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Agricultural Practice on the Korean Peninsula Taking into Account the Origin of Rice Agriculture in Asia

Based on Carl Sauer's hypothesis that agricultural activity may have first occurred around 6500 BP with the domestication of tropical plants, rice was long thought to have originated in Southeast Asia, where the climate is very warm and humid with plenty of rainfall. While the study of rice cultivation in Asia has been seriously undertaken because rice agriculture is associated with the origin and spread of pottery culture in the region, which is important in discussions regarding Northeast Asian population movements during the emergence of the Neolithic period, many new archaeological sites with evidence of older cultivated rice have been discovered throughout the 1980s and 1990s in China. Agricultural scientists now generally consider the middle-lower Yangtze River and Yunnan regions in China, which are actually farther north than Southeast Asia, as the cradle of the earliest rice cultivation. The dates and geographic location of rice cultivation were challenged even further after some carbonized rice hulls were excavated from the village of Sorori, in central South Korea. In this paper, some theoretical arguments related to the transition period from foraging to farming systems in Korean archaeology are introduced, and some arguments regarding the origin of rice, which is currently the most important crop for Northeast Asian peoples, are discussed. Based on a brief survey of research results, ecological conditions of Northeast Asia, the biological uniqueness of rice, and archaeological evidence for rice cultivation from the Sorori site in Korea, it is suggested that temporal and spatial frames for the early history of rice cultivation need to be expanded.

Keywords: *Rice, Sorori, cultivation, farming.*

From foraging to farming

The shift from foraging to farming was one of the most profound dietary changes in the history of modern humans (*Homo sapiens*). This transition is remarkable in light of the benefits and drawbacks that resulted, not only for human health but also for the social systems of Neolithic peoples. However, it is still not clearly understood when, where, and how agricultural production began. The impact of the transition from foraging to farming in human societies is also not clear. It is, however, reasonable to assume that people began cultivating some crops before they started full-scale farming.

While cultivation and sedentary life do not appear always to have gone hand in hand (Arnold, 1996; Kelly, 1995), mixed patterns of subsistence between foraging and farming might have occurred in the early stages of food production (Bender, 1975: 9). This type of mixed pattern might have occurred during the Neolithic period in Northeast Asia as well. In fact, in many ethnographic cases, hunter-gatherers have as many subsistence strategic options as food-producers do; for instance, they have their own systems of controlling animals and plants, as well as adapting to environmental and cultural conditions (Ibid.: 1). It is therefore highly likely that "the people who first domesticated and cultivated millets were 'affluent' hunters and gatherers who lived in permanent settlements and relied on a rich variety of wild plants and animals in addition to millets" (Smith, 1995: 136). Therefore, defining the difference between foraging and farming styles has mostly depended on differences in the scale of food collecting between these two subsistence systems (Hutterer, 1983: 173).

The introduction of pottery has always been considered intrinsically linked to the emergence of farming and sedentism, and this process has long been believed to have been initiated during the postglacial and Early Holocene period throughout much of the world. The origin of rice and rice cultivation in Asia have been subjects of intense interest because they are associated with the origin and spread of pottery culture in the region, and in turn directly connected with many arguments regarding cultural contacts among ancient peoples during the Neolithic period in Asia. In the case of the Korean peninsula, there is no strong evidence yet for Early Neolithic developments in the region. But many arguments and theories regarding Neolithic origins apply to the late Korean Neolithic period, when a new pottery style and more intensified farming and sedentism appeared.

Rice was long thought to have been first cultivated around 6500 BP in Southeast Asia, where the climate is very warm and humid with a monsoon rainfall pattern. But throughout the 1980s and 1990s, many newly excavated archaeological sites showed evidence of earlier rice cultivation (10,000–8000 BP) in China. Agricultural scientists generally suggest that the center of rice cultivation was in the middle-lower Yangtze River and Yunnan regions in China, geographical locations which are actually farther north than Southeast Asia. This has caused scholars to reevaluate the theory of Carl Sauer, who considered Southeast Asia as a cradle of the earliest agriculture. The dates and geographic location of rice cultivation have been challenged even further because carbonized rice hulls radiocarbon-dated to 17,000–13,000 BP have been excavated from two sandy peat soil layers in the village of Sorori, in central South Korea (Kim et al., 2013; Cheongwon Sorori…, 2000; Lee, Woo, 2001, 2003, 2004). However, because no association was found with any human material culture, and given its high latitude and unusually old chronology, some agricultural scientists have not been convinced of the archaeological importance of the site. This paper surveys some theoretical overviews and arguments regarding the Korean agricultural transition, along with a brief retrospective on studies of rice cultivation in Asia.

