9 A physical anthropology perspective on a mainland Southeast Asian agrarian population: prehistoric skulls of Ban Chiang

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1 Introduction

Ban Chiang is a prehistoric mounded village site located along the Upper Songkhram River in the province of Udon Thani, in the Sakon Nakhon Basin of the Khorat Plateau (Figure 1). The site was first discovered in the early 1960s. In 1967, Vidya Intakosai of the Thai Fine Arts Department (FAD) undertook a small test excavation at Ban Chiang and uncovered a complete inhumed skeleton with bronze and iron artefacts, together with plain and painted pottery vessels. Further excavations by Thai archaeologists in 1972-73 found evidence of bronze and iron metallurgy as well as skeletal remains. The Thai government encouraged further scientific research at the site, and a major research programme was jointly conducted in 1974–75 by the Fine Arts Department and the University of Pennsylvania Museum of Archaeology and Anthropology (UPMAA) under the direction of Pisit Charoenwongsa and Dr. Chester Gorman. This excavation uncovered conclusive evidence for the practice of bronze and iron metallurgy, many artifacts and remains of daily life, and approximately 134 burials. As a result of the 1974–75 excavations, the site achieved international fame and a listing on the UNESCO World Heritage Site List, both because of its beautiful red-on-buff pottery and its evidence for early bronze metallurgy.

The chronology has undergone revision over the years (Gorman & Charoenwongsa 1976; White 1982, 1986), but the most recent chronology (White 2008) dates the Early Period of the site to 2100–900 B.C., the Middle Period to 900 B.C.–300 B.C., and the Late Period to 300 B.C.–A.D. 300. The Protohistoric Period that followed saw the rise of the first states in mainland Southeast Asia. The occupation of Ban Chiang, still inhabited, thus stretches back at least four thousand years into the past.

After the FAD-Penn excavations, Thai and foreign archaeologists conducted surveys in the Sakhon Nakon Basin and adjacent parts of northern Thailand, looking for sites affiliated to the Ban Chiang Cultural Tradition. According to the 1991 survey of Ban Chiang Cultural Tradition (BCCT) sites, there are at least 126 sites with artefacts related to Ban Chiang located in the upper part of northeastern Thailand (Bannanurag & Bamrungwong 1991). Only sixteen of these sites (12.6% of the total discovered) have been

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investigated and excavated (Bannanurag et al 1992). Moreover, most of them were small-scale excavations, with only preliminary reports and without intensive study of artifacts recovered. Nonetheless, data from the surveys and the sixteen excavations have led to a more detailed understanding of the Ban Chiang Cultural Tradition, to the extent that the 126 sites can be now divided into seven distinct clusters.

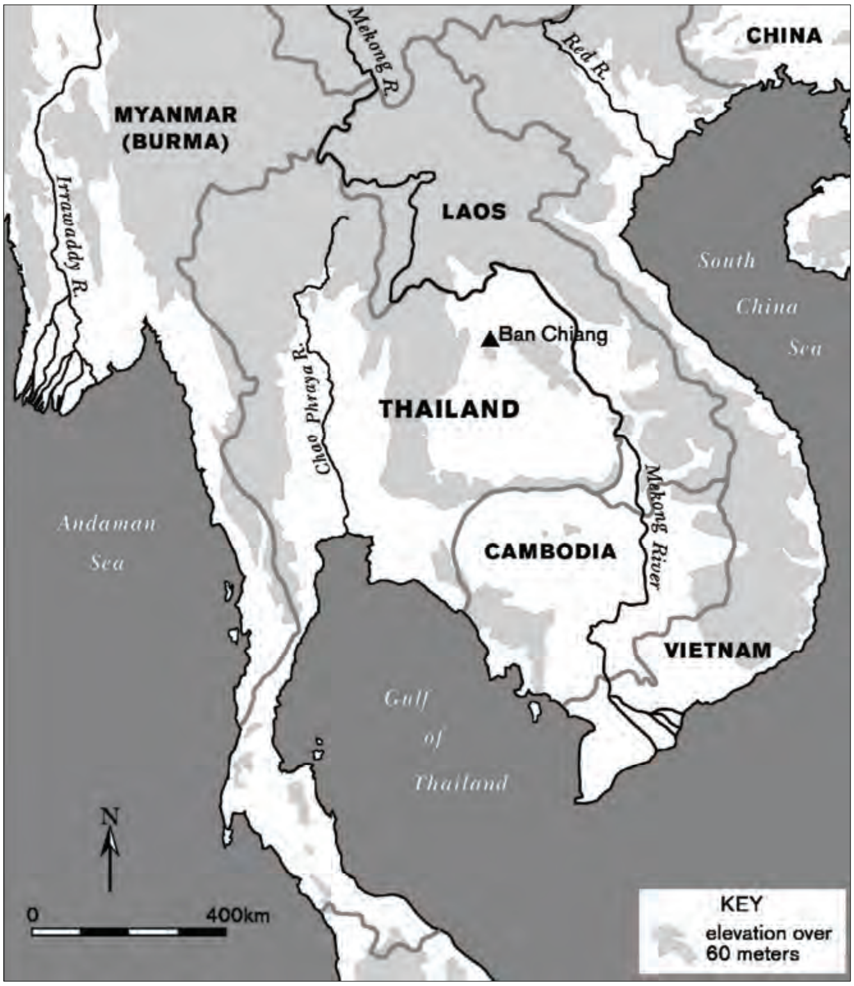

Figure 1: Map with location of Ban Chiang (by Ardeth Abrams).

2 Osteological studies of prehistoric skeletons in Thailand

The corpus of excavated and analysed human remains from Thailand is relatively small but growing. Published analyses from sites other than Ban Chiang in northern northeast Thailand include Sangvichien for Ban Kao (1966), Sangvichien & Supawan for Ban Thatu and Ban Om Kaew (1977), Pietrusewsky (1974 [Non Nok Tha]),Wiriyaromp for Ban Na Di (1984), Choosiri (1992; 1994 [Ban Tum and Ban Daeng Yai]), Agelarakis for Khao Wong Prachan valley (1997), Pureepatpong for excavation pit # S18 W22 at Ban Mai Chai Mongkhol (1996), Hutangkura for Ban Don Thong Chai (1997), Kae-In (1999 [Prasat Phanom Wan]), Tayles, Domett & Nelsen (2000), Nelsen, Tayles & Domett (2001), Boonlop (2003 [Ban Khok Khon]), Kaewsuwan (2003), Boonlop & Brown (2008 [Ban Khok Khon]). However, published analyses from Ban Chiang Cultural Traditions sites are much fewer; only five sites out of the 127 BCCT sites—Ban Thatu and Ban Na Di in Udon Thani, Ban Don Thong Chai and Ban Khok Khon in Sakon Nakhon, and Ban Chiang itself have had analyses performed. The skeletal material from Ban Chiang has received the most attention, from Pietrusewsky (1982, 1984, 1997), Douglas (1996, 1997), Douglas & Pietrusewsky (2007) and especially Pietrusewsky & Douglas (2002). In addition, Kaewsuwan (2003) analysed the subadult skeletons excavated from Wat Phosi Nai in 2003 to age subadults by teeth. There is an urgent need for more studies of the human remains from prehistoric Thailand, both to understand the morphological diversity of the prehistoric agrarian populations and to understand their genetic differences and similarities to modern-day populations.

