The origins of rice agriculture: recent progress in East Asia

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Knowledge of rice domestication and its archaeological context has been increasing explosively of late. Nearly 20 years ago rice from the Hemudu and Luojiajiao sites (FIGURE 1) indicated that rice domestication likely began before 5000 BC (Crawford 1992; Lin 1992; Yan 1990). By the late 1980s news of rice from the south-central China Pengtoushan site a thousand years older than Hemudu began to circulate (Bellwood *et al.* 1992; Hunan 1990; Pei 1989). Undocumented news of sites having a median date of 11,500 BP with domesticated rice has recently made the rounds (Normile 1997). In addition, the first domesticated rice in Southeast Asia, once thought to be to be older than the first rice in China, is not as old as once thought (Glover & Higham 1996: 422; Higham 1995). Finally, wild rice (*Oryza rufipogon*) was reported to be growing in the Yangzi valley, well outside its purported original range, making domestication there plausible (Yan 1989; 1990; 1997). Significant progress continued to be made in the 1990s and unlike research on other major crops, the literature is generally not accessible to western scholars, with some exceptions (Ahn 1993; Crawford 1992; Glover & Higham 1996; Higham 1995; MacNeish *et al.* 1997; Underhill 1997).

The 2nd International Academic Conference on Agricultural Archaeology (IACAA) convened in Nanchang, China in October, 1997 to assess the new archaeological, biological and ethnohistoric information pertaining to the evolution, spread, and production of rice in East Asia. Among the nearly 70 papers presented at the Nanchang conference were half a dozen on phytoliths, a similar number on the botany and evolution of rice, while the remainder covered a wide range of archaeological and historic topics related to rice. Additionally, preceding the conference was the publication of an edited volume on the origin and differentiation of Chinese cultivated rice (Wang & Sun 1996). The 36 chapters deal primarily with new archaeological or archaeobotanical data (seven papers); anatomical and morphological studies (five papers); and genetic research (17 papers). Many of the chapters also explore taxonomic issues. In this essay we update the current status of our knowledge of the origins of rice agriculture based on highlights of the conference and in the context of the recently published record. We focus on two themes: the new archaeobotanical evidence for rice agricultural origins in East Asia and identifying and understanding the role of the wild ancestors of domesticated rice.

New archaeological evidence

The number of sites from which rice remains have been reported from all periods in China vary from between 110 and 140, depending on the author (Tang *et al.* 1993; Wei 1995; You & Zheng 1995). These sites are predominantly younger than 5000 BC. About half are in the middle Yangzi valley while the remainder are distributed from south China to the lower Yangzi, as well as a few from the Huanghe (Yellow River) valley. The middle Yangzi valley comprises the Yangzi River and its main tributaries between the western end of the Three Gorges and the mouth of Lake Poyang (Poyang Hu) (FIGURE 1).

After 4000 BC the Middle Neolithic Daxi culture dominates the Middle Yangzi (TABLE 1

