

Infant Death in Late Prehistoric Southeast Asia



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INTRODUCTION

Of the three great crises of a Thai peasant's life—birth, marriage, and death—the village is most vitally concerned with death.

—de Young 1963:73

LEACH (1973) ONCE STATED THAT THE SOCIAL ORGANIZATION of prehistoric communities were forever sealed in a “black box,” and that archaeologists could never truly know what was inside. He states in response to the New Archaeologists' claims of scientifically clarifying how these social systems work in the past that “speculations about the workings of the sociological Black Box can never rate better than ‘well informed guesses’” (Leach 1973:768). In contrast, Metcalf and Huntington (1991:25) maintain in regard to the archaeological analysis of burial rites that “the study of death rituals is a positive endeavour because, regardless of whether custom calls for festive or restrained behaviour, the issue of death throws into relief the most important cultural values by which people live their lives and evaluate their experiences. Life becomes transparent against the background of death, and fundamental social and cultural values are revealed.” Furthermore, burial rites given to the young are especially useful for gaining insights into social and cultural factors of the society from which they are drawn (Renfrew and Bahn 2004:119–200; Tainter 1978).

The high proportion of deaths around full-term gestation in the early phases of the pre-metal site of Khok Phanom Di in central Thailand compared with other excavated sites in Southeast Asia is an enigma (Tayles 1999). This is an important issue in bioarchaeological analysis as the patterns and rates of subadult death are argued to be important measures of population health (Mensforth et al. 1978; Reidpath and Allotey 2003). To investigate whether this mortality pattern is “real” as a result of poor health or due to a social custom or cemetery subdivision,

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the aim of this paper is to compare perinatal¹ death distributions of Khok Phanom Di with later periods represented by the other prehistoric Thai skeletal samples. The consideration of social aspects of the prehistoric communities as reflected in infant burial ritual is an innovative avenue to investigate this issue further. Ethnographic information on infant burial rites in Southeast Asia and archaeological evidence of infant burial treatment and social organization will be used to assist with interpretation.

Although infant burial rites and practices have been described and documented in many archaeological works on inhumation sites in prehistoric Southeast Asia (e.g., Higham and Bannanurag 1990; Higham and Kijngam 1984; Higham and Thosarat 1998; White 1986), a detailed comparative study of these mortuary practices among several sites has not been investigated (Hudson 2002; O'Reilly 1999; Talbot 2002). Very rarely is bioarchaeology used to explore this social issue. As certain burial rites and customs can have an effect on whether an infant is included in a cemetery, and thereby an influence on the age distribution of the infant component in archaeological contexts (La Fontaine 1986:18; Mays 1993; Scheuer and Black 2000), the study of age distributions is an important tool to investigate burial practices. A useful method is the analysis of perinatal age at death distributions where age is estimated using long bone lengths. Tocheri et al. (2005:328) attest to the usefulness of this endeavour. They state that, in addition to providing information for demographic, epidemiological, and genetic research, it can also give insights into religious ideologies and mortuary treatment (Tocheri et al. 2005:328). Furthermore, archaeological sampling bias needs to be considered in interpretation of perinatal age distributions.

It is uncommon to find a large proportion of perinatal skeletal remains represented at archaeological sites (Tocheri et al. 2005). These skeletal remains are less likely to be preserved due to their fragile nature and greater organic component (Gordon and Buikstra 1981; Guy et al. 1997; Walker et al. 1988). There is also a problem of misidentification of these bones in an excavation context (Scheuer and Black 2000). Perinatal burials may be missed in the excavation process due to factors including bioturbation of soils that result in the disappearance of grave cuts and a lack of grave goods indicating an interment. The area chosen for excavation by the archaeologist may also have an impact on the recovery of these individuals. These combined factors contribute to the apparent underrepresentation of perinatal remains in most archaeological assemblages. In addition, there are many studies that infer cultural reasons for the underrepresentation of juvenile skeletons in the archaeological context. As stated by Lewis (2000:40–41), “[w]hen using data derived from cemetery samples it is important to remember that we are actually measuring *burial rates* and not *mortality rates*. Cultural practices may dictate if, and where, certain individuals were placed within a cemetery; non-adults are often clustered.” These practices may include infanticide and cemetery subdivision resulting in babies being buried in different places from the main inhumation area (Hausfater and Hrdy 1984; Jamieson 1995; Mays 1998:23–25; Saunders 2000:136; Scrimshaw 1984). For example, it has been shown in a number of historic African-American sites that infants and children were interred away from main community burial places (Jamieson 1995; Ucko 1969:271).

SOCIAL ORGANIZATION IN LATE PREHISTORIC SOUTHEAST ASIA

Recent excavations at a number of sites in Thailand have increased the sample of infants available for study from prehistoric Southeast Asia (Bayard 1971; Higham 2002; Higham et al. 2007; Higham and Thosarat 2004b; White 1986). These samples provide a rare opportunity to investigate the issues mentioned above. Archaeological evidence of social structure of the communities represented at the individual sites have been discussed extensively in the literature (Bayard 1972; Chang 2001; Higham 1996, 2002; O'Reilly 2001; Talbot 2002; Vincent 2004; White 1986, 1995), and for the purposes of this article are not repeated here. Rather, a brief overview of social organization development over time is presented to demonstrate some of the implications these changes have on mortuary practices. The following overview focuses, for the most part, on the orthodox view of social organization from sites in prehistoric Thailand following mainly the works of Higham (1989, 2002). Although it is acknowledged that the use of a typology as proposed by Elman Service (1962) is simplistic, and on some levels not applicable to Southeast Asia, it is used here for comparative purposes to highlight important social information in these societies that do not adhere to this social evolutionary model.

At the start of the four-step scheme is the band level or hunter-gatherer society (Renfrew and Bahn 2004:179). This has an egalitarian social organization and informal leadership. Archaeological sites with this form of social organization, due to their mobile settlement patterns, consist mainly of seasonally occupied sites and a smaller number of other specialized sites. Sites that adhere to this typology have been found from South China to Myanmar, mainly in inland rockshelters (Higham and Thosarat 1998:25). These sites have been ascribed the name of Hoabinhian after a "type-site" in Viet Nam and include Lang Rongrien in Southwest Thailand, Spirit Cave and Steep Cliff Cave in Northern Thailand, as well as Tham Pra and Sai Yok in Viet Nam (Anderson 1990; Gorman 1970). Representation of another type of prehistoric hunter-gatherer group has been found in the rich coastal areas of central Thailand. The initial occupation phase at Nong Nor, a site formerly located on an embayment of the coast of the Gulf of Thailand, is characteristic of this adaptation (Higham and Thosarat 1998). Archaeological analysis indicates that there was a brief occupation of a few months at this site consistent with a hunter-gatherer lifestyle (Mason 1998).

The next type of social organization in this scheme is termed a segmentary society. These societies operate on a larger scale than bands and usually consist of sedentary villages (Renfrew and Bahn 2004:180). These communities operate in an autonomous manner. Decisions affecting the community are made from within, with no permanent hierarchy or elite group, and without any outside authority (Higham 1998:129). Analysis at the pre-metal hunter-gatherer site of Khok Phanom Di has suggested that wealth oscillated between family groups over an occupation of about 600 years (Higham 1989:39; Higham and Thosarat 1994:110). This analysis shows that in rich environments hunter-gatherer groups can, contrary to commonly held assumptions, maintain a sedentary lifestyle and develop distinctions in wealth and status.

The social trends seen at Khok Phanom Di were maintained to some extent

with the appearance of bronze in Southeast Asia, much to the bewilderment of social archaeologists (Muhly 1988:16). Higham and Thosarat (1998), in reference to Bronze Age cemetery sites in Southeast Asia, conclude that although no two villages are alike, they follow a distinctive theme in that there is generally a moderate differential between burial clusters indicative of a society where individuals have the ability to achieve a higher status through their own merit. The lack of large settlements and military paraphernalia from these sites is congruous with the models of segmentary societies that have been proposed (O'Reilly 1999).

Another avenue to investigate the social organization at this time is to examine the organization of copper production. White and Piggott (1996), through an examination of this prehistoric activity in Northeast Thailand, have concluded that although mining and smelting reached industrial levels, it was carried out in small seasonal groups with no evidence of overarching production controls. A strong economic basis in community-based specialization does not adhere well with theories of social complexity development where there is a general assumption that this scale of production required an elite to control production (White 1995; White and Piggott 1996).

This problem with identification of social forms with the introduction of the Bronze Age in Southeast Asia proposed by existing archaeological theories is beginning to be addressed by the consideration of alternative theoretical models of social development (e.g., Crumley 1995:3; O'Reilly 2001, 2003; White 1995). However, recent excavation at the site of Ban Non Wat in Northeast Thailand, with abundant evidence of prehistoric life from the Neolithic to the Iron Age may challenge previous interpretations of social organization at this time. Of interest to this discussion are the extremely rich burials in the early Bronze Age, some of which are infants and children, argued to be indicative of a major social change occurring at this time in prehistoric Southeast Asia (Higham pers. comm.).

This organizational form met a major dislocation with the combined effects of iron availability and external influences through increased exotic trade (Higham 2002:170). This brings us to the third major form of social organization in Service's (1962) typology, the chiefdom. This form of social organization is characterized by increased complexity of social structure, productivity, population density, and the rise of institutionalized offices of leadership (Peebles and Kus 1977). The Mun River Valley in Northeast Thailand is a region where many sites that conform to this organizational form have been identified. At these sites there is a substantial increase in mortuary differentiation indicative of a rise of social status differentiation with an emphasis on hereditary relationships. The range of grave goods increases with a wider variety of materials being used, including iron, glass, and combinations of bronze and iron (O'Reilly 1999:289). O'Reilly (1999:289–290) proposes, on the assumption of the greater skills required to produce the elaborate grave goods, that there was an increase in craft specialization and standardization and therefore centralization of the production of goods during this time (Stein 1998). There is also evidence of an increasing amount of weaponry indicating population stress and conflict (Chetwin 2001; Higham and Thosarat 1998; Talbot 2002). The rise in social inequality in the development of chiefdoms laid the foundation for the transition to the state.

ANALYSIS OF PERINATAL AGE AT DEATH AT KHOK PHANOM DI
AND THE OTHER PREHISTORIC THAI SITES*Aims*

This study presents an analysis of the perinatal age at death distributions in prehistoric mainland Southeast Asia. The aim is to investigate the reason for the high mortality at full-term gestation at Khok Phanom Di compared with later sites and whether or not this difference in mortality is real or reflects differences in infant burial treatment and hence a social custom of cemetery subdivision. Objectives to fulfill this aim include an analysis of age at death distribution of the Khok Phanom Di perinates compared with those from the later sites as well as to modern age distribution data. Differences in evidence of social organization and a preliminary survey of whether infants were interred in burial jars or not among the sites and ethnographical information on infant burial treatment will be used for interpretation.

Estimation of Age Using Long Bone Length

Although long bone growth is considered more variable than dental formation in relationship to chronological age, the forming deciduous teeth in perinatal individuals are tiny and often not recovered in archaeological contexts. The estimation of dental age from available standards that have the first stage of dental development at around birth results in less precise age categories compared with long bone lengths (Moorrees et al. 1963). The use of long bone lengths for the estimation of age are also advantageous because bone growth and development is very rapid at this time, which results in large differences in bone length between age categories (Jeanty and Romero 1984). Because of this it has been argued that interindividual variation of long bone lengths for age is minimal in the perinatal period and only really becomes an issue in older children (cf. Lancaster 1990; Mays 1998:42–43).

