Journal of Archaeological Science: Reports 18 (2018) 408–419

Contents lists available at ScienceDirect

Journal of Archaeological Science: Reports

journal homepage: www.elsevier.com/locate/jasrep

# Possible diffuse idiopathic skeletal hyperostosis (DISH) in a 3000-year-old Pacific Island skeletal assemblage

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ARTICLE INFO

*Keywords:*
Hyperostosis
Stable isotopes
Diet
MetS
Teouma
Lapita

ABSTRACT

The Teouma skeletal assemblage represents a group of colonists from the earliest phase of the Vanuatu archipelago's prehistory. Previous examinations of the assemblage identified high levels of hyperostosis, which we investigate further here. Based on a differential diagnosis of conditions known to produce ectopic bone formation, we argue that the pattern of skeletal change is most consistent with diffuse idiopathic skeletal hyperostosis (DISH) although we acknowledge that, given the preservation of the sample, it is difficult to distinguish DISH from other causes of hyperostosis with absolute certainty. In modern and bioarchaeological studies, DISH has been associated with metabolic disease and dietary practices. Based on previous stable isotopes analyses, it is thought that the Teouma people were heavily reliant on purine-rich marine resources and terrestrial animal protein, the type of diet thought to contribute to DISH development. We therefore compared dietary stable isotope values of groups of individuals with and without evidence for DISH. No significant relationships between DISH status and carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) stable isotope values were observed, suggesting that individual access to particular dietary resources was not the cause of DISH in those affected from Teouma, although the dietary constraints of the colonizing context may still have played an important role in the development of this condition for individuals otherwise predisposed to the disease. Individual predisposition may have been influenced by a propensity for hyperinsulinemia or hyperuricemia, brought about by the selective pressures of the colonization process. The high prevalence of hyperostosis and DISH in this skeletal assemblage may be evidence for a prehistoric variant of metabolic disease, which is observed at a high frequency in the Pacific today.

## 1. Introduction

The Teouma skeletal assemblage comprises the earliest known inhabitants of the Vanuatu archipelago. The people interred at the Teouma site are thought to be a colonizing population associated with the Lapita Cultural Complex. Lapita artefacts first appear in the archaeological record of the Bismarck Archipelago around 3300 years ago or later (Spriggs, 2007; Summerhayes, 2007). The Lapita people became the first to cross the boundary between Near and Remote Oceania and, over a period of only a few hundred years, colonized previously uninhabited island groups as far east as Samoa (Fig. 1). To varying extents, they are the ancestors of modern Polynesians and other Pacific populations (cf. Kirch, 2000; Spriggs, 2011). It has been hypothesized that the Lapita people descended from Austronesian-speaking groups whose linguistic origin was in ancient Taiwan and recent analysis of aDNA from three Teouma crania and a Tongan individual have confirmed this link (Skoglund et al., 2016). The skeletal assemblage from the Teouma Lapita site in Vanuatu is the largest example of an initial colonizing population in the Pacific (Buckley et al., 2008). Examination of the skeletal health of these individuals has the potential to elucidate the possible origins and antiquity of some of the conditions affecting modern Pacific populations.

In 2007, Buckley published an analysis of the hitherto excavated portion of the Teouma skeletal assemblage (numbering 36 individuals at the time), which identified seven male individuals with erosive arthropathy. Buckley (2007) argued for a diagnosis of gout based on

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https://doi.org/10.1016/j.jasrep.2018.01.002
Received 25 May 2017; Received in revised form 18 December 2017; Accepted 4 January 2018

