 2.1). Zone 7 is the major rice growing region in Japan and was the region into which rice rapidly spread during the Yayoi Period (Akazawa 1982). Double rice cropping is limited to Zone 8 in China, where every other year three crops are often planted (Ren et al. 1985), and to southern Shikoku in Japan (Kolb 1971; Hsieh 1973). In many areas in East Asia the rice harvest is often followed by plantings of dry crops in drained rice paddies. Double cropping in China is most common in Zone 6 and in the Yangtze River basin (Tregear 1980). In Japan this practice takes place as far north as 37° north latitude, but difficulties arise in areas of heavy and continued snow cover (Trewartha 1963). The occurrence of double cropping increases to the south in Japan. The late fall plantings in the rice paddies include wheat, barley, rape, soybean and other legumes, sesame, and giant radish or *daikon* (*Raphanus sativus*).

Shifting or slash-and-burn agriculture is still practiced in the highlands of southern China and Japan. In the early 1960s about 152,000 households in Japan were engaged in this form of production (Trewartha 1963:209), mostly in the southwestern part of the country.

Chronology and Prehistory

The time span covered in this chapter ranges from about 8500 B.P. to 100 B.P. (Fig. 2.2). Chronological and processual problems, such as linearity of sequences and radiocarbon dating complexities, are simplified in Fig. 2.2; however, the chart serves as a useful guide for the discussions to follow. The time range is more a result of the availability of relevant data than it is of archaeological data pertaining to periods when actual domestication was taking place. Few data are available from times when domestication was occurring in northeastern Asia. As a result, I include all periods when any direct archaeological evidence of domesticated plants is available to elucidate problems and processes of domestication. The latest substantial archaeological data are from the 1100 B.P. Sakushu-Kotoni River site in Hokkaidō (Figs. 2.2–2.3). Some data from later sites in Japan are brought to bear on problems related to the Hokkaidō data. The Chinese sequence ends with the Han Dynasty because historic records from this period are useful and one of the last events of importance to this discussion occurs during this period—the expansion of wheat husbandry. The only data discussed in this paper that postdate the Bronze Age in Korea involve comparative wheat data from the 1100 B.P. Puyo site; cultigen remains from Korea are mainly Bronze Age.

China

In general, Chinese archaeologists assume that any site with ceramics and no evidence of metallurgy is Neolithic. Pre-8500 B.P. pottery-bearing sites are termed Early Neolithic. To date, no Early Neolithic sites have been identified on the Loess Plateau or on the North China Plain. Conversely, no Middle Neolithic sites, at least of the magnitude of the ones in North China, have been identified south of the Huai River. With the exception of the Zengpiyan Cave site (10,300–7000 B.P.) in Guilin (Chang 1986; Yan 1989), no evidence for domestication in South China exists before about 7000 B.P. At Zengpiyan dental and mandibular morphology of an estimated 67 pigs indicate that their domestication was taking place. Furthermore, 85 percent of the pigs did not live longer than two years. Chang (1986) is optimistic that plant husbandry was also established at Zengpiyan, but the evidence has not yet come to light.

So far, incontrovertible evidence for the earliest plant domestication in China is from the deciduous-forest zone of North China, in the context of well-established villages during the Middle Neolithic dating from 8500 to 7000 CAL.B.P. Chang (1986:89–90) reports four clusters of sites on the Loess Plateau that he assigns to the Peiligang culture: in southern Hopei (e.g., Cishan site); in Honan (e.g., Peiligang site); in the Wei River valley (e.g., the Laoguantai and Dadiwan sites); and in southern Shanxi (e.g., Lixiatsun site). In the northeast may be another Middle Neolithic cluster of sites that Yan (1989) places in the Xinlongwa culture. Four radiocarbon dates from Xinle suggest occupation there as early as 7500

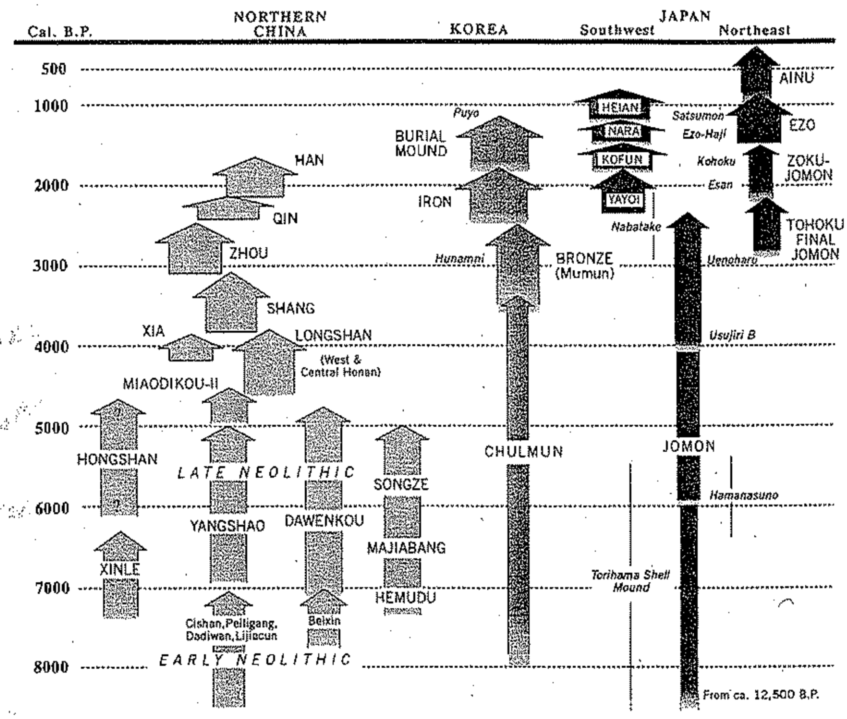

Fig. 2.2. Summary of Northeast Asian chronology. Arrow width is roughly proportional to the degree of dependence on food production. (Data for China and Korea from An 1989; Chang 1986; Nelson 1982; and Pearson 1982)

CAL.B.P., while the Xinlongwa site may date to the late eighth millennium B.P. (Chang 1986:175,181). Another Neolithic site in the same region dating to the eighth or ninth millennium B.P. is Cha-hai (Nelson 1990:239). Other possible Middle Neolithic occupations are in the Shandong, the northeast, east, and southern regions of the deciduous forest zone, and it seems reasonable to predict that the Shandong and Daxi Neolithic occupations extend back to at least the eighth millennium B.P. as well.

The Middle Neolithic occupations of the Loess Plateau consisted of villages supported by a mixed economy of hunting, gathering, fishing, and plant and animal husbandry (Chang 1986:90–95; Yan 1989). Sites are up to 140 m in diameter and in some areas are as dense as $1.5/km^2$. Cemeteries and living areas of plaster-floored houses comprise these early communities (Chang 1986:90). Three cultigens are reported from four sites of this period: foxtail millet, broomcorn millet, and a Chinese cabbage (*Brassica campestris*) (Yan 1989). Foxtail millet is reported from the Cishan site while broomcorn millet has been identified at the Dadiwan, Peiligang, and Xinle sites (Chang 1986; Yan 1989). Chinese cabbage has been found at one Middle Neolithic site (Dadiwan). Except for the Cishan site, indications of seed quantities are not reported. Some 80 pits at Cishan contained grain (Yan 1989). The foxtail millet is from the single sample that has been examined (Yan 1989). Husbanded animals during the Middle Neolithic are the pig (*Sus* sp.), dog (*Canis*), and, very likely, chicken (*Gallus* sp.) (Yan 1989).

The Late Neolithic, beginning about 7000 CAL.B.P., exhibits continuity with preceding phases. In the region of the Middle Neolithic cultures of the Huang and Wei rivers, the Yangshao culture persisted for some two millennia. The Dawenkou culture was established by this time on the lower elevations of the North China Plain east of the Yangshao culture. Developments continued in the north and east with the Xinle culture of Liaoning Province and the Hongshan culture of Liaoning Province and northern Hopei. In central coastal China, in the lower Yangtze and Huai rivers, the Majiabang and Hemudu cultures were established. The Yangshao is distributed over much of the Loess Plateau area of northern China. The period is best known to westerners through the excavations at the Banpo site. By the early 1960s over 400 Yangshao sites had been discovered (Archaeological Institute, Chinese Academy of Science 1963). Several temporal phases of the Yangshao have been defined; two are found at Banpo while four are rec-

