Journal of Archaeological Science: Reports 11 (2017) 435–446

Contents lists available at ScienceDirect

Journal of Archaeological Science: Reports

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

Linear and appositional growth in infants and children from the prehistoric settlement of Ban Non Wat, Northeast Thailand: Evaluating biological responses to agricultural intensification in Southeast Asia

Neha Dhavale [a], Siân E. Halcrow [a,*], Hallie R. Buckley [a], Nancy Tayles [a], Kate M. Domett [b], Andrew R. Gray [c]

[a] Department of Anatomy, University of Otago, Dunedin 9054, New Zealand
[b] College of Medicine and Dentistry, James Cook University, Townsville, Queensland 4811, Australia
[c] Department of Preventive and Social Medicine, University of Otago, Dunedin 9054, New Zealand

ARTICLE INFO

Article history:
Received 12 August 2016
Received in revised form 28 November 2016
Accepted 11 December 2016
Available online xxxx

Keywords:
Childhood growth
Subsistence
Physiological stress

ABSTRACT

The bioarchaeological model of health change predicts a deterioration in population health with the adoption and intensification of agriculture. However, research in mainland Southeast Asia challenges this model, showing no clear pattern of health deterioration associated with the intensification of rice agriculture. Childhood growth, a sensitive indicator of general population stress, is used in this paper to test the applicability of the bioarchaeological model at the prehistoric site of Ban Non Wat in Northeast Thailand. Agricultural intensification at Ban Non Wat is most apparent in the Iron Age rather than the earlier periods. Linear and appositional growth patterns of infants and children (n = 95) at Ban Non Wat were compared among the Neolithic, Bronze and Iron Age periods (1750 BCE–430 CE) to assess differences in growth patterns associated with agricultural intensification over time. Comparative analysis of linear growth found no evidence for differences among the chronological phases at the site. A detailed assessment of appositional growth from the larger Bronze Age sample showed no evidence for extreme nutritional stress. These findings are consistent with other bioarchaeology health research in prehistoric Southeast Asia. A gradual transition to intensified agriculture over time and retention of a broad-spectrum based diet at Ban Non Wat may have provided a buffer from the biological stress exhibited in other parts of the world during agricultural intensification.

1. Introduction

The adoption and intensification of agriculture has been traditionally viewed as an important landmark in the history of human civilization, resulting in social, economic, human biological and cultural transformations (Childe, 1936; Pinhasi and Stock, 2011). Bioarchaeologists reconstructing health among prehistoric agricultural populations in America and Europe found that with an increased reliance on agriculture, there was a corresponding deterioration in health. These studies, collectively interpreted in the form of a generalized model, posit that changes in subsistence strategies with an increased focus on agricultural activities led to significant alterations in the physical and cultural environments that negatively affected the health of farming populations (Cohen and Armelagos, 1984a; Cohen and Crane-Kramer, 2007). According to this model, although agricultural intensification facilitated producing and controlling food surpluses, it caused a shift in the dietary focus of populations from a broad range of resources exploited by earlier hunting foraging populations, towards a more restricted diet of less nutritious food crops (Cohen and Armelagos, 1984b). Studies have shown that the subsistence shift to intensified agriculture in some parts of the Old and New Worlds led to an increase in physiological stress (Larsen, 2006). The adoption of agriculture in some regions of the world also resulted in changes in social structure as food surplus allowed increasing social complexity, the expansion of trade networks and technological advancement (Pinhasi and Stock, 2011). Agrarian populations also had to adapt to an increase in pathogen loads with sedentism, increasing population density and proximity to domestic animals (Armelagos et al., 1991; Cohen and Armelagos, 1984b; Pearce-Duvet, 2006). These changes resulted in health deterioration as communities adapted to the changing biosocial environment.

Although many bioarchaeological studies have reported this change in health deterioration associated with increasing reliance on agriculture, some studies have showed no clear changes in health associated with the adoption and intensification of agriculture, questioning its universal applicability (Bridges, 1989; Hodges, 1987; Pietrusewsky and Douglas, 2001; Tayles and Oxenham, 2006). In particular, samples from Mainland Southeast Asia (MSEA) do not show evidence for deterioration in health with an increasing reliance on agriculture (Domett and Tayles, 2007; Douglas and Pietrusewsky, 2007; Halcrow et al., 2013;

* Corresponding author.
E-mail address: sian.halcrow@otago.ac.nz (S.E. Halcrow).

http://dx.doi.org/10.1016/j.jasrep.2016.12.019

Tayles et al., 2000). There is recent research reporting some evidence for a rise in infectious diseases in the Iron Age, consequent with the time of increased population density, trade networks and contacts with neighboring regions (Halcrow et al., 2016; Oxenham et al., 2005; Tayles and Buckley, 2004; Tayles et al., 2007). What is apparent from earlier research in MSEA is that the intensification of agriculture and its consequent health effects is different from other regions. This difference may be partly explained by the particular gradual transition in subsistence strategies in the context of high tropical biodiversity of MSEA, which allowed for the retention of a broad subsistence spectrum of resources naturally available in the region (Domett and Tayles, 2006; Douglas and Pietrusewsky, 2007; Pietrusewsky and Douglas, 2001).

