



Investigating the presence of foreigners and pig husbandry in ancient Bali: Stable isotopes in human and domestic animal tooth enamel



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ABSTRACT

Archaeological excavations at the Sembiran and Pacung archaeological sites in coastal Bali, Indonesia, have yielded pottery sherds and other material culture that derives from India and other locations on the Asian mainland, demonstrating that about 2000 years ago the north coast of Bali was in contact with cultures from mainland Asia. The area may in fact have hosted a harbour and perhaps even a community of foreign traders or immigrants. The Sembiran and Pacung excavations also yielded human remains from the same time period. We performed strontium, oxygen and carbon stable isotope analyses of tooth enamel from nine human skeletons to investigate whether the people interred at Sembiran and Pacung were from the local area or had travelled there from a distant home. Strontium isotope ratios were also measured in seven archaeological pig (*Sus cf. scrofa*) teeth, one archaeological canid tooth, and five modern snail (*Achatina fulica*) shells to help identify the local strontium isotope signature. The people interred at Pacung and Sembiran had similar oxygen and carbon isotope ratios but varying strontium isotope ratios which were higher than expected based on geology. Despite the abundance of foreign materials recovered, our isotope data can be most parsimoniously explained as deriving from a group of locally raised individuals who had a varying mix of coastal and inland plant resources in their diets. In addition, strontium isotope ratios from the pig teeth show interesting clustering, suggesting that two or three different husbandry practices may have been employed.

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1. Introduction

The Sembiran and Pacung archaeological sites on the north coast of Bali in Indonesia have produced ample evidence that the area was in contact with the cultures of mainland Asia about two thousand years ago. Pottery, glass beads, bronze and gold from these sites have been traced to several areas within India and mainland southeast Asia (Calo et al., 2015). Excavations at Sembiran and Pacung also revealed human skeletal remains, which raises the possibility that the sites not only had material goods from mainland Asia but also graves of traders or immigrants who brought the goods to Bali. We performed strontium, oxygen and carbon stable isotope ratio analyses of tooth enamel from nine human remains to investigate whether the people interred at Sembiran and Pacung were from the local area or had travelled there from a distant home.

While today the village of Sembiran (located about 2 km inland from the archaeological site of the same name) is home to about 5000 mostly

impoverished people who rely on cultivation of cash crops, government-issued rice supplies, and remittances from relatives who emigrated for employment elsewhere (Hauser-Schäublin, 2008), in the past the area was much more prominent. Oral histories and Dutch colonial records indicate that during the nineteenth century it was part of the Buleleng Regency and contained important shrines connected to the Batur temple, a ritual center for the Regency (Hauser-Schäublin, 2004). Furthermore, a remarkable set of copperplate inscriptions preserved by local villagers and dated to 922–1181 CE indicate that at that time the area was host to foreign trading communities and included a market and fortified settlement (Ardika, 2008; Hauser-Schäublin and Ardika, 2008). The inscriptions also contain regulations related to stranded ships and cargos; located along a major trade route leading from the Spice Islands to India and China, the Sembiran area likely included a significant harbour (Ardika, 2008). Archaeological excavations at the Sembiran and Pacung sites have now convincingly demonstrated that contact with India and mainland southeast Asia extends back at least 2000 years (Ardika and Bellwood, 1991; Ardika et al., 1997; Calo et al., 2015). The nature of the contact at that time remains uncertain, but the abundance and variety of foreign goods recovered during excavations indicate substantial exchange. To support this exchange, the area may have hosted communities of foreign traders or immigrants,

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some of whom may have been interred at the coastal Sembiran and Pacung sites (Fig. 1).

The possibility that at least one foreigner was interred at Pacung was first investigated by Lansing et al. (2004). Excavation of pit PCN III (just south of PCN IX; Fig. 1) during the 1980s recovered a loose human tooth from a deep level of the Pacung site. Lansing et al. performed mitochondrial DNA and carbon isotope ratio analyses on the tooth and claimed that both analyses independently indicated the tooth was not from a Balinese. Specifically, the DNA analysis produced mtDNA haplotype A, which is not found in modern Bali (Lansing et al., 2004) or indeed anywhere in modern Indonesia (Tumonggor et al., 2013). These DNA results have been questioned on procedural grounds (McLauchlan and Thomas, 2006; see also Lansing et al., 2006) and are difficult to assess based on currently available information. The carbon isotope ratio in collagen from the tooth (-21.1‰), indicating a dietary carbon isotope ratio of about -27‰ , is well within the range of ratios for C3 plants and thus is consistent with a terrestrially-based diet. Lansing et al. (2004) claim that a strongly terrestrial diet is unlikely in a coastal Balinese population and thus that the carbon isotope ratio supports a foreign origin for the tooth. McLauchlan and Thomas (2006) question the assumption that a terrestrial diet is unlikely in Bali. Our analysis includes carbon isotope ratios from additional human teeth which help to place the Lansing et al. result into a broader context.

To aid in interpreting the isotope data from the human remains, we also performed strontium, oxygen and carbon stable isotope ratio analyses of seven pig (*Sus cf. scrofa*) teeth from the Sembiran and Pacung excavations as well as a canid (cf. *Canis lupus familiaris*) tooth from Pacung. We expected these faunal remains to produce fairly tight data clusters reflecting the local environmental conditions; in particular the strontium isotope data was expected to have a small range that corresponds

with local geological strontium ratios. We will discuss the implications of our faunal isotope data both for the interpretation of the human remains and for what they suggest about animal husbandry on the north coast of Bali about two thousand years ago.

