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The Four Stages in the Origin of Rice Agriculture[1]

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Abstract: In recent years, due to the widespread application of flotation, a large number of plant remains related to the origin of rice agriculture have been found in the middle and lower reaches of the Yangtze River. Through the study of these new findings, it has been discovered that the origin of rice agriculture was a long and gradual process lasting for thousands of years. This process can be divided into four stages: the stage of gestation took place around 10,000 years ago—human society was still in the hunting and gathering phase, but archaeological evidence of human-used or even cultivated *Oryza* plants from that time has been discovered; the early stage of transition took place around 9000–7000 years ago—archaeological evidence of rice farming from that time has been found, such as villages, domesticated rice, farming tools, etc., but subsistence then was still mainly based on hunting and gathering, whereas rice farming and pig breeding, which fall into the agricultural production category, were only auxiliary production activities; the late stage of transition took place around 7000–5000 years ago, when the proportion of subsistence attained by hunting and gathering gradually declined while the proportion of rice farming increased day by day; and the stage of completion took place about 5000 years ago, when hunting and gathering was replaced by rice agriculture in the middle and lower reaches of the Yangtze River successively.
Keywords: rice agriculture, middle and lower reaches of the Yangtze River, origination, flotation results

摘　要：近些年来，由于浮选法的普遍应用，长江中下游地区发现了大量与稻作农业起源研究相关的植物遗存。通过对这些新资料的研究发现，稻作农业起源是一个漫长的渐变过程，历经数千年，期间可划分为四个阶段：距今 1 万年前后是孕育阶段，人类社会尚处在采集狩猎阶段，但考古发现了人类利用甚至耕种稻属植物的证据；距今 9000~7000 年是初期阶段，考古发现了稻作农业的证据，如定居村落、栽培稻、农耕工具等，但当时的生业经济依然是以采集狩猎为主，属于农业生产范畴的水稻种植和家猪饲养仅是辅助性的生产活动；距今 7000~5000 年是转变阶段，采集狩猎在生业经济中的比重日渐降

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低，而稻作农耕的比重日渐提高；距今 5000 年前后，长江中下游地区相继完成了由采集狩猎向稻作农业的转变，人类社会进入农业阶段。
关键词：稻作农业，长江中下游地区，起源过程，浮选结果

1 Introduction

China is one of the world's original centers of agriculture. Generally, it is believed that there are two independent sub-centers for China's agricultural origin: the first is dry-land agriculture, represented by the millets of *Setaria italica* and *Panicum miliaceum* centered along the Yellow River; the second is rice agriculture, represented by rice (*Oryza sativa*) planting centered in the middle and lower reaches of the Yangtze River. Recent studies have found that there may be a third sub-center of agricultural origin in China, namely the tropical agriculture characterized by tuber crops such as yam (*Colocasia esculenta*) distributed in the Pearl River basin (Zhao 2005).

Agriculture includes crop farming and livestock rearing, the former providing fodder to the latter. The remains of plants discovered in archaeological excavation should be the evidence that best reflects the characteristics of ancient agriculture. However, as organic substances, plants are prone to decay and are difficult to preserve for a long time in the cultural sediments of archaeological sites. What's more, ancient plant remains, such as most plant seeds, are normally so tiny that they are difficult to find with the naked eye. The unstorable and undetectable nature of plants poses certain difficulties to obtaining ancient plant remains during archaeological excavations.

However, because fire is an indispensable part of human life, there must be some plants in the dwelling places of ancient humans that were turned into charred material by fire. The chemical nature of charred material is very stable, and various erosive effects of soil normally have no effect on it, so it can be preserved for a long time in the cultural sediments of the sites. Charred materials are lighter than soil particles and have a slightly lower density than water. Therefore, when the soil is put into water, the charred material will float on the surface of water and can then be extracted. According to the characteristics of charred materials, archaeologists have designed the method of "flotation," which is used to find and obtain the remains of charred plants buried in archaeological sites. It has been proved that the flotation technique is the most effective means of obtaining ancient plant remains through archaeological excavation (Zhao 2004).

