# *New Dates for Prehistoric Asian Rice*

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THE EARLIEST CULTIVATION of the annual cereal *Oryza sativa*, according to current archaeological evidence and radiocarbon dates, occurred in the middle and lower part of the Yangzi Valley in central China during the slightly warmer climatic conditions of the early Holocene. The site of Hemudu in Zhejiang Province has become justly famous for its prolific rice remains dating to ca. 5000 B.C. (Chang 1986:208–212; Liu 1985). The recently excavated site of Pengtoushan in northern Hunan Province has now pushed the dating for rice back to possibly 6000 B.C. by both conventional and Accelerator Mass Spectrometry (AMS) radiocarbon dating (Yan 1991).

Elsewhere, such early dates for rice have been more difficult to establish. Although rice husk–tempered and cord-marked pottery from the site of Koldihwa in Uttar Pradesh, northern India, was formerly believed to predate 4500 B.C. (Sharma et al. 1980:198), the radiocarbon dates for the site are not directly on rice remains, and dates for similar pottery from the nearby sites of Mahagara and Kunjhun fall between about 2500 and 1000 B.C. (Clark and Williams 1990; Sharma et al. 1980:198–200; and see also Glover 1985, Liversage 1991, and Vishnu-Mittre 1989 for general discussions of Indian radiocarbon dates relating to rice). The Koldihwa dates thus lack verification as being pertinent for rice cultivation and can legitimately be challenged, although the beginnings of rice cultivation in northern India generally should have been under way by at least 2500 B.C., as this paper will indicate.

To the east of India, dates and contexts for rice in northern Thailand and northern Viet Nam currently postdate 3600 B.C. (see Higham 1989:123–130; White 1990). Expansion of rice cultivation after about 3000 B.C. into the islands of Southeast Asia, southward via Taiwan and the Philippines, can be documented from both archaeological and comparative Austronesian linguistic evidence (Bellwood 1985; Blust 1984–1985; Spriggs 1989). To date, however, archaeology has provided little clear evidence concerning the date of rice expansion toward the true equatorial zone of Malaysia and Indonesia. This paper presents evidence indicating that it was under way by at least 2300 B.C.

One of the problems in understanding the chronology of the dispersal of a major

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cultivated cereal such as rice is that so many of the archaeological dates are indirect and often somewhat equivocal in terms of their exact association with plant remains. In the case of rice this is clearly true for some of the assumed dates from India (such as those from Koldihwa) and Southeast Asia. However, new techniques of AMS radiocarbon dating provide a way through these problems by allowing the direct dating of rice grains or husk fragments actually incorporated into the fabrics of potsherds.

The use of cereal husks to temper pottery has been reported from early ceramic archaeological contexts in many parts of Asia (e.g., Vandiver 1987 for West Asia; Yan 1991 for China; Yen 1982 and McGovern 1989 for northern Thailand). Where the husks or grains come from a major food plant, such as the rice specimens discussed in this paper, it might be assumed that the plant concerned was cultivated rather than gathered from the wild. This assumption is made in this paper, although it is difficult to prove it universally for rice owing to the current unavailability of sure methods of separating rice husk fragments into wild and domesticated varieties.[1] For all of the sites discussed in this paper the cultural and/or biogeographical contexts suggest that the rice was cultivated. In the case of the Balinese site it should be pointed out that the rice husk–tempered pottery was actually imported, probably from India, although here the presence of rice phytoliths in the soil indicates that the plant was also cultivated locally.

The dates for rice temper in pottery presented here do not throw further light on the date(s) and place(s) of ultimate origin of domesticated rice, but they do add significantly to knowledge of the timing of the prehistoric dispersal of the plant from its presumed Chinese homeland into India and toward equatorial Southeast Asia. All the dates but one (that for Khairadih) are directly on rice grain or husk fragments,[2] so problems of context do not arise; these dates are unequivocally for rice and, of course, for the pottery that incorporates it.