3 The present study

For Ban Chiang itself, the metric and non-metric study of human skeletons excavated in 1974–1975 (especially Pietrusewsky & Douglas 2002) has provided us with a great deal of information regarding the interpretation and reconstruction of the ancient population. The analysis of the complete skeletons has allowed us to understand not only details about individuals (age at death, sex, stature, growth and development, physical activities, and biological affiliation) but also details at the population level: diet, nutrition, health and disease, trauma and injury, frequency of warfare, physiological stress, cultural use of teeth and bones, and demography (Larsen 1997, 2000).

However, in anthropology, there is a long history of studies focusing on the cranial measurements alone. Part of the reason for this focus lies in the relative ease with which the skull may be used to distinguish between individuals and between ethnic populations (Brothwell 1981:77). Metric and non-metric are two major categories of information which have been used traditionally to study and describe skulls. Skull dimensions and traits are influenced by age, diet, muscular development, mechanical pressure, and environment. Moreover, heritability studies have demonstrated an underlying genetic basis to many aspects of skull morphology. Comparisons of skull morphology based on both metric and non-metric data have long been one of the primary avenues for research in physical anthropology in order to characterise and determine relatedness among past and present human groups.

Because of the importance of Ban Chiang, the authors, while employed by the Fine Arts Department of Thailand, returned in 2003–2004 to supervise the excavation of another area of the site, one near Wat Phosi Nai (see Figure 2). This appeared to be a mortuary area, with 109 burials uncovered from 15 x 15 metres excavated area, 3.5 metres deep (see Figures 3 and 4, and Table 1; data tables begin on p. 191). All the previous excavations at Ban Chiang except for the joint 1974–1975 excavations have been limited in scope, so that the Ban Chiang 2003–2004 skeletal sample is the second largest sample to be uncovered at the site.

The skulls from these burials form the subject of this study. This chapter reports on preliminary results of a study of skull morphology from this Wat Phosi Nai sample, as well as some observations on mandibles. Our goal is to expand the data available on the diversity of human skull morphology in prehistoric mainland Southeast Asia, as well as to shed a bit more light on the controversy regarding migration of populations into Southeast Asia in the past. Standard methods of physical anthropology, including recording metric and non-metric variations, were applied to the specimens. The chapter also compares the 2003–2004 Ban Chiang human skull series with human skull remains from Ban Chiang 1974–1975 specimens, and the human skull samples from other Ban Chiang Cultural Tradition sites including Ban Na Di and Ban Khok Khon.

Figure 2: The excavation at Wat Phosi Nai, Ban Chiang in 2003 to 2004.

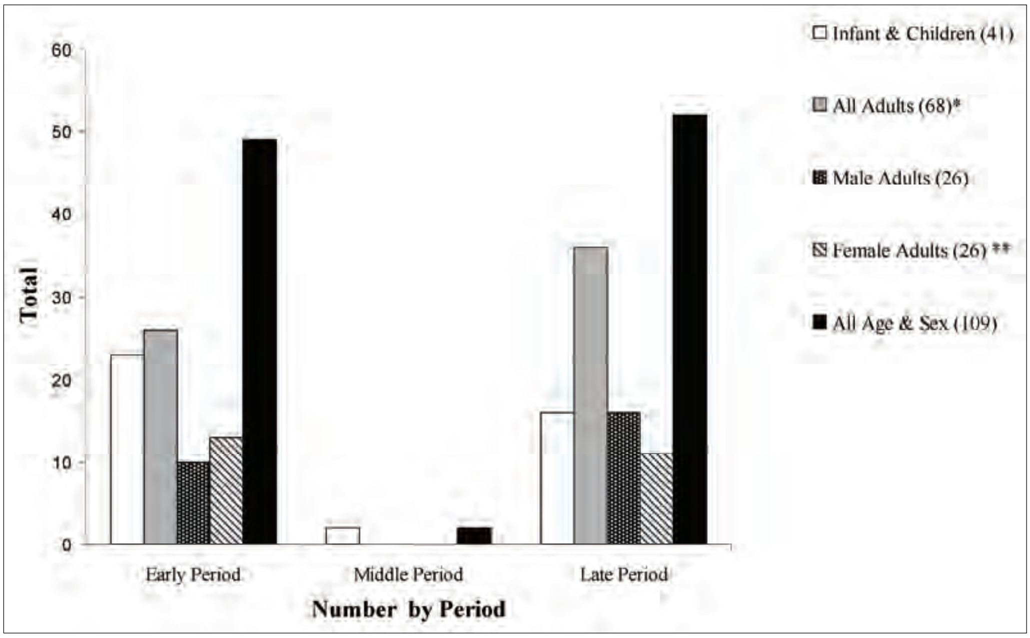

Figure 3: The number of individuals broken down by sex, ages at death, and period: * 6 adults unidentified for period including 4 adults unidentified for sex; ** 2 females unidentified for period.

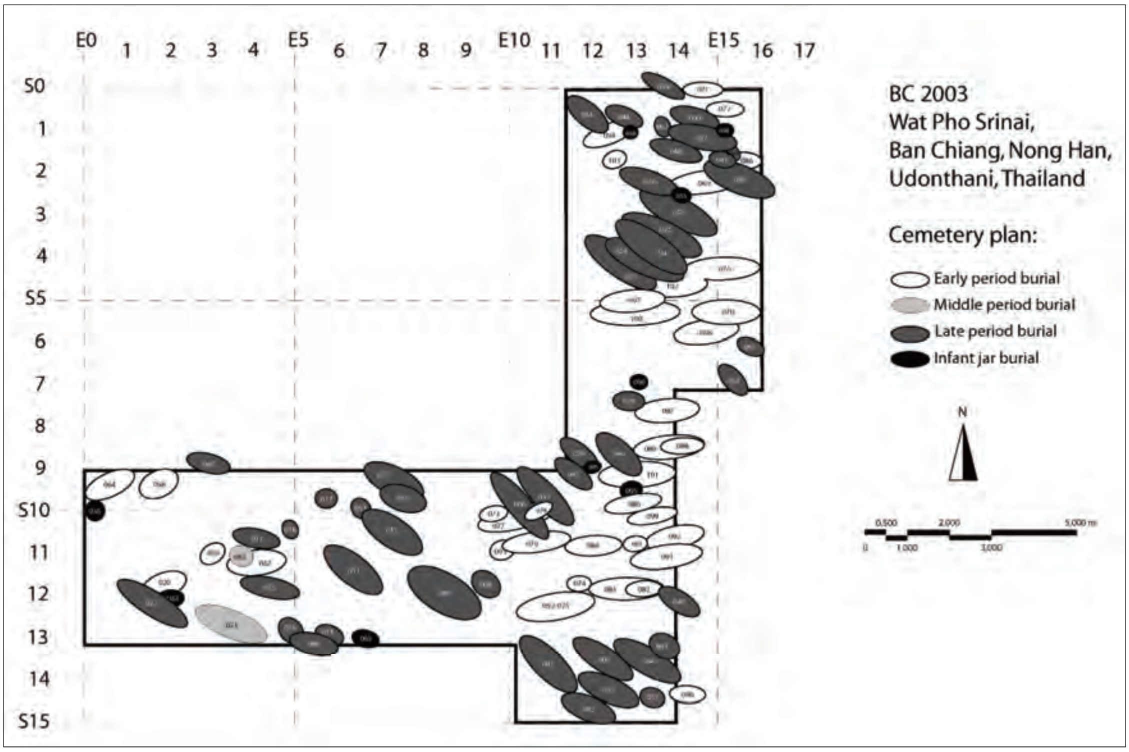

Figure 4: Cemetery plan at Wat Phosi Nai showing distribution of burials by cultural periods.