Comparative Perinatal Age at Death Distributions

The age distributions of modern perinatal deaths and births are useful in the interpretation of archaeological mortality data and have been used by bioarchaeologists to infer possible causes of death in perinatal samples (Mays 1993, 2003; Tocheri et al. 2005) (Fig. 1). Good comparative data on perinatal death is available for white children around the middle of last century from North America and England (Butler and Alberman 1969; Gibson and McKeown 1951; Hoffman et al. 1974). Mays (1993:886) using data from Hoffman et al. (1974) on white U.S. children born in 1968 observed that the distribution of stillbirths was skewed towards the earlier gestation periods (Fig. 1A). This distribution peaks at around full-term but this is not very pronounced (Mays 1993:886). These data showed an increase over time in the percentage of stillbirths occurring during the third trimester. Mays (1993:886) noted from Gibson and McKeown's (1951) data that, similarly to that observed for stillbirths, the distribution of live births dying within

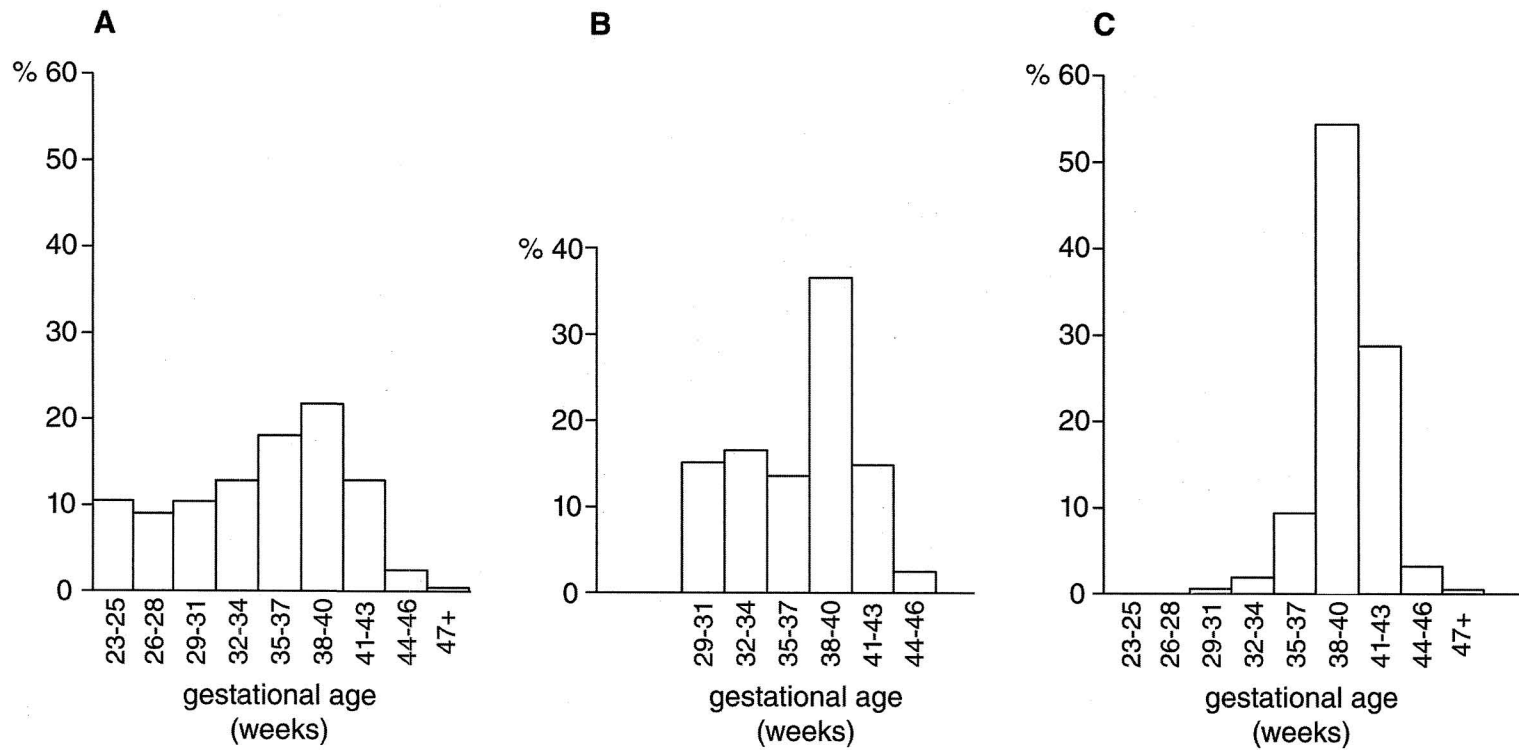


Fig. 1. Age at death and -birth distributions of modern perinatal individuals (from Mays 1993:885). Key: A = modern stillbirths; B = modern live births dying within seven days of birth; C = total modern live births.

the first week after birth also showed a pattern of skewness toward the earlier gestational ages (Fig. 1B). The distribution again peaked at full-term and is more pronounced than is the case for stillbirths. It should be noted, however, that apart from the pronounced peak in death of live born infants around full-term there seemed to be a decline in death through the third trimester. These data showed that death around the time of birth occurred more frequently in the pre-term baby and the incidence of death *in utero* was more common as the perinate neared full-term gestation. This pattern was also shown in a study of perinatal mortality in Britain in 1958 where the ratio of stillbirths to neonatal deaths increases during the third trimester (Butler and Alberman 1969:171). Butler and Alberman (1969:169) argued that this pattern may be explained by the clinical observation that infants born pre-term were more likely to result in neonatal death due to their immaturity and therefore inability to cope after birth. Conversely, they argued that prenatal deprivation may cause intrauterine death (Butler and Alberman 1969:169). The distribution of gestational age of live births had a normal distribution with a higher peak at full-term than the age distribution of death after live birth (Fig. 1C; Hoffman et al. 1974).

The Infanticide Issue

Infanticide or the killing of babies around the time of birth has been documented in all continents in different times in history as well as modern times (Hausfater and Hrdy 1984; Langer 1974; Mays 1993:883; Williamson 1978). The identification of this practice in an archaeological context is extremely difficult (Scott 1999:66). Smith and Kahila (1992) have produced a study on a large collection of infant bones excavated from a late Roman site at Ashkelon in Israel. Using long bone lengths and dental data they aged the perinates as around full-term. Based on this observation, the burial context and historical information on infanticide the authors argued that this site was a disposal area for unwanted babies. Smith and Kahila (1992) found that on sectioning a sample of teeth that none exhibited neonatal lines. Because of this, the findings that the infants had a narrow range of long bone lengths and were disposed of in a sewer, it was concluded that they were probably victims of infanticide (Smith and Kahila 1992).

Mays (1993) produced a valuable study on perinatal death in Romano-British sites. The age distribution at the combined sites was compared with that of the British medieval site of Wharram Percy and other modern perinatal gestational age at death and birth distributions as discussed above (Hoffman et al. 1974). The age distributions from the Romano-British sites had a pronounced peak at around full-term whereas Wharram Percy had a much flatter distribution with little central tendency. These differences have been shown to be statistically significant (Mays 1993). In comparison with gestational age data of stillbirths, deaths a few days after a live birth, and live births it was suggested that the perinatal age distribution from Wharram Percy was very similar to stillbirth and death soon after birth. Comparatively, the age distribution from the Romano-British sites was very similar to that of live births (Mays 1993). Mays (1993) argued on this basis, and using historical information, that the mortality results at the Romano-British sites were likely to represent the practice of infanticide. However, as discussed

TABLE I. DETAILS OF THE THAI PERINATAL SAMPLES INCLUDING REGION, CEMETERY DATES,¹ SAMPLE SIZE, AND NUMBER WITH MEASURABLE LONG BONES

SITE AND PREVIOUS BIOARCHAEOLOGICAL RESEARCH	REGION	CEMETERY DATES	TOTAL PERINATAL SAMPLES	NUMBER OF PERINATES WITH MEASURABLE LONG BONES (PERCENT OF TOTAL PERINATAL SAMPLE)
Khok Phanom Di (Domett 2001; Tayles 1999)	SE Thailand (Bang Pakong region)	4000–3500 B.P. (Higham and Thosarat 1994)	51	49 (96.1%)
Non Nok Tha (Douglas 1996; Pietruszewsky 1974 <i>a</i> , 1974 <i>b</i>)	NE Thailand (Chi River Valley)	Varied dates 4800–1800 B.P. (Bayard 1971; Douglas 1996:57; Pietruszewsky and Douglas 2002 <i>a</i> :221). Higham (1996:191) prefers an initial occupation between 4000–3500 B.P. with the bulk of occupation from 3500–3000 B.P.	4	2 (50.0%)
Ban Chiang (Douglas 1996; Pietruszewsky 1978, 1982, 1984, 1997; Pietruszewsky and Douglas 2002 <i>a</i> , 2002 <i>b</i>)	NE Thailand (Songkhram River)	4100–1800 B.P. Mostly from 4100–2300 B.P. (Higham and Thosarat 1998; Pietruszewsky and Douglas 2002 <i>a</i> :5)	6	5 (83.3%)
Ban Lum Khao (Domett 2001)	NE Thailand (Mun River Valley)	3000–2500 B.P. (Higham and Thosarat 1998:114)	15	11 (73.3%)
Ban Na Di (Domett 2001; Houghton and Wiriyaromp 1984)	NE Thailand (Songkhram River)	2900–2400 B.P. (Higham 2002:138)	10	9 (90.0%)
Noen U-Loke (Nelsen 1999; Tayles and Buckley 2004; Tayles et al. 1998)	NE Thailand (Mun River Valley)	c. 2300–c. 1500 B.P. (Higham 2002:197)	28	12 (42.9%)
Muang Sema (Pureepatpong 2001)	NE Thailand (Mun River Valley)	c. 2000–c. 1500 B.P. ² (Pureepatpong 2001; Thosarat, pers. comm.)	7	5 (71.4%)
		Total	121	93 (76.9%)

¹ It is noted that there is considerable disagreement on the cemetery dates for the sites of Non Nok Tha (Bayard 1996; Higham 1996) and Ban Chiang (Glover and Syme 1993:48; White 1997)

² No radiocarbon dates available, aged by material artifacts as late Iron Age (R. Thosarat, pers comm.)

later, a large number of studies from past populations have shown similar perinatal age distributions to that seen at the Romano-British sites.

Materials and Methods

This study investigates perinatal age at death from seven sites from different locations and time periods in late prehistoric mainland Southeast Asia, all of which are in present-day Thailand (Table 1 and Fig. 2). Khok Phanom Di is the only site that has individuals represented from the pre-metal period. Although Non Nok Tha and Ban Chiang have temporal sequences that span pre-metal to metal

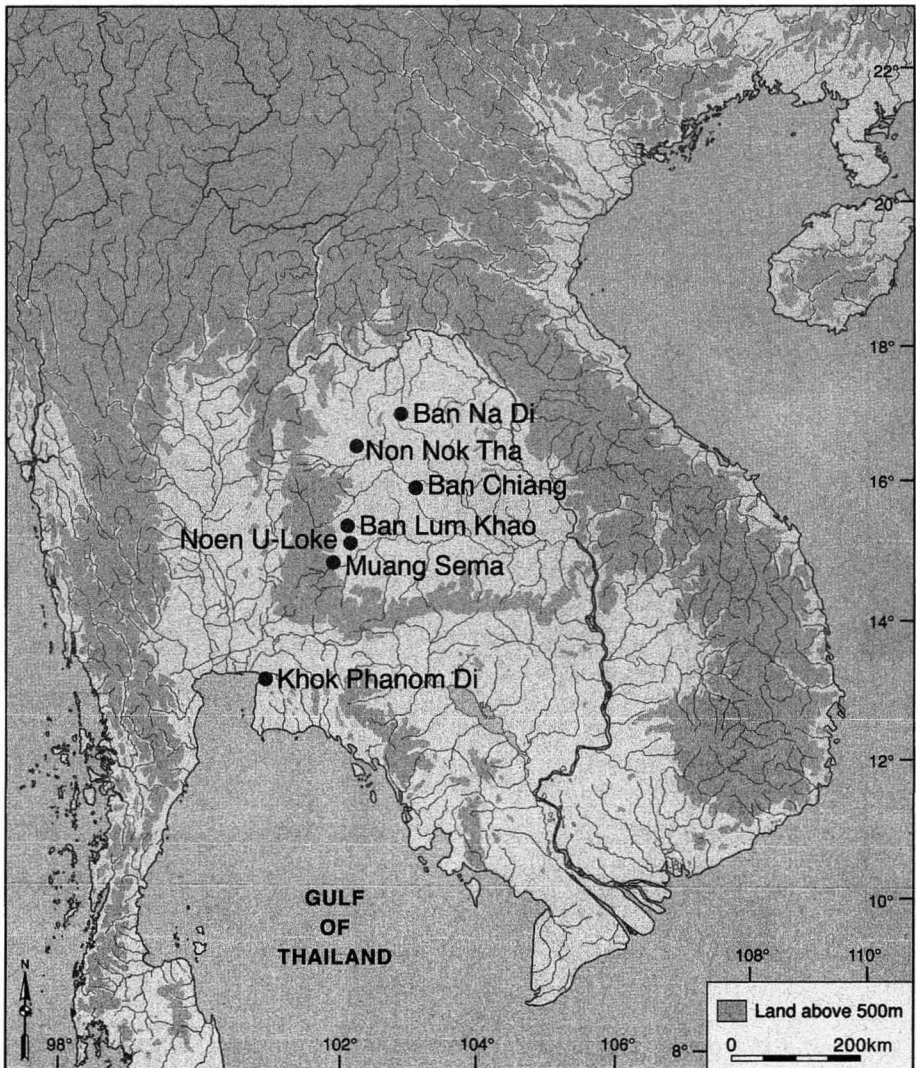


Fig. 2. Locations of sites in Southeast Asia.

