

Português (Portuguese Tertiary Man). This subject, among others, was discussed in 1880 in Lisbon, during the IX International Congress of Prehistoric Anthropology and Archaeology. Before this event, Carlos Ribeiro had carried out a series of archaeological surveys and excavations, gathering an excellent collection of prehistoric artifacts for the Comissão Geológica de Portugal (Geological Commission of Portugal).

In addition to organizing this Congress, Carlos Ribeiro discovered, studied, and published several prehistoric lithic objects that he found at Ota, which he called “sílexes da Ota” (the flint from Ota). The pioneering aspects of his studies into prehistoric materials in Portugal gave him the title of “Father” of Portuguese Prehistoric Archaeology. In 1887, 5 years after his death, several researchers established the *Sociedade Carlos Ribeiro* at Oporto, an association in archaeology and the natural sciences. This association established a journal that published articles by eminent scholars, such as Paul Choffat, José Leite de Vasconcelos, and Francisco Martins Sarmento.

Cross-References

- Europe: Early Upper Paleolithic
- Geoarchaeology
- Human Evolution: Theory and Progress

Further Reading

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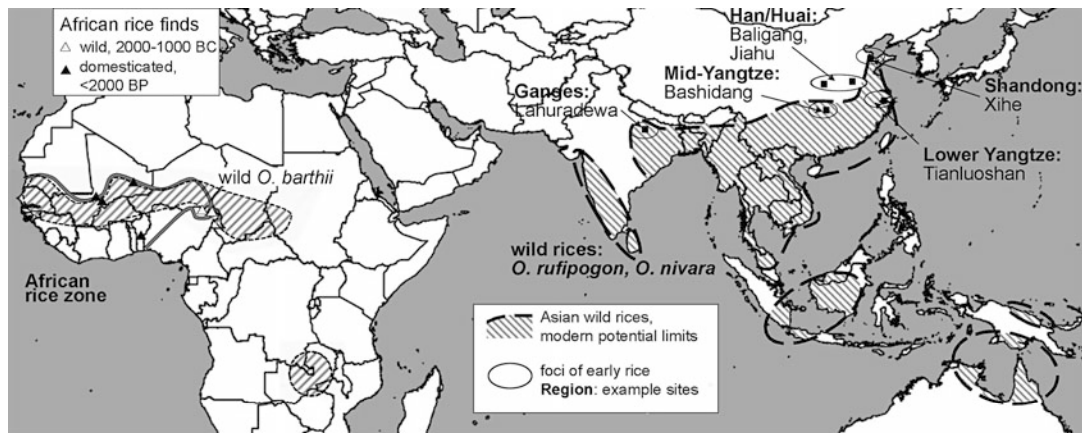
Rice: Origins and Development

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Basic Species Information

The genus *Oryza* consists of 24 species, among which two domesticated species are recognized. On the one hand, there is Asian rice, *Oryza sativa*; today one of the most widely grown and productive of world crops, which had its origins in southern and eastern Asia. On the other hand, there is African rice, *Oryza glaberrima*, which is native to and mostly restricted to western Africa (see Fig. 1). Asian rice is conventionally divided into two subspecies, subsp. *japonica* and subsp. *indica*, although more recent genetics suggests that five distinct groups should be recognized within *O. sativa* (Garris et al. 2005): *indica*, *aus*, *tropical japonica*, *temperate japonica*, and *aromatic*. Rice is closely related to bamboos but distantly related to the major cereals maize, wheat, and sorghum (Vaughan 1994). *Oryza sativa* and *O. glaberrima* and their wild progenitors are diploids ($2n = 24$) with AA genomes. Asian rice is closely related to a wild complex of annual and perennial species, often recognized as *Oryza nivara* and *O. rufipogon*, while African rice is domesticated from the annual *O. barthii*, which in turn is close to perennial *O. longistaminata* (Agnoun et al. 2012).

