Site of Baodun yields earliest evidence for the spread of rice and foxtail millet agriculture to south-west China

Jade d’Alpoim Guedes¹, Ming Jiang², Kunyu He², Xiaohong Wu³ & Zhanghua Jiang²

The Chengdu plain of south-west China lies outside the main centres of early domestication in the Huanghe and Yangzi valleys, but its importance in Chinese prehistory is demonstrated by the spectacular Sanxingdui bronzes of the second millennium BC and by the number of walled enclosures of the third millennium BC associated with the Baodun culture. The latter illustrate the development of social complexity. Paradoxically, however, these are not the outcome of a long settled agricultural history but appear to be associated with the movement of the first farming communities into this region. Recent excavations at the Baodun type site have recovered plant remains indicating not only the importance of rice cultivation, but also the role played by millet in the economy of these and other sites in south-west China. Rice cultivation in paddy fields was supplemented by millet cultivation in neighbouring uplands. Together they illustrate how farmers moving into this area from the Middle Yangzi adjusted their cultivation practices to adapt to their newly colonised territories.

Keywords: China, Sichuan, Baodun, third millennium BC, rice, foxtail millet, spread of agriculture

Supplementary material Texts S1–5, Table S1 and Figures S1–5 are published online at http://antiquity.ac.uk/projgall/dalpoimguedes337/

¹ Department of Anthropology, Harvard University, 11 Divinity Avenue, Cambridge, MA 02138, USA (Email: jguedes@fas.harvard.edu; author for correspondence)
² Chengdu City Institute of Archaeology, 18 Shi’erqiao Lu, Chengdu 610072, China
³ Department of Archaeology and Museology, Peking University, 5 Yibeiyuan Road, Haidian District, Beijing 100871, China

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Introduction

The spread of agriculture to south-west China had important implications for the local development of social complexity. It eventually led to the region becoming a population centre and a breadbasket throughout dynastic Chinese history, and to be the linchpin for the first unification of China in 221 BC (all BC dates are calibrated radiocarbon determinations [cal BC] or historical dates BC/AD; Sage 1992). Despite its clear importance for understanding the development of social complexity, relatively little is known about the spread of agriculture across China from its areas of first development in the Middle Huanghe and Middle and Lower Yangzi alluvial zones (Hunan Sheng Wenwu Kaogu Yanjiusuo 2006; Fuller et al. 2007, 2008; Liu et al. 2007). A recent paper in Antiquity (Zhang & Hung 2010) outlined possible avenues of spread into this region, but for lack of published data, the processes by which that occurred were not a primary focus of their discussion. The current article presents new data that add to this picture and allow us to revise some of the conclusions previously offered, as well as to discuss more concretely the differing but complementary roles that rice and millet agriculture played in this spread.

South-west China is ecologically diverse and contains a variety of ecosystems including the northern foothills of the Himalayas, the rugged landscapes of the Yunnan-Guizhou plateau and the Three Gorges, and the low lying plains of the Sichuan Basin (Figure 1). Rice was domesticated c. 7000–6000 BC in the Middle and Lower Yangzi valley (Crawford & Shen 1998; Fuller et al. 2007, 2008; Liu et al. 2007; Zhao 2010a), but agriculture appears to have taken more than 3000 years to spread to the south-west. This study provides the earliest directly dated evidence for the spread of agriculture to south-west China and argues that contrary to prior expectations, not only rice but also millet agriculture played an important role in this process. Furthermore, environmental factors, coupled with the different biological characteristics of these two crops, had profound effects on the development of social complexity in the region. In low-lying areas that provided the necessary ecological conditions for its success, rice agriculture could be intensified, spurring population growth and, inevitably, social change. Millets, on the other hand, were important for moving agriculture into the cooler and more difficult to irrigate uplands of the region.

The earliest evidence for rice and foxtail millet agriculture in south-west China comes from sites of the Baodun culture (c. 2700–1700 BC) in the Chengdu plain, Sichuan Province. From a complete absence of evidence for human occupation, the Chengdu plain suddenly became dotted with small hamlets and homesteads surrounding large walled sites (Chengdu Pingyuan Guoji Kaogu Diaocha Dui 2010). Ten walled sites have been discovered that range from 7–245ha in size (Wang 2006). The scale of these settlements and their enclosures, and by implication the labour force required to build them, suggests that important demographic and social transformations took place that would have been facilitated by abundant and reliable agricultural production.