TABLE 2. DIAPHYSEAL LENGTHS FROM THE THAI PERINATAL SKELETAL SAMPLE (n = 93) WITH SINGLE AND MEAN GESTATIONAL AGE ESTIMATIONS FROM REGRESSION METHODS

SITE AND BURIAL	DIAPHYSIS LENGTH (mm)						PERINATAL GESTATIONAL AGE ESTIMATION (IN WEEKS)											MEAN
	H	U	R	FM	T	FB	R1.01	R1.02	R1.04	R4.01	R4.03	RH	RU	RR	RFM	RT	RFB	
KPD B5.1	58.1	55.0	48.9	65.5	59.4	—	35.8	36.0	35.2	34.5	34.9	35.6	36.5	36.5	35.8	37.4	—	35.8
KPD B5.2	57.2	52.3	47.7	65.1	58.6	55.2	35.2	35.7	35.1	34.4	34.4	35.1	34.9	35.7	35.6	36.9	37.3	35.5
KPD B34	63.5	60.7	53.3	71.7	63.2	—	38.3	38.1	37.2	37.0	37.9	38.5	40.2	39.6	38.2	39.5	—	38.5
KPD B46	74.8	67.9	—	—	—	—	—	—	—	—	44.1	45.1	45.2	—	—	—	—	44.8
KPD B48	65.2	—	53.1	76.2	67.8	—	—	40.0	38.7	38.7	38.8	39.5	—	39.5	39.9	42.3	—	39.7
KPD B49	64.1	—	—	—	—	—	—	—	—	—	38.2	38.9	—	—	—	—	—	38.6
KPD B50	62.1	55.6	48.7	73.1	63.5	59.3	38.1	38.4	37.7	37.5	37.1	37.8	36.9	36.4	38.7	39.7	39.8	38.0
KPD B51	—	—	49.2	—	—	—	—	—	—	—	—	—	—	36.7	—	—	—	36.7
KPD B52	60.5	—	48.6	68.3	—	—	—	—	36.1	35.6	36.2	36.9	—	36.3	36.9	—	—	36.3
KPD B54	55.8	51.1	43.8	—	56.8	51.6	—	—	—	—	33.6	34.4	34.2	33.1	—	35.9	35.1	34.4
KPD B55	59.2	53.6	47.6	66.8	59.8	—	36.0	36.3	35.6	35.0	35.5	36.2	35.7	35.6	36.3	37.6	—	36.0
KPD B59	61.6	58.8	51.6	—	64.4	—	—	—	—	—	36.8	37.5	38.9	38.4	—	40.2	—	38.4
KPD B65	—	58.5	52.3	72.3	63.2	60.1	—	38.2	37.4	37.2	—	—	38.7	38.9	38.4	39.5	40.3	38.6
KPD B66	64.8	60.0	53.2	73.8	64.6	61.6	38.9	38.8	37.9	37.8	38.6	39.3	39.7	39.6	39.0	40.3	41.3	39.2
KPD B68	—	61.4	55.1	77.0	—	—	—	—	39.0	39.0	—	—	40.6	41.0	40.2	—	—	40.0
KPD B69	58.2	—	—	70.0	—	—	—	—	36.7	36.3	34.9	35.7	—	—	37.5	—	—	36.2
KPD B70	64.2	60.1	52.5	73.8	64.7	—	38.9	38.8	37.9	37.8	38.2	38.9	39.8	39.1	39.0	40.4	—	38.9
KPD B71	—	—	—	69.4	—	—	—	—	36.5	36.0	—	—	—	—	37.3	—	—	36.6
KPD B75	63.3	—	53.7	74.0	66.2	60.9	—	39.2	38.0	37.9	37.7	38.4	—	39.9	39.0	41.3	40.9	39.1
KPD B78	60.5	—	—	70.4	64.0	—	—	38.0	36.8	36.4	36.2	36.9	—	—	37.7	40.0	—	37.4
KPD B80	61.8	57.2	50.2	70.0	63.0	59.5	37.6	37.7	36.7	36.3	36.9	37.6	37.9	37.4	37.5	39.4	40.0	37.7
KPD B81	61.5	—	—	71.0	63.7	60.2	—	38.0	37.0	36.7	36.8	37.4	—	—	37.9	39.8	40.4	38.0
KPD B84	—	—	—	76.0	67.1	62.3	—	39.8	38.7	38.6	—	—	—	—	39.8	41.8	41.8	40.1
KPD B85	60.9	—	51.6	—	—	—	—	—	—	—	36.4	37.1	—	38.4	—	—	—	37.3
KPD B98	66.5	—	—	77.4	—	—	—	—	39.1	39.2	39.5	40.2	—	—	40.3	—	—	39.7
KPD B99	68.6	—	—	—	—	—	—	—	—	—	40.7	41.4	—	—	—	—	—	41.1
KPD B104	63.3	—	—	—	—	—	—	—	—	—	37.7	38.4	—	—	—	—	—	38.1
KPD B105	—	68.0	—	—	—	—	—	—	—	—	—	—	45.2	—	—	—	—	45.2
KPD B108	—	59.4	53.4	73.9	65.9	63.6	—	39.1	38.0	37.8	—	—	39.3	39.7	39.0	41.1	42.6	39.6

KPD B111	64.1	58.9	—	—	—	—	—	—	—	—	38.2	38.9	39.0	—	—	—	—	38.7
KPD B114	—	—	54.7	—	66.4	—	—	—	—	—	—	—	—	40.7	—	41.4	—	41.1
KPD B116	—	—	—	79.0	69.0	65.4	—	40.8	39.7	39.8	—	—	—	—	40.9	43.0	43.9	41.4
KPD B118	64.5	61.7	54.4	73.7	66.7	63.1	39.3	39.3	37.9	37.7	38.4	39.1	40.8	40.4	38.9	41.6	42.3	39.6
KPD B119	65.8	—	50.6	76.1	65.7	60.8	—	39.5	38.7	38.7	39.1	39.8	—	37.7	39.8	41.0	40.8	39.5
KPD B124	65.7	62.9	53.8	75.6	67.3	64.2	40.0	39.8	38.5	38.5	39.1	39.8	41.7	40.0	39.6	42.0	43.0	40.2
KPD B125	65.4	59.3	51.4	76.9	68.6	63.5	40.1	40.3	39.0	39.0	38.9	39.6	39.3	38.3	40.1	42.8	42.6	40.0
KPD B126	64.5	59.4	—	74.6	65.1	62.0	—	39.1	38.2	38.1	38.4	39.1	39.3	—	39.3	40.6	41.6	39.3
KPD B127	66.7	60.5	54.3	74.4	66.6	63.1	39.4	39.4	38.1	38.0	39.6	40.3	40.0	40.4	39.2	41.5	42.3	39.8
KPD B128	68.5	64.6	—	77.6	68.1	—	—	40.4	39.2	39.3	40.6	41.4	42.8	—	40.4	42.4	—	40.8
KPD B134	80.3	71.5	—	—	—	—	—	—	—	—	47.1	48.5	47.8	—	—	—	—	47.8
KPD B136	65.0	59.8	51.8	74.5	65.2	—	39.1	39.1	38.2	38.0	38.7	39.4	39.6	38.6	39.2	40.7	—	39.1
KPD B138	60.0	59.2	49.9	73.0	62.2	60.0	38.1	38.1	37.7	37.5	35.9	36.6	39.2	37.2	38.7	38.9	40.3	38.0
KPD B139	60.4	59.2	—	74.8	62.2	—	—	38.4	38.3	38.2	36.1	36.8	39.2	—	39.3	38.9	—	38.2
KPD B141	63.6	59.0	50.7	73.8	63.3	59.5	38.6	38.5	37.9	37.8	37.9	38.6	39.1	37.8	39.0	39.6	40.0	38.6
KPD B143	64.0	57.6	50.8	75.1	64.3	—	38.8	39.0	38.4	38.3	38.1	38.8	38.2	37.8	39.4	40.2	—	38.7
KPD B144	63.2	57.3	51.6	74.3	62.7	59.9	38.3	38.5	38.1	38.0	37.7	38.4	38.0	38.4	39.1	39.2	40.2	38.5
KPD B146	64.0	57.9	49.7	71.1	63.1	—	38.1	37.9	37.0	36.7	38.1	38.8	38.4	37.1	37.9	39.5	—	38.0
KPD B151	65.5	62.6	55.4	75.8	68.8	64.2	40.1	40.2	38.6	38.6	39.0	39.7	41.5	41.2	39.7	42.9	43.0	40.4
KPD B153	66.0	—	—	76.0	—	—	—	—	38.7	38.6	39.2	39.9	—	—	39.8	—	—	39.2
NNT 1968 B7A	—	—	—	—	53.6	—	—	—	—	—	—	—	—	—	—	34.2	—	34.2
NNT 1968 B86A	63.2	—	—	—	—	—	—	—	—	—	37.7	38.4	—	—	—	—	—	38.1
BC(ES) B48	—	—	53.4	74.4	65.8	62.3	—	39.2	38.1	38.0	—	—	—	39.7	39.2	41.1	41.8	39.6
BC(ES) B63	59.6	56.6	50.6	—	—	—	—	—	—	—	35.7	36.4	37.5	37.7	—	—	—	36.8
BC(ES) B64	62.0	—	—	70.7	—	—	—	—	36.9	36.6	37.0	37.7	—	—	37.8	—	—	37.2
BC(ES) B66	—	41.7	—	50.1	—	—	—	—	30.1	28.5	—	—	29.0	—	29.9	—	—	29.4
BC(ES) B77	65.5	—	54.2	77.4	—	—	—	—	39.1	39.2	39.0	39.7	—	40.3	40.3	—	—	39.6
BLK B3	70.0	65.0	58.4	—	—	—	—	—	—	—	41.5	42.2	43.1	43.5	—	—	—	42.6
BLK B9	—	—	—	—	68.4	—	—	—	—	—	—	—	—	—	—	42.6	—	42.6
BLK B14	54.9	—	—	64.1	—	—	—	—	34.7	34.0	33.1	33.9	—	—	35.3	—	—	34.2
BLK B50	—	—	—	81.7	68.4	—	—	41.2	40.5	40.9	—	—	—	—	42.0	42.6	—	41.4
BLK B58	65.8	—	—	—	—	—	—	—	—	—	39.1	39.8	—	—	—	—	—	39.5
BLK B62	81.0	—	—	—	—	—	—	—	—	—	47.5	49.0	—	—	—	—	—	48.3

(Continued)

TABLE 2 (Continued)

SITE AND BURIAL	DIAPHYSIS LENGTH (mm)						PERINATAL GESTATIONAL AGE ESTIMATION (IN WEEKS)												
	H	U	R	FM	T	FB	R1.01	R1.02	R1.04	R4.01	R4.03	RH	RU	RR	RFM	RT	RFB	MEAN	
BLK B70	—	52.7	—	66.5	—	—	—	—	35.5	34.9	—	—	35.1	—	36.2	—	—	35.4	
BLK B84	79.3	—	—	—	—	—	—	—	—	—	46.6	47.9	—	—	—	—	—	47.3	
BLK B103	47.1	—	—	51.2	47.0	—	—	30.3	30.5	28.9	28.8	30.1	—	—	30.4	30.9	—	30.0	
BLK B104	60.2	—	—	—	—	—	—	—	—	—	36.0	36.7	—	—	—	—	—	36.4	
BLK B107	—	61.9	—	—	—	—	—	—	—	—	—	—	41.0	—	—	—	—	41.0	
BND B4M	60.0	53.3	—	70.5	60.0	56.0	—	37.1	36.8	36.5	35.9	36.6	35.5	—	37.7	37.7	37.8	36.8	
BND B7M	48.7	43.7	39.2	53.0	46.6	45.0	30.1	30.5	31.1	29.6	29.7	30.8	30.0	30.2	31.1	30.7	31.5	30.5	
BND B8M	74.0	—	—	88.5	74.9	69.8	—	44.1	42.8	43.5	43.7	44.6	—	—	44.5	46.8	46.9	44.6	
BND B9M	—	52.0	45.4	64.5	57.4	53.8	—	35.3	34.9	34.1	—	—	34.7	34.2	35.4	36.2	36.4	35.2	
BND B18BM	—	—	—	—	67.7	—	—	—	—	—	—	—	—	—	—	42.2	—	42.2	
BND B24M	80.0	—	—	—	—	—	—	—	—	—	47.0	48.3	—	—	—	—	—	47.7	
BND B25M	59.1	56.3	—	70.6	62.5	—	—	37.7	36.9	36.5	35.4	36.1	37.3	—	37.7	39.1	—	37.1	
BND B30M	61.0	—	—	—	—	—	—	—	—	—	36.5	37.2	—	—	—	—	—	36.9	
BND B43M	62.1	—	—	—	—	—	—	—	—	—	37.1	37.8	—	—	—	—	—	37.5	
NUL B18	—	—	—	—	—	60.2	—	—	—	—	—	—	—	—	—	—	—	40.4	
NUL B19	66.7	—	—	—	—	63.7	—	—	—	—	39.6	40.3	—	—	—	—	—	42.7	
NUL B24	—	—	—	70.5	63.3	—	—	37.8	36.8	36.5	—	—	—	—	37.7	39.6	—	37.7	
NUL B38	62.9	59.6	52.0	72.2	64.2	60.5	38.4	38.4	37.4	37.1	37.5	38.2	39.5	38.7	38.3	40.1	40.6	38.6	
NUL B43	67.4	64.3	55.8	77.1	68.5	—	40.6	40.3	39.0	39.1	40.0	40.7	42.6	41.5	40.2	42.7	—	40.7	
NUL B77	54.3	44.5	—	—	—	—	—	—	—	—	32.8	33.6	30.5	—	—	—	—	32.3	
NUL B81	59.5	—	—	—	60.0	—	—	—	—	—	35.7	36.4	—	—	—	37.7	—	36.6	
NUL B88	64.6	61.7	54.9	75.4	—	—	—	—	38.5	38.4	38.5	39.1	40.8	40.8	39.6	—	—	39.4	
NUL B89	—	—	—	53.4	47.4	—	—	30.8	31.2	29.8	—	—	—	—	31.2	31.1	—	30.8	
NUL B100	65.7	60.3	53.0	75.7	66.3	62.1	39.6	39.6	38.6	38.5	39.1	39.8	39.9	39.4	39.7	41.4	41.6	39.7	
NUL B103	—	—	—	77.5	—	—	—	—	39.2	39.2	—	—	—	—	40.4	—	—	39.6	
NUL B106	—	—	—	68.0	—	—	—	—	36.0	35.5	—	—	—	—	36.8	—	—	36.1	