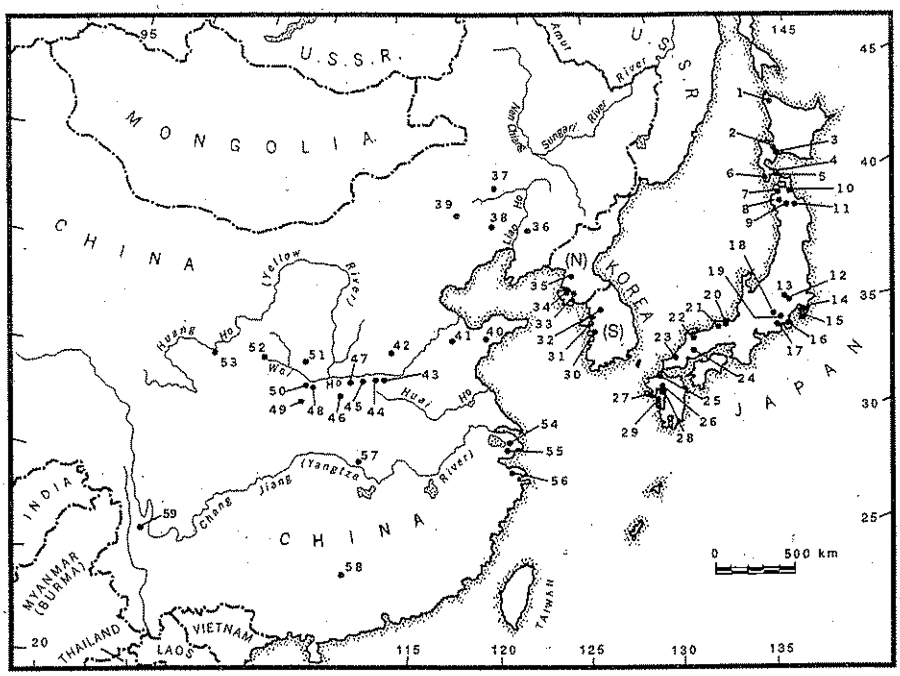

Fig. 2.3. Location of East Asian sites mentioned in the text. **Japan:** 1, Toyotomi; 2, Sakushu-Kotoni River, Idenshikōgaku, and Poplar Namiki; 3, Kashiwagigawa; 4, Usujiri; 5, Hamanasuno; 6, Kachiyama; 7, Kamegaoka; 8, Tareyanagi; 9, Aramachi; 10, Kazahari; 11, Ichinohe; 12, Daiichi Chuugakko; 13, Shimpukuji; 14, Shitakitabara; 15, Otsubo; 16, Yamagi; 17, Toro; 18, Sohara; 19, Idojiri; 20, Torihama; 21, Kuwagaishimo; 22, Megumi; 23, Ubuka Bog; 24, Nogoe; 25, Nabatake, Rokutanda, Itatsuke; 26, Wakudoishi; 27, Ikiriki; 28, Uenoharu; 29, Yamanotera and Kureishibaru. **Korea:** 30, Puyo; 31, Honamni; 32, Chit'am-ni; 33, Hunamni; 34, Soktali; 35, Chongok-ni. **China:** 36, Xinle; 37, Fuhokoumen; 38, Cha-hai; 39, Xinlingwa; 40, San-li-ho; 41, Dawenkou; 42, Cishan; 43, Peiligang; 44, Erlitou; 45, Miaodigou; 46, Xiawanggang; 47, Yangshao; 48, Jiangzhai; 49, Heijiawan; 50, Banpo; 51, Laoguantai; 52, Dadiwan; 53, Linxia; 54, Songze; 55, Majiabang; 56, Hemudu; 57, Kuanmiao-shan (Daxi Culture); 58, Zengpiyan Cave; and 59, Chien-ch'uan.

ognized at Jiangzhai (Cultural Relics Publishing House 1988). Yangshao sites are roughly five times the area of preceding Middle Neolithic communities. House structures, storage pits, and stone and bone technology are similar to those of preceding phases. New aspects include evidence of planned community layouts, pottery kilns, larger cemeteries often with multiple burials and at least one burial with rich grave goods, and the excavation of large ditches. Domesticated plant remains are reported from thirteen Yangshao period sites (Yan 1989). Foxtail millet is reported from seven sites, including Banpo. Broomcorn millet is reported only from Jiangzhai. Unidentified millet is reported from two sites in Honan Province (Yan 1989). Chinese cabbage is reported from Banpo and rice is reported from two Yangshao period sites, Heijiawan and Xiawanggang (Yan 1989). There is a single report of possible sorghum from Honan Province but, because no other Neolithic report of this crop has been made, it is in all probability a contaminant or a misidentification. Sorghum is not native to China and Ho (1977:475) contends that it did not become widely known in China until the thirteenth century A.D. Carbon isotope analysis indicates that the Yangshao diet may have been as much as 58 percent millet (Cai and Qiu 1984: cited in An 1989 and Yan 1989). This is similar to estimates of the maize (*Zea mays*) components of the Ontario Iroquois diet in North America (Schwarz et al. 1985).

By 6000 CAL.B.P., agricultural communities were established in south-central Ganzu Province. Chang (1986) prefers to group the several phases of the Gansu Province Late Neolithic with the Yangshao, while some prefer to identify the Gansu Province phases as separate cultures. Yan (1989), for example, lumps them within the Majiayao culture. Whatever the case, plant remains are similar to those reported from eastern Yangshao sites with the exception of hemp from the Linjia site and several reports of broomcorn millet. Five sites have foxtail millet while three have broomcorn millet. The broomcorn millet from Linjia consists of unthreshed inflorescences tied into bundles (Yan 1989).

A tradition contemporaneous with Yangshao, the Dawenkou culture, occupied the region east of the loess area to the coast, mainly on the Shandong Peninsula. Dawenkou is represented by about 100 sites, most of which are cemeteries (Chang 1986:159–60). House styles are not well known, although both pit houses and houses with floors at ground level are known; burials are the same as Yangshao interments (Chang 1986:162). Not surprisingly, because of the few domestic area excavations carried out, few plant food remains are reported from the Dawenkou sites. Foxtail millet is reported from two sites and broomcorn millet from one site (Yan 1989).

Local Neolithic phases are well known in southern Manchuria. Carbonized grains are reported from a posthole at the Xinle site dating to ca. 7500–6500 CAL.B.P. (Chang 1986:175–76). The grains are apparently broomcorn millet (Yan 1989). By 6500 CAL.B.P., food production was being carried out as far as 43° north latitude—the same latitude as south-central Hokkaidō, Japan.

Korea

In contrast to the food production of Neolithic China, Korean populations during the period from about 8000 B.P. to the fourth millennium B.P. (Fig. 2.2) are thought to have maintained a broad-spectrum subsistence base with millet husbandry appearing some time in the fourth millennium B.P. (Nelson 1982:115). This four- or five-millennia period in Korea is characterized by a high frequency of pottery known as Chulmun, or comb-pattern pottery (Nelson 1982; Pearson 1982). Little of it is actually comb-patterned but incising (trailing) is common. In contrast to Japanese mid-Holocene pottery, cord marking is rare, found only on ceramics in the south. Villages or hamlets of round, semisubterranean houses, as well as coastal shell middens, are known. In the Han River basin, site densities are as high as 1.0/2 km^2 (Nelson 1973). Houses are about 8.5 m^2 and 1 m deep, whereas in the Yalu River region houses are elongated with floor areas of about 20 to 30 m^2. The earliest potential cultigen report in Korea is from the undated Chulmun Chit'am-ni site (Di-Tap-Li), where two types of millet were found in the bottom of a dentate ware pot (Chard 1960; Kim 1978). The millets have not been specifically identified; cursory examination suggests they are either *Setaria italica* or *Panicum crusgalli* (Kim 1978). *P. crusgalli* is an outdated term for barnyard millet (*Echinochloa utilis*). Kim (1978) may have meant *Panicum miliaceum* (broomcorn millet). Similar cursory reports of buckwheat, sorghum, and barnyard millet in Hokkaidō have proven to be incorrect. Until proper identification of the grains is made, the Chit'am-ni report should be treated cautiously.

In southeastern Korea, bronze associated with plain Mumun pottery makes its appearance between 4000 and 3000 B.P. (Nelson 1982). Korean archaeologists place the beginning of the Bronze Age at 3000 B.P., when Mumun pottery and bronze are widely distributed throughout Korea (Nelson 1982). Unlike China, there are no bronze vessels, but weapons and symbols of status are the most common bronze items (Pearson 1982). The most common stone tool from this period is a crescent shaped knife (sickle) with two holes in it (Pearson 1982). The first rice in Korea is associated with radiocarbon dates of 3300 to 2850 B.P. at the Hunamni site (Choe 1982:524; Kim 1982:514; Nelson 1982:128; Pearson 1982). No rice is known from the Bronze Age in North Korea. Irrigation agriculture was probably established by the middle of the third millennium B.P. (Nelson 1982; Pearson 1982).

Japan

A tradition of mainly broad-spectrum foragers existed for much of the period from 12,000 B.P. until about 2400 B.P. in southwestern Japan, and until more recently in the northeast of that country (Fig. 2.1). The Jōmon period has been subdivided into six phases in the southwest and seven in the northeast. The justification for the dating of the individual phases is beyond the scope of this chapter; however, when a Jōmon site is discussed here, its phase assignment is provided together with pertinent dates. Considerable regional and temporal variation of the Jōmon is recognized, so no one settlement pattern or specific subsistence regime can be applied to the Jōmon as a whole (e.g., Akazawa 1982; Crawford 1983). Evidence for plant husbandry is present in some areas but lacking in others. As in Korea, coastal shell mounds are known for some areas and periods but not for others. At any rate, the Jōmon is superseded in the southwest by the Yayoi, a society that is characterized by substantial wet rice agriculture. The Hokkaidō Jōmon continues until about A.D. 500. Then it is followed by the Ezo period, a time of rapid change and increased interaction with the south. The Yayoi, too, is a period of culture change, in part due to processes involving increased contacts with the mainland. The southwestern sequence eventually led to a state-level sociopolitical organization, whereas Hokkaidō was the home of the historically documented Ainu. I have described the transition to agriculture in Japan as consisting of four phases (Crawford 1992). The first is mid-Holocene gardening and the second is the development of rice production in southwestern Japan. The third phase marks the development of agriculture in northwestern Honshū, while the final stage brings dry-land agriculture to Hokkaidō.

Dependence on food production generally increased through time in northern China, Korea, and Japan, excluding Hokkaidō. In Hokkaidō some populations were substantially agricultural during the early Ezo period, but the late Ezo or Satsumon populations and the Ainu seem to have depended less on plant husbandry (Crawford and Yoshizaki 1987), although this is still open to question. By the fourth millennium B.P. in China and the early first millennium A.D. in southwestern Japan and in Korea, dependence on domesticated resources was comparatively high. The Chulmun and Jōmon were primarily foraging stages, but some plant husbandry is evidenced in the Jōmon.

Initial Speculations (Japan)

The transition to wet-rice agriculture in Japan has been conservatively dated to between 2400 and 2300 B.P. This marks the beginning of the Yayoi, a wet-rice based tradition lasting nearly 700 years. As early as the 1950s and early 1960s at least ten cultigens had been identified from the Yayoi stage Toro site (Goto 1954). The plant remains include pear (*Pyrus communis*), soybean, and *adzuki* bean (*Vigna angularis*). Hops (*Humulus* sp.) is also reported but the plant is a native weed found throughout Japan. Buckwheat, in addition to five of these cultigens, was found at the Yamagi site (Goto 1962). At this point in the investigation of Japanese agricultural history, the Yayoi clearly possessed something that Jōmon sites did not: cultigen remains in excellent context.

The Jōmon is enigmatic in many ways. Jōmon peoples were sedentary, lived in pit house villages of varying sizes, had elaborate material culture, and in some areas and periods had relatively dense populations. In spite of these characteristics, which are usually associated with food production, the Jōmon is generally viewed as a foraging tradition. Until the late 1970s in Japan, little research was being directed toward understanding the parameters of Jōmon subsistence. Identification of bone from prehistoric sites was not uncommon, however, and by 1975 remains of some 39 plant taxa from 208 sites had also been reported (Watanabe 1975). Beyond this, there was little empirical, ecofactual information pertaining to postulated Jōmon agriculture.

