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The Demographic Profile of the Man Bac Cemetery Sample

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The chief aims of this chapter are to describe the Man Bac human skeletal sample in terms of its sex and age-at-death distributions. Moreover, the preservation of the sample will be discussed in the context of a demographic reconstruction of the past population, which will include a range of measures of fertility. Inferences regarding the demographic 'health' of the population will be made with reference to major social and behavioural changes seen in the region some 3,500 years ago.

MATERIALS

Preservation, Completeness and Disturbance

Over the course of three excavations undertaken from 2004/5 to 2007 at Man Bac, 84 individuals with a range of skeletal preservation were observed. Some skeletons were extremely incomplete and/or highly disturbed with only a few bone fragments and grave goods. Fortunately, these were in the minority as many skeletons were fully articulated and complete. Some of the subadults were in fact remarkably well preserved with many preserving separate epiphyses and the small developing bones of the hands and feet (see Appendix 1).

Six of the 84 burials are not included in any of the following calculations (MB05M35, MB07H2M11, MB07H2M23 and MB07H2M25 were not excavated, while MB07H1M13b and MB05M33 were represented by a few isolated teeth only), leaving a total sample for demographic analysis of 78. Of the assessable sample 47/78 (60.3%) were complete or near complete, and in many of these the bone quality was very good. A further 22/78 (28.2%) were classed as incomplete where they were missing a skull and/or some major limb bones, usually from some disturbance in prehistory, or they were not within the bounds of the excavation. Only 9/78 (11.5%) were considered highly incomplete and fragmented. These data indicates that excellent preservation existed at the Man Bac cemetery compared with many other Southeast Asian skeletal samples, with many showing significantly less well preserved material. For example, less than a third of burials were deemed to be near complete at Noen U-Loke (Tayles et al., 2007); only 18% at Ban Lum Khao where, although bone quality was good, there was a lot of disturbance (Domett, 2004). Nong Nor was poorly preserved, with only 19% complete (Tayles et al., 1998); and at Ban Chiang, more than half of the skulls and postcranial skeletons were incomplete or fragmented (Pietrusewsky and Douglas, 2002a). Khok Phanom Di is one of the few sites that is on a par with Man Bac in terms of preservation with less than 10% missing any major element (Domett, 2001). The well preserved nature of the Man Bac skeletal sample has enabled a thorough assessment of demography and health to be undertaken. A complete set of burial descriptions is provided in Appendices 1 and 3.

METHODS

Age-At-Death Estimation

Subadults

The most reliable method of the age-at-death estimation of children (up to approximately 12 years) is through observations of the development (calcification) and eruption of the dentition. The dentition has been found to be more strongly controlled by genetic factors and less influenced by environmental factors compared to skeletal growth (Ubelaker, 1987; Saunders, 1992) and is therefore a more reliable indicator of *biological* age and provides a close approximation of *chronological* age (Saunders, 1992).

All mandibular and maxillary elements from subadults were radiographed in order to provide accurate evidence of calcification (or formation), rather than relying on the stage of eruption of the deciduous and permanent dentition; the latter approach is thought to be less accurate (Halcrow et al., 2007). These results were then compared with published standards (Buikstra and Ubelaker, 1994; White, 2000). These standards are not derived from Asian populations, but they are used in the absence of more population-specific information. There is very limited information regarding the development of teeth in Southeast Asian children and that which is published (eg. Kamalanathan, 1960) is based on modern populations. A full review of the effect of using non-population specific standards on prehistoric Southeast Asian children has recently been reviewed by Halcrow et al. (2007).

A number of subadults at Man Bac did not have any dentition preserved. In these cases long bone development (either complete or partial diaphyses) were compared with those Man Bac subadults that had been aged from their dentition. This method establishes a population specific set of standards rather than relying on individuals from other Southeast Asian populations as the comparison. There is also considerable information provided by Scheur and Black (2000) on the development of individual skeletal elements, this was used in conjunction with the population standards. There were only two subadults (MB05M6 and MB05M22) who had neither dentition nor complete diaphyseal lengths with which to estimate age-at-death. For these individuals, sections of their long bones were compared to similar bone sections in individuals aged by their dentition.