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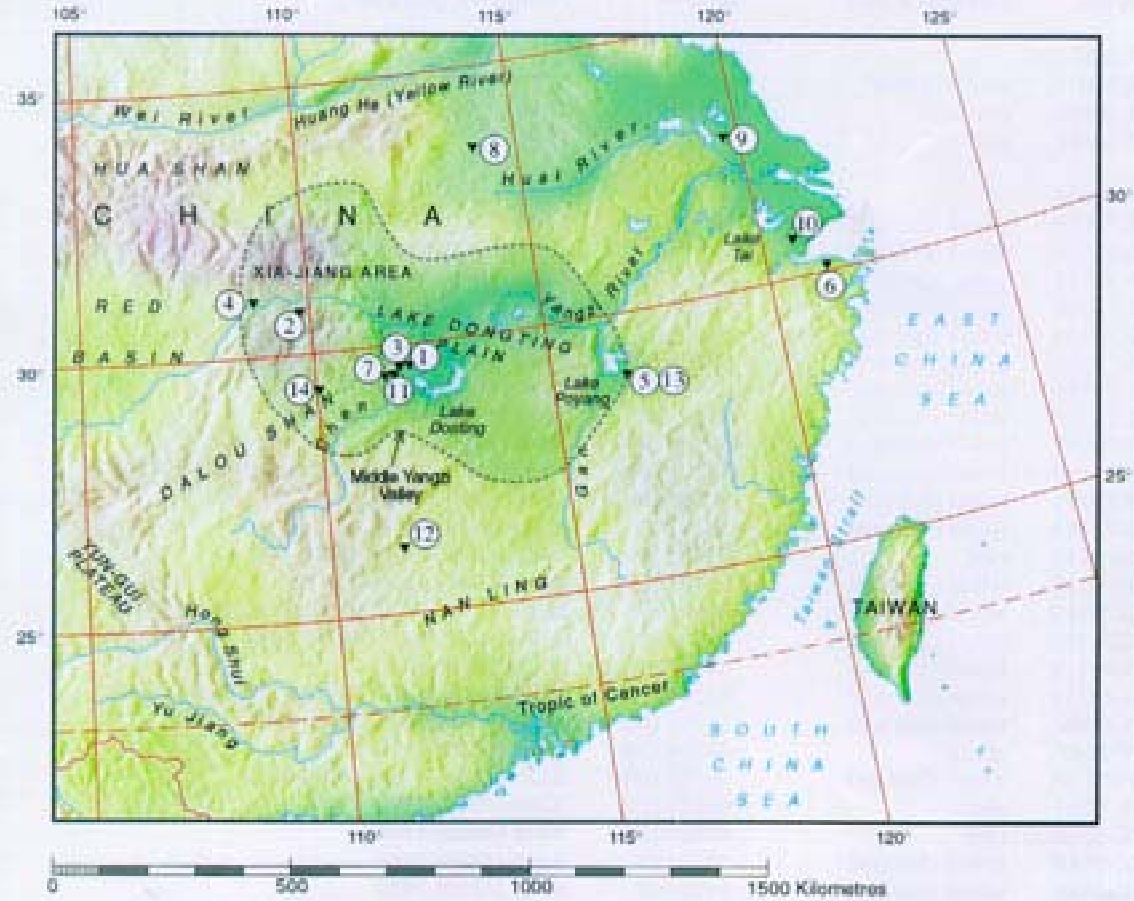

FIGURE 1. *South-Central China sites mentioned in text (in alphabetical order):*

1 *Bashidang* 八十垱
2 *Chengbeixi* 城背溪
3 *Chengtoushan* 城头山
4 *Daxi* 大溪
5 *Diaotonghuan* 吊桶环
6 *Hemudu* 河姆渡
7 *Hujiawuchang* 胡家屋场
8 *Jiahu* 贾湖
9 *Longqiuzhuang* 龙虬庄
10 *Luojiajiao* 罗家角
11 *Pengtoushan* 彭头山
12 *Yuchanyan* 玉蟾岩
13 *Xianrendong* 仙人洞
14 *Zaoshi* 皂市
Shaded area is the Middle Yangzi Valley.

calibrated years BC	Xiajiang Area	Dongting-Hu Area
2000		
3000	Daxi	Daxi
		Lower Tangjiagang Complex (?)
4000		
5000	Chengbeixi Complex	Zaoshi Complex
6000		
		Pengtoushan Complex
7000		
8000		

TABLE 1. *Chronology of Early Neolithic in the Middle Yangzi Valley, based on An (1991; 1994).*

