Dynamics of human diversity

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DAVID BULBECK

1 Introduction

This chapter synthesises current information on the *longue durée* history of the Malay Peninsula south of the Isthmus of Kra, a region referred to here as 'Malaya' (Figure 1). Climatically Malaya is humid, and warm to hot except where the mountainous terrain of central Peninsular Malaysia provides for cool temperatures at elevated altitudes. From south to north the northeast monsoon weakens while the southwest monsoon strengthens, resulting in a concomitant shift from equatorial to monsoonal forest and mangroves. In Peninsular Malaysia and southernmost Thailand, Melayu Malays—the Islamic subjects of the Melayu kingdoms (Malay, *kerajaan Melayu*) at the time that Europeans entered the region (Benjamin 2002)—constitute the most numerous ethnic group (Hamilton 2006). However, they share the rural landscape with a medley of other groups collectively known as Orang Asli (Malay for 'original people').

The Orang Asli are highly diverse in their biology, linguistics and lifeways. Variation in overt appearance has resulted in scholarly recognition of three broad Orang Asli categories for over 100 years (for example Martin 1905; Carey 1976; Rashid 1995; Hooker 2003), as best described by Cole (1945). The three categories correspond to the Aboriginal Malays who resemble the Melayu in features such as brown skin and straight to slightly wavy hair, the Senoi who are distinguished by wavy hair, and the Semang 'Negritos' who have dark skin and woolly hair. This tripartite division of the Orang Asli has been confirmed by studies of their teeth (Rayner & Bulbeck 2001; Bulbeck et al. 2005) and mitochondrial DNA (Hill et al. 2006). Linguistically, the Orang Asli include both Austronesian and Austroasiatic (Mon-Khmer) speakers—respectively, groups speaking dialects of standard Malay, and groups whose languages together constitute the Aslian clade of Austroasiatic (Benjamin 2002). The most recent study of the Aslian languages (Burenhult et al., this volume) confirms the existence of Southern, Central and Northern branches, as found in earlier studies (for example Benjamin 1976), but also finds that one language, Jah Hut, may be sufficiently distinct to constitute a fourth branch. Moreover, the traditional lifeways of the Orang Asli include groups that have met their subsistence needs through swidden agriculture in the lowlands or the highlands, those that have also relied on fishing and foraged forest foods to supplement their farmed produce, those that have specialised in

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collecting mangrove and rainforest produce for trade, and those that formerly survived as rainforest foragers (Benjamin 1985, 2002).