MS S5W97 B1	—	—	48.1	—	—	—	—	—	—	—	—	—	—	36.0	—	—	—	36.0
MS S5W97 BJ3.1	—	57.3	51.5	—	65.0	—	—	—	—	—	—	—	38.0	38.3	—	40.6	—	39.0
MS S86E159 B2.1	—	—	—	—	67.9	—	—	—	—	—	—	—	—	—	—	42.3	—	42.3
MS S86E159 B7.1	—	62.9	56.2	—	64.5	—	—	—	—	—	—	—	41.7	41.8	—	40.3	—	41.3
MS S86E159 B7.2	—	59.1	—	—	—	—	—	—	—	—	—	—	39.1	—	—	—	—	39.1

Abbreviations: B = burial; BJ = burial jar; KPD = Khok Phanom Di; NNT = Non Nok Tha; BC = Ban Chiang; BLK = Ban Lum Khao; BND = Ban Na Di; MS = Muang Sema; NUL = Noen U-Loke; H = humerus; U = ulna; R = radius; FM = femur; T = tibia; FB = fibula.

Gestational age estimation methods from Scheuer et al. (1980) and Scheuer and Black (2000).

Method R1.01 = $(0.1724(\text{FM}) + 0.1538(\text{T}) + 0.0674(\text{H}) - 0.0718(\text{R}) + 0.1397(\text{U}) + 7.2624) \pm 1.88$; Method R1.02 = $(0.1984(\text{FM}) + 0.2291(\text{T}) + 9.3575) \pm 1.87$; Method R1.04 = $(0.3303(\text{FM}) + 13.5583) \pm 2.08$; Method R4.01 = $(0.3922(\text{FM}) + 8.83) \pm 1.49$; Method R4.03 = $(0.5524(\text{H}) + 2.7825) \pm 1.24$.

Gestational age estimation methods from Sherwood et al. (2000).

Method RH = $(12.98 + 0.25(\text{H}) + (0.0024)(\text{H}^2)) \pm 2.12$; Method RU = $(14.28 + 0.19(\text{U}) + 0.0039(\text{U}^2)) \pm 2.08$; Method RR = $(13.53 + 0.25(\text{R}) + (0.0045)(\text{R}^2)) \pm 2.14$; Method RFM = $(10.91 + 0.38(\text{FM})) \pm 2.05$; Method RT = $(15.13 + 0.19(\text{T}) + (0.0031)(\text{T}^2)) \pm 2.06$; Method RFB = $(14.72 + 0.21(\text{FB}) + 0.0036(\text{FB}^2)) \pm 2.19$.

periods, the perinates with available long bone lengths were only from the latter. All of the sites are located on mounds and are primarily inhumation sites, although there is evidence for domestic and production activities (Bayard 1971; Higham 2002; Higham and Kijngam 1984; Higham and Thosarat 2004a; Pietruszewsky and Douglas 2002a). All the Northeast sites are located in valleys of tributaries of the Mekong River. Khok Phanom Di is a coastal site, located 22 km inland from the present shore of the Gulf of Thailand (Higham and Bannanurag 1990). The preservation of bone is variable among the sites. Khok Phanom Di had the best preservation, as indicated by the high proportion of perinates (49/51, 96.1%) with measurable long bones in the total perinatal sample compared with 44/70 (62.9%) at the other six sites (Table 1). In regard to the low numbers of small infants at Non Nok Tha, it should be noted that although overall the preservation of the burials was good, unfortunately, the soil conditions did not allow screening, which may have resulted in the loss of small subadult bones (Douglas 1996:50).

Long bone lengths were measured in millimeters using the Buikstra and Ubelaker (1994) standard with Mitutoyo digital calipers and rounded to one decimal place. Following Tocheri et al.'s study (2005), a combination of 11 regression equations from Sherwood et al. (2000), Scheuer et al. (1980), and Scheuer and Black (2000) were used for the estimation of gestational age (see Table 2). The arithmetic mean of the regression estimates was calculated to provide an overall age estimate for each individual and used in the analysis. All individuals under 50 weeks of gestation were included in the analysis following Tocheri et al. (2005). Data on modern age at death from the 1958 British sample were added to the figures for comparative purposes (Butler and Alberman 1969). All statistical analyses were performed using SPSS, Version 14.0 (SPSS Inc, Chicago, IL) or STATA, Version 9.0 (STATA Corporation, College Station, TX). The level of significance for all tests was set at 5 percent. The independent sample z-test for proportions was used to test for differences between proportions of full-term perinates, the Kolmogorov-Smirnov test for differences in age distributions, the two sample t-test for differences in mean gestational age, and Levene's test for differences in spread or variability of the age distributions.

Results

Table 2 shows the lengths of the skeletal elements and estimated ages from the regression equations and the mean age for each individual in the samples ($n = 93$). There are no individuals under 29 weeks of gestation, meaning that all lived at least into the third trimester of development. The World Health Organization's definitions of perinatal status are used here. Perinates under 37 weeks gestation are defined as pre-term or premature, those between 37 and 41.99 weeks as full-term and those 42 weeks and older as post-term (McIntosh et al. 2003). Twenty-four (25.8%) are premature, 58 (62.4%) were full-term and 11 (11.8%) were post-term. Of the Khok Phanom Di perinates with measurable long bone lengths ($n = 49$), a large proportion ($n = 38$, 77.6%) were aged as full-term, with only three individuals aged less than 36 gestational weeks. Two of these perinates aged under 36 weeks gestation, B (burial) 5.1 and B5.2, based on their burial context and very similar size, were probably twins. Twins are generally smaller for gesta-

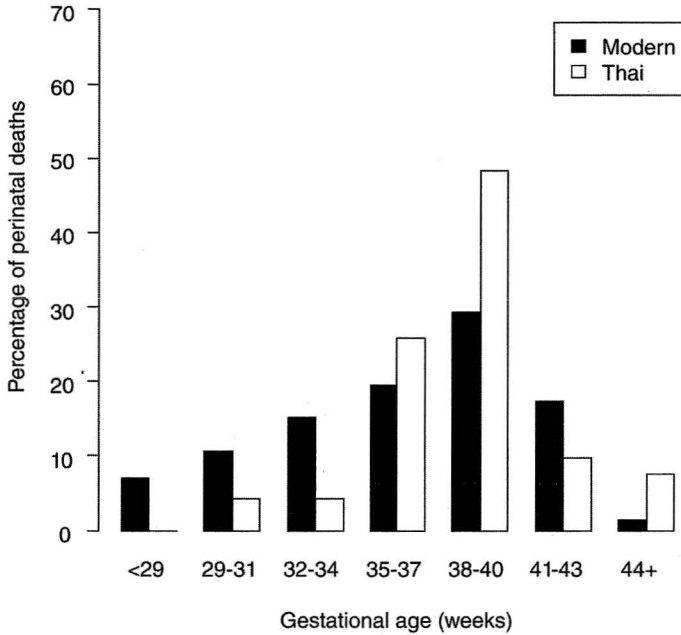


Fig. 3. Mean gestational age at death distributions of the combined Thai perinatal sample. The modern mortality data is plotted for comparison (Butler and Alberman 1969:48).

tional age than singletons but have a better chance of survival compared with singletons of the same weight (Kilpatrick et al. 1996). The later sites had a total of 44 infants with measurable long bone lengths. Of these 20 (45.5%) were considered full-term. The proportion of full-term perinates was higher at Khok Phanom Di than the other Thai sites (differences in proportions = 0.32, 95% confidence interval: 0.13 to 0.51). This difference in proportions was highly statistically significant (p -value = 0.001).

Figure 3 shows the age at death distribution of the Thai perinatal samples and of the modern data. There is a peak around 38 to 40 weeks gestation with most deaths occurring from 35 to 40 weeks gestation and the distribution being skewed toward the younger age categories. The modern data also has the majority of deaths occurring around this time but it is more spread out, although skewed to the younger ages.

Figure 4 shows the age at death distribution of the perinates from Khok Phanom Di and the combined later Thai sites. The age at death distribution of Khok Phanom Di is more tightly clustered around 38–40 weeks. The age distribution of the other Thai sites does not have such a pronounced peak around this time. There is also a higher percentage of perinatal death in the 35–37-week age category in the other Thai samples compared with the modern data. The mean gestational age at Khok Phanom Di was 39.0 weeks (standard deviation = 2.4), and the other Thai sites were 38.5 weeks (standard deviation = 4.3). This was not a statistically significant difference (mean difference = 0.57, 95% confidence interval: -0.90 to 2.04, p -value = 0.455). A statistical comparison of age distributions between Khok Phanom Di and the other combined Thai sites indicates that there

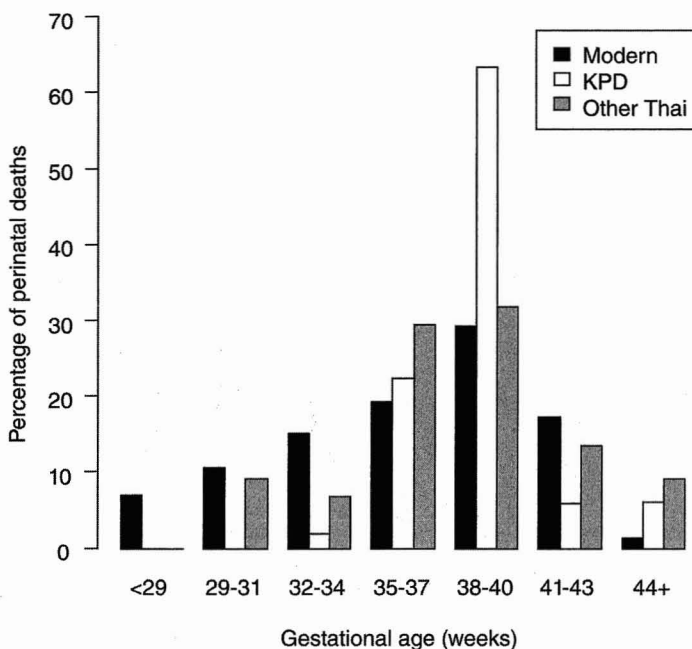


Fig. 4. Comparison of the mean age at death distributions of perinates from Khok Phanom Di and the combined other Thai sites. The modern mortality data is plotted for comparison (Butler and Alberman 1969:48).

was no significant difference (p -value = 0.109). However, there was a greater spread in the other Thai sites compared with Khok Phanom Di, a statistically significant difference (p -value < 0.001).

Figure 5 shows that the cumulative age distribution of the combined other Thai sites is similar to the plotted modern mortality, but deviates from the modern curve at less than 36 weeks of gestation. In comparison, the Khok Phanom Di cumulative age distribution does not follow that of modern mortality. This is due to the absence of pre-term individuals less than 34 weeks and the large proportion of deaths around 38–39 weeks.