Once the second permanent molar has erupted around the age of 12 years, the dentition is no longer the most reliable indicator of age-at-death. Skeletons of these older children at Man Bac were aged through observation of epiphyseal fusion, predominantly based on Scheur and Black (2000). Again these published standards are not based on prehistoric Asian children but provide an excellent summary of the information that is available.

The categorisation of 'subadults' is often different in different studies. The issues that arise from this have recently been reviewed (Halcrow and Tayles, 2008). Biologically, most growth and development of a skeleton has been completed by the late teenage years and into the early 20s. However, socially, particularly in prehistory, a person of this age has likely been contributing to the economy and life of the community for some years. In addition there are also issues involved if comparisons want to be made to previous studies. In this way, the allocation of a specific age range to subadults necessitates changes depending on the questions asked. This will be made clear in the following discussion.

Adults

The estimation of age-at-death in those over 15 years is most reliably estimated through observation of the pubic symphyseal face. The Suchey Brooks standards (Buikstra and Ubelaker, 1994) were used on the Man Bac skeletons where the pubic symphysis was preserved. For those adults with no pubic symphyseal face preserved, some of the younger adults were able to be aged through observation of late fusing epiphyses. For those adults with neither of these observations possible (N=7), age-at-death has been estimated using functions, developed by Oxenham (2000) on a Da But period (c. 5,500 years BP) sample from northern Vietnam. These functions were originally developed by regressing Scott's (1979) molar wear scores on age-at-death determinations based on either symphyseal or auricular morphology. In order to test the validity of using these functions on a different ancient Vietnamese population, age-at-death was estimated for the 26 Man Bac individuals for which there existed independent (for the most part based on pubic symphyseal morphology and epiphyseal fusion) age estimates. Of the independently aged sub-sample (N=26), 20 individuals (76.9%) were found to fall within the same 10 year age bracket as provided by independent age estimates. Four individuals (15.4%) fell into an adjacent age category (all were aged by tooth wear as 30-39 years, whereas symphyseal morphology in each instance indicated an age of 40-49 years), while the final 2 cases had pathological wear patterns. In total, 24/26 individuals (92.3%) had their symphyseal and/or epiphyseal fusion age estimates confirmed to within a single decade of tooth wear age estimates. On this basis, some confidence was placed in estimating the age-at-death, using tooth wear scores, of the 6 individuals without other forms of independent age estimation.

Sex Estimation

Standard morphological analyses of the pelvis and skull were the primary sources of information for estimating the sex of an adult skeleton at Man Bac (Buikstra and Ubelaker, 1994). Those without the pelvis or skull have not been estimated for sex.

Sex estimation of subadults has not been proven to be particularly reliable (e.g. Cardaso and Saunders, 2008; Vlak et al., 2008) so results are not presented here.

RESULTS AND DISCUSSION

Overview

Table 2.1 details the age-at-death and sex estimate of each individual where possible. Table 2.2 provides a summary of the age-at-death of all individuals and the sex estimate of adults where possible. From this information it is possible to state that the skeletal remains comprising the excavated sample probably provide a representative sample of the entire cemetery population. This is primarily based on the results of the subadult mortality rate and the sex ratio of adults. Waldron (1994) suggests at least 30% of any pre-industrial sample should be subadult (less than 15 years); anything much lower could lead to inaccurate epidemiological calculations. The Man Bac subadult sample comprises 59% of the total sample, well above the suggested 30%. This, however, is a quite high subadult mortality, reasons for which will be discussed later, but does suggest a good retrieval rate for these fragile skeletons. The adult sex ratio of males to females from Man Bac is 1:0.8 (15:12). This is reasonably close to parity, to indicate a non sex-biased cemetery.