Since the beginning of this century, the flotation technique has been rapidly popularized in Chinese archaeology. Over the past twenty years, the flotation technique has been used in hundreds of archaeological sites, and tens of thousands of soil samples have been collected and floated at these sites, from which an enormous amount of charred plant remains have been obtained. The number of charred plant

seeds alone is in the millions. Most of the charred plant seeds recovered through flotation belong to the remains of crops, including a large number of rice remains, like hulled and unhulled rice grains and rice spikelet bases (Zhao 2010). These new archaeological discoveries have provided important archaeological materials for exploring the origin of rice agriculture (Figure 1).

Rice is one of the most important cereals in the world today, with more than half of the world's population taking rice as its main food source (Swaminathan 1984). Therefore, the research on the origin of rice agriculture has always been an international hot topic. The conclusion that rice farming first appeared in the middle and lower reaches of the Yangtze River in China has basically gained consensus in the academic community at home and abroad (Jones and Liu 2009; Gross and Zhao 2014). According to the new archaeological findings of recent years, combined with previous research results, we have a new understanding of the origin of rice agriculture.

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Figure 1: Distribution of archaeological sites.

1. Xianrendong 仙人洞/ Diaotonghuan 吊桶环; 2. Yuchanyan 玉蟾岩; 3. Shangshan 上山;
4. Pengtoushan 彭头山/ Bashidang 八十垱; 5. Kuahuqiao 跨湖桥/ Xiaohuangshan 小黄山;
6. Jiahu 贾湖; 7. Baligang 八里岗; 8. Hemudu 河姆渡/ Tianluoshan 田螺山; 9. Liangzhu 良渚.

Agriculture refers to the production behavior of humans using the reproduction of plants and animals to obtain living resources. The essence of agriculture is the modification of plants and animals' living environments by human beings, which yields crops and domesticated animals. The interdependence of humans and crops and domesticated animals is gradually strengthened by way of a slow co-evolution; more specifically, the process of rice agriculture's origination refers to the co-evolution of humans and domesticated rice. Hunting and gathering transformed into rice farming as these initial alternative food sources gave way to an increasing reliance on agricultural production. This transformation was a very long and gradual process, during which the proportion of hunting and gathering was declining in human life, whereas the proportion of rice farming was increasing. Eventually, rice farming replaced hunting and gathering activities as the main body of human subsistence. New archaeological findings reveal that this gradual transformation was exceedingly slow and lasted for thousands of years; it could be roughly divided into four stages, namely, the stage of gestation, the early stage of transition, the late stage of transition, and the stage of completion.

2 The gestation stage of the origination of rice farming (around 10,000 years ago)

The earliest rice remains discovered in China were unearthed at four archaeological sites: the Xianrendong 仙人洞 site and the Diaotonghuan 吊桶环 site in Wannian 万年, Jiangxi Province (Zhao 1998), the Yuchanyan 玉蟾岩 site in Dao County 道县, Hunan Province (Yuan 1996), and the Shangshan 上山 site in Pujiang 浦江, Zhejiang Province (Jiang and Liu 2006), among which the charred rice grains unearthed from the Shangshan site were obtained through systematic flotation.

The Shangshan site was a settlement of the early Neolithic period. The cultural sediment of the site is divided into four layers that belong to different archaeological culture periods: Shangshan culture, Kuahuqiao 跨湖桥 culture, late Neolithic culture, and the Shang and Zhou periods. Shangshan culture took place around 10,000 years ago; Kuahuqiao culture took place about 8000 years ago; the late Neolithic culture of the Shangshan site is equivalent in terms of the chronology to the Hemudu 河姆渡 culture located in the Ningshao Plain, which took place about 6500 years ago; the Shang and Zhou periods include the Shang, the Western Zhou, and the Eastern Zhou dynasties, which took place around 3600–2200 years ago (Jiang and Sheng 2007).

