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Genealogy of Miniature Wet Rice Fields

——The Spread of Oasis Culture*——

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I The Excavation of Miniature Wet Rice Fields of Ancient Japan

The year 1979 was revolutionary for Japanese archaeology in providing a new outlook on the evolution of rice culture in Japan. In this year, one excavation report was published: archaeologists uncovered strange, miniature wet rice fields at the Hitaka site in Gunma Prefecture when they peeled off a layer of volcanic ash deposited by the eruption of Mount Haruna in the mid-sixth century. The scene was truly impressive: the excavated surface was found to be divided by small dykes into numerous regularly spaced small pans. Each pan was as small as 2 m by 2 m, and the dyke was low and narrow (Fig. 1). Excavators identified these pans as wet rice fields because of the recurring patterns of level surfaces demarcated by small dykes. The level pans provide the planting ground, and the small dykes the bank for ponding water. This identification was later confirmed by the abundant presence of rice plant opal in the surface soil. These small pans are arranged in a surprisingly regular way, and several tens or hundreds of them are clustered into a larger parcel surrounded by higher and bigger dykes which are lined with irrigation channels.

Before the excavation of the Hitaka site, people had no idea that ancient rice fields could be so small and regularly spaced, because the excavation at Toro site, which represented the Yayoi rice culture of Japan, had revealed a series of large and widely spaced rice fields. This excavation had provided the standard concept of what ancient rice fields were like. Therefore, the excavation of the mini-fields at Hitaka was truly revolutionary.

Similar miniature wet rice fields, here called mini-fields, were subsequently discovered in many other excavations at sites in the upper middle reaches of the Tone River, including Ofuro, Dodo, and Ashida Kaito. Excavations below Asama C pumice dated at the first half of the fourth century also revealed mini-fields. Footprints of ancient men were also recovered. Gunma Prefecture is now a center for the excavation of rice fields as well as upland fields, which were covered and preserved by ash-fall and pumice-fall just as the city life of Pompeii was preserved under thick ash-fall of Mt. Vesuvius.

The mini-fields are located on volcanic fans

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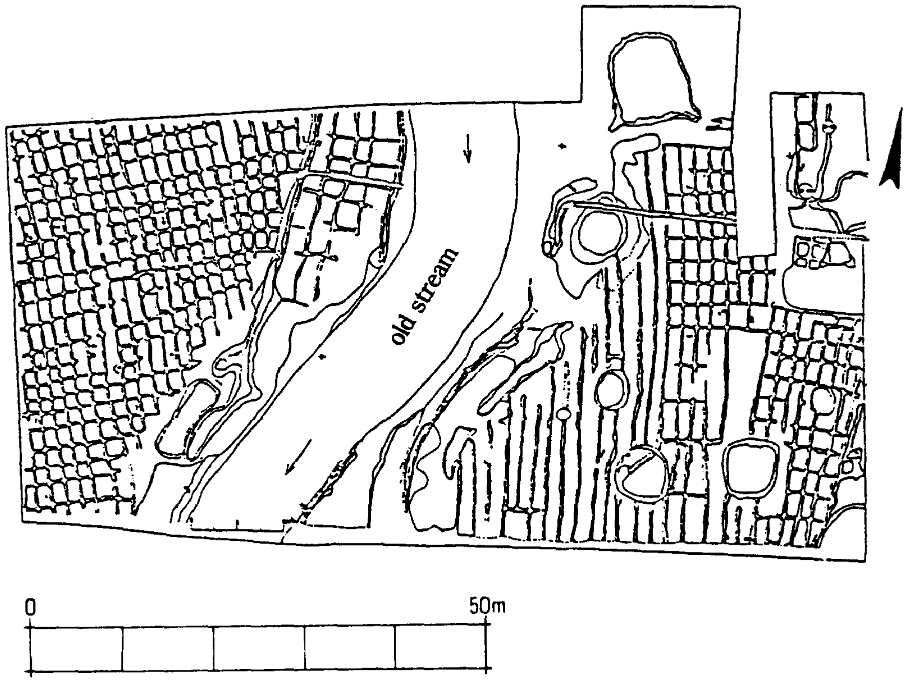

Fig. 1 Miniature Wet Rice Fields of Ancient Japan Uncovered at the Hitaka Site (6th Century A.D.) Takaya [1988]

and terraces dissected by tributaries of the Tone River. The Hitaka site, for example, is located on a very gently undulating volcanic terrace, and the Ofuro site on a gentle side-slope along a small stream flowing down the volcanic fan. This situation must have made it easy to tap water from these tributaries, and water barrages made of wooden stalks and piles were actually discovered at the Hitaka and Shinpo Tanaka sites. Thus, it is probable that these mini-fields were wet rice fields in which water was ponded by means of small dykes and irrigation channels. Excavations revealed that water was led into a large cluster of fields through an inlet cut in the larger dykes, then passed on to each of the mini-fields through notches cut in the small dykes. These notches are arranged in straight lines through the mini-fields like branches of irrigating channels stretching throughout the large cluster. Irrigated mini-fields in Gunma Prefecture definintely date back to the early Kofun period (the fourth century A.D.). The impetus of these findings led to mini-fields being discovered in other areas throughout Japan, from Kyushu to the northern end of Honshu, some of which date back to the early Yayoi period (the third century B.C.), and even to the late Jomon period (the fourth or fifth century B.C.). Major reports related to the excavation of ancient rice fields in Japan were compiled by Takaya and published in 1988 in an excellent data book which provided brief information in a set of location maps, plans of the ancient rice fields and other features [Takaya 1988].

II Propagation of Irrigated Cereal Cropping throughout Asia

The climate of Japan is rather humid, with annual precipitation exceeding 2,000 mm in Kyushu and ranging from 1,200 to 1,800 mm in most parts of Honshu. In most parts, upland rice can be cultivated with only natural precipitation. Volcanic regions, particularly in Kanto and Kyushu, are even now planted with upland dry rice to a considerable extent. The implication is that irrigation would not have been necessary for upland rice cultivation in this climate.

Irrigated mini-fields began to increase suddenly from the late Jomon to early Kofun period. Furthermore, these irrigated rice fields are associated with various agricultural implements like wooden hoes, spades and various levelling tools, polished stone knives and wooden knives for harvesting, wooden pestles and mortars, all of the highest perfection. These instruments were absent, or have not been recovered, in the preceding Jomon period.

How can we explain this sudden appearance of a highly elaborated cultural complex in Japan? Three hypotheses on the propagation of rice culture to Japan have been advanced by archaeologists and agronomists. Most archaeologists assume that rice culture was introduced from northern China via Korea into Kyushu. Many agronomists, on the other hand, tend to support the propagation from the Yangtse River basin to south Korea and Kyushu. Another hypothesis assumes the propagation from south China via the Ryukyu islands to Kyushu.