2. Stable isotope analysis

Stable isotope analysis is becoming a widespread technique in archaeology and good reviews of the general approach and methods are available (Bentley, 2006; Lee-Thorp, 2008; Tykot, 2004). For strontium, archaeologists are interested in the ratio of radiogenic ^{87}Sr to ^{86}Sr . Within geologic formations, this ratio changes over time as ^{87}Rb very slowly decays into ^{87}Sr . The ratio thus will vary across geographic regions with different geologic ages and compositions. Strontium ratios in sediment are unchanged when incorporated into plants and animals and therefore can be used to trace the geographic origin of an animal's overall diet. On the north coast of Bali, surface sediment is largely derived from past eruptions of the Batur volcano (Kalb, 2008). Batur is a Quaternary volcano with strontium isotope ratios of approximately 0.7040 (Whitford, 1975a). That ratio is consistent with data from Java, where volcano-derived strontium ratios tend to decrease from about 0.7055 to 0.7040 along a northwest to southeast transect (Whitford, 1975b). Similarly measurements of rocks from elsewhere in western Indonesia show strontium ratios below 0.7060; ratios between 0.7060 and 0.7100 are occasionally found in eastern Indonesia (Nishimura and Suparka, 1986). Thus the geologic underpinnings of the area indicate that the strontium signature of the Sembiran/Pacung region should be about 0.07040. Note however that geologically-based strontium signatures can be misleading because different rock types weather and release strontium at different rates, so the strontium available in the soil

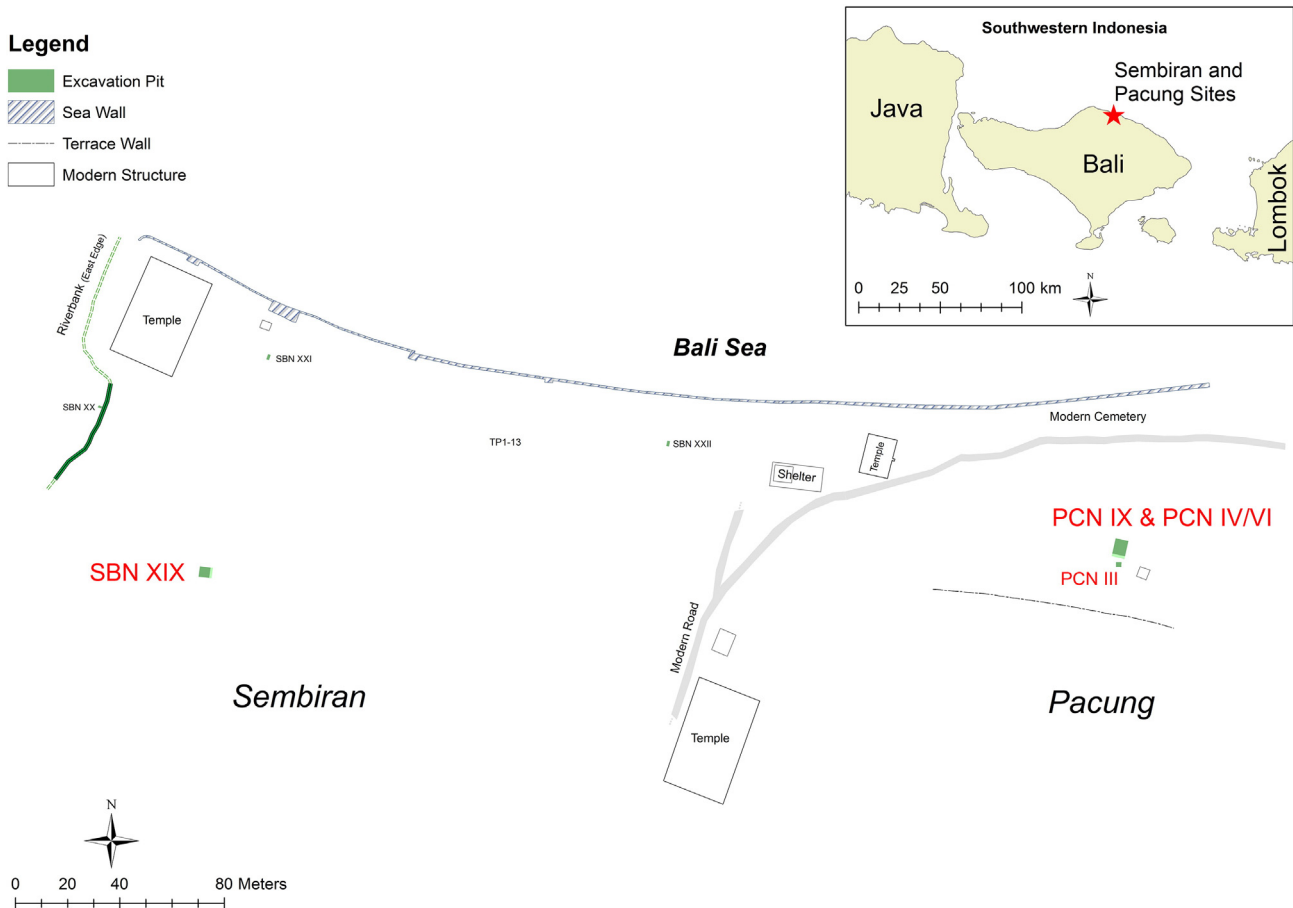


Fig. 1. Map showing the location of the Sembiran (SBN) and Pacung (PCN) excavation trenches near the north coast of Bali, Indonesia.

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