DISCUSSION

The combined Thai sample had a high proportion of deaths occurring at full-term. This is similar to the pattern of modern gestational age-at-birth distribution (Hoffman et al. 1974). However, on assessing the distribution with the Khok Phanom Di data separately it became apparent that the other Thai distribution is similar to modern mortality. There were more perinates represented in the mid to late third trimester in the other Thai samples compared with Khok Phanom Di. This may indicate that there was no differentiation in inclusion in the cemetery between premature stillbirths, live premature perinates dying after birth, and full-term perinates dying at or around birth. The deviation of the cumulative frequency distribution of the other Thai sites from the smoother modern data curve

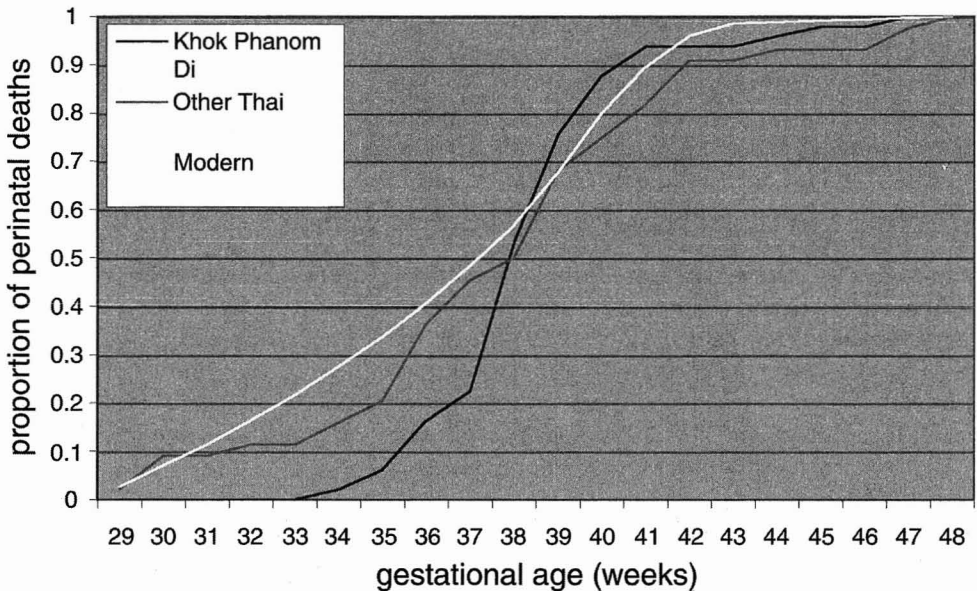


Fig. 5. Comparison of the cumulative frequency of perinatal age at death distributions at Khok Phanom Di and the other Thai sites. The modern mortality data is plotted for comparison (Butler and Alberman 1969:48).

was probably the result of the relatively small sample from the Thai sites. Mays (1993:886) has acknowledged that the higher quality of medical care available to modern newborns would result in fewer infant deaths in the first week after birth, as well as more premature infants surviving in the postpartum period compared with past societies. This prejudice of the comparative data may explain the higher percentage of death between 35 and 40 weeks in the other Thai data compared with the modern data.

In contrast with the other Thai data, the Khok Phanom Di sample had a very high, narrow peak of death occurring around 38–40 weeks. This indicates that a larger proportion of perinates were aged approximately 40–42 weeks, assuming that the standards were underestimating the perinates' age by approximately one or two weeks (Halcrow 2006). This assumption is made based on comparative analysis that has shown Southeast Asian full-term perinates were aged on average one to three weeks younger than their known age when using regression equations based on European perinates. The perinates at Khok Phanom Di could have been alive for a matter of days or possibly weeks before dying. The comparative lack of pre-term infants could mean that this part of the cemetery was set aside especially for these full-term infants and the pre-term individuals were buried elsewhere. Although it is also important to acknowledge preservation issues in an archaeological context that may impact the age distribution data, especially in the very young (Guy et al. 1997), the high quality of preservation at Khok Phanom Di does not support the possibility that the different age distribution at this site was the result of poor preservation.

As mentioned, the age at death distribution of the Khok Phanom Di individuals was similar to that of modern age at birth. This pattern of age distribution

has been interpreted to indicate infanticide (Mays 1993, 1998:66, 2003). To investigate the appropriateness of an argument for infanticide at Khok Phanom Di, ethnographic records were considered. It is acknowledged that these texts are not necessarily representative of conditions in prehistory as human cultures are not static over time; therefore, any inferences are very tentative. There is a lack of historical evidence of infanticide in mainland Southeast Asia. There is, however, reference to direct infanticide in pre-Hispanic and early colonial Philippines (Pedrosa 1983). Owen (2002:7) noted in a study of early demographic change that, although there is evidence of "indirect infanticide" in the form of reduced nutrition available to the mother and child in some Asian rural societies (Whyte 1974), there are no references to this in Southeast Asia. Fieldwork carried out by de Young (1963:49) in the late 1940s, although influenced by Buddhist religion, noted "[i]nfanticide is so unthinkable by Thai Buddhist standards that anyone who committed it would be judged insane. The high cultural value attached to bearing children is shown by the belief that sterility is sinful, since a sterile woman has not been blessed by Buddha." The practice of infanticide is often related to social constructions of gender worth and sex preference of children in societies (Scott 1999). Compared with other Asian countries including China, India, Nepal, and Taiwan, which have strong son preference, in present-day Thailand there is limited sex preference for children (Knodel et al. 1987; Wongboonsin and Ruffolo 1994). An interpretation of infanticide in prehistoric Thailand is not supported by historical and ethnographic sources. However, it should be reiterated that these descriptions and accounts can never tell us anything directly about prehistoric populations.

The burial context is important to consider in the interpretation of age-at-death distributions. Given that the Khok Phanom Di perinates were interred in the normal burial context it seems unlikely that they were unwanted (Higham and Bannanurag 1990; Higham and Thosarat 1994). Borić and Stefanović (2004:540–541), interpreting the high peak of death between 38–40 gestational weeks at two Southeast European sites from the Mesolithic and early Neolithic, argued that infanticide was not practiced. This interpretation was supported by evidence of the concern expressed toward the infants and pregnant women buried at the earlier Vlasac site in terms of burial ritual. It was also suggested that the infants at the later site of Lepenski Vir were especially selected for burial under the floors of certain buildings. Contrary to previous theories about sacrificial burial, this was related to cultural ideas about the connections between newborns and houses (Borić and Stefanović 2004:541–543).

It could also be argued that the high number of full-term perinates at Khok Phanom Di was the result of death during and shortly after birth. It is well known that it is typical for a large amount of deaths to occur around this age as it is a critical transition in a baby's life (Butler and Alberman 1969; Butler and Bonham 1963; Mays 1993). This peak in death has been acknowledged in the archaeological record as a normal occurrence (Bourbou 2003:308–309; Jantz and Owsley 1994:249; cf. Saunders et al. 1995). Conversely, Saunders et al. (1995) argue that it is only when the pre-term and full-term perinates are taken together that they constitute a high proportion of infant deaths. However, this is generally not the case in the archaeological literature where the majority of infant deaths have been shown to occur around full-term (Angel 1971; Borić and Stefanović 2004; Owsley and Jantz 1985). Jelliffe and Stanfield (1978) have noted that in tropical

regions the main causes of death during the neonatal period were infection, birth trauma, and pre-term birth. Ethnographic records of *samai gorn* in Thailand, which refer to an unspecified time in the past and, in this case, before the advent of medical intervention, have noted that mothers and infants often died in childbirth (Van Esterik 1985:147). A recent study of infant mortality in the United Arab Emirates showed that medical treatment contributed to the dramatic reduction of infant mortality by 20 percent over a 10-year period (Dawodu et al. 2000).

Perhaps the modern mortality distributions used as interpretive references by bioarchaeologists may be underrepresentative of mortality patterns that occurred in the past before the advent of medical specialists and Western medicine. That is, the perinatal mortality distribution may be more similar to the modern gestational age distribution at birth as a result of more perinates dying during birth. This proposition is supported by epidemiological surveys that have shown that over 70 percent of all neonatal deaths occur within the first week after birth and that small birth weight (or prematurity) is a leading cause (Liljestrand 1999; Preston and Haines 1991). As noted, the medical care currently available to newborns has resulted in fewer deaths in the first week after full-term and pre-term birth compared with the past. Mays (1993:886) state these factors “prejudice the comparison between the modern and the archaeological age distributions when investigating the possibility that the archaeological burials represent mainly infants dying of natural causes in the immediate post-natal period.” It should be noted, however, that the combined Thai data (excluding Khok Phanom Di) does follow the modern age at death distribution more closely, which lends support to the appropriateness of the use of these data for comparison. However, there are still more deaths of perinates in the 35–37- and 38–40-week age categories compared with the modern data, which may represent a higher risk of death in the immediate postpartum environment prior to the advent of modern medical treatment.

It is interesting that a number of studies, which present infant mortality data, also show a similar age distribution to Khok Phanom Di where about 70 percent of the perinates died between 38–40 weeks and 20 percent died between 35–37 weeks. These include samples from Roman-period Britain, Late Roman Israel, Middle Helladic period in Greece, the Mesolithic-Neolithic transition in Southeast Europe, and post-Contact Arikara Indian populations in North America (Angel 1971; Borić and Stefanović 2004; Gowland and Chamberlain 2002: Figure 1; Ingvarsson-Sundström 2003; Mays 1993, 2003; Owsley and Jantz 1985). This is not to say that the argument of infanticide having occurred at the Romano-British sites is not substantiated (Mays 1993, 2003). Rather, the lack of evidence of intentional killing of the young in Southeast Asian societies and the observation of this type of age distribution pattern in culturally and temporally diverse places support the idea that infanticide was generally not practiced in the prehistoric populations represented in this study.

Archaeological samples with high young adult female and infant mortality have been used as evidence for complications in pregnancy and childbirth (e.g., Joyce 2001:18; Tocheri et al. 2005:337). There was no evidence of an increased young adult female mortality at Khok Phanom Di (Domett 2001; Tayles 1999). Noen U-Loke, which also had a high number of perinatal deaths around the time of full-term, did not have evidence for an increased level of young adult female death (Tayles et al. 2007). Pregnancy complications, such as toxemia and pre-

mature rupture of the membranes and postpartum complications, such as hemorrhage, do not leave evidence on the skeleton (Slaus 2000). The only direct evidence for death having occurred during childbirth is perinatal remains in the pelvis of an adult female and it is very rare to find such cases in archaeological samples (Arriaza et al. 1988; Borić and Stefanović 2004; Owsley and Bradtmiller 1983). At Khok Phanom Di there were two cases of newborn individuals buried at the shoulder of an adult female, possibly representing death in childbirth (Fig. 6).

As stated there was a lack of pre-term perinates at Khok Phanom Di. An appealing argument is that the peak around full-term was the result of pre-terms



Fig. 6. *In situ* photograph of a full-term perinate (burial 48) buried alongside an adult female (burial 47) from Khok Phanom Di. This could possibly represent a perinate and mother who died from complications during or following childbirth. (Photograph courtesy of C.F.W. Higham)

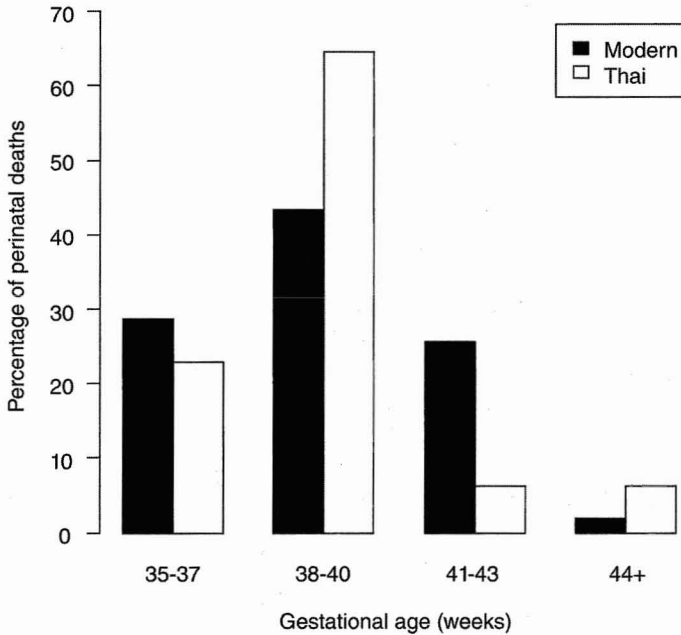


Fig. 7. Mean gestational age at death distribution of the Khok Phanom Di sample. The modern mortality data (with data under 35 weeks omitted) is plotted for comparison (Butler and Alberman, 1969:48).

being buried elsewhere. To entertain this argument the perinates that died before 35 weeks of gestation are omitted from the modern mortality data and compared with the Khok Phanom Di age distribution (Fig. 7). This results in a higher peak of mortality from 38–40 weeks in the modern mortality data. However, the peak of mortality around 38–40 weeks is still greater in the Khok Phanom Di sample, indicating that, in addition to premature perinates being buried elsewhere, there is a selection of these full-term infants at least in the part of the cemetery that was excavated.