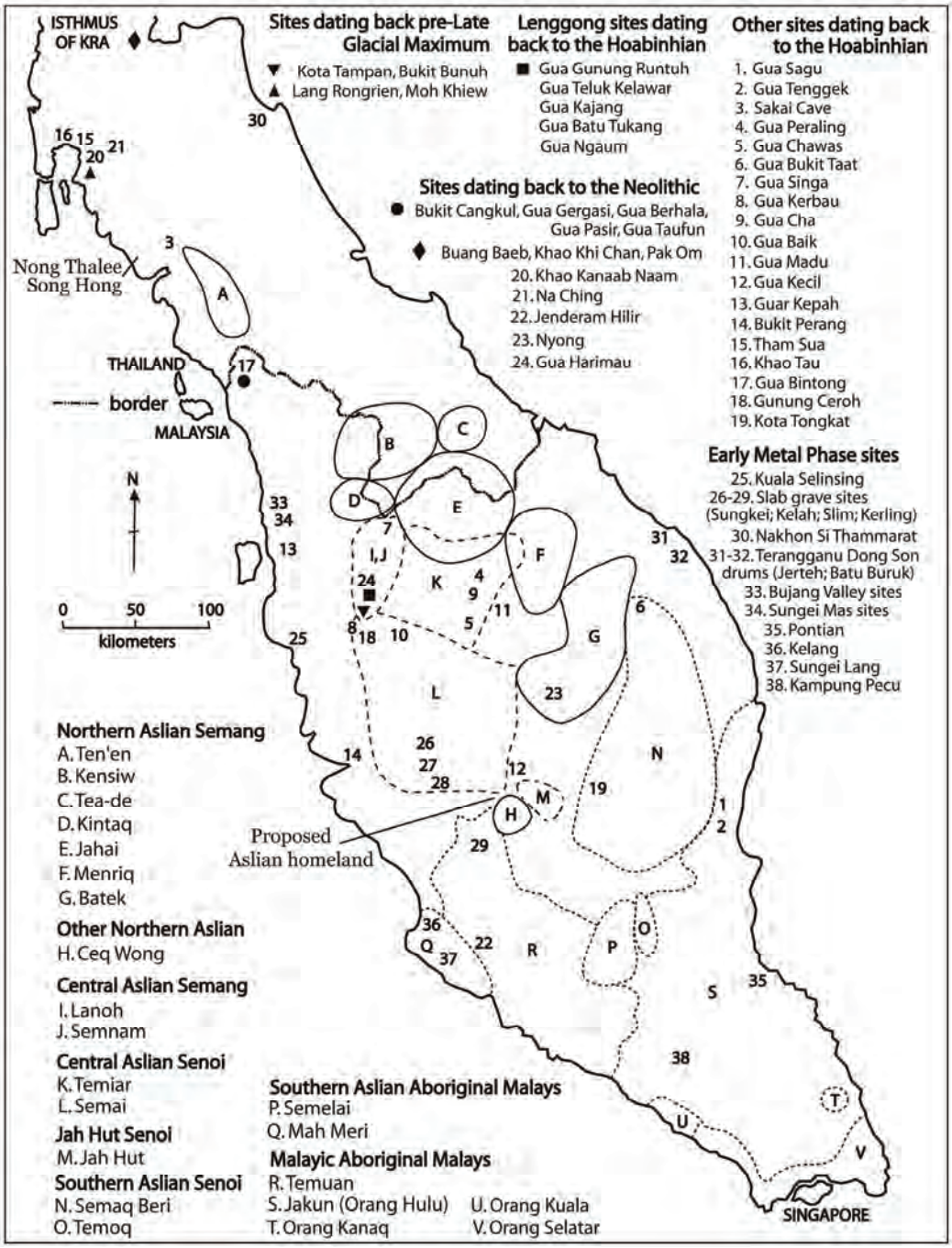

Figure 1: Malaya, showing distribution of the Orang Asli and location of sites mentioned in the text (Orang Asli distribution taken from Benjamin (1985) and Burenhult et al. (this volume)).

Fittingly diverse for people as variable as the Orang Asli is the range of scholarly opinion on how discrete the three divisions are and whether distinct origins should be sought. Nik Hassan (2005) has proposed that all of the Orang Asli as well as the Melayu are related linguistically and genetically, and that they differentiated during the late Holocene in response to maritime and cross-peninsular trade. Rambo (1988) accepted the

distinctiveness of the Orang Asli from the Melayu, but argued that the three Orang Asli divisions have resulted from biological adaptation to their particular environments. Benjamin (1985, 1987) explicated a model which associated the Aboriginal Malays with Southern Aslian or Malay dialects, ranked tribal social organisation, and an economic focus on collecting forest produce; the Senoi with Central Aslian, egalitarian tribal social organization, and swidden horticulture in the highlands; and the Semang with egalitarian bands of Northern Aslian speakers who foraged in the lowland rainforests. Benjamin emphasised that these three associations lack strict congruity, as further explored by Bulbeck (2003) and Burenhult et al. (this volume), but argued that they provide a window on how the Orang Asli differentiated within a framework of staggered origins in the peninsula. Fix (2002, this volume) has stressed the differentiation aspect of Benjamin's model, whereas Bellwood (1993, 1997) has focused on the implication of successive origin times. In Bellwood's view, as dealt with in due course, the Semang represent the 'Australo-Melanesian' foragers who had occupied Southeast Asia prior to the immigration from south China of 'Mongoloid' farmers who introduced Austroasiatic to the peninsula during the Neolithic, and Austronesian some 2000 years ago.