## RADIOCARBON METHODOLOGY

Fragments of each sherd were broken off and soaked in 40 percent hydrofluoric acid for several hours at room temperature to destroy clay- and silt-sized particles that frequently contain organic carbon not relevant to the time of manufacture of the pot. The residue after centrifugation was treated with dilute hydrochloric acid, distilled water, 5 percent ammonia solution to extract humic acids, and again with dilute acid and water. In all samples the final black residue was combusted at 900 °C with copper oxide and silver wire; the carbon dioxide released was collected, purified by sublimation, and sent in sealed tubes to the AMS facility at Livermore. Graphite was prepared from the carbon dioxide samples by catalytic reduction with hydrogen on to cobalt powder (Vogel et al. 1987) for measurement of carbon isotope ratios (Davis et al. 1990).

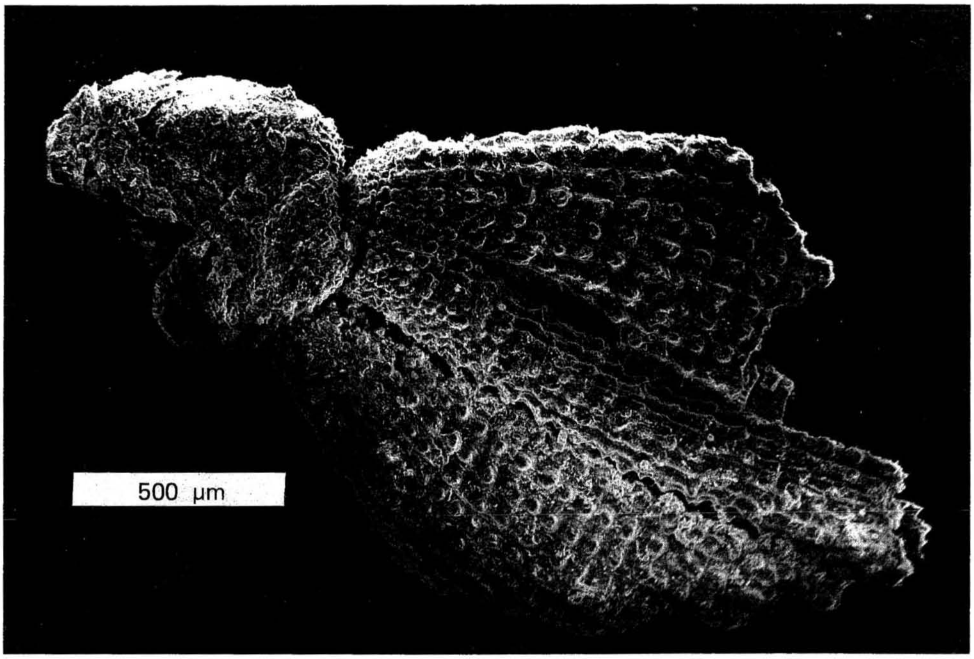
## RESULTS

Five dates are reported here (Table 1): two from northern India, two from Sarawak, and one from Bali. Samples of rice husk surfaces from two of these sites, plus the site of Khok Phanom Di in Thailand, are illustrated in Plates I and II.

TABLE 1. AMS RADIOCARBON DATES FOR ORGANIC INCLUSIONS IN POTTERY REPORTED IN THIS PAPER

| CAMS[a] NO. | MATERIAL | SITE | AGE B.P.[b] | CALIBRATED AGE[c] |
|---|---|---|---|---|
| 724 | Plant stems | Khairadih, India | 3990 ± 100 | 2853(2559,2544,2495) 2404 B.C. |
| 722 | Rice husks | CANU 42, India | 2990 ± 160 | 1430(1261)1000 B.C. |
| 723 | Rice husks | Sembiran, Bali | 2660 ± 100 | 910(818)790 B.C. |
| 725 | Rice grain | Gua Sireh, Sarawak | 3850 ± 260 | 2858(2334)1950 B.C. |
| 721 | Rice husks | Gua Sireh, Sarawak | 1480 ± 260 | A.D. 257(596)790 |

[a]Center for Accelerator Mass Spectrometry, Lawrence Livermore National Laboratory, Livermore, CA.
[b]Conventional laboratory age using Libby Half life of 5568 years.
[c]Calibrated ages (one sigma range) calculated from the University of Washington Radiocarbon Calibration Program 1987, rev. 2.0 (Stuiver and Reimer 1986).