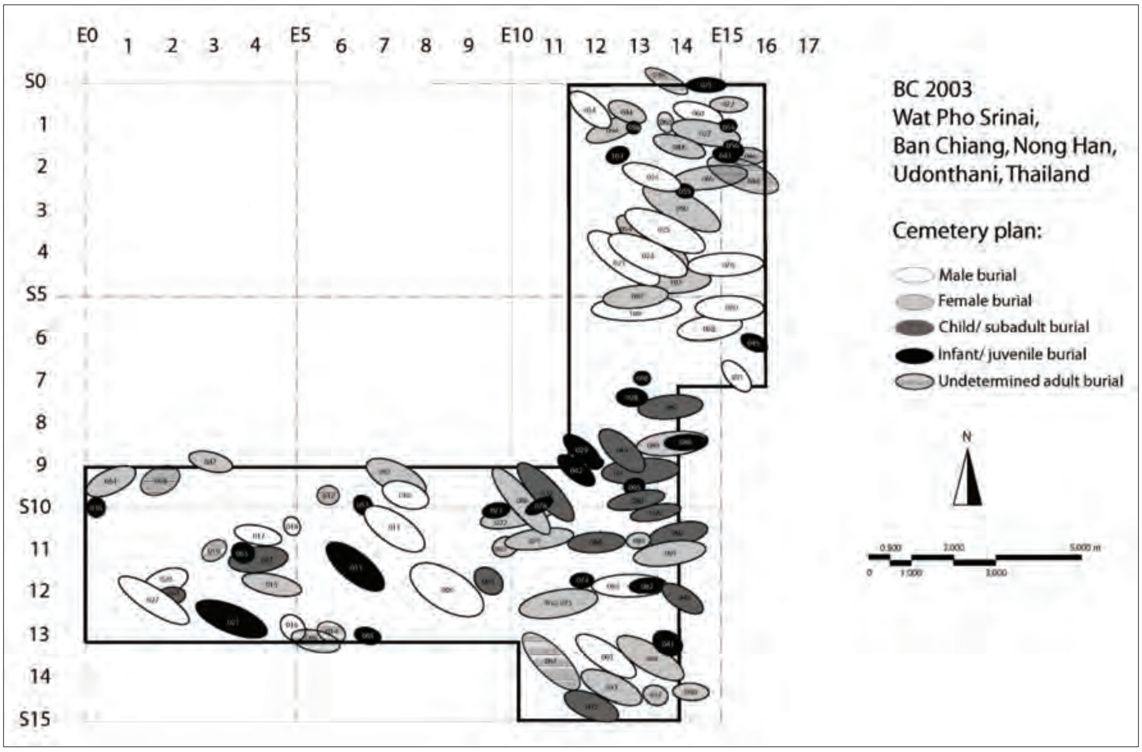

Figure 5: Cemetery plan at Wat Phosi Nai showing distribution of burials classified by sex and age.

4 Condition of the sample

The complete condition of these skeletons ranges from almost complete skeletons to fragmentary bones. Many burials are disturbed or mixed and the boundaries of the grave pits were difficult to clarify. The mixed and incomplete condition of many skeletons may be caused, in large measure, by recent disturbances. The first excavation of the area was in 1991; workers exposed the highest layer of skeletons and left the bones displayed as part of an open air museum exhibit. It was not until 2003 that the area was fully excavated and the bones and artifacts removed to museum storage, to be replaced in the exhibit by replicas. Overall, the preservation of the 2003–2004 Wat Phosi Nai Ban Chiang human skeletal series is poor to fair; just a few skeletons could be classified as being very well preserved. Excavation timing may have affected skeletal completeness of the lower layers as well; the excavation took place during the rainy season, with some resulting bone damage from the high water table and wet soil.

5 Methods

Standard methods of physical anthropology and human osteology were applied to the skeletal remains, including recording of metric and non-metrical variations. The methods given in Hillson (1990:180–187, 1992, 1996), Ubelaker (1984:46–54), and White (1991:308–313) were used to determined age at death. The methods provided by Brothwell (1981:62–63), Choosiri (1991:126–132), Ubelaker (1984:42–59), and White (1991:320–327) were used for sex assessments. Methods of craniometry and cranioscopy are given in Boonprakorb (1993), Howells (1973), Krogman (1962), Laughlin & Jorgensen (1956), Martin & Saller (1957), Sangvichien (1970), Sjovold (1984), Stewart (1940), White (1991), and Wilder (1920).

The excavation at Wat Phosi Nai in 2003–2004 revealed skeletal remains of individuals in both burial and non-burial contexts. A total of 109 skeletons were in sufficiently good condition to be studied. Of these, 41 were subadults with ages ranging from a few months to 18 years of age. Thirty of the subadults were aged between newborn and 4 years, six aged between 5–9 years, four aged between 10–14 years, and six aged between 15–19 years at time of death. Sixty-eight of the 109 remains were determined to be adults. Seventeen died between 20–24 years of age, six were aged between 25–29 years, eight were aged between 30–34 years, fourteen were aged between 35–39 years, one was 40–44 years of age at death, fifteen were aged between 45–49 years, and two were older than 50 years. Among these adults, there are 26 males (38.23 % of all adults), 26 females (38.23 % of all adults), and 16 adults are of undetermined sex (23.52 %, 16/68).

Nevertheless, among the skeletons with fair to poor preservation there are 17 skulls which are complete enough to study. Of these, eight individuals are from the Early Period (2,100 to 900 BC), three males and five females. Nine other individuals are from the Late Period (300 BC to 300 AD), eight males and one female. No well-preserved skulls datable to the Middle Period were unearthed from the 2003–2004 excavation at Wat Phosi Nai cemetery.

5.1 Craniometric Data

This section presents the measurements and indices from 17 adult skulls from the 2003–2004 Ban Chiang series, including size and shape characteristics as detailed in Tables 2 and 3. (Data tables are assembled at the end of the chapter.)

Eighteen measurements of the cranium and four measurements of the mandible are shown.

Average sizes and shapes of the 2003-2004 Ban Chiang series skulls have been classified categorically to represent standard ranges in the long tradition of anthropological measurements for human skeletons (Howells 1973; Martin & Saller 1957). The ratios of two or more measurements presented in Tables 4 and 5 are useful expressions of shape that can be used for making comparisons among groups of people (White 1991:292). The average male and female cranium of this series is medium.

