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A review on the spread of prehistoric agriculture from southern China to mainland Southeast Asia

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Abstract The origins and spread of agriculture was one of the milestones in human history. When and how prehistoric agriculture spread to mainland Southeast Asia is highly concerned, which contributed to the formation of modern Austroasiatic in this region. Previous studies mainly focused on the time and route of rice agriculture's introduction into Southeast Asia while millet agriculture was not paid proper attention. Here we analyze 312 ^{14}C dating data yielded from charred seeds of rice (*Oryza sativa*), foxtail millet (*Setaria italica*) and broomcorn millet (*Panicum miliaceum*) from 128 archaeological sites in China and mainland Southeast Asia. The result shows that millet farming was introduced to mainland Southeast Asia in the late third millennium BC and rice farming was in the late second millennium BC. The agriculture of mainland Southeast Asia might originate from three areas, Southwest China, Guangxi-West Guangdong and coastal Fujian. The spread route of ancient agriculture in Southwest China is close to the "Southwest Silk Road" recorded in literature, which implies there was possibly a channel of cultural exchanges on the eastern margin of Tibetan Plateau already in the late Neolithic period, laying the foundation for the Southwest Silk Road later.

Keywords Mainland Southeast Asia, Southern China, Agriculture spread, Prehistoric age, Southwest Silk Road

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1. Introduction

Since trans-continental cultural exchange and collision is one of the driving forces for the development of human societies (Sherratt, 2006), globalization in prehistory has always been a scientific issue concerned. Recent studies reveal that several east-west cultural channels existed in prehistoric Eurasia, which promoted the flow and spread of species, technologies and ideas, and played a crucial role in Eurasian development in the late Neolithic to Bronze age from 4500 to 3000 years before present (BP, taken as AD1950, similarly hereinafter) (Jones et al., 2011; Zhang, 2017; Chen et al., 2017). Actually, the south-north culture exchange in prehistoric eastern Eurasia was also intensive. As archaeological discoveries suggested, there were many similarities in material cultures between southern China and mainland Southeast Asia since the Paleolithic age: Pebble tools were widely made in the early and middle Paleolithic age and small flake tools were used during the late period (Wang, 1997). Cord-impressed wares originated from southern China were widely distributed in East Asia, Southeast Asia and South Asia, revealing trans-regional cultural interaction in eastern Eurasia (Kharakwal et al., 2004). Waves of Neolithic farmers from southern China migrated into mainland

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Southeast Asia (Diamond and Bellwood, 2003; Lipson et al., 2018; McColl et al., 2018; Matsumura et al., 2019). Studies mentioned above outlined the prehistoric cultural exchanges between southern China and mainland Southeast Asia.

However, the current understanding of how rice and millet agriculture was introduced to Southeast Asia is insufficient (here, agriculture refers to rice and millet agriculture. Millets include foxtail millet and broomcorn millet). It's widely accepted that *japonica* rice (*Oryza sativa* subsp. *japonica*) was domesticated in the Middle and Lower Yangtze regions (Zhou, 1948; Second, 1985; Yan, 1990; Sun et al., 1997; Fuller, 2011; Larson et al., 2014), while foxtail millet (*Setaria italica*) and broomcorn millet (*Panicum miliaceum*) were in northern China (Lu et al., 2009; Yang et al., 2012). The grains and husks of rice recovered from prehistoric sites in mainland Southeast Asia were identified as *japonica* rice by the analysis of ancient DNA (Bellwood et al., 2011; Castillo et al., 2016), indicating that the rice and millet farming of mainland Southeast Asia originated from China. It's necessary to detail the route and time of agriculture introduced to mainland Southeast Asia (Higham, 1996; Zhang and Hung, 2010; Fuller et al., 2010; Silva et al., 2015). In addition, a recent increase in archaeobotanical and ^{14}C dating data has made it possible to discuss the issues in detail.

2. Materials and methods

Aiming to reconstruct the spatial and temporal southward movement of rice and millets, here we summarize the crop remains unearthed from mainland Southeast Asia, Southwest China (including provinces of Sichuan, Yunnan and Guizhou) and South China (including provinces of Guangdong, Guangxi, Fujian and Taiwan) (Figure 1; Table 1), to deepen the understanding of the cultural exchanges between the two regions in prehistoric era.

Due to the different preservation environment and work of archaeological sites, the uneven distribution of available archaeobotanic data has been a major problem we are facing. For example, many systematic flotation results of plant macro-remains in Sichuan have been reported, while there are only a few records of rice phytoliths or rice husks tempered in pottery sherds in eastern Guangxi and western Guangdong published. The material we reviewed here are the macro-remains of rice and two millets. Firstly, specimens with direct ^{14}C dating are preferred, which provide the most solid evidence to discuss the southward spread of rice and millets. Then, those macro-remains, which are not directly dated but their age can be studied by stratigraphical and typological approaches, are also acceptable. In the case that micro-remains, phytoliths or starch grains of crops, are older than the dated marco-remains in the region, we will take them into discussion. Based on these selective materials, we sort out the earliest rice and millets in different regions and reconstruct the logical spreading process according to archaeobotanic data first. Then combined with the local archaeological cultures, we will outline the spreading process of early agriculture from southern China to mainland Southeast Asia.