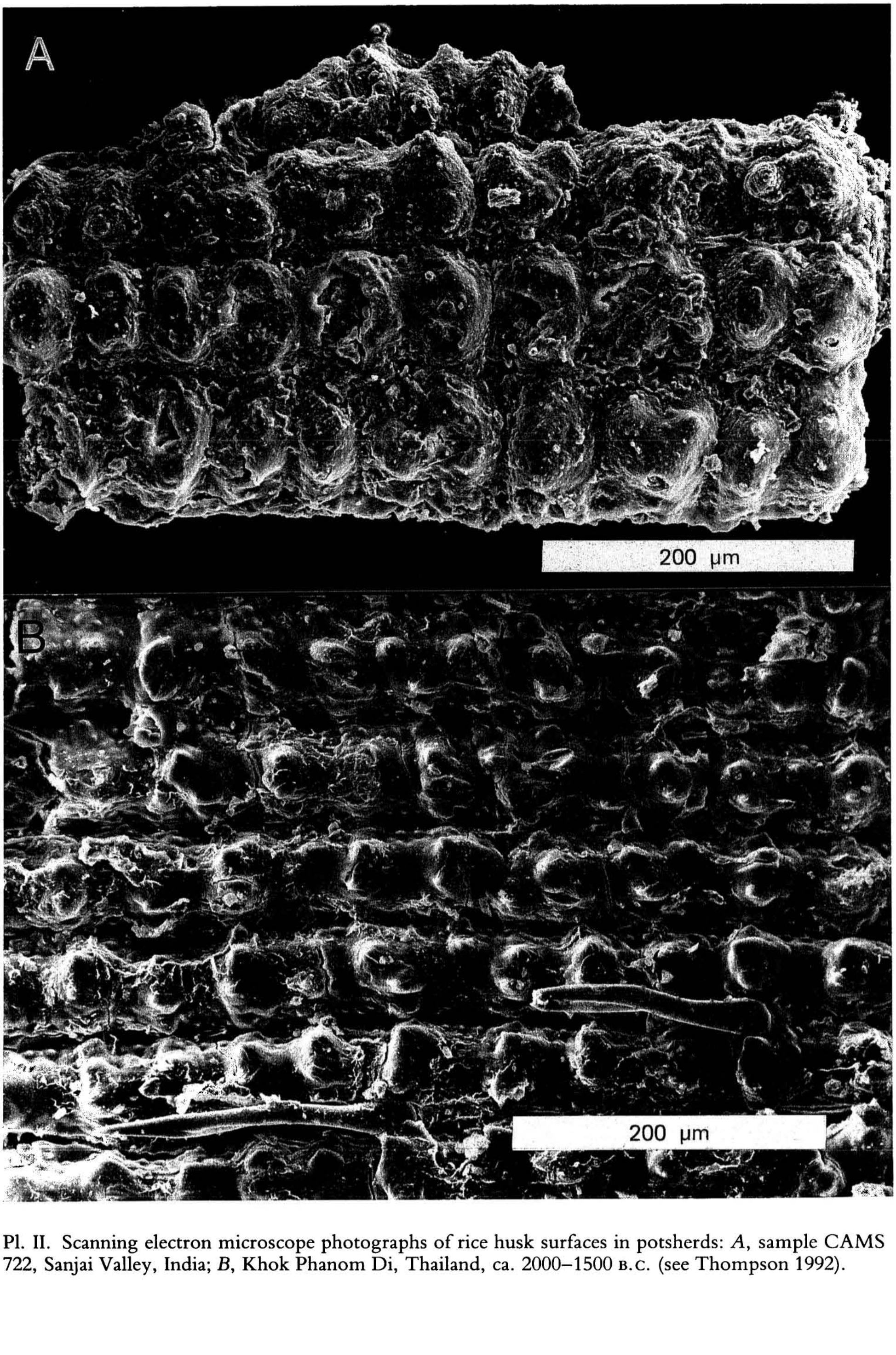



Pl. I. Scanning electron microscope photograph of rice husk surfaces in potsherd: husk and spikelet base, sample CAMS 721, Gua Sireh, Sarawak.