Given the sudden arrival of the Baodun culture on the Chengdu plain c. 2700 BC and the absence of any obvious antecedent, its origins have been the subject of much discussion (Jiang 2001; Huang & Zhao 2004; Flad & Chen 2006; Zhang & Hung 2010). The lack of evidence for hunter-gatherer occupation in this area is surprising. Although geomorphological remodelling in this river delta may have hidden or destroyed the evidence,
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Figure 1. Location of main sites discussed in the text. 1) Baodun (2700–2000 BC); 2) Zhongba 1 (2500–1750 BC); 3) Jigongshan (1500–1300 BC); 4) Chengtoushan (4400–3500 BC); 5) Haimenxian (1600–400 BC); 6) Shifodong (1500–1000 BC); 7) Gantuoyan (1900–1200 BC); 8) Liangdiu (c. 3000 BC); 9) Shanghai; 10) Chengdu. The Chengdu plain is outlined in red.

over five years of systematic survey in the Chengdu plain have failed to document any prior hunter-gatherer occupation (Chengdu Pingyuan Guoji Kaogu Diaocha Dui 2010). As a result, scholars have been silent on the potential role played by such populations in this spread and have hypothesised that the Baodun culture was established by agriculturalists migrating into the region (Jiang 2001; Huang & Zhao 2004; Zhang & Hung 2010).

Similarities in ceramic typology have led some to suggest that the Baodun culture represents the spread of millet-growing Majiayao agriculturalists from the highlands of western and north-eastern Sichuan into the Chengdu plain (Jiang 2001; Huang & Zhao 2004). Others have pointed to the walls surrounding sites of the Baodun culture as evidence for regional interaction with areas to the east (Flad & Chen 2006; Fuller & Qin 2009), where similar walled settlements have been found in the Middle Yangzi valley at sites of the Taijiagang (c. 4400 BC), Daixi (4300–2500 BC; Hunan Sheng Wenwu Kaogu Yanjiusuo 2007), Qijialing (3000–2500 BC) and Shijiahe (c. 2500–2000 BC) cultures (Zhongguo Shehui Kexue Yuan Kaogu Yanjiusuo 1965; Beijing Daxue Kaogu Xueyuan Xi et al. 1992). All of those were supported by rice agriculture, and this has led several scholars to suggest that the arrival of the Baodun culture on the Chengdu plain marks the expansion of rice-growing agriculturalists into the region (Flad & Chen 2006; Zhang 2008; Fuller & Qin 2009; Zhang & Hung 2010).

To clarify the direction of the spread of agriculture into the Chengdu plain and to characterise the type of agricultural systems implicated in this spread, we carried out the first systematic archaeobotanical investigation at the type site of the Baodun culture during two excavation seasons (winter 2009 and 2010; Chengdu Shi Wenwu Kaogu Yanjiusuo © Antiquity Publications Ltd.
et al. 2000; He et al. 2012). The Baodun site is surrounded by inner and outer walls that enclose areas of 66 and 245ha respectively. Radiocarbon dates as well as pottery chronology show that this is the earliest known Baodun settlement in the region, with deposits dating to roughly 2700–2000 BC (Chengdu Shi Wenwu Kaogu Yanjiusuo et al. 2000) (Figure 2; see also online supplementary material Text S1 and Table S1).

**Archaeological context and methods**

A total of 364m$^2$ were excavated at Baodun during two field seasons (He et al. 2012), and 41 flotation samples were extracted from ash pits as well as from stratigraphic layers and ditches. Of these, 35 samples have been assigned to three different phases of the Baodun occupation and six samples to the Han Dynasty based on accompanying archaeological materials (Table 1). The high clay content of the sediment made machine flotation unfeasible. The samples were thus floated using bucket flotation, as described in Pearsall (2000: 29–33), and light fractions were recovered with a 0.25mm sieve.
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Table 1. Phase and context of flotation samples from Baodun.