I do not intend to discuss the merits of these hypotheses here, but rather to propose the view that the propagation of rice culture from China to Japan constitues only one segment of the global propagation process of cereal cultivation throughout the Asian continent. Most Japanese archaeologists assume unquestioningly that cereal culture on the irrigated mini-fields originated in China; but is this view correct? Rice may have been domesticated in China or in India; but did the design of irrigated mini-fields originate in China, too?

Most theories on the origin of agriculture concern only the remains of domesticated plants and the evolution of wild varieties to cultivated types. This trend is understandable because plant remains are rather easy to recover from excavation sites, while it was almost impossible to excavate the fields themselves. Now, however, thanks to the skill of Japanese excavators, we can collect direct evidence on cultivated fields.

Here I wish to present the hypothesis that: the irrigated cereal culture that was initiated in the oasis towns of western Asia propagated throughout the Eurasian Continent and arrived in Japan in the prehistoric period. The mini-fields that have been excavated from the ground surface of the late Jomon and early Kofun period provide the evidence for this propagation.

Irrigated mini-fields are distributed worldwide. An example of a wet rice field in present-day Sumatra (Tapanuli basin) is shown in Fig. 2. Each plot measures less than 2 m by 2 m.

Fig. 2 Miniature Wet Rice Fields of the Tapanuli Basin, Sumatra

These are prepared by making the large dykes around the large clusters, then introducing water from the upper inlet. Individual plots are then formed between longitudinal dykes with small latitudinal dykes made of grass. These small plots are not closed but linked each other by small apertures through which water passes. The superhumid climate here allows a good harvest of rice to be obtained by dry cropping if weeding is not neglected. Why, then, is irrigation needed?

Fig. 3 shows an irrigated field in the Deccan plateau. After ploughing and land cleaning, the field is partitioned into mini-plots by small dykes, with irrigation channels running between the plots. Plots receive water successively: water flow in the channel is impeded by putting soil clods in, then led through notches cut in the channel dykes into the two plots facing each other across the channel. Once the plots are ponded, the notches are closed, the impedance is moved one plot downstream, and water is led into the next two plots. In this manner, all plots in the field are ponded. Water is not ponded continuously in this case, its purpose being to saturate the soil. Rice and *ragi* (*Eleusine coraccana*) are transplanted on the saturated soil.

Fig. 3 Miniature Irrigated Fields in Bangalore, India, Planted with Rice and *Ragi*

Fig. 4 shows similarly irrigated miniature upland fields in Jaipur near the Taal desert, India. Water is raised from a well by cattle moving to and fro, and led into mini-plots. Wheat is broadcast on the irrigated plots.

Fig. 4 Miniature Irrigated Fields in Jaipur, India, Planted with Wheat

Mini-fields become more common the drier the climate becomes. In the Nile valley, for example, such fields are intensively utilized: in addition to wheat planted are beans, vegetable, herbs, rootcrops, sugar cane, alfalfa for cattle. Since the Nile valley has desert climate, irrigation is the only determining factor of wet or dry land, green or barren cover, and life or death.

From this brief glance, it is clear that irrigation and the miniature design are absolutely necessary in a desert climate. In addition, the early occurrence of wheat cultivation in western Asia needs to be taken into consideration. Thus it appears likely that cereal cultivation in irrigated mini-fields originated in the dry steppes and deserts of western Asia.

My hypothesis mentioned above assumes the spread of a monistic concept of cereal culture: the irrigated mini-plots found in ancient Japan, present-day Sumatra, the Deccan plateau and the Nile valley did not evolve separately in different regions but are manifestations of such a monistic concept which spread through different ecological settings in a short period during prehistoric times. The fundamental, monistic concept of cereal culture originated in the oasis culture as irrigated wheat and barley cropping in the dry steppes of western Asia, and was propagated to neighboring regions, where other cereal cultigens were domesticated under the impetus of this propagation. What is needed, then, is a bird's eye view of the propagation of cereal cultivation from western Asia, its impact on millet cultivation in central Asia and northern China, and finally on wet rice cultivation in southern China, Japan and Southeast Asia.

III Oasis Culture in Western Asia

After the Pleistocene era, a humid climate spread to the Mediterranean coasts and Zagros flanks of western Asia. The ground surface was covered by annual *Graminae* grass and sporadic stands of oaks and nut-bearing trees. Various varieties of barley and wheat which were present as wild grass started to be utilized. By the tenth millennium B.C., incipient cultivation of barley and wheat, lentils, peas, and flax had started in the Levant and Zagros regions. Digging sticks with additional stone weights, stone sickles made of deeply serrated flint, various grinding stones and querns were already present in this period. Animal domestication also took place: sheep, goat, cattle in Zagros and the Taurus mountains, and goat, sheep and gazelle in Levant. Storage pits for grain were also known.

At this stage, however, cropping activities would be replaced by hunting and collection when conditions were unfavorable. People depended more on wild grains in favorably rainy years, but reverted to collecting nuts like pistachio and almond in drier years. Such a subsistence economy can not be called agriculture, but half-culture. The use of wild grains at this stage was similar to the use of acorns in the deciduous forests of early Jomon-period Japan. Half-culture of grains is supposed to have continued until the end of the seventh millennium B.C.

The seventh millennium B.C. apparently saw a revolutionary change in the half-culture of grains, and the grain cultivating sphere expanded rapidly. This rapid expansion was probably prompted by the remarkable increase of grain yield that was due, among other things, to the development of irrigation technology in the xerophytic climate. Evidence of irrigation channels has been recovered from Choga Mami site, which is located on the fan of the Ganjir river at the foot of the Zagros mountains [Oats and Oats 1976]. Water was probably tapped from the apex of the fan by a small stone weir and carried by simple channels. This irrigation system is dated around 5,500 years B.C. In the present-day Zagros mountains, a much more simple irrigation method is adopted, namely, bund irrigation; soil is piled into bunds so as to store surface runoff. Water running down rills is also utilized by putting soil and stones in the rill and leading water to cropping plots. These fields are otherwise dependent on natural rainfall *in situ*, and are usually dry. When it rains, runoff is collected and benefits small portion of the fields. The Zagros mountains have many fans and side-slopes along the rivers which are suitable for this type of simple irrigation.