The Korean agricultural transition

Some attempts have been made by Korean archaeologists to explain the transition period from hunting and gathering to farming in Korea. According to J.-J. Lee (2001b: 21), those attempts are mainly based on theories emphasizing either migration or population pressure. As with other regions in the world, a simple process theory based on migration and diffusion, concepts popular in the culture-history school up until the early 1960s, had dominated archaeological discourse in explaining prehistoric cultural change in Korea.

While all the basic and main chronological frameworks and archaeological models of the culture-history school are still well accepted in describing prehistoric Korea, some are now under debate. Most studies from the 1960s and 1970s used migration theory to connect Korean Neolithic Chulmun and Bronze Age Mumun pottery cultures to continental areas such as China and Siberia (see (Kim J.-B., 1975; Kim J.-H., 1964; Kim W.-Y., 1967)). These studies emphasize direct population movements from other regions onto the Korean peninsula and focus on the initial moment for the emergence of farming and on the migration routes of the farmers. While this approach echoes Braidwood's natural-habitat hypothesis (Braidwood, 1960; Courses…, 1962), it does not provide detailed explanations for the transition process or reasons for the change to farming (Lee J.-J., 2001b: 19).

Another theory, population-resource imbalance, has been applied by Choe (1982, 1991), Choe and Bale (2002) and Norton (1996, 2007), who argue that changing environments and/or increased population size resulted in a population resource imbalance that eventually forced a shift to agriculture in Korea. According to Choe (1982, 1991), environmental changes creating a colder climate between 5500 and 4000 BP disrupted the equilibrium condition between the population and its resources, eventually resulting in resource depletion that brought about the first cultivating of plants. Norton (1996, 2007), however, emphasizes only resource depletion caused by sedentism from the Late Neolithic period (4000–3000 BP) rather than stressing any environmental factors. According to him, settlements created population increases and food shortages. These hypotheses again lack any direct evidence for increasing population pressure (Lee J.-J., 2001a: 28). In other words, there is no direct evidence to support the earlier models that environmental change or a population increase could be a direct cause for the transition to agriculture in Korea, although there is environmental and archaeological evidence to suggest climate and population changes (Ibid.; Lee G.-A., 2011: s324).

In contrast, J.-J. Lee (2001a, 2001b) suggests that social demand theory might best explain the appearance of the Mumun agriculturalists of the Bronze Age period on the Korean peninsula, where increasing social complexity caused resource stresses during the late Chulmun period. She combines population-resource imbalance with the social approach, emphasizing socioeconomic competition among hunter-gatherers to produce food surpluses (Lee J.-J., 2001a: 312–322). According to J.-J. Lee, environmental changes and/or population increase during the Middle Neolithic period resulted in some structural change in population movements inside the Korean peninsula, which created "a certain degree of resource stress", and causing the Korean Chulmun pottery people to gradually learn "the benefits of agriculture as a storable supplement that could support the accumulation of wealth" (Ibid.: 324–325). She states that while there is no obvious explanation for the population increase in southern Korea, she hypothesizes that the Mumun pottery people of the northern peninsula, who had advanced technological and social complexity, moved down to the southern peninsula (Ibid.: 324). Therefore, although she emphasizes two theories, social demand and population-resource imbalance, J.-J. Lee suggests that the main cause for the development and spread of the Korean agricultural transition in the southern peninsula is population migration.

According to J.-J. Lee (2001b: 22–23), there are three possible scenarios that might have occurred in Korea. The first consists of population movements with a quick spread of farming culture. The second scenario, as originally suggested by K. Nelson (1992, 1999), is early secondary diffusion and long-term cultural adaptation along with the increasingly important status of farming. And the third possibility is that there were different adaption scenarios based on different environmental situations on the Korean peninsula. J.-J. Lee also suggests the possibility of a combination of migration and cultural diffusion in certain regions, and notes that these multi-causational models should have been considered in approaches to the transition period from hunting and gathering to farming in Korea.

As seen in the examples of the studies above, many current Korean scholars do not accept the idea of the total population replacement theory that is usually associated with Braidwood's theory in the era of the culture-history school, although the concept of migration is still of central importance in explanations. In other words, Korean archaeologists have focused on investigating whether there was primary diffusion by the movement of new populations, or secondary or cultural diffusion without population movement from the outside. In general, as seen above, Korean scholars have emphasized the ideas of secondary diffusion and native evolution more than population replacement theories.

Given new archaeological data along with increasing amounts of new data for environmental changes in the Holocene, it is expected that a more detailed and reliable explanation for the spread of farming to Korea and the interaction process during the transition to farming will be proposed in Korean archaeology.

