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Detection of temporospatially localized growth in ancient Southeast Asia using human skeletal remains

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ABSTRACT

Measures of population growth can provide significant insights into the health, adaptivity and resilience of ancient communities, particularly the way in which human populations respond to major changes, such as the transition to agriculture. To date, paleodemographic tools have facilitated the evaluation of long term, regional population growth, while identification of intraregional variability and short-term growth has been more challenging. This study reports on the application of a new method for estimating the rate of natural population increase (RNPI) from skeletal remains. We have applied the method to ancient Southeast Asian samples and, based on the LOESS fitting procedure, our preliminary results indicate a trend of temporal homogeneity and spatial heterogeneity. This trend is validated against the existing archaeological narrative for the region and, we argue, may indicate intraregional variability in population responses to major technological, economic and sociocultural events, consistent with the variable response observed at the regional level. Due to the critical importance of temporospatial specificity to a vast array of paleodemographic research questions, we have evaluated the precision, assumptions and limitations of this method in the context of other existing paleodemographic methods. Our RNPI measure, in isolation or in combination with existing methods, provides a promising tool that can be used to develop a deeper and more localized understanding of the conditions impacting on population dynamics and, conversely, community responses to change.

1. Introduction

Reconstructing the dynamics of past human population growth can provide insights into the health, adaptivity and resilience of ancient human communities. In particular, researchers have sought to evaluate population changes following major events, such as changes in subsistence and epidemics (Armelagos and Cohen, 1984; Johansson and Horowitz, 1986; Armelagos et al., 1991; Bocquet-Appel, 2002; Bocquet-Appel and Naji, 2006; DeWitte and Wood, 2008; Pinhasi and Stock, 2011; DeWitte, 2014, 2015). The most prominent example of this is the adoption and/or transition to and intensification of agriculture, and the concurrent major demographic event known as the Neolithic Demographic Transition (NDT). The transition occurred in different regions at different times, and there is growing evidence that not all populations responded in the same way (Armelagos and Cohen, 1984; Armelagos et al., 1991; Tayles et al., 2000; Domett, 2001; Oxenham, 2006; Domett and Tayles, 2007; Bellwood and Oxenham, 2008; Pinhasi and Stock, 2011; Willis and Oxenham, 2013). Nonetheless, the NDT has been commonly associated with substantial population increase due to increased and stabilized resources and reduced mobility permitting shorter inter-pregnancy intervals, as well as various health and social impacts resulting from ecological and economic changes (Armelagos and Cohen, 1984; Armelagos et al., 1991; Bocquet-Appel, 2002; Bocquet-Appel and Naji, 2006; Pinhasi and Stock, 2011).

Until now, estimates of population growth have been made based on biological sources, including DNA (Harpending, 1994), skeletal measures of fertility (Bocquet-Appel, 2002; Bocquet-Appel and Naji, 2006; Downey et al., 2014; Kohler and Reese, 2014), and archaeological sources, the most popular of which are demographic temporal frequency analyses (dTFA) (Collard et al., 2010; Peros et al., 2010; Shennan et al., 2013; Downey et al., 2014; Tallavaara et al., 2015; Zahid et al., 2016; Brown, 2017). Faith in paleodemographic findings based on skeletal remains has fluctuated over time. Efforts made in response to Bocquet-Appel and Masset's (1982) '*Farewell to Paleodemography*' produced a range of solutions to identified methodological issues (e.g. Van Gerven and Armelagos, 1983; Buikstra and Konigsberg, 1985; Gage, 1988; Konigsberg and Frankenberg, 1994), and work by Hoppa and Vaupel (2002) and the attendees of the Rostock workshop

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on age-at-death estimation offered elegant methods to reconstruct mortality profiles. Nonetheless, Gage and DeWitte (2009) observed that a gap has persisted between advancing theory and methodology, and application to real samples (work by DeWitte (2014, 2015) and DeWitte and Wood (2008) has exemplified the possibilities when improved techniques are applied). In this paper we report on the first application of a new method that has been developed for estimating the rate of natural population increase per annum (RNPI) (McFadden and Oxenham, 2018a), from skeletal remains, by quantifying the contribution of births and deaths to population growth.

Both archaeological (Higham, 1989; Oxenham et al., 2011, 2015; Bellwood et al., 2011; Oxenham et al., 2018) and population mobility (Matsumura and Oxenham, 2014; Oxenham and Buckley, 2016; Lipson et al., 2018) research has tracked the timing of the emergence of the Mainland Southeast Asian (MSEA) Neolithic, which is characterized by the introduction of domestic plants and animals as well as a major increase in population size (as evidenced by the appearance of numerous sites and characteristic forms of material culture). Similarly, the emergence of the MSEA Bronze and Iron Ages, with attendant developments in social complexity and significant increases in population size, the latter evidenced by marked increases in the number of sites as well as the size of such sites, is well attested (Higham, 1996; O'Reilly, 2006; Higham and Higham, 2009; Rispoli et al., 2013). MSEA is clearly particularly well suited to paleodemographic hypothesis testing due to well-dated cultural sequences and a sophisticated understanding of major changes in the population structure and mobility in the region in antiquity. Indeed, the archaeological and population mobility data suggests a scenario whereby the region saw a major influx of people (a Neolithic demographic transition) and a new system of subsistence (farming), followed by the introduction of bronze and iron technologies in the context of ever increasing social complexity and population sizes. This begs the question: do the demographic data, derived from cemeteries associated with these major transitional events, match archaeological and population history data?