5.2 Vault Shape

Cranial vault shape is typically expressed by three indices: the cranial (or length-breadth), height-length, and height-breadth (Pietrusewsky & Douglas 2002). The cranial index (breadth/length X 100) in the average male in this series is mesocranial or medium (range from 69.9 to 85.2), while the females are predominantly mesocranial (range from 74.1 to 83.8). Cranial height expressed as a proportion of cranial length (height-length index) indicates that the average is hypsicrane or high cranium in both males (range from 77.8 to 80.3) and females (range from 69.6 to 80.8). Females, however, have slightly higher crania than males. In the height-breadth cranial index, both males and females have high crania, best classified as acrocrane; the male index ranges from 93.1 to 107.8, and the female index ranges from 87.5 to 107.1. These data suggest that most males and females are similar in the horizontal view, with medium crania in length and breadth. In the vertical view, males and females have mostly high crania. However, female crania overall are smaller than male crania. In addition, similarity in size and shape between male and female crania is affected by diet (Larsen 1997, 2000). This implies that prehistoric males and females at Ban Chiang consumed a similar range of foods.

5.3 Face Shape

Descriptions of the relative shape of the facial skeleton include ratios such as upper facial and total facial (mandible included) indices. Both the upper and total facial indices show medium to high values in males while female facial indices are on the average medium. However, facial proportions are very similar in both sexes. Face morphology is also described by the proportions of the orbit, nasal aperture, and palate. As a rule, orbital shapes (orbital index) are broad or hypericonch in both sexes. The nasal aperture average of males is mesorrhine or medium, which is very similar to the female nasal aperture shape. Some males and females however have broad (chamaerrhine) or very broad (hyperchamaerrhine) nasal apertures. The palatal shape, derived from the external breadth compared to the external length of the palate, is broad in both sexes.

5.4 Mandible Shape

The ramus index and the jugomandibular index are two indices which describe the size and shape of the mandible. In this sample, the jugomandibular index from both sexes suggests a slightly narrower mandible in females than in males. The average ramus index is slightly broader in the males than the females.

5.5 Skull Non-metric Data

The non-metric characteristics of the BC 2003–2004 Ban Chiang skull series are presented below in Tables 6 and 7 for male and female adults.

Figure 6: Male skull of B # 076 from BC 2003 series.

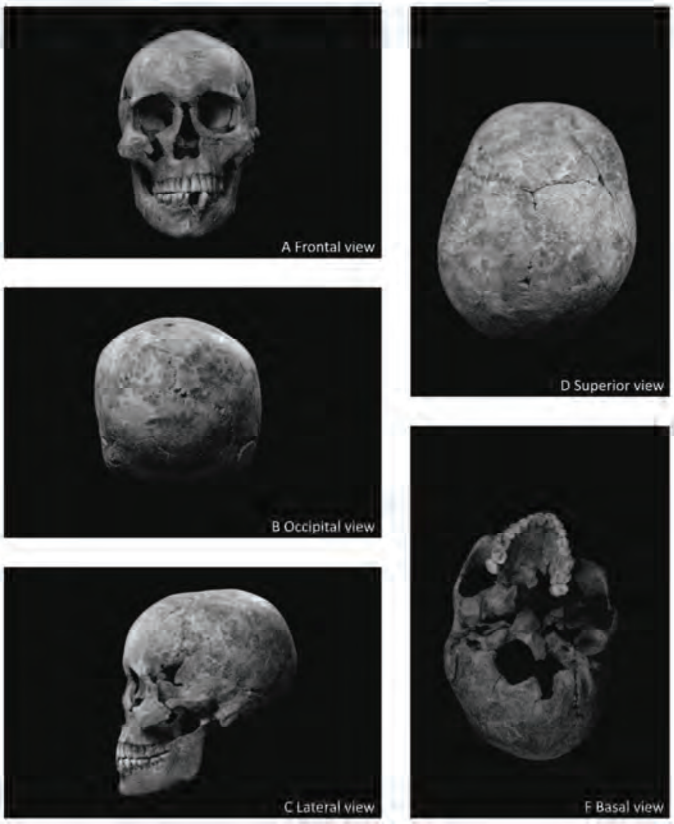

Figure 7: Female skull of B # 091 from BC 2003 series.

Two of the most complete skulls, one male and one female, were selected to illustrate skull shapes. A male skull (Figure 6): *Frontal* view shows slightly marked supra-orbital ridges and well-marked robust zygomatics. The upper facial and nasal apertures are both medium in size and shape. The *occipital* view shows the arched form of the vault and the haus-form or the pentagonal shape of the vault. The *left lateral* view shows both slight supra-orbital ridges and prognathic upper face. The cranium is of medium height relative to both breadth and length. The mastoid processes are quite large. *Superior* view shows that the cranial vault is quite symmetrical with a sphenoid shape in average together with ellipsoid and ovoid shapes. The *basal* view indicates a broad palate and moderate to marked dental wear of the maxillary teeth, as well as well-marked shoveling in the upper central incisors.

Male mandible shown by the above pictures: the *frontal* view shows healed premortem tooth loss. The chin shows a bilobate structure and is angled inferiorly. The gonio-condylar index indicates a well-diverged ramus. The *left and right lateral* views show the mandible with a single mental foramen on each side. The ramus index shows a relatively narrow or tall ramus in the low end of the male range. The coronoid process is higher than the mandibular condyle. The *occlusal* or *superior* view of the mandible (not shown here) shows moderate, even tooth wear. The jaw is non-rocker and is quite broad relative to its length.

Female skull (Figure 7): The *anterior* or *frontal* view exhibits a broad nasal aperture. The *occipital* view exhibits a strongly arched form of the vault. The *left lateral* view shows the smooth curvature of the frontal and occipital morphology typical of females in the sample. The upper face is prognathic; the zygomatics are quite broad and robust. The cranium is of medium height relative to both breadth and length. The mastoid process is quite small to medium in size. In the *superior* view, the cranial vault is quite asymmetrical with a sphenoid shape. On the *basal* view of the skull the maxillary molar teeth show moderate dental wear, well-marked shovel shaping of the upper incisors, and a broad palate. The superior and basilar views of the cranium, however, show plagiocephaly and a much skewed cranial base, a result of the reconstruction of the vault.

Female mandible shown by above pictures: the *anterior* view exhibits post mortem tooth break in the left central incisor. The chin has medial and bilateral points and is angled inferiorly. The gonio-condylar index reflects a quite divergent ramus. The left lateral view shows a single mental foramen and the mandible is not rocker-jawed. The ramus index reflects a relatively narrow ramus. In the *occlusal* view (not shown here), the right mandibular condyle is gone. There is moderate tooth wear and premortem tooth loss of the third molar on the right side.

6 Comparisons

Table 8 compares metrical measurements from seven different prehistoric skeletal sets from mainland Southeast Asia, including the 2003–2004 sample from Ban Chiang Wat Phosi Nai and the 1973–1974 sample from Ban Chiang (Pietrusewsky & Douglas 2002). Other samples are from the two sites of Ban Khok Khon (BKK, 98–99) (Boonlop 2003), and Ban Na Di (BND) (Wiriyaromp 1984). Both of these sites are in the same area as Ban Chiang, the Sakon Nakhon basin or upper part of the Khorat Plateau.

Cranial measurements suggest that most prehistoric inhabitants in the region, at least from Vietnam, Laos, and Thailand, have no significant difference in their cranial size. Specifically, six cranium measurements (maximum length, maximum breadth, maximum frontal breadth, minimum frontal breadth, biorbital breadth, and interorbial breadth) are not dramatically different from other prehistoric populations in the Sakon Nakhon Basin of northeast Thailand and mainland Southeast Asia, as the data shows in Table 8.