The understanding of health change in Southeast Asian prehistoric populations has thus far been largely based on a diachronic assessment using multiple sites that range temporally from the Neolithic to the Iron Age from different geographic locations (Domett and Tayles, 2007; Douglas, 1996; Douglas and Pietrusewsky, 2007; Halcrow, 2006; Halcrow et al., 2013; Halcrow and Tayles, 2008b; Halcrow et al., 2016; Oxenham et al., 2006; Oxenham et al., 2005). Until recently, there has not been a site that spans the period of agricultural intensification in the region, preventing scholars from making temporal comparisons of population health with a continuous population history over time and at one location. Ban Non Wat situated in the Upper Mun River Valley (UMRV) catchment in Northeast Thailand (Fig. 1), provides a unique opportunity to examine prehistoric health during the period when agriculture intensified. Ban Non Wat, with a large skeletal sample of around 690 burials (Newton, 2014; Tayles and Halcrow, 2016) spanning from ca. 1750 BCE to 430 CE, from incipient rice farming to a developed wet-rice agricultural economy and a technologically advanced society (Higham, 2014; Higham, 2015; O'Reilly, 2014), is an ideal sample for investigating any temporal changes in physiological stress to increasing reliance on agriculture. The isotopic evidence from this site indicates there was little long distance immigration (Cox et al., 2011; King et al., 2015), suggesting the genetic composition of the sample is homogenous, which provides a particularly strong platform for addressing the question of health change over time.

Childhood growth is a sensitive indicator of the overall health of a population and is helpful in assessing health in modern and past populations (Eveleth and Tanner, 1990; Goodman and Armelagos, 1989; Halcrow and Tayles, 2008a). As such, this paper assesses the growth of infants (individuals between 0 and 0.9 years of age) and children (1 to younger than 12 years of age) as a proxy to evaluate physiological stress at Ban Non Wat. The analysis aims to test the applicability of the bioarchaeological model of health change by examining whether there is evidence for growth retardation in the infants and children as agriculture intensified over time at the site. In most of the previous bioarchaeological studies assessing prehistoric health in Southeast Asia, the direct assessment of childhood growth was not possible owing to limited skeletal sample size of infants and children at the sites (Halcrow, 2006). However, with the recovery of a large skeletal

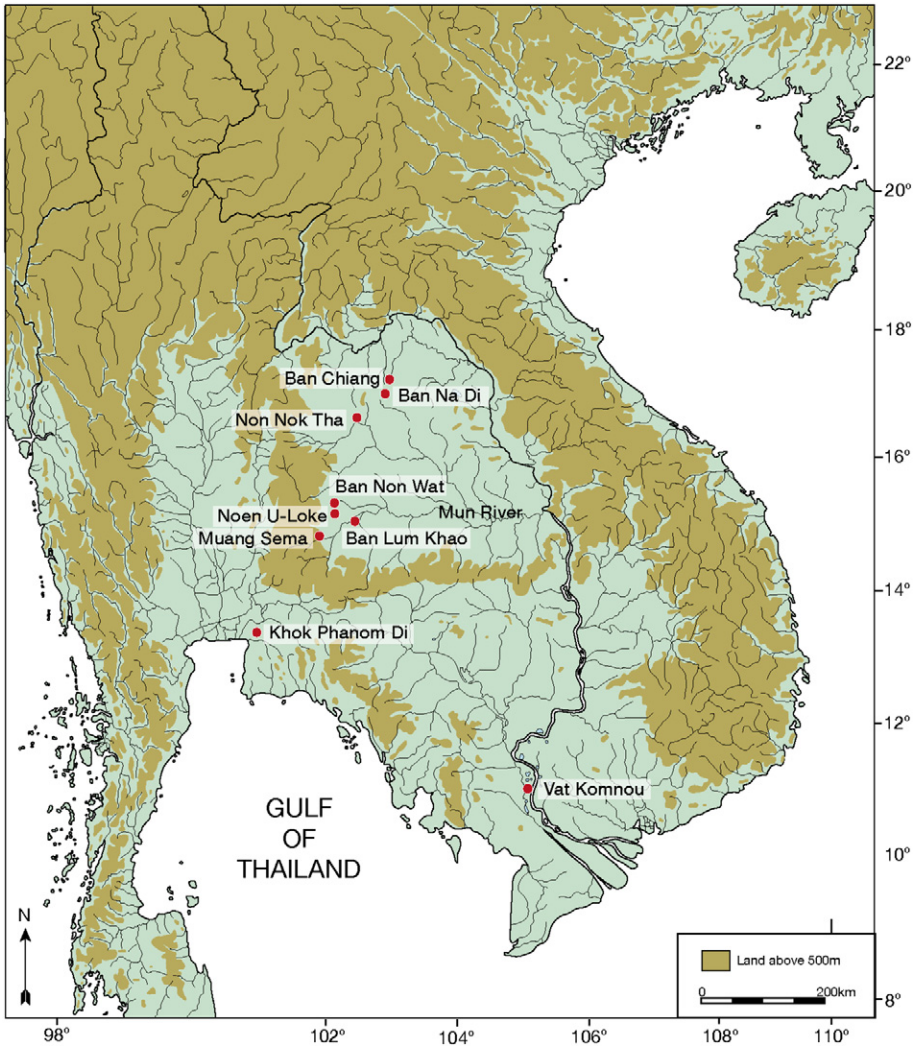

Fig. 1. Location of Ban Non Wat, situated in the upper Mun River valley, northeast Thailand (and other sites mentioned in this paper).