The question of Orang Asli ethnogenesis has been of great interest to me, and involved me in several recent studies that have presented substantial new information on Orang Asli biological attributes (Rayner & Bulbeck 2001; Bulbeck et al. 2005; Bulbeck & Lauer 2006; Hill et al. 2006). Of particular note is the survey of their mitochondrial DNA (mtDNA), which successfully teased out the complex nature of genetic interactions between populations in the peninsula and those in surrounding regions (Hill et al. 2006). While this study confirmed some of the main points argued by Bellwood (1993, 1997), it also highlighted the simplifications of his three-layer model. Subsequent research on the mtDNA of surrounding populations has additionally allowed fine-tuning of the interpretation of the Orang Asli data, as detailed by Oppenheimer (this volume), who was also one of the protagonists in the original Hill et al. (2006) study. Where my contribution differs from Oppenheimer's is in my slightly different retention of the interpretations advanced in the original study, and my focus on Malaya's archaeology, including its human osteological record. As will be elaborated in due course, this archaeological perspective allows us to appreciate Orang Asli diversity in terms of successful adaptations to the new niches that have been successively created as a result of environmental change, population incursions and long-distance interactions over time (cf. Benjamin 1985, 1987).

Historical linguists agree on tracing the Aslian languages back to an original Austroasiatic language, labelled proto-Aslian, established in Malaya by 4000 years ago (Burenhult et al., this volume). However, the details of Aslian linguistic diversification, and the interaction between Southern Aslian and the later arriving Malayic dialects, are noted as topics for ongoing research (Benjamin 1987, 2002). Fortunately, Malaya has a rich archaeological record, thanks to well over 100 years of research into the region's numerous limestone rockshelters and open-air sites, and these data provide invaluable information about Malaya's past. The sites of relevance to this chapter (Figure 1) date from approximately 75,000 years ago, which is the earliest date for when *Homo sapiens* could have colonised Malaya (Soares et al. 2009; Oppenheimer 2009; see discussion below), to 1300–1400 CE, when the Melayu settled Malaya and in due course established Melaka as their capital (Hooker 2003). Comparisons with the archaeological record in Sumatra are important, both because Sumatra and Malaya were connected by land until c. 8000 years ago (Bulbeck 2003), and because Sumatra was the Melayu homeland (Adelaar 2004).

The widely touted terms 'Palaeolithic' (Old Stone Age) and 'Mesolithic' (Middle Stone Age) have little relevance for Malaya where, as we shall see, the important issues are the

development of the local 'Hoabinhian' cobble-based industry, and the subsequent incorporation of Neolithic technology. This chapter follows Vietnamese terminology (Nguyen et al. 2004) in defining the Neolithic by the presence of polished stone tools and pottery, leaving open the relationship of these archaeologically durable remains to the advent of agriculture, especially 'arboriculture' or the management of economically useful palms and trees (Latinis 2000). As will become clear, the Neolithic transition in Malaya was less an event and more a process of extended interaction with multiple outside regions. Further, the existence of a Bronze Age in Malaya prior to the arrival of iron technology is by no means certain. Accordingly, depending on context, the terms Early Metal Phase, Bronze/Iron Age and Iron Age will all be employed for the proto-historical period corresponding approximately to the first millennium CE. Finally, all cited radiocarbon dates from Malaya (identified as 'years BP') are uncalibrated, and, thus, most are minimum ages, especially with reference to the Pleistocene (whose junction with the Holocene is set at 10,000 years ago).

2 Late Quaternary environmental change

Tropical forest has been the natural vegetation of Malaya throughout most of the Holocene, when the sea has stood at or above its current level. Analysis of pollen and phytoliths from the Nong Thalee Song Hong swamp in southern Thailand documents the local formation of tropical forest between 11,000 and 9000 years BP, and its further expansion during the early Holocene. Beforehand, mosaics of savannah and woodland dominated the vegetation between 21,000 and 11,000 years BP, when sea levels were as much as 120–150m lower than today (Kealhofer 2003). A similar scenario of environmental change, including evidence of cooler Pleistocene temperatures than today's, has been reconstructed by Taylor et al. (2001) from their analysis of plant pollen and spores, dating back to 23,000 years BP, at the Nee Soon swamp in Singapore.