A few archaeologists in the early 1900s, such as Torii, Oyama, and Sumida, proposed that Jōmon technology was agriculturally related (see Kotani 1972; Sasaki 1971; Tozawa 1982; and Tsuboi 1964, for discussion). Tsuboi (1964) considered an apparently large population increase from Early to Middle Jōmon in the Chubu district to be evidence for a shift to food production. Fujimori (1965) added at least nine traits to the list of secondary evidence for agriculture: paucity of stone tools; functional differentiation of pottery; snake, human, and sun effigies on pottery; stone clubs; clay figurines; stone monuments; and the proliferation of digging tools and grinding stones. Several carbonized cakes were uncovered at these sites leading to speculation that the cakes were cultigen products. No plant remains were identified to support the hypothesis of Middle Jōmon agriculture, but Fujimori suspected that millet was grown, and others proposed that root crops were husbanded (Esaka 1977).

While Chūbu and northeastern Jōmon population densities were relatively high, the opposite is apparent in southwestern Japan. Koyama (1978, table 3) estimates that 82 percent of Jōmon sites are in northeastern Japan. The low site density in the southwest, according to Kondo (1964), suggests a scarcity of resources. Kondo (1964) proposes that rice, when it was introduced, solved a resource scarcity problem and was, therefore, rapidly accepted. Others, such as Nakao (1966) and Ueyama (1969) suggest that scarcity provided pressure to develop new resources. Nakao and Ueyama also noticed something else: the low density Jōmon occupations were situated in an environmental zone distributed not only over southwestern Japan, but also over southern China, northern Southeast Asia, northeastern India, and southern Korea—in the broadleaf evergreen forest zone (Shōyōjurin-tai) (Zones 7 and 8 in Fig. 2.1). Swidden systems were prevalent in these areas and it was supposed that the subsistence mode of what has come to be known as the "Shōyōjurin-tai Culture" was a solution to resource scarcity problems throughout this region (e.g., Ueyama 1969; Ueyama et al. 1976). Swidden was part of a postulated five-stage sequence leading to wet-rice agriculture. The second stage has been termed *hansaibai*, or semicultivation (Nakao 1966). Native plants, including nut trees, were semicultivated according to this model. Ueyama et al. (1976:88–89) suggest that nuts increased in size as a result of this process. Swidden agriculture lies developmentally between *hansaibai* and wet-rice husbandry in this model. Sasaki (1971) uses comparative ethnographic data to suggest the presence of slash-and-burn agriculture during the Jōmon (see also Pearson and Pearson 1978; Sasaki et al. 1982).

Secondary data have played a major role in establishing the pre-Yayoi agriculture hypotheses. The Middle Jōmon, particularly in Chūbu, characteristically had relatively elaborate material culture and apparently high population densities. Late and Final Jōmon swidden seemed possible in southwestern Japan in light of ethnographic data from similar environmental zones elsewhere in Asia. The few plant remains discovered by 1970, including the carbonized cakes from the Chūbu area, did little to confirm or deny the Middle Jōmon hypothesis. There is some evidence for bottle gourd and rice in later Jōmon sites, such as Shimpukuji, Wakudoishi, Rokutanda, Nogoe, Itatsuke, Yamanotera, and Kureishibaru (discussed in Kotani 1981), which supports the suspicion that plant husbandry was present by about 3000 B.P.

Archaeobotany and Recent Research

Since 1970 a few efforts to recover plant remains have nearly all added fuel to the pre-Yayoi plant husbandry debate. Flotation at the Final Jōmon Uenoharu site on Kyūshū recovered one barley grain and two rice kernels (Kotani 1972:231–32). One red bean is reported from the same site but is considered to be wild on the basis of its small size. No measurements are given, but the small size could also be a result of carbonization. Kotani's work clearly demonstrated the value of recovering plant remains systematically to test subsistence related hypotheses in Japan—an observation made much earlier elsewhere in archaeological research (see, for example, Watson 1976).

Unfortunately, Kotani's early finds had little or no impact on the direction of research taken by Japanese archaeologists. Flotation is rarely conducted in Japan outside Hokkaidō today. It appears that influential local archaeologists have made their own conclusions about plant food subsistence and see no need to test what is self-evident. For example, Akazawa (1982) has constructed a model of differential acceptance of plant husbandry in two regions of prehistoric Japan. Akazawa claims that the prehistoric inhabitants of the Noto Peninsula had little interest in plant food and, therefore, resisted the introduction of rice. No systematic attempt to collect plant remains from the area was carried out, however; therefore, the model is untested. Yet this suggestion is cited in western literature as fact. Nevertheless, wherever purposive collections of prehistoric plant remains have been made in Japan since Kotani's work, results have tended to confirm the existence of some form of plant husbandry. A type of graded water sieving (*suisenbetsu*) used at the Nabatake site, for example, has resulted in the recovery of cultigens from as early as 2700 to 3000 B.P. (Kasahara 1982, 1984).

In the Early and Middle Jōmon, evidence points to the existence of gardening, although it was likely of minor economic value. The constituent of carbonized cakes from eight Middle Jōmon sites has been identified as beefsteak plant or *shiso* (*Perilla frutescens*), a cultigen in the mint family (Matsutani 1983, 1984). The Torihama Shell Mound, a stratified wet site in Fukui Prefecture, contains a wealth of plant remains, including cultigens. Bottle gourd (*Lagenaria siceraria*) (both seeds and parts of the rind), bean (either mung or black gram), *egoma* (a mint cultigen variety of *Perilla frutescens*), burdock, hemp, paper mulberry (*Broussonetia papyrifera*), and Chinese cabbage have been reported (Okamoto 1979, 1983; Umemoto and Moriwaki 1983). A single seed each of bottle gourd and beefsteak plant occur in Initial Jōmon levels. In addition, three broken melon-like cucurbit seeds were recovered. Nakanishi (1983) notes that the seeds do not resemble the local wild melon, *Tricosanthes*. From the published photographs the seeds appear to be those of melon (*Cucumis melo*). Five bottle gourd seeds and pieces of gourd rind are reported from one other Early Jōmon shell midden, Otsubo in Chiba

Prefecture. Finally, peach seeds are reported from the Ikiriki site near Nagasaki, Kyūshū (Minamiki et al. 1986). Peach is not native to Japan. The seeds are from water-logged, marine Early Jōmon deposits. The earliest specimens are from levels VIIIa and VIII'a. The top of level VIIIa is dated to 5660 ± 90 B.P., while two dates are available from level VIII'a: 5830 ± 30 and 5930 ± 30 B.P. (Minamiki et al. 1986). In the same deposits are large quantities of anchor stones indicating substantial seafaring activities that could have provided the mechanism for the introduction of peach from the mainland, where it was native. At any rate it would appear that gardening was a component of Jōmon subsistence in some areas of southwestern Japan by the Early Jōmon.

There is some evidence for early gardening in northeastern Japan as well. A systematic study of carbonized plant remains and related data from eight phases spanning 4,000 years points to barnyard grass and buckwheat husbandry, as well as increasing ecological disruption (Crawford 1983). The evidence for barnyard grass husbandry, an increase in caryopsis size by the end of the Middle Jōmon (Crawford 1983), is not conclusive so more research is required in the Middle and later Jōmon periods of southwestern Hokkaidō. A single buckwheat seed from near the floor of an early Jōmon pit house at the Hamanasuno site is still the only example of a seed of this cultigen in the Jōmon period. Confirmatory evidence for the presence of buckwheat in Early Jōmon Japan comes in the form of pollen from Ubuka Bog in southwestern Japan (Tsukada et al. 1986). Buckwheat pollen composes as much as 1 percent of the more than 1,000 grains counted in sediments radiocarbon dated to 6600 ± 75 B.P. (Tsukada et al. 1986:633).

Some data thought to be relevant to the Shōyōjurin-tai Culture hypothesis have been collected from Kuwagaishimo, a wet site near Kyōtō (Tsunoda and Watanabe 1976). Many of the remains of wild and weedy taxa are not carbonized so it is difficult to assess whether they represent utilization by the Jōmon. Acorn and a Japanese buckeye (*Aesculus turbinata*) are common among the uncarbonized remains. The remains are used to support the hypothesis that a leaching technology evolved in order to utilize these nuts, which contain tannic acid. Grinding stones are interpreted to be part of the leaching toolkit, not tools for grinding or bruising grain (Tsunoda and Watanabe 1976). The Kuwagaishimo material culture is thought to have been rooted in the Middle Jōmon of the Chūbu district and to have diffused from there (Tsunoda and Watanabe 1976). Tsunoda and Watanabe (1976) believe that the Chūbu Middle Jōmon was characterized in part by intensive nut exploitation, not cultigen husbandry; furthermore, because diffusion, as they see it, moved from east to west, the west to east developmental sequence of agriculture that ultimately had been introduced from the mainland is contradicted. They are not willing to accept slash-and-burn agriculture in the Middle or Late Jōmon, but believe the intensive use of nuts and other plants to be a local variant of the semicultivation stage or *hansaibai* in the development of the final stage of the Shōyōjurin-tai swidden-based culture.

Using data from several wet sites, including Torihama, Nishida (1980, 1981, 1983) proposes that chestnut and walnut cultivation was the solution to apparent resource scarcity. His interpretation is based on plant remains that consist mainly of uncarbonized nut remains. Charcoal from these two nut trees is abundant at these sites as well. Nishida concludes that the charcoal quantities reflect the importance of these trees in an environmental context where they would not be abundant without human intervention. Nishida assumes that all the uncarbonized nut remains are food remains, an assumption not adequately explored. The Kuwagaishimo plant remains fit this model as well (Nishida 1981, 1983). Neither Nishida (1976) nor Tsunoda and Watanabe (1976) discuss the significance of carbonized rice grains, barley, and beans (probably *adzuki*) from the Late Jōmon deposits at Kuwagaishimo.

