Antiquity Vol 82 Issue 316 June 2008

Immature rice and its archaeobotanical recognition: a reply to Pan

Dorian Q Fuller[1] & Ling Qin[2]

[1] *Institute of Archaeology, University College London, 31-34 Gordon Square, London WC1H 0PY, UK (Email: d.fuller@ucl.ac.uk)*

[2] *School of Archaeology and Museology, Peking University, Beijing, China*

In order to study the origins of rice agriculture, archaeologists need to clarify the expectations of how hunter-gatherers would have engaged with wild rice, what selection pressures caused by cultivation contributed to the evolution of the domestication syndrome, and how the evolution of these traits might be studied through multiple lines of archaeobotanical evidence. In her response to Fuller *et al.* 2007 (Pan 2008), Ms Pan has drawn attention to the issue of immaturity of spikelet remains from the site of Kuahuqiao, although this was not *'central'* to our argument. Rather it was one piece of evidence amongst several lines of evidence drawn from across a number of sites. We have drawn on evidence from grain morphometrics, in particular from three Lower Yangtze region sites and two sites in other regions (Fuller *et al.* 2007: Figure 6), evidence of rice leaf bulliform phytoliths from 14 sites (*ibid*.: Figure 7), awn hair densities from one site, as well as qualitative descriptions and personal observations of immature spikelets. The Kuahuqiao report provided just one example of the latter.

The use of wild, shattering rice requires that some grain loss by shattering be balanced against grain loss by immaturity. The proportion depends on when during a plant's development cycle it is harvested. As we demonstrated, efficient foraging would have necessitated the gathering of many immature spikelets with incompletely filled grains. These high levels of immature spikelets must have continued into early cultivation before non-shattering forms dominated populations and because of the asynchronous maturity of the whole population. Immature gathering of wild grains is documented amongst wild millet gatherers of Australia (Allan 1974); and techniques to minimise grain lost to shattering by bundling panicles early in formation are documented for gatherers of wild rice in India (Vaughan *et al*. 2008: 403) and American Wild Rice (Jenks 1900). The presence of a clear majority of mature wild type spikelet bases at Kuahuqaio (Zheng *et al*. 2007) indicates that the early cultivators here must have contended with the challenge of immaturity, and thus unfilled spikelets must have been present. The question is how do we recognise this and quantify it archaeologically.

The quantities indicated by Pan are correct, and those previously referred by us have transposed grains and dehusked spikelets. This was due to mistakes in the original source in which bilingual table headings in English & Chinese did not correspond, and we followed the English headings. The fact remains that immature (unfilled) spikelets were present in significant quantities, as logically must have been the case given the wild status of the majority of the spikelet bases.

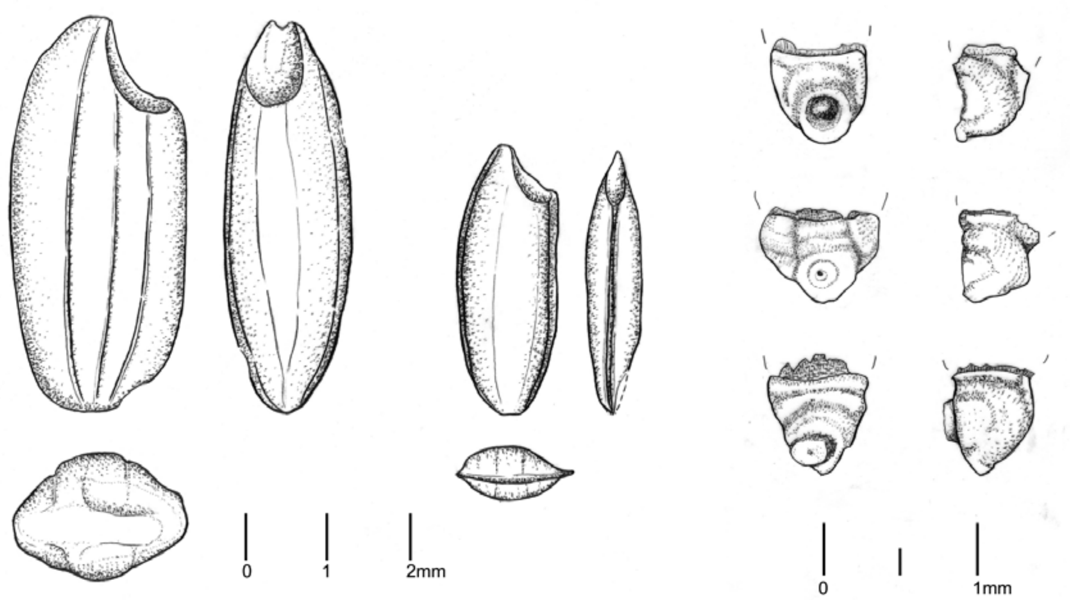

*Figure 1. Drawings of carbonised archaeological rice specimens from Neolithic Caoxieshan 2008 excavations (*c*. 4000 BC), Jiangsu, illustrating the qualitative contrasts between mature, immature, wild and domesticated archaeological specimens. At left, grains in which the smaller immature grain has sharp papery edges (drawings by QL). At right, rice spikelet bases (front and side views) of typical domesticated type (top), typical wild type (middle) and immature type with protruding scar (drawings by DF).*

