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Millets, Rice, Social Complexity, and the Spread of Agriculture to the Chengdu Plain and Southwest China

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Abstract Southwest China played a pivotal role in the spread of agriculture across East and Southeast Asia. Both rice and millet were important in the spread of populations and the expansion of agriculture into this region. Recent finds in the mountainous peripheries of Sichuan Province show that the earliest inhabitants of this region practiced a combination of broomcorn and foxtail millet agriculture (ca 4000–2500 BC). These crops are adapted to high altitude and arid environments, which facilitated their movement across this region and eventually into the Tibetan Plateau. At around 2700 BC, a combined system of rice and foxtail millet agriculture appears suddenly in sites of the Baodun culture on the Chengdu Plain. The use of this double cropping system provided advantages to the inhabitants of this region in both risk reduction and yield. I argue that this had important consequences for spurring population growth, facilitating expansion into new territories and the development of social complexity.

Keywords Southwest China · Rice · Millet · Spread of agriculture

Introduction

The region of Southwest China covers the municipality of Chongqing and the provinces of Sichuan, Yunnan, and Guizhou in the People's Republic of China. Situated at the boundary of the Tibetan high plateau and low-lying plains, both linguists and archaeologists have pointed to the important role that this region played in the spread of agriculture into Southern China and eventually Southeast Asia (Bellwood 2005a; 2006; Higham 2002; Van Driem 2005; Zhang and Hung 2010). Recent evidence from sites in the highlands and basin of Sichuan provide important data for understanding how and when agriculture spread into this region (Fig. 1). These data relate to two agricultural systems of interest for understanding population movement and the spread of languages in the region.

The first is the early spread of millet agriculture to the highlands of the Hengduan mountain range to the west and the south and the Qinling mountain range to the north of the Sichuan Basin and the Tibetan Plateau. Current evidence suggests that this spread occurred from Northwest China ca 3500 BC or earlier. The second is the spread of rice and foxtail millet agriculture to the undulating hills of the Sichuan Basin itself, specifically to the large level area of the Chengdu Plain in the Northwest portion of the Basin. Here, a system of rice and foxtail agriculture appears suddenly in sites of the Baodun culture ca 2700 BC. Combined rice and foxtail millet formed a perfect packet for agricultural expansion, thanks to their versatility and capacity for intensification and potential to reduce risk. From this area, rice and foxtail millet agriculture spread rapidly into Yunnan, possibly Guizhou, and ultimately into Southeast Asia.

The spread of agriculture to this area appears to be accompanied by an increase in social complexity as well as population density. In particular, the appearance of rice and foxtail millet agriculture on the Chengdu Plain is accompanied by a number of sociopolitical transformations which include a settlement pattern dominated by a limited number of large, central places. These sites are surrounded by walls that would have required considerable investment in terms of labor. Weed flora indicates that labor investments were not limited to wall installations, but may also have involved

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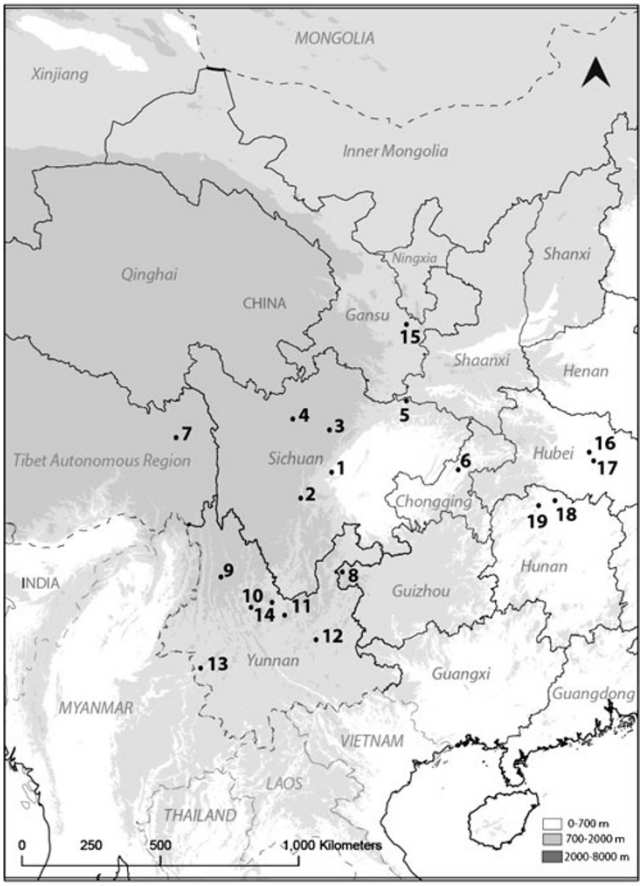

Fig. 1 Location of main sites mentioned in the text: (*1*) Baodun; (*2*) Shizishan/Maiping; (*3*) Yingpanshan, Boxi, and Jiangduichen; (*4*) Haxiu; (*5*) Zhongzipu; (*6*) Zhongba; (*7*) Changdu Karuo; (*8*) Jigongshan; (*9*) Haimenkou; (*10*) Baiyangcun; (*11*) Dadunzi; (*12*) Haidong; (*13*) Shifodong; (*14*) Mopandi; (*15*) Dadiwan; (*16*) Qujialing; (*17*) Shijiahe; (*18*) Pengtoushan; and (*19*) Chengtoushan.

investments in water management and the creation of rice paddies. These data hold important implications for understanding how early agriculturalists expanded into this region and adapted their patterns of subsistence to widely varied environmental settings. The timing of these finds also hold broader implications for the spread of population and languages into Southwest China.

Setting the stage: new dates for the origins of rice and millet agriculture

Our understanding of the origins of rice and millet agriculture has changed considerably over the past 10 years and a brief review of these changes is necessary in order to set the finds from Southwest China in context. Recent debates on the origins of rice cultivation have led to a reevaluation of the timing and locus of its emergence. Although this material lies largely outside the scope of this paper, we will give a brief review of these debates to orient the reader. Excluding some suspect pre-Holocene sites,[1] there is some evidence that rice cultivation began by at least 8000–7000 cal. BC in the Lower Yangzi River basin at sites such as Shangshan (ca 8000 cal. BC) (Jiang and Liu 2006; Liu et al. 2007; Yuan 2002). Here, it has been argued that rice grains used to temper pottery show signs of initial or early domestication. Following its cultivation ca 8000–7000 cal. BC, rice is thought to have dispersed to the Central East Yellow River Valley by 7000–6000 cal. BC. A contrasting model proposes that rice cultivation in the Lower Yangzi basin began somewhat later (6000 cal. BC) based on a reevaluation of the data and an examination of the emergence of non-shattering traits in rice spikelet bases (Fuller et al. 2007; Fuller et al. 2008a, b; Fuller and Qin 2010; Zheng et al. 2007).