<table>
<thead>
<tr>
<th>Cultural division</th>
<th>Stratigraphic layers</th>
<th>Ashpits</th>
<th>Ditch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baodun Phase 1</td>
<td>9</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>Baodun Phase 2</td>
<td>1</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>Baodun Phase 3</td>
<td>4</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Han Dynasty</td>
<td>4</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>18</strong></td>
<td><strong>18</strong></td>
<td><strong>5</strong></td>
</tr>
</tbody>
</table>

Results

The significance of taxa derived from the two seasons of excavation at the Baodun site was assessed using measures of ubiquity and density (Pearsall 2000). For rice, foxtail millet and vetch these were calculated on the basis of presence of caryopsis or cotyledon. Plant parts such as spikelet bases that are recoverable for rice but not for millets, and therefore not directly comparable, were excluded. Ubiquity for Job's tears (Coix sp.) was calculated from fragmented utricles as well as from the presence of caryopsis, as experiments show that it is unlikely that the latter will preserve in the archaeological record (see supplementary Text S3).

An analysis of all Baodun culture samples combined shows a clear predominance of rice (Oryza sativa) (ubiquity = 96.4 per cent and density = 0.7 seeds per litre; Figures 3 & 4). Remains of foxtail millet (Setaria italica) were also recovered (Figure 4). Despite their relatively high ubiquity (41 per cent), these were low in density (0.04 per litre) and absolute count (34 identified caryopses as compared to 1451 for rice in Baodun culture levels; see Table 2). A number of other crops supplemented the diet during the Baodun period. These include Job's tears (Coix sp.; see Text S3 and Figure S2), a small seeded vetch (Vicia sp.; see Text S4 and Figure S4) and two other kinds of bean in the Vigna complex (see Text S4 and Figure S4). In addition, condiments like beefsteak plant (Perilla sp.) and a single type of fruit, the hawthorn (Cratagus sp.), were also found at the site (Figure S5).

Rice and foxtail millet agriculture

The high ubiquity and density of rice makes it evident that it was an important component of the diet at Baodun. An examination of rice spikelet bases further suggests that the rice cultivated at Baodun was part of a domesticated package, with the majority of those unearthed from the site (55 per cent) showing a domesticated morphology (Figure 5). These patterns are similar to those found in other domesticated assemblages such as that of the Liangzhu site in the Lower Yangzi valley (c. 2200 BC; Fuller et al. 2009).

Although foxtail millet cultivation appears to have been known by the inhabitants of Baodun, its remains are relatively rare. This may be partly due to patterns of preservation. Experimental studies have shown that because of their relatively larger surface areas, smaller seeds such as millets may not survive the carbonisation process as well as larger seeds such as rice (d'Andrea & Catherine 2008; Märkle & Rösch 2008; Castillo 2011).
Figure 3. Ubiquity in percentage for main economic taxa at the site of Baodun on the basis of 29 samples.

Figure 4. Domestic grains unearthed from the site of Baodun. a) Rice (Oryza sativa) from T1586 H2 (Phase 2); b) foxtail millet (Setaria italica) from T2431 (4) H11 (Phase 1); c) rice spikelet bases (from left to right): immature, domesticated, wild; from T2431 H8 (Phase 1). Assignment of spikelet bases to categories follows Fuller et al. (2009); all scales are 1mm.
Table 2. Summary of the archaeobotanical material examined and identified from the site of Baodun.