A large-scale flotation was carried out as part of the archaeological excavations of the Shangshan site, and more than 450 soil samples were collected and floated (Zhao and Jiang 2016). The remains of plants unearthed from the flotation of the Shangshan site were not abundant, but 59 charred rice grains and 7 rice spikelet bases were found

(Table 1). The majority of them were from the samples of the late Neolithic and the Shang and Zhou periods; two charred rice grains were from the Shangshan culture samples dating back to 10,000 BP. One of these two rice grains is intact, measuring 3.73 mm long, 1.67 mm wide, and 1.72 mm thick (Figure 2). Among samples unearthed, there were 5 charred rice grains and 3 spikelet bases that belong to the Kuahuqiao culture, dating back to 8000 BP. The length of the two intact charred rice grains was 3.73 mm and 4.90 mm, respectively, the width 1.92 mm and 2.02 mm, and the thickness 1.32 mm and 1.42 mm (Figure 3).

Table 1: The charred rice remains unearthed from the Shangshan site

	Shangshan culture	Kuahuqiao culture	Late Neolithic period	Shang and Zhou periods	**Total**
Charred rice grains (complete)	1	2	8	8	19
Charred rice grains (broken)	1	3	11	25	40
Rice spikelet bases		3	4		7

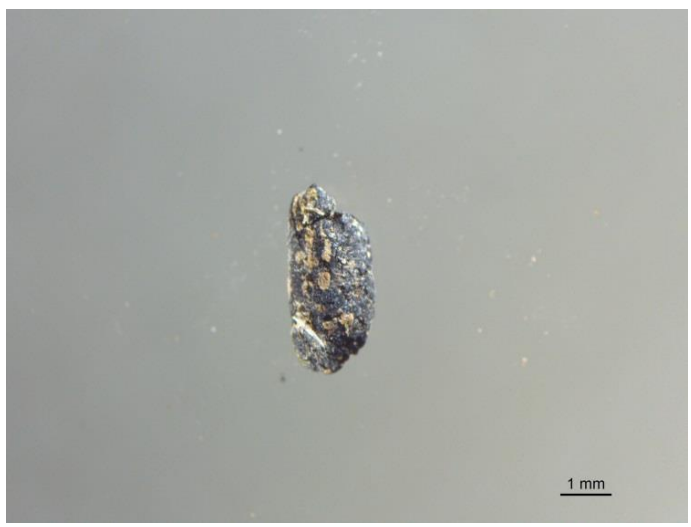

Figure 2: Charred rice grain of the Shangshan culture period, unearthed from the Shangshan site.

In addition to the charred rice grains obtained by flotation, other kinds of rice remains of the Shangshan culture period were also found. For example, in the fracture surface of Shangshan culture pottery, the leaf fragments of plants mixed in the clay could be clearly observed, including rice husks (Figure 4) (Jiang and Liu 2006). In addition, a number of charred rice husks were found in some of the burnt soil blocks unearthed in the early cultural strata of the Shangshan site. Due to the small number of charred rice grains unearthed by flotation from the Shangshan culture period, it is at present impossible to do a quantitative analysis on whether there was rice farming in

the Shangshan culture period. However, considering the fact that the people of Shangshan culture formed the habit of mixing rice husks in clay when making pottery, and the fact that rice husks were often incinerated for some purpose, it is not difficult to speculate that during this period, which was around 10,000 years ago, the local people not only ate rice but also had a high overall demand for rice. Additionally, some naturally cracked large stone fragments were unearthed at the Shangshan site, similar in shape to harvesting tools such as stone knives. Some scholars surmise that these are early farming tools (Zheng and Jiang 2007).