Another possible center for rice domestication lies in the Middle Yangzi River valley sites of the Pengtoushan culture. Compared to the sites of the Lower Yangzi, very little systematic work has been carried out in this area. Based on an evaluation of published rice measurements from the site of Bashidang (6400–6000 BC), Fuller et al. (2008a) have suggested that these fall into the range of wild/immature rice. It is unclear if this represents a stage of pre-domestication cultivation or if these finds are representative of wild rice gathered by foragers. Based on present data, we cannot eliminate the possibility of a second center of domestication in this region. At any rate, by the time that the settlements of Daxi culture were established in this region (ca 4000 BC), it is clear that their inhabitants were heavily reliant on rice agriculture (Xiang and Huang 1995; Nasu et al. 2007). In addition to rice, foxtail millet has also been unearthed at the Daxi cultural site of Chengtoushan (4400–3300 BC). This shows that a part of the repertory from northern China had already been incorporated into the subsistence regime of the south. For a more extensive discussion of these sites, I refer readers to the articles by Bellwood (this volume) and Fuller (this volume).

In comparison to rice, investigations on the origins of millet agriculture are relatively new. Both Bettinger et al.

[1] While initial reports situated the origins of rice cultivation in China at late Pleistocene cave sites such as Yuchanyan (ca. 16000–12000 BC) and Zengpiyan (ca. 8000–5000 BC) (Yuan 2002; Zhang and Yuan 1998), recent re-excavations and continued analysis have considerably changed our understanding of the role of these sites in the origins of Chinese agriculture. For instance, systematic flotation at the site of Zengpiyan produced no rice despite a large variety of other paleobotanical finds (Zhao 2003a). Recent reinvestigation of the site of Yuchanyan provided no support for the notion that rice agriculture was being practiced alongside the use of early pottery (16300–13430 BC) (Boaretto et al. 2009). Similarly, recent reevaluations of phytolith evidence from the sites of Diaotonghuan and Xianrendong show that these sites are representative of hunting and gathering rather than agricultural tradition (Zhao 2010a). Until more solid evidence for rice exploitation is unearthed from late Pleistocene sites, we have chosen to eliminate these sites from our discussion.

(2010a, 2007) and Liu et al. (2009) have recently proposed that millet cultivation first arose in the upland foothill desert margins to the north of the Yellow River sometime before 6000 BC as a means of dealing with increasing climatic instability. However, the paucity of archaeobotanical data means that it is difficult to determine the exact point in time at which these transformations occurred. Some of the earliest concrete evidence comes from Dadiwan, where it is clear that broomcorn millet was consumed (by both humans and the animals they raised as early as 5900 BC) (Barton et al. 2009; Gansu 2006; Liu et al. 2004). A recent paper has tried to push the evidence for millet cultivation even earlier. Phytolith and chemical work at the Peiligang culture site of Cishan concluded that between 8300 and 6700 cal. BC, the inhabitants of the site were reliant on broomcorn millet (Lu et al. 2009). However, the lack of contextual and cultural historical evidence surrounding these finds makes it difficult to say whether these are representative of a food-producing or foraging context (Bettinger et al. 2010b). The finds of broomcorn and foxtail millet at sites of the Xinglongwa culture (6000–5500 BC) also suggest a possible center of domestication in Northeastern China (Zhao 2005).

The spread of agriculture into Southwest China

The mechanism, timing, and spread of rice and millet agriculture into what today is called Southwest China is still poorly understood. Currently, the earliest evidence for the spread of agriculture into this region comes from Sichuan Province, where two types of agriculture appear to have been intertwined with the spread of populations and possibly language families. In recent years, the spread of rice agriculture has received considerable attention and has been viewed as playing a central role in the spread of population, social complexity, and language across East Asia (Bellwood 2005a, b; Cavalli-Sforza 2002; Fuller and Qin 2009). However, the spread of millet agriculture, both alone and in combination with rice agriculture, also played an important role in these phenomena. We will review the archaeobotanical evidence for the spread of both these crops in this section.

Millet agriculture and early settlements on the mountainous peripheries

Millet agriculture appears to have been well adapted to the highlands of western Sichuan, thanks to its short growing season and ability to tolerate cold and arid climates (Chai 1999; Mann 1946). These characteristics allowed it to spread rapidly to sites situated at a range of different altitudes. The spread of millet agriculture into the Sichuan highlands is closely linked to the expansion of the Yangshao culture out of its homeland in the provinces of Qinghai, Gansu, and Henan.

Prior to the arrival of millet agriculture in this region, little is known about its early inhabitants. Evidence from the site of Ziyang makes it clear that the mountainous peripheries of the Sichuan Basin have been occupied since Paleolithic times (Ye 1998). However, there is a long gap of time between these Pleistocene occupations and the later Majiayao culture agricultural sites discovered in this region. The discovery of microliths at many sites in the mountainous foothills of Sichuan province suggests this gap in time may be an artifact of excavation practice and that hunter–gatherers forming part of the North China microlithic interaction sphere could have occupied this region as early as 20000 BC (Bettinger et al. 2010a, b).

Microliths have been unearthed at many sites to the Northwest and Northeast of the Sichuan Basin. However, in all of these sites, microliths are found in association with cultural material such as pottery, adzes, axes, and chisels, which is characteristic of later agricultural settlements. They thus appear to be dated too much later than those known from the microlithic in Gansu and Qinghai Provinces. To the northeast, a number of sites have yielded microliths which show similarities to cultural traditions further north in Qinghai or Gansu (Ye 1992; Zhongguo Sichuan 1991). C-14 dates have only been carried out at the site of Zhongzipu, leading the excavators to suggest the remains date to between 5000 and 3500 BC (Zhongguo Sichuan 1991). In the northwestern foothills of the Sichuan Basin, microliths have also been found at sites such as Yingpanshan (ca 3300 BC) (Chengdu et al. 2002). Similar lithic material has also been unearthed in the southern peripheries of the Chengdu Plain at the sites of Shizishan and Maiping (Ma 1992; Zhongguo Sichuan 1991). Very few of these sites have been the object of careful excavations or direct dating. It is thus unclear whether the microliths, ceramics, and other remains are actually contemporaneous. As later agriculturalists moved into this area, it is possible that their settlements were placed on top of hunter–gatherer encampments. As they built house foundations and dug graves, they could have brought earlier material to the surface. Much more careful and finer excavation of these sites is needed in order to resolve these chronological problems. Doing so may prove that the hunter–gatherer occupation of this region has a much longer history than previously thought.

The expansion of late Yangshao culture sites into the highlands surrounding the Sichuan Basin is better understood. The Yangshao culture first appears in the Central Plains and is found more widely in the Miaodigou phase (ca 4000–3500 BC), when it expands to Gansu and Eastern Henan. The Majiayao phase (ca 3500–2500 BC) is

characterized by westward spread into the provinces of Qinghai and Gansu (Yan 1989). Extensive work carried out by the Chengdu City Institute of Archaeology over the last decade shows that this culture expanded not only west but also southward into the Sichuan highlands as early as the Miaodigou period. However, to date, remains of this phase have been unearthed at only two sites: that of Boxi and Jiangduichen (Chen 2007).