In the early stages irrigation was probably started not for grain cultivation but for domestic use when habitation sites advanced onto the dry steppes. Those habitation sites were needed as stepping stones along the trade route. Obsidian, chlorite, carnelian, and natural copper came from the Zagros and the Taurus mountains, and salt, asphalt, sulphur and fish come from the xerophytic Mesopotamian plain. Traders were obliged to pass through the xerophytic plain, and gradually built trading posts. They got water for their life and cattle from fan apexes by channels. Settlements took the form of walled towns with densely packed huts inside. Garden culture was probably begun around water places by the use of water tapped from rivers. The high yield of irrigated plots must have attracted people's attention to this new type of economy. People spent more time and effort in opening the channels and exploiting new water sources, which they wanted not only for their life and domestic cattle but also for irrigating the crops. Here, a new life style, differed from collecting, hunting and trading, was originated.: it was agriculture. People found a new economy which integrated hoeing, irrigation, seeding, harvesting and milling. Each technology had already long existed, but the new economy assembled these technologies and opened a new horizon where people depended solely on cultivating crops on irrigated fields. And to avoid the danger of losing all their crops in poorly irrigated large fields, they probably partitioned the fields into mini-plots, some of which at least would survive and be harvested even in drier years. This stage of agriculture is called oasis culture.

Choga Mami is one of such settlements, and its excavation revealed various seeds such as emmer wheat, bread-wheat, two-rows barley, six-rows barley, flax, lentil, pea, and pistachio. Ploughing existed in the fifth millennium B.C.

Features of grain cultivation in oasis culture are described in clay tablets of the third dynasty of Ur, which have been translated by Kramer [1963]. The translation known as the farmer's almanac may be summarized as follow.

(1) Watch the opening of dykes, ditches, and mounds, then flood the field.
(2) After the field is emptied of water, let shod oxen trample it; after having its weeds ripped out by them, the field is made level.
(3) Plough the field with two oxen, using two types of plough. After ploughing, the field is harrowed and raked three times.
(4) Make eight furrows in 6 m strips by plough.
(5) Drop the barley seed uniformly two fingers deep. Use up one *shekel* of barley for each *garush* (6 m by 6 m).
(6) After seeding, make diagonal ploughing for covering.
(7) After sprouts have broken through, say a prayer to the goddess Ninkilim, and shoo away the flying birds.
(8) During the growth of barley, irrigation is repeated four times. The timing of irrigation is adjusted to the growth of barley.
(9) Harvesting is done with a team of three men: a reaper, a person who bundles and a person who sets up the bundles.
(10) Leave the fallen kernels on the ground for needy children and gleaners to pick.
(11) Roast some of the mown barley so that the prayer of the mown barley will be said for you.
(12) Threshing is done with oxen drawing the threshing sledge.
(13) Heap up the uncleaned barley, say the

prayer of the uncleaned barley. On the day the barley is to be cleaned, have it laid on sticks, and say a prayer evening and night. Winnow the uncleaned barley with an overpowering wind.

(14) Stock the grain in bins of 30 *gur*.

The yield of grain obtained from this oasis culture was up to 70 times the amount of seeded gain [Maekawa 1974]. Herodotus reported the average being 200 times and maximum reaching 300 times. This productivity is amazingly high compared to medieval Europe where yield rarely exceeded 10 times the seeded amount.

Actual views of oasis culture can be found in the wall paintings and reliefs on *mastaba* and mortuary gifts of the Nile valley, and also in the Mesopotamian seal. Material recovered from the third millennium B.C. shows a high degree of elaboration of cultivation implements and methods. Ploughs drawn by two oxen were common: in Mesopotamia ploughs were fitted with drill seeder and operated by three men, one controlling the double handle of the plough, one putting seeds into the seeder bowl, and the third leading two oxen. In the Nile valley seeding was mostly done by broadcasting, and followed immediately by cattle-trampling to stamp the seeds into the mud. Harvesting was done with a large sickle fitted with deeply serrated flints. Durum wheat, however, was hand-picked and threshed with slit-thresher.

Most hoes in the older cultures were wooden. The handle and sole were fastened together with rope to make a sharp angle. Bronze soles appeared in the middle of the second millennium B.C., while iron soles appeared in the latter half of the second millennium B.C.

Irrigation depended on river water. The water level fluctuation in the Nile valley was more advantageous than in Mesopotamia, since fields were inundated directly by natural flooding which subsided in autumn. People could sow seed immediately after the water subsided. In Mesopotamia, people needed to raise water and store it in channels and pools, since the floods subsided early in summer. For raising water, they used *shaduf* (sweep-well) and Persian wells worked by cattle.

Cattle-trampling was common for threshing, for preparation of soaked grounds, and also for stamping-in of seeds. Buffalo-trampling is still used for land preparation in the Malaysian Archipelagoes, Sri Lanka and Madagascar. Its genealogy is linked with the irrigated cereal cropping of western Asia, which utilizes various domestic animals.

The Fertile Crescent and the irrigated xerophytic plain of Mesopotamia established themselves as the agricultural center of the Neolithic world. Plants and stocks domesticated in the Orient are numerous: many kinds of wheat, barley, peas, broadbeans, lentils, chickpeas, onions, cucumber, lettuce, parsley, fennel, coriander, anis, carrot, radish, turnip, fruit trees like apple, pear, cherry, plum, grape, olive, pommegranite, fig, and date, and pistachio, hazelnuts, almond; and stock like goat, sheep, cattle. The Orient occupied an unrivalled position as a center of agriculture.

This position is characterized clearly by the trade commodities which the third dynasty of Ur, for example, exported to the Persian Gulf. These were mainly grains, but also included sesame oil, dates, wool, cloth, and clothings. Import commodities were beautiful timber like ebony, zebu cattle, peacocks, ivory, monkeys, carnelian, lapis lazuli, gold, silver, copper, tin, etc [Klengel 1979]. Briefly, the Orient received luxuries, bronze material, precious metals and stones, and rare products of the tropics in exchange for grains. In the Red Sea trade, the ancient Egyptians received frankincense, myrrh, cinnamon, gold, ivory and slaves in exchange for grains. The relief carved on the wall of Hatshepsut's temple on the west bank of Luxor shows an Egyptian ambassador at Punt buying incense, woods, ivory, silver, goats, and cattle, and carrying them by galley.

Orientcivilization commanded the ancient world with the wealth produced by irrigation agriculture, and it collected wealth and luxuries from other parts of the world. In this trade-oriented structure, agriculture was integrated with trade activities, and it was never a subsistence agriculture. Agricultural products played a key role as strategic commodities, and because of this situation, orientagriculture became aggressive and far-reaching.

IV Induction of Millet Culture in Central Asia and Its Propagation to Northern China

Under the influence of the aggressive and far-reaching irrigated cereal culture of western Asia, indigenous millet varieties were domesticated in central Asia, Afghanistan and Pakistan. Millets like foxtail millet have been considered to have originated in northeast China. But Sakamoto and his coworkers recently proposed the hypothesis that they were domesticated in central Asia, Afghanistan and Pakistan. Their studies indicate that the center for morphological variation and wild varieties of millet is located in central Asia; and the center for morphological variation and genetically undifferentiated varieties of foxtail millet is located in Pakistan, Afghanistan and central Asia [Sakamoto 1987].