lab no.	material dated	BP date	calibrated years BC
Chengbeixi			
BK84028	animal bone*	6800±80	5770 (5630) 5530
ZK-2643	pottery*	8220±250	7850 (7260, 7170, 7150, 7110, 7110) 6470
ZK-2644	pottery*	8274±234	7880 (7300) 6570
Hemudu			
BK75057	wood charcoal	6310±100	5440 (5260) 5000
BK75058	wood charcoal	5050±100	4040 (3910, 3880, 3800) 3640
BK78101	wood charcoal	6060±100	5230 (4940) 4730
BK78102	wood charcoal	6040±100	5220 (4930) 4720
BK78103	wood charcoal	5910±90	4960 (4790) 4540
BK78104	wood charcoal	6310±170	5570 (5260) 4840
BK78105	wood charcoal	5560±80	4540 (4430, 4360) 4247
BK78106	wood charcoal	5610±80	4670 (4460) 4330
BK78109	wood charcoal	6260±200	5570 (5230) 4730
BK78110	wood charcoal	5310±100	4350 (4220, 4200, 4150, 4120, 4090) 3950
BK78111	wood charcoal	6050±100	5220 (4940) 4720
BK78113	wood charcoal	5610±80	4670 (4460) 4330
BK78114	**rice**	**6240±100**	**5420 (5220, 5150) 4930**
BK78115	wood charcoal	5940±85	5040 (4800) 4610
BK78116	wood charcoal	6200±85	5290 (5210, 5170, 5140, 5110, 5090) 4930
BK78117	wood charcoal	5270±90	4330 (4070, 4060, 4040) 3820
BK78118	wood charcoal	5210±100	4320 (3990) 3790
BK78119	wood charcoal	6200±100	5320 (5200, 5170, 5140, 5110, 5090) 4860
PV-0028	wood charcoal	5320±100	4350 (4220, 4200, 4150, 4110) 3950
PV-0047	acorn	6260±130	5440 (5230) 4860
WB77-01	wood charcoal	5975±100	5120 (4900, 4880, 4850) 4610
ZK-0263	acorn	6065±120	5260 (4940) 4710
ZK-0263(2)	**rice**	**6085±100**	**5250 (4960) 4780**
ZK-0589	wood charcoal	5370±95	4440 (4230) 3980
ZK-0589	wood charcoal	5365±90	4440 (4230) 3980
ZK-0590	wood charcoal	6200±85	5290 (5210, 5170, 5140, 5110, 5090) 4930
Hujiawuchang			
OxA2218	**rice husk in pottery***	**6395±90**	**5450 (5320) 5140**
OxA2219	humic acid in pottery*	6695±80	5690 (5580) 5440
OxA2222	**rice husk in pottery***	**6500±100**	**5580 (5440) 5260**
OxA2223	humic acid in pottery*	6715±80	5700 (5590) 5440
OxA222w	charcoal in pottery*	7590±80	6540 (6420) 6220
OxA222x	charcoal in pottery*	11,190±100	11,390 (11,150) 10,930
OxA222y	charcoal in pottery*	7385±80	6380 (6180) 6010
OxA222z	charcoal in pottery*	11020±100	11210 (10990) 10770
OxA2731	**rice husk in pottery***	**6775±90**	**5770 (5620) 5480**
OxA2733	**rice husk in pottery***	**6540±170**	**5700 (5440) 5090**
Jiahu			
N/A	*Phase I*	*7920±150*	*7260 (6750, 6710) 6424*
N/A	*Phase I*	*7960±150*	*7300 (6990, 6960, 6860, 6850, 6770) 6460*
N/A	*Phase I*	*7520±125*	*6550 (6370) 6050*
N/A	*Phase III*	*7017±131*	*6120(5920, 5920, 5850) 5600*
N/A	*Phase II*	*7137±128*	*6190 (5970) 5700*
N/A	*Phase II*	*7105±122*	*6180 (5960) 5690*