With the transition to the Majiayao phase (ca 3500 BC), sites become widely spread across western Sichuan. In this region, two radiocarbon dates place this phase at approximately 3300–2600 cal. BC (Aba et al. 2008). Sites of this period show clear cultural affinities with the Majiayao heartland. This is clearest in the painted pottery excavated from these sites. Recent analysis of this pottery has shown that it was traded into Western Sichuan from the Majiayao heartland in Gansu and Qinghai (Cui et al. 2011; Hong et al. 2011). Archaeobotanical analysis of two sites relating to this phase is currently in progress at the Chinese Academy of Social Sciences (Zhao 2008). Remains from the site of Haxiu (ca 3300–2700 BC) show that subsistence was based on both broomcorn (*Panicum miliaceum*) and foxtail (*Setaria italica*) millet (Aba et al. 2008, 2007; Zhao 2008). Remains from the site of Yingpanshan (ca 3300–2500 BC) show a similar pattern (Chengdu et al. 2002; Zhao 2008). The movement of millet agriculture into this region is also accompanied by pig husbandry, and the bones of domestic pigs have been uncovered at nearly all Majiayao sites in Western Sichuan (He et al. 2009).

In addition, it is likely that these millet agriculturalists were responsible for transmitting their agricultural technology into the high-altitude environment of the Tibetan Plateau. Painted pottery, domesticated pigs, foxtail, and broomcorn millet all appear at the site of Changdu Karuo (3500–2200 BC) on the Tibetan Plateau around the same date as the expansion of the Majiayao culture into Western Sichuan. This demonstrates the apparent ease with which millet agriculture was able to move and adapt to different ecological zones (d'Alpoim Guedes et al. in preparation; Xizang and Sichuan 1985).

Given the proximity of these sites to the Chengdu Plain, we might expect that the first occupation of this agriculturally rich area occurred from the north and was connected to the Majiayao. In fact, pottery unearthed at the early phases of the site of Guiyuanqiao on the Chengdu Plain indicates that millet agriculturalists may have occasionally descended into lower elevation contexts such as the Chengdu Plain (Wan, personal communication).[2]

Millet agriculturalists (and possibly earlier hunter–gatherer populations) on the peripheries of the Sichuan Basin played an important role in the spread of agriculture into Southwest China. Both foxtail and broomcorn millet have short growing seasons, are arid adapted, and can survive in a wide array of climatic conditions, making them well suited to mobility and expansion, especially landscapes with highly variable and vertical topography such as the mountainous foothills of western Sichuan. Shared cultural attributes with sites in northwestern China also suggest that millet agriculturalists in the Southwest China highlands could have played a role in the spread of populations, languages, and genes.

Spread of rice agriculture into the Chengdu Plain: evidence from the site of Baodun

Sites of the Baodun culture constitute a lynchpin for understanding how rice agriculture moved into Southwest China as they contain some of the earliest archaeobotanical evidence for this region as a whole. The sites of the Baodun culture appear suddenly on the Chengdu Plain at around 2700 BC. Even the earliest sites of this culture exhibit signs of developed social complexity. The remains of around ten walled sites pertaining to the Baodun culture have been discovered, ranging from 7–245 ha in size (Chengdu Gongzuo 2001; Chengdu and Pixian 1999; Chengdu et al. 1998; Chengdu and Pixian 2001; Chengdu et al. 2000; He 2011; Yan and Jiang 1999; Zhongri 2001). Data from the Chengdu Plain Archaeological Survey project as well as recent excavations carried out by the Chengdu City Institute of Archaeology indicate that smaller scale settlements were also present alongside these larger walled enclosures (Chengdu Guoji 2010; Chengdu 2002, 2004a, 2005a, 2006a, b, c, 2007; Chengdu and Pixian 2005; Chengdu and Xindu 2010). The scale of these enclosures and the labor required to build them hints at the beginnings of social complexity in the region. The type site of Baodun (2700–2100 BC) is surrounded by an interior and exterior wall and covers a total surface area of 245 ha, but the internal organization of these sites is still poorly understood. Large numbers of ashpits containing domestic refuse as well as a few wattle and daub houses have been unearthed. Installations unearthed at the site of Gucheng in Pixian county have been interpreted as serving a ritual function, suggesting that these walled sites may also have functioned as ritual centers (Chengdu and Pixian 2001).

Similarities in ceramic decoration, shape, and manufacture (particularly at the site of Baodun itself) have led some scholars to suggest that the Baodun culture has its origins in the Majiayao culture sites to the northwest, particularly Yingpanshan (He 2011; Huang and Zhao 2004). Others have pointed to possible connections in sites of the Jialing River valley to the northeast of the plain (Jiang 2001). Underlying both of these theories is the implication that the inhabitants

[2] Archaeobotanical analysis is currently being carried out by d'Alpoim Guedes and Wan (in preparation) for the site of Guiyuanqiao.

of the Baodun culture practiced millet rather than rice agriculture. Others have pointed to the large walls surrounding the sites of the Baodun culture as evidence of regional interaction with areas to the east (Flad and Chen 2006; Fuller and Qin 2009). Walled settlements have been found at sites associated with rice agriculture such as those of the Taijiagang (ca 4400 BC) and Daxi cultures (4300–2500 BC) in the Middle Yangzi River valley (Hunan 2007). They have also been discovered in sites of the Qujialing cultures (3000–2500 BC) and Shijiahe cultures (ca 2500–2000 BC) (Beijing et al. 1992; Zhongguo 1965). This has led several scholars to hypothesize that the arrival of the Baodun culture on the Chengdu Plain is the result of the expansion of rice agriculturalists into this region from the east (Fuller and Qin 2009; Zhang 2008; Zhang and Hung 2010).

Systematic flotation carried out at the site of Baodun provides good data for understanding the early movement of rice agriculture into the region (d'Alpoim Guedes and Jiang 2011). The significance of taxa at this site was evaluated using a ubiquity score (Pearsall 2000). Ubiquity is calculated on the basis of the total percent of samples in which a species is present regardless of whether it occurs as one seed or many. As different plant species vary hugely in the numbers of seeds they produce, estimating the significance of taxa using counts alone can be misleading. Charred seeds are most likely to enter archaeological site as a result of routine activities. Theoretically, plants which are most closely related to human activity are more likely to be brought back onto an archaeological site and hence abandoned or discarded on this site. Using ubiquity is thus well suited to make inferences about the overall importance a given taxa played at a site.

The predominance of rice (*Oryza sativa*) at Baodun is clear, with a total ubiquity of 100% of all samples collected during two seasons of excavation. A few examples of foxtail millet (*S. italica)* were also unearthed; however, these had a relatively low ubiquity of 33% (d'Alpoim Guedes and Jiang 2011). Interestingly, no broomcorn millet (*P. miliaceum*) was found in the samples even though this formed an important contribution to the diet in sites of the mountainous peripheries. The lower ubiquity of foxtail millet may be an artifact of preservation. Experimental studies have shown that because of their higher surface area, smaller seeds such as millets may not survive the carbonization process as well as larger seeds like rice (Castillo this volume; D'Andrea 2008; Markel and Rosch 2007; Wright in preparation). Despite its lower ubiquity, it is thus likely that foxtail millet still formed an important component of the diet at Baodun. Foxtail millet could have been cultivated either alongside rice agriculture during the summer or could have been planted in the fall as a late season after the rice harvests were collected or as a fallback crop in years of poor yield. Further work is needed to determine the season of its sowing. Together, rice and foxtail millet formed a diversified food strategy and a risk resistant package which was adjustable to different ecological settings.