2.1 Mainland Southeast Asia

In southern Thailand, both rice phytoliths and rice husks tempered in potteries were excavated at Khok Phanom Di. Direct dating of the rice husks from sherds respectively yielded two dates, 5039–4646 and 4826–4438 cal a BP (calibrated dates, similarly hereinafter) (Thompson, 1996; Ramsey et al., 2002). In a study of a nearby Bronze age cemetery, Nong Nor, rice husks from five potteries buried with the dead were dated and the earliest one was 3442–3000 cal a BP from Burial 105 (Hedges et al., 1993). In northeastern Thailand, carbonized rice unearthed from Burial 3 of Non Nok Tha was dated to 3445–3071 cal a BP (Hedges et al., 1991). Rice remains from other sites, such as Ban Non Wat, etc., were in the first millennium BC or later based on direct ^{14}C dating (Higham C and Higham T, 2009).

The early foxtail millet and broomcorn millet remains were recovered from the Khao Wong Prachan (KWP) Valley of Thailand. Studies on Non Pa Wai, Nil Kham Haeng and Non Mak La in this area, show millet farming was practiced during the early occupation, and turned to mixed farming of rice and millets during the late occupation. The earliest foxtail millet was unearthed at Non Pa Wai, which was directly dated to 4417–4158 cal a BP (Weber et al., 2010). Carbonized millets without direct dating were excavated from Rach Nui (3555–3265 a BP) in southern Vietnam, as well as Khao Sam Kaeo (2400–2100 a BP) in Malay Peninsula (Oxenham et al., 2015; Castillo, 2017; Castillo et al., 2018). Moreover, Panicoideae phytoliths were extracted from many local sites in the second millennium BC (Kealhofer and Piperno, 1994; Kealhofer and Grave, 2008).

2.2 Southwest China

The earliest rice in Southwest China are from Chengdu Plain: The rice unearthed in Baodun was directly dated to 4790–4432 cal a BP (d'Alpoim Guedes et al., 2013), and that in Guiyuanqiao was 4530–4250 cal a BP (d'Alpoim Guedes and Wan, 2015). In the Middle Dadu Valley, carbonized rice and the two millets were found through flotation in Longwangmiao (4700–4500 a BP) (SICRA et al., 2011). Similar crop assemblage was also seen in the Neolithic deposits of Henglanshan in Anning Valley, where a seed without identification was dated back to 4470–4120 cal a BP (CIA et al., 2016b). Carbonized rice from Liantang in the Middle Jinsha River was dated to 4160–3960 cal a BP (CIA et al., 2016b).