Finally, cultigens are reported from the stratified Nabatake site in Saga Prefecture, northern Kyūshū (Kasahara 1982, 1984). The site has Early, Middle, and Final Jōmon components, as well as early Middle Yayoi occupations. The three cultigens reported by Kasahara (1982) in the Jōmon levels (Final Jōmon) are rice, beefsteak plant, and foxtail millet. A single foxtail millet grain is from level 11 of Units CI–CIV (Kasahara 1982:378). *Shiso* (22 seeds) is found in levels 8, 10, and 11, and two rice grains are from levels 8 and 11. Final Jōmon radiocarbon dates at the site are 3000 ± 80 B.P. (level 13), 4030 ± 65 B.P. (level 12), and 2680 ± 80 B.P. (levels 10–11), 3230 ± 100, 2960 ± 90, and 2620 ± 60 B.P. (level 8) (Tosu-shi Kyōiku Iinkai 1982). Levels 8 to 11, those with cultigens, range in date from 3330 to 2560 B.P. Additional cultigens in the Yayoi levels include hemp, peach, and melon. Watanabe and Kokawa (1982) examined a sample of large seeds from Nabatake and report four seeds of mung bean or *ryokuto* (*Vigna radiatus*) from the Final Jōmon horizon as well.

Northeastern Spread of Plant Husbandry

Most researchers argue that, after rice husbandry was established in southwestern Japan in the Early Yayoi (Kanaseki and Sahara 1978), it diffused rapidly northeastward to about 35° north latitude during the Middle Yayoi. Not until the development of a rice variety that was capable of tolerating more northern climates did rice move to about 41° north latitude. Kondo (1964) and Sahara (1975) estimate that this third stage took place during the Middle to Late Yayoi. Akazawa (1982) believes that the flourishing Jōmon fishing societies in the east resisted rice agriculture, resulting in a cultural dichotomization (Akazawa 1982:203). Yayoi-influenced rice production moved northeastward, but initially only inland where "intensive plant collecting and/or incipient plant cultivation of native species" (Akazawa 1982:200) was taking place. The inland Jōmon populations, therefore, appear to have been more receptive to rice agriculture than their coastal counterparts. In recent years, however, prehistorians have viewed the rapid Early Yayoi spread as first a migration followed by the overwhelming reproductive success of the migrants (Brace et al. 1989; Hanihara 1987). Under these circumstances, receptivity of the Jōmon to rice may not have been as much of a factor as Akazawa suggests. Akazawa, however, provides valuable data about exploitation territory and technology regarding fish, but plant remains have not been collected from the same eastern coastal areas. Until they are collected, the reasons for the apparent differential acceptance of rice should remain open to question. In addition, the Tōhoku Yayoi was established in northern Honshū no later than three to four centuries after the Yayoi began in Kyūshū. I have questioned elsewhere the differential rate of Yayoi development in southwestern and northeastern Japan (Crawford 1992). Whatever the case, the Yayoi in northernmost Honshū maintained a local identity as a result of the acculturation of Final Jōmon populations (Crawford and Takamiya 1990).

Evidence contradicting the view of a wave of rice agriculture slowly progressing to the northeast by the Late Yayoi has been recovered in Tōhoku. Kuraku (1984) reports rice paddies and rice impressed pottery from the Tareyanagi site in Aomori Prefecture (first century A.D.) contemporaneous with Middle Yayoi in southwestern Japan. This rice may be descended from Jōmon rice in southwestern Honshū, but Hoshikawa (1984) hypothesizes that an early ripening rice variety was introduced from Kyūshū via the Japan Sea directly to northern Honshū, bypassing southwestern Honshū. Rice in Tōhoku could well have evolved from earlier rice in the area. A few rice grains and hull fragments are reported from a locality of the Final Jōmon Kamegaoka Culture in Aomori Prefecture in association with Ōbora A pottery (Sato 1984), which is contemporaneous with the Early Yayoi. Rice husks in pottery at the Aramachi site in Aomori Prefecture are a further indication that rice was present there about 2200 or 2300 B.P. (Ito 1984). The earliest rice in northeastern Japan has been accelerator radiocarbon dated to 2540 ± 240 B.P. (TO-2022). The rice is from the Late Jōmon component of the Kazahari site (D'Andrea 1992). Clearly, rice may have as long a history in the northeast as in the southwest. After the northern Yayoi was established, a dry farming system with barley, wheat, and millet gained success, probably at the expense of wet rice husbandry (Crawford 1992; Crawford and Takamiya 1990).

Elsewhere in northeastern Japan little is known about the subsistence of phases between the later Jōmon and the first historic period occupations. Prehistorians recognize non-Yayoi groups who are known as the Zoku-Jōmon, Continuing, or Epi-Jōmon (Fig. 2.2) in Tōhoku and Hokkaidō. Few villages are known from this period in Hokkaidō, the majority of sites being cemeteries. The Zoku-Jōmon and Tōhoku Yayoi were contemporary, with the two groups exchanging pottery, beads, and occupying mutually exclusive territories. Cultigens are reported from three Zoku-Jōmon sites: barley from K135 (Sapporo Station, North Entrance site) (Crawford 1987), hemp from Ebetsu Buto (Yamada 1986), and barley and rice from Mochiyazawa (D'Andrea 1992). The seeds are so few in number, however, that a case for Zoku-Jōmon plant husbandry is difficult to justify in view of their settlement pattern and technology. Village sites become common again about A.D. 600 with the development of the Ezo phase, generally acknowledged to be ancestral Ainu (Yoshizaki 1983). Until recently, the cultural sequence of Hokkaidō was described as a series of foraging societies culminating in the historically documented Ainu. In recent years, however, it has been discovered that food production played a significant role in early Ezo subsistence (Crawford 1992; Crawford and Takamiya 1990; Crawford and Yoshizaki 1987).

The Cultigens

The archaeobotanical assemblage from Ezo period Hokkaidō, besides confirming the existence of what appears to be an intensive phase of plant husbandry in some parts of Hokkaidō, provides an important body of data pertaining to prehistoric agricultural systems that are not based on rice in eastern Asia. Eleven or twelve cultigen taxa have been identified from the Sakushu-Kotoni River and other Ezo period sites in Hokkaidō (Crawford 1986; Crawford and Takamiya 1990; Crawford and Yoshizaki 1987). Sorghum and buckwheat are reported from one site each (Satsumae and K441 respectively) (Yoshizaki 1989). With a few exceptions, such as bottle gourd, Chinese cabbage, and paper mulberry, cultigens found at sites elsewhere in temperate East Asia are also found in Hokkaidō. The Hokkaidō data thus provide a focus for the discussion of cultigen history and descriptions. Crops in the grass family (Gramineae or Poaceae) are presented first, followed by a discussion of other cultigens listed in alphabetical order of common names.

Barley (*Hordeum vulgare*)

China is one center of diversity for barley (Harlan 1968; Zeven and Zhukovsky 1975:81). If barley was introduced to China from western Asia, then at least two millennia of isolation from western Asian gene pools would have provided ample time for the evolution of local genotypes and phenotypes. The possibility remains open, however, that barley was independently domesticated in China. *H. spontaneum*, the wild relative of cultigen barley, is reported in Tibet and Szechwan and may be the progenitor of Chinese naked barley (Chang 1983:78). Unfortunately, the archaeological evidence for the spread and diversification of eastern Asian barleys is nonexistent.

Takahashi (1955) has described the Asian forms of barley and at least one study identifies a separate Chinese subspecies, *H. vulgare* ssp. *humile* (Zeven and Zhukovsky 1975:81). This subspecies is a short, six-row barley. Takahashi's (1955) taxonomy does not include this subspecies, but he makes some observations on the distribution of certain characteristics of Asian barley that separates it into what he terms "Occidental" and "Oriental" groups. Three examples of traits with distinctive distributions are the alleles for tough rachis, frequencies of naked barley, and the occurrence of semibrachytic forms. Type E of three genotypes (Types E, W, and ew) of tough rachis barley dominates (95–100 percent) the "Oriental" region (China, South Korea, and southern Japan) while high frequencies of Type W (62–72 percent), similar to southwestern Asia, Europe, and the Soviet Union, occur in the "Occidental" region (Manchuria, North Korea, and northern Japan) (Takahashi 1955:240). Takahashi (1955) believes that this is a result of independent migrations into eastern Asia of two types of barley with separate evolutionary lines. Takahashi's "Oriental" line could be related to the barley that Chang (1977) suggests is derived from the plateau area of southwestern China.

Naked barley is found in two areas: the southern, warmer parts of the winter barley zones of central China, South Korea, and southern Japan, and the spring barley zones of northern Japan (Chang 1977:252). On average, half of the barley in these areas is the naked form (Chang 1977:252). Takahashi's map (1955:257) illustrates that only a small percentage of the Hokkaidō barley is hulled in contrast to the Tōhoku region where most of the barley is hulled. Both naked and hulled barley grains compose the Sakushu-Kotoni River site collection, but the proportions of naked versus hulled types have not been estimated yet. Based on my own observations, both types are present in significant quantities. The Ainu apparently grew both forms, but naked barley was more important to them (Hayashi 1975). A form of barley unique to eastern Asia is reported mainly in Japan and Korea where it was introduced from Japan at the turn of the twentieth century (*ca.* A.D. 1910) (Hayashi 1975:256). This is the semibrachytic form (*uzu*). A single gene is responsible for shortening plant parts without affecting their width, resulting in a variety of barley that tolerates heavy manuring in warm and rainy weather (Hayashi 1975:256). The semibrachytic form is restricted to southwestern Japan while only "normal" forms are found in Hokkaidō and Tōhoku (Takahashi 1955). Some normal forms are also found in southwestern Japan.