Archaeology and rice cultivation in Asia

While many topics related to the origin of an agriculture economy are still subjects of great debate in Asian archaeology, it is incontestable that today rice is widely cultivated in these tropical and temperate regions. The origin of rice culture and its spread are pertinent to various academic fields. Although the precise time and place of rice domestication will perhaps never be known, there have been many discoveries of rice at archaeological sites in Asia over the last several decades.

Many early botanists and rice specialists believed that the earliest rice cultivation occurred in regions within geographical areas that had a variety of food sources during the year (Sauer, 1952). Sauer, who popularized the main theories on the origins of agriculture, rejected Southwest Asia as a cradle of the earliest agriculture. He instead suggested Southeast Asia as the region for the earliest agriculture, while many scholars thought Southeast Asia was only a very early center of the shift from foraging to farming. This was thought to be so because Southeast Asia has regions where food availability and agricultural production were naturally favored. It is believed that the earliest rice cultivators might have settled down near the edge of the uplands on gently rolling hills and close to freshwater resources (Sauer, 1947, 1952). However, many archaeologists dismiss this hypothesis because archaeological evidence for agriculture in Southeast Asia appears later than in Southwest Asia and China.

Many rice specialists before the 1970s supposed that the original home of Asian cultivated rice was in northern India. There, rice had a wide distribution with many varieties of rice species (Tang, 2004: 18). Another area discussed by scholars as an origin for rice cultivation was the south foothills of the Himalayan Mountains (see (Chang T.-T., 1976)). This area stretches from India to the mountain ranges of mainland Southeast Asia, including southwestern China. The area also provides a diversity of cultivated species of rice. Again, archaeological evidence from the area has not supported the earliest existence of cultivated rice. Some of the earliest evidence for cultivated rice from mainland Southeast Asia, in northeastern Thailand, is found at Non Nok Tha and Ban Chiang. At the Non Nok Tha site (dating 2300–2000 BC by AMS), pottery is tempered with rice chaff. At the coastal site of Khok Phanom Di (dating 2000 BC), in southern Thailand, rice-tempered pottery was also found (Glover, Higham, 1996: 422). Some scholars speculate that the occurrence of cultivated rice varieties in the later layers of the site might have been the result of trade between local hunter-gatherers and inland farmers (Higham, 2002: 77).

Although some wild rice from the Ganga valley in India is dated between 11,000 to 10,000 BP (Wenming, 2002: 152), and rice from the Xom Trai site in Vietnam is dated between 19,000–17,000 BP (Glover, Higham, 1996: 421), chronological dates for the archaeological evidence of cultivated rice from these sites are not reliable (Crawford, 2005; Crawford, Chen, 1998). No archaeological evidence has yet been found in the region to indicate the existence of cultivated rice earlier than that found in China.

Currently, archaeological evidence shows that China has the oldest rice remains and the richest rice culture. Before the 1970s, studies of the origin of rice agriculture had suggested the Yunnan region in southern China as the possible location for the earliest rice cultivation in Asia. Although some scholars still speculate that rice was brought under cultivation in southern China or the Yunnan areas where wild and traditional species of rice existed, rice specialists reject these areas as a center for the mutation of rice, favoring instead the areas between the middle-lower Yangtze River and the upper Huai River. In fact, various archaeological data indicate that the Yangtze River areas began the rice agriculture much earlier than any other areas in China (Yasuda, 2002: 130). The dates of rice from archaeological sites around the region range between 14,000 and 6500 BP (Crawford, 2005; Crawford, Chen, 1998; Fuller, Qin, Harvey, 2008; Fuller et al., 2010; Tang, 2004; Yasuda, 2002, 2008), and the region is at the far northern edge of the range of wild rice today. This suggests that the center of rice cultivation was actually farther north than had been previously supposed. However, since the Yangtze River areas do not provide "enough evidence of wild rice, these theories were often based on circumstantial evidence. One of them was based on ancient records, the second was based on the search for wild rice among cultivated rice and the third was based on ancient climatic evidence" (Wenxu, 2002: 216).

Rice cultivation in Korea

On the Korean peninsula, the oldest cultivated millet and rice discovered are dated between 5500 and 4000 BP as dry-field crops (Ahn, 2008; Choe, 1991: 31; Crawford, Lee, 2003; Lee J.-J., 2001a; Han et al., 2002; Kim W.-Y., 1982: 515; Song, 2001). However, it is believed that these earliest plants did partially contribute to hunter-gather subsistence in the region. While there is no conclusive evidence of domesticated plants and animals during the Early Neolithic period in Korea (Lee J.-J., 2001a), it is believed that the earliest paddy-rice field, dating around 3400–3000 BP, has been excavated on the southern part of the Korean peninsula (Bale, 2001; Crawford, Lee, 2003; Lee G.-A., 2011: s326).