TABLE 2. *Radiocarbon dates from early Chinese sites with rice remains.*

lab no.	material dated	BP date	calibrated years BC
Longqiuzhuang			
ZK-2776	wood charcoal	4663±120	3690 (3490, 3470, 3380) 3040
ZK-2777	wood charcoal	4351±120	3350 (2920) 2620
ZK-2778	wood charcoal	4451±130	3510 (3090, 3060, 3050) 2710
ZK-2785	wood charcoal	4614±104	3640 (3360) 2950
ZK-2795	wood charcoal	4954±114	3980 (3710) 3390
ZK-2796	wood charcoal	4374±95	3350 (3010, 30107, 2920) 2700
Pengtoushan			
BK89017	charcoal	7770±110	7000 (6550) 6380
BK89019	charcoal	7770±110	7000(6550) 6380
BK89020	charcoal	7945±100	7190 (6850, 6850, 6760, 6730, 6730) 6490
BK89021	charcoal	8380±115	7580 (7470, 7440) 7050
BK89022	charcoal	8135±90	7420 (7040) 6730
OxA1275	humic acid in pottery*	7930±80	7040 (6760, 6740, 6710) 6550
OxA1277	humic acid in pottery*	6552±110	5610 (5440) 5270
OxA1280	charcoal in pottery*	9785±180	9930 (9040) 8430
OxA1281	charcoal in pottery*	7890±90	7040 (6650) 6470
OxA2215	humic acid in pottery*	7610±80	6550 (6420) 6220
OxA2216	charcoal in pottery*	8290±80	7500 (7310) 7040
OxA2217	charcoal in pottery*	8490±80	7590 (7500) 7320
OxA2220	charcoal in pottery*	7590±80	6540 (6420) 6220
OxA2221	charcoal in pottery*	11,190±100	11,390 (11,150) 10,930
OxA2224	charcoal in pottery*	7385±80	6380 (6180) 6010
OxA2225	charcoal in pottery*	11,020±100	11,210 (10,990) 10,770
BK87002	pottery	9100±120	8400 (8080) 7940
BK87050	wood charcoal	8200±120	7490 (7250, 7220, 7200, 7180, 7140, 7120,7100) 6770
BK89016	wood charcoal	7815±100	7010 (6600) 6420
BK89018	bamboo-charcoal	7945±170	7310 (6850, 6850, 6760, 6730, 6730) 6420
OxA1273	charcoal in pottery*	9065±300	8970 (8060) 7480
OxA1274	ester kinds in pottery*	7055±100	6110 (5940, 5910, 5880) 5690
OxA1282	charcoal in pottery*	8455±90	7580 (7490) 7300
OxA2210	**rice in pottery***	**7775±90**	**6990 (6550) 6420**
OxA2211	humic acid in pottery*	7520±90	6470 (6370) 6170
OxA2212	charcoal in pottery*	8550±80	7850 (7540) 7440
OxA2213	charcoal in pottery*	9220±80	8420 (8330, 8310, 8240, 8200) 8050
OxA2214	**rice in pottery ***	**7250±140**	**6380 (6100, 6100, 6050) 5780**
Yuchanyan			
N/A	animal bone	12060±120	12530 (12120) 11760
Zhaoshi			
BK82081	charcoal*	6920±200	6160 (5730) 5440

* AMS date
bold: sample date on rice
italics: mixture of rice, charcoal and other material
Calibrated at 2σ with the program CALIB 3.0 (Stuiver & Reimer). Calibrations are rounded to the nearest 10 years. One or more intercepts are presented between the 2σ ranges.

TABLE 2 (continued). *Radiocarbon dates from early Chinese sites with rice remains.*

and FIGURE 1). Early Neolithic predecessors of Daxi indicate a complex developmental history (An 1994; He 1989; Lin 1990; Lin & Hu 1993; Meng 1993). To the north of Daxi is the Lijiacun Complex dating from 6000–7000 BC. To the south in Hunan province the earliest Neolithic site is reportedly Yuchanyan (9000–8000 b.c.) (Yan 1997). These Early Neolithic populations appear to have been using rice, but how early its use began, when it became domesticated, and under what circumstances are issues under investigation.

Rice from at least nine Early to Middle Neolithic sites has been either AMS dated or associated with radiocarbon dates (82 dates, TABLE 2). The earliest of the 14 direct dates on rice is no older than 7000 BC and range to 5000 BC at Hemudu. The oldest rice grains are dated to 6000–7000 BC at the Pengtoushan and Jiahu sites (FIGURE 1) (Chen & Jiang 1997; Pei 1989; Zhang & Wang 1998). The latter, being north of the Yangzi Valley, is the most northerly report of rice at this time. Although the rice from Jiahu is claimed to be the oldest so far dated in China (Chen & Jiang 1997), the Pengtoushan AMS rice dates are not significantly younger. The oldest AMS date (OxA-2210) from Pengtoushan appears to be only marginally younger than the oldest Jiahu dates. Older occupations at these sites are suggested by dates on charcoal, pottery, and other materials. However, the AMS dates on rice are the best indicator of its antiquity. The oldest dates from Pengtoushan have been rejected (An 1994; Chen & Hedges 1994).

