Early farming in Island Southeast Asia: an alternative hypothesis

Tim Denham*

Several recent articles in *Antiquity* (Barker *et al.* 2011a; Hung *et al.* 2011; Spriggs 2011), discuss the validity of, and revise, portrayals of an Austronesian farming-language dispersal across Island Southeast Asia (ISEA) during the mid-Holocene (approximately 4000–3000 years ago). In conventional portrayals of the Austronesian dispersal hypothesis (e.g. Bellwood 1984/85, 1997, 2002, 2005; Diamond 2001; Diamond & Bellwood 2003), and its Neolithic variant (e.g. Spriggs 2003, 2007), farmer-voyagers migrated out of Taiwan approximately 4500–4000 cal BP to colonise ISEA from 4000 cal BP (Bellwood 2002) and the Mariana Islands and Palau by *c.* 3500–3400 cal BP (Hung *et al.* 2011). The descendants of these voyagers subsequently established the Lapita Cultural Complex in the Bismarck Archipelago by *c.* 3470–3250 cal BP (Kirch 1997; Spriggs 1997) and became the foundational cultures across most of the Pacific from *c.* 3250–3100 cal BP (Kirch 2000; Addison & Matisoo-Smith 2010; dates for Lapita in Denham *et al.* 2012). A major problem with this historical metanarrative is the absence of substantial archaeological evidence for the contemporaneous spread of farming from Taiwan (Bulbeck 2008; Donohue & Denham 2010; Denham 2011).

There is widespread consensus that the colonisation of most of Remote Oceania after 3250–3100 cal BP was enabled by vegetative forms of cultivation and plants characteristic of the New Guinea region, as well as a suite of animal domesticates—chicken, dog and pig—of ultimate mainland Asian origin. There is considerable uncertainty and debate concerning how this Pacific production system developed within the maritime landscape of ISEA and Near Oceania during the mid-Holocene, especially within the putative framework of Austronesian dispersal (from *c.* 4500–4000 cal BP), and before its dispersal eastward to Remote Oceania (from 3250–3100 cal BP). In this discursive note, which draws upon a host of recent literature, an alternative view of early agriculture in ISEA is proposed that does not rely upon Austronesian dispersal from Taiwan. This alternative working hypothesis is based upon multidisciplinary evidence from ISEA, including the generation and spread of associated animal and plant domesticates. This interpretation does not privilege one region over another; rather it is multilocal and multidirectional.

Plant domesticates

East Asian agriculture is predominantly associated with the cultivation of sexually reproduced plants in fields, although a region of early vegetative propagation has been proposed in southern China (Zhao 2011). Open-field cultivation of domesticated rice was practiced in the Yangtze River region of China after 7000 cal BP (Fuller *et al.* 2009), became established

* *School of Historical and European Studies, La Trobe University, Kingsbury Drive, Bundoora VIC 3083, Australia (Email: t.denham@latrobe.edu.au)*

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on Taiwan by at least 4800 cal BP (Bellwood 2005, 2011), and yet was seemingly not widely established in ISEA until after 2000 cal BP (Anshari *et al*. 2001).

Plant domesticates from East Asia, such as rice (*Oryza sativa*) and foxtail millet (*Setaria italica*), are largely absent from the archaeobotanical record of early (here meaning pre-3000 cal BP) agriculture in ISEA (Donohue & Denham 2010). The identification of domesticated rice is problematic because criteria to differentiate wild and domesticated forms (e.g. compare Liu *et al*. 2007 with Fuller *et al*. 2009), as well as to differentiate *O. sativa* from other wild rice species that occur throughout ISEA, are either contentious in macrofossil (seed and rachis) and microfossil (pollen, phytolith and starch grain) assemblages, or have not been rigorously applied (Paz 2005). Consequently, all claims for early (pre-3000 cal BP) domesticated rice in ISEA should be viewed cautiously until archaeobotanical finds are evaluated more systematically.