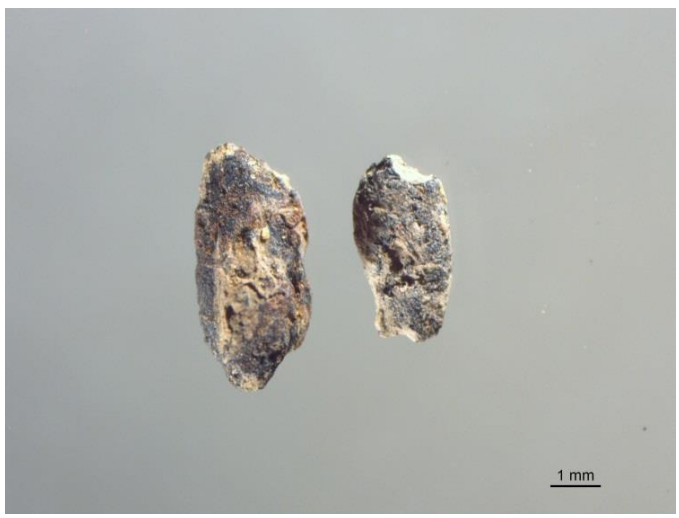

Figure 3: Charred rice grains of the Kuahuqiao culture period, unearthed from the Shangshan site.

Figure 4: Rice husks mixed in the clay of pottery, unearthed from the Shangshan site.

However, there are few house remains found at the Shangshan site belonging to the Shangshan culture period; what's more, the shape of the house foundations is not neat. The pottery's shape is simple because it was made at low heat with rough procedures. The stone tools are primarily simply processed large stone fragments and chipped stones, and the unearthed animal bones are all identified to be those of wild animals. Based on the above evidence, the ancient people who lived in the Shangshan site around 10,000 years ago are believed to have relied on hunting and gathering for their livelihood as before, including eating wild rice growing around the site. On the other hand, the unearthed rice remains and other relevant evidence also indicate that in order to obtain more wild rice resources, the people of the Shangshan site had begun to implement certain farming practices, such as cultivation.

Cultivation refers to various human behaviors intended to facilitate the growth of plants, such as clearing and improving lands, sowing, weeding, irrigating, etc. It should be emphasized that the ancient humans initially adopted certain farming behaviors only to increase the amount of plants acquired, instead of consciously changing the genetic and morphological characteristics of the plants. The cultivated ones, especially those first cultivated, may belong to wild plants in terms of morphological characteristics and even genetic characteristics (Harris 2007). Therefore, the cultivation carried out by the people of the Shangshan culture period was only meant to increase the amount of rice harvested, or to indirectly increase the amount of wild rice that grew naturally. Whether the early cultivated rice was wild or domestic, or in other words, whether it was still wild rice or had evolved into domesticated rice in terms of morphological and genetic characteristics, is an academic problem worthy of careful analysis and research, and at present it is hard to draw any conclusions. But no matter what, farming behavior represented by cultivation is the premise of rice domestication, and is also a prerequisite for the formation of rice agriculture. According to this, the emergence of cultivation can be called the stage of gestation in the origination of rice agriculture. The discovery of the Shangshan site and other sites dated to 10,000 BP is believed to belong to this stage.

3 The early stage of transition to rice agriculture (9000–7000 years ago)

The period around 8000 years ago was a crucial time in the development of China's Neolithic Age, during which settled villages appeared, proper farming and livestock rearing were initiated, pottery making was gradually standardized, and the proportion of polished stone implements was continuously increasing. This period is called the "early Neolithic Age" (An 1979), or "the early stage of middle Neolithic Age" (Yan 1987) by archaeologists. Currently the archaeological sites found in China with apparent characteristics of rice farming also belong to this period, including the Pengtoushan 彭

头山 site and the Bashidang 八十垱 site from Li County 澧县, Hunan Province (Hunan Provincial Institute of Cultural Relics and Archaeology 2006); the Kuahuqiao site of Xiaoshan 萧山 (Zhejiang Provincial Institute of Cultural Relics and Archaeology and Xiaoshan Museum 2004), and the Xiaohuangshan 小黄山 site of Shengzhou 嵊州 (Zhang et al. 2005), Zhejiang Province; the Jiahu 贾湖 site of Wuyang 舞阳 (Henan Provincial Institute of Cultural Heritage and Archaeology 1999), the Baligang 八里岗 site of Dengzhou 邓州 (Zhang et al. 2000), Henan Province, etc. Among these sites, systematic flotation techniques have been employed in the Jiahu site and the Baligang site (Zhao and Zhang 2009; Deng and Gao 2012). This paper takes the Jiahu site as an example to discuss the development of rice farming in this period.