Pookajorn (1996) proposed a transition to moister conditions between the Late Glacial Maximum (LGM) and terminal Pleistocene based on the archaeological evidence from Levels 2 and 3 of the Moh Khiew rockshelter in southern Thailand. Both levels produced pollen taxa reflecting moist conditions and the remains of forest-dwelling fauna. Level 3 is dated to between 9000 and 11,000 years BP, whereas the underlying Level 2 is dated no more precisely than <26,000 years BP, based on a radiocarbon determination near the top of Level 1 (Pookajorn 1996). Given the limited evidence for environmental change between Levels 2 and 3, it would be unlikely that Level 2 is more than a few thousand years older than Level 3. In fact, no site in Malaya has produced positive evidence for habitation between 15,000 and 26,000 years BP, an observation that probably reflects scanty use of the present-day Malaya landmass at the height of the LGM, owing to the relocation of the coastally oriented population to lowlands now inundated by sea (Bulbeck 2003).

Between 26,000 and 43,000 years BP, sea levels were higher than at the LGM, and evidence for habitation comes from the basal archaeological deposits of two rockshelters in southern Thailand, viz. Lang Rongrien as well as Moh Khiew (Figure 1). Mudar & Anderson (2007) discuss the evidence for a climate at the time that was cooler and drier than at present, and an environment dominated by a forest-savannah mosaic, as would be consistent with the pre-LGM faunal remains recovered from both sites. However, the sites' faunal taxa are mutually exclusive, and this observation has been interpreted as indicating sporadic visits to Lang Rongrien by a coastally oriented population, in contrast to more intensive habitation at Moh Khiew (Mudar & Anderson 2007).

Malaya's *H. sapiens* inhabitants have apparently exerted an increasing influence on their environment over time. Starting with the pre-LGM period, we find that Mudar & Anderson (2007) did not see any need to address the topic of controlled burning of the vegetation. However, referring to the period between the LGM and the end of the Pleistocene, both Taylor et al. (2001) and Kealhofer (2003) allude to the possibility of human-mediated fires. Additionally, Taylor et al. (2001) interpret the high levels of mid-Holocene charcoal at Nee Soon swamp as evidence of early farming activities in Singapore. Similarly, Kealhofer (2003) argues for forest management in southern Thailand after 8000 years BP, leading to intentional planting of useful trees by 6500 years BP, more intensive arboriculture by 6000–5000 years BP, and slash-and-burn agriculture by 4000 years BP. This argument is indirectly strengthened by the evidence for woodworking and possible tree felling revealed by the use-wear on Hoabinhian stone tools from northwest Thailand (Bannanurag 1988:77).

A range of economically useful plants was propagated through forest management practices by mid-Holocene times. These include the betel-nut palm, to judge by the observation of betel-stained teeth at the Guar Kepah shell midden (Bulbeck 2005a), and other palms, bananas, and rice, based on Kealhofer's (2003) phytolith evidence. Further evidence of early rice production comes from the reconstruction of the term 'rice' in proto-Aslian by historical linguists (Gianno & Bayr 2009) and the rice grains from Cultural Level 2 at Sakai Cave, in southern Thailand, which Pookajorn (1996) dates to the mid-Holocene. The sites of Nyong and Jenderam Hilir in Peninsular Malaysia are important as indications of Neolithic open-air settlements, complementing the predominance of rockshelters in the inventory of Malaya Neolithic sites (Leong Sau Heng 1991; Bulbeck 2004a). However, neither Nyong nor Jenderam Hilir provides sufficient justification to infer an agriculturally focused economy. Instead, as will be argued below, the range of mid-Holocene adaptations probably ranged from mixed swidden-forager to fully foraging economies.

3 Late Pleistocene to mid-Holocene artefact assemblages

The first studies of the Stone Age in tropical Asia were undertaken by European antiquarians, who unsurprisingly promulgated a Eurocentric perspective. Synthesising the available information, Movius (1944) drew a contrast between the Pebble Tool Complex of Southeast Asia and the Acheulian hand-axe assemblages of India and places westward. Movius further distinguished between Southeast Asia's ancient 'chopper/chopping-tool' assemblages and its more recent but 'culturally stagnant' Hoabinhian assemblages. In recent years, archaeologists have been at pains to identify hand-axes in Southeast Asia (for example, Nguyen et al. 2004; Mokhtar 2006; Simanjuntak et al. 2006), by which they mean cobbles, usually bifacially flaked, with flat, relatively wide bases and a pointed shape at the opposing end (labelled as pointed wide-based cobbles in Table 1). Of more direct relevance, the concept of an ancestor-descendant relationship between chopper/chopping-tool and Hoabinhian assemblages has been challenged by the recovery of chronologically intermediate assemblages dominated by cores and/or small flakes (Anderson 1990).