In addition, the data are compared in Table 9 with modern Thai skull specimens in northeast Thailand from the Department of Anatomy, Faculty of Medicine, Khon Kaen University (KKU) (Boonlop 2003). These skeletal remains came from donated bodies used in medical anatomy courses. To produce a comparative sample, the authors selected 17 skulls similar in sex and age of death to the prehistoric Wat Phosi Nai collection as representative of modern humans in the northeast region.

In Table 9 and Table 10, the prehistoric skulls of BC 2003 (WPSN) are compared with the modern northeast Thai skulls in twenty-two traits for both males and females. The tables indicate that the prehistoric skulls and modern skulls are approximately the same size in both males and females. Some metrical traits in the female skulls, however, suggest a difference between the two female series. These traits, for example maximum cranial length, maximum cranial breadth, maximum frontal breadth, and bimaxillary breadth, show that the female skulls from the prehistoric period are larger than the modern skulls. This data is similar to the results from previous comparative studies between the prehistoric specimens from Ban Khok Khon and modern skulls in northeast Thailand (Boonlop 2003).

7 Non-metrical dental traits

'Shovel-shaped teeth' is a term that refers to a condition where the upper or lower incisors have raised ridges along the sides of the inner surface. Because of the general resemblance of this crown form to a shovel, the terminology 'shovel-shaped teeth' was proposed to describe this diagnostic tooth shape of East Asian populations (Hrdlicka 1920). Scott & Turner (1997) used the varying expressions of this trait to divide modern East Asian populations into two groups, the Northern and the Southern Mongoloid. The Northern Mongoloid group (Sinodonts) includes the Chinese, Tibetans and other inhabitants of northern and eastern Asia, and is characterised by a very high (60%–90%) incidence of advanced shovel-shaping; the Southern (Sundadont) group, including Southeast Asians, Polynesians, and Micronesians, have a moderate incidence of the trait (20%–50%). Pietrusewsky and Douglas's analysis of their Ban Chiang sample indicated that the incidence of advanced shovel-shaping for all incisors was 56.8% (Pietrusewsky & Douglas 2002:52).

Other non-metrical traits used to differentiate populations include winging (rotated incisors) and Carabelli's cusp, an additional cusp on the tongue side of the maxillary molars. Pietrusewsky & Douglas's sample showed an overall incidence of winging of 6.1% and of Carabelli's cusp at 7.0%, consistent with other Pacific and East Asian populations.

8 Conclusions

The first aim of this study was to examine a recently excavated skeletal sample from the important site of Ban Chiang in northern northeast Thailand to see how the metric and non-metric traits in this sample compared with analysed samples from nearby sites in Thailand, and then with samples from adjacent areas in Laos and Vietnam.

Our study has shown that the prehistoric inhabitants from Ban Chiang Cultural Tradition villages and modern Thai in northeast Thailand have similarities of skull morphology with other people in adjacent areas, especially in Laos, Vietnam

(Pietrusewsky 2006a:59–90) and Cambodia (Pietrusewsky 2006b:86–95). Similarities include the percentages of the incidence of shovel-shaped incisors, a distinctive non-metric trait of the East Asian population. Moreover, the preliminary result of comparisons between the BC 2003–2004 human skull series and the other series indicates that the prehistoric population of Ban Chiang as revealed in Wat Phosi Nai were similar in cranial size and tooth shape to the early inhabitants of neighboring prehistoric agricultural villages, such as Ban Na Di and Ban Khok Khon, as well as to the inhabitants of Ban Chiang buried at other portions of the site.

The second aim of the study was to compare this Ban Chiang sample with a comparative sample of modern skulls from the same region of Thailand. It was hoped that this comparison would offer some data to help resolve the ongoing controversy as to whether many or most of the population traits in Southeast Asia were brought in by migrants from southern China or belonged to populations long-established in the region. In terms of regional comparisons, the dental morphology of the Northern Mongoloid, or Sinodont, is characterised by very high percentages of shovel-shaped or double shovel-shaped incisors and winged incisors. The Sundadont, or Southern Mongoloid dental complex, show little winging and lower percentages of shovel or double shovel-shaped incisors (Scott & Turner 1997:177–187). The teeth analysed in the Ban Chiang WPN 2003 sample, along with the contemporaneous series from other sites and the modern NE Thailand sample, place the Ban Chiang Wat Phosi Nai sample in the Sundadont category (Boonlop 2003; Matsumura et al 2010; Pietrusewsky & Douglas 2002).

The non-metrical data of crania, teeth, and mandibles indicate that many traits which were present in the prehistoric period continue into the present. Craniometric measures and indices indicate that the skulls in this series are of moderate dimensions comparable to other collections from this area. As a rule, though, the prehistoric skulls from the BC 2003 (WPSN) series are a bit larger than the modern NE Thailand skulls, especially in the breadth and length of the orbital area and cheek bones (Boonlop 2003:319–324). The average male and female skulls show diversity of form, with both ovoid and sphenoid shapes in the superior view, and arched or pentagonal shape of the vault in the occipital view. Prognathic upper facial regions are a long-standing trait. The zygomatic arches are broad and robust, especially in the male, and the nasal apertures are moderate to broad in shape and size. Upper central incisors are marked by shovel shaping, and some characteristics such as extra cusps and Carabelli’s cusp are also observed in the upper molar teeth. All of these traits are continuous from past to present.

The study of prehistoric human skulls uncovered from Ban Chiang in 2003–2004 in the Wat Phosi Nai area should help in suggesting alternative explanations for the morphological diversity in variation of the mainland Southeast Asia region, past and present. As Pietrusewsky (2006a) explains, the peoples and cultures of this region are more influenced by its past population than by current geopolitical boundaries. The people of the region, especially in prehistory, are often assumed to be a southern branch of Mongoloid or eastern Asian groups. However, in recent years, new archaeological and linguistic perspectives of the prehistory of mainland Southeast Asia and East Asia have emerged. One idea that has been proposed strongly by some archaeologists and linguists is that the development of agriculture (especially rice domestication) and the dispersal of languages most likely diffused from southern China in an agricultural colonisation model (Higham 1996; Higham & Thosarat 1998; Pietrusewsky 2006a). In contrast to this model of incoming agriculturalists expanding into Southeast Asia, some physical anthropologists have proposed the Population Continuity Model, which argues that the current Southeast Asia inhabitants evolved from earlier groups settled in this region since at least the middle to late Holocene onward (Turner 1990). The study of prehistoric skulls from the most recent archaeological excavation at Ban Chiang in 2003–2004 has provided support to the latter model as presented in Pietrusewsky & Douglas (2002:234–235, 256–257), as it helps to demonstrate the differences between the characteristic Southeast Asia Sundadont dental complex and the characteristic Chinese Sinodont complex.

This is only a preliminary study. Further work on cranial and dental pathologies and dental metric traits is planned, along with a more advanced comparison with other skeletal samples in Southeast Asia and southern China.