Domestic-type rice is uncommon at sites pre-dating 3000 cal BP in ISEA, except in association with pottery (Paz 2002, 2005; Barker *et al*. 2011a). The paucity and ceramic associations of finds have led several commentators to infer that domesticated rice was originally derived from extralocal trade (Paz 2002), or was a minor ritual or status crop (Hayden 2011; Barton 2012), until it became a major staple after *c*. 2000 cal BP (Anshari *et al*. 2001; Barton & Denham 2011). Furthermore, the archaeobotany of foxtail millet at pre-3000 year-old sites in ISEA is non-existent (following Paz 2002).

There is extremely sparse evidence to suggest that East Asian plant domesticates and farming spread across ISEA before 3000 cal BP. Certainly agricultural implements and crops of East Asian origin occur within ISEA (e.g. Bellwood & Dizon 2005), but only after the period of purported Austronesian expansion from Taiwan. Consequently, the dispersal of Austronesian languages from Taiwan and the spread of East Asian farming should be decoupled in the ISEA context; at this scale they are discrete historico-geographic phenomena before at least *c*. 3000 cal BP (Donohue & Denham 2010; Barker *et al*. 2011b).

If cereal-based cultivation from East Asia was not significant for the development of early cultivation practices in ISEA, what was? Another neighbouring region that provides insights on the development of agriculture in ISEA is New Guinea. Agricultural practices were comparatively early on New Guinea, dating to at least *c*. 6950–6440 cal BP (Denham *et al*. 2003, 2004). Unusually in global terms (Smith 1998; Bellwood 2005; Barker 2006), early agriculture on New Guinea was not accompanied by animal domestication.

In contrast to East Asia, cultivation and arboricultural practices on New Guinea focus upon the vegetative reproductive capacity of plants, often grown together in plots under polyculture (Bourke & Harwood 2009). Vegetative forms of propagation and transplantation predominate for trees (e.g. breadfruit, *Artocarpus altilis*), shrubs (e.g. aibika, *Abelmoschus manihot*), herbs (e.g. bananas, *Musa* spp.), grasses (e.g. sugarcane, *Saccharum officinarum*) and root crops (e.g. taro, *Colocasia esculenta* and yams, *Dioscorea* spp.) (Kennedy & Clarke 2004; Bourke & Harwood 2009).

Rather than being an insignificant region for the development of agriculture, the initial stages in the domestication of several globally significant food plants for subsistence and commerce (FAO 2012) can be traced to ISEA and the New Guinea region (following Lebot 1999). These include: bananas (Perrier *et al*. 2011), sugarcane (Grivet *et al*. 2004) and some yams, especially the greater yam (*Dioscorea alata*; Malapa *et al*. 2005; Lebot 2009).

Some of these plants spread across the Old World tropics, including the Pacific, mainland Southeast Asia, southern Asia and Africa, where they were integrated into traditional systems of cultivation before the periods of European exploration and colonisation (e.g. Perrier *et al.* 2011). Other New Guinea domesticates remain of regional importance, such as sago (*Metroxylon sagu*; Kjær *et al.* 2004), breadfruit (Zerega *et al.* 2004) and some taro varieties (Lebot *et al.* 2004). Numerous other plant domesticates have remained only locally significant; they did not disperse far beyond New Guinea and Island Melanesia, e.g. canarium almond (*Canarium indicum*; Yen 1996), or are largely confined to the altitudinal range of domestication in the highlands or lowlands of New Guinea, e.g. *karuka* and *marita* pandanus, respectively (*Pandanus* spp.; Stone 1982).

The archaeobotany of vegetative propagation, like that for cereal cultivation, is minimal in ISEA. However, multiple lines of evidence suggest early agricultural practices there were more likely to have been vegetative and incorporated plants domesticated within ISEA and New Guinea, rather than reliant on the sexual reproduction of cereals from East Asia (Denham 2005, 2011). This conclusion is not a 'fantasy' (contra Spriggs 2011: 524), but is based upon a thorough assessment of the multidisciplinary evidence.