This hypothesis is epoch-making, since it means that the millet cultivation of early neolithic northern China was not indigenous, as hitherto believed. The proposed locations for domestication are known to have had intercourse with Mesopotamia from antiquity, and constitute windows for east-west contact through the Tarim basin and the Tien Shan steppe to China.

While wheat and barley are winter crops, millet and foxtail millet are summer crops. Because of this attribute, millets must have proceeded eastward to areas of summer rain. At the foot of the Kung Lung and Tien Shan mountains, there were many oases fed by ice-melt river channels. These oases made a series of stepping stones for oasis culture as well as for the traders' caravans.

Although few archaeological excavations have been made in the Tarim basin, the Astana site in the Turfan basin produced remains from the fifth millennium B.C. of such objects as stone sickle blades, grinding stones and stone pestles, which are believed to represent an agricultural economy, which must have required irrigation under the xerophytic climate.

The spread of millet culture advanced further eastward and entered the Wei Shui (渭水) basin through the Hexi (河西) corridor, and covered the entire Hua Bei (華北) plain in a short time. This is suggested by the dense distribution of cultural sites dating back to the sixth millennium B.C. in the provinces of Gan Su (甘粛), Shan Xi (陝西), He Bei (河北), and He Nan (河南). Da

Di Wan (大地湾), Lao Guan Tai (老官台), Pei Li Gang (裴李崗), Ci Shan (磁山) are representative sites. Similar culture has been found at the Bei Shin (北辛) site in Shantung and the Xin Le (新楽) site in Liao Ning (遼寧). These cultural sites[1)] are characterized by millet culture, particularly foxtail millet, and carry similar tools, like a skate-board type quern and pestle, a stone hoe sole, and a deeply serrated stone sickle. The assemblage of potteries is also quite similar. Deep bucket-type pottery (called Shen Fu Guan, 深腹罐), sometimes with tripods, various bowls, and amphora-like vessels are the main constituents. Potstands and horned objects made of clay are also always found. It is interesting to note the similarity of the potstands to those found in western Asia and the Near East. Millet was stored in deep pits. Some of them are the same as the so-called flask-shaped pits which are found in Jomon villages in Japan.

In sum, the foxtail millet culture which appeared in northern China in the sixth millenium B.C. is suggested to have been induced by the impetus of cereal culture propagated from western Asia. And this impetus was imported not into isolated rural areas, but into the busy trading posts in Gan Su (甘粛) and Shau Xi (陜西) which acted as windows for east-west trade.

V Induction of Wet Rice Culture in Southern China

Propagation of millet culture into northern China further induced the domestication of wild rice in southern China. A large stock of rice plants and unhusked grains were found at the Ho Mu Tu (河姆渡) site, which dates back to the early fifth millennium B.C. Unhusked rice grains were also recovered at the Ruo Jia Jiau (羅家角) site, which dates back to the end of the sixth millennium B.C. It is noteworthy that most ancient rice cultures are distributed along the Yangtse River. According to Hakari, the Li Jia Cun (李家村) site, which was believed to belong to early millet culture, also revealed unhusked rice grains embedded in fired soil.

Archaeological evidence alone tends to indicate that domestication of wild rice took place in the lower to middle reaches of the Yangtse River. One question arises here: did wild rice exist along the Yangtse River in ancient times? The present distribution of wild rice in China is confined to more southern parts, like the Xi Jiang (西江) basin, Yunnan (雲南), the Kui Cu (貴州) highlands, and Taiwan (台湾). But, in a survey of Chinese literature, Ding Yin (丁穎) found historical descriptions which indicated the possibility of wild rice presence in marshlands of Jang Su (江蘇), Zhe Jang (浙江), and An Hui (安徽) [丁穎 1957]. Yen Wen Ming (厳文明) [1982b] assumes that wild rice had advanced considerably northward during the hypsithermal age, which dates back 7,000 to 4,000 years BP, and reminiscent groups of the wild rice which survived in the following cold age were recorded in the historical literature.

The Ho Mu Tu site is located geographically between hills and plains [浙江省分物管理委員会・浙江省博物館 1978]. Remains involve lots of water chestnut and lotus fruits, fish bone, *Macaca* ape, domesticated pig, and water buffalo, and imply an environment not far from marsh. The excavated house timbers indicate a

1) Excavation reports on these cultures are found in *Kaogu Xuebao* (考古学報) No. 1, 1984; No. 2, 1984; No. 3, 1981; No. 3, 1980.

structure resembling a house on piles. Rice remains were found deposited 20 cm thick on the elevated floor. Varieties included both *indica* type long grains (*hsien*, 籼) and *japonica* type round grains (*keng*, 粳). Tools recovered included a digging scoop made of bone, and wooden and stone hoes. A long stone knife found is thought to be a harvesting knife. Notable among the pottery was a rice-cooking vessel (*fu*, 釜). Rice was cooked as grains as it is now.

Rice culture at the Ho Mo Tu site seems to have been well advanced in view of the large amount of recovered rice remains. Domestication of rice must date back earlier.

VI Ecological Considerations

From an ecological point of view, millet cultivation in northern China and rice culture in southern China require entirely different management. The first requirement of the former is to resist the dry climate, while that of the latter is to annihilate weeds.

The situation in northern China is very similar to the arid hills and xerophytic plain of western Asia. The design of irrigated mini-fields was immediately propagated to the Tarim basin and northern China. In the Tarim basin the design was followed strictly because of the xerophytic climate. But once in the Hua Bei (華北) plain, where annual precipitation is around 500 mm, the design can be applied more loosely, and in favorable situations it can be replaced by natural rain-feeding, as in the Fertile Crescent. Therefore, after its introduction into the Hua Bei plain, irrigated millet cultivation was split into two types: rain-fed and irrigated. In other words, the design of irrigated mini-fields is an ecotype which can penetrate desert. Design of cereal culture can penetrate desert by metamorphosing into the xerophytic ecotype, and once it meets milder conditions, it reverts to several ecotypes.

Thus, the principle of management is to secure and preserve soil moisture, which means dry farming in case of millet cultivation in northern China. This is achieved either through irrigation or through repeated ploughing where the annual precipitation exceeds 300 mm.

Rice domestication, on the other hand, was induced as cultivation of humid millet under a more humid climate and probably in marshy conditions. This situation naturally supports the flourishing growth of weeds, like *Cyperaceae* and *Graminae*. Therefore, the principle of rice culture is to annihilate the competing grass. This was achieved by two means: by cutting down the grass, then inundating the field deeply; and by transplanting seedlings which had been prepared separately. Therefore, rice culture started as wet or ponded cultivation with transplanting from the beginning.