A high proportion (55%) of the rice spikelets unearthed at the sites showed a domesticated morphology, whereas only 11% of spikelets exhibited a wild morphology. These data indicate that rice agriculture was transmitted to the Chengdu Plain as a fully domesticated package. The presence of weeds associated with wet field agriculture, such as sedges (Cyperaceae), further suggests that when rice agriculture moved, it may have moved along with the technology for water management (d'Alpoim Guedes and Jiang 2011). The results of flotation carried out at Baodun make it clear that its inhabitants were heavily reliant on rice agriculture. It is consequently tempting to construct a scenario whereby rice agriculture moved into the Sichuan Basin due to expansion from these cultures to the east.

Despite the lack of archaeobotanical evidence from regions to the east of the plain, one can hypothetically consider two different routes for this spread. The first of these is a northern route, following the Yangzi River through the Three Gorges area. However, the lack of evidence from Eastern Sichuan makes this claim hard to evaluate. Flotation has only been carried out at one site in the eastern part of the Sichuan Basin: Zhongba. The samples from Zhongba range in date from 2500 to 200 BC (Zhao and Flad ND). Despite signs of some cultural connections with rice-producing sites of the Middle Yangzi, flotation at Zhongba shows a clear reliance on broomcorn and foxtail millet and not on rice. Only one fragmentary grain of rice is present in the samples from phase 1 (2500–1750 BC) and none were found in the two poorly preserved samples from phase 2. Only in phase 3 (1100–200 BC) does the ubiquity of rice increases slightly. The lack of wetland weeds associated with paddy agriculture further suggests that the few finds of rice may not have been grown locally. Based on data from only one site, it is difficult to say whether or not this pattern of subsistence is reflective of the entire Eastern Sichuan or a small geographical locale. Zhao and Flad (ND) have suggested that this may be due to local conditions surrounding the site. It is indeed possible that the more vertical topography of this area may have presented a challenge for creating 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 route through the foothills of Guizhou Province, from which it could have moved northward into the Sichuan Basin. To date, very little archaeobotanical work has been carried out in Guizhou Province. The earliest evidence comes from the Bronze Age site of Jigongshan, where rice appears to have formed an important part of the

assemblage (Guizhou et al. 2006). No radiocarbon dates have been carried out at this site; however, based on pottery chronology, it is said to be contemporaneous with the late Shang, placing it at roughly ca 1300–1500 BC. The late date of these finds has led Zhang and Hung (2010) to hypothesize that the spread of agriculture into this region occurred in the opposite direction and diffused into Guizhou from the Sichuan Basin. However, it is probable that the lack of earlier evidence in this region mostly reflects the dearth of archaeological investigation in the province as a whole. Further research in these areas is needed to determine the route via which rice agriculture moved into the Sichuan Basin.

Spread of agriculture beyond the Sichuan Basin

Only a few archaeobotanical finds have been published from Southwest China as a whole and fewer still have been directly dated. To the south of the Chengdu Plain, in Yunnan Province, rice has been found in the Neolithic phases of the Haidong site of the Shizhaishan culture which dates to approximately 2500 (Xiao 2001; Zhang and Hung 2010). It is unclear, however, what materials were used for dating this site and what layers the finds of rice came from. Rice husks have also been found at the sites of Baiyangcun (ca 2300–2000 cal. BC) (Yunnan 1981; Zhang and Hung 2010). Slightly later, rice has also been discovered at the site of Yongping Xinguang, which dates to approximately 2050–1750 cal. BC according to dates carried out on sediment (Yunnan et al. 2002). A few remains of carbonized rice were uncovered in a ditch at this site. Reliable dates for rice come only from later periods, and rice has been unearthed from the early phases of the Haimenkou site ca 1600 BC (Xue 2010) and from the site of Mopandi in Yongren County (ca 1400 BC) (Zhao 2003a, b). Similarly dated finds of rice come from the site of Dadunzi in Yuanmou (Yunnan 1977). Much further south, rice is present at Shifodong where it was directly dated to 1400 BC (Zhao 2010b). Among these sites, systematic flotation has only been carried out at the sites of Haimekou and Shifodong.

Systematic flotation is needed in the earlier sites in this region to determine whether millet agriculture accompanied rice on its spread southwards. The spread of millet agriculture into this region is much less well documented, but it is likely that this is due in large part to sampling strategies. The use of a large mesh size or hand picking favors the recovery of rice. Millets are much smaller and can rarely be seen by the naked eye during the course of an excavation. The underrepresentation of millet in the archaeological record of Southwest China may be an artifact of sampling strategies. In the rest of Southwest China, foxtail millet has only been reported from sites where systematic flotation has been carried out, such as the Bronze Age sites of Haimenkou and Shifodong in Yunnan (Xue 2010; Zhao 2010b). In both of these sites, foxtail occurs alongside rice agriculture. This indicates that foxtail millet cultivation (combined with rice agriculture) formed part of the package of agricultural expansion into southern China.

Together, rice and foxtail millet formed a versatile and risk-resistant package that was able to adapt to the varying altitudes, water, and climatic conditions which characterize the landscape of Southwestern China. The mountainous foothills of Yunnan Province required extensive terracing work in order for rice paddy cultivation systems to become successful in this area. In the early stages of agricultural expansion into this area, a switch to foxtail millet may have facilitated movement into more challenging vertical topographies. Here, rice agriculture may have been initially limited to the narrow valley bottoms. In order to reach the levels of productivity achieved in flat lands such as the Yangtze delta or the Chengdu Plain, extensive landscaping and the creation of terraces would have been necessary. By substituting foxtail millet in the early times of expansion, a food source was assured in a challenging environment. Recent evidence from Central Thailand suggests that millet agriculture may have 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 Southwest China.

Conclusion

The spread of both rice and millet agriculture seems to have been closely associated with the transfer of cultural traits, technology, and possibly population movement. In particular, the spread of rice agriculture to the Sichuan Basin is accompanied by important social change. The first of these changes is signaled by a demographic transition. Factors which point to this transition include an increase in the total number of sites (from a single find in periods prior to the arrival of rice agriculture to more than 40 sites in the Baodun period) as well as an increase in site size. In addition, large walls and the development of water management technology for the use of paddies signal an ability to harness a larger labor force.