The aforementioned sites do not help fill a gap well known in Chinese prehistory, the relative lack of late Pleistocene to early Holocene assemblages (Chang 1986; Elston *et al.* 1997; MacNeish *et al.* 1997). Filling this gap, particularly in the context of rice agricultural origins, is the research of a Sino-American project directed by the Andover Foundation and Beijing University (MacNeish *et al.* 1997) in the Dayuan basin, Jiangxi province. Zhao (1997; 1998), a member of the team, makes a case for Late Pleistocene wild rice collection followed by a mix of wild rice and early domesticated rice harvesting and finally the use of primarily domesticated rice by 7500 b.p. (6400 BC). Isotopic analysis of human bone from Xianrendong and Diaotonghuan are consistent with an argument for rice consumption during the Late Pleistocene to Early Holocene transition (MacNeish *et al.* 1997: 25). Unfortunately, the dating is less confident than we would like (see Zhao 1997 for a discussion).

Until now, open sites have had shed little light on the Pleistocene–Holocene transition in the Yangzi valley. This may soon change. Pei Anping, the excavator of Pengtoushan, presented a paper on a hitherto unreported middle-late Pengtoushan assemblage at the Bashidang site (Pei 1998) (FIGURE 1). Although the work is still in progress and we are not at liberty to say much about Bashidang, we can report that it is a floodplain site that spans the Upper Palaeolithic through Middle Neolithic (Pei 1998). The Pengtoushan layer is waterlogged and preservation is superb. Large quantities of rice grains have been recovered, as have remains of other plants, including the water caltrop (*Trapa* sp.) that may show evidence of being domesticated. This aquatic plant has also been reported from Hemudu and provides some of the earliest evidence for a broader development of aquatic plant use in China, not just rice production.

Still current is the view that rice, after its domestication in China, diffused along three possible routes (An 1998) to Korea during the Bronze Age and subsequently moved to Japan about 300 BC. This scenario is being challenged. In fact, the spread of rice to Korea and Japan is still a relatively poorly understood issue (An 1998; Lin 1992). Of the three proposed routes of entry of rice into Japan, the one from southern China northward through Okinawa into Kyushu via the Ryukyu Islands is highly improbable now. Rice never attained much importance in Okinawa and arrived there about AD 800 from the north (Takamiya 1997). The two northern routes are the most likely. Elsewhere, South Korean researchers report that the earliest rice there appears to date to about 4300 b.p. (3000 BC) at Locality 1 of the Kawaji site, Ilsan City (Lee & Park 1997). Nearly 300 rice grains were recovered from peat layers there. Rice phytoliths have also been extracted elsewhere from three comb-patterned pottery assemblages (Chulmun or Neolithic). The oldest dates to about 5500 b.p. (4400 BC) at the Juyupri site, Ilsan City. Based on this evidence Kim *et al.* (1997) suggest that rice was first introduced to the west coast of Korea around 5000 b.p. (4000 BC) and spread from there to the Han River basin. By the Korean Bronze Age, rice appears to have been part of a crop complex that included barley, wheat, millet and hemp at Chodong-ni where the population also collected nuts and tubers (Heu *et al.* 1997). In Japan the earliest AMS dated rice grains are associated with the Late Jomon in Northern Honshu (about 1000-800 BC) (D'Andrea *et al.* 1995). As in Bronze Age Korea, this rice is associated with millet and wild plant foods. If rice was first introduced to northeastern Japan from the southwest rather than straight across the Sea of Japan, evidence for rice in southern Honshu and Kyushu should be older than 1000 BC. In fact, rice phytoliths dating from the Early to Middle Jomon have been reported from southwestern Japan (Yoshizaki 1997). If the earlier Korean and Japanese dates for rice are accurate, rice may have been grown there shortly after it appeared in the Yangzi delta, if not at the same time. If these interpretations are confirmed, not only is rice domestication being pushed back in time, but so is its spread from China. Some rethinking about the respective prehistories will be in order.