Were these 'core-flake' assemblages related to the arrival of *H. sapiens* in Southeast Asia, and did they later evolve into the Hoabinhian as a cultural adaptation of *H. sapiens* foragers to their forested environment? Questions like these would have been unimaginable during Movius's day or indeed until 1980, when the general assumption was that *H. sapiens* in East Asia had evolved from locally ancestral *H. erectus* populations (for example, Weidenreich 1947; Coon 1962; Wolpoff 1980). However, these questions are

now highly pertinent in view of the new orthodoxy whereby *H. sapiens* had evolved in Africa during the Late Pleistocene prior to colonising other landmasses of the tropical and temperate world (Day & Stringer 1982; Wainscoat et al. 1986; Cann et al. 1987; Stringer 1994; Oppenheimer 2003; Cameron & Groves 2004).

Before addressing the question of associations between species of *Homo* and stone artefact assemblages, certain points of terminology require explanation. First, the nodules extracted from the landscape for manufacturing stone tools of the Hoabinhian and related industries are water-rounded cobbles whose dimensions exceed those of pebbles as defined by geologists. Confusingly, the term 'pebble' is widely used in the archaeological literature when referring to these cobbles, but, in this chapter, it will be substituted by the geologically correct term 'cobble' (White & Gorman 2004). Secondly, the term 'core' will here be restricted to nodules of stone with one or more striking platforms, produced as a knapped surface, for the detachment of flakes at an approximately perpendicular orientation to the striking platform (see Figure 2f). The distinction is made here between cores in this sense and 'flaked cobbles' with the flakes detached at a shallow orientation relative to the flaking surface (see Figure 2d).

Thirdly, this chapter follows Kamminga (2007) in defining 'sumatraliths' as cobbles with a completely flaked perimeter and shallow flaking across most or all of a single face. Kamminga analysed the Hoabinhian assemblage from Sai Yok in south-central Thailand in terms of cobble reduction used to produce sumatraliths, and argued they had been hafted for use as woodworking adzes. One defining characteristic of Kamminga's reduction sequence is the avoidance of bifacial cobble working. Such bifacial flaking would result in cobbles with bifacial circumferential working at earlier reduction stages, and in pieces that resemble hand-axes or picks with comprehensive bifacial flake removal. The second defining characteristic is a completely knapped perimeter (see Figure 2a), in preparation for centripetal flake removal, which distinguishes sumatraliths from pebbles with flakes unifacially detached in a less structured process. The third defining feature is the production of a flattish flaked surface, as opposed to the medially crested surface of 'chopper' forms (Figure 2c). Figure 2b depicts a sumatralith from the Late Pleistocene site of Kota Tampan, which (as we shall see) would appear to be some 65 millennia older than Malaya's other sumatraliths.

In Malaya, bifacial flaking of cobbles is such a common feature of assemblages younger than 15,000 years BP that it could be nominated as a defining characteristic of the Malayan Hoabinhian (Table 1). It has not been documented for assemblages older than 26,000 years BP, except Bukit Bunuh, which is difficult to distinguish from the terminal Pleistocene/Holocene Hoabinhian assemblages except for its pointed wide-based cobbles ('hand-axes'), which rarely occur in the latter assemblages (Table 1). The other three pre-26,000 year BP assemblages (Kota Tampan, and the basal deposits at Lang Rongrien and Moh Khiew) have a further difference from Hoabinhian assemblages, in that cores are at least as strongly represented as flaked cobbles (Table 1). The singularly Hoabinhian aspect of the Bukit Bunuh assemblage certainly cannot be ascribed to site type; whereas the vast majority of the sites listed in Table 1 are rockshelters, Bukit Bunuh and Kota Tampan are both lithic scatters on ancient lakeshores. In addition, Bukit Bunuh is not chronologically distinguishable from the two early rockshelter assemblages; its luminescence dating of around 40,000 years ago would place it in the same age bracket as basal Lang Rongrien (Table 1), while initial occupation at Moh Khiew predated 26,000 years BP by an unknown period of time (Pookajorn 1996). Based on the present evidence, it would be difficult to disagree with Mokhtar's (2006) view that Bukit Bunuh is too Hoabinhian-like

for archaeologists to assume a terminal Pleistocene introduction of the Hoabinhian to Malaya.