Of course some unfilled, lightly-filled or sterile (and sometimes diseased) spikelets are a normal part of modern domesticated rice harvests, but we expect these in relatively lower proportions compared to those in the earlier stages of gathering or cultivation. Modern agronomic data are therefore a poor analogue. Also these immature spikelets are separated from filled (mature) spikelets during threshing and winnowing (Thompson 1996: 127), and should be a very minor contaminant only of dehusking assemblages. The fact that these are present together with the broken husks (from *dehusking*) implies that they were harvested in quantity with filled spikelets. (All spikelets, filled or unfilled, normally survive *threshing* intact). The task of the archaeobotanist should be to document the presence and proportion of such remains and to track over time how the ratio of immature to mature rice spikelets changed and how this relates to the evolution of other elements of the domestication syndrome. We suggested a number of lines of evidence that might indicate the presence of immature rice. The mixture of flattened (unfilled) spikelets together with broken husk (from dehusking waste) at Hemudu (visible in photographs) and Tian Luo Shan (studied by us) and suggested by the description of the Kuahuqiao material represents one line. Our comparative studies of modern and archaeological samples indicate that better lines of evidence come from qualitative traits of spikelet bases and grains (Figure 1). Preservation of whole spikelets is exceptional and restricted to rare sites and contexts. Criteria from spikelet bases or grain which are both normally charred and recovered by flotation are more useful. The category of spikelet bases with a protruding vascular bundle ('immature type') may sometimes be produced in domesticated rice, but it is actually extremely rare in our reference collection of 57 populations of domesticated rice (occurring in 33 per cent of populations and normally 1-5 per cent of spikelets in those populations). Our ongoing archaeobotanical studies based on systematic samples from four sites in the Lower Yangtze region and one in central China indicate that these types and wild types show a marked quantitative decline over the levels documented from Kuahuqiao or Hemudu era Tian Luo Shan.

Pan has suggested that we mistranslated the term *bi gu*, but we suggest that she is in error in applying a restricted modern agronomic interpretation of this as *only* 'sterile'. The original meaning, according to the Eastern Han dictionary 说文解字 *shuo wen jie zi* (*c.* AD 100), means 'a not well-grown millet (crop)' (秕，不成粟也). As used colloquially, and in modern Chinese dictionaries, it is used generally to refer to unfilled spikelets (including immature, sterile or sometimes diseased grains). A well-known Chinese proverb states that with three rains at the start of autumn (*Li-Qiu*) [before harvest], the *bi dao* turns into *mi* [edible rice] (立秋三场雨，秕稻变成米). In other words this category includes unfilled (not diseased/sterile) spikelets.

Ancient economics: optimal foragers or poor farmers?

A final theoretical point regards how we conceive the economies of ancient populations. We insist that remains of rice and evolution of rice must be seen in the context of whole assemblages which included many wild foods, including potential staple nuts (Fuller *et al*. 2007: Table 1). We also presume that past populations had economies that tended towards efficiency in the long run. Optimal foragers would target rice immature to ensure yields (and balance that against nut collecting); early cultivators at Kuahuqiao would be expected to do the same, but with gains in efficiency as domesticated rice increased as a proportion of the crop. Pan suggests, as have Liu *et al*., that the empty husks came from poor harvests, such as *'a poor year for rice'* (Liu *et al*. 2007: 1063). Kuahuqiao, which was occupied for perhaps 600 years (6000-5400 BC based on a sequence of 22 radiocarbon dates through 3 cultural phases), and later sites (Tian Luo Shan, Hemudu) seem to show a consistent pattern of the presence of these *bi gu* spikelets. Presumably we should not conclude that these indicate a continuous series of poor years over the centuries.

Acknowledgements

The authors thank Professor Ding Jin-long for the invitation to carry out archaeobotanical sampling and analysis at Caoxieshan, and permission to illustrate some finds from that site here.

References

ALLAN, H. 1974. The Bagundji of the Darling Basin: cereal gatherers in an uncertain environment. *World Archaeology* 5: 309-22

FULLER, D.Q, E.L. HARVEY & L. QIN. 2007. Presumed domestication? Evidence for wild rice cultivation and domestication in the fifth millennium BC of the Lower Yangtze region. *Antiquity* 81: 316-31.

JENKS, A.E. 1900. *The wild rice gatherers of the upper lakes: a study in American primitive economics* (Annual report of the Bureau of American Ethnology to the Secretary of the Smithsonian Institution; Volume 19, Part 2). Washington (DC): Government Printing Office.

LIU, L., G.-A. LEE, L. JIANG & J. ZHANG. 2007. Evidence for the early beginning (c. 9000 cal BP) of rice domestication in China: a response. *The Holocene* 17: 1059-68.

PAN, Y. 2008. Immature wild rice harvesting at Kuahuqiao, China? *Antiquity* 82. Available at http://www.antiquity.ac.uk/ProjGall/pan/index.html.

THOMPSON, G.B. 1996. *The excavations of Khok Phanom Di, a prehistoric site in central Thailand. Volume IV. Subsistence and environment: the botanical evidence* (The Biological Remains Part III). London: The Society of Antiquaries of London.

VAUGHAN, D.A., B.-R. LU & N. TOMOOKA. 2008. The evolving story of rice evolution. *Plant Science* 174: 394-408.

ZHENG, Y., G. SUN & X. CHEN. 2007. Characteristics of the short rachillae of rice from archaeological sites dating to 7000 years ago. *Chinese Science Bulletin* 52: 1654-60.