The Jiahu site is located in the upper reaches of the Huai River, the transition area from northern subtropical zone to the warm temperate zone. Through the excavation it was found that the distribution area of the Jiahu site covered around 50,000 square meters, surrounded by trenches. Inside the area there was a residential place, a burial place, and a workshop place, so it was clearly a well-designed village with residents all year round. The archaeologists unearthed a large number of cultural relics, including pottery, stone implements, bone implements, etc. The stone implements furthermore encompass lots of farming tools, such as spades for cultivation, stone sickles for harvesting, millstones for grain processing, etc. The radiocarbon dates indicate that the cultural remains of the Jiahu site are between 9000–7500 years old (Henan Provincial Institute of Cultural Heritage and Archaeology 1999).

During the excavation of the Jiahu site, 125 soil samples were collected and floated, and abundant charred plant remains were unearthed, including hundreds of charred rice grains (Figure 5), as well as a considerable number of other edible wild plants remains, such as water chestnuts (*Trapa* sp.) (Figure 6), lotus roots (*Nelumbo nucifera*) (Figure 7), acorns (*Quercus* sp.), soybeans (*Glycine* sp.), etc. It is worth noting that in the Jiahu site there were also a large number of weed seeds unearthed by flotation, including some species of farmland weeds. Weeds appeared with the emergence of humans, and it is a special kind of plant attached to human production and life. After a long-term evolution, weeds become a plant group that take an artificial environment as their main living environment, and farmland weeds even grow with crops (Qiang 2001). Therefore, the unearthed farmland weeds in the archaeological sites could indirectly reflect the status of agricultural production activities.

The archaeological evidence, including farming tools, rice remains, farmland weeds, and indications of people settling in villages, clearly show that rice farming was a means of subsistence at the Jiahu site. Yet through quantitative analysis, it was discovered that compared with the wild food resources like water chestnuts, lotus roots, and acorns, the rice remains unearthed in the Jiahu site did not have a clear advantage (Figure 8), which means that rice was not dominant among the food resources of the Jiahu people.

Figure 5: Charred rice grains unearthed from the Jiahu site.

Figure 6: Fragments of water chestnut unearthed from the Jiahu site.

Figure 7: The lotus root remains unearthed from the Jiahu site.

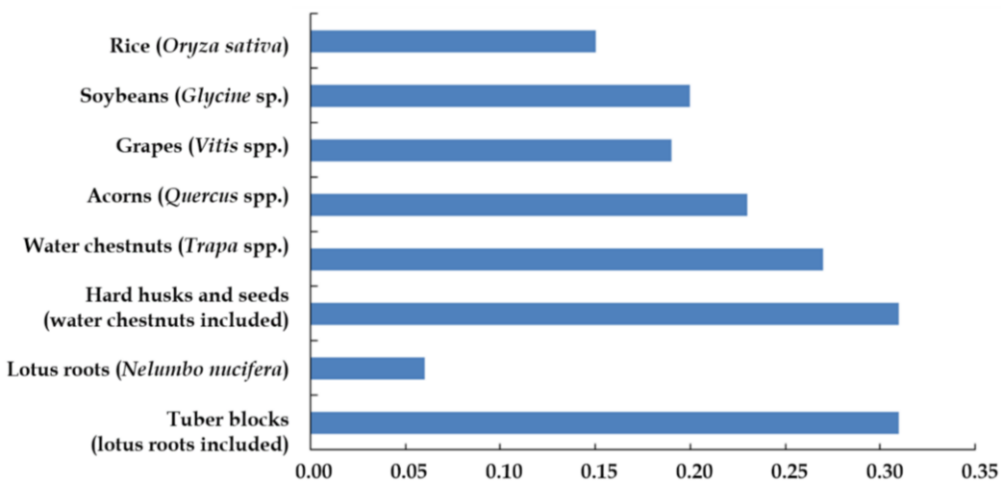

Figure 8: The ubiquity of edible plant remains from the Jiahu site.

