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Ancient DNA typing of archaeological pig remains corroborates historical records

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ABSTRACT

The recent increase in both the abundance and taxonomic range of DNA sequence data in public repositories makes it possible to determine the maternal origin of lineages of faunal archaeological material by characterizing its mitochondrial DNA. Among the most commonly represented taxa are domesticated animals, for which extensive genetic characterization has revealed high levels of genetic diversity and (in at least some cases) strong phylogeographic clustering. Such information has significant implications not only for characterizing important aspects of the occupation history of archaeological sites, but also in providing novel insights into colonisation history and the scale and scope of trade and exchange networks. This can be done through studying the origins and dispersal of proxy organisms such as commensal and domesticated animals, as well as economically important wild fauna. To illustrate this approach, we compare historical records of maritime movement of people and pigs from two sites on Lord Howe Island, Australia, to phylogeographic results of DNA extracted from pig bones.

1. Introduction

Reconstructing the movement of people, their domestic animals and commensal mammals throughout the world has been successfully attempted using mitochondrial DNA (mtDNA) from modern and ancient sources of DNA (Matisoo-Smith et al., 1998; Larson et al., 2007a; Larson et al., 2007b). For this to be practical, two criteria need to be met. Firstly, a large mitochondrial reference database of a target species must be available. Mitochondrial DNA (mtDNA) is favoured over nuclear DNA for aDNA studies because many more copies of mtDNA are present within cells, thereby increasing the probability of survival and recovery from bones and other organic remnants. In addition, the lack of recombination in mtDNA facilitates phylogenetic and demographic reconstruction using recovered sequences. However, given the rapid rate of post-mortem DNA decay (Hoss et al., 1996; Smith et al., 2003) and the difficulty of amplifying long tracts of aDNA, it is necessary to target a small yet variable portion of the mitochondrial genome for analysis. To meet these conditions, the most common genetic target for aDNA provenancing is the hypervariable region within the mitochondrial control region: a non-coding segment of the mtDNA genome that exhibits a rapid evolutionary rate relative to other mtDNA loci.

Secondly, the genetic signature recovered from the sample must be characteristic of a specific (and preferably restricted) geographic region. Direct correlations between genetic signatures and geographic provenance has been demonstrated for pigs (Larson et al., 2005), cows (Troy et al., 2001), rabbits (Hardy et al., 1995), goats (Naderi et al., 2007), sheep (Guo et al., 2005; Kijas et al., 2006), and to some extent for chickens (Liu et al., 2006) though the phylogeographic signal is less strong in horses (Vila et al., 2001) and dogs (Savolainen et al., 2002). In the case of pigs, a single nucleotide polymorphism is sufficient to place an individual's maternal origin within a specific and circumscribed region of the world (Larson et al., 2005; Larson et al., 2007a; Larson et al., 2007b).

Oceanic islands present an ideal opportunity to test the results of aDNA phylogeography against historical records. Prior to human settlement, oceanic islands were devoid of domestic species. Determining the origins of introduced domestics to these islands using a morphological approach is difficult given the phenotypic similarities between domestic animals derived from different geographical regions.

1.1. Lord Howe Island

Faunal material was excavated at two sites on Lord Howe Island, a small remnant volcanic island located between the Australian east coast and New Zealand in the Tasman Sea (Fig. 1).

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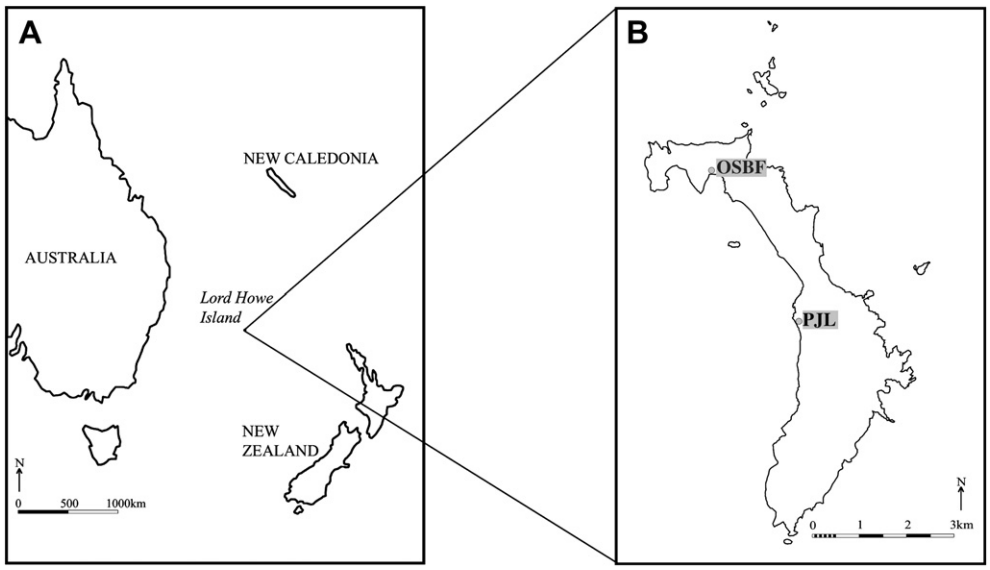

Fig. 1. Two maps depicting (A) the position of Lord Howe Island within the Tasman Sea, and (B) the location of the OSBF and PJL sites on the island.