Subadults

The subadult section of the demographic profile can be very useful in providing a picture of health and quality of life in a prehistoric sample. This group is

Table 2.1 The age-at-death and sex estimation of each individual from Man Bac (2004/5 to 2007).

Excavation ID	Burial No.	Sex	Age-at-death	Notes
MB05	1		18 mths +/- 5 mths	incomplete, fragmented
MB05	2		neonate	near complete
MB05	3		6 mths +/- 2 mths	near complete
MB05	4		2 yrs +/- 6 mths	incomplete
MB05	5		18 mths +/- 3 mths	near complete
MB05	6		~18 mths	incomplete
MB05	7		neonate	incomplete
MB05	8		6 mths	incomplete
MB05	9	Female	40-49 yrs	near complete
MB05	10		9 yrs +/- 9 mths	near complete
MB05	11	Male	18-25 yrs	near complete
MB05	12		2 yrs +/- 6 mths	near complete
MB05	13	?	16 yrs	near complete
MB05	14		2.5 yrs	near complete
MB05	15	Female	17-18 yrs	incomplete
MB05	16a	Female	40-49 yrs	incomplete
MB05	16b		neonate	incomplete, fragmented
MB05	17	?	Adult	incomplete, fragmented
MB05	18		18 mths +/- 3 mths	near complete
MB05	19	?	Adult	incomplete, fragmented
MB05	20	Male?	15-29 yrs	near complete
MB05	21		6 mths	near complete
MB05	22		18 mths	incomplete, fragmented
MB05	23		15 mths	incomplete
MB05	24		8 yrs +/- 9 mths	near complete
MB05	25		5 yrs +/- 9 mths	near complete
MB05	26		4-5 yrs +/- 1 yr	incomplete, fragmented
MB05	27	?	Adult	incomplete
MB05	28	Female?	15-29 yrs	incomplete
MB05	29	Male	30-30 yrs	near complete
MB05	30		6 months	near complete
MB05	31	Male	20-29 yrs	near complete
MB05	32	Male?	15-29 yrs	incomplete, fragmented
MB05	33			teeth only
MB05	34	Female	40-40 yrs	near complete
MB05	35			not excavated
MB05	36		3 yrs +/- 6 mths	incomplete

Table 2.1 continued next page.

Table 2.1 (continued).

Excavation ID	Burial No.	Sex	Age-at-death	Notes
MB07H1	1		12 yrs +/- 6 mths	incomplete
MB07H1	2		neonate	incomplete,fragmented
MB07H1	3		12-18 yrs	near complete
MB07H1	4	Female?	30+ yrs	incomplete
MB07H1	5	Male	40-49 yrs	near complete
MB07H1	6		6 mths +/- 2 mths / 9 mths +/-2 mth	near complete
MB07H1	7		1 yr +/- 3 mths	incomplete
MB07H1	8	Male	30-39 yrs	near complete
MB07H1	9	Male?	15-29 yrs	incomplete
MB07H1	10	Male?	40-49 yrs	near complete
MB07H1	11	Female	50+ yrs	near complete
MB07H1	12		neonate	incomplete,fragmented
MB07H1	13a	?	30+ yrs	incomplete
MB07H1	13b		~10 yrs	incomplete
MB07H1	14	?	30+ yrs	incomplete
MB07H2	1	Male	40-49 yrs	near complete
MB07H2	2		12-18 yrs	near complete
MB07H2	3		neonate	incomplete
MB07H2	4		18 mths	incomplete
MB07H2	5	Female	20-25 yrs	near complete
MB07H2	6		2 yrs +/- 6 mths	near complete
MB07H2	7		18 mths +/- 5 mths	near complete
MB07H2	8		1 yr +/- 3 mths / 18 mths +/- 5 mths	near complete
MB07H2	9		neonate	incomplete
MB07H2	10	Male	30-39 yrs	near complete
MB07H2	11	?	Adult	not excavated
MB07H2	12	Female	50+ yrs	near complete
MB07H2	13		4 yrs +/- 9 mths	near complete
MB07H2	14		neonate	near complete
MB07H2	15		4 yrs +/- 9 mths	near complete
MB07H2	16		1 yr +/- 3 mths / 18 mths +/- 5 mths	incomplete
MB07H2	17		13-18 yrs	near complete
MB07H2	18	Female	18-24 yrs	near complete
MB07H2	19	Male	20-24 yrs	near complete
MB07H2	20		6 mths +/- 2 mths	near complete
MB07H2	21		9 mths +/- 2 mths	incomplete
MB07H2	22	Female	30-39 yrs	near complete
MB07H2	23	?	Adult	not excavated
MB07H2	24	Female?	40-49 yrs	near complete
MB07H2	25	?	Adult	not excavated
MB07H2	26		18 mths +/- 5 mths	near complete
MB07H2	27	Male	30-39 yrs	near complete
MB07H2	28		neonate	near complete
MB07H2	29		7 yrs +/- 9 mths	incomplete
MB07H2	30	Male	30-39 yrs	near complete
MB07H2	31		4 yrs +/- 9 mths	near complete
MB07H2	32	Male	<25 yrs	near complete