### *Northern India: Khairadih, Ballia District, Eastern Uttar Pradesh*

Khairadih, a neolithic/chalcolithic mound on the right bank of the Ghaghra River, was excavated by a team from Banaras Hindu University between 1980 and 1986 (Singh 1987–1988). The pottery of the first occupation in the site (Period I) includes, amongst a wide range of ceramic types, rice husk–tempered black and red ware of the common Gangetic type together with a few cord-marked sherds. A piece of organic-tempered black and red ware from the middle of the Period I deposit (Ravindra Kumar, pers. comm., 1990), given to Bellwood by Purushottam Singh of BHU in 1986, has given a date of 3990 ± 100 B.P., or a mean age of 2544 B.C. after calibration (CAMS 724). This date is on plant stems in the matrix of the sherd, in this case only possibly and not certainly from rice. However, the reported presence of definitely rice-tempered pottery in the same layer upholds the significance of the date.

Previously run conventional radiocarbon dates from Period I deposits at Khairadih (exact locations not published) have means of 2890, 2980, and 3070 uncal B.P. (Singh 1987–1988:33). The CAMS date reported here therefore pushes back the date for rice at the site by about a millennium. It also provides one of the oldest dates for rice from India, although a large number of sites in Uttar Pradesh, Bihar, and West Bengal have rice-associated conventional dates between about 3750 and 3000 uncal B.P. (Vishnu-Mittre 1989: Fig. 2). The rice-husk impressions in clay in the Harappan site of Lothal, according to the date list published in Possehl (1979:359), are probably of a similar date to those from Khairadih.




Pl. II. Scanning electron microscope photographs of rice husk surfaces in potsherds: *A*, sample CAMS 722, Sanjai Valley, India; *B*, Khok Phanom Di, Thailand, ca. 2000–1500 B.C. (see Thompson 1992).

### *Northern India: Site CANU 42, Sanjai Valley, Singhbhum District, Southern Bihar*

Site CANU 42 is one of many surface exposures in the Sanjai Valley surveyed and collected by Bellwood with a team of Indian archaeologists in 1984 (Ghosh et al. 1984*b*). Rice husk–tempered sherds (Pl. IIA) with no surface decoration were found at several sites in the valley in association with polished stone adzes. Earlier test excavations at a site in the Sanjai Valley called Barudih (Ghosh et al. 1984*a*) produced four conventional dates between 3000 and 2500 uncal B.P. for similar materials, in this case with iron artifacts. The date for CANU 42 is 2990 ± 160 B.P., or a mean date of 1261 B.C. after calibration (CAMS 722). The rice husk–tempered pottery seems to be the oldest in the Sanjai Valley according to its stone tool associations in the surface surveys, although it also appears to overlap in time with the local beginnings of iron metallurgy. It seems possible that the introduction of rice cultivation, presumably by Austroasiatic-speaking peoples, into this remote part of the southern Chota Nagpur Plateau may have occurred a millennium or more later than into the more fertile and accessible Ganga plains to the north.

### *Indonesia: Sembiran, Northeastern Bali*

The site of Sembiran, excavated by I.W. Ardika in 1987 and 1989, has produced an occupation layer at a depth of about 3 to 3.5 m with Indian Rouletted Ware and other Indian imported sherds, a sherd with a graffito in Kharoshthi script, hundreds of glass beads, and part of a stamp used for impressing a wax mold for the lost wax casting of a bronze drum (Ardika and Bellwood 1991). Local materials include large amounts of pottery and a few items of bronze and iron. The soil layers in the site contain rice phytoliths.[3] Historical dates for the Rouletted Ware and the Kharoshthi graffito can be placed with some confidence in the first two centuries A.D., with outer limits between 150 B.C. and A.D. 400. The AMS date on rice husk–tempered pottery from the same level thus came as something of a surprise, being 2660 ± 100 B.P., or a mean date of 818 B.C. after calibration (CAMS 723). The sherd is from a large and well-fired black-slipped storage vessel that comes from a geological source very close (but not identical) to that of the Rouletted Ware according to neutron activation and X-ray diffraction analyses (Ardika 1991). It is certainly not of local Balinese manufacture and could perhaps be from northern India (Bengal?).

At present there is no clear answer to the question of why this date should be about 800 years older than the historical date and there is no reason to assume any contamination of the sample. It is perhaps worth noting that AMS radiocarbon dates on rice-tempered pottery from the site of Ban Don Ta Phet in west-central Thailand give an average calibrated result in the fourth century B.C. (Glover 1990:36–37)—a date also several centuries earlier than would previously have been assumed for the Indian beads and other materials recovered there. There is a problem here of a seeming lack of fit between AMS radiocarbon dates and early historical contexts in Southeast Asia that future research will need to address.