First, comparison of long-term archaeobotanical records suggests that early forms of plant exploitation in ISEA and the New Guinea region were similar (Barton & Paz 2007; Lewis *et al.* 2008; Denham 2011). They were based upon the management and exploitation of tuberous plants and trees, reflecting shared arboricultural and vegecultural orientations (reviewed in Barton & Denham 2011). These types of plant exploitation did not change with the advent of the 'Neolithic', often inferred by the appearance of red-slipped pottery. Sites on Borneo and Timor indicate continuity in the exploitation of tuberous plants before and after this putative transition (Barker *et al.* 2011a and Oliveira 2012, respectively). Except for the addition of rice as a minor crop, people continued to be oriented to their rainforest environments, including the exploitation of plants, in similar ways.

Secondly, if early farming was associated with, and enabled, the expansion of Austronesian languages across ISEA in approximately 4000–3000 cal BP, then synchronous environmental impacts marking its spread would be anticipated. Although the archaeological visibility of early cultivation practices is currently minimal (Barker *et al.* 2011a & b), palaeoecological records of vegetation history demonstrate that the antiquity and degree of disturbance, or clearance, of tropical rainforests were geographically variable and occurred from *c.* 8000 cal BP onwards in parts of ISEA (Donohue & Denham 2010; Hunt & Prematilake 2012). These records are suggestive of a mosaic of different types of plant exploitation across ISEA and New Guinea during the Holocene. In some places, these practices coalesced into forms of cultivation through time, whereas in others they did not (Denham 2011).

Thirdly, archaeobotanical, genetic and linguistic evidence for the domestication and dispersal of plants westward from New Guinea into ISEA shed light on cultivation practices for which we currently lack archaeological traces (Denham & Donohue 2009; Denham 2010; Perrier *et al.* 2011). For example, parthenocarpy arose in *Musa acuminata* ssp. *banksii* on New Guinea with subsequent westward movement under vegetative forms of cultivation to ISEA, where intra- and inter-specific hybridisation yielded new cultivars, including triploids, which were subsequently adopted by Austronesian language speakers (Perrier *et al.* 2011). A similar geodomestication pathway has been invoked for sugarcane: initial

domestication on New Guinea with subsequent westward movement (Grivet *et al*. 2004). In contrast, the pathways for taro (Lebot *et al*. 2004) and some yams (Malapa *et al*. 2005) are less clear and plausibly reflect multiple historical processes of domestication and dispersal (Denham 2010). These plants were all seemingly domesticated in the maritime world of ISEA and New Guinea (Lebot 1999) and spread under vegetative forms of cultivation before any evidence of Austronesian language dispersal there.

Fourthly, and following from above, these multi-disciplinary insights receive linguistic corroboration because the words for many significant food plants in ISEA cannot be assigned to Proto Austronesian (PAn)—the ancestral Austronesian language on Taiwan—before dispersal southward. Rather, most of the widespread words for banana, breadfruit, sago, taro, yam (*Dioscorea alata*) and numerous other cultivated plants appear in the Austronesian lexicon only after dispersal southward into ISEA (Pawley 2007; Donohue & Denham 2010). The words were plausibly integrated into Malayo-Polynesian languages from people already cultivating or exploiting these plants in ISEA and need not be suggestive of an origin on Taiwan. Of note, the word for sugarcane reconstructs to PAn (on Taiwan), suggesting that the plant had been spread there before Austronesian language dispersal, although another species of edible *Saccharum* could be implicated; whereas the word for 'chew on sugarcane', which is how the sugar is traditionally extracted within ISEA and New Guinea, only reconstructs to Proto Malayo-Polynesian (Pawley 2007).

In sum, there is no solid basis to infer that cultivation practices spread from Taiwan *c*. 4000–3000 cal BP as part of the purported Austronesian farming-language dispersal. The weight of multidisciplinary evidence is currently more suggestive that vegetative forms of plant exploitation, including cultivation, were practiced in parts of ISEA before, and largely continued unchanged for at least a millennium after, Taiwanese cultural influences become apparent.