From the perspective of the study of zooarchaeology, the animal bones unearthed at the Jiahu site were mainly from wild animals, and the quantity and variety of domesticated animals were few, including dogs and pigs (Luo 2012, 134–142). The latest research results show that domesticated pigs that could be identified by morphological characteristics were first discovered in the sediments of phase II of the Jiahu culture, and those belonging to phase I were still displayed as wild boars (Cucchi et al. 2011). This suggests that livestock husbandry along with crop farming in Jiahu

was just getting started.

It needs to be pointed out that at the Jiahu site a large number of fish bones and mollusk shells were found. The amazing number of the unearthed fish bones demonstrates that fishing played a vital role in Jiahu subsistence (Henan Provincial Institute of Cultural Heritage and Archaeology 1999; Zhao and Zhang 2009). Considering the fact that lotus roots and water chestnuts obtained by flotation also grew in water, Jiahu people are believed to have mainly lived on aquatic animals and plants resources.

Nevertheless, around 8000 years ago Jiahu people began to farm rice, and are thought to have also raised pigs; however, their main food source came from fishing and gathering. In other words, the main body of Jiahu subsistence still relied on hunting (fishing) and gathering, while rice farming and pig breeding were merely auxiliary production activities. The flotation results of the Baligang site reflect a similar situation; for example, the plant food resources in the early Yangshao 仰韶 period included rice and acorns, which means farming and gathering coexisted (Deng and Gao 2012).

The origin of rice agriculture was a gradual process of shifting from hunting and gathering to agricultural production. In the early stages of this process, hunting and gathering were dominant, and crop cultivation and livestock breeding were complementary activities. The Jiahu site could be representative of rice agriculture in its early stages. The Baligang site, the Pengtoushan site, the Bashidang site, the Kuahuqiao site, and the Xiaohuangshan site are believed to reflect this stage as well.

4 The late stage of transition to rice agriculture (7000–5000 years ago)

The Hemudu site, discovered in Yuyao 余姚, Zhejiang Province, in the 1970s, stirred up academia at home and abroad (Zhejiang Provincial Institute of Cultural Relics and Archaeology 2003). As the sediments of the Hemudu site are waterlogged, the cultural accumulation has been soaked for a long time, which provides a favorable preservation condition for a variety of organic matter relics. Therefore, unusually rich plant remains were unearthed, such as acorn, water chestnut, *Euryale ferox*, etc., among which the most notable was a large number of rice remains. Some scholars inferred that an agricultural society emerged in the Hemudu culture period (Liu 2006). However, because the excavation did not use scientific sampling methods, quantified analysis and comparison could hardly be conducted on the unearthed plant remains, so the importance of wild plants such as acorn, water chestnut, etc. in the subsistence of Hemudu people at that time remains unknown. Therefore, whether rice was really the main food of the Hemudu people, and whether rice farming was indeed the economic subject of the Hemudu culture, are still problems worth discussing.

In recent years, the newly discovered Tianluoshan site has offered an opportunity to answer these questions. The Tianluoshan site is also located in Yuyao, Zhejiang Province, only 7 kilometers from the Hemudu site. These two sites are similar in terms of the micro-environment and the waterlogged sediments, and their cultural assemblages are basically the same. Both of the sites contain a wealth of various kinds of organic relics, including plant remains (Zhejiang Provincial Institute of Cultural Relics and Archaeology 2007). Therefore, the Tianluoshan site is almost a copy of the Hemudu site. During the excavation of the Tianluoshan site, a variety of scientific archaeological methods were used to collect the information buried in the site in a comprehensive and systematic way (Zhejiang Provincial Institute of Cultural Relics and Archaeology 2011; Wang et al. 2010), including the use of flotation techniques to obtain plant remains. As of now, 222 soil samples have been collected and floated, and a large number of plant remains have been unearthed.

