Modelling the geographical origin of rice cultivation in Asia using the Rice Archaeological Database

Fabio Silva[1]*, Chris J Stevens[1], Alison Weisskopf[1], Cristina Castillo[1], Ling Qin[2], Andrew Bevan[1] and Dorian Q Fuller[1]

[1]UCL Institute of Archaeology, London, United Kingsom
[2]Peking University, School of Archaeology and Museology, Beijing, China
*fabio.silva@ucl.ac.uk

An extensive database of archaeological evidence for rice across Asia, including 400 sites from mainland East Asia, Southeast Asia and South Asia (see [1] for an earlier version) is used to compare several models for the geographical origins of rice cultivation and infer the most likely region(s) for its origins and subsequent outward diffusion.

The approach is based on regression modelling (eg. [2]) wherein goodness of fit is obtained from a quantile regression [3] of the archaeologically inferred age versus a least-cost distance from the putative origin(s). The Fast Marching method [4] is used to estimate the least-cost distances based on simple geographical features (cf. [5] and [6]) and the efficiency of different goodness of fit indices were compared using Monte Carlo simulations.

The origin region that best fits the archaeobotanical data is also compared to other hypothetical geographical origins derived from the literature, including from genetics, archaeology and historical linguistics. The model that best fits all available archaeological evidence is a dual origin model with two centres for the cultivation and dispersal of rice focused on the Middle Yangtze and the Lower Yangtze valleys (cf. [7] and [8]).

References

[1] D. Q. Fuller, J. van Etten, K. Manning, C. Castillo, E. J. Kingwell-Banham, A. R. Weisskopf, L. Qin, Y. Sato, R. Hijmans. *The contribution of rice agriculture and livestock pastoralism to prehistoric methane levels: an archaeological assessment*. The Holocene **21**, 743–759 (2011). doi: 10.1177/0959683611398052

[2] J. Steele. *Radiocarbon dates as data: quantitative strategies for estimating colonization front speeds and event densities*. Journal of Archaeological Science **37(8)**, 2017–2030 (2010). doi: 10.1016/j.jas.2010.03.007

[3] R. Koenker. *Quantile Regression*. Cambridge, Cambridge University Press (2005).

[4] J. A. Sethian. *A fast marching level set method for monotonically advancing fronts*. Proceedings of the National Academy Sciences **93(4)**, 1591–1595 (1996).

[5] F. Silva F and J. Steele. *Modeling boundaries between converging fronts in prehistory*. Advances in Complex Systems **15(01n02)**, 1150005 (2012). doi: 10.1142/S0219525911003293

[6] F. Silva and J. Steele. *New methods for reconstructing geographical effects on dispersal rates and routes from large-scale radiocarbon databases*. Journal of Archaeological Science **52**: 609–620 (2014). doi: 10.1016/j.jas.2014.04.021

[7] D. Q. Fuller and L. Qin. *Water management and labour in the origins and dispersal of Asian rice*. World Archaeology **41(1)**, 88–111 (2009). doi: 10.1080/00438240802668321

[8] D. Q. Fuller, T. Denham, M. Arroyo-Kalin, L. Lucas, C. J. Stevens, L. Qin, R. G. Allaby and M. D. Purugganan. *Convergent evolution and parallelism in plant domestication revealed by an expanding archaeological record*. Proceedings of the National Academy of Sciences **111(17)**, 6147–6152 (2014). doi: 10.1073/pnas.1308937110