The presence of a settlement pattern with a limited number of large central places with possible ritual installations surrounded by smaller hamlets and homesteads also points to a degree of social complexity and possible specialization. However, these horizontal transformations of the social landscape do not appear to be reflected vertically. In other regions of China at the same period of time, studies of grave goods show the development of a

clear social hierarchy (Liu 2004). Across the board, burials from the Baodun culture are simple pit burials which contain few offerings, hinting at a communal ethos as a governing principal of society. Interestingly, this pattern appears to be consistent throughout much of the Bronze Age. The cultures which followed, Sanxingdui (1700–1150 BC) and Shi'eriqiao (1150–600 BC), were at the center of social networks that brought gold, ivory, the raw material for bronze, marble, jade, and other precious materials together for use in elaborate ritual contexts (Bagley 2001; Chen 1989; Chengdu 2004b; Flad n.d.; Sichuan 1987; Sun 2000; Thote and Bagley 2003; Wang and Ye 1993). Despite the heavy investment in ritual paraphernalia at Sanxingdui and at the later Shi'erqiao period site of Jinsha, no marked social hierarchy is present in the graves from either of these cultures (Chengdu 2003, 2004a, c, 2005b; d'Alpoim Guedes et al. 2006; Sun 2000). As rice and millet agriculture moved, their potential to support greater population densities and harness more labor created important social change. However, while this social change is reflected in the means of production in the Sichuan Basin, this region did not follow the trajectory to marked social hierarchy which accompanied the transition to intensive agriculture in other regions of China.

Given current evidence, it is difficult to say whether the rice and foxtail millet agricultural package practiced by the inhabitants of Baodun arrived in the plain as a result of population movement or simply the diffusion of ideas and technology. Although the sudden appearance of this package as well as associated developed social complexity appear to point to input from the east, the lack of archaeological evidence from surrounding regions such as Guizhou and Eastern Sichuan make it difficult to substantiate this conclusion. For now, all we can point to are clear contacts between areas both to the east and northwest of the plain.

Both rice and millet agriculturalists were responsible for the transmission of important agricultural technology across Southwest China and they must be considered in any linguistic or population history model for this region. Millet agriculture with its short growing season and tolerance to aridity is well adapted to the upland environments and mountainous foothills which characterize much of the landscape in Southwest China. The large flat expanse of the Chengdu Plain with its ample water sources presented an ideal environment for wetland rice production. The combination of rice and foxtail millet agriculture in this region formed a formidable package. In areas with challenging vertical topography, requiring extensive landscaping for the creation of paddies such as the foothills of Yunnan and Guizhou Provinces and possibly the Three Gorges region, foxtail millet could have substituted rice agriculture in the early days of agricultural expansion. In low-lying regions such as the Chengdu Plain, where the creation of paddies and water management technology is relatively simple, rice agriculture could be easily intensified. By adding foxtail millet, either as a fallback or a late season crop, this agricultural system gained in both risk reduction and yield, possibly spurring population growth and the development of social complexity. Because of its binary, interchangeable nature, this agricultural system also facilitated expansion into new territories.

Current models have focused to a large extent on the role of rice agriculture in the spread of languages across Eastern and Southeast Asia; however, they should not ignore the importance that foxtail millet had in the ancient agricultural package. In addition, they should not ignore the importance of populations living in the mountainous corridors of the Himalayan foothills, where a package formed of two highly adaptable millet crops allowed the technology of agriculture to be carried both to the lowlands and eventually into the challenging environment of the Tibetan Plateau.

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References

Aba ZQZW, Sichuan SWKY, Chengdu SWKY, Maerkang XWXB, Aba ZW. Sichuan Maerkang Haxiu Yizhi Diaocha Jianbao (A report on the survey at the site of Haxiu in Ma'erkang). Sichuan Wenwu. 2007;2007(4):8–16.

Aba ZQZW, Sichuan SWKY, Chengdu SWKY, Ma'erkang XWT. Sichuan Ma'erkang Xian Haxiu Yizhi 2003, 2005 Nian Diaocha Jianbao (Report on the 2003 and 2005 surveys carried out at the site of Haxiu in Ma'erkang, Sichuan Province). Chengdu Kaogu Faxian. 2008;2006:1–14.

Bagley R, editor. Ancient Sichuan: Treasures from a lost civilization. Princeton: Princeton University Press; 2001.

Barton L, Newsome SD, Chen F, Wang H, Guilderson TP, Bettinger RL. Agricultural origins and the isotopic identity of domestication in Northern China. Proc Natl Acad Sci. 2009;106 (14):5523–8.

Beijing DKX, Hubei SWKY, Shijiahe KD, Hubei SKDB. Shijiahe Yizhiqun Diaocha Baogao (Report on the group of sites at Shijiahe). Nanfang Minzu Kaogu. 1992;5:213–94.

Bellwood P. Examining the farming/language dispersal hypothesis in the East Asian Context. In: Sagart L, Blench R, Sanchez-Mazas A, editors. The peopling of East Asia: Putting together archaeology, linguistics and genetics. London: Routledge; 2005a. p. 17–30.

Bellwood P. The first farmers: The origins of agricultural societies. Malden: Blackwell; 2005b.

Bellwood P. Asian farming diasporas? Agriculture, languages and genes in China and Southeast Asia. In: Stark MT, editor. Archaeology of Asia. Malden: Blackwell; 2006. p. 96–118.

Bettinger RL, Barton L, Richerson PJ, Boyd R, Wang H, Choi W. The transition to agriculture in Northwestern China. Developments in Quaternary Sciences. 2007;9(7):83–101.

Bettinger RL, Barton L, Morgan C. The origins of food production in North China: A different kind of agricultural revolution. Evol Anthropol. 2010a;19:9–21.

Bettinger RL, Barton L, Morgan C, Chen F, Wang H, Guilderson TP, Ji D, Zhang D. The transition to agriculture at Dadiwan, People's Republic of China. Curr Anthropol. 2010b;51(5):703–14.

Boaretto E, Wu X, Yuan J, Bar-Yosef O, Chu V, Pan Y, Liu K, Cohen D, Jiao T, Li S, Gu H, Goldberg P, Weiner S. Radiocarbon dating of charcoal and bone collagen associated with early pottery at Yuchanyan Cave, Hunan Province, China. Proceedings of the National Academy of Sciences. 2009;106(24):9595–600.

Cavalli-Sforza L. Demic diffusion as the basic process of human expansions. In: Bellwood P, Renfrew C, editors. Examining the farming/language dispersal hypothesis. Cambridge: Cambridge University Press: McDonald Institute for Archaeological Research; 2002. p. 79–88.

Chai Y. Mizi (Broomcorn millet). Beijing: Zhongguo Nongye Chubanshe; 1999.

Chen X. Guanghan Sanxingdui Yizhi Fajue Gaikuang, Chubu Fenqi Jianlun "Zaoshu Wenhua" De Tezheng Jiqi Fazhan (On the excavations at Sanxingdui, a preliminary analysis of early Shu culture's particularities and development). Nanfang Minzu Kaogu. 1989;1989(2):213–31.

Chen J. Boxi, Yingpanshan Ji Shawudu-Qianxi Minjiang Shangyou Xinshiqishidai Yanbian de Jieduanxing (Boxi, Yingpanshan and Shawudu—The cultural development of Neolithic cultures in the Upper Min River). Kaogu Yu Wenwu. 2007;2007(5): 65–70.