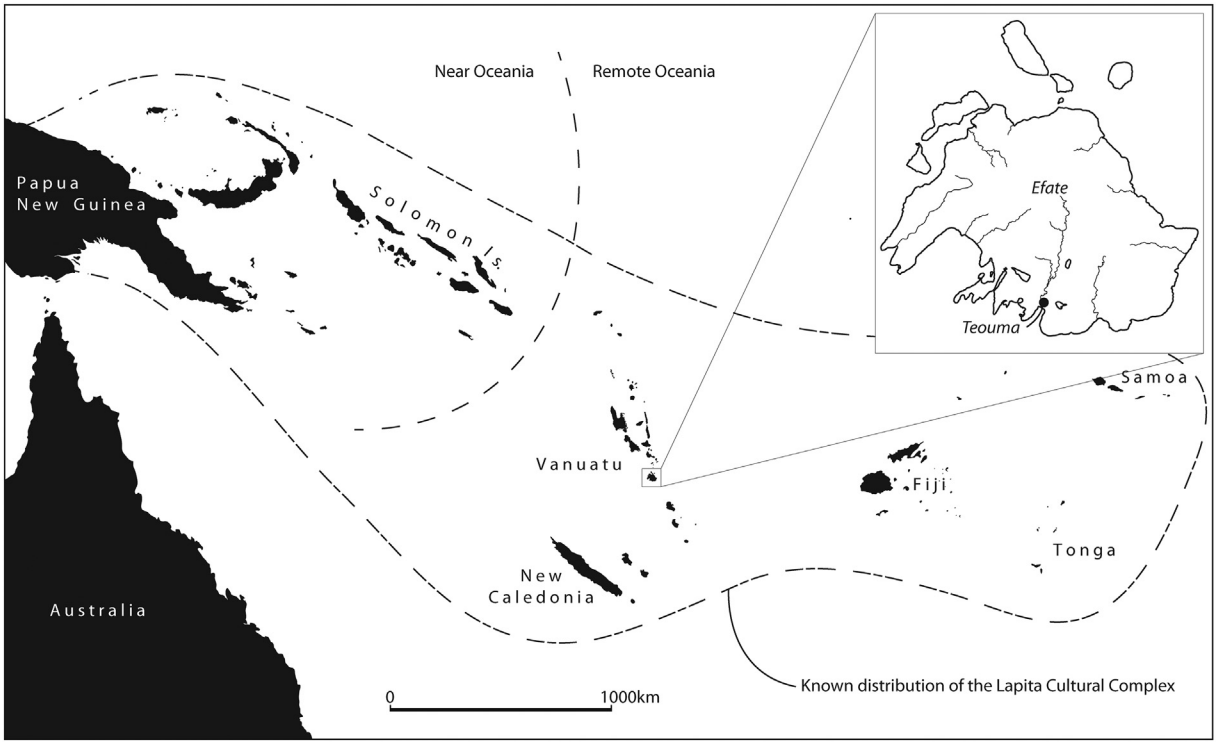


**Fig. 1.** The extent of the Lapita expansion and location of the Teouma site on the island of Efate, Vanuatu.

modern Polynesian epidemiology, which features high rates of hyperuricemia and metabolic syndrome conditions as a result of inherited genetic predisposition. This study and a more general report on health and disease at Teouma (Buckley et al., 2008) also noted the presence of diffuse skeletal hyperostosis affecting the spine and appendicular skeleton in the sample. Subsequent excavations have augmented the assemblage (n = 97 individuals) and recent work on this larger assemblage has identified a high prevalence of entheseal ossifications as well as osteophytosis and eburnation at joints (Foster et al., 2013). Here we examine the etiology of the skeletal hyperostosis in the complete assemblage and investigate the underlying causes of these bony modifications within the colonizing context of the Teouma population through the stable isotope evidence for diet.

### 1.1. The paleopathology of DISH

Based on work by Rogers et al. (1997), Waldron (2009) has argued that within any population a proportion – up to a fifth – will be prone to the ossification of soft tissues ('bone formers') and that diffuse idiopathic skeletal hyperostosis (DISH) represents the extreme end of a bone forming spectrum. DISH is more frequently observed in males relative to females and is rarely observed in individuals younger than 40 years of age (Waldron, 2009).

While the cause of DISH is unclear, in modern populations it has been associated with the metabolic syndrome (MetS) and its diagnostic components (Eckel et al., 2005), including obesity, dyslipidemia, abnormal glucose tolerance/hyperglycemia, hyperinsulinemia, diabetes, and elevated blood pressure/hypertension (El Miedany et al., 2000; Julkunen et al., 1971; Kiss et al., 2002a; Littlejohn and Smythe, 1981; Mader and Lavi, 2009; Mader et al., 2009a; Mata et al., 1997; Miyazawa and Akiyama, 2006; Pappone et al., 1996; Verzyroglou et al., 1996). Definitions of MetS emphasize the effects of hyperinsulinemia on its development (Eckel et al., 2005), which has also been suggested as an etiological factor in the development of DISH (Littlejohn and Smythe, 1981; Littlejohn and Hall, 1982; Littlejohn, 1985): insulin may act as a growth factor, promoting bone proliferation (Littlejohn and Hall, 1982). MetS is associated with diets high in fatty foods and refined sugars and there is a trend towards its increase in indigenous populations adopting 'westernized' diets (Barnard et al., 1998; Lanaspa et al., 2011; Ogle, 2001).

In the palaeopathological setting, the connection between DISH, obesity and diabetes in modern populations led to the hypothesis that elevated levels of DISH in Medieval monastic skeletal samples were related to dietary practices (Rogers and Waldron, 2001; Waldron, 1985). Specifically, Waldron (1985) highlighted consumption of a greater amount and variety of meat and alcohol by the monks relative to others in the population. Excessive consumption of such foods may have contributed to an increased risk of "occupational corpulence" (Waldron, 1985: 1763) and diabetes, which may have, in turn, predisposed those living in monasteries to DISH (Rogers and Waldron, 2001). Based on these arguments, the presence of DISH in high-class individuals, for example, the Grand Dukes of Florence, Italy, during the 16th–17th centuries AD (Giuffra et al., 2010), has been attributed to a diet similarly high in meat and alcohol and low in fresh fruit and vegetables that led to obesity. In support of their dietary reconstruction, Giuffra et al. (2010) cite isotopic evidence demonstrating high $\delta^{15}N$ values indicative of a meat-based diet (Fornaciari, 2008).

The analysis of carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) stable isotope ratios is a well-established method to assess prehistoric diet using human bone collagen (see reviews by Katzenberg, 2000; Lee-Thorp, 2008; Schwarcz and Schoeninger, 1991; Sealy, 2001). Despite the purported relationship between DISH and diet, few published studies have specifically examined the carbon and nitrogen stable isotope ratios of individuals with and without DISH. Müldner and Richards (2007) showed that the $\delta^{15}N$ and $\delta^{13}C$ values in four male individuals with signs of DISH from the Later Medieval period at Fishergate, York, in England fell well above the male mean stable isotope values for the sample. They attributed this trend to diet, suggesting that the consumption of meat and marine fish disposed these individuals to the disease. A PhD dissertation by Spencer (2008) examined the relationship between DISH and dietary isotopes in a number of monastic and non-monastic skeletal assemblages from the United Kingdom. When