There is some disagreement on whether barley is named on Shang oracle bones (Chang 1983:77). Ho (1977:448) believes that two characters for wheat are found on the oracle bones and that a character for barley is not. Whatever the case, there are no publications of confirmed archaeological finds of barley from China. Barley is reported from the late fourth millennium B.P. Hunamni site in Korea, so it is safe to assume that barley was grown in China during the early Shang Dynasty. Ho (1977:449) has already suggested that barley was introduced to eastern Asia by 4000 B.P. Two reports of barley suggest that it entered Japan by the beginning of the third millennium B.P. This is certainly possible because of its early appearance in Korea as well. The single carbonized grain from the Late Jōmon Uenoharu site in Kyūshū is a short grain measuring 3.8 mm in length by 2.0 mm in width. Two barley grains from the Late Jōmon Kuwagaishimo site near Kyōtō are longer but still relatively short, measuring 5.0 by 3.3 mm and 5.4 by 2.5 mm (estimated from Plate 4 in Tsunoda and Watanabe 1976). Barley remains are not found in substantial quantities in Japan until the Kofun Period. By this time, sizeable populations of relatively short-grained barley are evident. A sample of 100 caryopses from the Daiichi Chūgakkō site in Kawagoe City, Saitama Prefecture, has average length, width, and thickness (range) of 5.0 (2.5–7.1), 2.3 (1.4–3.3), and 1.8 (1.2–2.7) mm, respectively (Naora 1956:271). A population of 1,000 kernels from the Shitakitabara site in Chiba Prefecture averages 5.0(3.6–7.1) by 2.7(1.8–3.5) by 2.2 (1.4–3.0) mm (Naora 1956:273, 282). One other group of barley grains (n = 60) from the same site has mean dimensions of 6.3 (5.0–8.0), 2.6 (1.8–3.1), and 2.2 (1.5–2.8) mm.

Although our sample of archaeological barley is small, some conjecture is in order. The three samples from Saitama and Chiba prefectures segregate into two groups based on grain length. Shorter grains are relatively abundant in one sample from each prefecture. One sample from Chiba Prefecture contains no grains shorter than 5.0 mm, and grains longer than 7.0 mm compose more than 10 percent of the sample. The grain widths do not show a corresponding dichotomy, suggesting that grain length varies independently of width in these samples. For northern Japan, archaeological barley populations should be primarily long-grained if Takahashi (1955) is correct in his interpretation that only "normal" barley was grown there. Archaeological grain size (mainly breadth), however, can be affected by crop processing methods, such as sieving. Without knowing whether a grain sample was processed before carbonization, the representativeness of any one sample cannot be assessed. Furthermore, grain size variation in *uzu* barley has not yet been documented. We have identified some 30,000 barley grains from Sakushu-Kotoni River so far. Because the sample comes from a variety of contexts, it is likely representative of the whole population at the site. By contrast, we have no such assurances for Naora's (1956) data. The Ezo grains are generally "normal" size. A sample of 1,378 grains have mean (range) length, width, and thickness measurements of 5.3 (3.1–8.5), 2.5 (1.3–4.0), and 2.1 (0.9–3.2) mm, respectively. About 10 percent of the sample is shorter than 3.9 mm, suggesting that a proportion of the Sakushu-Kotoni River population is outside the range of variation of Takahashi's (1955) "Occidental" barley. Small examples of barley are evident in the first millennium A.D. in Japan. The one sample of predominantly "normal" barley from Hokkaidō suggests that the distributions of *uzu* and "normal" barley may well have been forming their historically documented pattern by the middle of the first millennium A.D. in Japan. The significance of the form of the Uenoharu and Kuwagaishimo grains is difficult to assess without comparative archaeological material from the same time period elsewhere in eastern Asia. Clearly, considerable work needs to be done on East Asian barley.

Barnyard Millet (*Echinochloa utilis*)

A common grass seed in northeastern Jōmon sites is barnyard grass or barnyard millet. Kidder (1959:54) mentions seeds of this grass from a Jōmon site and this report has occasionally been cited as evidence of millet husbandry by the Jōmon (e.g., Turner 1979). No confirmation of this identification has been made, however, nor is the context of the seeds reported. Research on several phases of Initial to Early Jōmon in southwestern Hokkaidō, however, supports the contention of its use by 5000 B.P. (late Early Jōmon) and the intensification of its contribution to the Jōmon by 4000 B.P. (the end of the Middle Jōmon) (Crawford 1983:31–34). An increase of nearly 15 percent in the size of the seeds over one millennium is cited as evidence for local domestication taking place. A carbonized mass adhering to a Middle Jōmon ceramic sherd contains at least one *Echinochloa* seed with portions of the palea and lemma (glumes enclosing the caryopsis or grain) still attached. The size and shape of the specimen is within the range of the cultigen barnyard millet. Barnyard grass caryopses are present in the Sakushu-Kotoni River samples but they are few in number and all are the size of wild specimens.

At the Ubuka Bog in southwestern Japan (Tsukada et al. 1986), grass pollen grains larger than 41 microns represent at most 5 percent of the pollen between 6600 and 3100 B.P. Such large grains suggest cereal plant husbandry during the Jōmon in southwestern Japan (Tsukada et al. 1986:633). More attention should be paid to the smaller carbonized grass seeds from Jōmon sites to test the existence of cereal plant husbandry from the Early Jōmon and subsequent periods. Two taxa closely related to barnyard grass are *Echinochloa crusgalli* var. *frumentacea* (or *E. frumentacea*) and *E. utilis* (Yabuno 1966). *E. utilis* is derived from *E. crusgalli*. The two taxa are in the same genome, one that does not include *E. frumentacea*, the Indian cultigen form (Yabuno 1966:320–21). The presence of barnyard millet in Ezo period Hokkaidō has not yet been confirmed but is reported from three historic sites in southwestern Japan (Matsutani 1984). The distinctions between *E. utilis* and broomcorn millet (*Panicum miliaceum*) are subtle. Several hundred grains in the size range of broomcorn millet at Sakushu-Kotoni River are relatively broad, have longer embryos, and are relatively smooth compared to broomcorn millet. Pending further study, I suggest that these are barnyard millet. A flotation sample collected from the Okawa site in Hokkaidō in 1989 contains the only confirmed example of barnyard millet in post-A.D. 600 Hokkaidō. Okawa, however, has a historic component and the grain could be recent.

Distinct from the food grain forms of *Echinochloa* are the weed forms associated with rice fields. Among the most noxious weeds of rice are members of the barnyard grass complex (Barrett 1983). One, *E. crusgalli* (L) Beauv. var. *crusgalli*, is a small-seeded weedy form while a large-seeded form is *E. crusgalli* (L) Beauv. var. *oryzicola* (Vasing) Ohwi, a crop mimic of rice (Barrett 1983:265). Archaeobotanical studies of subsistence systems based on wet rice in eastern Asia should pay close attention to this barnyard grass complex. Large seeds of *Echinochloa* should be carefully examined to distinguish *E. utilis* from *E. crusgalli* var. *oryzicola*. The two grains can be distinguished by their morphology.

There are several reports of Yayoi barnyard millet. Kasahara et al. (1986:121), for example, report 48 seeds from the Early Yayoi component and 3 seeds from the Final Jōmon level at the Megumi site in Yonago city. It is important, however, to determine whether this is actually the crop form or rice paddy weed form of *Echinochloa*. If it is the paddy weed form, then the question of Yayoi barnyard millet production is still open.

Broomcorn or Common Millet (*Panicum miliaceum*)

Broomcorn millet is a tetraploid and the species is not known as a wild form, although there are several Asian species that may have contributed to the broomcorn millet genome (Smith 1976). Zeven and Zhukovsky (1975:32) note that China is the primary center of diversity for broomcorn millet. Botanical descriptions of broomcorn millet are not found in early Chinese documents (Chang 1983:66), but the plant is mentioned on oracle bones and in the *Book of Odes* (Ho 1977:438). Ho (1977) summarizes the philological evidence for *Panicum* and concludes that it was introduced to western and southern Asia from China. It has been identified at three Middle Neolithic and five Late Neolithic sites on the Loess Plateau (Yan 1989). Broomcorn millet has one of the lowest water requirements of any cereal (Smith 1976), insuring its success on the Loess Plateau in the early mid-Holocene. Its domestication probably began earlier than 8500 B.P., when it is first found as a domesticated form.

There is only one report of Jōmon broomcorn millet and it is from a Late Jōmon context at the Kazahari site, Aomori Prefecture (D'Andrea 1992). Similarly, the only Yayoi broomcorn millet recovered to date is from the same site (D'Andrea 1992). Broomcorn millet was an important crop at Sakushu-Kotoni River (over 64,000 specimens) during the ninth century A.D. It appears to have become important sometime between A.D. 300 and A.D. 800 in Japan.

The broomcorn millet from Hokkaidō is nearly all hulled, that is, only caryopses are present except for a few examples. A sample of 604 grains from the Kashiwagigawa site have mean length, width, and thickness measurements of 1.8, 1.8, and 1.4 mm, respectively.

Foxtail Millet (*Setaria italica* ssp. *italica*)

Foxtail millet also has a long history of use in eastern Asia. Three cultigen races are known: moharia from southwestern Asia and Europe, maxima from the Far East and Transcaucasian Russia, and indica from southern Asia (Rao et al. 1987). All available evidence points to its domestication in East Asia, although independent domestication elsewhere cannot be ruled out (Rao et al. 1987). Chang (1986) and Yan (1989) report foxtail millet from one Middle Neolithic and 15 Late Neolithic sites in North China. By 8000 B.P., foxtail millet seems to have become an important crop. Large quantities of carbonized remains of this grain were apparently found at Banpo (Ho 1977). Unfortunately, we lack any thorough botanical studies of these remains. According to the directors of the Banpo Museum, the plant remains have not been examined since they were excavated in 1956 (personal communication, 1986). As an archaeobotanist who has spent considerable time working on collections containing the three kinds of millets discussed in this chapter, I am concerned about casual reports such as these. The foxtail millet identification is likely correct, but other millets may be present in small proportions. So far, of 21 sites with millet in the Middle and Late Neolithic, only one site (Linjia) has both foxtail and broomcorn millet (Yan 1989). Until thorough, documented analyses are reported, these concerns will remain.

Historic documents show that foxtail millet was an important crop by the Zhou Dynasty (Chang 1983:66–67). The earliest confirmed report of foxtail millet from Korea is from the Bronze Age Hunamni and Honamni sites (Choe 1982:524; Kim 1982:514; Nelson 1982:128). Some foxtail millet is reported from the Final Jōmon levels at the Nabatake site in Kyūshū. A few reports of foxtail millet come from Yayoi sites (e.g., Kasahara et al. 1986). Cultigen *Setaria* may be present as early as the late Middle Jōmon in Hokkaidō. I recently reexamined carbonized grass specimens from Usujiri B and found at least nine specimens in one sample to be morphologically indistinguishable from foxtail millet seeds. In addition, foxtail millet is reported from the Late Jōmon component of the Kazahari site (D'Andrea 1992). Foxtail millet is the most numerous of the grains at Sakushu-Kotoni River; but, because the caryopses are so small (105 seeds from the site measure 1.2 by 1.0 by 0.7 mm; and 1,081 seeds from the Kashiwagigawa site measure 1.3 by 1.3 by 1.0 mm), the food value obtained from this grain was probably somewhat lower than that obtained from barley and broomcorn millet in the early Ezo. Two weedy species of *Setaria, S. glauca* and *S. italica* ssp. *viridis,* are the most common weedy grasses in the Sakushu-Kotoni River samples.