Chengdu SWKY. Chengdu Jinsha Yizhi 2001 Nian Huangzhongcun Gandao Guihua Daolu B xian Didian (Report on the 2001 excavations at the locale of the line B of the main road planning area in Huangzhongcun area of the Jinsha Site). Chengdu Kaogu Faxian. 2002;2002:42–61.

Chengdu SWKY. Jinsha Yizhi Shudufeng Huayuancheng Erqi Didian Shijue Jianbao (A brief report on the excavations at the locale of Shudufeng Huayuancheng Erqi at the site of Jinsha). Chengdu Kaogu Faxian. 2003;2001:33–53.

Chengdu SWKY. Chengdu Jinsha Yizhi "Zhixin Jinshayuan Yiqi" Didian Fajue Jianbao (Brief report on the excavations at the locale of Zhixin Jinshanyuan Yiqi at the site of Jinsha, Chengdu). Chengdu Kaogu Faxian. 2004a;2002.

Chengdu SWKY. Chengdu Jinsha Yizhi I Qu "Meiyuan" Dongbeibu Didian Fajue Yiqi Jianbao (A brief report on the first seasons of excavations at the Northeast "Meiyuan" locale of the site of Jinsha). Chengdu Kaogu Faxian. 2004b;2002:96–171.

Chengdu SWKY. Chengdu Jinsha Yizhi Wanbo Didian Kaogu Kantan Yu Fajue Shouhuo (Results of the excavation and archaeological investigation at the Wanbo locale of the site of Jinsha). Chengdu Kaogu Faxian. 2004c;2002:62–95.

Chengdu SWKY. Chengdushi Gaoxin Xiqu "Gewei Yaoye Yiqi" Xinshiqi Yizhi Fajue Jianbao (Brief report on the Neolithic site of "Gewei Yaoye Yiqi" in Gaoxin District, Chengdu). Chengdu Kaogu Faxian. 2005a;2003:163–85.

Chengdu SWKY. Jinshacun Yizhi Renfang Didian Fajue Jianbao (A brief report on the excavations at the Renfang locale of the site of Jinsha). Chengdu Kaogu Faxian. 2005b;2003:89–119.

Chengdu SWKY. Chengdu Gaoxin Xiqu Mopu Shengwu Keji Didian Guyizhi Fajue Jianbao (A brief report on the ancient site of Mopu Shengwu Keji Didian in Gaoxin District, Chengdu). Chengdu Kaogu Faxian. 2006a;2004:82–97.

Chengdu SWKY. Chengdu Gaoxin Xiqu Sichuan Fangyuan Zhongke Didian Guyizhi Fajuejianbao (A brief report on the site of Sichuan Fangyuan Zhongke in Gaoxin District, Chengdu). Chengdu Kaogu Faxian. 2006b;2004:53–68.

Chengdu SWKY. Chengdu Xinjinxibaozhuangchang Didian Guyizhi Fajue Jianbao (A brief report on the site of Xinjinxibaozhuangchang). Chengdu Kaogu Faxian. 2006c;2004:98–117.

Chengdu SWKY. Chengdu Shi Zhonghai Guoji Shequ Guyizhi Fajue Jianbao (A brief report on the excavations at the site of Zhonghai Guoji Shequ). Chengdu Kaogu Faxian. 2007;2005:141–207.

Chengdu Gongzuo SWK. Wenjiang Xian Yufucun Yizhi 1999 Niandu Fajue (The 1999 excavations at the site of Yufucun in Wenjiang County). Chengdu Kaogu Faxian. 2001;1999:40–53.

Chengdu Guoji PKD. Chengdu Pingyuan Quyu Kaogu Diaocha (2005–2007) (2005–2007 Archaeological survey in the Chengdu Plain). Nanfang Minzu Kaogu. 2010;6:255–78.

Chengdu SWKGD, Pixian B. Sichuan Pixian Gucheng Yizhi Diaocha yu Fajue (Report on the survey and excavation of the site of Gucheng in Pixian County, Sichuan. Wenwu. 1999;1999 (1):32–42.

Chengdu SWKY, Pixian WG. Sichuan Pixian Gucheng Yizhi 1998–1999 Niandu Fajue Baogao (Report on the excavations of 1998–1999 at the site of Gucheng, Pixian, Sichuan Province. Chengdu Kaogu Faxian. 2001;1999:29–39.

Chengdu SWKY, Pixian WG. Chengdushi Gaoxin Xiqu Hangkonggang Guyizhi Fajue Jianbao (A report on the ancient site of Hangkonggang in West Gaoxin district, Chengdu). Chengdu Kaogu Faxian. 2005;2003:218–43.

Chengdu SWKY, Xindu QWG. Chengdu Shi Xinduqu Banzhuyuanzhen Zhongyi Yizhi Fajue Shouhuo (Results on the excavation from the site of Zhongyi at Banshuyuanzhen in Xindu area, Chengdu City). Chengdu Kaogu Faxian. 2010;2007:29–45.

Chengdu SWKGD, Sichuan LDLK, Wenjiang XWG. Sichuan Sheng Wenjiang Yufucun Yizhi Diaocha yu Fajue (The survey and excavation of the site of Yufucun in Wenjiang County, Sichuan). Wenwu. 1998;1998(12):38–56.

Chengdu SWKY, Aba ZQZW, Maoxian B. Sichuan Maoxian Yingpanshan Yizhi Shijue Baogao (Report on the site of Yingpanshan in Maoxian County, Sichuan). Chengdu Kaogu Faxian. 2002;2000:1–77.

Chengdu et al. [Chengdu SWKY, Sichuan DLKJ, Zaodaotian DCLWY]. Baodun: Xinjian Baodun Yizhi Fajue he Yanjiu (Baodun: A report on the research and excavations at the site of Baodun in Xinjian County). ARP Chengdu; 2000.

Cui J, Wu X, Yang Y. Sichuan Maoxian Xinshiqi Yizhi Taoqi de Chengfen Fenxi Ji Laiyuan Chulun (A discussion on the composition and origin of the pottery from Maoxian, in Sichuan Province). Wenwu. 2011;2011(2):79–85.

d' Alpoim Guedes J, Fu C, Zhang Q. Bio-archaeology at Jinsha: Preliminary results from the site of Huangzhongxiaoqu. Chengdu Kaogu Faxian. 2006;2005:409–23.

d'Alpoim Guedes J, and Jiang M. Xinjian Baodun Yizhi 2009 Niandu Kaogu Shijue Fuxuan Jieguo Fenxi Baogao (Report on the results of the flotation from the 2009 excavations at the site of Baodun in Xinjin). Chengdu Kaogu Faxian. Tbd. 2011;2009 (in press).

d'Andrea AC. T'ef (*Eragrostis tef*) in ancient agricultural systems of highland Ethiopia. Econ Bot. 2008;64:547–66.