Animal domesticates

The primary animal domesticates associated with early farming practices in ISEA, Near Oceania and most islands of Remote Oceania (Hung *et al*. 2011)—domestic chicken (*Gallus gallus*), dog (*Canis familiaris*) and pig (*Sus scrofa*)—all originate on mainland Asia. These domesticates were dispersed variably across ISEA from different source regions between *c*. 4000 and 3000 cal BP, after which they became more ubiquitous and entwined in the long-term history of agriculture in Oceania.

The inhabitants of ISEA, New Guinea and Near Oceania had no pre-existing experience with domestic animals. Although human-mediated animal translocations had occurred within both regions well before 4500 cal BP—in the early Holocene in Wallacea and from the Late Pleistocene between New Guinea and the Bismarck Archipelago (White 2004; Dobney *et al*. 2008)—these translocations constituted the anthropogenic expansion of the wild resource base rather than domestication. In this context, the rearing of domestic animals must have radically transformed people's relationships to their environment and to each other.

The oldest domesticated pig remains in ISEA date to *c*. 4500–4000 cal BP at Nagsabaran in northern Luzon (Piper *et al*. 2009) and plausibly reflect early introduction across the

Batanes Strait from Taiwan (also see Hung *et al.* 2007). However, genetic research (Larson *et al.* 2007) suggests these were not the pigs that eventually spread across southern ISEA to Near Oceania and into Remote Oceania, as would be inferred from portrayals of the Austronesian farming-language dispersal. Pigs did not even spread from the Philippines to the Mariana Islands around 3500 years ago together with red-slipped pottery, and dogs are absent at Nagsabaran until 2500 years ago (Hung *et al.* 2011). Similarly, domestic pigs are absent at Niah and most other sites in ISEA until the last 2000 years (Barker *et al.* 2011a), and chicken remains are extremely rare within ISEA before 3500 cal BP (Bellwood 2011).

The Nagsabaran record, together with those of animal domesticates elsewhere in ISEA, suggest that chicken, dog and pig did not spread as part of an agricultural package southward from Taiwan. Other than the movement of domestic pigs to northern Luzon around 4500–4000 years ago, current archaeological and genetic evidence is more suggestive of mainland SEA introductions of these domesticates to most of ISEA (following Dobney *et al.* 2008). These domesticates are still only variably present in the archaeological record of early, or formative, Lapita in the Bismarck Archipelago after 3470–3250 cal BP, but they were taken, albeit sometimes selectively, by the bearers of Lapita pottery on their first forays into Remote Oceania after 3250–3100 cal BP (Kirch 1997; Spriggs 1997).

In sum, the animal domesticates of farming in ISEA exhibit different origins and patterns of dispersal to plant domesticates. The keeping of animal domesticates was completely foreign to this region and all three of the principal domesticates originated on mainland Asia. The geographically and historically variable archaeozoological records in ISEA, New Guinea and Near Oceania suggest multiple introductions and multiple pathways for the spread of each species before approximately 3250–3100 cal BP, after which they co-occur more commonly at sites in these regions and Remote Oceania.

Multiple pathways to agriculture in ISEA

The different origins, dispersals and adoptions of animal husbandry and plant cultivation, respectively, in ISEA and Near Oceania before colonisation of the majority of Remote Oceania from 3250–3100 cal BP remain to be unravelled. The Asian origin for domesticated animals and the predominant New Guinea and partially indigenous origin for domesticated plants suggest complex histories of agricultural transformation within ISEA and Near Oceania approximately 4500–3000 years ago. Animals and plants dispersed across ISEA through differential incorporation into, and transformation of, pre-existing practices of food procurement and production.

