Ancient and historic dispersals of sweet potato in Oceania

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On his voyages across the Pacific, Captain James Cook encountered geographically disparate Polynesian societies, including those living on Easter Island, Hawai'i, and the north island of New Zealand. These far-flung communities cultivated a South American domesticate, the sweet potato (*Ipomoea batatas*). Subsequent debates concerning the timing and nature of the dispersals of sweet potato into and across the Pacific have proven contentious, including Thor Heyerdahl's famous *Kon Tiki* voyage from South America to Easter Island (1). Archaeological research has now conclusively shown that the sweet potato was introduced to Central Polynesia by approximately A.D. 1200 to 1300 (2), most likely by Polynesian voyagers who reached South America and subsequently spread the crop to the widely dispersed islands of the Polynesian triangle (e.g., ref. 3). Now, Roullier et al. (4) use genetic analyses (chloroplast and nuclear microsatellites) of modern and historically collected herbaria samples to clarify longstanding questions concerning historical dispersals of sweet potato across the Pacific. In sum, their research confirms key aspects of the "tripartite hypothesis" for sweet potato dispersal, with major implications beyond Oceania.

Addressing the Tripartite Hypothesis

Explorers' accounts and archaeobotanical records provide only a coarse-grained historical framework for the sweet potato in the Pacific (5). Roullier et al., in PNAS (4), demonstrate that, when these are combined with genetic analyses of modern and historical samples from across the Pacific, a much finer-grained interpretation of the multiple dispersals of sweet potato can be reconstructed. Roullier et al.'s findings directly address the tripartite hypothesis, which sequential authors have proposed to account for the spread of different named cultivar groups, each with different geographical origins and historical associations, across the Pacific (6–9):

a) The *kumara* lineage from the west coast of South America was introduced to Eastern Polynesia by voyagers approximately 1000 to 1100 y ago.
b) The *camote* lineage from MesoAmerica was introduced by Spanish galleons sailing between the Philippines and Mexico at approximately A.D. 1500.
c) The *batata* lineage from the Caribbean was circumlocuitously introduced by Portuguese traders via Europe in the 16th century.

The sources of these sweet potato cultivar groups correspond to two recently identified gene pools: one in the Caribbean/Central America and the other in northwestern South America (centered on Peru/Ecuador) (10). Each gene pool is associated with an independent domestication event, followed by dispersal throughout tropical America. These regionally specific gene pools have distinctive genetic markers that enable the differentiation of the *kumara* lineage derived from the Southern gene pool and the *batata* and *camote* lineages derived from the Northern gene pool.

Roullier et al.'s research has significance far beyond the sweet potato, as well as potentially beyond the Pacific.

Foremost, their research shows that the Western Pacific gene pool of sweet potato was introduced by European voyagers and is primarily descended from the *batata* and *camote* lineages (Northern gene pool). As would be anticipated based on introductions from relatively few maritime sources, there is limited genetic diversity. Having said this, the authors discern some variation within the Western Pacific; namely, the contribution of the *kumara* lineage (Southern gene pool) is greater in Island Melanesia than in New Guinea and Island Southeast Asia. This may reflect an earlier or later introduction of *kumara* lineage sweet potatoes to Island Melanesia through interaction with Polynesia, although the authors note limited gene flow between the eastern and western Pacific (4).

Of related significance, the sweet potato in New Guinea is primarily descended from *batata* and *camote* lineages (Northern gene pool), indicating a post-European introduction after A.D. 1500, rather than an earlier introduction from Polynesia (*kumara* lineage). Although the authors do not pursue the point, this is highly significant, because it demonstrates the "big man" social institution is almost certainly less than 500 y old. The big man is an archetype of cultural anthropology (11), is characteristic of traditional highland societies in the main intermontane valleys of New Guinea (12), and is thought to have become more defined following the adoption of intensive sweet potato cultivation and pig husbandry (13). Previous cultivation in the highlands was almost certainly based on taro (*Colocasia esculenta*) (14).

Modern cultivars in the Eastern Pacific gene pool are also dominated by *batata* and *camote* lineages (Northern gene pool). However, the authors use the analysis of herbaria samples, including some collected on Captain Cook's first voyage of 1769, as well as those collected up to the early 20th century, to demonstrate recent replacement, or reshuffling, of *kumara* lineages by *batata* and *camote* introductions during the past century (4). Namely, the analysis of historically collected samples seemingly confirms the hypothesis that *kumara* lineages were introduced to the eastern Pacific by Polynesian voyagers, which archaeological evidence indicates occurred by approximately A.D. 1200 to 1300.