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Table 1: Distribution of the BC 2003–2004 (WPSN) burials by age and sex (listed by burial number)

	Male	Female	Sex Undetermined	Total (N[a])
0-4.9			13, 21, 28, 29, 36, 41, 42, 45, 53, 55, 56, 59, 61, 63, 65, 67, 71, 73,74, 78, 80, 82, 85, 88, 95, 96, 98, 103,107, 113, 114	31
5-9.9			8, 40, 43, 92, 99, 101,	6
10-14.9			32, 49, 108, 116	4
15-19.9	2, 18	18, 77, 97,	84, 109	7
20-24.9	3, 76, 83,	75, 89, 93, 94,	14, 19, 31, 47, 58, 66, 86, 105, 110, 111	17
25-29.9	16	72	46, 51, 62	5
30-34.9	4, 11, 20, 34, 104	57, 115		7
35-39.9	10, 23, 24, 25, 26, 68, 100, 106	37, 44, 64, 91,	1, 38	14
40-44.9		6		1
45-49.9	9, 22, 60, 70, 79	15, 27, 33, 48, 50, 54, 69, 81, 102, 112		15
50-54.9	17			1
55-60+		90		1
Total (N[a])	25	26	58	109

N[a] = number of individuals

Table 2: Means and standard deviations for skull measurements in male adults of BC 2003-2004 (WPSN)

	Male (N[b] = 11)			
Measurement (mm)	**n[c]**	**Mean**	**SD[d]**	**Range**
Maximum cranial length, M-1 / H-GOL	6	177.3	10.7	167–193
Maximum cranial breadth, M-8 / H-XCD	9	137.3	8.5	127–150
Minimum frontal breadth, M-9 / H-FMB	7	95.8	6.6	87–109
Maximum frontal breadth, M-10 / H-XFB	7	114	7.1	107–128
Basion-bregma height, M-17 / H-BBH	4	138.2	8.9	130–151
Biorbital breadth, H-EKB	3	97.3	5.5	92–103
Bizygomatic breadth, M-45 / H-ZYB	4	126.2	6.2	118–132
Bimaxillary breadth, M-46 / H-ZMB	3	104	12	92–116
Facial height (Nasion-gnathion), M-47	4	118	2.8	114–120
Upper facial height (Nasion-alveolare), M-48	4	66.5	11.6	49–73
Posterior interorbital breadth, M-49	2	32	0.0	32
Anterior interorbital breadth, M-50	4	25.7	2.6	22–28
Orbital breadth (left), M-51a	4	39.5	3.1	35–42
Orbital height , M-52	4	36.2	1.7	34–38

	Male (N[b] = 11)			
Measurement (mm)	**n[c]**	**Mean**	**SD[d]**	**Range**
Nasal breadth, M-54 / H-NLB	6	27.6	2.5	25–32
Nasal height, M-55 / H-NLH	4	51.2	2.2	48–53
Palatal length, M-62	3	49	4.3	46–54
Palatal breadth, M-61 / H-MAB	4	42.5	3.1	38–45
Bigonial breadth, M-66	6	104.5	8.8	92–114
Mental foramen height, M-69(1)	10	32.6	4.1	26–40
Height of mandibular ramus, M-70	4	59.5	6.8	50–66
Breadth of mandibular ramus, M-71	6	34.5	2.1	32–38

[a] The measurement source is given with a capital letter followed by the name or number of the measurement in that source, if available. H = Howells 1973; M = Martin & Saller 1957
[b] = number of adults (> 18 years)
[c] = number of measurements from the BC 2003-2004 (WPSN) series.
[d] = standard deviation.

Table 3: Means and standard deviations for skull measurements in female adults of BC 2003–2004 (WPSN)

	Female (N[b] = 6)			
Measurement (mm)	**n[c]**	**Mean**	**SD[d]**	**Range**
Maximum cranial length, M-1 / H-GOL	6	173	4.8	167–181
Maximum cranial breadth, M-8 / H-XCD	6	137.5	6.0	126–144
Minimum frontal breadth, M-9 / H-FMB	6	95.1	5.4	87–100
Maximum frontal breadth, M-10 / H-XFB	6	108	8.7	100–122
Basion-bregma height, M-17 / H-BBH	6	133.6	6.3	126–141
Biorbital breadth, H-EKB	4	95.5	1.2	94–97
Bizygomatic breadth, M-45 / H-ZYB	4	125.2	4.2	119–128
Bimaxillary breadth, M-46 / H-ZMB	5	105.6	2.8	102–109
Facial height (Nasion-gnathion), M-47	5	111.2	5.8	105–120
Upper facial height (Nasion-alveolare), M-48	5	70.4	2.8	68–75
Posterior interorbital breadth, M-49	6	28	2.9	25–33
Anterior interorbital breadth, M-50	6	24.3	3.0	21–29
Orbital breadth (left), M-51a	4	40.2	0.9	39–41
Orbital height , M-52	5	37	1.4	36–39
Nasal breadth, M-54 / H-NLB	6	27	2.9	25–33
Nasal height, M-55 / H-NLH	5	49.2	4.4	43–53
Palatal length, M-62	5	50.6	1.5	49–52
Palatal breadth, M-61 / H-MAB	6	42.8	3.4	39–49
Bigonial breadth, M-66	5	96.4	2.4	93–99

	Female ($N^b = 6$)			
Measurement (mm)	**n^c**	**Mean**	**SD^d**	**Range**
Mental foramen height, M-69(1)	5	27.6	3.0	24–31
Height of mandibular ramus, M-70	5	53	4.2	50–60
Breadth of mandibular ramus, M-71	5	34.8	1.9	32–37

[a] The measurement source is given with a capital letter followed by the name or number of the measurement in that source, if available. H = Howells 1973; M = Martin & Saller 1957
[b] = number of adults (> 18 years)
[c] = number of measurements from the BC 2003–2004 (WPSN) series.
[d] = standard deviation.

Table 4: Means and standard deviations for skull indices in male adults of BC 2003–2004 (WPSN)

	Male ($N^b = 11$)				
Indices	**n^c**	**Mean**	**SD^d**	**Average type**	**Range**
Neurocranium					
Cranial or Length-breadth index	6	77.2	5.8	Mesocranial	69.9–85.2
Length-height index	4	78.8	1.2	Hypsicranial	77.8–80.3
Breadth-height index	4	99.4	6.7	Acrocranial	93.1–107.8
Transverse frontal index	7	84.2	6.4		74.2–92.3
Transverse fronto-parietal index	7	70.2	3.6		65.5–75.5
Transverse craniofacial index	4	94.0	5.7		89.1–102.3
Mean height index	4	155.0	7.9	High cranial	147.5–165.6
Face					
Facial index	4	93.5	3.3	Leptoproscopic	89.3–96.6
Orbital index	4	91.9	3.9	Hypericonch	87.8–97.1
Inter orbital index	2	27.7	0.7		27.1–28.2
Nasal index	4	53.2	6.2	Chamaerrhine	47.1–61.5
Maxilla					
Palatal index	3	87.6	7.1	Brachystaphyline	82.6–95.7
Mandible					
Ramus idex	4	60.2	11.2		50–76
Jugomandibular index	3	79.1	6.4		73.4–86.1

[a] The measurement source is given with a capital letter followed by the name or number of the measurement in that source, if available. H = Howells 1973; M = Martin & Saller 1957
[b] = number of adults (> 18 years)
[c] = number of measurements from the BC 2003–2004 (WPSN) series.
[d] = standard deviation

Table 5: Means and standard deviations for skull indices in female adults of BC 2003–2004 (WPSN)