Rice (*Oryza sativa*)

Rice was domesticated in subtropical or tropical Asia rather than in the northeast, which is the subject of this chapter. Domestication seems to have occurred as the range of this grass expanded out of the highlands of Southeast Asia and southwestern China (Chang 1976a). The specific place or places of rice domestication, however, cannot be determined (Chang 1976a, 1976b; Oka 1988:110). *Oryza rufipogon* is accepted as the wild ancestor of cultigen rice (Oka 1988). This wild rice continuously grades from perennial to annual types. The latter is usually called "weedy rice" while the former is called "wild rice." Weed races (known as spontanea forms) hybridize freely with domesticated rice. Furthermore, the perennial and annual forms of *O. rufipogon* are distributed in a continuous belt from the foothills of the Himalayas to the Mekong region (Chang 1976b:101). Annual weedy rice, but not the perennial form, is also distributed in the Lower Yangtze River basin (Oka 1988; Yan 1989).

Three ecogeographic races are normally recognized: *Oryza sativa* var. *indica, O. sativa* var. *javanica,* and *O. sativa* var. *sinica* (*japonica*) (Chang 1976a). The *sinica* type, as Chang (1976a) refers to it, is traditionally known as *O. sativa* var. *japonica.* Following Oka (1988), I refer to it as "Japonica" and *O. sativa* var. *indica* as "Indica." Oka (1988:146) does not accept the *javanica* variety as a true type. It has never been formally defined and is essentially identical to Japonica. Oka groups Chang's *javanica* rices into a tropical subgroup of Japonica. Wild rice is not split into Indica or Japonica forms, although weedy rice does show some differentiation into similar types (Oka 1988:163). Gene flow between Indica and Japonica is restricted; F1 hybrids are sterile (Oka 1988). Rice produced in northern China, Japan, and Korea is all Japonica (Chang 1985; Oka 1988:154). Japonicas are also grown at higher elevations in northern Thailand and southern China where the lowland rice variety is Indica (Oka 1988:154). The evolution of the two types is as yet unexplained. Oka (1988:169) proposes that the founders of each type became established after the domestication of rice had begun. Japonica is usually considered to be short-grained while Indica is long-grained. This criterion is rather unreliable, however. The variation of grain size within the two groups gives a 39 percent chance of misclassification (Oka 1988:144).

The early evidence for rice domestication is rather sparse. Chang's identification of the early rice from Non Nok Tha, Thailand (5500 B.P.), as a form intermediate between wild and domesticated could be construed to mean that rice agriculture was not part of the sixth millennium B.P. economy of northern Thailand (Yen 1982:52). Yen (1982:63) points out that this is an oversimplification; gene exchange between wild forms and forms grown in early rice fields was an ongoing process that could have resulted in the intermediate characters observed on archaeological specimens. Earlier rice comes from layer 4 at the Hemudu site (7000 CAL.B.P.), just south of Shanghai in the lower Yangtze River region. It is mainly long grain, described as subspecies *Xian Ding* (Yu 1976:21). Some short grain rice is also present in the same samples (Yan 1989:18). The mixtures are about 80 percent Indica-type and 20 percent Japonica-type (Oka 1988:136). Grass pollen as large as 49.5 microns has been recovered from the same level (Chekiang Provincial Museum 1978:107). The rice reported from the Luojiajiao site in Zhegiang Province from about 7000 B.P. is Japonica (Chang 1985). If rice was differentiated into Indica and Japonica varieties by 7000 B.P., the initial steps in the domestication process must have occurred much earlier than this. Before these reports, the earliest reports of short-grain rice, besides that from Hemudu, were from the Yangtze basin, dated to 3311 ± 136 CAL.B.C. and 2696 ± 190 CAL.B.C. (Chang 1983:73). The earliest rice in northern China is from the Yangshao site belonging to the Miaodikou II Phase (about 4200 to 5000 B.P.) reported by Andersson (1934). This rice is short-grained (Chang 1983:73). Accelerator radiocarbon dates on rice from the Andaryan site in the Philippines give the first solid date for rice in that area: 3400 ± 125 B.P. (Snow et al. 1986). This rice is also identified by T.-T. Chang as an intermediate form (Snow et al. 1986).

The weedy, spontanea form of rice has been recently found growing in the Yangtze basin (Yan 1989). Yan assumes that the weedy form is ancestral to domesticated rice and concludes, on the basis of this evidence, that rice could have been domesticated independently in the Yangtze basin. It is an oversimplification to assume that the weed form of *O. sativa* is ancestral to domesticated rice. The possibility that rice was independently domesticated in this region, however, should remain open.

Rice is known from the late fourth millennium B.P. Hunamni site in Korea (Choe 1982). In addition, a few examples of Late and Final Jōmon (about 3000 B.P.) rice have been reported from Nabatake (Kasahara 1982) and Uenoharu (Kotani 1972) in southwestern Japan. One measurable kernel from Uenoharu is relatively short-grained (4.4 by 2.2 by 1.8 mm). The Late Jōmon rice from the Kazahari site is also relatively short-grained. Data accumulated from over 100 Yayoi sites have yet to show the presence of any rice other than the short-grain Japonica variety whose length, width, and thickness measurements range from 3.7–5.3 by 1.3–2.0 by 3.0–3.7 mm, respectively (Sato 1971). Nineteen carbonized rice grains from Sakushu-Kotoni River are the northernmost prehistoric examples of this cultigen in Japan. The rice is relatively short-grained, averaging 4.1 by 2.6 mm. It must be kept in mind, however, that grain size is an unreliable characteristic for identifying rice varieties. The most probable route of entry of rice to Japan is from the lower Yangtze River in China, an area where both short- and long-grained rice were grown in prehistory, to South Korea and then to Kyūshū or directly to Kyūshū, bypassing Korea (Akazawa 1982).

Wheat (*Triticum aestivum*)

Wheat has a relatively long history in East Asia, although how long is currently open to question. Japan and Korea are considered to be secondary centers of diversity of this genus (Zeven and Zhukovsky 1975:33). East Asian wheat is fast ripening, has precocious forms, and crosses easily with rye, something southwestern Asian varieties do not do (Zeven and Zhukovky 1975:33). Oracle bone inscriptions indicate the presence of wheat in China by the late second millennium B.C., leading Ho (1977) to suggest that it must have been introduced sometime earlier. Chang (1983:77), however, does not agree that wheat is noted on oracle bone inscriptions. The earliest radiocarbon date associated with Chinese wheat is 3010 ± 90 B.P. at Chien-ch'uan (Chang 1977:455). Ho (1977:448), however, claims that archaeological wheat reports have not been verified. Not until spring wheat was introduced from Central Asia during the Han Dynasty did it surpass barley in importance (Ho 1969; Chang 1983:79). By 2300 B.P., wheat was being grown in Korea (Kim 1982). Today, spring wheat is grown mainly north of the Great Wall.

Japanese wheat has played an important role in modern wheat breeding. A dwarf variety of wheat known as Nōrin-10 (a catalogue number for the Department of Agriculture and Forestry or Nōrin) was used in crosses to produce a hardy dwarf wheat that has become an important crop in Mexico (Janick et al. 1981). This variety of wheat was reported as early as 1893 (Janick et al. 1981). It matures early, is short, and has stiff straw (Peterson 1965:223). Vavilov (1951:196) was also aware of small grained wheat in East Asia, and describes it as early ripening and low growing.

Interestingly, archaeological wheat from Japan and Korea is unusually small, indicating the importance of a variety of dwarf wheat in that part of Asia as early as the Kofun period. The evidence based on grain morphology also indicates that this wheat is neither club wheat (*Triticum aestivum* ssp. *compactum*) nor Indian dwarf wheat (*T. aestivum* ssp. *sphaerococcum*), the two dwarf varieties known to have been grown extensively in prehistory (Crawford and Yoshizaki 1987). The shape of the kernels is closer to the shape of Indian dwarf wheat grain from Pakistan and northern India, but this wheat never moved into East Asia (Zeven 1980). The Japanese wheat may be a form unique to Japan and Korea (Crawford and Yoshizaki 1987). It likely occurs in the Chinese archaeological record as well, because the source of the Korean and Japanese wheat is China.

Naora (1956) confusingly reports the presence of normal bread wheat, as well as compact wheat, from the Kofun period in Japan. His interpretation is based on twelve specimens of wheat from the Sohara site in Yamanashi Prefecture, six of which are identified by Naora (1956) as *T. vulgare* (*T. aestivum* in the modern terminology). The six examples of *T. vulgare* (*T. aestivum*) are smaller (averaging 4.0 by 2.5 by 2.0 mm) than the compact grains he reports (averaging 4.4 by 3.5 by 2.8 mm) (Naora 1956:283). All the specimens of wheat from the Sohara site seem to be the Japanese compact type. The wheat from Sakushu-Kotoni River currently numbers 5,666 specimens and is all free-threshing. The grains are unusually short compared to three other examples from Korea and Japan (Table 2.2). In general, however, except for some grains from Idenshikōgaku, the archaeological wheat from East Asia is all relatively compact. Only 38 of a total of 204 wheat grains from the Idenshikōgaku site, Hokkaidō University, are compact; the rest are large. There is reason to believe the large grains are from a relatively late deposit at the site. Similar large wheat grains have been accelerator radiocarbon dated to 210 ± 50 B.P. at the Poplar Namiki site, Hokkaidō University (Crawford and Takamiya 1990). First millennium A.D. northern Japanese wheat may be an extreme form of the compact wheat that probably had a wide distribution in East Asia. A compact Japanese wheat is known from archaeological sites as late as the end of the Edo period (end of the nineteenth century A.D.) in southwestern Japan (Okada 1985).