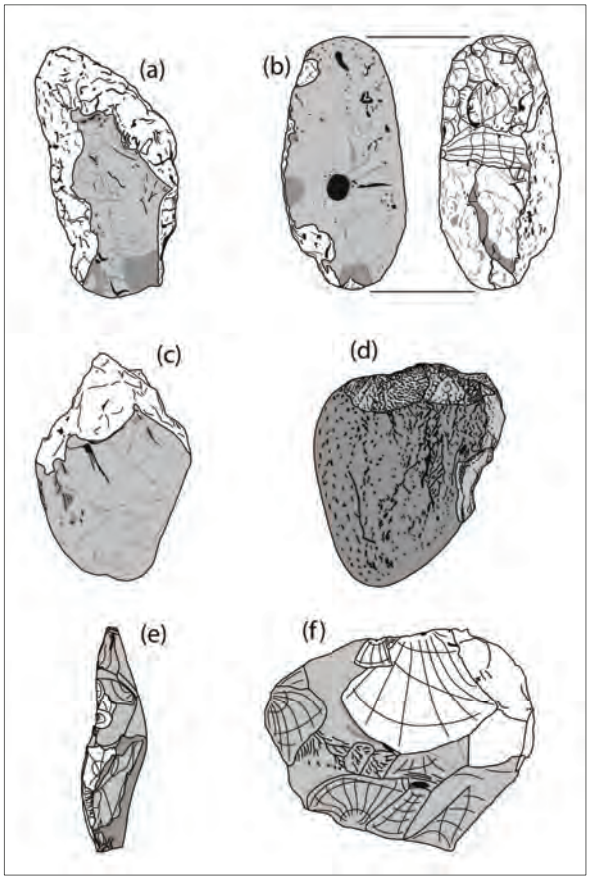

Figure 2: Stone artefacts from Late Pleistocene lithic scatters in Malaya (not to scale)

a) Kota Tampan cobble unifacially flaked around most of its perimeter (based on Zuraina 2003:62)
b) Kota Tampan sumatralith; cobble unifacially flaked across entire face (based on Zuraina 2003:73)
c) Kota Tampan cobble flaked to produce a chopper (based on Zuraina 2003:63)
d) Bukit Bunuh quartzite cobble with unifacial edge flaking (based on Zuraina 2003:74)
e) Bukit Bunuh retouched chert flake with traces of use wear (based on Zuraina 2003:77)
f) Bukit Bunuh chert core, rotated and multi-platform (based on Zuraina 2003:75).

Kota Tampan also presents interpretative difficulties, but of a different nature to those for Bukit Bunuh. Its age of 74,000 years ago, inferred from the Toba ash fall which seals the site, sits right at the earliest plausible estimates for the arrival of *H. sapiens* mtDNA in Southeast Asia (Soares et al. 2009; cf. Macaulay et al. 2005). It would be convenient to ascribe the Kota Tampan assemblage to an archaic local hominin which had been made extinct by the Toba eruption, and the other Late Pleistocene Malaya assemblages to early *H. sapiens*. However, there is nothing about the Bukit Bunuh and basal Lang Rongrien and Moh Khiew assemblages that would distinguish them as a group from Kota Tampan, with its 20 cores, ten unifacially flaked cobbles, retouch on a small number of flakes, and four flat-based cobbles equipped with a pointed shape at the opposing end (Zuraina 1990). While Zuraina's Figure 8 illustrates two unifacial chopper-like cobbles, unifacial choppers

are also recorded for Bukit Bunuh (Figure 2d), basal Lang Rongrien (Anderson 1990:56) and even some Holocene assemblages (for example Zolkurnian 1998). Especially given Zuraina's (1990) observation of ground edges on one of the Kota Tampan cobbles, and the sumatralith referred to above (Figure 2b), it would be very difficult to dissociate Kota Tampan from an early presence of *H. sapiens*. Accordingly, Kota Tampan couples with Jwalapuram in India (Petraglia et al. 2007) in suggesting that the oldest time estimates for modern human mtDNA in Asia would correctly date to the Toba eruption, and in particular reflect the post-Toba lineage proliferation of the small number of early Asian *H. sapiens* that were able to survive this cataclysmic eruption (Ambrose 1998; Oppenheimer 2009).