In brief, the design of cultivation is very different for oasis culture and dry farming on one hand and ponded cultivation on the other. In terms of water management, while irrigation exists both, its aims are very different: in oasis culture it aims to water the crop by intermittent saturation, while in ponded farming it aims to annihilate grass by continuous ponding. In terms of planting method, direct seeding is indigenous to oasis culture and dry farming, while transplanting is essential to ponded cultivation.

Once ponded rice cultivation was established, this new technology was propagated in several directions. It was carried as such to coastal wetlands in southwestern China, and to the humid forest of Southeast Asia, where ponded cultivation was transformed to shifting cultivation in which rice was seeded directly on burned ground and depended on the perhumid climate for its ripening. New plots opened in the forest have no weeds, but become covered by vigorous growth of weeds after a few years' cultivation. Then, cropping plots are abandoned and left for the forest to regenerate, under conditions which weeds are annihilated. Rice cultivation was also transferred to the dry farming zone in northern China, where rice grains were seeded directly on irrigated mini-plots. In other words, when rice cultivation spread to northern China it was accepted in the framework of oasis culture and dry farming.

VII Evolution of Agriculture in China

In northern China of the fourth millenium B.C., Yang Shau (仰韶) culture succeeded the early millet culture of Ci Shan (磁山) and Pei Li Gang (裴李崗). Yang Shau culture was similarly based on foxtail millet cultivation, but archaeological remains also included charred rice grains.

One remarkable change is that the skate-board querns and stone pestles which were so popular in the earlier millet culture in the Hua Bei plain decreased sharply in Yang Shau culture. This implies a change in cooking method from powder to whole grain. Various other implements like the stone sickle, stone knife, polished axe, weighted digging hoe and others continue to exist. Storage pits also continued and, among other things, flask-shaped pits increased. Silkworms are believed to have been domesticated in this culture. The most remarkable feature of Yang Shau culture is its polished painted pottery, which distributed throughout Eurasia along the desert and steppe belt.

In northern China of the third millennium B.C., Lung Shan (竜山) culture succeeded Yang Shau culture. It is characterized by polished black pottery. Some of this pottery, called black egg-shell ware, was clearly intended to imitate bronze ware. Newly added agricultural tools include a concave stone knife and a shell knife for harvesting, a wooden straight hoe, and a branched hoe. Flask-shaped storage pits continued. Skate-board stone querns diminished remarkably. Wheat and spelt wheat were discovered in this period from the mortuary offerings at Turfan in Xinjiang (新疆). Wheat seems to have propagated in Lung Shan culture. Thus, millet culture and its implements gradually shed the features of cereal culture in western Asia and became indigenous to China.

The rice cultivatioin in the Yangtse basin evolved in successive stages. In contrast to Ho Mu Tu, Song Zhe (崧沢) and Liang Xu (良渚) culture had implements specifically designed for weed control. These include triangular plough soles made of sharp-edged stone, and asymmetric triangular stone implements. The latter are called soil-breakers (Fig. 5). In my view, these would have been sod-cutters used for peeling off the root-mat. The use of these implements is closely related to the tide-affected environment of the lower reaches of the Yangtse River. In this situation, ponding of the rice fields is easy, as small creeks are filled with back-up fresh water at high tide. Such ponded fields do not need to be tilled: all that is needed is to peel off the root-mat of weeds. This practice is still popular in coastal wetlands of Southeast Asia. In the Bicol region of the

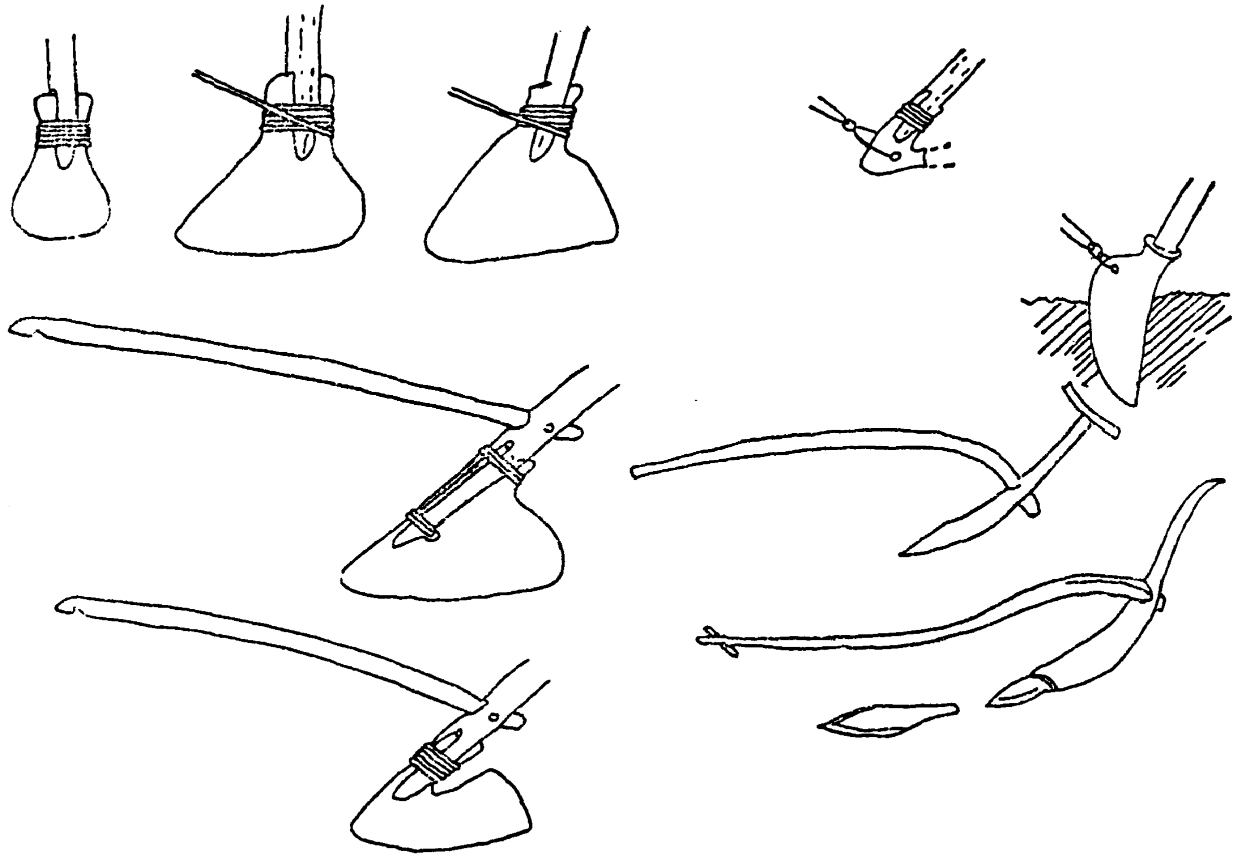

Fig. 5 Soil Breaker and Its Assumed Use (from [牟永抗・宋兆麟 1981])

Philippines, for example, an iron blade similar in shape to the sod-cutter is fixed on a plank and drawn by buffalo (Fig. 6). Root-mat on the fields is cut into 2m-wide strips, which are peeled off, piled up, and disposed of as manure. The sod-cutter may have been used like the *tajak*, which is a popular tool in the coastal wetlands today. The *tajak* is wielded like a golf club, and cuts the grass at ground surface (Fig. 7).