Island Southeast Asia was not a passive 'no-[hu]man's land' over which external influences swept between 4500 and 3000 years ago. The inhabitants of ISEA were active agents in the generation of early farming practices during the mid-Holocene (following Paz 2010). They differentially integrated new plants into pre-existing practices of cultivation and management, and adopted new husbandry practices for the rearing of introduced animal domesticates. These processes were not structured by an out-of-Taiwan migration. Rather they entailed introductions from multiple source regions and, as a result, were characterised by the differential co-occurrence of plants and animals across ISEA. There was considerable

continuity in plant exploitation, as noted for Borneo and Timor, and considerable variability in the antiquity of animal domesticates across the region, as noted for chicken and pig. These emergent forms of farming, generated within ISEA rather than imported *in toto* from East Asia, enabled the expansion of Austronesian speaking peoples across that region, Near Oceania and Remote Oceania, as well as to Madagascar.

To conclude, beyond domesticated pigs in northern Luzon, there is almost no archaeological evidence to infer farming-language dispersal southward from Taiwan into ISEA approximately 4500–4000 years ago. Within the maritime landscape of ISEA, some East Asian cultural influences spread widely, e.g. red-slipped pottery (cf. Solheim 2006); however, a substantive introduction of East Asian plants and cultivation practices did not occur until much later. Instead, early agriculture was primarily based on plants that were cultivated and domesticated in ISEA and New Guinea. Early husbandry was based on animal domesticates of ultimate mainland Asian origin that spread to and across ISEA along multiple pathways from multiple sources. The integration of largely indigenous plant domesticates and exotic animal domesticates within ISEA and Near Oceania would have facilitated the expansion of Austronesian languages in those regions; further coalescence formed the subsistence practices that enabled the subsequent colonisation of the majority of Remote Oceania from 3250–3100 cal BP.

References

Addison, D. & E. Matisoo-Smith. 2010. Rethinking Polynesian origins: a West-Polynesia Triple-I model. *Archaeology in Oceania* 45: 1–12.

Anshari, G., A.P. Kershaw & S. van der Kaars. 2001. A late Pleistocene and Holocene pollen and charcoal record from peat swamp forest, Lake Sentarum Wildlife Reserve, West Kalimantan, Indonesia. *Palaeogeography, Palaeoclimatology, Palaeoecology* 171: 213–28.

Barker, G. 2006. *The agricultural revolution in prehistory*. Oxford: Oxford University Press.

Barker, G., L. Lloyd-Smith, H. Barton, F. Cole, C. Hunt, P.J. Piper, Z.R. Rabett, V. Paz & K. Szabo. 2011a. Foraging-farming transitions at the Niah Caves, Sarawak, Borneo. *Antiquity* 85: 492–509.

Barker, G., C. Hunt & J. Carlos. 2011b. Transitions to farming in Island Southeast Asia: archaeological, biomolecular and palaeoecological perspectives, in G. Barker & M. Janowski (ed.) *Why cultivate? Anthropological and archaeological approaches to foraging-farming transitions in Southeast Asia*: 61–74. Cambridge: McDonald Institute for Archaeological Research.

Barton, H. 2012. The reversed fortunes of sago and rice, *Oryza sativa*, in the rainforests of Sarawak, Borneo. *Quaternary International* 249: 96–104.

Barton, H. & T.P. Denham. 2011. Prehistoric vegeculture and social life in Island Southeast Asia and Melanesia, in G. Barker & M. Janowski (ed.) *Why cultivate? Anthropological and archaeological approaches to foraging-farming transitions in Southeast Asia:* 17–25. Cambridge: McDonald Institute for Archaeological Research.

Barton, H. & V. Paz. 2007. Subterranean diets in the tropical rainforest of Sarawak, Malaysia, in T.P. Denham, J. Iriarte & L. Vrydaghs (ed.) *Rethinking agriculture: archaeological and ethnoarchaeological perspectives*: 50–77. Walnut Creek (CA): Left Coast.

Bellwood, P. 1984/85. A hypothesis for Austronesian origins. *Asian Perspectives* 20: 107–17.

– 1997. *Prehistory of the Indo-Malaysian archipelago*. Honolulu: University of Hawai'i Press.

– 2002. Farmers, foragers, languages, genes: the genesis of agricultural societies, in P. Bellwood & C. Renfrew (ed.) *Examining the farming-language dispersal hypothesis*: 17–28. Cambridge: McDonald Institute for Archaeological Research.