### *Sarawak: Gua Sireh*

The cave site of Gua Sireh lies about 55 km southeast of Kuching in the Serian District of the Semarahan Division in western Sarawak. Excavations in the cave by Ipoi Datan in 1989 produced evidence for ephemeral preceramic occupation dating from the Late Pleistocene and Early Holocene, followed by levels with pottery (Ipoi and Bellwood 1991). The oldest pottery has impressed surface patterns made by the use of carved, basketry-wrapped or cord-wrapped beaters. One sherd of this type with a pattern of parallel-ribbed impression on its surface contained a whole grain of carbonized rice (but otherwise no husk material) that gave a date of 3850 ± 260 B.P., or a mean date of 2334 B.C. if calibrated (CAMS 725). This sherd was recovered from a layer bracketed by conventional dates on charcoal of 3990 ± 230 uncal B.P. (ANU 7049) and 3220 ± 190 uncal B.P. (ANU 7047) (Ipoi and Bellwood 1991:389–391). It therefore fits solidly into the site sequence and can be accepted without reservation.

So far, this is the oldest radiocarbon date for rice in the equatorial zone of Southeast Asia (Gua Sireh is located at a latitude of 1°20′N). It supports a hypothesis that rice was taken into parts of equatorial Southeast Asia by the earliest agricultural settlers, presumably speakers of Austronesian languages (Bellwood 1985; Spriggs 1989), during the mid or late third millennium B.C.

Gua Sireh has a second AMS date, on rice-husk temper (Pl. I) from a sherd higher in the site stratigraphy in the layers with metal and glass beads. This sherd has a fairly elaborate decoration of carved paddle-impressed diamonds and it belongs to a class of pottery, probably associated with Malay expansion, termed Tanjong Kubor Ware by Bellwood and Omar (1980). The date is 1480 ± 260 uncal B.P., or a mean date of A.D. 596 after calibration (CAMS 721). Tanjong Kubor Ware has previously been rather loosely dated to between ca. A.D. 700 and 1500 in other sites of the region (Bellwood and Omar 1980), so this date falls close to expectations.

Both of the dated sherds from Gua Sireh are of a fabric that appears to be local to the site, although the possibility of some localized movement of prehistoric pottery cannot be ruled out. The limestone hill that contains Gua Sireh, however, is flanked by extensive rice fields today and there seems little reason to doubt that rice could have been grown there in the remote past. It is perhaps unusual that the site is so far inland for such an early date as CAMS 725, and this probably suggests that rice cultivation in adjacent coastal regions of Borneo might have begun several centuries earlier.

## CONCLUSIONS

This is not the place to discuss every radiocarbon date pertinent to tracing the early expansion of rice cultivation in Asia. There are still far too many gaps in the record, as well as problems of context and reliability for individual dates, of the type discussed by Spriggs (1989) with respect to dates for the Island Southeast Asian Neolithic. This is to be expected when only a small number of the dates are directly on rice materials. Nevertheless, a skeletal working hypothesis for the spread of rice cultivation (Fig. 1) suggests an initial focus in the middle and lower Yangzi Valley commencing by 6000 B.C., followed by appearances in southern China, northern Thailand, and Taiwan by ca. 3000–4000 B.C. Further dispersal into northern India and central Thailand (Khok Phanom Di; Higham and Bannanurag 1990), and into the Northern Hemisphere regions of Island Southeast Asia, was well under way by 2500 B.C. However, rice clearly confronted both cultural and environmental barriers in the eastern equatorial parts of Indonesia, such that it was never taken as a cultivated plant into the Pacific Islands, with the single exception of the Mariana Islands of Micronesia.