particularly vulnerable to environmental and cultural pressures, and their response to such pressures can indicate how robust the whole population may have been in buffering against these pressures (Saunders, 2008; Lewis and Gowland, 2007; Bogin 1999; Goodman and Armelagos, 1989).

The subadult section of Man Bac is also worthy of further detailed examination given their high mortality (46/78, 59%). Figure 2.1 (and Table 2.2) shows the breakdown of the subadults into specific age classes. The 1-4 year age group shows the highest mortality (21/78, 26.9%), with the infant age class at 20.5% (16/78). It would perhaps be more typical to see the highest mortality in the infant age class representing the most vulnerable period in the first year (typically the first month) of life (Goodman and Armelagos, 1989). Table 2.3 and Figure 2.2 provide a demographical comparison between Man Bac and other Southeast Asian samples.

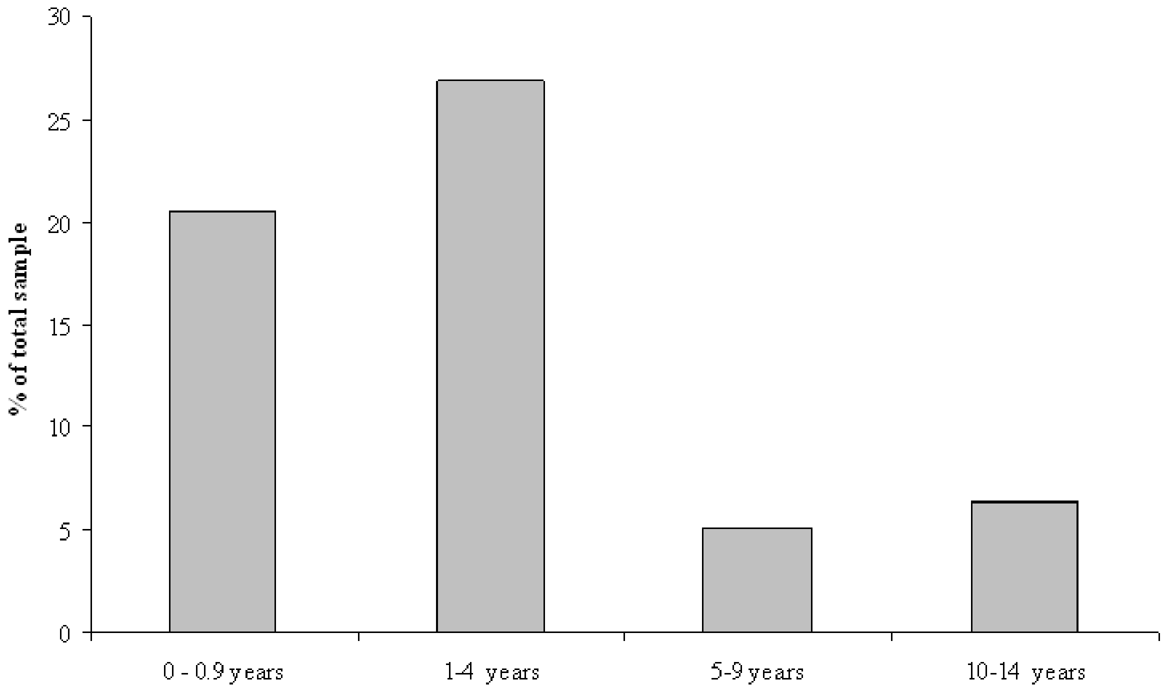

Figure 2.1 Age specific mortality for Man Bac subadults as a percentage of the total sample (n=78).

Table 2.2 Demographic profile of the skeletal remains from Man Bac.

Age	Number	%							Notes
0 - 0.9	16	20.5							
1-4	21	26.9							
5-9 years	4	5.1							
10-18	5	6.4							1
Subtotal	46	59.0							
			Female	%	Male	%	?sex	%	
18-29	11	14.1	4		7				2
30-39	9	11.5	2		5		2		
40-49+	7	9.0	4		3				
50+	2	2.6	2		0				
Unknown	3	3.8	0		0		3		
Subtotal	32	41.0	12	37.5	15	46.9	5	15.6	
Total	78								3

Notes:
1: Includes those aged 12-18 years and 13-18 years
2: Includes adults aged 15-29 years, 17-18 years, 18-24 years, 18-25 years
3: Excludes MB05 M33 and M35; MB07H2 M25, M23 and M11

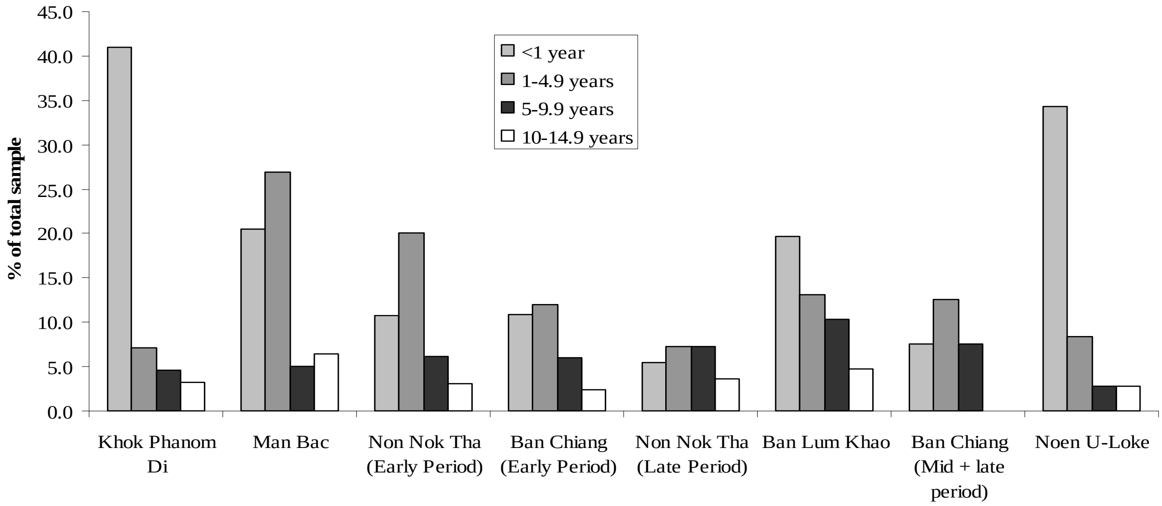

Figure 2.2 Subadult mortality across prehistoric Southeast Asia.