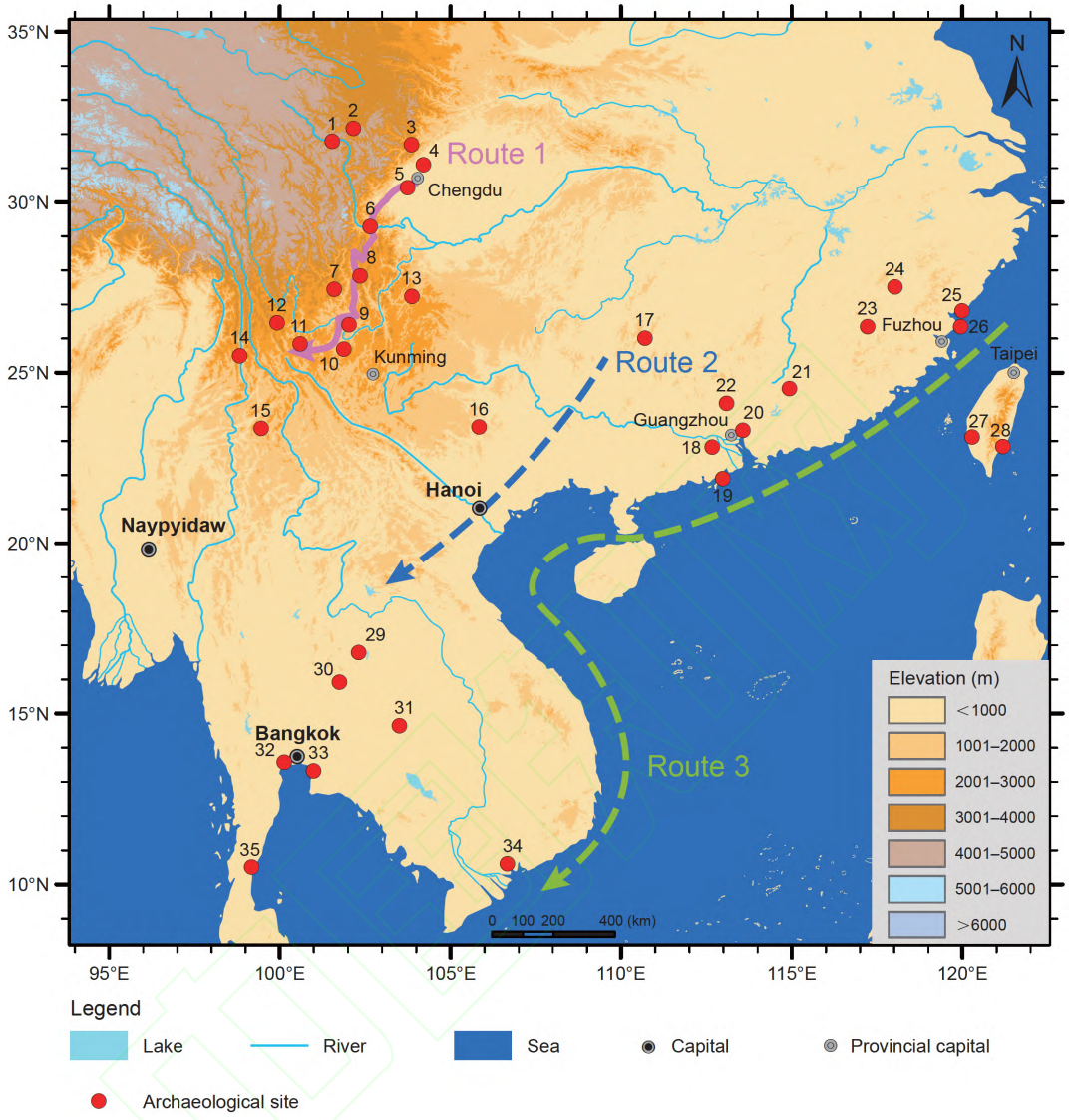

Figure 1 Key archaeological sites mentioned in the text and three proposed routes of crop spread. 1, Liujiazhai; 2, Haxiu; 3, Yingpanshan; 4, Guiyuanqiao; 5, Baodun; 6, Longwangmiao; 7, Guijiabao; 8, Henglanshan; 9, Liantang; 10, Dadunzi; 11, Baiyangcun; 12, Haimenkou; 13, Jigongshan/Wujiadaping; 14, Shilinggang; 15, Shifodong; 16, Gantuoyan; 17, Xiaojin; 18, Guye; 19, Xincun; 20, Chaling; 21, Laoyuan; 22, Shixia; 23, Nanshan; 24, Hulushan; 25, Huangguashan/Pingfengshan; 26, Dapingding; 27, Nanguanlidong; 28, Chaolaiqiao; 29, Non Nok Tha; 30, Ban Non Wat; 31, Non Pa Wai/Nil Kham Haeng/Non Mak La; 32, Khok Phanom Di; 33, Nong Nor; 34, Loc Giang/An Son/Rach Nui; 35, Khao Sam Kaeo.

The earliest rice on Yunnan-Guizhou Plateau is from Baiyangcun, dating back to 4574–4424 cal a BP (Martelloa et al., 2018). Other rice remains from sites of Jigongshan, Wujiadaping, Shilinggang and Shifodong, etc., were all dated to the second millennium BC or later (GZICRA et al., 2006a, 2006b; YICRA et al., 2010; Li et al., 2016).

Abundant millet remains were recovered at the sites of Liujiazhai, Haxiu and Yingpanshan in western Sichuan, dating to ca. 5000 a BP (ATQCRC et al., 2010; Zhao and Chen, 2011; Li, 2014). Two millets dominated the archaeobotanic assemblage of Guiyuanqiao Phase I, and a broomcorn millet was dated to 4850–4550 cal a BP. In Baodun culture sites in Chengdu Plain, millets usually coexisted with rice, demonstrating they were as early as rice (Shi, 2012; d'Alpoim Guedes et al., 2013). Carbonized millets were unearthed from Longwangmiao (SICRA et al., 2011). They dominated macro-remains from Guijiabao as well, with the earliest broomcorn millet dated to 4842–4644 cal a BP (CIA et al., 2016a). The earliest millets on Yunnan-Guizhou Plateau were recovered from Baiyangcun Phase I, directly dated to 4818–4523 cal a BP (Martelloa et al., 2018). Millets unearthed from sites of Dadunzi, Haimenkou and others, were generally later than 4000 a BP (Min, 2013; Jin et al., 2014). It should be noted that the millets from Gantuoyan Phase II (3800–2800 a BP) in southeastern Yunnan-Guizhou Plateau, were identified as ragi millet (*Eleusine coracana*) domesticated in Africa (ATGZ and Napo Museum, 2003). Ragi millet was also reported at

Table 1 Key rice and millet remains unearthed in southern China and mainland Southeast Asia[a)]