A wide variety of plant remains were found in the flotation samples from the Tianluoshan site. Edible plant taxa included rice (Figure 9), water chestnut (Figure 10), acorn (Figure 11), *Euryale ferox*, gourd (*Lagenaria*), Nepali hog plum (*Choerospondias axillaris*), persimmon (*Diospyros* sp.) (Figure 12), kiwi fruit (*Actinidia* sp.) (Figure 13), etc. (Fuller et al. 2011). Among these plants, only rice is a domestic crop; the rest belong to wild plant groups. According to the results of quantitative analysis, it can be found that rice was one of the important food resources of Tianluoshan, and people who lived in the period of the Hemudu culture were indeed engaging in rice farming activities. Meanwhile, however, rice farming had not completely replaced hunting and gathering activities to become the main economic subject of the Tianluoshan people or even the Hemudu culture. Gathered wild plants such as water chestnut, *Euryale ferox*, and especially acorn were still important food resources at that time.

Figure 9: Charred rice grains unearthed from the Tianluoshan site.

Figure 10: Water chestnuts unearthed from the Tianluoshan site.

Figure 11: Acorns unearthed from the Tianluoshan site.

Figure 12: A seed of persimmon unearthed from the Tianluoshan site.

Figure 13: Seeds of kiwi fruit unearthed from the Tianluoshan site.

In addition to charred rice grains, rice rachises and spikelet bases were also discovered in the flotation samples from the Tianluoshan site. One of the most fundamental differences between domesticated rice and wild rice is the characteristic of nonshattering, i.e., the grain of domesticated rice will no longer fall naturally after maturation. The natural shattering of wild rice refers to the separation of grains and spikes. The connecting parts of the two are called rachises on the spikes and spikelet bases on the grains. Whether the rice is nonshattering is directly related to the characteristics of the connection surface of the rachises and the spikelet bases. Through a comparative analysis with modern samples, it is found that there is a concave circular ring mound at the surface of the spikelet base. The ring mound of the spikelet base of wild rice is neat, and the middle depression is shallow (Figure 14), whereas the ring mound of the spikelet base of the domesticated rice is not neat, slightly folded, and the middle depression is quite deep (Zheng, Sun, and Chen 2007). Therefore, rice spikelet bases serve as an important standard to distinguish domesticated rice from wild rice. The research results of a Sino-foreign joint research team suggest that in the rice spikelet bases in the Tianluoshan site, the proportion of rice spikelet bases that belong to the domesticated rice is very low: in the early samples (approximately 6900 BP), it accounts for only 27.4%, and in the late samples (about 6600 BP), it accounts for 38.8% (Fuller et al. 2009). Therefore, not only was the formation of rice farming a slow evolutionary process, but also the domestication of cultivated rice was a very long evolutionary process.

Figure 14: The ring mound of the spikelet base of wild rice.

It has been mentioned repeatedly that the shift from hunting and gathering to rice agriculture is a long evolutionary process rather than a black-or-white revolution. Based on the analysis of the results of the flotation at the Tianluoshan site, in the Hemudu culture period, the lower reaches of the Yangtze River were still in the transition stage from hunting and gathering to rice agriculture.

5 The stage of completion of the origin of rice agriculture (around 5000 years ago)

When did rice agriculture finally replace hunting and gathering and become the main body of social economy in the middle and lower reaches of the Yangtze River? Based on the archaeological discoveries, it appears that a rice-based agricultural society emerged in the Liangzhu 良渚 culture of the lower reaches of Yangtze River (Zhao 2010); in other words, around 5000 years ago, rice agriculture finally replaced hunting and gathering to become the social economic subject of the lower reaches of Yangtze River.

Liangzhu culture was located in the Taihu basin, and according to the radiocarbon dates, took place between 5200–4300 years ago. In recent years, the Zhejiang Provincial Institute of Cultural Relics and Archaeology has found the ruins of a magnificent