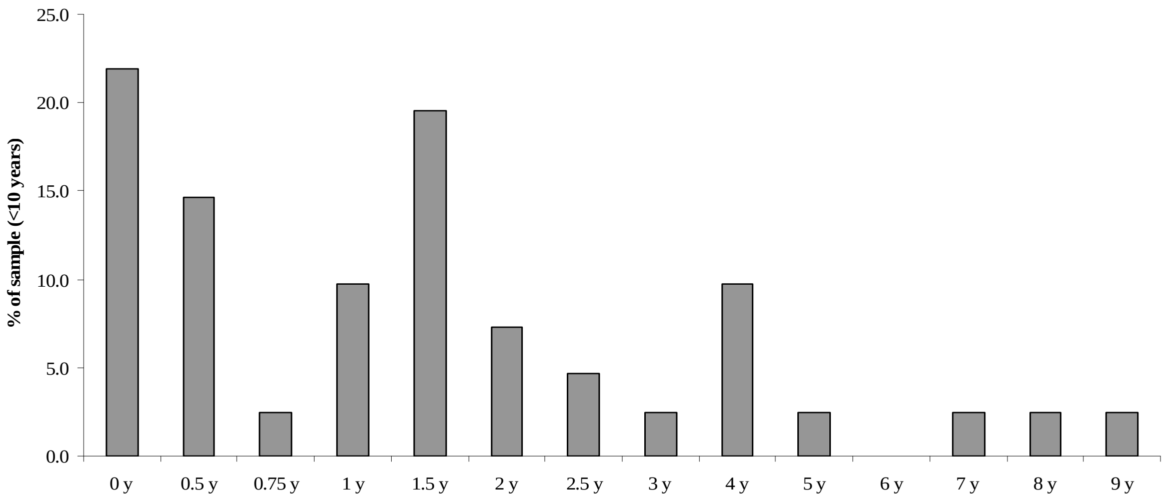

Figure 2.3 Subadult mortality by age at Man Bac (as a proportion of the total of 0-9 year olds, N= 41).

Evidence from three sites, Khok Phanom Di, Ban Lum Khao, and Noen U-Loke, that span the neolithic, Bronze and Iron Ages respectively, indicate that all have higher mortality rates in the less than 1 year of age class, with a decrease with age. Other sites, such as Ban Chiang and Non Nok Tha, have higher mortality in the 1-4 year olds. However, Pietrusewsky and Douglas (2002b) state that subadults in the Ban Chiang sample are underrepresented, although, they are just within the 30% cut-off suggested by Waldron (1994), but at Late Non Nok Tha only 12.5% were subadults (less than 15 years) (Douglas, 1996). All samples of skeletons in Figure 2.2 have particular sampling issues but perhaps Khok Phanom Di, Ban Lum Khao and possibly Noen U-Loke are somewhat more representative.

Given that the sample size is quite adequate for Man Bac, with a good retrieval rate for subadult skeletons, it is likely that taphonomic reasons are not the explanation for the discrepancy in mortality between the first year of life and 1-4 years of age. In order to delve into this further it is useful to break down the data into more specific age ranges. Figure 2.3 shows the breakdown of those subadults less than 10 years of age (N=41). There appear to be peaks at 0 years (N=9) and 1.5

Table 2.3 Palaeodemographic values for Man Bac and other prehistoric Southeast Asian communities (from Oxenham et al., 2008b, but with new data for Man Bac).

Sample	Time period	<5 years	5-9.9 years	10-14.9 years	15-19.9 years	20+ years	JA Ratio	D20+/ D5+	MCM	DR
Khok Phanom Di	Neolithic	48.1	4.5	3.2	5.2	39.0	0.20	0.750	0.091	1.30
Man Bac	Neolithic - Early Bronze	47.4	5.1	3.8	3.8	35.9	0.25	0.737	0.097	1.48
Non Nok Tha (Early)	Neolithic - Bronze Age	27.7	4.8	2.4	2.4	62.6	0.12	0.867	0.047	1.27
Ban Chiang (Early)	Neolithic - Bronze Age	20.6	5.4	2.2	7.9	64.5	0.12	0.851	0.052	0.52
Non Nok Tha (Late)	Bronze Age	5.0	5.0	2.5	1.3	86.3	0.09	0.908	0.032	0.30
Ban Lum Khao	Bronze Age	32.7	10.3	4.7	4.7	47.7	0.30	0.708	0.108	1.38
Ban Chiang (Mid + Late)	Iron Age	17.4	6.5	0.0	10.9	65.3	0.10	0.842	0.055	0.48
Noen U-Loke	Iron Age	43.0	2.8	2.8	3.7	47.7	0.11	0.709	0.058	1.45