On the Japanese archipelago, where the existence of Jomon agriculture is still a subject of debate (see (Crawford, 2008)), there is increasing evidence that later Jomon populations may have practiced a form of slash-and-burn agriculture with some minor crop cultivation, especially root crops. There was no evidence for paddy-rice cultivation until around 3000–2500 BP (Aikens, Rhee, 1992; D'Andrea et al., 1995; Imamura, 1996), but some rice remains have been found, dating from 4000 to 5000 BP, at a site in western Japan near the southern Korean peninsula (Toyama, 2002: 269).

While it is now generally accepted that Korea was a region of secondary agricultural origins, there are several different models for explaining the diffusion routes of cultivated rice culture from China to Korea and Japan (Fig. 1). Since the northern Korean peninsula has shown evidence of earlier millet cultivation while the southern Korean peninsula shows all later rice-growing evidence, some scholars have insisted that rice culture moved from southern and central coastal

Fig. 1. Discussed rice diffusion routes.

China to Korea and Japan (see, e.g., (Kim W.-Y., 1982; Lindstrom, Uchiyama, 2012: 284)). Another similar theory has considered the Southeast Asian and southern China regions as centers for the rice culture route to Korea and Japan, and this theory is loosely accepted, even though many archaeological sites from the Yangtze River area have reported earlier rice evidence (Ahn, 2010: 92; Takamiya, 2001). However, some scholars (see, e.g., (Ahn, 2010; Choe, 1982)) insist that rice agricultural culture was introduced from the northeastern area of China to the southern Korean peninsula and later into Japan, after rice culture had been introduced into northeastern China, where millet agriculture was dominant. Currently, the southern China and Southeast Asian route theories are not supported, while the other two theories are still under debate.

While the possible earliest paddy field in China may date to 6000–5000 BP (Fuller, Qin, Harvey, 2008), rice discovered at the sites of settled village communities from the Hunan Province and Hubei Province in southern China are dated 8500–8000 BP. Another very famous Chinese Neolithic site, Hemudu, represented a well-established rice agricultural community and is dated 7000–6900 BP (Barnes, 1993; Bellwood, 2005; Crawford, 2005; Chang K.-C., 1986; Fuller, Qin, Harvey, 2008; Fuller et al., 2010; Liu, 1985). Recent arguments as to whether some of the rice from Hemudu should be considered wild or cultivated are discussed in Y. Sato (2002) and D. Fuller et al. (Fuller, Qin, Harvey, 2008). Fuller and others especially argue that there should be more systematic studies to look at wild and cultivated rice variations in China in order to establish evolutionary models that can be used for further spatial and temporal comparisons (Ibid.).

The possibility of earlier agriculture in the Korean Neolithic period has been argued in Korean archaeology for a long time, and the middle-of-the-road view was that the transition period between the Neolithic and the Bronze Age marks the advent of the first agricultural stage in prehistoric Korea. Now, it seems that the time frame will be extended at least a few thousand years earlier. Recently, studies of impressions on pottery are believed to be "an effective method for reconstructing subsistence from sites without plant residue" (Son, Nakamura, Momohara, 2010: 34). This technique, enthusiastically practiced in Japan but not much in Korea yet, found millet impressions on Neolithic pottery sherds dated between 7000 and 6000 BP (Chosun Daily News, 2011). While many sherds bearing the impressed forms of major crops have been described in the site reports, most of these go no further in assessment than a macroscopic examination for reporting purposes (Kim M.-K., 2010: 52). Although many of these sherds were collected from a surface survey, and therefore some chronological issues have been discussed, it is expected that more extended and controlled impression studies could provide us with further valuable information (Ibid.: 53).

An interesting recent update is that a Neolithic site discovered in a sand field near the eastern coastline of South Korea, only about 400 m (437 yards) away from the sea and near the demilitarized zone, has revealed the first ancient farm land with associated residential areas from the Neolithic period in Northeast Asia (Hankyoreh News, 2012). It is also reported that the site is estimated to date from the Middle Neolithic period, around 5000 BP, based on the evidence of pottery sherds, stone arrowheads and carbonized millet, and on an absolute dating of soil. As seen in the case of the theories related to the transition period of Korean agriculture, many discussions around rice diffusion routes are also intertwined with the subject of the identity of the Mumun culture in the Korean Bronze Age.

Sorori rice in Korea

In 1998, it was reported that 59 carbonized rice grains (18 of ancient rice, 41 of quasi-rice) from two peat soil layers of an archaeological site in the village of Sorori in central South Korea were dated earlier than any other rice remains previously found. The carbonized ancient rice was dated to 13,010 ± 190 to 12,520 ± 150 BP, and the quasi-rice to 17,310 ± 310 BP (Kim K.-J. et al., 2013; Lee, Woo, 2003), the oldest examples of cultivated rice that have been excavated in Asia (Lee, Woo, 2001, 2003).