Rice is cultivated in a wide range of ecological habitats, from dryland to wetland fields, to terraces cut in the slopes of hills and even in deep water up to 4 m. It can grow in altitudes from sea level to 3,000 m and is cultivated as far north as 50° in China and as far south as 40° in Argentina (Vaughan 1994; Fuller et al. 2011). Under rainfed conditions, 800 mm of rainfall can be taken as a minimum with higher precipitation preferred. African rice is a traditional staple over major areas of western Africa, while Asian rice is the staple cereal of the most densely populated countries and regions. Many varieties exist,



Rice: Origins and Development, Fig. 1 Map showing the distribution of wild progenitor rices in Asia and Africa, locations of sites with important evidence of African rice, and areas discussed in relation to early rice cultivation in Asia

especially in Asian rice, to cater to different tastes. There are sticky and fragrant varieties and colors from white to red and black. The total world production of rice in tonnes is second to maize with China and India being the largest rice producers (FAOSTAT 2012). Asian *Oryza sativa* has been widely grown in western Africa for the past few hundred years, but it remains the case that native *O. glaberrima* tends to be more reliable on poor soils without the application of expensive fertilizers (Richards 1996; Agnoun et al. 2012).

Major Domestication Traits

Rice has been studied in great detail by botanists and geneticists unravelling a complicated history which is still subject to disagreement. Divergent views mainly focus on the origins of domesticated rice. The single-origins model points towards China as the center of origin, whereas the multiple-origins model indicates *O. sativa japonica* was first domesticated in China and *O. sativa indica* later in India (Fuller et al. 2010). The genetic evidence has established that the two subspecies have different mitochondrial genomes and therefore corroborates two distinct origins, with *indica* derived from an annual *O. nivara*-like ancestor and *japonica* from the perennial *O. rufipogon*. However, those who favor

a single origin argue that *indica* was derived from *japonica* rice, with some local gene flow from wild populations (e.g., Molina et al. 2011). What is clear is that hybridization, which may represent intentional breeding, has played an important role in the history of rice as has regional diversification and adaptation (Fuller 2011).

Rice caryopses are one of the most easily recognizable archaeobotanical remains (Fig. 2). Grains are long and laterally compressed. These are characterized by an oblique tip with length-wise ridges corresponding to the lemma and palea, which had contained the grain. Grain measurements are highly variable, especially in length, but domesticated forms usually have thicker and wider grains than their wild ancestors, making many domesticated types shorter and plumper in contrast to thin wild forms (Murray 2007; Fuller et al. 2010). Other important lines of archaeological evidence include husk patterns, spikelet bases, and phytoliths (Fig. 3). The husk (lemma and palea) has a distinctive and regular reticular pattern. This is often identifiable from husk impressions in ceramics in which rice was used as temper. Advances in archaeobotany have also made it possible to distinguish wild from domesticated rice by examining the spikelet base rachilla scars (Fuller et al. 2009). Unlike wild rice, domesticated rice does not naturally disperse its seeds when ripe, making the spikelet

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Fig. 2 SEM image of caryopsis of modern rice showing the ridges and profile of small embryo