Broader Implications

Roullier et al.'s research has significance far beyond the sweet potato, as well as potentially beyond the Pacific. Significantly, genetic evidence for *kumara* lineage sweet potato in eastern Polynesia supports other evidence for pre-European contacts between Polynesia and western South America (15). Parsimony suggests Polynesian, rather than South American, voyagers as the prime movers, given that Polynesians colonized remote archipelagos and islands throughout the vast Pacific Ocean.

Second, the use of herbaria samples clearly demonstrates how a reliance on modern samples can skew genetic interpretations of long-term history. The past two centuries have opened up vast areas of the world to expanded spheres of interaction and engagement, albeit initially indirect and along localized exchange pathways. Nonetheless, new varieties of plants and breeds of animals have been introduced, become widespread, and replaced more traditional gene pools. Problematically, most genetic studies are reliant on the interpretation of modern samples because of the difficulties in

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extracting ancient DNA in many contexts (examples of exceptions are provided in refs. 16–18); however, herbaria, museum, and other samples offer excellent and often underused opportunities for historic genetic research as proxies for more ancient distributions.

Finally, not only do these findings (4) have substantive implications for clarifying the long-term history of Polynesia and New Guinea, they also demonstrate the rates with which domesticates can be adopted by traditional societies, and the rates of resultant social transformations. Similar types of introduction and dispersal occurred before and after European colonization in many areas of the world, yet most are poorly understood. There is often a lack of multidisciplinary evidence, including the archaeological findings to provide a chronology for genetic results. There is also another recurrent problem; the connectivities, transformations, and dynamism of traditional societies in many areas of the world continue to be underestimated for periods before European exploration.

1. Heyerdahl T (1950) *The Kon Tiki Expedition* (Allen and Unwin, London).
2. Hather JG, Kirch PV (1991) Prehistoric sweet potato (Ipomoea batatas) from Mangaia Island, central Polynesia. *Antiquity* 65:887–893.
3. Ladefoged TN, Graves MW, Coil J (2005) The introduction of sweet potato in Polynesia: Early remains in Hawai'i. *J Polyn Soc* 114:359–374.
4. Roullier C, Benoit L, McKey DB, Lebot V (2013) Historical collections reveal patterns of diffusion of sweet potato in Oceania obscured by modern plant movements and recombination. *Proc Natl Acad Sci USA* 110:2205–2210.
5. Ballard C, Brown P, Bourke RM, Hardwood T, eds (2005) *The Sweet Potato in Oceania: A Reappraisal* (Oceania Publications, Sydney).
6. Barrau J (1957) L'énigme de la patate douce en Océanie. *Etudes d'Outre-Mer* 40:83–87.
7. Yen DE (1974) *The Sweet Potato in Oceania: An Essay in Ethnobotany* (Bishop Museum Press, Honolulu).
8. Green R (2005) Sweet potato transfers in Polynesian prehistory. *The Sweet Potato in Oceania: A Reappraisal*, eds Ballard C, Brown P, Bourke RM, Harwood T (Oceania Publications, Sydney), pp 43–62.
9. Lebot V (2009) *Tropical Root and Tuber Crops: Cassava, Sweet Potato, Yams and Aroids* (CABI, Wallingford, UK).
10. Roullier C, Rossel G, Tay D, McKey D, Lebot V (2011) Combining chloroplast and nuclear microsatellites to investigate origin and dispersal of New World sweet potato landraces. *Mol Ecol* 20(19):3963–3977.
11. Sahlins MD (1963) Poor man, rich man, big-man, chief: Political types in Melanesia and Polynesia. *Comp Stud Soc Hist* 5:285–303.
12. Strathern AJ (1971) *The Rope of Moka: Big-Men and Ceremonial Exchange in Mount Hagen, New Guinea* (Cambridge Univ Press, Cambridge).
13. Golson J, Gardner D (1990) Agriculture and sociopolitical organisation in New Guinea Highlands prehistory. *Annu Rev Anthropol* 19:395–417.
14. Denham T (2011) Early agriculture and plant domestication in New Guinea and Island Southeast Asia. *Curr Anthropol* 52:S379–S395.
15. Lawler A (2010) Beyond Kon-Tiki: Did Polynesians sail to South America? *Science* 328(5984):1344–1347.
16. Erickson DL, Smith BD, Clarke AC, Sandweiss DH, Tuross N (2005) An Asian origin for a 10,000-year-old domesticated plant in the Americas. *Proc Natl Acad Sci USA* 102(51):18315–18320.
17. Jaenicke-Després V, et al. (2003) Early allelic selection in maize as revealed by ancient DNA. *Science* 302 (5648):1206–1208.
18. Larson G, et al. (2007) Phylogeny and ancient DNA of Sus provides insights into neolithic expansion in Island Southeast Asia and Oceania. *Proc Natl Acad Sci USA* 104(12):4834–4839.