– 2005. *First farmers: the origins of agricultural societies*. Oxford: Blackwell.

– 2011. Holocene history in the Pacific region as a model for worldwide food producer dispersals. *Current Anthropology* 52(S4): S363–S378.

Bellwood, P. & E. Dizon. 2005. The Batanes archaeological project and the 'out of Taiwan' hypothesis for Austronesian dispersal. *Journal of Austronesian Studies* 1: 1–31.

Bourke, R.M. & T. Harwood (ed.) 2009. *Food and agriculture in Papua New Guinea*. Canberra: ANU E Press.

Bulbeck, D. 2008. An integrated perspective on the Austronesian diaspora: the switch from cereal agriculture to maritime foraging in the colonisation of Island Southeast Asia. *Australian Archaeology* 67: 31–51.

Denham, T.P. 2005. Envisaging early agriculture in the Highlands of New Guinea: landscapes, plants and practices. *World Archaeology* 37: 290–306.

– 2010. From domestication histories to regional prehistory: using plants to re-evaluate early and mid-Holocene interaction between New Guinea and Southeast Asia. *Food and History* 8: 3–22.

– 2011. Early agriculture and plant domestication in New Guinea and Island Southeast Asia. *Current Anthropology* 52(S4): S379–S395.

Denham, T.P. & M. Donohue. 2009. Pre-Austronesian dispersal of banana cultivars west from New Guinea: linguistic relics from eastern Indonesia. *Archaeology in Oceania* 44: 18–28.

Denham, T., S.G. Haberle, C. Lentfer, R. Fullagar, J. Field, M. Therin, N. Porch & B. Winsborough. 2003. Origins of agriculture at Kuk Swamp in the Highlands of New Guinea. *Science* 301: 189–93.

Denham, T.P., S.G. Haberle & C. Lentfer. 2004. New evidence and interpretations for early agriculture in Highland New Guinea. *Antiquity* 78: 839–57.

Denham, T.P., C. Bronk Ramsey & J. Specht. 2012. Dating the appearance of Lapita pottery in the Bismarck Archipelago and its dispersal to Remote Oceania. *Archaeology in Oceania* 47: 39–46.

Diamond, J. 2001. Polynesian origins: slow boat to Melanesia? *Nature* 410: 167.

Diamond, J. & P. Bellwood. 2003. Farmers and their languages: the first expansions. *Science* 300: 597–603.

Dobney, K., T. Cucchi & G. Larson. 2008. The pigs of Island Southeast Asia and the Pacific: new evidence for taxonomic status and human-mediated dispersal. *Asian Perspectives* 47: 59–74.

Donohue, M. & T.P. Denham. 2010. Island Southeast Asia during the mid-Holocene: reframing Austronesian history. *Current Anthropology* 51: 223–56.

Food and Agriculture Organization of the United Nations (FAO). 2012. *FAO Statistical Yearbook 2012 World Food and Agriculture*. Rome: FAO.

Fuller, D.Q., L. Qin, Y. Zheng, Z. Zhao, X. Chen, L.A. Hosoya & G.-P. Sun. 2009. The domestication process and domestication rate in rice: spikelet bases from the Lower Yangtze. *Science* 323: 1607–10.

Grivet, L., C. Daniels, J.C. Glaszman & A. D'Hont. 2004. A review of recent molecular genetics evidence for sugarcane evolution and domestication. *Ethnobotany Research and Applications* 2: 9–17.

Hayden, B. 2011. Rice: the first Asian luxury food?, in G. Barker & M. Janowski (ed.) *Why cultivate? Anthropological and archaeological approaches to foraging-farming transitions in Southeast Asia*: 75–94. Cambridge: McDonald Institute for Archaeological Research.