Two research aims are addressed in this study: first, we wanted to test whether the RNPI method could be used to identify a similar trend in population growth to that observed in the archaeological record in MSEA (thereby validating the results), and second, to evaluate the accuracy, precision, and limitations of the RNPI method identified through its application.

2. Materials

In order to evaluate the utility of our method for estimating the rate of natural increase, specifically its ability to identify an archaeologically observed trend in population dynamics, we sought to apply it to data from Southeast Asia where the recent application of Bayesian analyses of radiocarbon results has provided a firm chronological framework within which to consider changes in subsistence, technology, and social organization. Substantial evidence exists to indicate an overall trend in the region of high population growth during the Neolithic (the NDT) (e.g. see Matsumura and Oxenham, 2014; Oxenham et al., 2015), and continued growth through the Bronze and Iron Age (Higham, 1996; O'Reilly, 2006; Higham and Higham, 2009; Rispoli et al., 2013), although the exact rates and pattern of growth are unknown.

We obtained data from eleven sites in mainland Southeast Asia, three of which span multiple time periods. Table 1 provides the sites, sources of data, the time periods, and sample sizes. Data for eight sites were obtained from published sources, while some data for three sites were contributed by the authors. The time periods represented in the study range from pre-Neolithic to Iron Age. Eight sites are located in Thailand, two sites in Vietnam, and one site in southern China (Fig. 1). Age estimates, sample sizes, radiocarbon dates and technological period (e.g. Neolithic, Bronze Age) have been represented as reported in the cited sources unless otherwise stated below.

2.1. Huiyaotian

Huiyaotian is located in Qingxiu district in southern China, not far from Man Bac and Cong Co Ngua in northern Vietnam (Zhen et al., 2017). The site dates to 7000-6300BP and is characterized by shell middens, polished stone axes and adzes, and various bone and shell implements (Zhen et al., 2017). A total of 56 individuals were included in this sample (Zhen et al., 2017).

2.2. Cong Co Ngua

Cong Co Ngua is located in northern Vietnam, 30 km from the coast (Oxenham et al., 2018). The faunal remains indicate the dominant animals consumed were large bodied mammals, while the predominant plant material consumed was canarium nuts (Oxenham et al., 2018). Pottery, stone tools, and bone and shell artefacts are associated with the site, with the stone tools being notably different from those found at younger Neolithic sites such as Man Bac and An Son (Oxenham et al., 2018). The 2013 season assemblage is analysed here, which includes 172 individuals (Oxenham et al., 2018).

2.3. Khok Phanom Di

Khok Phanom Di is a large Neolithic site in Thailand. During the occupation period, the population transitioned from estuarine-based hunter-gathering to rice cultivation, and back again (Tayles, 1999). There are seven mortuary phases represented at the site. A total of 154 individuals were identified, all of which were able to be aged (Tayles, 1999).

2.4. Man Bac

The Neolithic site of Man Bac is located in northern Vietnam and was excavated in 1999, 2001, 2004–5, and 2007 (Oxenham et al., 2011). Faunal remains found at the site included domesticated pigs, representing the majority, and a small proportion of hunted wild mammals (Sawada et al., 2011). The 84 individuals (78 being assigned an age) from the 2004/5 and 2007 seasons are analysed here (Domett and Oxenham, 2011).

2.5. Ban Non Wat

Ban Non Wat is a large site located in northeast Thailand. Excavations between 2002 and 2007 revealed burials and cultural material dating to the Neolithic, Bronze Age and Iron Age have been found at the site (Higham, 2011a; Higham, 2011b; Higham and Kijngam, 2011). Remains of domesticated pigs and cattle are found at the site, as well as evidence of domesticated dogs and rice cultivation (Higham, 2011a). Tayles et al. (2015) reported 83 individuals for the Neolithic population, 317 individuals for the Bronze Age, and 224 for the Iron Age. There are three mortuary phases in the Iron Age occupation which correspond to periods at Noen U-Loke, though notably one of four periods is not represented at Ban Non Wat (Higham and Kijngam, 2011). There is evidence that shell ornaments, clay goods, woven and fabric items, and iron, bronze and lead objects were produced at the site during the Iron Age occupation (Iseppy, 2011).

2.6. Non Nok Tha

Non Nok Tha is located in northeast Thailand and was excavated in 1965–1966 and 1968 (Pietrusewsky, 1974). Three periods are represented at Non Nok Tha: the Early pre-metal period, the Middle Bronze working period, and the Late Iron working period (Pietrusewsky, 1974). The burials at Non Nok Tha span the Early and Middle periods, and Pietrusewsky (1974) divided these into Phase I, including the two Early phase and the first Middle phase, and Phase II