Of the four pre-LGM assemblages reviewed here, that from basal Lang Rongrien is the best described (Anderson 1990), and also the least Hoabinhian-like (Table 1). Assessment of the 1181 artifacts from Level 1 at Moh Khiew is particularly difficult in view of these artifacts' peremptory description, and relies on impressionistic appraisals from scattered sources. In addition to the major role of unifacial pebble tools at this level (Chitkament 2006–07), Pookajorn (1996:204) states that the 'typology and raw material of bifacial tools from this cultural level are almost the same as those … from Lang Rongrien … older than 37,000 BP', which would suggest cores rather than bifacially flaked pebbles (cf. Anderson 1990). Pookajorn (1994, 1996) also mentions numerous 'flake tools' from Level 1, as well as the other Moh Khiew levels, but this assessment must have been made on the basis of the flakes' shape rather than signs of retouch, because Chitkament (2006-07:141) found very few signs of retouch in his sample of Moh Khiew flakes. Fortunately, illustrations and more complete descriptions of the flaked stone artifacts in the higher levels, and use-wear study on the Level 2 flakes (Pookajorn 1994; Chitkament 2006-07), permit a more certain characterisation (Table 1) of the Hoabinhian assemblages in Levels 2 to 4. (Level 5 at the site is described as having similar flaked lithics to those in Level 4, in addition to pottery and polished stone adzes.)

As shown in Table 1, numerous rockshelters in Peninsular Malaysia have an occupation history restricted to the terminal Pleistocene and Holocene, based on the available radiocarbon dates. A frequent characteristic of these Hoabinhian assemblages in Peninsular Malaysia is the lack of cores, a feature that dates back to the terminal Pleistocene in southeast Malaya (Table 1). Sumatraliths, on the other hand, regularly appear only as of the early Holocene and in western Peninsular Malaysia and Sumatra, with no documented cases in southern Thailand, and very rare instances in central or eastern Peninsular Malaysia (Adi 2000:157; see below). Sumatraliths' restricted chronological and geographical distribution appears to monitor maritime interaction across the Melaka Strait as it underwent flooding during the early Holocene (Bulbeck 2008).

It should be noted here that the radiocarbon chronology of Gua Gunung Runtuh and Gua Singa, both of which have produced sumatraliths, relies on dates from freshwater shell. These dates are likely to be in the order of 2000–3000 years older than the true age of the shell (Adi 2000) and, thus, are shown in Table 1 as overestimates. Togi Ndrawa on Nias Island, immediately west of Sumatra, has been well dated but the lithics are poorly described. From the account provided by Forestier et al. (2005), sumatraliths and other unifacial pebbles do not appear until the third level, which dates to between c. 9500 and 3000 years BP. Further information from Wiradnyana (2008) indicates the presence of cores and retouched flakes, at least in the upper levels. The Togi Ndrawa Hoabinhian assemblage would appear to be broadly similar to that excavated at Gua Pandan, in South Sumatra, which extends the documented distribution of Hoabinhian sites in Sumatra (Forestier et al. 2006; Simanjuntak et al. 2006). Sumatra's Hoabinhian is best represented

in the massive shell middens of coastal northeast Sumatra (Heekeren 1972), associated with early Holocene radiocarbon dates (Edwards McKinnon 1991).