Flad R, Chen P. The archaeology of the Sichuan basin and surrounding areas during the Neolithic period. In: Li S, v Falkenhausen L, editors. Salt archaeology in China: Ancient salt production and landscape archaeology in the Upper Yangtse Basin: Preliminary studies, vol. 1. Beijing: Kexue Chubanshe; 2006. p. 183–259.

Fuller D, Qin L. Water management and labor in the origins and dispersal of Asian rice. World Archaeology. 2009;41(1):88–111.

Fuller D, Qin L. Declining oaks, increasing artistry, and cultivating rice: The environmental and social context of the emergence of farming in the Lower Yangtze Region. Environ Archaeol. 2010;15(2):139–59.

Fuller D, Harvey E, Qin L. Presumed domestication? Evidence for wild rice cultivation and domestication in the fifth millennium BC of the Lower Yangtze Region. Antiquity. 2007;81:316–31.

Fuller D, Ling Q, Harvey E. Evidence for a late onset of agriculture in the Lower Yangtze Region and challenges for an archaeobotany of rice. In: Sanchez-Mazas A, Blench R, Ross M, Lin M, Pejros I, editors. Human Migrations in Continental East Asia and Taiwan: Genetic, Linguistic and Archaeological Evidence. London: Taylor and Francis; 2008a. p. 40–83.

Fuller D, Ling Q, Harvey E. Rice archaeobotany revisited: Comments on Liu et al. (2007). Antiquity. 2008b;82(315). Online Project Gallery.

Gansu SWKY. Qinan Dadiwan: Xinshiqi Shidai Yizhi Fajue Baogao (Qin'an Dadiwan: Excavation report on the Neolithic site). Beijing: Wenwu Chubanshe; 2006.

Guizhou SK, Sichuan DLK, Weining W. Guizhou Weining, Jigongshan 2004 Nian de Fajue Baogao (Report on excavations at the site of Jigongshan in Weining County, Guizhou). Kaogu. 2006;8 (2006):11–27.

He K. Baodun Yizhi 2009 Nian Fajue Jianbao (A brief report on the 2009 excavations at the site of Baodun). Chengdu Kaogu Faxian. 2011;2009 (in press)

He K, Jiang C, Chen J. Qianlun Dongwukaoguxue Zhong Liangzhong Rouliang Guji Fangfa-Yi Yingpanshan Chutu de Dongwu Guge Weilie (A brief discussion of two methods of calculating the contribution of meat in zooarchaeology—An example from the site of Yingpanshan). Kaogu yu Wenwu. 2009;2009(5):95–9.

Higham C. Languages and farming dispersals: Austroasiatic languages and rice cultivation. In: Bellwood P, Renfrew C, editors. Examining the farming/language dispersal hypothesis. Cambridge: McDonald Institute for Archaeological Research; 2002.

Hong L, Cui J, Wang H, Chen J. Chuanxi Majiayao Leixing Caitao Chanyuan Fenxi yu Tantao (A provenance study of the Majiayao painted pottery found in Sichuan Province). Nanfang Minzu Kaogu. 2011;7:1–58.

Huang H, Zhao B. Baodun Wenhua de Faxian Jiqi Laiyuan Kaocha (On the discovery and origin of the Baodun culture). Zhonghua Wenhua Luntan. 2004;2004(2):14–8.

Hunan SWKY. Lixian Chengtoushan: Xinshiqishidai Yizhi Fajuebaogao (Lixian Chengtoushan: The Neolithic site excavation report). Beijing: Wenwu Chubanshe; 2007.

Jiang Z. Chengdu Pingyuan Zaoqi Chenzhi Jiqi Kaoguxue Wenhua Chulun (A preliminary discussion on the cultures of the early walled cities of the Chengdu Plain). In: Su B, editor. Su Bingqi yu Dandai Zhonguo Kaoguxue (Su Bingqi and Chinese archaeology). Beijing: Kexue Chubanshe; 2001.

Jiang L, Liu L. New evidence for the origins of sedentism and rice domestication in the Lower Yangzi River, China. Antiquity. 2006;80:355–61.

Liu L. The Chinese Neolithic: Trajectories to the early states. Cambridge: Cambridge University Press; 2004.

Liu C, Kong Z, Lang S. Dadiwan Yizhi Nongye Zhiwu Yicun Yu Renlei Shengcun de Huanjing Shentao (An in-depth discussion on the botanical remains unearthed at the site of Dadiwan and their significance for the environment of the occupants of the site). Zhongyuan Wenwu. 2004;4:26–30.

Liu L, Lee G-A, Jiang L, Zhang J. Evidence for the early beginning (c. 9000 cal. BP) of rice domestication in China: A response. Holocene. 2007;17(8):1059–68.

Liu X, Hunt HV, Jones MK. River valleys and foothills: Changing archaeological perceptions of North China's earliest farms. Antiquity. 2009;83(319):82–95.

Lu H, Zhang J, Liu K, Wu N, Li Y, Zhou K, Ye M, Zhang T, Zhang H, Yang X, Shen L, Xu D, Li Q. Earliest domestication of common millet (*Panicum miliaceum*) in East Asia extended to 10,000 years ago. Proc Natl Acad Sci. 2009;106(18):7367–72.

Ma J. Hanyuan Xian Shizishan Xishiqishidai Yizhi (The Neolithic site of Shizishan in Hanyuan County). In: Zhongguo Kaoguxue Nianjian 1991. Beijing: Wenwu Chubanshe; 1992. p. 270.

Mann, Harold. Millets in the Middle East. Empire Journal of Experimental Agriculture. 1946; 208–16

Markel T, Rosch M. Experiments on the effects of carbonization on some cultivated plant seeds. Vegetation History and Archaeobotany. 2007;17:257–63.

n.d. Flad R. Bronze, jade, gold, and ivory: Valuable objects in ancient Sichuan. In: Urton G, editor. The Construction of Value in the Ancient World. Los Angeles: Cotsen Institute of Archaeology; 2012.

Nasu H, Momohara A, Yasuda Y, He J. The occurrence and identification of *Setaria italica* (L.) P. Beauv. (Foxtail millet) Grains from the Chengtoushan site (ca. 5800 cal B.P.) in Central China, with reference to the domestication centre in Asia. Vegetation History and Archaeobotany. 2007;16(6):481–94.

Pearsall DM. Paleoethnobotany: A handbook of procedures. 2nd ed. New York: Academic Press; 2000.

Sichuan SWGX. Guanghan Sanxingdui Yizhi (The site of Sanxingdui in Guanghan). Kaogu Xuebao. 1987;1987(2):227–54.

Sun H. Sichuan Pendi de Qingtongqi Wenhua (The Bronze Age of the Sichuan Basin). Beijing: Kexue Chubanshe; 2000.

Thote A, Bagley R. Chine, L'Enigme de l'Homme de Bronze: Archeologie du Sichuan (XII-IIIe siecle av. J.-C). Paris: Findakly; 2003.

Van Driem G. Tibeto-Burman vs Indo-Chinese: Implications for population geneticists, archaeologists and prehistorians. In: Sagart L, Blench R, Sanchez-Mazas A, editors. The peopling of East Asia: Putting together archaeology, linguistics and genetics. London: Routledge Curzon; 2005. p. 81–106.