The Sorori site was first found in a 1994 salvage-project survey of Paleolithic tools buried in surface soil at the planned area for the Ochang Industrial Complex. The site is located between 36 and 37 degrees north latitude and at the low hillside of Osung Mt, about 2 km (1.24 miles) from the Mihochun River, which is the upper stream of the Kumkang River (Kim J.-Y. et al., 2003). At the first excavation in 1997–1998, 11 short *japonica* type ancient rice grains and 1 slender smooth ancient rice grain with 2 kinds of quasi-rice were found. Many Paleolithic tools, such as cleavers, scrapers, notches, cores, and flakes, were also found in the upper culture layer (Cheongwon Sorori…, 2000). Questions from archaeologists and rice specialists about the ancient rice led to a second excavation in 2001. Six short ancient rice hulls and some quasi-rices were found, and these confirmed the presence of ancient rice from the site. Most of the rice grains were found in the middle peat layer (14,800–12,500 BP, 32.13–31.36 m above sea level). In the lower peat layer, 1 grain of quasi-rice was found (5 dating samples, 17,300 to 16,300 BP) (Lee, Woo, 2003: 34). The quaternary geological layers were well preserved, and there was the presence of a cultural layer, Paleolithic layers and thick peat layers. However, since there was no cultural evidence in the layers with the rice grains, the significance of the Sorori rice is still being debated among scholars.

Much research indicates that southern regions of Northeast Asia, especially near the Yangtze River area, were 3–4° C warmer and damper during the period of 15,000–7,000 BP than at present (Smith, 1995: 122; Tang, 2004: 20; Zheng, Bao Yin, Petit-Maire, 1998). A study analyzing charcoal from the archaeological sites of the central-southern Korean peninsula indicates cool climatic conditions before 51,000 BP, and warm, and dry conditions at 18,630–16,400 BP (Park, Kim, Lee, 2004). According to one pollen analysis from the Sorori site (Kim J.-Y. et al., 2003: 51–53), the center of the southern Korean peninsula was covered by deciduous forests or mixed forests with warm and wet swamp conditions around 16,680–13,010 BP. Deciduous and broad-leaved forests with warm and swamp vegetation were present up to 9500 BP (Fig. 2). The Sorori site shows that the area finally changed into a swamp environment with *Gramineae* predominant after an interval of cool conditions in the early period. The soil structure of the site was flooded by mud and formed in dry, warm climatic conditions during the Holocene. Another soil analysis from the Jangheungri site, which has comparable geological conditions, indicates a similar result (Ibid.: 54–56). Some coleopteran insect fossils have also been excavated from the Sorori site. The identified species are known to have fed on the roots of wetland plants (Lee, Woo, 2001: 99–104). Therefore, it is possible to suppose that the Sorori site was a wetland environment, and this result corresponds with those of other environmental studies from pollen analysis.

While there is no lithic evidence from the layers with evidence of rice at the Sorori site, many Paleolithic sites besides the Sorori site have been found in the central region of South Korea. The archaeological sites have reported repeated occupations, and human fossils were excavated from one of them (Lee, Woo,

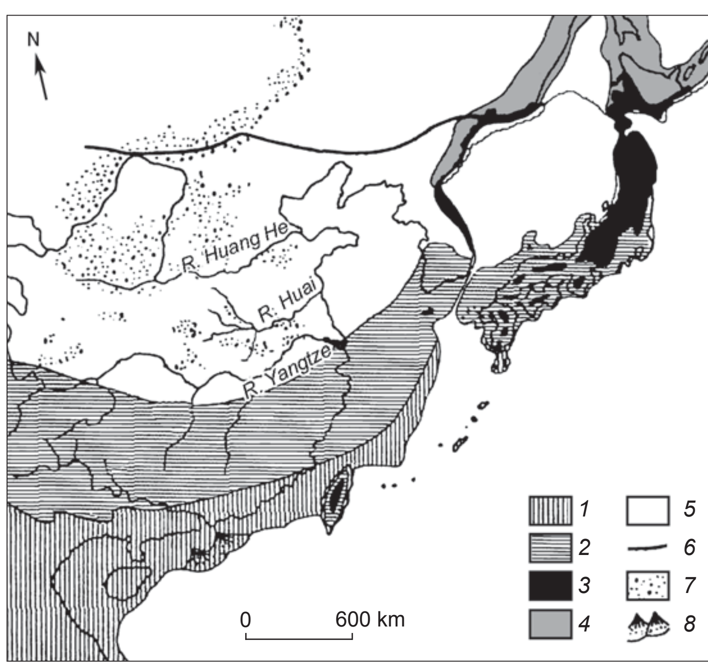

Fig. 2. Phytogeographic zones at the time of the Last Glacial Maximum, 21,000–15,000 BP in East Asia (after (Cohen, 2002: 217, fig. 1; Yasuda, 2002: 217–227)).

