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Complexities in the palaeoenvironmental and archaeological interpretation of isotopic analyses of the Mud Shell *Geloina erosa* (Lightfoot, 1786)

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ABSTRACT

Isotope signals derived from molluscan shell carbonates allow researchers to investigate palaeoenvironments and the timing and periodicity of depositional events. However, it cannot be assumed that all molluscan taxa provide equally useful data owing to species-specific biological and ecological traits. The Mud Shell, *Geloina erosa* (Lightfoot, 1786) (syn. *Polymesoda coaxans*, syn. *Polymesoda erosa*), an infaunal mangrove bivalve, is a common component of archaeological deposits along Australia's tropical north coast and throughout the Indo-West Pacific. The ubiquity of *G. erosa* has led to numerous researchers incorporating this taxon into interpretations of associated deposits, particularly in the generation of radiocarbon chronologies and as a palaeoenvironmental proxy. Despite this, concerns have been expressed regarding the impact of *G. erosa* physiology and ecology on associated geochemical signals. Adaptations allowing the survival of this species within its highly changeable mangrove environment may introduce complexities into radiocarbon and environmental data archived within its shell. This study combines local environmental and hydrological data with isotopic analysis ($\delta^{18}O$, $\delta^{13}C$, and ^{14}C) of live-collected specimens to explore the interpretability of geochemical proxies derived from *G. erosa*. Results suggest a number of factors may impact geochemical markers in unpredictable ways, eroding the usefulness of associated interpretations.

1. Introduction

Reconstructing past environments assists archaeologists in approaching interpretations of human-environment relationships, which underpin fundamental cultural and behavioural decision-making processes. Geochemical archives derived from the calcium carbonates of molluscan shell represent sources of geochronological and palaeoenvironmental data, often providing the foundation for archaeological investigations in coastal contexts. While it is considered best practice to preferentially select filter-feeding bivalves for geochemical analyses (Forman and Polyak, 1997; Hogg et al., 1998; Petchey et al., 2008), owing to a diet dominated by suspended phytoplankton and dissolved inorganic carbon (DIC) (Tanaka et al., 1986), recent studies have suggested that this is an overly-simplistic view that does not account for species-specific physiological and ecological factors (Petchey et al., 2013). Therefore, assessing whether a particular taxon can provide meaningful information is central to ensuring the validity of associated interpretations.

The common mangrove bivalve *Geloina erosa* (syn. *Polymesoda coaxans*, syn. *Polymesoda erosa*) is an important component of past and present economic systems throughout the Indo-West Pacific region (e.g. Carter, 2014; Coleman et al., 2003; Davies, 1985; Gimin et al., 2005; Meehan, 1982; Morton, 1976; Willan and Dredge, 2004). As *G. erosa* is frequently found in archaeological shell midden deposits along Australia's north coast, the species has been utilised as part of approximately 30 radiocarbon chronologies since the late 1980s (see Ulm and Reid, 2000; Williams et al., 2014). Additionally, stable isotope studies from Australia (Hinton, 2012; Twaddle et al., 2016) and Borneo (Stephens et al., 2008) have sought to characterise *G. erosa* as an accurate palaeoenvironmental proxy. Despite geochemical data from *G. erosa* shell being employed to support numerous facets of archaeological interpretation, few studies have examined the reliability of information derived from the species in any detail.

Several biological and physiological attributes developed by adult *G. erosa* to survive the harsh conditions of their landward mangrove habitats have the potential to negatively impact the usefulness of geochemical data from shell carbonates. Complexities associated with

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variable respiration and feeding behaviours, periods of aerial exposure, brackish water conditions, and irregular environmental fluctuations may complicate isotopic fractionation, pathways, and profiles (Petchey et al., 2012; Schöne, 2008). Characterising the magnitude of any such effects using modern live-collected specimens can assist in determining the efficacy of employing geochemical data from archaeological *G. erosa* shell to characterise seasonality of site-use, palaeoenvironmental reconstruction, and radiocarbon dating. This study combines modern local environmental observations with sclerochronological analyses of *G. erosa* specimens live-collected from Bentinck Island, southern Gulf of Carpentaria in order to determine whether isotopic analysis of shell carbonate from this species can support reliable interpretation.

2. Background

2.1. Study area

The South Wellesley Islands are located along Australia's tropical north coast in the southern Gulf of Carpentaria (Fig. 1). This region exhibits a wet tropical climate primarily controlled by interactions between the Australian monsoon and south-easterly trade winds, producing a stark dichotomy between one wet (November–March) and one dry (May–August) season annually. Wet and dry seasons are primarily delineated by rainfall intensity and frequency with 92–95% of the average 1200 mm of precipitation occurring during the wet season (BOM, 2016). Heavy rain during the wet season causes extensive flooding across much of the island chain with low-lying areas and estuarine systems inundated annually. Combined runoff from this local flooding and input from mainland catchment systems cause significant shifts in productivity and hydrology in the southern Gulf of Carpentaria (Burford et al., 2009; Oliver and Thompson, 2011; Twidale, 1966). Conversely, the dry season exhibits very little rainfall, a stable marine environment, and strong south-easterly winds. These main seasons are punctuated by two short transitionary periods, April (Wet-Dry transition) and September/October (Dry-Wet transition), which exhibit a combination of both wet and dry season characteristics.