The island appears to have been uninhabited prior to its discovery in 1788 (Rabone, 1940; Anderson, 2003), but rapidly became a key resupplying destination for passing whaling, sealing, trade and colonial ships. These ships included locally owned colonial vessels that operated around the Tasman Sea, those frequently trading between the colonies and Asia, and long-distance traders and whalers from Britain and the Americas. The ship traffic to the uninhabited island during the first 40 years following its discovery resulted in the release of domesticated pigs (*Sus scrofa*) and goats (*Capra hircus*). As a result of these introductions and ships sporadically resupplying, it is likely that several native species, such as the White Gallinule (*Notornis alba*) and the White-throated pigeon (*Columba vitiensis godmanae*) became extinct or highly endangered by the time permanent settlement began on the island in 1834 (Hutton, 1990).

Originally settled by a small group comprised of three British ex-whalers and their Maori wives and children, Lord Howe was subsequently colonised with the aim of formalising its role as a place of refreshment. Employed by a local Australian whaling firm, the settlers established the island as a supply depot by developing a small scale agricultural industry (Nichols, 2006). Staple crops such as potatoes, onions, cabbages and kumara (*Ipomoea batatas*) were introduced and grown expressly for the ship trade, while local fish, mutton bird (*Puffinus pacificus, P. carneipes*) and feral game were offered for trade as well as providing a significant portion of the local subsistence. Pigs and goats already on the island were incorporated into this enterprise, but whether the initial settlers brought additional pigs and goats along with their fowl (*Gallus* and *Anser*) and dogs (*Canis*), or these stocks were further supplemented by the passing ships is unclear (Rabone, 1940). The supply trade continued on the island until the increased availability of petroleum products in the mid 1850s precipitated a global slump in the whaling industry (Mawer, 1999). By the 1870s the shipping trade was almost finished and the Lord Howe economy was forced to move away from the supply trade in favour of agricultural exports, such as the export to Europe of an endemic palm tree, *Howea fosteriana,* for use as an indoor ornamental plant (Rabone, 1940; Nicholls, 1952).

Archaeological investigations of the settlement landscape of Lord Howe were undertaken as part of doctoral research in 2004 by one of the authors (Kimberley Owens from the Australian National University), and focused on midden materials from two domestic occupation sites, OSBF and PJL (Fig. 1). OSBF is the earliest site on the island, dating from around 1834 to about 1845–50 and was most probably built and occupied by the first settlers who came directly from New Zealand mainland whaling stations. These first settlers may have brought pigs with them from New Zealand or from the Australian colonies. There are also indications that by this time there was already a significant feral pig population established on the island (Nicholls, 1952), which was descended from animals released on at least two occasions by British, American or local Colonial ships for the express purpose of establishing a feral stock which passing ships could reliably draw upon (Rabone, 1940; Nicholls, 1952). Post-cranial elements of pig and goat are poorly represented in the earliest occupation layers of the excavations, suggesting that the bulk of the meat bearing portions of these animals were exported from the island as articles of trade, most likely in a smoked or salted state.

The PJL house site dates from the 1860s to about 1920 and an excavation revealed an increased variety and frequency of post-cranial pig, goat and other domesticate skeletal elements, indicating that fewer primary products of these taxa were being traded off the island. By the time this site was established, shipping was on the decline, although there remained ample opportunity for supplementary domestic stock (particularly pigs) to be brought to the island; either as specific imports from the colonies, China or Britain, or as opportunistic trade items with passing ships who had a surplus of livestock but not vegetables (Rabone, 1940; Nicholls, 1952). As shipping decreased further, opportunities for new domestic stock arrivals became fewer and the frequency of ships from outside the local region decreased

2. Materials

Four pig teeth from kitchen midden deposits at OSBF and four pig teeth from domestic underfloor deposits at PJL were collected from occupation levels dating from the 1830s to the 1840s (OSBF) and the 1860s to 1920s (PJL). Both midden and underfloor deposits also contained a wide selection of domestic refuse, including a large variety of faunal remains from domestic and native species, common 19th century British household ceramics and glassware, Scottish clay tobacco pipes, and common beads, buttons and