<table>
<thead>
<tr>
<th>Litres of sediment processed</th>
<th>Phase 1</th>
<th>Phase 2</th>
<th>Phase 3</th>
<th>Han</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood (≥ 2mm) weight (grams)</td>
<td>237</td>
<td>187.5</td>
<td>264</td>
<td>156.5</td>
</tr>
<tr>
<td>Cultivated plants</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oryza sp. seed + fragment + immature</td>
<td>189</td>
<td>170</td>
<td>128</td>
<td>23</td>
</tr>
<tr>
<td>Oryza sp. spikelet bases</td>
<td>663</td>
<td>65</td>
<td>181</td>
<td>17</td>
</tr>
<tr>
<td>Oryza sp. embryo</td>
<td>24</td>
<td>18</td>
<td>16</td>
<td>2</td>
</tr>
<tr>
<td>Setaria itálica whole + fragments</td>
<td>21</td>
<td>6</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Immature Setaria sp.</td>
<td></td>
<td></td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>Possibly cultivated plants</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upland</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vicia sp.</td>
<td>59</td>
<td>3</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Vigna sp.</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Vigna cf. angularis</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vigna cf. radiata</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Perilla sp.</td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Wetland</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coix caryopsis</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Coix involucral bract fragments</td>
<td>22</td>
<td>131</td>
<td>147</td>
<td>3</td>
</tr>
<tr>
<td>Fruits/nuts</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cratageus sp.</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Undetermined nutshell fragments</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paddy field and wetland weeds</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potamogeton sp.</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Fimbristylis sp. whole + fragments (silicified)</td>
<td>334</td>
<td>504</td>
<td>226</td>
<td>13</td>
</tr>
<tr>
<td>Fimbristylis sp. (small type) (silicified)</td>
<td>3</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>cf. Equisetum sp. stem sections (silicified)</td>
<td>55</td>
<td>16</td>
<td>27</td>
<td></td>
</tr>
<tr>
<td>Upland and dryfield weeds</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digitaria sp. whole + fragments</td>
<td>27</td>
<td>1</td>
<td>6</td>
<td>28</td>
</tr>
<tr>
<td>Wild Setaria sp. whole + fragments</td>
<td>13</td>
<td>4</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Elesine indica (possibly uncarbonised)</td>
<td>3</td>
<td>6</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Hackelochloa sp. whole + fragments + immature (silicified)</td>
<td>38</td>
<td>511</td>
<td>243</td>
<td>22</td>
</tr>
<tr>
<td>Undetermined Fabaceae</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Caryophyllaceae</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Chenopodium sp. whole + fragments</td>
<td>61</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Galium sp.</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Xanthium sp.</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Hyoscamus sp.</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solanum sp. whole + fragments</td>
<td></td>
<td>1</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Verbena sp.</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sambucus sp.</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Weeds common to both upland and paddy fields</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cyperaceae cotyledon</td>
<td>14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cf. Scirpus sp. pericarp</td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>cf. Carex sp.</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>cf. Cyperus sp.</td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Echinochloa sp.</td>
<td>11</td>
<td>8</td>
<td>1</td>
<td>9</td>
</tr>
</tbody>
</table>
Table 2. Continued.

<table>
<thead>
<tr>
<th></th>
<th>Phase 1</th>
<th>Phase 2</th>
<th>Phase 3</th>
<th>Han</th>
</tr>
</thead>
<tbody>
<tr>
<td>cf. <em>Miscanthus</em> sp.</td>
<td>39</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lamiaceae cf. <em>Stachys</em> sp.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Polygonum</em> sp./<em>Persicaria</em> sp.</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polygonaceae</td>
<td></td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><strong>Undetermined specimens</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Panicoid grass type 3</td>
<td>2</td>
<td>2</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Panicoid cf. <em>Andropogon</em> type 4</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Calamagrostis</em> sp./<em>Eragrostis</em> sp./<em>Aira</em> sp.</td>
<td>17</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Undetermined panicoid grass whole + fragments</td>
<td>22</td>
<td>13</td>
<td>6</td>
<td>11</td>
</tr>
<tr>
<td>Undetermined seeds</td>
<td>31</td>
<td>15</td>
<td>20</td>
<td>3</td>
</tr>
</tbody>
</table>

Figure 5. *Rice spikelet bases from the site of Baodun: phases 1–3 combined.*

Numbers of identified specimens could also be due to difficulties in recognising *Setaria italica* fragments and distinguishing them from other panicoid weeds. Its low numbers suggest, however, that foxtail millet was not an important focus of agricultural production at Baodun.

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Weeds of cultivation

Rice can be cultivated in either dryland/upland fields or in wetland paddy fields. It is now generally accepted that the domestication of *Oryza japonica* took place in the Central or Lower Yangzi valley (Crawford & Shen 1998; Crawford 2006; Londo *et al.* 2006; Liu *et al.* 2007; Sweeney & McCouch 2007; Fuller 2008). The spread of rice agriculture up the Yangzi is presumed to have involved wetland rice (Fuller & Qin 2009; Fuller *et al.* 2010). The presence of possible upland systems of rice cultivation in northern China and Korea (Fuller *et al.* 2011), however, suggests that the kind of rice agriculture transmitted to the Chengdu plain could also have involved upland varieties. Since some weeds are specific to ecological zones, these can be used as indicator species to distinguish between wetland and upland systems of cultivation (Bogaard *et al.* 1999; Raju 1999; Jones *et al.* 2005; Castillo 2011).