Region	Site	Date of Rice (cal a BP)	Date of Millet (cal a BP)	Reference
Main Southeast Asia	Nong Nor	Rice husk in sherd 3442–3000*	N/A	Hedges et al., 1993
	Non Pa Wai	1st Millennium BC	4417–4158*	
	Non Mak La	1st Millennium BC	2nd Millennium BC	Weber et al., 2010
	Nil Kham Haeng	2756–2492*	2nd Millennium BC	
	Ban Non Wat	2746–2459*	N/A	Higham and Higham, 2009
	Non Nok Tha	3445–3071*	N/A	Hedges et al., 1991
	Loc Giang	Rice spikelet bases in sherds 4000–3300	N/A	Barron et al., 2017
	An Son	Rice spikelet bases in sherds 4250–3150	N/A	Bellwood et al., 2011; Barron et al., 2017
	Rach Nui	3555–3265		Castillo et al., 2018
	Khao Sam Kaeo	2400–2000		Castillo et al., 2016
Sichuan	Liujiazhai	N/A	5500–4700	Li, 2014; SICRA et al., 2012
	Haxiu	N/A	5500–4700	ATQCRC et al., 2010
	Yingpanshan	N/A	5300–4600	Zhao and Chen, 2011
	Guiyuanqiao	4530–4250*	4850–4550*	d'Alpoim Guedes and Wan, 2015
	Baodun	4790–4432*	Coexist	d'Alpoim Guedes et al., 2013
	Longwangmiao	4800–4500		Yan et al., 2013; SICRA et al., 2011
	Henglanshan	4470–4120		CIA et al., 2016b
	Liantang	4160–3960*	4100–3970*	
	Guijiabao	N/A	4842–4644*	CIA et al., 2016a
Yunnan-Guizhou	Baiyangcun	4574–4424*	4818–4523*	Martelloa et al., 2018
	Dadunzi	4139–3928*	4144–3880*	Jin et al., 2014
	Haimenkou	3692–3571*	3966–3706*	Min, 2013
	Jigongshan	3444–3219*	N/A	GZICRA et al., 2006a
	Wujiadaping	3471–3166*	N/A	GZICRA et al., 2006b
	Shifodong	3358–3066*	Coexist	YICRA et al., 2010
	Shilinggang	2724–2384*	Coexist	Zhang et al., 2017
	Gantuoyan	3859–3596*	Coexist	ATGZ and Napo Museum, 2003
Guangxi-Guangdong	Xiaojin	4500	N/A	ATGZ and ZCRC, 2004; Zhang and Hung, 2009
	Chaling	4526–4418*	N/A	Xia et al., 2019
	Laoyuan	4690–4246*	N/A	Yang et al., 2018
	Shixia	4348–4091*	N/A	Yang et al., 2016
Fujian-Taiwan	Nanshan	4974–4846*	Coexist	Yang et al., 2018
	Hulushan	3842–3649*	Coexist	Ge et al., 2019
	Huangguashan	3980–3846*	Coexist	Deng et al., 2018a
	Pingfengshan	3826–3632*	Coexist	
	Nanguanlidong	5000–4300	5000–4300	Tsang et al., 2017
	Chaolaiqiao	Phytolith 4200–4000	N/A	Deng et al., 2018b

a) *, Direct dating of rice/millet remains; N/A, rice/millet not available; Coexist, rice coexisted with millet at the same site; ATGZ, Archaeology Team of Guangxi Zhuang Autonomous Region; ATQCRC, Aba Tibetan and Qiang Autonomous Cultural Relics Committee; CIA, Chengdu Institute of Archaeology; GZICRA, Guizhou Provincial Institute of Cultural Relics and Archaeology; YICRA, Yunnan Provincial Institute of Cultural Relics and Archaeology; ZCRC, Cultural Relics Committee of Ziyuan

Shifodong by Kan (1983), but the published image of ragi millets is too blurred to be identified. Besides, no other ragi millet was recovered in the follow-up official excavation at Shifodong (YICRA et al., 2010), Therefor, the early identification could be insecure. For this reason, we take these two cases as foxtail millet in our study.

2.3 South China

So far, in the inland of Guangdong and Guangxi, only

Xiaojin site produced a large quantity of rice grains from Phase II. However, a series of ^{14}C dates of charcoals yielded from this site are not consistent with their stratifications. The age of Phase II is estimated at ca. 4500 a BP based on its culture features (ATGZ and ZCRC, 2004; Zhang and Hung, 2009). In addition, a few rice phytoliths were extracted and sporadic pot sherds or burnt soil tempered rice grains or husks were found now and then in this region. Their dates are controversial, but later than those from Xiaojin, which is commonly accepted (GDICRA and Fengkai Museum, 1998; Zhao et al., 2005; Xiang and Yao, 2006; Zhang et al., 2008; Zhang and Hung, 2009).

A small amount of rice phytoliths extracted from Xincun (5300–4420 a BP) in eastern Guangdong were identified as wild rice (Yang et al., 2013). Waterlogged rice seeds were unearthed at Guye (5000 a BP). However, rice grains from Neolithic layers were proved to be intrusion due to the direct AMS ^{14}C dating to Ming and Qing Dynasties (Cui, 2007; Yang et al., 2016). The definite early rice came from Laoyuan and Shixia in eastern Guangdong, directly dated to 4690–4246 and 4290–4095 cal a BP (Yang et al., 2016, 2018). Rice arrived in Pearl River Delta later which was dated to 4526–4418 cal a BP at Chaling (Xia et al., 2019).

Up to now, no prehistoric millet has been discovered in Guangdong and Guangxi.

In Fujian, ten carbonized rice grains were unearthed in Tomb 2 of Dapingding site, which were dated to 7571–7442 cal a BP (Wu, 2018). Tens of thousands of seeds were found from Layer 19–23 at Nanshan, which were mainly rice and the two millets (STIACASS et al., 2018). Directly dated rice from Layer 22 was 4974–4846 cal a BP (Yang et al., 2018). Both micro- and macro-remains of rice and millets were found at Huangguashan and Pingfengshan (4200–4000 a BP) (Deng et al., 2018a). Rice and millets were found through flotation at Hulushan, where the rice remain was dated to 3842–3649 cal a BP (Ge et al., 2019). A large number of crops, including rice and the two millets, have also been found at Nanguanlidong (5000–4300 a BP) in Taiwan. However, no dating result of the crops have been published (Tsang et al., 2017). Rice bulliform phytoliths identified as domesticated were found at Chaolaiqiao in Taitung (4200–4000 a BP) (Deng et al., 2018b).