ancient city in the core area of Liangzhu culture, namely, the Yuhang region of Zhejiang Province (Zhejiang Provincial Institute of Cultural Relics and Archaeology 2008; Liu and Wang 2014). The ancient Liangzhu city is threefold in form. The outer city is surrounded by a rampart which is roughly square in shape, covering an area of 8 square kilometers. Inside the outer city is the inner city surrounded by a mud-piled wall with a pebble foundation. The wall is also square in shape and about 6.8 kilometers long. Inside the inner city, there is a neat rectangular platform, believed to be part of the noble residence, with an area of about 300,000 square meters and a height of 12 meters. In addition, in the north of the ancient city, there is a large water conservancy project built in the Liangzhu culture period which is a series of dams stretching for more than 10 kilometers, built in mud and wrapped in grass (Liu et al. 2017). Building such a huge construction project requires a lot of labor as well as the support of complex social organizations and management agencies. The Liangzhu culture remains found in previous archaeological excavations demonstrate its social division of labor and hierarchical polarization, such as graves with exquisite funerary jade objects—for example, the *yuyue* 玉钺 (jade axe) representing the military authority, the *yucong* 玉琮 (jade *cong*) reflecting religious authority, and so on. It is apparent that the Liangzhu culture possessed most prerequisites of an ancient state, marking the formation of the ancient civilization.

According to incomplete statistics, it took around 12 million cubic meters of soil to construct the Liangzhu ancient city and the water conservancy project. If 10,000 people worked for 200 days a year, it would have taken six years to finish the whole construction. If an ancient society can transfer such an amount of workforce to construction labor that has nothing to do with production of basic means of subsistence, it means that this society has a relatively well-established agricultural production system and a high level of agricultural production. Once a human society has developed into an agricultural society and its agricultural production has reached a certain level, devoting only a part of the labor force to farming suffices to meet the basic needs of subsistence for the whole society. What's more, there is a surge in the number of archaeological sites belonging to the Liangzhu culture in the lower reaches of the Yangtze River. For example, in the area around Taihu Lake, especially around the Hangzhou bay, the Liangzhu cultural sites are unusually densely distributed (Wang 2008). The sudden significant increase in regional population is also believed to be closely related with the rapid development of rice agriculture, because only with the support of fairly developed rice agriculture could the survival of a large population in relatively small areas be ensured.

New findings of archaeobotany have confirmed the rapid development of rice agriculture in the Liangzhu culture period. For example, the Maoshan 茅山 site, an ancient rice field found in the north of the ancient city of Liangzhu, reached a certain

size with well-planned ridges and channels (Zheng, Chen, and Ding 2014). Moreover, a pit filled with abundant charred rice grains has been recovered near the rectangular platform which is believed to be part of the noble residence. It is speculated to have been a grain cellar that was abandoned after catching fire. Through scientific conversion and measurement, we learned that the charred rice excavated from this pit weighed around 11.5 tons in total before it was burnt (Ye and Yan 2014).

From the above, we may safely come to the conclusion that in the Liangzhu culture period, the lower reaches of Yangtze River completed the transition from hunting and gathering to rice farming and had become agricultural societies.

6 Conclusion

The origin of rice agriculture is a long and gradual process rather than an overnight change. The new archaeological data obtained by flotation in recent years have demonstrated that the origination of rice agriculture took thousands of years. How to divide this long process has become a new topic in archaeological research. Flotation techniques based on systematic sample collection and efficient extraction methods can be used to acquire a large number of charred plant remains during archaeological excavations. Archaeobotanical laboratory work based on the identification of plant taxa and quantitative analysis can restore the characteristics of subsistence of different periods. The process of rice agriculture's origination can then be put in order and specific stages of this process can be divided.

About 10,000 years ago, ancient humans living in the middle and lower reaches of the Yangtze River began to cultivate wild rice in order to obtain more food. With the interference and influence of human behaviors, a new species, domesticated rice, progressively evolved from the natural wild rice population. At the same time, the production activities on which human society depended for its livelihood began to gradually shift from hunting and gathering to rice farming. The origin of rice agriculture was a very slow process that went on for thousands of years. In this lengthy process, the status of hunting and gathering in the subsistence of human beings fell while that of rice agriculture rose. About 5000 years ago, rice agriculture finally replaced hunting and gathering to become the most important economic activity in the middle and lower reaches of the Yangtze River. From then on, the human history of the region was characterized by agricultural society.

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