Cultural ideas relating to an individual's age as evidenced through grave wealth or mortuary treatment can be considered when interpreting age distributions in cemetery populations. Although, it has been acknowledged that there are some problems with an approach that ascribes differing mortuary treatment to different status during life, often there are few alternatives (Parker Pearson 1982; Ucko 1969:266–268; Wason 1994). Although there are some conflicting interpretations of the changes in social organization that occurred in the Bronze Age in prehistoric Southeast Asia (Higham 2002; O'Reilly 1999, 2001, 2003; White 1986, 1995), there is evidence of changes in burial treatment of the young over time. It has been suggested that familial ties were important at Khok Phanom Di (Higham 1989:39; Higham and Thosarat 1994:110). However, this is more apparent in terms of infant burial goods in the later sites (O'Reilly 1999; Talbot 2002). For example, at Ban Lum Khao and Noen U-Loke infants were not excluded from the usual burial practices and were sometimes given high expenditure of wealth (Hudson 2002; O'Reilly 1999:262; Talbot 2002). Talbot

(2002:86) states that although the difference between subadult and adult burials were the most notable distinction in terms of wealth in the cemetery in the earlier graves, “a more complex social structure evidenced by the emergence of especially rich subadult burials” occurred over time. Therefore it could be argued that the exclusion of pre-term infants at Khok Phanom Di was a cultural phenomenon. With the increased emphasis on ascribed status, as evidenced in the archaeological record in the later prehistoric communities (O’Reilly 1999:262; Talbot 2002), infants born into a particular family may have had social standing even if they were stillborn or died at or shortly after birth.

A comprehensive comparative study of burial treatment of young infants among the sites has not been undertaken in Southeast Asia. Although the aim of this article is not to do so, a brief comparison of whether or not infants were interred in jars highlights a possible temporal or diachronic difference in the mortuary treatment among the sites (Douglas 1996; Higham and Kijngam 1984; Higham et al. 2007; Pietrusewsky and Douglas 2002a; Pureepatpong 2001). This survey of infant mortuary treatment is far from exhaustive, however, it contributes to understanding the differences in the age at death distributions among the sites. While acknowledging that Khok Phanom Di and only a small sample ($n = 9$) of infants at Non Nok Tha were the only sites with infants represented in pre-metal times, it was uncommon for these infants to be buried in jars. It is interesting that only one subadult was buried in a mortuary vessel at Khok Phanom Di. This was an infant of about 16 months of age in a later mortuary phase of the site. This pattern of perinatal burial custom meets a dislocation in the later sites where the majority of the infants, including pre-term, full-term, and post-term individuals, were buried in jars (Fig. 8). This difference in burial rites for the infants at Khok Phanom Di also hints at a cultural difference that could account for the underrepresentation of pre-term infants at this site (Hudson 2002).

Archaeologists have related the differentiation of infants in mortuary practices to the idea of becoming a recognized member of society. Hudson (2002:74) alluded to this difference in infant burial practices between Khok Phanom Di and the later sites. She noted that, although there was a widespread differentiation of infant burial rites among the sites, there were indications that the concept of the individual was different for Khok Phanom Di. For example, at Khok Phanom Di there was a distinctive threshold in terms of life stages that came after surviving for about the first month from birth; after this it was more likely that infants were interred with grave goods (Hudson 2002:74). The perinatal infants at Khok Phanom Di were differentiated in the mortuary context by the lack of grave goods, which has been interpreted as their liminal status in the community (Higham and Thosarat 2004b; Hudson 2002:66). This, Hudson has explained (2002:67), may be tied to beliefs about the concept of life or the vulnerability of the individual at this age somehow becoming associated with the category of individual. It could be similarly argued that the pre-term perinates at Khok Phanom Di were given different mortuary treatment and/or buried somewhere different as they had not reached a certain threshold of personhood in the community or were considered of different status than the full-term perinates.

This differentiation of mortuary treatment of the very young has been shown at a cemetery site on the Island of Saï in the Sudan. Murial et al. (2004:275–276)



Fig. 8. Infant jar burials from Noen U-Loke. Left: full-term infant (burial 100); right: pre-term infant (burial 89). (Photographs courtesy of C.F.W. Higham)

have noted that the biological age of the subadults was closely related to their social age. Similarly to the situation at Khok Phanom Di, it is not until a later age in infancy that they received similar burial treatment to the adults. Similar findings have been observed at the site of Vlasac in Southeast Europe where far more elaborate burial rituals were carried out for older infants compared with full-term perinates (Borić and Stefanović 2004). This was interpreted as differing stages of social embodiment being related to biological age (Borić and Stefanović 2004:540). This appears to be a universal phenomenon in human societies where different cultural divisions are recognized and linked to different physiological stages. As Levine (1998:113) states “every culture has a conceptual division of the life course into stages linked roughly or precisely to age and imputed maturational capacities, with associated social responsibilities and stereotypical psychological characteristics. Something equivalent to infancy and childhood stages seems to be universal, although the number of age linked partitions and their meanings vary considerably.”

Although speculative, a possible explanation for differing burial rites attributed to the pre-term perinates at Khok Phanom Di (because very pre-term infants do not live more than a few hours after birth), is that the infants needed to live for a certain period of time out of the womb before they were given certain burial rites. This has been documented in historical records from pre-Christian Rome where babies under nine days old were not grieved over nor buried in the cemeteries (Soren and Soren 1995:43–44). Steel (1995:200) has interpreted the lack of energy in terms of burial ritual and wealth for infant and perinatal remains in Iron Age Cyprus as an indication that these individuals were not viewed as members of the community. Patel (1994) noted that in a contemporary Rajasthan village in India when an infant dies there is a lack of elaborate ritual. This was attributed to the fact that infants had not acquired the social personality or status that adults have in that society (Patel 1994:142). Contrary to this finding, Meskell’s (2000) research at the New Kingdom Egyptian worker’s village of Deir el Medina argued that infants, full-term and premature perinates, were perceived as part of the community. Meskell (2000:425) states, citing Feucht (1995:94), “while already in the womb, the unborn child was considered a living being and as such required protection in the social realm.” Furthermore, different burial treatment and place of burial have been noted in various studies. For example, in the Ashanti Hinterlands on the Gold Coast of Africa infants under eight days of age were buried in pots in the town center, while in some tribes in the region there was an absence of burial ritual for these babies (Ucko 1969:271).

Literature pertaining to infant burial practices in traditional communities in Southeast Asia is limited. Although there are problems with using ethnographic texts as analogies for prehistoric communities, in that there is an underlying assumption that little cultural change has occurred between the prehistoric time in question and the modern societies on which the ethnographies are based, they can be of value when no other sources of evidence are available. An ethnographic text on burial custom and funerary rites in northern Thailand written in 1967 alluded to the fact that death of a child during birth is viewed as a bad form of death, and that there were no burial rites given to a mother who died during childbirth (Anusaranasāsanakiarti and Keyes 1980). If the child also died in birth it was taken and buried with the mother. It is important to note, however, that this account was based on Buddhist rituals. The burial rituals given to a two-

month-old baby in a village in Lawa, Northwest Thailand have been recorded in an ethnographic account (Kauffmann 1980:100). Kauffmann stated that he was surprised to find the little coffin and evidence that it was going to receive a grave hut because he “thought that little children were buried without circumstance” (100). This comment, although indicating that subadults were attributed burial rites, may also be read to suggest that other infants this age or younger were seldom given burial rites and corroborates the preceding arguments regarding the possibility of differential treatment of pre-term infants. It is clear that there are difficulties with using modern information on mortuary ritual to tell us about the past and further archaeological analysis is needed to gain a better understanding of prehistoric infant burial rites in this area.

It seems that the lack of pre-term perinates at Khok Phanom Di may have been the result of a different burial custom compared with the other sites. There are a limited number of archaeological sites from the pre-metal period in Southeast Asia with which to compare these findings. The pre-metal inhabitants at the Northeast Thai sites of Ban Non Wat and Ban Chiang practiced interring perinatal individuals in burial jars. This may represent a regional cultural difference in infant burial practices. It has been noted that there was only one infant found at Ban Kao, a Neolithic site in Central Thailand. This may indicate that infants were buried elsewhere from the adults, which may imply differential mortuary treatment (Higham 2002:105). Pietrusewsky and Douglas (2002:179) included a discussion on the subadult burial jars of Ban Chiang and other comparative sites in Central and Northeast Thailand. They suggest that there may have been an age-related pattern in jar burials at Ban Chiang and that this changed over time (Pietrusewsky and Douglas 2002:179). Overall there was a general “lack of uniformity” in infant burial treatment among different sites in Thailand (Pietrusewsky and Douglas 2002:179). Regional distinctions in infant burial practices have been found in the South Deccan Neolithic in India and attributed to local cultural circumstances (Raczek 2003). Raczek (2003:250) stated “[b]y performing burial rites in socially prescribed ways, surviving members of society—family, neighbors, or other representatives of the deceased’s community—show support for upholding social structures”.

This hypothesis of different infant burial rites between Khok Phanom Di and the other Thai sites fits with the previous interpretation by Pietrusewsky and Douglas (2002:254) of a distinct cultural and genetic population at Khok Phanom Di compared with the Northeast sites of Ban Chiang and Non Nok Tha. The genetic difference is supported by a number of observations including the comparative absence of evidence of thalassemia at the Northeast sites compared with Khok Phanom Di, multivariate comparative analysis of cranial metrics (Pietrusewsky 1988), and the significantly smaller size of the adult individuals at Khok Phanom Di (Domett 2001; Pietrusewsky and Douglas 2002:254). That the Bronze Age cemetery represented at Nong Nor had infant burial jars and the appearance of an infant burial jar near the end of the mortuary sequence at Khok Phanom Di hint that at this time there was an adoption or integration of immigrant’s ideas including infant burial practices into their existing social fabric. Further research into this issue is needed as it can potentially contribute to knowledge on pertinent topics including the adoption of agriculture, trade, and migration at this important time in prehistoric Southeast Asia. Comparative research by Anne-Sophie Coupey and Jean-Pierre Pautreau of mortuary ritual for infants and

children in Thailand and other Southeast Asian countries being undertaken concurrently with this study will be useful for this purpose.

The question remains of the contribution of excavation sampling bias to the age at death results. Even if the narrow age at death distribution around full term at Khok Phanom Di is the result of excavation bias, which is likely given the small area that was excavated (10 × 10 sq. m), it still indicates that the perinates were given differential treatment in that they were buried in a different part of the cemetery.

It could be argued that the high number of deaths were a result of a high stress environment at Khok Phanom Di. However, in this case there would also be high pre-term mortality. Although not discounting that the individuals at Khok Phanom Di did experience a high amount of stress, this argument alone does not explain the deficiency of pre-term individuals at the site. A consideration of this point is important for the study of health and disease as the exclusion of the pre-term perinatal individuals may mean that the documented high infant mortality reported at Khok Phanom Di may in fact have been even higher (Tayles 1999).

CONCLUSIONS

Although no definitive statements could be given to explain the comparatively high number of full-term perinates at Khok Phanom Di, the inclusion of these infants in the normal realms of burial ritual indicate that infanticide was unlikely to have been practiced. Unfortunately, without using destructive methods we are unable to differentiate between perinates that were stillborn or that died soon after birth. It seems unlikely that premature deaths occurred at a lesser rate at Khok Phanom Di. Rather, the premature infants were probably buried outside the area excavated, suggesting a possible cultural difference in terms of burial practices compared with the Northeast sites. With the increasing amount of archaeological investigation a wealth of knowledge on social aspects of Southeast Asian prehistory is beginning to emerge (Chang 2001; Higham 2002; O'Reilly 1999, 2001, 2003; Talbot 2002; Vincent 2004; White 1986, 1995). An important topic not investigated in detail to date is a comparative study of infant burial practices. A brief survey of the infant burial rites at these sites reveals a lack of burial jars at Khok Phanom Di compared with the later sites. This lends further support to the possibility that a cultural difference in burial practice existed. This study illustrates not only the merits of using archaeological information on social organization for bioarchaeological interpretation but also that social information can be gleaned through the study of human remains. Further multidisciplinary research in prehistoric Southeast Asia, including the study of human biology and cultural remains, is needed to test this tentative interpretation of proposed cultural differences between Khok Phanom Di and the Northeast Thai sites at this important time in Southeast Asian prehistory. Contrary to the opinion of Leach (1973) it is clear that this "black box" of social information about the past is far from sealed.

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NOTE

1. For the purposes of this paper perinatal and perinates refer to pre-term, full-term and post-full-term individuals under the age of 50 weeks gestation.