Adzuki and Mung Beans (*Vigna angularis* and *V. radiatus*)

The *adzuki* and mung beans, both of which occur at Sakushu-Kotoni River, are members of the subgenus *Ceratotropis* of the genus *Vigna* (Marechal et al. 1978; Verdcourt 1970). *Ceratotropis* has an exclusively asiatic and oceanic distribution. The black gram or *urd* (*V. mungo*) is one other important cultigen in this subgenus. Black gram and mung are apparently derived from *V. radiata* var. *sublobata* (Verdcourt 1970), which is found today in eastern Africa and Madagascar (Marechal et al. 1978). *V. angularis* var. *nipponensis* is probably the wild ancestor of *adzuki*. Its distribution is limited to Japan (Marechal et al. 1978:214). *Adzuki* is the bean usually reported from prehistoric Japan and Korea. The only other archaeological mung beans (carbonized) reported in this area are from the Early Jōmon strata at the Torihama Shell Mound. Historic references to *adzuki* and mung beans in China are not found until the sixth century A.D. (Li 1983:47–48). Three probable mung beans and one other bean believed to be black gram were found in samples collected in 1975 (Umemoto and Moriwaki 1983). The hilum width and shape were used to distinguish the two taxa, but a scanning electron microscope examination of the seed coats of the archaeological specimens appears to be the primary basis for distinguishing the beans from each other and from other species and varieties of *Vigna*. In my opinion the patterns observed on the archaeological specimens are not clear in the published illustrations. The Torihama bean identifications should best be left open to question for the time being.

Adzuki and mung beans appear in historic records in eastern Zhou (Chang 1983:81), but there are no archaeological data pertaining to their putative domestication in China. In Japan the earliest appearance of the *adzuki* bean is in the Final Jōmon, where it appears in flotation samples from Uenoharu (Kotani 1972) and Nabatake (Kasahara 1984; Watanabe and Kokawa 1982). Most of the 61 beans from Sakushu-Kotoni River are *adzuki*. Some are mung, while a

Table 2.2 East Asian Wheat Measurements

Site and Location	Mean (Range) mm	Standard Deviation	N[a]
Sakushu-Kotoni River Site, Hokkaidō			
length	3.4 (2.1–5.5)	0.43	403
width	2.4 (1.4–4.2)	0.41	403
thickness	2.2 (1.1–3.5)	0.38	403
Idenshikōgaku, Hokkaidō			
length	5.2 (3.7–6.7)	0.70	131
width	3.4 (2.1–4.6)	0.51	131
thickness	2.8 (1.8–3.9)	0.47	131
Ichinohe, Iwate Prefecture			
length	4.1 (3.5–5.0)	0.29	48
width	2.8 (2.3–3.7)	0.33	48
thickness	2.2 (1.8–3.1)	0.28	48
Puyo, South Korea			
length	4.2 (3.2–5.3)	0.43	100
width	2.2 (1.4–3.5)	0.31	100
thickness	1.8 (1.2–2.3)	0.22	100

Sources: Wheat measurement information for the Sakushu-Kotoni River site and Idenshikōgaku site are derived from Crawford (1991); for Ichinohe from Sato (1986); and for Puyo from Naora (1956).

[a]This number represents the number of grains in the measured sample, not the total site sample. Wheat grains in the measured sample are all carbonized.

few are not identifiable to species. The Hokkaidō *Vigna* length, width, and thickness measurements are 6.0 (4.8–7.1), 3.9 (3.0–4.8), and 3.8 (2.3–5.0) mm, respectively.

Hemp (*Cannabis sativa*)

Hemp is a cultigen with a variety of uses, including oil and food from the fruit, fiber from the stems, and drugs from the flowers and fruiting tops (Bailey 1976:218). The genus, according to Bailey (1976), is monotypic, while Zeven and Zhukovsky (1975:130) and Beutler and Der Marderosian (1978) recognize a separate species, *C. ruderalis,* which may be derived from cultigen hemp. The Ezo phase sample consists of at least 160 achenes distributed in 14 samples at Sakushu-Kotoni River, which were derived mainly from one midden sample (124 specimens).

Hemp is indigenous to temperate central Asia (Bailey 1976:218; Simmonds 1976:203). Literary references to hemp date from 1122 B.C. in China (Li 1974:440). Li (1974:438) proposes that it was in use at least 3,000 years earlier in northern China on the basis of evidence for the existence of textiles and fiber production at Yangshao. The only direct evidence for hemp husbandry in the North China Neolithic is from the western Yangshao (Majiayao) Culture at the Linxia site (5500–4500 B.P.) where carbonized hemp fruit was found in pottery on a house floor (Chang 1986:143). Fibres and achenes have been identified from the Early Jōmon levels at Torihama in southwestern Japan (Kasahara 1984).

Melon (*Cucumis melo*)

Three broken melon seeds from Sakushu-Kotoni River make this the northernmost archaeological occurrence of this taxon in Japan and the only prehistoric example from Hokkaidō. The generally accepted area of origin for melon is western Africa (Bailey 1976:342; Whitaker and Bemis 1976:67; Zeven and Zhukovsky 1975:30). Whitaker and Bemis (1976:67) consider India to be a secondary center of diversity, while Zeven and Zhukovsky (1975:30) describe China as a secondary center of diversity. Some 5,076 melon seeds have been found at 102 archaeological sites in Japan (Fujishita 1984:640). Thirty-six of the sites are Yayoi (1,557 seeds), while one, the Yamanotera site on Kyūshū, is Final Jōmon (1 seed). A melon seed, presumably *Cucumis* sp., is reported from the Early Jōmon levels at Torihama (Kasahara 1983). The northernmost reports before the Hokkaidō discovery were from Miyagi Prefecture, near Sendai, dating to the eighth and ninth centuries A.D.

Beefsteak Plant and *Egoma* (*Perilla frutescens*)

P. frutescens is grown today for its aromatic leaves and oil seeds, as well as its medicinal properties in China, Japan, and Korea (Li 1969). It is an annual herb with two forms: green-leaved (*egoma*) and red-leaved (beefsteak plant or *shiso*). Beefsteak plant is *P. frutescens* (L.) Britt var. *crispa* Benth [*P.crispa* (Thunb.) Nakai]. *Egoma* is classified as *P. frutescens* var. *japonica* Hara (see also Bailey 1976:846; Zeven and Zhukovsky 1975:34). *Egoma* is usually associated with slash-and-burn (swidden) agriculture, while beefsteak plant is usually a cultigen of house gardens (Matsutani 1983:183). *Egoma* and beefsteak plant seeds are distinguishable, but with some difficulty.

Seeds of *Perilla* are present in the Sakushu-Kotoni River collection, although not in great abundance (14 seeds). Its occurrence in other Ezo phase sites affirms this cultigen's presence by 800 A.D. in Hokkaidō. Its main area of diversity is China (Zeven and Zhukovsky 1975:34), but no prehistoric or early historic Chinese references to this plant exist. The earliest data are from Japan. A single beefsteak plant seed comes from the Initial Jōmon level 13 at Torihama and seven specimens are from Early Jōmon levels (Kasahara 1983). Seeds of beefsteak plant or the closely related *egoma* are a constituent of carbonized cakes from eight Middle Jōmon sites in Nagano, Giifu, Fukushima, and Nagano prefectures (Matsutani 1983:183). Beefsteak plant is a component of the Nabatake site Final Jōmon samples as well.

Other Cultigens

Buckwheat, bottle gourd, Chinese cabbage, great burdock, lacquer tree (*Rhus vernicifera*), and paper mulberry are reported from a few Jōmon sites. Yayoi sites also include peach, apricot (*Prunus armeniaca*), plum (*Prunus salicina*), pear, soybean, and pea (*Pisum sativum*) (Kasahara 1986; Kotani 1972:70–75; Naora 1956; Sato 1971). Buckwheat is the only taxon of this group thought to have been grown at Ezo phase sites. This is inferred from buckwheat pollen identified at six Ezo sites; it is recorded from six Zoku-Jōmon sites as well (Okada and Yamada 1982:28). The same authors consider the appearance of such pollen significant because buckwheat is pollinated by insects (windborne pollen contaminates samples more easily than does insect-borne pollen) and the samples were taken from within house floors. Buckwheat pollen is present in sediments dating to 6600–4500 B.P. at Ubuka Bog (Tsukada et al. 1986). The earliest buckwheat pollen in northern Japan is from burned clay at the Late Jōmon (ca. 3000 B.P.) Kyūnenbashi site, Iwate Prefecture (Yamada 1980). Only one carbonized buckwheat seed is attributed to the Jōmon period, found in a late Early Jōmon pit house at the Hamanasuno site, Hokkaidō (Crawford et al. 1978; Crawford 1983). Extensive flotation sampling at the same and later sites in the area has produced no further examples. Uncarbonized buckwheat seeds are reported from Yayoi wet sites (Goto 1962). It is entirely possible that the rarity of carbonized buckwheat seeds at Jōmon and Yayoi sites is due to preservation factors. For example, among the earliest buckwheat in the Netherlands is a single carbonized achene from the twelfth-century Dommelin site (Van Vilsteren 1984:230). Van Vilsteren (1984) reports that uncarbonized examples are common in cesspits and that in these contexts it is never carbonized. In other words, the carbonized sample is not representative of buckwheat's actual importance. If the Hamanasuno buckwheat is not intrusive, it may not be showing up more often in Jōmon and later contexts as a result of preservation problems. However, hundreds of carbonized buckwheat achenes have been found at the Kachiyama historic (Japanese) site in Kaminokuni, Hokkaidō (Kaminokuni-cho Kyōiku Iinkai 1986). The wild parent of domesticated buckwheat, *Fagopyrum cymosum*, is a temperate eastern Asian plant (Campbell 1976:235) and is not native to Japan.

Chinese cabbage comprises four subspecies in China and Japan, two Chinese cabbages (*Brassica campestris* ssp. *chinensis* and *pekinensis*), Indian mustard (*B. campestris* ssp. *nipposinica* or *B. juncea*), and Chinese savoy (*B. campestris* ssp. *narinosa*) (Zeven and Zhukovsky 1975:29). Chinese cabbage was domesticated in East Asia, according to Zeven and Zhukovsky (1975) and Bailey (1976). McNaughton (1976:47) finds no evidence for its ancient cultivation in China, although the evolution of a subspecies in eastern Asia points to some historical depth for its use there. Li (1983:35), however, reports that Chinese cabbage seeds were recovered from the Banpo site. The National Museum in Beijing displays a ceramic sowing container from Banpo that contained Chinese cabbage seeds.