The predominant weed in the Baodun assemblage is *Fimbristylis* sp., a member of the sedge (Cyperaceae) family most closely resembling the species *F. dichotoma*. Experimental work carried out by the authors demonstrates that the high silica content of these species leads to them being preserved in a silicified form even following charring. This particular sedge is reported as a common weed of rice paddy or wetland environments (Soerjani *et al.* 1987; Wang 1990; Raju 1999). Roughly 79 per cent of the samples containing rice also contained this weed, thus implicating an association with wet rice agriculture. Other weeds that may be associated with paddy agriculture include cf. *Equisetum* sp. and *Potamogeton* sp. (Soerjani *et al.* 1987; Wang 1990; Raju 1999). However, weeds associated with dryland crops were also recovered from Baodun. These include *Hackelochloa* sp. (Soerjani *et al.* 1987) as well as plants such as *Vicia* sp., which could also have been consumed. Hence although it is clear that wetland agriculture was practiced at Baodun, weeds from dryland contexts are also present. These could have come from fields of foxtail millet or disturbed areas around the site, but further research is needed to eliminate the possibility of their association with upland rice (see Table 2 and Figure S1).

Discussion

Discussions about the spread of agriculture to deep south and south-west China (Guanxi and Guandong provinces) have focused primarily on documenting the spread of rice (Zhao *et al.* 2005; Zhang 2008; Fuller & Qin 2009; Zhang & Hung 2010). A closer look at the archaeobotanical record, however, shows that both rice and millets played crucial roles in the spread of agriculture into these regions. The expansion of rice agriculture into south-west China as a whole largely post-dates 3000 BC, leaving a gap of almost 3000 years between its domestication farther east on the Yangzi and the Baodun evidence (Zhang & Hung 2010). The spread into south-west China occurs at a much slower rate than the spread of rice agriculture along the Chinese coast and to the north (Crawford *et al.* 2005, 2006). It is important to consider the reasons for this.

Paddy rice is a desirable staple because of its high yield. If the type of rice introduced to south-west China was indeed a lowland/paddy type of *Oryza japonica*, as the evidence from Baodun suggests, it would have required large amounts of water for its growth (in a paddy environment), high temperatures in order to achieve maturity and a long growing season.
Foxtail millet, in contrast, has a shorter growing season than rice and is tolerant of both aridity and low temperatures (Cardenas 1983; Saseendran et al. 2009). Cultivation of millet would have allowed farmers expanding into the drier and cooler upland territories that characterise the foothills of the Three Gorges, Yunnan and Guizhou to maintain subsistence versatility and reduce their risk (d'Alpoim Guedes 2011).

The spread of foxtail millet into the region is much less well documented than that of rice, and this is likely due in large part to sampling strategies as well as to the issues of preservation noted above. Use of a large mesh sieve or hand picking favours the recovery of rice. Millets are much smaller and can rarely be seen by the naked eye during excavation. The apparent under-representation of millets in the archaeological record of south-west China may thus be an artefact of sampling strategies (Weber & Fuller 2008).

Recent archaeobotanical data from the Middle Yangzi shows that both rice and foxtail millet were grown by the inhabitants of Chengtoushan (Figure 1) between 3800–3500 BC (Yasuda et al. 2004; Nasu et al. 2007, 2011). However at Chengtoushan, as at Baodun, the proportion of foxtail millet grains in the assemblage is low. The fact that the inhabitants of Baodun relied to a large degree on paddy rice and had knowledge of foxtail millet, and the presence of walled sites and some similarities in cultural material (Sun 2000), suggest a strong connection between the Chengdu plain and the Middle Yangzi. One can consider three routes by which this spread may have occurred. The first, proposed by Zhang and Hung (2010), is a northern route, following the Yangzi River through the Three Gorges. Recovery of botanical remains by flotation has only been carried out at one early site in this area: Zhongba Phase 1 (2500–1750 BC; Zhao & Flad forthcoming). Despite evidence of some cultural connections with rice-producing sites of the Middle Yangzi, the archaeobotanical remains from Zhongba Phase 1 show a clear reliance on broomcorn and foxtail millets (over 90 per cent of the total seed assemblage). Only a single fragmentary grain of rice was unearthed from deposits dating to this period. The vertical topography of the Zhongba area may have presented a challenge to the creation of the water management systems associated with rice paddy agriculture, thus prompting the use of dryland crops.