Wang R, Ye M. Sichuan Pendi Beiyuan Xinshiqishidai Kaogu Xinshouhuo (New Advances on the Neolithic on the Northern marges of the Sichuan Basin). In: Lin S, Lin X, Zhao D, editors. Sanxingdui yu Bashu Wenhua (Sanxingdui and Bashu Culture). Chengdu: Bashu Chushe; 1993.

Weber S, Lehman H, Barela T, Hawks S, Harriman D. Rice or millets: early farming strategies in prehistoric Central Thailand. Archaeological and Anthropological Sciences. 2010;2(2):79–88.

Xiang X, Huang X. Daxi Wenhua (The Daxi culture). In: Yang B, editor. Hubei Kaogu Faxian yu Yanjiu (Archaeological discoveries and research in Hubei). Wuhan: Wuhan Daxue Baoshe; 1995. p. 26–43.

Xiao M. Yunnan Kaogu Shulue (A brief report on Yunnan archaeology). Kaogu. 2001;2001(12):3–15.

Xizang W, Sichuan DL. Changdu Karuo (The Neolithic site of Karuo in Chamdo). Beijing: Wenwu Chubanshe; 1985.

Xue Y. Yunnan Jianchuan Haimenkou Zhiqu Yicun Chubu Yanjiu (A preliminary investigation on the archaeobotanical material from the site of Haimenkou in Jianchuan County, Yunnan). Beijing: Peking University; 2010.

Yan W. Lun Banpo Leixing he Miaodiguo Leixing (Banpo type and Miaodiguo type). Perspectives on the Yangshao culture. Beijing: Wenwu Chubanshe; 1989. p. 110–21.

Yan J, Jiang Z. Sichuan Dujiangyan Mangcheng Yizhi Diaocha yu Shijue (Trial excavations and survey at the site of Mangcheng, Dujiangyan, Sichuan). Kaogu. 1999;1999(7):14–27.

Ye M. Guangyuan Shi Zhongzipu Yingpanling Xishiqi Yizhi (The Microlithic site of Yingpanliang in Zhongzipu, Guangyuan City). In: Zhongguo Kaoguxue Nianjian 1991. Beijing: Wenwu Chubanshe; 1992. p. 269.

Ye M. Sichuan Jiushiqishidai Yicun Qianlun (A simple discussion of Paleolithic artifacts from Sichuan). In: Sichuan Daxue Kaogu

Zhuanye Chuangjian Sanshiwuzhounian Jinian Wenji (Festschrift in honor of thirty-five years of the archaeology concentration at Sichuan University). Chengdu: Sichuan Daxue Chubanshe; 1998. p. 1–23.

Yuan J. Rice and pottery 10,000 yrs. BP at Yuchanyan, Dao County, Hunan Province. In: Yasuda Y, editor. The origins of pottery and agriculture. New Delhi: Rohli Books; 2002. p. 157–66.

Yunnan SB. Yuanmo Dadunzi Xinshiqishidai Yizhi (The site of Dadunzi in Yuanmo). Kaogu Xuebao. 1977;1977(1):43–72.

Yunnan SB. Yunnan Bingchuan Baiyangcun Yizhi (The site Baiyangcun in Binchuan, Yunnan). Kaogu Xuebao. 1981;1981(3):365–6.

Yunnan SWKY, Dali ZWG, Yongping XWG. Yunnan Yongping Xinguang Yizhi Fajue Baogao (Report on the excavations at the site of Yongping in Yunnan Province, China). Kaogu Xuebao. 2002;2002(2):203–34.

Zhang C. The Neolithic of Southern China—Origin, development and dispersal. Asian Perspectives. 2008;47(2):299–329.

Zhang W, Yuan J. A preliminary study of ancient excavated rice from Yuchanyan site, Dao County, Hunan Province. Acta Agronomica Sinica 1998;24(4):416–420.

Zhang C, Hung H-C. The emergence of agriculture in Southern China. Antiquity. 2010;84:11–25.

Zhao Z. Fuxuan Yu Tanhua Zhiwu Yicun de Yanjiu (Flotation and carbonized plant remains). In: Zhongguo SKKY, Guangzi ZZWG, Guilin ZYB, Guilin SWG, editors. Guilin Zengpiyan (The site of Zengpiyan in Guilin). Beijing: Wenwu Chubanshe; 2003a.

Zhao Z. Yunnan Yongren Mopan di Xinshiqishidai Yizhi Chutu de Daogu Yicun Fenxi Baogao (Report on the rice remains excavated at the Neolithic site of Yongren Mopandi in Yunnan Province). Kaogu Xuebao. 2003b;2003(2):294–5.

Zhao Z. Cong Xinglonggou Yizhi Fuxuan Jieguo tan Zhongguo Beifang Zaozuo Nongye Qiyuan Wenti (Discussion on Chinese dry crop agriculture from flotation results in Xinglonggou site). In: Wang R, Tang H, editors. Dongya Guwu (Antiquities of Eastern Asia). Wenwu Chubanshe: Beijing; 2005. p. 188–99.

Zhao Z. New data and new issues for the study of origin of rice agriculture in China. Archaeological and Anthropological Sciences. 2010a;2:99–105.

Zhao Z. Shifodong Yizhi Chutu de Zhiwu Yicun Fenxi Baogao (Report on the archaeobotanical remains unearthed at the site of Shifodong). In: Yunnan SK, Chengdu SWKY, editors. Gengma Shifodong. Beijing: Wenwu Chubanshe; 2010b. p. 368–73.

Zhao Z., Flad R. n.d. Report on floatation results from the Zhongba site in Chongqing. In: Li S., L. v. Falkenhausen., editors. Salt Archaeology in China: Ancient salt production and landscape archaeology in the Upper Yangzi Basin: Research on Zhongba, pp. TBD, vol. 3. Kexue Chunbanshe, Beijing

Zhao Z. Origin of agriculture in China: a Case study from the Sichuan Basin in the spread of agriculture in Asia: Understanding early settlements in the Chengdu Plain Harvard University; 2008, October 14–17.

Zheng Y, Sun G, Chen X. The characteristics of Rachis on rice spikelets from archaeological sites before 7000 BP. (Chinese Science Bulletin). Kexue Tongbao. 2007;52:1037–41.

Zhongguo SKY. Jingshan Qujialing (The site of Qujialing in Jingshan). Beijing: Kexue Chubanshe; 1965.

Zhongguo Sichuan SKYG. Sichuan Guangyuan Shi Zhongzipu Xishiqi Yicun (The microlithic site of Zhongzipu in Guangyuan City, Sichuan). Kaogu. 1991;4:289–99.

Zhongri LKDD. Dujiangyanshi Mangcheng Yizhi 1999 Niandu Fajue Gongzuo Jianbao (A brief report on the 1999 excavations at the site of Mangcheng in Dujiangyan City). Chengdu Kaogu Faxian. 2001;1999:99–126.