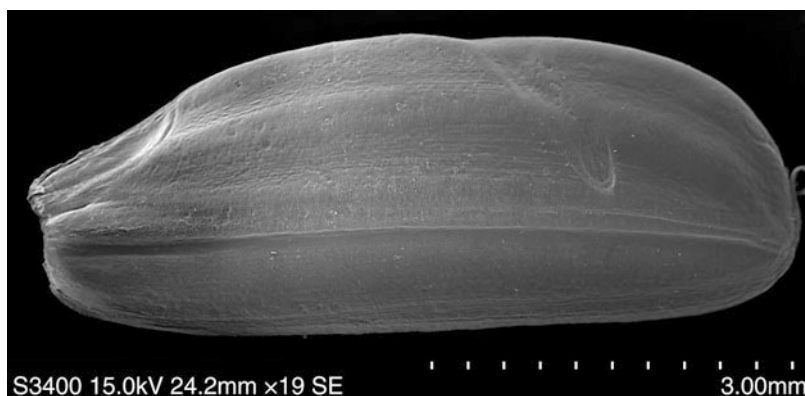
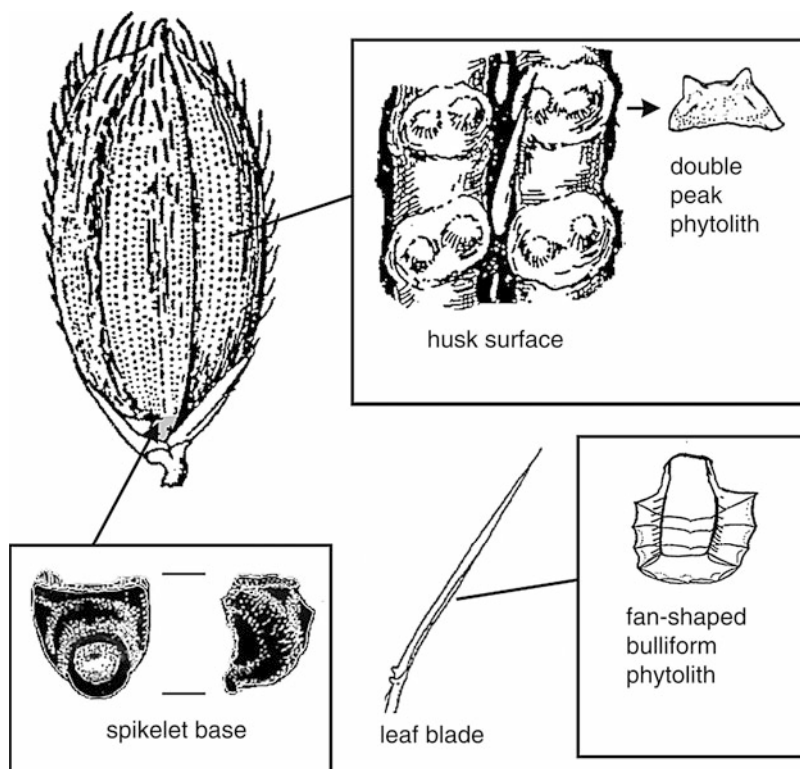
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Fig. 3 Illustrations of lines of archaeobotanical evidence for rice in addition to grains, including rice husk, spikelet bases, and two main phytolith morphotypes



base a key line of evidence in tracking the domestication process. Other important lines of archaeological evidence are bulliform phytoliths from rice leaves and double-peaked phytoliths from the husks. Both are certainly diagnostic of *Oryza* and show variation within and between species, but there remain debates about the utility of these phytoliths for tracking the domestication process or separating *indica* versus *japonica*

(Fuller et al. 2008, 2010). In Africa, there has been less archaeobotanical research on rice (Murray 2007), with little application so far of spikelet base studies or phytoliths.

Domesticated rice exhibits qualities derived from both its wild species. *O. nivara* is an annual species preferring open habitats but also growing in swampy areas, is daylength insensitive, and self-fertilizing. *O. rufipogon* is a perennial

species better adapted to wetlands, is often daylength sensitive, and cross-fertilizing. It is found across a wider geographic range than *O. nivara* including extending to northern Australia and southern China (Vaughan 1994) but previously extending in eastern China northwards towards the Shandong peninsula (Fig. 1; Fuller et al. 2010). *O. sativa* is annual and self-fertilizing like *O. nivara*, though some domesticated rice varieties also grow in deep water and are photosensitive like *O. rufipogon* (Sang & Ge 2007). As rice spread through Asia, hybridization with local wild populations is thought to have provided additional adaptive traits (Fuller 2011). Similar processes are likely in African rice (Richards 1996).