Hung, H.-C., Y. Iizuka, P. Bellwood, K.D. Nguyen, B. Bellina, P. Silapanth, E. Dizon, R. Santiago, I. Datan & J.H. Manton. 2007. Ancient jades map 3000 years of prehistoric exchange in Southeast Asia. *Proceedings of the National Academy of Sciences (USA)* 104: 19745–50.

Hung, H.-C., M.T. Carson, P. Bellwood, F.Z. Campos, P.J. Piper, E. Dizon, M. Bolunia, M. Oxenham & C. Zhang. 2011. The first settlement of Remote Oceania: the Philippines to the Marianas. *Antiquity* 85: 909–26.

Hunt, C.O. & R. Prematilake. 2012. Early Holocene vegetation, human activity and climate from Sarawak, Malaysian Borneo. *Quaternary International* 249: 105–19.

Kennedy, J. & W.C. Clarke. 2004. *Cultivated landscapes of the southwest Pacific* (Research Management in the Asia-Pacific Working Paper 50). Canberra: The Australian National University.

Kirch, P.V. 1997. *The Lapita peoples: ancestors of the Oceanic world*. Oxford: Blackwell.

– 2000. *On the road of the winds: an archaeological history of the Pacific Islands before European contact*. Berkeley: University of California Press.

Kjær, A., A.S. Barfod, C.B. Asmussen & O. Seberg. 2004. Investigation of genetic and morphological variation in the sago palm (*Metroxylon sagu*; Arecaceae) in Papua New Guinea. *Annals of Botany* 94: 109–17.

Larson, G., T. Cucchi, M. Fujita, E. Matisoo-Smith, J. Robins, A. Anderson, B. Rolett, M. Spriggs, G. Dolman, T.-H. Kim, N.T.D. Thuy, E. Randi, M. Doherty, R.A. Due, R. Bollt, T. Djubiantono, B. Griffin, M. Intoh, E. Keane, P. Kirch, K.-T. Li, M. Morwood, L.M. Pedriña, P.J. Piper, R.J. Rabett, P. Shooter, G. Van den Bergh, E. West, S. Wickler, J. Yuan, A. Cooper & K. Dobney. 2007. Phylogeny and ancient DNA of *Sus* provides insights into Neolithic expansion in Island Southeast Asia and Oceania. *Proceedings of the National Academy of Sciences (USA)* 104: 4834–39.

Lebot, V. 1999. Biomolecular evidence for plant domestication in Sahul. *Genetic Resources and Crop Evolution* 46: 619–28.

– 2009. *Tropical root and tuber crops: cassava, sweet potato, yams, aroids*. Wallingford: CABI.

Lebot, V., M.S. Prana, N. Kreike, H. van Heck, J. Pardales, T. Okpul, T. Gendua, M. Thongjiem, H. Hue, N. Viet & T.C. Yap. 2004. Characterisation of taro (*Colocasia esculenta* (L.) Schott) genetic resources in Southeast Asia and Oceania. *Genetic Resources and Crop Evolution* 51: 381–92.

Lewis, H., V. Paz, M. Lara, H. Barton, P.J. Piper, J. Ochoa, T. Vitales, A.J. Carlos, T. Higham, L. Neri, V. Hernandez, J. Stevenson, E.C. Robles, A. Ragragio, R. Padilla, W. Solheim II & W. Ronquillo. 2008. Terminal Pleistocene to mid-Holocene occupation and an early cremation at Ille Cave, Palawan, Philippines. *Antiquity* 82: 318–35.

Liu, L., G.-A. Lee & L. Jiang. 2007. Evidence for the early beginning (*c.* 9000 cal BP) of rice domestication in China: a response. *Holocene* 17: 1059–68.

Malapa, R., G. Arnau, J.L. Noyer & V. Lebot. 2005. Genetic diversity of the greater yam (*Dioscorea alata* L.) and relatedness to *D. nummularia* Lam. and *D. transversa* Br. as revealed with AFLP markers. *Genetic Resources and Crop Evolution* 52: 919–29.