Ancestry of domesticated rice

In recent years the indigenous Chinese domestication of rice has attained general acceptance (Li 1993). This contrasts with views of a decade earlier when there was no international consensus (Crawford 1992). One view popular during the 1970s and 1980s saw *Oryza sativa* domesticated in the highlands of southwestern China or southern Asia and from there it would have spread to the east coast (Chang 1976; 1983; Liu 1975; You 1986). Although this theory was based on wild rice distributions and genetic relations between wild rice and domesticates in the Yun-Gui Plateau (Yunnan-Guizhou highland, FIGURE 1), archaeological evidence has not been forthcoming (Cheng 1994; Liu 1994; Tang *et al.* 1993).

The closest relatives of *Oryza sativa* are the perennial *O. rufipogon* Griff. and the annual *O. nivara* (Chang 1976). The three species are interfertile. Perhaps acknowledging this interfertility, Chinese scholars tend to eschew the latter term calling all wild rice, including spontanea forms (described below), *O. rufipogon* (common wild rice or CWR). In reality, the three species are best considered to be sub-species of one species, but the current classification will likely not be abandoned any time soon. Two main races, sometimes termed sub-species, of *O. sativa* are japonica and indica, also commonly known as short-grained and long-grained rice, respectively. Japonica has temperate and tropical forms. The latter is commonly termed javanica rice. Numerous intergrading hybrids between *O. sativa* and its two wild relatives are found in, and adjacent to, rice fields (Chang 1976: 100). These 'spontanea' forms are 'sometimes indistinguishable from *O. nivara*' (Chang 1976: 100). Today, the distribution of *O. rufipogon* , the most common wild rice species in China, is much broader than once thought (see Chang 1976). *O. rufipogon* ranges between 100°47'E and 121°15'E and between 18°9'N and 28°14'N latitude which includes northern Jiangxi and Hunan provinces (Cooperative Team 1984). Based on a collection of nearly 4000 samples, *O. rufipogon* was found to be distributed in eastern and southeastern China, not just in the commonly cited Yun-Gui Plateau (Chang 1976). Palaeoclimatic and pollen data indicate that during the middle Holocene temperatures in the Lower Yangzi Valley were about 3–4°C higher than today with precipitation over 800 mm (Tang *et al.* 1993). The northern limit of wild rice in the Neolithic may have extended north to Lake Tai (Tang *et al.* 1993). Annual wild *Oryza* is apparently rare in China and probably all is the weedy, spontanea type (Wang *et al.* 1998). Weedy rice is found throughout the southern Korean Peninsula and includes a feral japonica cultivar and three types of crosses: indica with japonica; wild with indica; and wild with japonica (Heu 1997).

Where japonica and indica fit in relation to the wild and domesticated *Oryza* is being actively researched. Two independent domestications, one of japonica in China and one of indica in South Asia, have been hypothesized for some time (Second 1984). Recently, isozyme analysis indicates that perennial wild rice (*O. rufipogon*) is the direct ancestor of cultivated rice (Wang 1994). Only four years ago wild rice seemed to have three types: keng-like (47·82%), hsien-like (14·13%), and keng-hsien intermediate (25·0%) wild rice (Wang 1994: 50). One suggestion is that keng (japonica) rice was probably derived from the keng-like perennial wild rice (*O. rufipogon*) growing in the woodlands and marshlands in the Middle-Lower Yangzi Valley with its centre in the Lake Tai region. Hsien (indica) rice evolved from different progenitors with strong hsien elements further south

(Tang *et al.* 1993). Their argument was based on distributions of wild rice and archaeological remains, and an extensive examination of rice remains from archaeological sites, especially those from Hemudu. Now, results of genetic research (both nuclear and chloroplast DNA) indicate that CWR in China is differentiated only negligibly into indica- and japonica-like types (Wang *et al.* 1998: 93). Differentiation in wild rice appears to be evident when South Asian populations are considered. Chinese researchers identify the japonica type as the main genotype in China while the indica type is found primarily in South Asia (Huang *et al.* 1996: 100; Sun *et al.* 1998). Based on this evidence, geneticists suggest that japonica rice originated in China while indica evolved in South Asia and China (southernmost) (Sun *et al.* 1998).