	Female (N[b] = 6)				
Indices	**n[c]**	**Mean**	**SD[d]**	**Average type**	**Range**
Neurocranium					
Cranial or Length-breadth index	6	79.4	3.1	Mesocranial	74.1–83.8
Length-height index	6	77.3	4.6	Hypsicranial	69.6–80.8
Breadth-height index	6	97.4	7.1	Acrocranial	87.5–107.1
Transverse frontal index	6	88.4	6.8		81.9–98
Transverse fronto-parietal index	6	69.2	2.5		65.2–72.4
Transverse craniofacial index	4	91.5	7.1		82.6–100
Mean height index	6	153.1	5.0	High cranial	144.7–160.4
Face					
Facial index	4	90.0	3.0	Leptoproscopic	86.5–93.7
Orbital index	4	92.6	5.5	Hypericonch	87.8–97.5
Inter orbital index	4	24.0	2.6		21.6–27.3
Nasal index	5	55.8	5.7	Chamaerrhine	49.0–62.2
Maxilla					
Palatal index	5	84.6	8.8	Mesostaphyline	78.8–100
Mandible					
Ramus idex	5	65.9	6.2		58.3–74
Jugomandibular index	4	76.4	2.5		73.8–79.8

[a] The measurement source is given with a capital letter followed by the name or number of the measurement in that source, if available. H = Howells 1973; M = Martin & Saller 1957
[b] = number of adults (> 18 years)
[c] = number of measurements from the BC 2003–2004 (WPSN) series.
[d] = standard deviation

Table 6: Non-metric data for skulls in male and female adults of BC 2003–2004 (WPSN)

Traits	**Male**		**Female**	
	Present	**N = 11**	**Present**	**N = 6**
Shape of Skull				
Norma verticalis				
Ellipsoid	√	1 (present in this many skulls)		
Ovoid	√	1		
Sphenoid	√	6	√	6
Norma occipitalis				
Arch	√	6	√	6
Haus	√	3		
Suture				

Traits	Male		Female	
	Present	**N = 11**	**Present**	**N = 6**
Metopic suture	√	2		
Wormain	√	3	√	3
Inca			√	1
Foramen / Notch				
Parietal foramen	√	2		
Supraorbital				
Notch-Single			√	2
Notch - Double	√	1	√	4
Foramen - Single	√	1	√	1
Foramen - Double	√	3	√	1
Infraorbital foramen				
Single	√	4	√	5
Piriform aperture				
Anthropine	√	2	√	3
Paranasal fossa			√	1
Paranasal sulcus	√	5	√	2
Clinocephalia	√	1	√	2
Pterion				
H-Shape	√	6	√	5
Mandible				
Mylohyoid arch/bridge	-	-	-	-
Mandibular torus	-	-	-	-
Mental foramen (single)	√	11	√	6

Table 7: Non-metric data for teeth in male and female adults of BC 2003-2004 (WPSN)

Traits	Male		Female		Unidentified	
	Present	**N = 16**	**Present**	**N = 13**	**Present**	**N = 4**
Teeth						
Shovel shape (I)	√	2	√	4	-	-
Groove cingulum (I)	√	2	√	1	-	-
Carabelli's cusp (UM)	√	1	-	-	-	-
Protostylid cusp (LM)	-	-	√	1	-	-

Table 8: Means (in mm) and Standard Deviations for 6 cranial measurements recorded in seven prehistoric male sample series in Mainland SEA

Measurement [a]	**Con Co Ngua (n = 5)** [b]		**NE Vietnam (n = 7)** [b]		**Laos (n = 5)** [b]		**BC 2003-2004 (WPSN) (n = 11)** [b]		**Ban Chiang (BC-BCES) (n = 10)** [b]		**Ban Na Di (n = 3)** [b]		**Ban Khok Khon (n = 1)** [b]	
	Mean	**SD** [c]	**Mean**	**SD** [c]	**Mean**	**SD** [c]	**Mean**	**SD** [c]	**Mean**	**SD** [c]	**Mean**	**SD** [c]	**Mean**	**SD** [c]
MAXCRANL	187.2	6.0	188.6	6.2	182.4	3.5	177.3	10.7	182.7	8.6	179.7	9.9	188.0	0.0
MAXCRANB	135.8	7.6	133.4	6.0	138.6	4.1	137.3	8.5	139.8	9.0	135.3	3.2	140.0	0.0
MAXFRONB	118.2	9.8	115.7	5.0	118.6	4.0	114.0	7.1	118.8	4.7	117.3	2.9	108.0	0.0
MINFRONB	100.2	7.3	96.0	2.6	95.0	2.1	95.8	6.6	96.8	5.0	99.0	1.0	91.0	0.0
BIORBITB	99.2	6.9	102.6	4.2	98.8	3.3	97.3	5.5	98.9	4.1	97.7	0.6	99.0	0.0
INTERORB	30.2	2.9	29.0	1.4	30.8	1.6	32.0	0.0	26.8	3.0	27.7	2.1	29.0	0.0

Note: Table adapted from Pietrusewsky & Douglas (2002:231)

[a] The measurement sources are as follows (a capital letter is followed by the name of the measurement within that source; M = Martin & Saller 1957, H = Howells 1973); MAXCRANL = Maximum cranial length (M-1), MAXCRANB = Maximum cranial Breadth (M-8), MAXFRONB = Maximum frontal breadth (M-10), MINIFRONB = Minimum frontal breadth (M-9), BIORBITB = Biorbital breadth (H-EKB), INTERORB = Interorbital breadth (M-49).

[b] n = number of crania.

[c] SD = standard deviation

Table 9: Means and standard deviations for skull measurements in male adults of BC 2003-2004 (WPSN) and modern NE Thai at KKU

Measurement (mm) / Indexa	BC 2003 (WPSN) (N[b] = 11)				Modern NE Thai at KKU (N[b] = 9)			
	n[c]	Mean	SD[d]	Range	n[c]	Mean	SD[d]	Range
Maximum cranial length, M-1 ** / H-GOL ***	6	177.3	10.7	167–193	9	166.3	7.1	157–178
Maximum cranial breadth, M-8 / H-XCD	9	137.3	8.5	127–150	9	142.2	7.3	129–154
Minimum frontal breadth, M-9 / H-FMB	7	95.8	6.6	87–109	9	100.7	3.7	95–105
Maximum frontal breadth, M-10 / H-XFB	7	114	7.1	107–128	9	92.2	4.1	84–99
Basion-bregma height, M-17 / H-BBH	4	138.2	8.9	130–151	9	135.6	4.0	130–140
Biorbital breadth, H-EKB	3	97.3	5.5	92–103	9	95.0	1.9	92–98
Bizygomatic breadth, M-45 / H-ZYB	4	126.2	6.2	118–132	9	134.2	2.1	132–138
Bimaxillary breadth, M-46 / H-ZMB	3	104	12	92–116	9	101.2	3.7	93–105
Facial height (Nasion-gnathion), M-47	4	118	2.8	114–120	7	119.0	6.7	110–127
Upper facial height (Nasion-alveolare), M-48	4	66.5	11.6	49–73	8	71.1	4.1	66–77
Posterior interorbital breadth, M-49	2	32	0.0	32	9	27.4	3.0	22–31
Anterior interorbital breadth, M-50	4	25.7	2.6	22–28	9	22.5	1.6	21–25
Orbital breadth (left), M-51a	4	36.2	1.7	34–38	9	33.7	1.8	31–36
Orbital height , M-52	6	27.6	2.5	25–32	8	27.5	2.5	22–30
Nasal breadth, M-54 / H-NLB	4	51.2	2.2	48–53	8	52.3	4.5	46–59
Nasal height, M-55 / H-NLH	3	49	4.3	46–54	8	45.2	2.1	42–49
Palatal length, M-62	4	42.5	3.1	38–45	8	42.0	2.9	36–46
Palatal breadth, M-61 / H-MAB	6	104.5	8.8	92–114	8	100.8	2.94	98–107
Bigonial breadth, M-66	10	32.6	4.1	26–40	8	31.9	2.4	27–35
Mental foramen height, M-69(1)	4	59.5	6.8	50–66	8	62.3	5.9	52–69
Height of mandibular ramus, M-70	6	34.5	2.1	32–38	8	33.8	2.5	31–39
Breadth of mandibular ramus, M-71	4	36.2	1.7	34–38	9	33.7	1.8	31–36