Another potential route for the spread of rice agriculture is a southern one through the foothills of Guizhou Province and then northward into the Sichuan Basin. The earliest archaeobotanical evidence from Guizhou comes from the Bronze Age site of Jigongshan (1500–1300 BC) where rice remains dominate the archaeobotanical assemblage (Guizhou Sheng Kaogusuo & Sichuan Daxue Lishixi Kaogu Jiaoyansuo 2006). The late date of these finds has led Zhang and Hung (2010) to hypothesise that agriculture spread from the Sichuan Basin into Guizhou and not vice versa. It is probable, however, that the absence of earlier evidence from Guizhou is a product of the dearth of archaeological and archaeobotanical investigations in this province. A third potential route is through the Han River valley, which is situated to the north of the Sichuan Basin, but no archaeobotany has been carried out in this area. Indeed, considerable further research in both Guizhou and Sichuan is needed to understand the development of agriculture in south-west China and the identity of the farmers who were instrumental in introducing it to this region.

In addition to the sites mentioned above, foxtail millet has been reported at all sites where systematic flotation has been carried out in deep south and south-west China. These include the Bronze Age sites of Haimenkou (1600–400 BC; Xiao 1995; Xue 2010) and Shifodong in...
Site of Baodun yields earliest evidence for the spread of rice and foxtail millet agriculture to south-west China

Yunnan (1500–1000 BC; Zhao 2010b), as well as Gantouyan in Guangxi (1900–1200 BC; Guangxi Zhuang Zizhiqu Wenwu Gongzuodui & Napo Xian Bowuguan 2003) (Figure 1). Data from sites in western Sichuan and the Tibetan Plateau show that agricultural systems based entirely on millet were present in the foothills of this region as early as 3500 BC (Xizang Wenguanhui & Sichuan Daxue Lishixi Kaogu Jiaoyansuo 1985; Zhao & Chen 2011). Recent evidence from central Thailand suggests that millet agriculture preceded the spread of rice agriculture into Southeast Asia (Weber et al. 2010). More systematic flotation and sampling of archaeological sites may show that the same is true for south-west China.

The mountainous foothills of Yunnan Province and Guizhou required extensive terracing and complex irrigation systems for rice paddy cultivation systems to be successful. In fact, historical sources such as the Man Shu (Book of southern barbarians [Fan 1961]) suggest that the systems of terraced paddies that we associate with the landscape today do not pre-date the Tang Dynasty (AD 618–907) (Fan 1961; Li 2000; Bouchery 2010). In the early stages of agricultural expansion into the Yunnan-Guizhou plateau and the Three Gorges, we predict that an emphasis on foxtail millet (and, later, western domesticates) may have facilitated movement into these more challenging vertical topographies providing a reliable and easy-to-manage alternative in an environment where the risk of failure of rice agriculture was high. Although data from early sites in this area are lacking, systematic flotation at the site of Haimenkou (1600–400 BC) in Yunnan supports that hypothesis. Xue’s (2010) analysis of plant remains indicates that experiments with rice agriculture were short lived, and rice was quickly replaced by more arid and cold-adapted western domesticates like wheat.

Compared to these upland environments, the large flat expanse of the Chengdu plain, with its ample water sources, presented an ideal environment for wetland rice production, one that shared some key characteristics with the Middle and Lower Yangzi. Discussions with local farmers have revealed that the bunded paddies that characterise current rice agriculture in the Chengdu plain require relatively little labour investment (interviews carried out in December 2010). The many large rivers that crisscross the plain would also have provided a readily accessible source of water for flooding paddy fields. When farmers familiar with both millet and rice agriculture moved into this area, possibly from further downstream on the Yangzi, they exploited these advantageous conditions by introducing rice agriculture, which could easily be intensified. The walled sites of the Baodun culture represent some of the earliest traces of the complexity in the Chengdu plain that this agricultural system was able to support. Sustained by a reliable, intensifiable and highly productive agricultural system, the Chengdu plain later became the centre of important social networks epitomised by the spectacular bronzes from the sites of Sanxingdui and Jinsha (Sichuan Sheng Wenwu Guanli Xieyuanhui 1987; Sun 2000; Bagley 2001). Farmers moving into this region were able to maximise their returns by adapting their crop repertoire to these new environments. Where the ecological and topographic conditions permitted, rice agriculture was intensified, spurring population growth and the development of social complexity. Foxtail millet (and, later, other western domesticates such as wheat and barley), were crucial in allowing an agricultural lifestyle to move into previously uncolonised areas and facilitated expansion into new orographically defined territories such as Yunnan and, ultimately, Southeast Asia. The introduction of systematic archaeobotanical analyses to south-west China will allow
us to test these hypotheses and to understand the role that crops and their environments played in shaping human history in the region, and how humans adapted their technology and agricultural systems in response.

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References


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