Japanese researchers are making a substantial contribution to solving these and other problems. Yoichiro Sato of Shizuoka University has DNA evidence indicating that differentiation between indica and japonica rice took place before domestication (Sato 1997). Sato, unlike the Chinese specialists, retains the *O. rufipogon*/ *O. navira* distinction in wild rice classification; the former is distributed mainly in China while the latter is mainly distributed in South Asia. Although Sato's evolutionary model is more complex than can be summarized here, his work indicates that the annual wild rice (*O. nivara*) is the ancestor of indica while the perennial *O. rufipogon* is ancestral to japonica. Weedy forms of rice evolved from hybrids of *O. rufipogon* and *O. nivara*. These weedy forms may be some of the plants assumed by some to be wild ancestors of domesticated rice. If this is the case, some of the confusion regarding the ancestry of domesticated rice is understandable. Furthermore, Sato and his team are able to add DNA analyses of archaeological rice in China to their model and have found no evidence for indica in the Chinese archaeological record. How perennial rice evolved into annual rice in the Yangzi basin is problematic. Sato suggests that the annually disturbed habitats at the edges of wetlands would have selected for an annual habit (Sato 1996). Water levels varying annually under the influence of the monsoonal wet–dry season shift would have been responsible for maintaining these habitats (see also Glover & Higham 1996). Finally, Sato's archaeological DNA evidence shows the presence of tropical, not temperate, japonica in the Yangzi valley. The origin of temperate japonica is still unknown (Sato 1997).

The DNA evidence for japonica rice conforms to an opinion that early archaeological rice grain remains from China belong to one type (Sato 1997; Wang *et al.* 1998) despite numerous reports to the contrary. Others have pointed out the difficulty in identifying japonica and indica carbonized grains by morphological criteria (Crawford 1992). Ahn (1993: 98), though, is convinced that length-to-width ratios (L/W) of rice grains, as well as their overall size, can differentiate races of modern rice (with a 20% overlap). Charring does not seem to change the L/W ratios significantly (Ahn 1993). Rather than using the modern race categories, Ahn prefers to describe ancient grains as 'slender' or 'large and round', reflecting his concern that ancient rice may have a range of undifferentiated types (1993: 119). Wild rice has 'slender' grains that are not significantly smaller than slender cultigen grains so size should not be a criterion to distinguish wild from cultigen rice; rather, differentiation into types provides evidence of domestication (Ahn 1993: 120). Consistent with this view is the study of 4000 rice grains from the stratified Longiuzhuang site (TABLE 2) (Tang *et al.* 1996). Over time, rice grain measurements exhibit a marked increase in variation, yet they are all considered to be japonica. Another approach is to try to distinguish races of archaeological rice by their phytoliths (Tang *et al.* 1996; Zhang 1996). The latter technique is in its infancy, and should be treated with caution for the time being.

The domestication or wild status of the earliest rice grains is not clear. Pei (1989) felt that the rice from Pengtoushan was cultivated. Ahn (1993) suggested that it was not. For now, the earliest rice (Pengtoushan, Jiahu and Yuchanyan) appears to be wild-like rather than fully domesticated and it may have taken two to three thousand years for fully domesticated rice to appear (Tang *et al.* 1996; Wang *et al.* 1998). Furthermore, the Bashidang rice does not appear to be differentiated into indica and japonica types and is an archaic type according to Zhang & Pei (1996). Unfortunately, the best criterion for distinguishing wild from domesticated rice, the presence or absence of a brittle rachis, is not evidenced at these sites so the wild-like form of the grain should not be taken as evidence that they are in fact the remains of wild *Oryza*. Nor should we conclude that the rice at these sites must have been domesticated. Importantly, rice was being harvested at the three sites, but it remains to be seen whether the rice was being purposefully planted or harvested in the wild. The interpretation of phytoliths from Diaotonghuan is consistent with the argument (Zhao 1997; 1998) that wild *Oryza* was the first to be harvested and that it was not until about 6500 BC that primarily domesticated rice was harvested. Tang *et al.* (1996) find evidence in the Longqiuzhuang collection that artificial selection becomes clear only after 6300 b.p. (roughly 5000 BC). The Hemudu collection contains four grains of wild rice identifiable through their long and dense awn bristles, evidence of brittle rachis, and narrow grains (Tang *et al.* 1994). Tang *et al.* (1994) cite this identification as evidence of the distribution of wild rice in the lower Yangzi during the early Holocene. The phytolith evidence from Diaotunghuan, together with the Hemudu site macroremains, makes a strong case for the presence of wild *Oryza* in the middle Yangzi in the early Holocene.