Subadults <15 years; JA Ratio – Juvenile Adult Ratio; D20+/D5+ - proportion of those aged over 20years compared to those aged over 5years; MCM - Mean childhood mortality; DR – dependency ratio

Note: In order to make comparisons with these Southeast Asian samples, the Man Bac sample age ranges (Table 2.2) have been modified to fit this format.

years (N=8) in particular, but also a lesser peak at 6 months (N=6) (Figure 2.3). This is similar to the pattern reported by Oxenham et al. (2008a) where it was suggested the effects of weaning could be responsible for the second mortality peak at 18 months. It is well accepted that the risk of dying is highest at birth and within the first week or so of birth (see discussion in Halcrow et al., 2008: 388), therefore a peak at the neonate period is not surprising and conforms to expectations. Peaks at 6 months and 1.5 years may well relate to other well known phenomena, those of the introduction of solid foods at 6 months and weaning around 2-4 years (Lewis and Roberts, 1997). The weaning period is known to be associated with significant risk of morbidity and mortality for a number of factors. This is the time period where breast milk is removed from the infant diet and replaced with foodstuffs likely to contain a higher pathogen load and lead to gastrointestinal infection and diarrhoea which can be a serious disease in young children. The infant is also now required to develop its own antibodies to new diseases and can no longer rely on antibodies from breast-milk. In addition, the infant's immature gastrointestinal system is required to adapt to digesting larger amounts of these new foodstuffs and can result in calorie deficiencies and also induce diarrhoea (Lewis and Roberts, 1997; Goodman and Armelagos, 1989).

If the peak at 1.5 years indicates the period of weaning at Man Bac then it may be considered to have occurred quite early in comparison with developing countries today (Lewis and Roberts, 1997). However, it is also possible that the age-at-death estimation methods for Southeast Asian children are inappropriate, as many are based on American or European children. Halcrow et al. (2007) suggest Southeast Asian subadults (in this case older children) are being overaged by 1 or sometimes 2 years when European standards for the permanent dentition, such as Moorrees et al. (1963), are used to estimate age-at-death. Therefore it is quite possible younger Southeast Asian children and infants are also being overaged; at the very least age-at-death estimation methods need to be considered as a factor in the interpretation of the timing of significant events during childhood (Halcrow et al., 2007). It may be possible to combine demographic evidence with enamel hypoplasia presented later (Chapter 7) in order to further investigate a possible peak of stress.

Adults

Thirty two (41%) of the 78 burials excavated were those of adult individuals. As mentioned above there were both males and females identified at a ratio of 1:0.8 (15:12) and this difference is not statistically significant (FET p-value = 0.5867). There were five adult individuals that were not able to be assigned a sex estimate. Three of these could also not be assessed for age. This small number of unknowns is indicative of the excellent preservation of the material.

Table 2.2 indicates the distribution of males and females in each of the major age ranges. Although there are some disparities within the age groups, there were no statistically significant differences in the proportion of males and females within each age range (18-29 years FET p-value = 0.395; 30-39 years FET p-value = 0.286; 40-49+ years FET p-value = 0.347). This is probably at least partly due to the small sample sizes within each class. There were slightly more young adults than middle or older aged adults but the differences were not statistically significant (18-29 years vs 30-39 years FET p-value = 0.783; 18-29 years vs 40-49+years FET p-value

= 0.783; 30-39 years vs 40-49+ years FET p-value = 1.000).