Relatively narrow temperature ranges evident in the South Wellesley Islands are typical of tropical climates, with average temperature maxima of 34.6 °C during December and minima of 23.1 °C occurring during June (BOM, 2016). Accompanying these temperature shifts are changes to humidity, which peak during the wet season, although high humidity quickly dissipates with the onset of dry season conditions (Memmott, 1979:48). Records from the nearest sea surface temperature (SST) recording station (Karumba (1999–2006), c.150 km southeast of

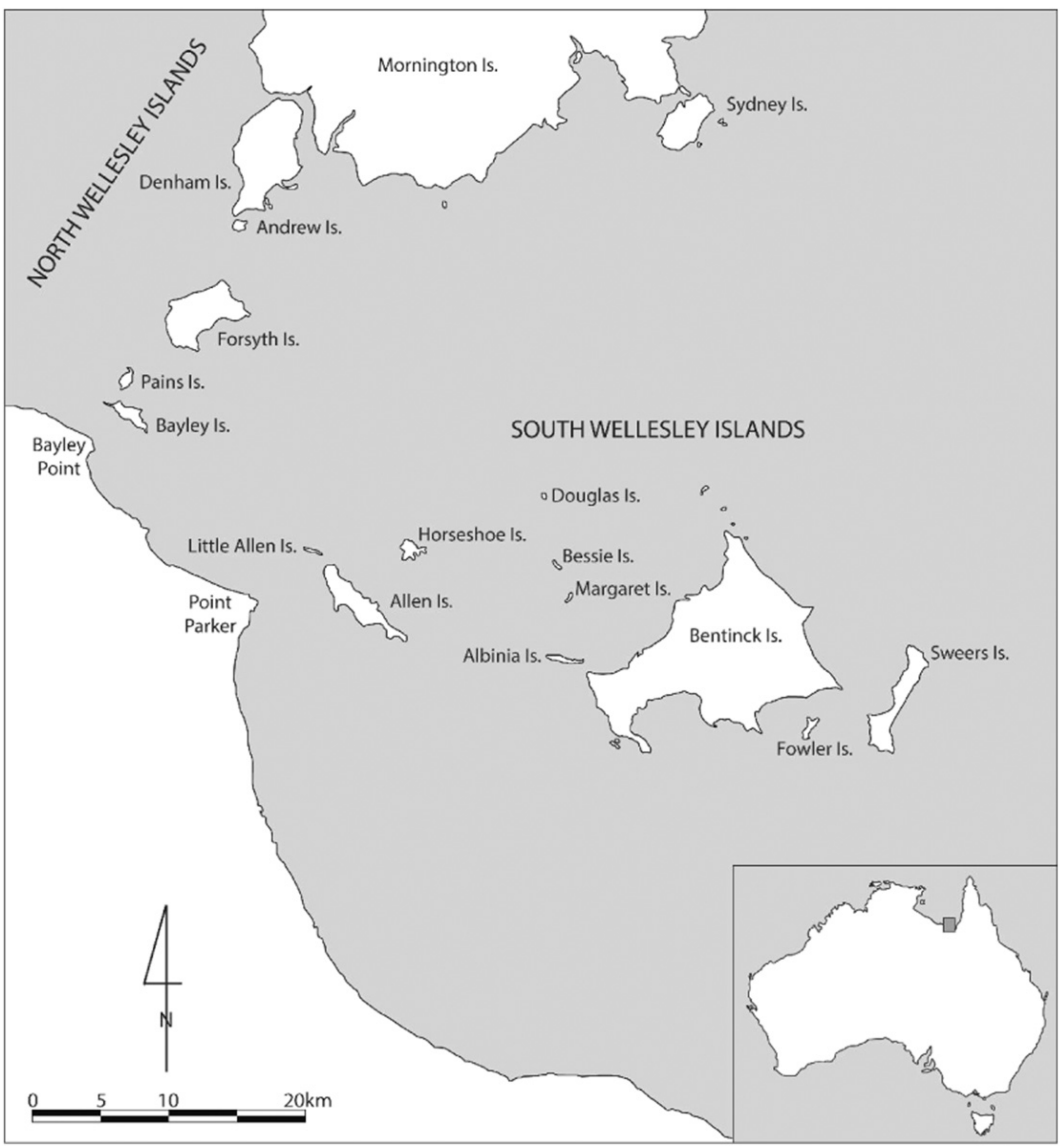

Fig. 1. The South Wellesley Islands are located in the southern Gulf of Carpentaria, Australia.