Conclusions

The 2nd IACAA assessed a diverse and growing database on early rice in China. It also highlighted the differing models of the biosystematics of *Oryza sativa* and its closest relatives. The taxonomic perspective of Chinese scholars who lump wild and weedy rices into one taxon, *O. rufipogon*, contrasts with the view held outside China that at least two wild species are ancestral to Asian rices. Nevertheless, there is some agreement on japonica originating in south-central China and indica originating in South and/or Southeast Asia. However, it is apparent that some see indica rice in its domesticated form in the Yangzi valley relatively early. This implies that it diffused to the region from the south at a relatively early date. But indica may not actually be part of the early archaeological record in China. DNA analysis of archaeological grains indicates the presence of only japonica in the Yangzi valley during the Neolithic, a view more compatible with the current understanding of the nature of wild rice in the area. The fact that it is apparently tropical japonica means that the origin of the temperate form is still unknown.

Adaptations during the Pleistocene to Holocene transition are being clarified but little can be concluded for now. Understanding the spread of rice to Korea and Japan is still in its infancy, but evidence is mounting for its presence there much earlier than the 1st millennium BC. Crucial areas that seem to be missing in the discourse on rice agricultural origins are the broader ecological and cultural context in which the process took place. So far, explanations of the transition to rice agriculture tend to be climatically deterministic. Systematic interdisciplinary studies of agricultural origins should help as they have elsewhere. We hope to see research on seasonality, scheduling, anthropogenesis, weed complexes and many more related issues in the near future.

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Special section
Rice domestication

EDITED BY CAROLINE MALONE

It is timely to publish a Special section of ANTIQUITY on the theme of Rice Domestication. There has been much research and activity under way, quietly making enormous strides in knowledge and new data on rice and its antecedents. Last year, the 2nd International Academic Conference on Agricultural Archaeology was held at Nanchang in China, and numerous papers presented new material, analysis and interpretation. For too long, the relative lack of secure evidence and analysis has meant that agricultural origins in East Asia have been considered as a footnote to the better-documented evidence and debate on West Asia and Mesoamerica. This new activity and dissemination of material provides a means to look again, with renewed interest and excitement, at East Asia as a major centre for plant domestication and subsistence intensification. We are pleased to publish a range of papers here, which have been specially written for us by researchers who attended the conference and, in some cases, discovered the new evidence.

Two papers (**Crawford & Shen** and **Higham & Lu**) provide overviews of the state of archaeological research throughout East Asia, and the dispersal of rice to south Asia and beyond. They introduce new material and discuss how research is moving towards finer chronologies, climatic studies, studies of phytoliths, dispersal patterns, other foodplants and the genetic origins of rice. Their splendid discussions provide a background for the additonal four papers, which include specific site studies presented by Chinese colleagues. **Pei Anping** describes the important discoveries in the Middle Yangtze River area at the sites of Bashidang and Pengtoushan. **Zhang Juzhong & Wang Xiangkun** report on their work at the site of Jiahu, which has also yielded evidence for very early rice cultivation and manipulation, and place it in its wider context. **Zhao Zhijun** reports on phytolith research at the cave site of Diaotonghuan, and debates the issues of rice domestication in the middle Yangtze river. Finally, Tracey Lie-Dan Lu presents her experimental work on the growth and harvesting of a related cereal grass, green foxtail (later to become millet), and the implications that this work has on the domestication process of cereals in China.

We are delighted to include this range of new information and research approaches from colleagues spaced across the globe. Indeed, this academic diversity is fitting, since rice is now one of the two or three most important staple foods of modern subsistence (one-third of the world's population depend upon it). Much work in the last two to three decades has been focused on the Old World crops of the Levant or the New World crops of Mesoamerica. It is appropriate that a balance is maintained in our knowledge of subsistence strategies across the world, and that important new material, and the archaeological discussions relating to it, reach a wide audience.