No millet found in coastal Fujian has been dated yet. Considering the archaeological contexts, they were as early as the rice of the same context at Nanshan, Pingfengshan, Huangguashan, Nanguanlidong and Hulushan.

3. Results

There are totally 312 direct ^{14}C dates published in China and mainland Southeast Asia, including 147 dates for rice remains (Figure 2) and 165 for millets (Figure 3).

Combining together these ^{14}C dates and the corresponding localities, it can more intuitively reflect the process of early agriculture dispersal. As Figure 2 shows, since rice was domesticated until 5000 a BP, it was confined to the north of 30°N, namely Yangtze Valley and northern China. Then it moved greatly southward to around 26°N at ca. 4900 a BP. With the longitude information, there were two branches of rice southward spread: One reached the coastal Fujian and the other reached Yunnan-Guizhou Plateau. Approximately 1500 years later, rice had moved southward to 13°N, i.e. mainland Southeast Asia at ca. 3400 a BP. As is shown in Figure 3, millet agriculture was confined to the north of 35°N before 4800 a BP and then quickly moved southward to 27° N, where it is the mountainous area of western Sichuan, and then immediately advanced to Yunnan-Guizhou Plateau near 26°N. Due to the lack of direct ^{14}C dates, the millet farming in coastal Fujian is not shown in Figure 3, but this branch can not be ignored. By 4400 a BP, millet farming reached 15°N, that is to say, southern Indo-China Peninsula.

In short, there were two branches of rice and millet moving to southern China, the east and the west routes, and both might be the possible source of agriculture in mainland Southeast Asia. It should be noted that the two rice remains unearthed at Dapingding were around 7500 a BP. Wu (2018) identified them as cultivated *japonica* rice. However, it is difficult to accurately identify domesticated rice or at least not only by the morphological features of the grain. In addition, the date does not conform to the overall chronological framework of the local subsistence. Therefore, the data are excluded in this paper.

The time of rice and millet arriving in mainland Southeast Asia is another important issue. The date of millets at Non Pa Wai was consistent with their context, which confirms that millet farming appeared in northeast Thailand at 4400 a BP. Millets were found at Rach Nui and Khao Sam Kaeo, indicating that millet played a role in the prehistoric mainland Southeast Asia. At present, the earliest and definite evidence of rice farming in this region is from Non Nok Tha in the late second millennium BC. Although the direct dating result of rice husks tempered in a pottery sherd at Khok Phanom Di is 5039–4646 cal a BP, it is earlier than its material cultural feature and contradicts its archaeological stratifications (Ramsey et al., 2002). The same problem happened in the dating results of Nong Nor (Hedges et al., 1993). Therefore, these two data are excluded in this paper. The rice remains from Non Nok Tha occurred much later than the previous understanding. Traditionally, rice farmers were thought to have arrived in mainland Southeast Asia during the period of 4500–4000 a BP (Higham, 2003). Nevertheless, it lacks direct archaeological evidence at present. For the moment, we adopt the earliest direct ^{14}C dates, 3400 a BP and 4400 a BP, as the beginning time of rice and millet farming in mainland Southeast Asia, respectively. In this case, rice farming was