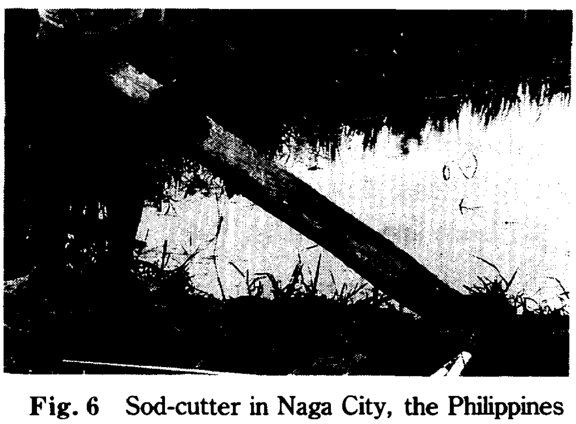

Fig. 6 Sod-cutter in Naga City, the Philippines

Fig. 7 Weed-cutting by *Tajak* in Banjarmasin, Indonesia

VIII Trends in the First Millennium B.C.

At the end of the second millennium B.C., an accident occurred that had a large impact on the agriculture of Eurasia. This was the appearance and propagation of iron implements. In western Asia, the iron sickle, iron plough sole and so on appeared in early first millennium B.C. In China, the production of cast iron started in the Chun Giu Zhanguo (春秋戦国) era and was utilized for agriculture tools. The use of iron tools presumably stimulated the excavation of irrigation channels. Zheng Guo Cu (鄭国渠) of the Quin (秦) dynasty, and Jing Cu (井渠), and Guang Cu (白渠) of the Han (漢) dynasty are examples. Although *cu* (渠) irrigation derives water from rivers, the structure of the *cu*, with a vertical shaft and an underground channel, seems to be derived from the *quanat* of western Asia.

The development of *cu* irrigation stimulated irrigated culture in the Hua Bei plain, as a result of which several texts on agriculture were published. The detailed descriptions by *Lan Sheng Zhi Shu* (氾勝之書) of the second century B.C. and *Ci Min Yao Shu* (斉民要術) of the sixth century A.D., for example, evince clear images of the ancient agriculture of China. The backbone of this culture was dry farming, in many respects similar to that of western Asia. Rice culture in the Hua Bei plain, described in *Ci Min Yao Shu* [後魏賈思勰 1976: 100–108], is definitely a transformation of ponded rice culture into dry farming. The field was irrigated and ploughed several times, then rice was broadcast on the mud. This is in clear contrast to ponded rice culture. The text on ponded rice culture does not mention tillage, but instructs in detail how to prepare irrigation tanks, channels, feeder channels, and how to pond fields in order to annihilate weeds.

Miniature upland fields are also described in these texts [*ibid.*: 42–70]. *Dai Tian Fa* (代田法) was designed by an agricultural officer in Han era. The field was arranged in furrows and ridges each one foot wide, and their locations were alternated every year. Grains were seeded in rows in the furrows. The text on the tillage mentions a team comprising two ploughs, two cattle, and three men. This design is quite similar to that described in the farmer's almanac of Mesopotamia. *Lan Sheng Zhi Shu* gives instruction in a method called *Co Tian Fa* (区田法). Unit field is 8 ft by 33 ft, which was arranged in furrows and ridges each one foot wide. For seeding, this was further subdivided into 5-inch squares. One passage in *Lan Sheng Zhi Shu* states: "It is better to make the dimensions of rice fields smaller. The larger they are the more difficult it is to control water depth." Intensive culture in regularly spaced mini-plots using cattle for plowing is not suitable for a vast, rainfed plain, but suits exactly oasis culture in a limited area.

In the Chungkiu-Zhanguo era, dry farming of the Hua Bei plain established grain culture involving foxtail millet, millet, rice, wheat and barley as major crops, and various implements like the cattle-drawn plough, several kinds of hoe, the spade, stone knife, iron knife, and the iron sickle. Fields were of various kinds: rainfed dry-farming fields, and irrigated miniature upland fields and rice fields.

The irrigated mini-fields which appeared in Japan in the Yayoi and Kofun periods are considered to have been transferred, through the Hua Bei plain, from the oasis culture which established in the seventh millennium B.C. in western Asia.

The rice culture whose remains have been excavated from the Yayoi and Kofun eras had been refined to perfection in China before it was brought to Japan. However, iron casting technology was much delayed in Japan, therefore, tools were all made of wood. Cattle-drawn ploughing was also lacking in Japan.

The propagation of rice culture to Japan, however, must be much older than the Yayoi era. Ponded cultivation, and shifting cultivation as its derivative form, are thought to have been brought to Japan in the remote Jomon period. Two reports deal with the excavation of unhusked rice grains from the middle Jomon period, one from Kumamoto, the other from Tochigi [Shimizu 1957; Kumamoto Prefectural Education Commitee 1952]. Both sites are on volcanic terraces that were suited not to ponded cultivation but to shifting cultivation.

If shifting cultivation was indeed practiced, then ponded cultivation should also have existed. But ponded cultivation of rice in natural marshes is difficult to trace. The usual excavation method depending on detecting recurring patterns of flat pans and raised dykes would not be effective, since dykes were not made in the early phases of ponded cultivation. The ponded cultivation, for example, which is practiced in coastal wetlands of Southeast Asia at present is operated as follows:

(1) At the beginning of the rainy season, grass and sedge in an area of backswamp is flattened by rolling with a 2–3 m log. Then two people, one pressing a big knife down into the sod, the other pulling the knife, cut the flattened grass and sod layer into strips. Then the grass is cut on the sod surface and peeled off by a *tajak*.

(2) Back-up water at high tide inundates the backswamp naturally. The peeled-off grass is left in the water to rot, then spread as manure.

(3) Seedlings are prepared separately on house floors or dykes. Banana leaves are spread and covered with a thin mud layer, on which germinated seeds are broadcast. The seedlings are covered with banana leaves to prevent damage by birds and rats. Two weeks later the seedlings have many white roots and are peeled from banana mat and transplanted into the prepared field for the first time. One month later the grown seedlings are removed, divided into a few tillers and transplanted again.

(4) Almost no care is taken after this final transplanting. Because of the tidal irrigation reaching to 40–50 cm in depth, weed growth is kept to a minimum.