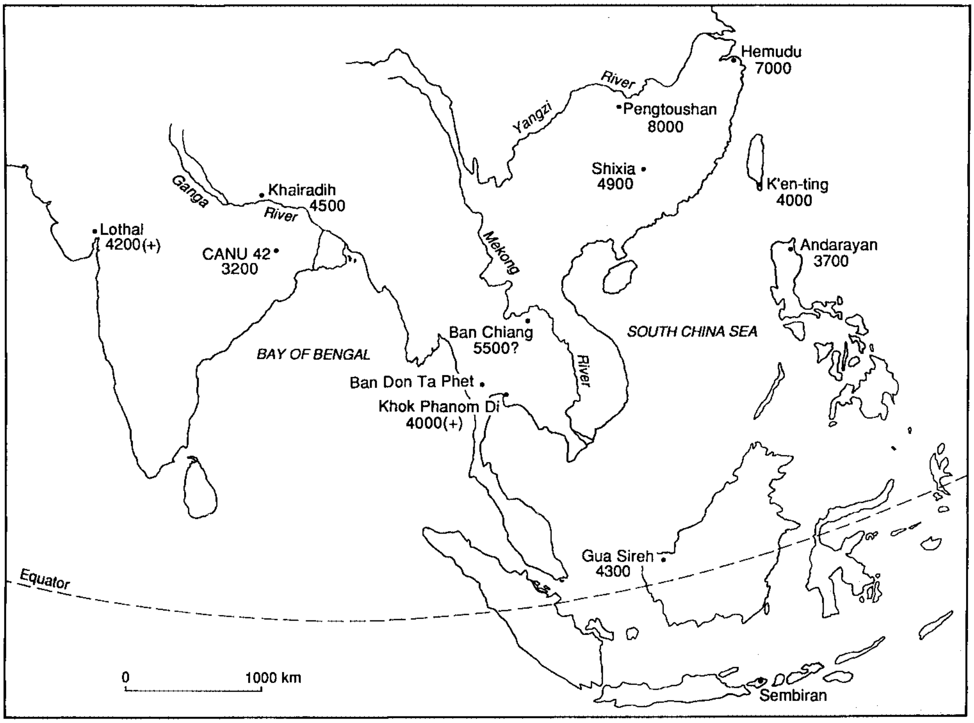



Fig. 1. Radiocarbon ages (cal B.P., approximated) for the early presence of rice, presumed cultivated, in various regions of Asia. For more detailed plots of dates see Oka (1988:130); Vishnu-Mittre (1989:2). Sites shown here but not discussed in the text are K'en-ting (Li 1983), Andarayan (Snow et al. 1986), and Shixia (An 1988).

It is hoped that future research will produce dates for early rice cultivation on the major Indonesian islands such as Java and Sulawesi. The rice date for Bali published here is obviously not helpful for this particular question because the sherd is from an imported vessel, but the presence of rice phytoliths in the site still renders rice cultivation by 2000 years ago fairly certain. Dates almost twice as old as this can be expected from these islands if the Gua Sireh sample is any guide.

## NOTES

1. A detailed discussion of the morphological features of rice husks (shapes of abscission scars and presence or absence of awns) that might be used to differentiate wild from cultivated forms has recently been prepared by one of the authors of this paper (Thompson 1992). Unfortunately, none of the relevant features have been recognized in the fragmentary temper material under discussion here.
2. In identifying the rice husks, Gill Thompson extracted fragments from broken sherds and mounted them on circular scanning electron microscope specimen holders using nail polish. Additional conductive colloidal silver or carbon was sometimes applied to the undersurfaces to prevent charging. Specimens were coated with 1000F of gold using Dynavac 12/14 C evaporative coater and examined at the Electron Microscope Unit of the Research School of Biological Studies, Australian National University, using a Cambridge Stereoscan 360 Scanning Electron Microscope with the accelerating voltage at 20 kv. The photographs were taken using Ilford FP4 film.
3. Identified by Doreen Bowdery, Department of Prehistory and Anthropology, Australian National University.

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## ABSTRACT

Accelerator Mass Spectrometry radiocarbon dates for rice husks and grains embedded in the fabric of pottery from India, Sarawak, and Bali are presented. Although it is not possible to prove that these specimens are all from cultivated and domesticated rices, their cultural and biogeographical contexts suggest that this was the case. The results can be used to support a dispersal of rice cultivation from the presumed Yangzi homeland to as far as the Ganga Valley and equatorial Malaysia by at least the mid-third millennium B.C. KEYWORDS: Rice, prehistory, India, China, Southeast Asia.