Oliveira, N.V. 2012. Recovering, analyzing and identifying *Colocasia esculenta* and *Dioscorea* spp. from archaeological contexts in Timor-Leste, in M. Spriggs, D. Addison & P.J. Matthews (ed.) *Irrigated taro (*Colocasia esculenta*) in the Indo-Pacific: biological, social and historical perspectives* (Senri Ethnological Studies 78): 265–84. Osaka: National Museum of Ethnology.

Pawley, A. 2007. The origins of early Lapita culture: the testimony of historical linguistics, in S. Bedford, C. Sand & S.P. Connaughton (ed.) *Oceanic explorations: Lapita and western Pacific settlement*: 17–49. Canberra: ANU E Press.

Paz, V. 2002. Island Southeast Asia: spread or friction zone?, in P. Bellwood & C. Renfrew (ed.) *Examining the farming-language dispersal hypothesis*: 275–85. Cambridge: McDonald Institute for Archaeological Research.

– 2005. Rock shelters, caves, and archaeobotany in Island Southeast Asia. *Asian Perspectives* 44: 107–18.

– 2010. Comment. *Current Anthropology* 51: 244.

Perrier, X., E. De Langhe, M. Donohue, C. Lentfer, L. Vrydaghs, F. Bakry, F. Carreel, I. Hippolyte, J.-P. Horry, C. Jenny, V. Lebot, A.-M. Risterucci, K. Tomekpe, H. Doutrelepont, T. Ball, J. Manwaring, P. de Maret & T.P. Denham. 2011. Multidisciplinary perspectives on banana (*Musa* spp.) domestication. *Proceedings of the National Academy of Sciences (USA)* 108: 11311–18.

Piper, P.J., H.-C. Hung, F.Z. Campos, P. Bellwood & R. Santiago. 2009. A 4000-year-old introduction of domestic pigs into the Philippine Archipelago: implications for understanding routes of human migration through Island Southeast Asia and Wallacea. *Antiquity* 83: 687–95.

Smith, B.D. 1998. *The emergence of agriculture*. New York: Scientific American Library.

Solheim II, W.G. 2006. *Archaeology and culture in Southeast Asia: unraveling the Nusantao*; with contributions from D. Bulbeck & A. Flavel. Manila: University of the Philippines Press.

Spriggs, M. 1997. *The Island Melanesians*. Oxford: Blackwell.

– 2003. Chronology of the Neolithic transition in Island Southeast Asia and the western Pacific: a view from 2003. *Review of Archaeology* 24: 57–80.

– 2007. The Neolithic and Austronesian expansion within Island Southeast Asia and into the Pacific, in S. Chiu & C. Sand (ed.) *From Southeast Asia to the Pacific: archaeological perspectives on the Austronesian expansion and the Lapita cultural complex*: 104–25. Taipei: Centers for Archaeological Studies Research and for Humanities and Social Sciences, Academica Sinica.

– 2011. Archaeology and the Austronesian expansion: where are we now? *Antiquity* 85: 510–28.

Stone, B.C. 1982. New Guinea Pandanaceae: first approach to ecology and biogeography, in J.L. Gressitt (ed.) *Biogeography and ecology of New Guinea:* 401–36. The Hague: Junk.

White, J.P. 2004. Where the wild things are: prehistoric animal translocations in the circum New Guinea Archipelago, in S. Fitzpatrick (ed.) *Voyages of discovery: the archaeology of islands*: 147–64. Westport (CT): Praeger/Greenwood.

Yen, D. 1996. Melanesian arboriculture: historical perspectives with emphasis on the genus *Canarium*, in B.R. Evans, R.M. Bourke & P. Ferrar (ed.) *South Pacific indigenous nuts*: 36–44. Canberra: ACIAR.

Zerega, N.J.C., D. Ragone & T.J. Motley. 2004. Complex origins of breadfruit (*Artocarpus altilis*, Moraceae): implications for human migrations in the Pacific. *American Journal of Botany* 91: 760–66.

Zhao, Z. 2011. New archeobotanical data for the study of the origins of agriculture in China. *Current Anthropology* 52(S4): S295–S306.

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