REFERENCES CITED

- ANDERSON, D. D.
1990 *Lang Rongrien Rockshelter: A Pleistocene–Early Holocene Archaeological Site from Krabi, Southwestern Thailand*. Philadelphia: The University Museum of the University of Pennsylvania Press.
- ANGEL, J. L.
1971 *The People of Lerna: Analysis of a Prehistoric Aegean Population*. Washington D.C.: Smithsonian Institution Press.
- ANUSARANASĀSANAKIARTI, P. K., AND C. F. KEYES
1980 Funerary rites and the Buddhist meaning of death: An interpretive text from northern Thailand. *Journal of the Siam Society* 68: 1–29.
- ARRIAZA, B., M. ALLISON, AND E. GERSZTEN
1988 Maternal mortality in pre-Columbian Indians of Arica, Chile. *American Journal of Physical Anthropology* 77: 35–41.
- BAYARD, D. T.
1971 *Non Nok Tha: The 1968 Excavation, Procedure, Stratigraphy, and Summary of the Evidence*. Otago University Monographs in Prehistoric Anthropology. Vol. 4. Dunedin: University of Otago.
1972 Excavation at Non Nok Tha, northeast Thailand 1968: An interim report. *Asian Perspectives* 13: 109–143.
1996 Bones of contention: The Non Nok Tha burials and the chronology and context of early Southeast Asian bronze, in *Ancient Chinese and Southeast Bronze Age Cultures: The Proceedings of a Conference Held at the Edith and Joy London Foundation Property, Kioloa, NSW, February 8–12, 1988: 889–940*, ed. N. Barnard and F. Bulbeck. Taiwan: Taipei Southern Material Centre Inc.
- BORIĆ, D., AND S. STEFANOVIĆ
2004 Birth and death: Infant burials from Vlasac and Lepenski Vir. *Antiquity* 78: 526–546.
- BOURBOU, C.
2003 Health patterns of proto-Byzantine populations (6th–7th centuries AD) in south Greece: The cases of Eleutherna (Crete) and Messene (Peloponnese). *International Journal of Osteoarchaeology* 13: 303–313.
- BUIKSTRA, J. E., AND D. H. UBELAKER
1994 *Standards for Data Collection from Human Skeletal Remains*. Arkansas Archaeological Survey Report No. 44. Arkansas: Fayetteville.
- BUTLER, N. R., AND E. D. ALBERMAN, EDS.
1969 *Perinatal problems: The second Report of the 1958 British Perinatal Survey under the auspices of the National Birthday Trust Fund*. Edinburgh: E. and S. Livingstone Ltd.
- BUTLER, N. R., AND D. G. BONHAM
1963 *Perinatal Mortality: The First Report of the 1958 British Perinatal Mortality Survey, under the Auspices of the National Birthday Trust Fund*. Edinburgh: E. and S. Livingstone Ltd.

- CHANG, N. J.
2001 Personal ornaments in Thai Prehistory: Nong Nor, Ban Lum Khao and Noen-U-Loke. Ph.D. thesis. University of Otago, Dunedin.
- CHETWIN, J. N.
2001 War before Angkor: The evidential and theoretical context of warfare in prehistoric Thailand. Masters thesis. University of Otago, Dunedin.
- CRUMLEY, C. L.
1995 Heterarchy and the analysis of complex societies, in *Heterarchy and the Analysis of Complex Societies*: 1–9. ed. C. Ehrenreich, C. L. Crumley, and J. Levy. Washington D.C.: American Anthropological Association. Archaeological Papers No. 6.
- DAWODU, A., M. VARADY, M. VERGHESE, AND L. AL-GAZALI
2000 Neonatal audit in United Arab Emirates: A country with a rapidly developing economy. *Eastern Mediterranean Health Journal* 6:55–64.
- DE YOUNG, J. E.
1963 *Village Life in Modern Thailand*. Berkeley: University of California Press.
- DOMETT, K. M.
2001 *Health in Late Prehistoric Thailand*, B.A.R. International Series 0946. Oxford: Archaeopress.
- DOUGLAS, M. T.
1996 Paleopathology in human skeletal remains from the Pre-metal, Bronze and Iron Ages, Northeastern Thailand. Ph.D. diss. University of Hawai'i, Honolulu.
- FEUCHT, E.
1995 *Das Kind im Alten Agypten*. Frankfurt and New York: Campus Verlag.
- GIBSON, J. R., AND T. MCKEOWN
1951 Observations on all births (23,970) in Birmingham, 1947. III Survival. *British Journal of Social Medicine* 5:177–183.
- GLOVER, I. C., AND B. SYME
1993 The Bronze Age in Southeast Asia: Its recognition, dating and recent research. *Man and Environment* 18:41–72.
- GORDON, C. C., AND J. E. BUIKSTRA
1981 Soil pH, bone preservation, and sampling bias at mortuary sites. *American Antiquity* 46:566–571.
- GORMAN, C. F.
1970 Excavations at Spirit Cave, North Thailand: Some interim impressions. *Asian Perspectives* 13:79–107.
- GOWLAND, R. L., AND A. T. CHAMBERLAIN
2002 A Bayesian approach to ageing perinatal skeletal material from archaeological sites: Implications for the evidence for infanticide in Roman-Britain. *Journal of Archaeological Science* 29:677–685.
- GUY, H., C. MASSET, AND C.-A. BAUD
1997 Infant taphonomy. *International Journal of Osteoarchaeology* 7:221–229.
- HALCROW, S. E.
2006 Subadult Health and Disease in Late Prehistoric Mainland Southeast Asia. Ph.D. thesis. University of Otago, Dunedin.
- HAUSFATER, G., AND S. B. HRDY
1984 *Infanticide: Comparative and Evolutionary Perspectives*. New York: Aldine.
- HIGHAM, C.F.W.
1989 *The Archaeology of Mainland Southeast Asia*. Cambridge: Cambridge University Press.
1996 *The Bronze Age of Southeast Asia*. Cambridge: Cambridge University Press.
2002 *Early Cultures of Mainland Southeast Asia*. Bangkok: River Books.
- HIGHAM, C.F.W., AND R. BANNANURAG, EDS.
1990 *The Excavation of Khok Phanom Di: A Prehistoric Site in Central Thailand*. Volume I: *The Excavation, Chronology and Human Burials*. London: Society of Antiquaries of London, Research Report L.

- HIGHAM, C.F.W., AND A. KIJNGAM
1984 *Prehistoric Investigations in Northeastern Thailand*. Oxford: B.A.R. International Series 231.
- HIGHAM, C.F.W., A. KIJNGAM, AND S. TALBOT, EDS.
2007 *The Origins of the Civilization of Angkor*. Volume 2: *The Excavation of Noen U-Loke*. Bangkok: The Thai Fine Arts Department.
- HIGHAM, C.F.W., AND R. THOSARAT
1994 *Khok Phanom Di: Prehistoric Adaptation to the World's Richest Habitat*. Case Studies in Archaeology Series. Fort Worth: Harcourt Brace College Publishers.
1998 *Prehistoric Thailand: From Early Settlement to Sukhothai*. Bangkok: River Books.
2004a *The Excavation of Khok Phanom Di: A Prehistoric Site in Central Thailand*. Volume VII: *Summary and Conclusions*. London: The Society of Antiquaries of London.
2004b *The Origins of the Civilization of Angkor*. Volume 1: *The Excavation of Ban Lum Khao*. Bangkok: The Thai Fine Arts Department.
- HOFFMAN, H. J., C. R. STARK, F. E. LUNDIN JR., AND J. D. ASHBROOK
1974 Analysis of birth weight, gestational age, and fetal viability, U.S. births, 1968. *Obstetrical and Gynecological Survey* 29:651–681.
- HOUGHTON, P., AND W. WIRIYAROMP
1984 The people of Ban Na Di, in *Prehistoric Investigations in Northeastern Thailand*: 391–411, ed. C.F.W. Higham and A. Kijngam. Oxford: B.A.R. International Series 231.
- HUDSON, B.
2002 Ancient Young: The mortuary treatment of infants and children in prehistoric Thailand. Honours diss. University of Otago, Dunedin.
- INGVARSSON-SUNDSTRÖM, A.
2003 Children lost and found: A bioarchaeological study of the Middle Helladic children in Asine with a comparison to Lerna. Ph.D. thesis. Uppsala University.
- JAMIESON, R. W.
1995 Material culture and social death: African-American burial practices. *Historical Archaeology* 29:39–58.
- JANTZ, R. L., AND D. W. OWSLEY
1994 Growth and dental development in Arikara children, in *Skeletal Biology of the Great Plains: Migration, Warfare, Health and Subsistence*: 247–258, ed. D. W. Owsley and R. L. Jantz. Washington, D.C.: Smithsonian Institute.
- JEANTY, P., AND R. ROMERO
1984 *Obstetrical Ultrasound*. London: McGraw-Hill.
- JELLIFFE D. B., AND J. P. STANFIELD
1978 *Diseases of Children in the Subtropics and Tropics*. London: Edward Arnold Ltd.
- JOYCE, R. A.
2001 Burying the dead at Tlatilco: Social memory and social identities, in *Social Memory, Identity, and Death: Anthropological Perspectives on Mortuary Rituals*: 12–28, ed. M. S. Chesson. Archaeological Papers of the American Anthropological Association No. 10. Arlington: American Anthropological Association.
- KAUFFMANN, H. E.
1980 Some social and religious institutions of the Lawa (Northwestern Thailand): Part III. *Journal of the Siam Society* 68:87–125.
- KILPATRICK, S. J., R. JACKSON, AND M. S. CROUGHAN-MINIHAN
1996 Perinatal mortality in twins and singletons matched for gestational age at delivery at > or = 30 weeks. *American Journal of Obstetrics and Gynecology* 174:66–71.
- KNODEL, J., A. CHAMRATRITHIRONG, AND N. DEBAVALYN
1987 *Thailand's Reproductive Revolution: Rapid Fertility Decline in a Third-World Setting*. Madison: University of Wisconsin Press.
- LA FONTAINE, L.
1986 An anthropological perspective on children in social worlds, in *Children of Social Worlds*: 10–30, ed. M. Richards and P. Light. Cambridge: Polity Press.
- LANCASTER, H. O.
1990 *Expectations of Life: A Study in the Demography Statistics, and History of World Mortality*. New York: Springer-Verlag.

- LANGER, W. L.
1974 Infanticide: A historical survey. *History of Childhood Quarterly* 1:353–365.
- LEACH, E. R.
1973 Concluding Address, in *The Explanation of Culture Change: Models in Prehistory*: 761–771, ed. C. Renfrew. Pittsburgh: University of Pittsburgh Press.
- LEVINE, R. A.
1998 Child psychology and anthropology: An environmental view, in *Biosocial Perspectives on Children*: 102–130, ed. C. Panter-Brick. Cambridge: Cambridge University Press.
- LEWIS, M. E.
2000 Non-adult palaeopathology: Current status and future potential, in *Human Osteology in Archaeology and Forensic Science*: 39–57, ed. M. Cox and S. Mays. London: Greenwich Medical Media.
- LILJESTRAND, J.
1999 Reducing perinatal and maternal mortality in the world: The major challenges. *British Journal of Obstetrics and Gynaecology* 106:877–880.
- MASON, G. M.
1998 The shellfish, fish and crab remains, in *The Excavation of Nong Nor: A Prehistoric Site in Central Thailand*: 173–223, ed. C.F.W. Higham and R. Thosarat. University of Otago Studies in Prehistoric Anthropology No. 18. Dunedin: Department of Anthropology, University of Otago.
- MAYS, S. A.
1993 Infanticide in Roman Britain. *Antiquity* 67:883–888.
1998 *The Archaeology of Human Bones*. London: Routledge.
2003 Comment on 'A Bayesian approach to ageing perinatal skeletal material from archaeological sites: Implications for the evidence for infanticide in Roman Britain' by R. L. Gowland and A. T. Chamberlain. *Journal of Archaeological Science* 30:1695–1700.
- MCINTOSH, N., P. J. HELMS, AND R. L. SMYTH, EDS.
2003 *Forfar and Arneil's Textbook of Pediatrics*. Edinburgh: Churchill Livingstone.
- MENSFORTH, R. P., C. O. LOVEJOY, J. W. LALLO, AND G. J. ARMELAGOS
1978 Part Two: The role of constitutional factors, diet, and infectious disease in the etiology of porotic hyperostosis and periosteal reactions in infants and children. *Medical Anthropology* 2:1–59.
- MESKELL, L.
2000 Cycles of life and death: Narrative homology and archaeological realities. *World Archaeology* 31:423–441.
- METCALF, P., AND R. HUNTINGTON
1991 *Celebration of Death: The Anthropology of Mortuary Ritual*. Cambridge: Cambridge University Press.
- MOORREES, C.F.A., E. A. FANNING, AND E. E. HUNT
1963 Formation and resorption of three deciduous teeth in children. *American Journal of Physical Anthropology* 21:205–213.
- MUHLY, J. D.
1988 The beginnings of metallurgy in the Old World, in *The Beginnings of the Use of Metals and Alloys*: 2–20, ed. R. Maddin. Cambridge: MIT Press.
- MURAIL, P., B. MAUREILLE, D. PERESINOTTO, AND F. GEUS
2004 An infant cemetery of the Classic Kerma period (1750–1500 B.C., Island of Sai, Sudan). *Antiquity* 78:267–277.
- NELSEN, K. M.
1999 The dental health of the people from Noen U-Loke, a prehistoric Iron Age site in north-east Thailand. M.Sc. thesis. University of Otago, Dunedin.
- O'REILLY, D.J.W.
1999 A diachronic analysis of social organization in the Mun River Valley. Ph.D. thesis. University of Otago, Dunedin.
2001 From the Bronze Age to the Iron Age in Thailand: Applying the heterarchical approach. *Asian Perspectives* 39:1–19.