The paper mulberry, reported from Torihama (Kasahara 1983), is cultivated in warmer parts of Japan (Ohwi 1965). Zeven and Zhukovsky (1975) include this tree in their China-Japan center. Great burdock is cultivated in China and Japan today and Kasahara (1983:49) believes it was introduced from China. Ohwi (1965) does not list it in the flora of Japan. The lacquer tree is cultivated in southwestern Japan and China for its sap, which is used in lacquer production. Wooden artifacts and pottery from Jōmon sites occasionally are lacquered. Seeds of *Rhus* are common in flotation samples from the Kameda Peninsula (Crawford 1983), but the species is unknown.

An important aspect of northern Chinese plant husbandry was the domestication of fruit trees. These include apricot, pear, and peach, which are thought to have been domesticated long before the Zhou period (Li 1983:34). Most of these make their appearance in Japan during the Yayoi, along with soybean, pea, and plum (discussed in Kotani 1972:70–75). Peach, however, may have been introduced to Kyūshū as early as 6000 B.P. (Tarami-cho Kyōiku Iinkai 1986).

A carbonized sample of safflower achenes is reported from a Satsumon pit house at the Toyotomi site in northeastern Hokkaidō (Crawford 1985; Kohno 1959). An unknown quantity was originally collected, but just a few examples remain at the Asahikawa City Museum. These achenes were originally identified as buckwheat (Kohno 1959). One safflower achene has been found at Sakushu-Kotoni River. Safflower is native to the Middle East and the earliest record of its use is from Egypt about 1600 B.C. (Knowles 1976:31). The Far East is one of seven centers of diversity for this cultigen (Knowles 1976:132). The only other report of the early presence of safflower in Japan is Yamazaki's (1961) description of dye extraction in the eighth century A.D. in southwestern Japan.

Discussion and Directions for Future Research

The domestication and dispersal of crops in East Asia is a relatively untapped research area. In China, little is known of the period immediately preceding 8000 B.P., the period when domestication was well under way. Nothing is known about these processes in Korea during the early Holocene. Although human settlement patterns and technological developments for the same period in Japan are well documented, plant remains have been collected from only a few Initial Jōmon sites. There is little evidence for early Holocene Japanese populations being other than foragers. For the time being, the earliest innovations in plant domestication in East Asia seem to have taken place in North China. Domestication appears to have occurred in a steppe-forest or forest zone. The closest analogue to North Chinese agricultural origins is found in the Near East. Before 10,000 B.P. in the Near East, habitation was localized in favorable zones and the steppe was little used (Moore 1989:624); agriculture evolved in unusually favorable circumstances, but shortly thereafter rainfall decreased, evaporation increased, and forests retreated (Moore 1985:11). Evidence for more steppe-like conditions in mid-Holocene North China suggest that the environment there was undergoing a similar transformation. The processes identified in the Near East may serve as valuable hypotheses to test in North China.

The few sites in Japan from which substantial plant remains have been recovered are producing provocative data regarding the evolution of plant husbandry in East Asia. Some reviewers (e.g., Rowley-Conwy 1984) reject the possibility of plant husbandry before 3000 B.P., whereas others (e.g., Kasahara 1984; Tozawa 1983) accept the presence of limited plant husbandry earlier than that. Reports of cultigens from other Early Jōmon sites, such as Hamanasuno, Otsubo, and Ikiriki, are suggesting that Torihama is not unique. Pollen evidence from Ubuka Bog in southwestern Honshū further supports the existence of Early Jōmon plant husbandry. The data indicate that buckwheat, hemp, great burdock, paper mulberry, bottle gourd, bean, Chinese cabbage, and perhaps millet were present in Japan or undergoing domestication during the Early Jōmon. The fact that nearly a decade of excavations at Torihama have resulted in so few examples of each plant indicates the lack of economic importance of plant husbandry at that time. In addition, the paucity of remains stresses the importance of extensive sampling of plant remains from Jōmon sites. Buckwheat is equivocally part of this Early Jōmon list, while barnyard grass is a more likely candidate for a husbanded plant in northern Japan. All pre-3000 B.P. records in Japan are of plants belonging to Zeven and Zhukovsky's China-Japan center, except for bottle gourd, black gram, and mung bean. Bottle gourd's wide distribution in both the Old World and New World by 3000 B.P. and its early presence in Japan indicate that it became part of the China-Japan center by at least 5000 B.P. The identification of mung bean and black gram in 6000 B.P. Japan is suspicious because no further archaeological examples of this bean are known from prehistoric eastern Asia. The problem may be a matter of distinguishing types of *Vigna,* assuming they are *adzuki,* or it may be that all early beans in eastern Asia are *adzuki,* derived from a local ancestor. I would urge a program of accelerator radiocarbon dating in Japan to test the age of many of these cultigens.

Barley, rice, foxtail millet, *adzuki* bean, and melon were added to the complement of cultigens by the Final Jōmon. Wheat seems to be a later addition, probably during the Yayoi period, but wheat did not become common until the Kofun period. Cultivation of apricot, soybean, pea, peach, persimmon, plum, pear, and watermelon is also apparent during the Yayoi. Safflower is known from historic records to have been present in southwestern Japan by the eighth century A.D., and archaeological data demonstrate its early (ninth century A.D.) appearance in Hokkaidō.

Data from Korea for foxtail millet, barley, wheat, rice, soybean, and *adzuki* are not out of line with the Japanese situation. Sorghum is reported from Korea as well, but it is rare in the Japanese archaeological record. Nevertheless, the range of archaeological cultigen remains from Korea is narrower than that from prehistoric Japan. The undated Chulmun millets are the earliest potential cultigens reported from Korea (Kim 1978). Rice, barley, millet, sorghum, and soybean are more securely identified and contextually placed at the Hunamni and Honamni Bronze Age sites (Choe 1982:524; Pearson 1982). The Bronze Age millets are foxtail and broomcorn (Kim 1982:514). Red (*adzuki*) bean is reported from the Bronze Age Soktali site and from an early first millennium A.D. shell mound in Kimhoe, where the earliest wheat in Korea is also reported (Kim 1982:514, 517). By the end of the fourth millennium B.P. many of the cultigens reported in early Japan are present in Korea, but the research is unsystematic and does not tell us what was happening in Korea at the same time as the Early and Middle Jōmon in Japan. We should expect to see in Korea the early gardening of the cultigen mint *egoma* or beefsteak plant, bottle gourd, Chinese cabbage, and other cultigens reported from Jōmon sites.

Substantial Neolithic adaptations had evolved in North China by 8000 B.P., approximately contemporaneous with the Initial Jōmon of Japan and the earliest documented Chulmun of Korea. For the time being, foxtail and broomcorn millet, hemp, and Chinese cabbage are the only cultigens in early sites in Japan and Korea that are also reported in the Chinese Early Neolithic, and the Yangshao, Dawenkou, and Xinle cultures of the later Neolithic of China. Whether China will prove to be the source of all the other cultigens reported from Japan and Korea remains to be seen.

In a summary article on Jōmon subsistence, Richard and Kazue Pearson (1978) indicated the paucity of data and the points of view of Japanese prehistorians on Jōmon subsistence. They made five recommendations: flotation should be instituted on a large scale, bottom-land areas where agriculture is extensive today should be investigated for signs of prehistoric food production, pollen analysis in conjunction with archaeology should be furthered, ethnographic analogy should be judiciously applied, and archaeological cultures in Japan should be interpreted within an ecosystemic paradigm to reconstruct Jōmon subsistence and the organization of Jōmon production (1978:26–27). In the last decade, progress has been made on these recommendations, as well as on other dimensions of subsistence ecological research, but considering the provocative data now available, little actual headway is being made, and in northern China and Korea progress is particularly slow.

Archaeological evidence for plant husbandry in Japan is nearly as early as any from eastern Asia. The earliest collections comprise plants that are part of the China-Japan center of cultigen diversity defined by Zeven and Zhukovsky (1975). The only unequivocal non-eastern Asian cultigens in this early group are melon, bottle gourd, and mung bean. Bottle gourd is the only one in secure Early Jōmon contexts. The others, including hemp, paper mulberry, *adzuki* bean, beefsteak plant, great burdock, millet, and Chinese cabbage, are plants with a long history of use in Asia; besides *adzuki* bean and millet, little is known about the prehistory of these plants in Japan. The examples before the Late and Final Jōmon in Japan appear unusual because of their uniqueness, but this could well be due to a lack of research. The best available data to westerners from China at the moment are historic records. The earliest confirmed Korean data on plant husbandry are contemporaneous with the Late and Final Jōmon.

Further research on Jōmon sites in southwestern and northeastern Japan should be carried out, and the collection of plant remains from all sites, not just wet sites, should become routine. For the present, explaining plant husbandry origins in Japan, Korea, and China will be difficult until much more basic research is accomplished. Research today is also beginning to focus on the spread of agriculture to northern Japan. Some archaeologists are proposing diffusion of rice and other plant husbandry from Kyūshū directly to the north, bypassing the southwest entirely. Carbonized plant remains from several late first millennium A.D. occupations on Hokkaidō have produced evidence of a phase of extensive plant husbandry in a context where it had only been suspected before.

There is some urgency to increase the scale of research on the origins of plant husbandry in Asia. China, Korea, and Japan are all facing pressures on the archaeological database. In the 1984 field season on Hokkaidō, eighty sites comprising a total of 183,500 square meters were excavated at a cost (in U.S. dollars) of about $4 million, yet in the ten years preceding 1984, flotation samples had been taken from fewer than ten sites on the entire island and extensive collections of such remains from Jōmon sites in southern Japan number even fewer than that. It is imperative that this situation be remedied as soon as possible if we are ever to obtain an understanding of the complexities and achievements of ancient East Asian agriculture.

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Notes

1. Many crops exhibit centers (regions) of genetic diversity. Some crops do not. Centers of diversity should not be confused with centers of origin. Crops still in their center of domestication often exhibit lower diversity than crops in secondary centers (areas to which the crops have diffused) (Harlan 1975:56). The reasons for diversity have relevance to prehistorians because a long history of continuous cultivation in an area and cultural diversity, which is associated with crop variety preferences, are two factors that encourage diversity (Harlan 1975:149).

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