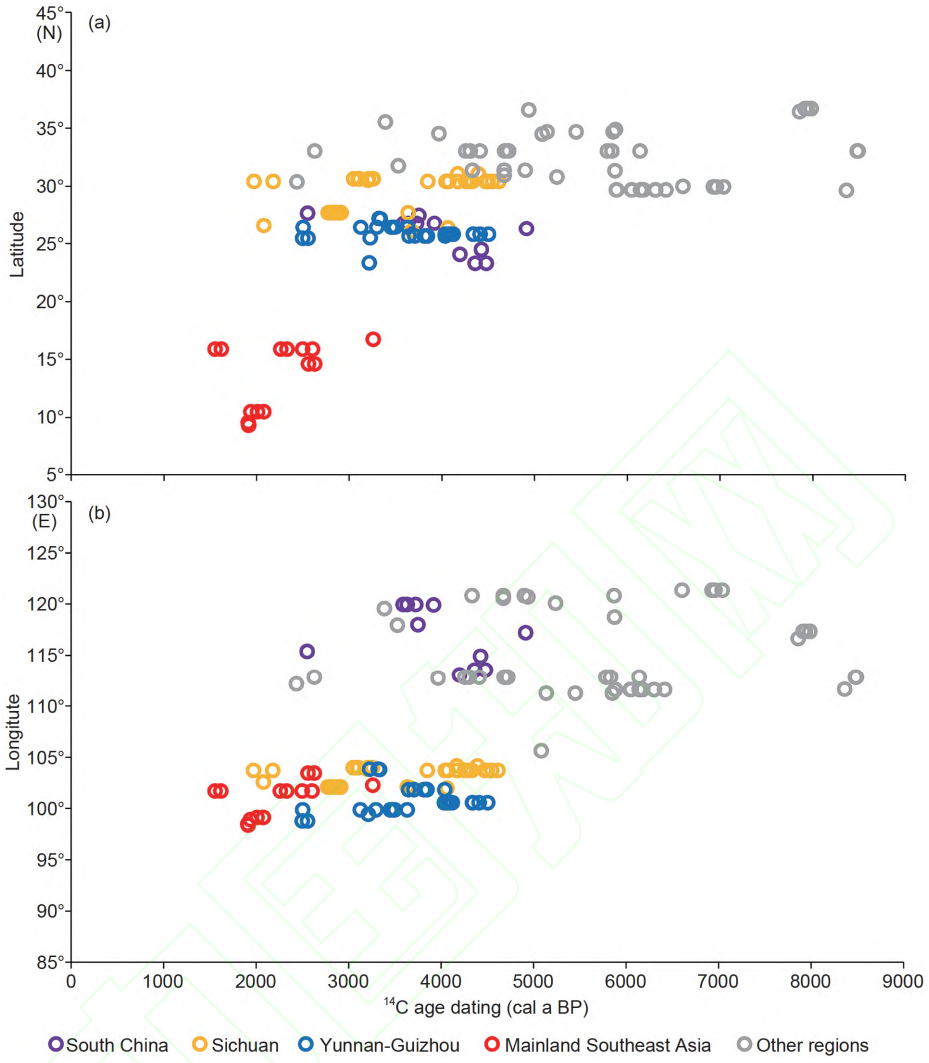

Figure 2 The spatio-temporal changes of direct ^{14}C dates of rice remains. (a) By latitude; (b) by longitude.

introduced much later than millets. However, a possible reason is that the earlier rice remains have not yet been discovered, and further work is needed to continue the discussion.

4. Discussions

4.1 The source of early agriculture in mainland Southeast Asia

In order to trace the source of early agriculture in mainland Southeast Asia, it is necessary to look for earlier clues from archaeological sites in the adjacent areas. Evidence of earlier rice and millet has been found in both South and Southwest China. To further determine the origin of prehistoric agriculture in mainland Southeast Asia, the next step is to analyze the regional archaeological background.

4.1.1 South China

Before the introduction of agriculture into South China in the late Neolithic age, there had been indigenous hunter-gatherers in Guangxi and western Guangdong. In coastal Fujian and Guangdong, a type of mixed hunter-gather culture occurred under the influence from the Middle Yangtze Valley. Farming was faced with different cultureal traditions when introduced into the two regions (Zhang and Hung, 2012). Coastal Guangdong and Fujian had long been affected by the Middle and Lower Yangtze River, where farming traditions developed. Once it needs a subsistence transformation in the coastal area, agriculture could be imported along the existing cultural channels. In contrast, Guangxi and western Guangdong had been developing independently without external influence. Therefore, it is reasonable that rice farming firstly reached the coastal area, which has been proved by the existing archaeobotanic evidence (Yang et al., 2018; Xia et al., 2019).

However, the discussion above only explains the "source" of rice in South China. As for the "flow", it is necessary to consider the cultural relationships between these regions and

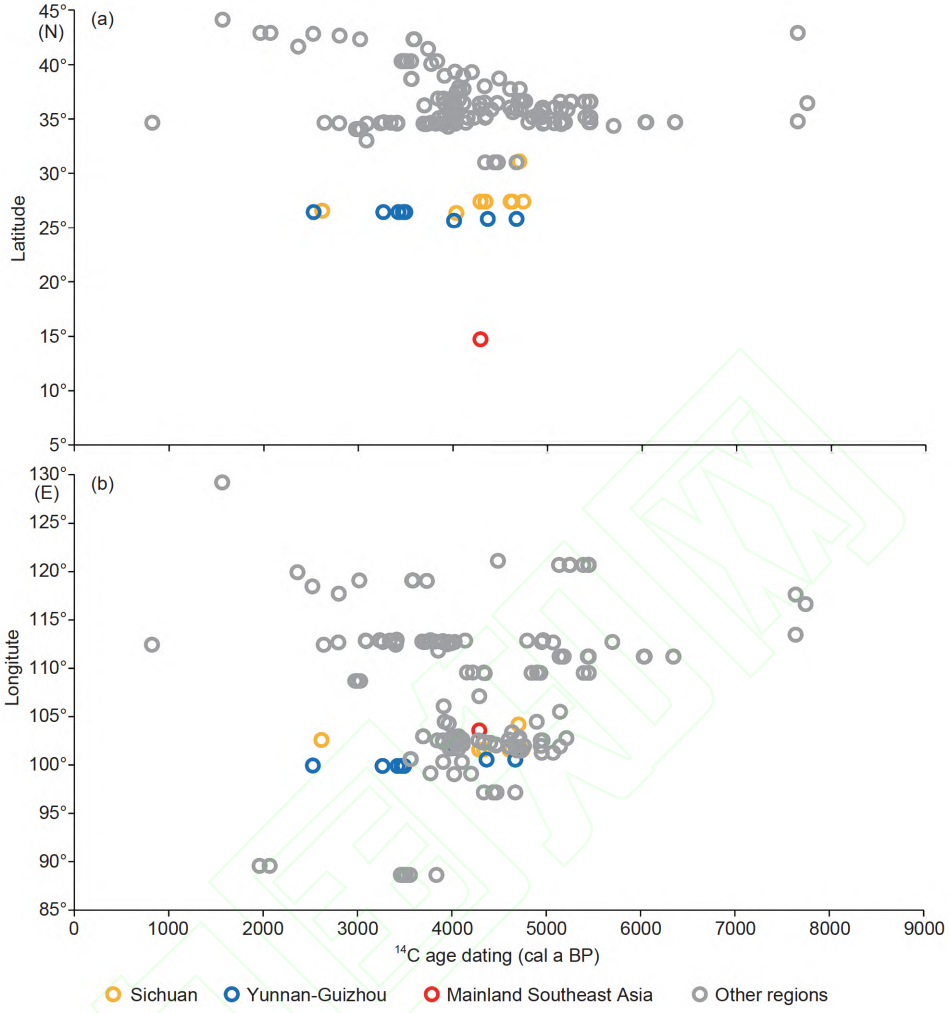

Figure 3 The spatio-temporal changes of direct ^{14}C dates of millet remains. (a) By latitude; (b) by longitude.