1 – broad-leaved evergreen forest of the subtropical temperate zone; *2* – mixed deciduous/broad-leaved forest; *3* – subarctic deciduous forest; *4* – tundra and forest-tundra; *5* – forest and steppe; *6* – edge of the permafrost area; *7* – desert and forest; *8* – alluvial fan.

2004). The lithic evidence from those sites shows that some crucial changes occurred from the Late Pleistocene to the Early Holocene, such as increasing numbers of small and extensively retouched tools around 30,000 BP, and acquisition of raw materials from long distances (Bae, 1992: 17, 1997: 2; Seong, 1998, 2008). All these changes in lithic technology can be interpreted to show that the Late Paleolithic people might have carried out a greater variety of activities than those from earlier periods (Kong, Lee, 2004: 102; Seong, 2008, 2009). Assuming that only some simple stone tools, such as "digging sticks and stone hoes" and "ground-edge slate or flaked chert knives" would have been needed for simple cultivation and harvesting activities (Glover, Higham, 1996: 433), it is possible to suppose that one of the lithic forms from the central region of South Korea, the tanged point (also called a knife-blade), could have been used to cultivate ancient rice at the Sorori site.

Cultivated or wild?

The types of cultivated rice are usually divided into two sub-species: *Oryza sativa* and *Oryza glaberrima*. *O. sativa* is more widely utilized in the world. *O. glaberrima* is popular mostly in Africa. It is believed that the "wild progenitor of *O. sativa* is the Asian common wild rice, *O. rufipogon*, which shows a range of variation from perennial to annual types. That of *O. glaberrima* is *O. barthii* (= *O. breviligulata*), which is an annual grass endemic to West Africa. The two cultigens were domesticated independently. They have discrete differences in key characters and intermediate plants are rare" (Oka, 1991: 58). While scholars still debate the genetic connections among rice species, domesticated rice in Asia (which mainly originated from *O. sativa*) is normally divided into two subspecies: *indica* (called long grain in general) and *japonica* (short grain) (Wenming, 2002: 152). The forms of divergence between these two species are still debated, and the range and habitat of wild species thought to have contributed to the cultivated forms are also investigated by rice specialists researching the distribution of cultivated species. Today, *indica* is grown in most Southeast Asian regions including southern China, while *japonica* is grown in northern China, Korea, and Japan. Thus, it is indicated that *indica* is better adapted to the zone of monsoonal rainfall (tropical and subtropical lowlands), and "is cultivated south of 33 degrees north latitude and up to 2000 meters above sea level. *Japonica* is adapted to shorter growing seasons and colder temperatures north of 33 degrees north latitude and at higher elevations in southern China. Gene flow between *indica* and *japonica* is restricted, so we know that they were established as separate domesticated varieties very early" (Smith, 1995: 127). Currently, archaeological sites with rice evidence from both Southeast Asia and Northeast Asia show the existence of *O. sativa*. Some sites with evidence of the earliest cultivated rice from southern China and the Yangtze River areas show the existence of both *indica* and *japonica* types together. The identification, however, of these types is usually complicated by a substantial overlap in grain size (Ibid.).

The scholars who excavated the Sorori site divide rice grains from the site into two groups of rice and two groups of quasi-rice. Although there are variations in size, including both short and long forms, the grains at the site are very different compared to present-day cultivars (Heu, Lee, Woo, 2003: 62). According to Heu and others, "the variation of short grain type within a limited area, like in this pit, might imply the primitive evolutionary stage… Though we could not see the variations, due to single sample of slender grain, the morphology of long grain is peculiar from those of short and also from those of long grains of present day cultivars" (Ibid.). The quasi-rices, divided into two groups, show that the quasi-rice 1 form includes both smaller and larger grains than current *japonica* cultivars. The other group, the quasi-rice 2 form, shows a size similar to the recommended cultivars of today. Most of the short grains, however, are morphologically similar to those of Ilssan ancient rice (discovered in Korea in 1991, see (Sohn, Shin, Chang, 1992), which does not look exactly like current *japonica* cultivars.