(5) Harvesting is done ear by ear with a small handknife.

Thus, ponded cultivation of rice leaves almost no artificial remains. It has no miniaturization. Its precursor which originated in the wetlands along the Yangtse River may have been similar. There is no reason why this type of rice culture should not have been brought from the Yangtse River basin to Japan in the middle or even early Jomon era.

IX Dispersal of Rice Culture in Asia

Given the present sparse excavation density, it is difficult to draw a full picture of the propagation of rice culture in Asia. Yet, tentative proposals can be made based on avaliable excavation data and ecological assumptions extrapolated to the less or unsurveyed areas. Fig. 8 presents a tentative compilation and extrapolation of the existing data.

Rather more data are available for China, and these have been compiled by Yen Weng Ming [厳文明 1982] to show the achronological expansion of rice culture (Fig. 8). From the archaeological data alone, the primary center of rice culture in China appears to be the lower Yangtse River basin. The ponded rice cultivation that was established there spread inland in the course of time to the middle Yangtse River basin, where artificial ponded cultivation was developed. It is to be noted that rice grains excavated in the primary center included both *japonica* and *indica* types, which are called *keng* and *hsien* in China respectively. Furthermore, excavation reports reveal, although Chinese scholars have not noticed, the probable presence of *bulu*-type rice grains. *Bulu*-type rice has been given various names by Japanese scholars, including tropical insular type and B type, and it is characterized by large grains,

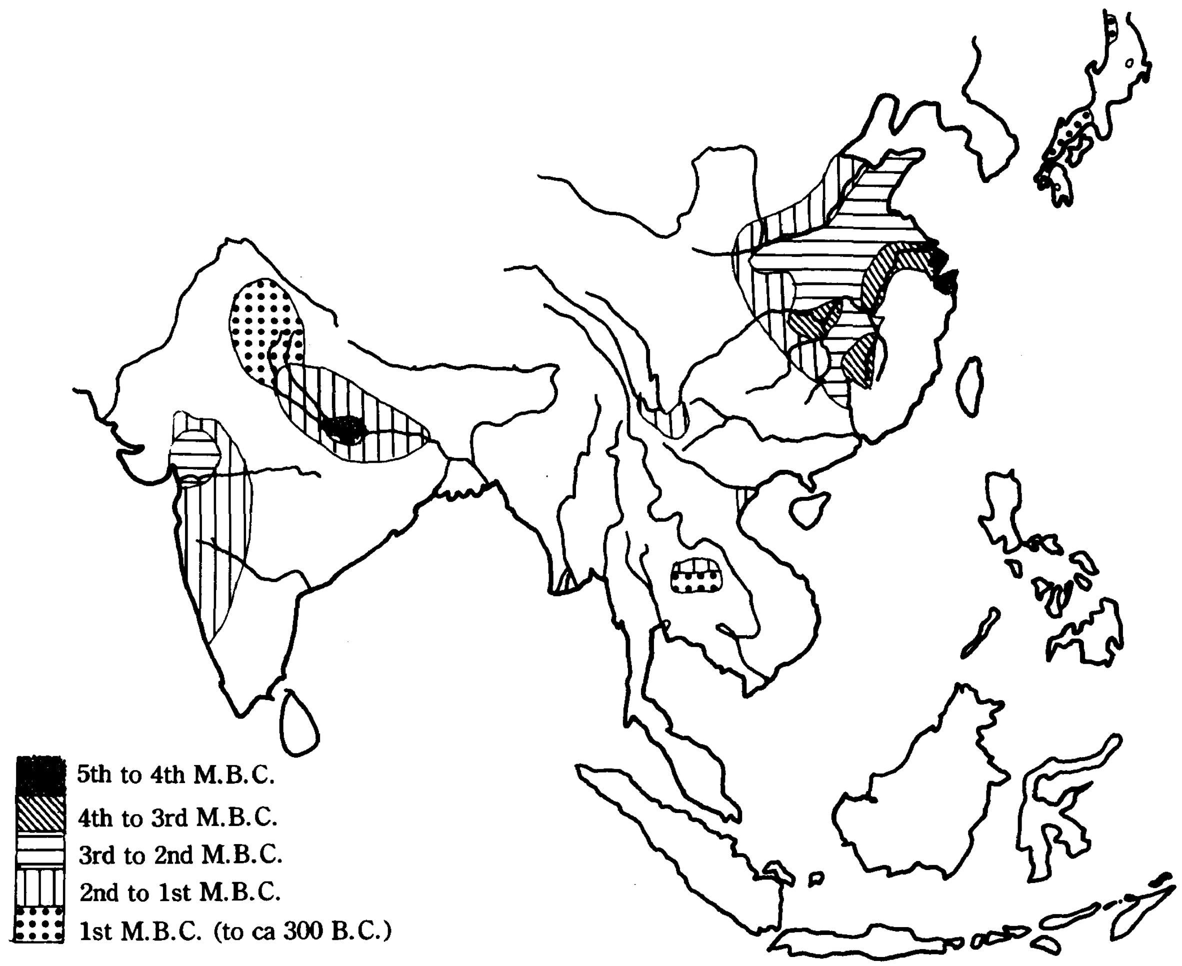

Fig. 8 Chronological Expansion of Rice Culture as Assumed from Archaeological Excavation (Based on Yen Wen Ming for China and Randhawa for India)

Table 1 Appearance of Different Types of Rice Culture in Asia

China		
Primary center		
Yangtse River basin 6th to 5th millennium B.C.	ponded cultivation	weeding by ponding, transplanting
Secondary center		
Hua Bei plain 3rd to 2nd millennium B.C.	dry farming	ploughing and irrigation, broadcasting
Yunnan highlands 2nd millennium B.C.	shifting cultivation	weeding by forest regrowth, dibbling
Northern Vietnam 2nd millennium B.C.	ponded cultivation	transplanting, varieties suited to winter rain
India		
Primary center		
Ganges-Yamuna basin 5th millennium B.C.	ponded cultivation	weeding by ponding, transplanting
Secondary center		
Malabar coast 3rd to 2nd millennium B.C.	shifting cultivation	weeding by forest regrowth, dibbling
Non-central Deccan 2nd millennium B.C.	dry farming	ploughing and irrigation, broadcasting.
Southeast Asia		
Dispersed rice culture	shifting cultivation	weeding by forest regrowth, dibbling
Core area		
Northeast Thailand		
2nd milliennium B.C.?	ponded cultivation	ponding, transplanting
1st millennum A.D.?	dry farming	rainfed, broadcasting
Central and East Jawa		
1st millennium B.C.?	ponded and shifting cultivation	transplanting, dibbling
1st millennium A.D.	dry farming	broadcasting
Japan		
Volcanic footslopes		
3rd millennium B.C.	shifting cultivation	dibbling?
Marsh		
3rd millennium B.C.?	ponded cultivation	ponding, transplanting
1st millennium B.C.	Yayoi style ponded cultivation	ponding, transplanting
1st millennium A.D.	Kofun style dry farming	irrigation, transplanting

remarkable awns, fewer tillers and more grains per panicle, non-photosensitivity and tall height.[2)]

The ponded rice cultivation established in the Yangtse River basin was transformed in order to adapt to ecologically and culturally different environments as it spread into the surrounding areas. Three secondary centers were formed: (1) the Hua Bei plain, (2) the Yunnan highlands, (3) the North Vietnamese coasts. The rice culture that proceeded towards drier Hua Bei plain was transformed into a dry farming system. Although the excavation of mini-fields in China has not yet been reported, I assume that miniature irrigated rice culture was present there, and that this was dispersed to Japan and has appeared in the excavation sites of Yayoi and Kofun periods.