mainland Southeast Asia. Not only is Guangxi adjacent to the inland northern Vietnam, they had a similar geographical environment and human setting with a hunter-gatherer subsistence in the middle Neolithic age. The archaeological culture in coastal Fujian was closer to those in Taiwan and Island Southeast Asia, and those in coastal mainland Southeast Asia as well. It seems that mainland Southeast Asia is more similar to the inland Guangdong and Guangxi than the coastal area. However, only rice and no millets have been found in prehistoric Guangxi-western Guangdong up to now, so the most we can say is that only rice farming might come from inland areas of Guangdong and Guangxi. Taking into account the similarities in material culture along the shore and the excellent navigation ability of prehistoric groups (Clarkson et al., 2017), there might exist an ocean route along the coastal areas (Bellwood, 2011) (Figure 1). In view of the earlier appearance of millet farming in mainland Southeast Asia than rice, and the absence of millets in coastal Guangdong, the ocean route was possibly originated from coastal Fujian, where there were both rice and millets. Archaeological sites in southern Indo-China Peninsula, such as Loc Giang, An Son and Rach Nui in southern Vietnam, were indeed unearthed rice remains earlier than 3000 a BP. Unfortunately, the coastal areas still lack evidence of millet agriculture earlier than Non Pa Wai.

4.1.2 Southwest China

Neolithization in Southwest China began in the mid fourth millennium BC and was heavily influenced by Northwest China through the "Crescent-Shaped-Cultural Communication Belt". The strong role of Majiayao culture can be detected in the early remains in the Upper Dadu and Min Valleys in western Sichuan (Jiang, 2004). At the beginning of the third millennium BC, the migrants from Northwest entered Chengdu Plain, developing the earliest Neolithic culture, Guiyuanqiao Phase I (5100 a BP), in the plain. Then with influence from the Middle Yangtze River and Xiajiang area, it gradually evolved to Baodun culture (4600–4000 a BP) (Wan and Lei, 2013; He, 2016). There is no chronological framework of archaeological cultures in

Yunnan-Guizhou Plateau, where the local discoveries can only be divided into different cultural types according to their cultural features (Wang, 1994; Li, 1998). The earliest is Baiyangcun type in Erhai Lake catchment and Shizhaishan type in Dian Lake Basin, estimated as early as 5000 a BP. Other types were later than 4000 a BP (Xiao, 2001). Even though the archaeological work is limited in the region between Chengdu Plain and Yunnan-Guizhou Plateau, the early potteries in this region have a close relationship with those in western Yunnan, i.e. Baiyangcun (Wan, 2013; CIA et al., 2016a), which indicates that there were intensive cultural communications in the late Neolithic age on the southeastern margin of Tibetan Plateau.

The early agriculture in Chengdu Plain was closely related to cultural communications. The Majiayao migrants who moved southward in the fourth millennium BC brought millet farming to western Sichuan. There was single millet farming at Yingpanshan, Haxiu and Liujiazhai around 5000 a BP (ATQCRC et al., 2010; Zhao and Chen, 2011; Li, 2014). Then they entered Chengdu Plain. At Guiyuanqiao, there were only a few rice remains during Phase I, but the direct date fell within Phase II. So, locals should heavily depend on millet farming during Phase I. Since this is based on only four flotation samples of Guiyuanqiao, the conclusion still needs to be tested by further study. At the beginning of Guiyuanqiao Phase II, it gained cultural influence and rice from the Middle Yangtze River (Sun, 2009; Wan and Lei, 2013). A mix farming of rice and millet had appeared in Chengdu Plain since then. South of the plain, it was the same cropping system before wheat and barley appeared at Longwangmiao, Henglanshan, Liantang and the like (SICRA et al., 2011; CIA et al., 2016b). This should be the result of southward movement of agriculture from Chengdu.

At present, the earliest systematic archaeobotanic data on Yunnan-Guizhou Plateau was from Baiyangcun (4600–4000 a BP), where the plant assemblage was dominated by rice, foxtail millet and broomcorn millet. Martelloa et al. (2018) believed that they were introduced as a crop package in the mid third millennium BC. As for other sites with systematic flotation, before the introduction of wheat and barley, they all practiced the same food production, which may be taken as a reference for speculating the early cropping in this region. In a word, there developed a cultural and agricultural communication channel of Chengdu Plain-Western Sichuan Mountain-Yunnan-Guizhou Plateau at 4500 a BP. Southwest China could be one origin of rice and millet farming introduced into mainland Southeast Asia.