As mentioned, because the Sorori rice was not excavated with any cultural material, scholars have been arguing whether Sorori rice is cultivated or wild (Ahn, 2010). Rice specialists who generally agree that the Sorori rice is a cultivated form base their opinions on morphological features of the rice. According to Sato, "wild rice, *O. rufipogon* has a long bristle on the awn and the density of this bristle is also higher than that of the cultivated rice" (cited after (Yasuda, 2002: 130)). Wild rice also has a brittle rachis and its awn is long (Ibid.). Although the rachis of wild rice is very brittle, facilitating efficient dispersal of seeds, some wild rice would have a tough rachis due to the process of mutations (Ibid.: 141–142; Sato, 2002). It is reported that the rachis form on the Sorori rice is similar to those of current cultivars. According to the result of an experiment by Morishima (Ibid.: 130), a wild rice community changes into the cultivated form of rice after a few generations of cultivation. Prehistoric rice collectors would have unconsciously favored rice species with more stabilized and strong forms so that grains would not be easily dropped on the ground as they grew (Bender, 1975: 53). Although rice from the Sorori site has been determined through DNA analyses to have rather little genetic likeness (39.6 %) to modern wild/raised rice, "the evolutionary relationship of these quasi-rices with rice, including wild species, is not understood yet" (Heu, Lee, Woo, 2003: 62).

Rice biology

As discussed in the previous section, the regions popularly discussed by scholars for the origin of early rice cultivation are mainly considered based on environmental conditions in the areas. In other words, core areas for the earliest rice cultivation are associated with environmental conditions that required no human modification. Sauer (1952) suggested that a reliable water supply must have existed at the area of the earliest rice cultivation. Most rice specialists agree that regions with high temperature, humidity, rainfall, water availability, and a great deal of sunshine were best for the earliest cultivation of rice (Huke, 1976: 37). Current studies indicate that temperature is one of the main factors affecting the growth of the rice plant. Vergara states, "the rice plant exposed to low temperatures at seedling stage may undergo a reversible strain due to the decrease in chemical reactions and physical processes, but recovers when favorable weather comes" (1976: 72). This also indicates that rice itself might have some adaptability to the environment. In fact, rice is currently raised not only at very high latitudes, such as central Czechoslovakia at 50° north latitude and Hokkaido in Japan over 40° north latitude, but also at some high altitude areas of Nepal and India, where the growing season temperatures average much lower than those of Southeast Asia and southern China (Huke, 1976: 38). However, it is necessary to note that rice cultivation in these areas might not have been possible without human effort and ingenuity (Ibid.: 40). Nevertheless, it is in general true that rice is still cultivated in difficult environmental conditions and produces reasonable yields. As seen, rice is grown under more diverse environmental conditions than any other major food crop in the world. All things considered, it might be too early to determine that wild and/or cultivated rice originated solely in tropical or subtropical regions where sufficient water resources combined with high temperatures were available throughout most of the year.

Discussion and conclusion

Southeast Asian regions were favored by some scholars as the cradle of the earliest rice cultivation before many archaeological sites in the Yangtze River region were found to contain not only evidence of cultivated rice, but also well-developed rice-farming societies. Scholars suggesting Southeast Asia and far southern China for the origin of agriculture argue that the geographical range of wild rice did not reach as far north as the Yangtze River. They also point out that "the early rice-farming societies along the Yangtze were already highly developed and that evidence for the first stages of rice cultivation is missing" (Smith, 1995: 119–120). They assert that cultivated forms of rice were introduced from somewhere farther south than the Yangtze regions. Although there is not much evidence for the existence of wild rice in the Yangtze River regions, some types of wild rice have recently been found along the middle and lower Yangtze (Ibid.). However, arguments are still ongoing as to whether these wild types are genetically connected with any of the ancestral species of wild and, later, cultivated rice. While in many cases rice discovered at archaeological sites in Southeast Asia cannot be determined, in the absence of clear chronologies, to have been produced locally or traded, no direct archaeological evidence has been found and proven to support the earliest origin of cultivated rice in Southeast Asia.

According to Sauer's premise, the hunter-gatherers in Southeast Asia knew wild plants well before they began to use them as part of their regular dietary system. A transition from foraging to farming eventually occurred among people inhabiting a place with various types of plants. Sauer supposed that an initial cultivation process might have occurred with garden horticulture rather than field agriculture (1952). He also suggested that the initial stages of agriculture involved root crops which were reproduced as a food resource. He hypothesized that these root crops were first propagated in the wet tropics of Southeast Asia, because the root crops, such as yam, taro, and manioc, are less labor oriented and more stable, although less productive compared with seed crops, such as rice and wheat. While it is now generally agreed that hunter-gatherers in Southeast Asia practiced cultivation activities on tubers or crops before an agricultural system really started, no direct archaeological evidence supporting this hypothesis has been found (Bellwood, 1997: 203). Therefore, Sauer's hypothetical reconstructions of the origin of agriculture in Southeast Asia "were plausible but never testable" (Ibid.).