[a] The measurement source is given with a capital letter followed by the name or number of the measurement in that source, if available. H = Howells 1973; M = Martin & Saller 1957

[b] = number of adults (> 18 years)

[c] = number of measurements from the BC 2003–2004 (WPSN) series.

[d] = standard deviation

Table 10: Means and standard deviations for skull measurements in female adults of BC 2003–2004 (WPSN) and modern NE Thai at KKU

Measurement (mm) / Index[a]	**BC 2003 (WPSN) (N[b] = 6)**				**Modern NE Thai at KKU (N[b] = 6)**			
	n[c]	**Mean**	**SD[d]**	**Range**	**n[c]**	**Mean**	**SD[d]**	**Range**
Maximum cranial length, M-1 ** / H-GOL ***	6	173.0	4.8	167–181	6	160.1	7.3	150–168
Maximum cranial breadth, M-8 / H-XCD	6	137.5	6.0	126–144	6	142.1	4.9	136–149
Minimum frontal breadth, M-9 / H-FMB	6	95.1	5.4	87–100	6	92.3	3.8	86–97
Maximum frontal breadth, M-10 / H-XFB	6	108.0	8.7	100–122	6	96.5	4.0	90–101
Basion-bregma height, M-17 / H-BBH	6	133.6	6.3	126–141	6	131.8	2.4	130–135
Biorbital breadth, H-EKB	4	95.5	1.2	94–97	6	94.5	3.6	90–99
Bizygomatic breadth, M-45 / H-ZYB	4	125.2	4.2	119–128	6	128.1	4.0	122–132
Bimaxillary breadth, M-46 / H-ZMB	5	105.6	2.8	102–109	6	95.1	4.1	92–102
Facial height (Nasion-gnathion), M-47	5	111.2	5.89	105–120	5	112.0	4.6	106–118
Upper facial height (Nasion-alveolare), M-48	5	70.4	2.88	68–75	6	65.5	3.0	61–69
Posterior interorbital breadth, M-49	6	28.0	2.9	25–33	6	27.1	0.9	26–29
Anterior interorbital breadth, M-50	6	24.3	3.0	21–29	6	22.8	0.7	22–24
Orbital breadth (left), M-51a	4	40.2	0.9	39–41	6	39.3	1.7	37–42
Orbital height , M-52	5	37.0	1.4	36–39	6	32.7	1.7	31–36
Nasal breadth, M-54 / H-NLB	6	27.0	2.9	25–33	6	28.8	4.3	24–36
Nasal height, M-55 / H-NLH	5	49.2	4.4	43–53	6	48.4	2.4	44–51
Palatal length, M-62	5	50.6	1.5	49–52	6	44.5	3.2	41–50
Palatal breadth, M-61 / H-MAB	6	42.8	3.4	39–49	6	38.1	3.3	33–42
Bigonial breadth, M-66	5	96.4	2.4	93–99	5	95.2	3.2	90–98
Mental foramen height, M-69(1)	5	27.6	3.0	24–31	5	31.0	2.5	28–35
Height of mandibular ramus, M-70	5	53.0	4.2	50–60	5	55.6	3.3	52–59
Breadth of mandibular ramus, M-71	5	34.8	1.9	32–37	5	30.4	1.9	29–33

[a] The measurement source is given with a capital letter followed by the name or number of the measurement in that source, if available. H = Howells 1973; M = Martin & Saller 1957

[b] = number of adults (> 18 years)

[c] = number of measurements from the BC 2003–2004 (WPSN) series.

[d] = standard deviation

Table 11: Selected non-metric observations in BC 2003 (WPSN) permanent dentitions in male and female

Trait / Tooth / Variant[b]	Male, N[a] = 16			Female, N[a] = 13		
	A	/O[c]	%	A	/O	%
Shovel-shaped incisors						
Maxillary central						
absent	7	/8	87.5	4	/6	66.6
slight	1	/8	12.5	1	/6	16.6
moderate	0	/8	0.0	1	/6	16.6
Maxillary lateral						
absent	7	/8	87.5	4	/6	66.6
slight	1	/8	12.5	1	/6	16.6
moderate	0	/8	0.0	1	/6	16.6
Mandibular central						
absent	9	/ 13	69.2	10	/ 11	91.0
slight	4	/ 13	30.8	1	/ 11	9.0
Mandibular lateral						
absent	9	/ 13	69.2	10	/ 11	91.0
slight	4	/ 13	30.8	1	/ 11	9.0
Maxillary winging						
present	0	/ 9	0.0	0	/ 10	0.0
Carabelli's cusp						
Maxillary 1st molar						
present	1	/ 9	11.1	0	/ 8	0.0
Maxillary 2nd molar						
present	0	/ 9	0.0	0	/ 8	0.0

[a] Total number
[b] Presence versus absence unless other variation noted
[c] A = affected teeth, O = observed teeth

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Biological anthropology, also known as physical anthropology, is a scientific discipline concerned with the biological and behavioral aspects of human beings, their extinct hominin ancestors, and related non-human primates, particularly from an evolutionary perspective. It is a subfield of anthropology that provides a biological perspective to the systematic study of human beings. Early agriculturalist population diasporas? Farming, languages and genes. Annual Review of Anthropology 30: 181â€“207. Bentley, R.A. 2004. Characterising human mobility by strontium isotope analysis of the skeletons, in Higham, C.F.W. & Thosarat, R. (ed.)Â Ban Chiang and northeast Thailand: The palaeoenvironment and economy. Journal of Archaeological Science 6: 211â€“33. Hillson, S. 1997.Â Ban Chiang, a prehistoric village site in Northeast Thailand I: the human skeletal remains. Philadelphia: University of Pennsylvania Museum of Archaeology and Anthropology. Price, T. D. 2000. William W. Howells, American physical anthropologist, who specialized in the establishment of population relationships through physical measurement. He is also known for his work in developing anthropologicalâ€¦ Earnest A. Hooton.Â Franz Weidenreich, German anatomist and physical anthropologist whose reconstruction of prehistoric human remains and work on Peking man (then called Sinanthropus pekinensis) and other hominids broughtâ€¦ Paul Broca. French anthropologist and pathologist. Paul Broca, surgeon who was closely associated with the development of modern physical anthropology in France and whose study of brain lesions contributed significantly to understanding the origins ofâ€¦ Edward W. Gifford. American anthropologist.