4.2 The transmission route of agriculture from Southwest China to mainland Southeast Asia

The "Maoniu Road" (Figure 1) in texts, is very similar to the way agriculture moves in Southwest China. The Maoniu Road is one branch of the Southwest Silk Road and the route was documented as Chengdu-Qionglai-Mingshan-Ya'an-Xingjing-Hanyuan-Ganluo-Yuexi-Xide-Mianning-Xichang-Dechang-Miyi-Huili-Panzhihua-Yongren-Dayao-Dali (Qu, 2011). Rice and millets appeared in both Chengdu and Hanyuan, earlier than 4500 a BP. Although there is no such early crop remains in Xichang and Huili, rice and millets were unearthed at sites of Henglanshan and Liantang in this region later (4400–4000 a BP). In the Jinsha Valley near Yongren, archaeological culture at Bingnongbinghong, a newly excavated site, was similar to those of Maiping in Hanyuan and Baiyangcun in Dali. It indicates they were contemporaneous, meaning Bingnongbinghong was occupied as far back as 5000–4500 a BP (personal communication). Evidences available on this route showed that the predecessor of the Southwest Silk Road had appeared as early as the late third millennium BC. As for the dispersal route of rice-millet agriculture from northwestern Yunnan to mainland Southeast Asia, it is impossible to say because of the absence of archaeological or archaeobotanic materials between southern Yunnan-Guizhou Plateau and northern mainland Southeast Asia.

4.3 The way of agriculture spreading to mainland Southeast Asia

The same assemblage, rice and millet, appeared repeatedly at all the early sites in Yunnan-Guizhou Plateau and coastal Fujian, but the crop package was broken in mainland Southeast Asia. At least the available evidences support that millet farming was firstly introduced into this area, while rice was "lost" in the process of southward movement. Considering millet grains are smaller and more difficult to be preserved and found than rice, the lack of rice cannot be explained as only an omission in excavation. Then, was there still a crop package when early agriculture moved to mainland Southeast Asia? If so, why was millet firstly adopted? If not, when did rice get "lost"?

The earliest millets in mainland Southeast Asia were from KWP Valley. Weber et al. (2010) pointed out that it was a relatively fertile clay in the river terrace, but a silty soil with strong water seepage ability in the piedmont zone, where archaeological sites were located and which was relatively suitable for dry farming. Paleoenvironmental studies show that, in the late Neolithic age, it was less arboreal and more herbaceous regionally, more suitable for dry farming as well in terms of the climate factor (Kealhofer, 2002). Therefore, millet farming in KWP at 4400 a BP may be a survival strategy adopted by local inhabitants to adapt to natural environment. In addition, it was upland rice that were cultivated in Neolithic mainland Southeast Asia, which was different from wet rice in China (Fuller et al., 2011; Martelloa et al., 2018). The transition from wet to upland rice can be regarded as, on the one hand, an adaptation to the local

environment; on the other hand, an environmental inadaptability of wet rice from China, which was one of the reasons why rice farming was introduced later.

Rice farming in KWP did not appear until the first millennium BC. Khok Phanom Di, not far from KWP, was believed to have cultivated rice in 4000–3500 a BP (Higham, 2002), which was much earlier than that in KWP. Those KWP settlements should have access to rice farming theoretically, but they didn't accept it. Intensive and systematic archaeobotanic analysis have been carried out at Khok Phanom Di with no millet remains found. In other words, inhabitants of Khok Phanom Di should have possible contact with millet farmers in theory. Interestingly, they said no either.

Therefore, the subsistence strategy of a prehistoric settlement was related to the regional climate, landscape, ecology and even cultural traditions. In view of this, to discuss the dispersal mode of prehistoric agriculture, we cannot simply deny the crop package of rice and millets. It's possible that only part of the package was integrated into the local subsistence; it's also possible that rice had been lost before arrival in the southern Indo-China Peninsula. If it is the latter situation, when and where was rice introduced into mainland Southeast Asia again? To answer these questions, as has been repeatedly emphasized, further archaeological and archaeobotanic studies are needed in the future.

4.4 Conclusion

In summary, millet agriculture appeared in the late third millennium BC and rice in the late second millennium BC in mainland Southeast Asia. Multiple evidences show that millets had played an important role in local food production from the late Neolithic to the Iron Age. According to the current published ^{14}C dating data, rice and millets may be introduced from coastal Fujian or the inland of Southwest China; Guangdong and Guangxi was another possible source of rice as well. The rice and millet spread from coastal Fujian to southern Indo-China Peninsula is very likely by ocean. In Southwest China, the story is that rice from the Middle Yangtze River and millets from Northwest China met in Chengdu Plain in the early third millennium BC and moved to Yunnan-Guizhou Plateau as a crop package, then to mainland Southeast Asia. Early agriculture spread from Chengdu Plain to Yunnan-Guizhou Plateau along the Maoniu Road in literature. It remains unclear how early agriculture spread from Yunnan-Guizhou Plateau to mainland Southeast Asia.

The successive arrivals of millets and rice indicated that there were different waves of early agriculture introduced from China to mainland Southeast Asia by different routes. The spread process was quite complicated, which highlights the importance of archaeological work. However, unbalanced distribution of archaeobotanic data severely limits the room for current studies. Systematic archaeobotanic analysis and precise dating are urgently needed, especially in northern mainland Southeast Asia, southern Yunnan, Guangxi and inland Guangdong. In addition, the spread and diffusion of agriculture is not only human activities, but also deeply influenced and restricted by environment, especially in the prehistoric period. Therefore, the regional climatic and environmental background and niches of archaeological sites need to be explored in the future.

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