The rice culture that proceeded towards the humid and mountainous Yunnan highlands was transformed into shifting cultivation. This rice culture is assumed to have evolved many features which strongly affected the rice culture in the mountain areas of Southeast Asia. These include agricultural practices and rituals like (1) the use of a small shovel mounted on a long bamboo rod for making seed holes, (2) agricultural rituals with birds as omens for choosing garden sites, for planting, for harvesting, and so on, (3) invoking the rice soul to bring good harvest by beating the bronze drum, (4) the belief that the rice soul stored in holy rice needs to be renewed and passed on to newly harvested seeds, (5) the use of human- and buffalo-trampling in the marshy rice fields in valley bottoms, (6) the building of rice granaries on poles with discs to keep out rats, (7) the belief that offerings of human heads are needed for a good harvest, (8) mortuary rituals whereby many buffaloes are offered to the deceased, (9) brewing of rice wine with addition of roasted rice, and so on.

The strong influence of this Yunnan rice culture presumably reached as far as eastern Indonesia, in view of the fact that the Dong Song drum is distributed in the Timor area, and many of the features mentioned above are found in insular Southeast Asia.

The other secondary center, i.e., the Red River delta and northern Vietnam insular sea area accepted ponded cultivation from the Yangtse River basin, taking over its technology. However, one important change is believed to have taken place in terms of cropping season due to the rainfall pattern of this area, which, unlike the summer rain type of most of continental Asia, is characterized by winter rain. Therefore, this area has traditional varieties called winter-spring rice, that is, rice which is planted in winter and harvested in spring. In other parts of continental Asia, rice is usually grown during the summer. The change in cropping season is important in relation to insular Southeast Asia, where winter rain predominates. Thus, the sea-going traders who sailed out from the secondary center of northern Vietnam and arrived on the Indonesian coast had no difficulty in adjusting planting season. They could follow the cropping calendar they had followed at home. The secondary center in northern Vietnam acted as a window for the dispersal of rice cultivation from the continent to the islands. The people who carried this rice culture are believed to have penetrated to the South China Sea coasts including the Southwest

2) In a chapter on "The Homeland of *Oryza sativa*," Oka discusses the various topics related to prehistoric rice cultivars [Oka 1988: 125–140].

China coast, the Vietnam coast, the Thai Gulf and the Malay coast, Borneo's northern coast and coasts of the Philippines. This assumption is based on the wide distribution of the Ling-Ling-O, a special type of ear-ring, throughout the trading sphere[3)] formed by these coasts.

The propagation of rice culture from primary and secondary centers in China occurred in successive waves to Japan and Southeast Asia. The major wave occurred in the first millennium B.C., when ponded cultivation and shifting cultivation dispersed. The propagation of oasis type rice culture to Japan from the Hua Bei plain took place later, and reached its peak in the third to fourth century A.D.

Excavation data from India are more scarce than those from China. Data compiled in Fig. 8[4)] are taken from Randhawa except for Koldhiwa in Allahabad. The Koldhiwa datum is still considered doubtful and is not specified as cultivated rice. The dating is also much older than that of the other sites by as much as 2000 years. I am inclined to believe, however, that the Koldhiwa datum is meaningful and should be considered in a positive light, because rice could well have been domesticated separately in the Ganges plain in a similar way to that in China. It must have been induced by millet cultivation which originated near to the Ganges plain. The extensive natural marshes at the confluence of the Ganges and Yamuna rivers provided a habitat for the domestication of marshy millet, that is, rice. Even if we dismiss this idea, it is still conceivable that rice in India was domesticated in Gujarat in the Harappan culture.

Rice culture in India presumably started as ponded cultivation, as it did in China. As it spread outward from the primary center, however, it was adjusted to the oasis culture and dry farming system. This trend is even now evident in most parts of India. People tend to irrigate rice fields intermittently, not to pond them continuously. Miniature irrigated fields are ubiquitous. People use the plough often, for land tillage, weeding, and intertillage. People often broadcast rice seeds on dry soil and do not hesitate to plough the germinated fields. They also broadcast pre-germinated rice grains on the irrigated and puddled soil. Drill-seeders are used separately after ploughing, or attached to the plough so as to put seeds under the plough-sole. All these practices indicate a strong attachment to the oasis culture and dry farming system.

The dry farming of the Indian subcontinent began to exert a strong influence on Southeast Asia in the latter half of the first millennium A.D. This means that the dispersal of Indian-type rice culture to Southeast Asia followed the dispersal from South China later by at least several hundred years. The dispersal was most remarkable in the plains of Cengla, Khumer and Pagan. It also arrived in the islands, taking root in Central and East Jawa as is depicted in the Javanese inscriptions and in the reliefs at Borobdur temple. Dry rice fields, presumably under shifting cultivation, were transformed into *sawah* (wet rice fields), and the India-type plough was imported into Jawa by the eighth century A.D. at least. Central and East Jawa occupy the driest portion of the Malay

3) An interesting discussion on the specific distribution of the Ling-Ling-O type ear-ring in the Dong Song period in the South China Sea is given by Yokokura [1987].

4) Data on China are cited from Yen Weng Ming [厳文明 1982a], and those on India are based on Randhawa [1980: 272] and *Indian Archaeology*, 1974–75, A Review, p. 76, p. 80; 1975–76, A Review, p. 88.

archipelago, and this ecological situation was favorable to migrants from the Indian savannah, who brought dry farming culture with them.

These processes contributed to the congregation of all three types of rice culture and their numerous combinations in Southeast asia. The miniature rice fields of Tapanuli in Sumatra shown in Fig. 2, for example, need to be reconsidered in this context. They are the result not of indigenous evolution from shifting cultivation to ponded cultivation, but rather of the preservation of the practice of partitioning the fields into mini-plots, which is indigenous to oasis culture. In sum, oasis culture penetrated even into the tropical rain forest.

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