- 2003 Further evidence of heterarchy in Bronze Age Thailand. *Current Anthropology* 44:300–306.
- OWEN, N. G.
2002 Population and society in Southeast Asia before 1900. IUSSP Regional Population Conference. Bangkok, Thailand.
- OWSLEY, D. W., AND B. BRADTMILLER
1983 Mortality of pregnant females in Arikara villages: Osteological evidence. *American Journal of Physical Anthropology* 74:331–336.
- OWSLEY, D. W., AND R. L. JANTZ
1985 Long bone lengths and gestational age distributions of post-contact period Arikara Indian perinatal infant skeletons. *American Journal of Physical Anthropology* 68:321–328.
- PARKER PEARSON, M.
1982 Mortuary practices, society and ideology: An ethnoarchaeological study, in *Symbolic and Structural Archaeology*: 99–103, ed. I. Hodder. Cambridge: Cambridge University Press.
- PATEL, T.
1994 *Fertility Behaviour: Population and Society in a Rajasthan Village*. Delhi: Oxford University Press.
- PEDROSA, R.
1983 Abortion and infanticide in the Philippines during the Spanish contact. *Philippiniana Sacra* 18:7–37.
- PEEBLES, C. S., AND S. M. KUS
1977 Some archaeological correlates of ranked societies. *American Antiquity* 42:421–448.
- PIETRUSEWSKY, M.
1974a *Non Nok Tha. The human skeletal remains from the 1966 excavations at Non Nok Tha, Northeastern Thailand*, University of Otago Studies in Prehistoric Anthropology Vol. 6. Dunedin: University of Otago.
1974b The palaeodemography of a prehistoric Thai population: Non Nok Tha. *Asian Perspectives* 17:125–140.
1978 A study of early Metal Age crania from Ban Chiang, Northeast Thailand. *Journal of Human Evolution* 7:383–392.
1982 The ancient inhabitants of Ban Chiang: The evidence from the human skeletal and dental remains. *Expedition* 24:42–50.
1984 Pioneers of the Khorat Plateau: The prehistoric inhabitants from Ban Chiang. *Journal of the Hong Kong Archaeological Society* 10:90–106.
1988 Multivariate comparisons of recently excavated Neolithic human crania from the Socialist Republic of Vietnam. *International Journal of Anthropology* 3:267–283.
1997 The people of Ban Chiang: An early Bronze-Age site in Northeast Thailand. *Bulletin of the Indo-Pacific Prehistory Association* 16:119–148.
- PIETRUSEWSKY, M., AND M. T. DOUGLAS
2002a *Ban Chiang, A Prehistoric Village Site in Northeast Thailand I: The Human Skeletal Remains*, Thai Archaeology Monograph Series 1, University Museum Monograph 111. Philadelphia: University of Pennsylvania Museum of Archaeology and Anthropology.
2002b Intensification of agriculture at Ban Chiang: Is there evidence from the skeletons? *Asian Perspectives* 40:157–178.
- PRESTON, S. H., AND M. R. HAINES
1991 *Fatal Years: Child Mortality in Late Nineteenth-Century America*. Princeton: Princeton University Press.
- PUREEPATPONG, N.
2001 A preliminary report of an analysis of human skeletal remains from Muang Sema, Nakhon Ratchasima Province, Northeast Thailand (in Thai). 12th Regional Office of the Thai Fine Arts Department: Phimai, Nakhon Ratchasima.
- RACZEK, T. P.
2003 Subsistence strategies and burial rituals: Social practices in the late Deccan Chalcolithic. *Asian Perspectives* 42:247–266.
- REIDPATH, D. D., AND P. ALLOTEY
2003 Infant mortality rate as an indicator of population health. *Journal of Epidemiology and Community Health* 57:344–346.

- RENFREW, C., AND P. BAHN
2004 *Archaeology: Theories, Methods and Practice*, 4th ed. New York: Thames and Hudson.
- SAUNDERS, S. R.
2000 Subadult skeletons and growth-related studies, in *Biological Anthropology of the Human Skeleton*: 135–162, ed. M. A. Katzenberg and S. R. Saunders. New York: Wiley-Liss.
- SAUNDERS, S. R., D. A. HERRING, AND G. BOYCE
1995 Can skeletal samples accurately represent the living population they come from? The St. Thomas' cemetery site, Belleville, Ontario, in *Bodies of Evidence: Reconstructing History Through Skeletal Analysis*: 69–89, ed. A. L. Grauer. New York: Wiley-Liss.
- SCHUEER, J. L., AND S. BLACK
2000 *Developmental Juvenile Osteology*. San Diego: Academic Press.
- SCHUEER, J. L., J. H. MUSGRAVE, AND E. P. EVANS
1980 The estimation of late fetal and perinatal age from limb bone length by linear and logarithmic regression. *Annals of Human Biology* 7:257–265.
- SCOTT, E. C.
1999 *The Archaeology of Infancy and Infant Death*, BAR International Series 919. Oxford: Archaeopress.
- SCRIMSHAW, S.C.M.
1984 Infanticide in human populations: Societal and individual concerns, in *Infanticide: Comparative and Evolutionary Perspectives*: 439–462, ed. G. Hausfater and S. B. Hrdy. New York: Aldine.
- SERVICE, E. R.
1962 *Primitive Social Organization: An Evolutionary Perspective*. New York: Random House.
- SHERWOOD, R. J., R. S. MEINDL, H. B. ROBINSON, AND R. L. MAY
2000 Fetal age: Methods of estimation and effects of pathology. *American Journal of Physical Anthropology* 113:305–315.
- SLAUS, M.
2000 Biocultural analysis of sex differences in mortality profiles and stress levels in the late medieval population from Nova Raca, Croatia. *American Journal of Physical Anthropology* 111:193–209.
- SMITH, P. AND G. KAHILA
1992 Identification of infanticide in archaeological sites: A case study from the Late Roman–Early Byzantine periods at Ashkelon, Israel. *Journal of Archaeological Science* 19:667–675.
- SOREN, D., AND N. SOREN
1995 Who killed the babies of Lugnano? *Archaeology* 48:43–48.
- STEEL, L.
1995 Differential burial practices in Cyprus at the beginning of the Iron Age, in *Archaeology of Death in the Ancient Near East*: 199–204, ed. S. Campbell and A. Green. Exeter: The Short Run Press.
- STEIN, G. J.
1998 Heterogeneity, power, and political economy: Some current research issues in the archaeology of Old World complex societies. *Journal of Archaeological Research* 6:1–45.
- TAINTER, J. A.
1978 Mortuary practices and the study of prehistoric social systems. *Advances in Archaeological Method and Theory* 1:105–141.
- TALBOT, S.
2002 From the Iron Age to Angkor in northeast Thailand. Ph.D. thesis. University of Otago, Dunedin.
- TAYLES, N.
1999 *The excavation of Khok Phanom Di: A prehistoric site in Central Thailand*. Vol. 5: *The People*. London: The Society of Antiquaries of London, Research Report L.
- TAYLES, N., AND H. R. BUCKLEY
2004 Leprosy and tuberculosis in Iron Age Southeast Asia? *American Journal of Physical Anthropology* 125:239–256.

- TAYLES, N., S. E. HALCROW, AND K. DOMETT
 2007 The people of Noen U-Loke, in *The Origins of the Civilization of Angkor*. Vol. 2: *The Excavation of Noen U-Loke*: 243–304, ed. C.F.W. Higham, A. Kijngam, and S. Talbot. Bangkok: The Thai Fine Arts Department.
- TAYLES, N., K. NELSEN, H. BUCKLEY, AND K. DOMETT
 1998 The Iron-age people of Noen U-Loke, northeast Thailand: A preliminary review of the first two field seasons. *Bulletin of the Indo-Pacific Prehistory Association* 17:75 (abstract).
- TOCHERI, M. W., T. L. DUPRAS, P. SHELDRIK, AND J. E. MOLTO
 2005 Roman period fetal skeletons from the East Cemetery (Kellis 2) from Kellis, Egypt. *International Journal of Osteoarchaeology* 15:326–341.
- UCKO, P. J.
 1969 Ethnography and archaeological interpretation of funerary remains. *World Archaeology* 1:262–280.
- VAN ESTERIK, P.
 1985 The cultural context of breastfeeding in rural Thailand, in *Breastfeeding, Child Health and Child Spacing: Cross-Cultural Perspectives*: 139–161, ed. V. Hull and M. Simpson. London: Croom Helm.
- VINCENT, B. A.
 2004 *The Material Culture (Part II), The Excavation of Khok Phanom Di a Prehistoric Site in Central Thailand*, Vol. 6. London: Reports of the Research Committee of the Society of Antiquaries of London No. LXX.
- WALKER, P. L., J. R. JOHNSON, AND P. M. LAMBERT
 1988 Age and sex biases in the preservation of human skeletal remains. *American Journal of Physical Anthropology* 76:183–188.
- WASON, P.
 1994 *The Archaeology of Rank*. New Studies in Archaeology. Cambridge: Cambridge University Press.
- WHITE, J. C.
 1986 A revision of the chronology of Ban Chiang and its implications for the prehistory of Northeast Thailand. Ph.D. diss. University of Pennsylvania, Philadelphia.
 1995 Incorporating heterarchy into theory on sociopolitical development: The case from Southeast Asia, in *Heterarchy and the Analysis of Complex Societies*: 101–123, ed. R. M. Ehrenreich, C. L. Crumley, and J. E. Levy. Archaeological Papers of the American Anthropological Association, No. 6. Arlington: American Anthropological Association.
 1997 A brief note on new dates from the Ban Chiang cultural tradition. *Bulletin of the Indo-Pacific Prehistory Association* 16:103–106.
- WHITE, J. C., AND V. C. PIGOTT
 1996 From community craft to regional specialisation: Intensification of copper production in pre-state Thailand, in *Craft Specialization and Social Evolution: In Memory of V. G. Childe*: 151–175, ed. B. Wailes. University Museum Monographs. Philadelphia: University of Pennsylvania Museum of Archaeology and Anthropology.
- WHYTE, R. O.
 1974 *Rural Nutrition in Monsoon Asia*. Kuala Lumpur: Oxford University Press.
- WILLIAMSON, L.
 1978 Infanticide: An anthropological analysis, in *Infanticide and the Value of Life*: 61–75, ed. M. Kohl. Buffalo: Prometheus.
- WONGBOONSIN, K., AND V. P. RUFFOLO
 1994 Thailand's fertility culture: Prospects for below replacement levels. International Symposium on Issues Related to Sex Preference for Children in a Rapidly Changing Demographic in Asia. Seoul.

ABSTRACT

Important information on demography, epidemiology, inter-population differences in growth, infant burial practices, and social aspects of the community can be gleaned from the study of perinatal bones. The increasing number of perinates

unearthed from prehistoric sites in Southeast Asia provides a rare opportunity to investigate these issues. The high number of full-term infants represented at the site of Khok Phanom Di in Central Thailand (4000–3500 B.P.) remains an enigma. This is an important issue for bioarchaeologists as infant mortality patterns are sensitive barometers of the health and fertility of a population. This study investigated the perinatal age distributions of several chronologically spread sites in prehistoric Southeast Asia with differing subsistence modes and evidence of social complexity. Results show that the age distribution in the collection from Khok Phanom Di is different from the other skeletal samples, with a comparatively higher number of full-term perinates represented. Explanations including infanticide, issues of health and disease, and infant burial practices are considered. It seems likely that the age distribution results from different burial rites of pre-term infants as a consequence of social and cultural differences between Khok Phanom Di and the other sites. This study emphasizes the important contribution bioarchaeological research and the comparative study of infant burial rites can make in understanding aspects of social change in prehistoric communities. **KEYWORDS:** bioarchaeology, infant burial practices, perinatal age at death distributions, prehistoric mainland Southeast Asia, social organization.