More historical ecological aspects of the region are now emphasized by some scholars (see (Bailey et al., 1989; Hutterer, 1988; Maloney, 1998)) to discuss, where, when, and why hunter-gatherers in the regions would really need to consider agricultural processes for their subsistence systems. While it has been found out that most tropical soils are relatively poor and not even suitable for agriculture (Hutterer, 1988: 72), Endicott and Bellwood argue that small nomadic foraging groups can survive with wild resources only (1991: 181). Therefore, scholars have focused on environmental conditions of the regions for pre-agricultural people. Thus, it might be true that extensive agricultural systems are not ideal in general in Southeast Asia, except in some regions, such as coastal lowlands, river bottoms, and areas with good volcanic soils, but it is still plausible that small-scale farming activities with basic cultivation processes of rice might have been developed somewhere in Southeast Asia. Sauer's premises are therefore still valuable, although the assumption of a single center for the origin of agriculture and subsequent diffusion processes have been widely criticized. Although current archaeological evidence, rice biology, and agronomical approaches clearly indicate that the beginnings of rice cultivation were not necessarily limited to only one region, further work testing Sauer's premises must be done before abandoning his hypothesis regarding Southeast Asia as the cradle of early agricultural systems.

Currently, because most of the earliest rice sites now known are from China, many scholars agree that the center for the earliest cultivation of rice lies near central and southern China. While all cultural history of Northeast Asia is based on the diffusion theory from China to other regions in Asia, some old arguments for the southern, central, or northern China route for spreading of rice cultivation from China to Korea and Japan are still subjects of debate (Choe, 1982; Chon, 1992; Kim W.-Y., 1982; Nelson, 1982a, b; Takamiya, 2001).

There may not be enough archaeological evidence to evaluate the importance of the Sorori site until more reliable archaeological data have been recovered from the southern Korean peninsula. At the same time, if scholars all agreed that the Sorori rice is a cultivated form, some of our knowledge of rice biology and hypotheses based on it would need to be revised. For instance, it is traditionally supposed that the proper ecological conditions for the growth of wild rice are limited to regions below 30° north latitude, and the area for the earliest development of rice cultivation should be within a region where wild rice forms are known to currently grow. Since we do not have any strong reason to believe that there is only one center of primary agricultural and domestication processes, the origination of agriculture might have occurred independently in different regions of the world (Bender, 1975: 15). It is also possible that mixed farming systems could be coeval. Bender also argued that we need to be careful with our own archaeological bias. According to her, archaeologists who work in regions such as Southwest Asia and Mesoamerica where archaeological finds are usually better preserved, but where there is a lack of indigenous root-crops, tend to favor seed-crops as the origin of agriculture, though seed crops are generally more difficult to cultivate (Ibid.).

By the same token, it might not be necessary for archaeologists or rice specialists to find archaeological sites or regions indicating all genetic variations of rice from the earliest progenitor to current rice forms consumed together in the region. Human beings have various ways of adjusting to all kinds of environmental conditions. Many different factors in ecological and social environmental conditions have been reported to produce change in human behavior as seen in the archaeological record. While all kinds of human societies' possible responses to environmental conditions have been considered as major processes in their cultural history, settlement movements, aside from adaptation and manipulation processes, might have been involved and played major roles in the history of agricultural processes, regardless of the scale of the population in question, or the distance traveled by that population. Rice specialists have to keep in mind that no progenitor form of the Sorori rice has been found. It is also very important to consider that the climatic conditions of the southern Korean peninsula during the last glacial period were similar to those of southern China, which is 5–10° lower latitude than southern Korea (Cohen, 2002: 223). More effort on reconstructing the environmental conditions of the regions, especially the paleoclimatic conditions of the Late Pleistocene, is necessary. There is a need to increase our understanding of the overall regional human ecosystems, with a human ecosystem "defined as an ecological system that includes humans and has multiple (physical, biological, social, and cultural) input and output environments which link to other ecosystems" (Pavao-Zuckerman, 2000: 34).

Although the origin of cultivated rice remains an enigma, we may need to refocus our perspective. Perhaps there is not one single region of early rice cultivation that is the ancestor of all cultivated varieties today. Although as S.-M. Ahn said, "the Sorori rice could have been transported from the warmer southern region around the paleo-Yangtze channel by Paleolithic foragers or migratory birds" (2010: 90), we still need to consider the possibility that there may be multiple origins for domesticated rice. Based on the Sorori rice case, it is probable that earlier cultivated rice could be found near the Yangtze River as well as in regions farther north somewhere in Asia. More approaches which emphasize the historical ecological aspects of the region, and more accumulated archaeological evidence would be essential and necessary for future studies.

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