Timing and Tracking Domestication

African rice origins remain obscure. Final Stone Age sites, with ceramics, in the region west of Lake Chad in Nigeria have produced evidence for the gathering and use of wild *Oryza longistaminata* (e.g., Bigga & Kahlheber 2011) by the second millennium BCE, but with no clear sequence leading to domestication. The earliest domesticated rice finds are grain assemblages from the Iron Age at Dia in the middle Niger River valley in Mali, dating after 800 BCE (Murray 2007). Finds from a few other sites in Mali and elsewhere indicate that African rice was associated with urban sites through first millennium CE and into the Islamic period.

In Asia, five regions are discussed in relation to possible centers of rice cultivation and domestication origins. It is plausible that several of these areas were involved in parallel processes of domestication. The best documented is in the Lower Yangtze where Tianluoshan is representative of a regional sequence of evolutionary change towards domesticated rice. A pre-domestication phase showing morphological change is evident in the sites of Kuahuqiao (6000–5400 BCE), Tianluoshan, and Hemudu (5000–4500 BCE), with agricultural field systems based on domesticated rice emerging by the terminal Majiabang culture (by c. 4000 BCE)

at sites such as Caoxieshan and Chodun (Fuller et al. 2008, 2009, 2010). The middle Yangtze region provides some of the earliest evidence for rice use from phytoliths in postglacial cave sites (from c. 16000 to 15000 BCE), while cultivation was probably practiced by the time of Bashidang (7000–6000 BCE) with domestication by subsequent phases. Also important in debates is the site of Jiahu on the Huai river (7000–6000 BCE), which lacks clear evidence for rice domestication but has been linked to comparably aged evidence from Baligang some 150 km away on the Han river valley (Zhang & Hung 2013). At Baligang, significant proportions of domesticated spikelet bases occur, suggesting comparability to Tianluoshan or later sites in terms of domestication status. Rice finds from the Houli culture of Shandong are of similar age (Jin et al. 2013) but plausibly wild gathered. While the data from China is rapidly accumulating, they suggest that more than one region may have been involved in parallel development of early rice cultivation and domestication.

By contrast, in India, the search for domestication is focused on the Ganges valley. Combining archaeobotany and genetics suggests that *O. sativa* subsp. *indica* emerged through hybridization from a proto-*indica* that was managed in a morphologically wild state (Fuller et al. 2010; Fuller 2011) with introduced domesticated *japonica* rice, perhaps c. 2000 BCE. The earliest evidence of rice use in the middle Ganges at Lahuradewa has an AMS date of c. 6400 BCE but was plausibly wild gathered or under pre-domestication cultivation. Clear domesticated rice began to become widespread across northern India between 2000 and 1500 BCE. From the Ganges to the Yangtze region, Asian rice cultivation spread to become a major agricultural staple throughout much of monsoon Asia between 1000 and 0 BCE, and it also began to be adopted on a smaller scale as a crop in Mesopotamia (for a review, see Fuller et al. 2010). Asian rice reached eastern Africa during the Swahili period from c. CE 800 (Walshaw 2010), but may not have been added to western African agricultural diversity until the sixteenth century.

Cross-References

- Agrarian Landscapes: Environmental Archaeological Studies
- Agriculture: Definition and Overview
- Archaeobotany
- Domestication Syndrome in Plants
- Domestication: Definition and Overview
- Genetics of Early Plant Domestication: DNA and aDNA
- Jiahu: Agriculture and Domestication
- Phytolith Studies in Archaeology
- Plant Domestication and Cultivation in Archaeology
- Plant Processing Technologies in Archaeology

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Rivers: Environmental Archaeology

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Introduction

River environments have played a major role in our understanding of the human past. Humans and other hominids have a long record of using the resources associated with river environments. Whether it is short-term use of a specific resource or long-term settlements, riparian systems have provided valuable habitats. The relationship between humans and river environments has changed over time. Humans have always used