Palaeodemographic Calculations

Palaeodemographic calculations can provide measures of fertility within a population (Jackes 1992). Table 2.3 provides the results of the calculations for the juvenile/adult ratio (JA ratio = ratio of children aged between 5 and 15 years to adults aged 20 years and over) and the mean childhood mortality (average of probability measures 5q5, 5q10, 5q15 from a life table), both of which have increasing values with increasing fertility. The D20+/D5+ ratio (the proportion of individuals living over 20 years to all the individuals that survived to at least 5 years of age) decreases with increasing fertility.

The values for Man Bac in comparison with other Southeast Asian samples indicate that Man Bac has a high JA (0.25), a high MCM (0.097) and a lower D20+/D5+ (0.737) (Table 2.3). This would indicate that Man Bac has a high level of fertility in comparison with other samples. On a broader scale, for example in comparison with worldwide values for JA and MCM indicated in Jackes (1994), the Man Bac values are still high and, like Ban Lum Khao, indicate a population that was rapidly growing. Khok Phanom Di also shows high fertility values (high JA and MCM and low D20+/D5+), and like Man Bac, has a very high sub 5 year old mortality (Table 2.3). The sample from Noen U-Loke also showed a high proportion of individuals dying before 5 years of age, but the JA and MCM values (which do not take this into account) are much lower (0.11 and 0.058 respectively) although the D20+/D5+ value (0.709) is low, similar to Man Bac. These results tend to show that Noen U-Loke is still growing but at a much slower rate than Man Bac (Domett and Tayles, 2006).

The dependency ratio (DR, Table 2.3) shows that Man Bac had the highest value (1.48). This means that were a high number of children per adult. An earlier report on the smaller 2005 Man Bac sample alone indicated an extremely high DR of 4.48 (Oxenham et al., 2008b). After subsequent excavations and an enlargement of the skeletal sample that has been reduced to 1.48 which, although still high, indicates the value of excavating as much of a prehistoric site as possible. Other sites with high DR values include Noen U-Loke (1.45), Ban Lum Khao (1.38), and Khok Phanom Di (1.30).

SUMMARY

The state of preservation of the Man Bac human skeletal material is excellent by Southeast Asian standards with nearly 60% of individuals complete or near complete. The age-at-death of the vast majority of subadult and adult remains was determined using a range of age-appropriate techniques. An unexpected bimodal subadult mortality distribution was noted, with an expected peak among the neonates and an unexpected peak at approximately 18 months of age. If the 18 months peak is not an artefact of the age-at-death determination methods employed, it may be correlated with weaning behaviours. While the majority of adults were aged using either epiphyseal fusion timing or pubic symphyseal morphology, a small subset were aged using dental wear functions developed on a temporally earlier northern Vietnamese sample. Testing of the accuracy of these equations was carried out on known age Man Bac individuals. That these equations could be accurately applied to the Man Bac assemblage suggests that similar tooth wear trajectories existed in both populations. Why this should be the case may be due to the observation that both the Man Bac and mid Holocene Da But communities were primarily hunter-gatherers in very similar environments, rather than agriculturalists. Adult sex estimation suggests an expected ratio of males to females, again supporting the demographic representativeness of the sample.

The demographic reconstruction of the Man Bac sample suggests a community experiencing elevated levels of fertility. The conclusions of an earlier assessment of a much smaller Man Bac sample (see Bellwood and Oxenham, 2008) are reconfirmed by this study, although the extreme values for each of the fertility measures in the earlier study have been substantially revised with a much larger sample. Nonetheless, Man Bac, along with Khok Phanom Di, essentially contemporaneous populations, show levels of fertility consistent with a major economic and/or behavioural shift in the region. These demographic findings are entirely consistent with the elevated levels of physiological disruption and oral disease, and the evidence for population shifts discussed in later chapters.

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