In addition to the Sumatra shell middens, similarly large middens are known across the Melaka Strait. Guar Kepah, previously dated to the fifth millennium BP from consideration of sea-level stands and the artefactual content (Bulbeck 2003), should probably be dated a millennium earlier based on subsequent research into the Peninsula's sea-level changes (cf. Anderson 2005), as would also be consistent with the c. 6000 year BP charcoal dating from the Bukit Perang midden (Bulbeck 2003). In southern Thailand, the Tham Sua midden has a basal radiocarbon determination on marine shell of around 6500 years BP, below the deepest sherd of pottery which otherwise occurs throughout the deposit; the site would have extended over dozens of square metres (Anderson 2005).

Gua Gunung Runtuh also has a very small number of cores and a single 'palaeoadze', described as similar to Kota Tampan examples (Zuraina et al. 1994), while two hand-axes are reported from Gua Bintong, which is referred to as Bukit Chuping in the earlier literature (Matthews 1961:47). Gua Bintong is dated to around 5000 years ago by Rabett (2005), although it also has late Holocene artifacts such as bronze (Leong Sau Heng 1989). The chronology tabulated for Gua Kajang is based on two charcoal determinations of c. 6000 and 9000 years BP (Zuraina 1998) from a virtually aceramic section of the site (Chia 1998:160), although later habitation would also be indicated by the recovery of pottery from above the site's lime-impregnated levels (Matthews 1961).

Polished and ground stone artifacts occur sporadically in contexts older than 5000 years BP in Malaya. Examples include two polished stone fragments from Layer 6 of Lang Rongrien (Anderson 1990:45), the waisted ground adzes from Guar Kepah (Matthews 1961:27–28), and flaked pebbles with polished edges from the deepest levels at Gua Kerbau (Bulbeck 2003) and the c. 6000-year BP levels of Gua Peraling (Adi 2000:114). The virtually aceramic Malaysian site of Gua Madu produced two extensively flaked tools with smoothly ground edges (Matthews 1961:55–56), while Buang Baeb and Khao Khi Chan in southern Thailand have ground stone tools broadly dated between 4000 and 6000 years BP (Srisuchat 1993). Combined with indications that sumatraliths (Kamminga 2007) and other edge-flaked pebbles (Bannanurag 1988) may have had a role in tree felling, the evidence from Malaya's lithics is fully compatible with Kealhofer's (2003) scenario of increasing forest clearance between 8000 and 4000 years BP.

Also consistent with this scenario, based on lithics, is the ceramic evidence. Cordmarked pottery older than 5000 years BP includes a single sherd from Layer 5 of Lang Rongrien (Anderson 1990), the pottery from Tham Sua dated to shortly after 6400 years BP, the cups and bowls from the nearby sites of Buang Baeb and Khao Tau (Anderson 2005:145), the pottery found at all levels in Guar Kepah (Matthews 1961:27), and the Gua Peraling Layer 3 potsherds dated to 5720 $\pm$ 210 BP (Adi 2000). Therefore, the date of 4000–5000 years BP for the pottery at Gua Kecil, based on a radiocarbon assay on collagen from pottery-associated bone (Bellwood 1993:35), should not be taken as marking the onset of the Neolithic in Malaya.

Bellwood (1978) nominated Sørenson's 'Ban Kao culture' as the source for Malaya's Neolithic, but subsequent research shows that this 'cultural package' should be decomposed into its multiple constituent elements. One element, cordmarked pottery, was widespread from 5000–6000 years BP onwards, not only in Malaya (as noted above) but also across Mainland Southeast Asia (Higham & Thosarat 1998; Nguyen et al. 2004). A second element, tripod ware, has a focus of distribution and its earliest dates in Malaya (within a Southeast Asian context). Tripod vessels are dated to between 4000 and 5000 years BP (radiocarbon dates on bone from the associated burials) at Buang Baeb and Khao

Khi Chan near the Isthmus of Kra (Srisuchat 1993), 4400 years BP at the nearby site of Khao Kanaab Nam (Anderson 2005:147), and 4000 years BP at Jenderam Hilir in Peninsular Malaysia (Leong Sau Heng 1991). Additional examples from undated contexts occur at Na Ching in southern Thailand (Anderson 1988), Gua Singa on the Thailand-Malaysia border (Azman 1998), and Gua Bintong, Bukit Cangkul, Gua Kodiang, Gua Gergasi, Gua Pasir, Gua Taufan and Gua Baik in western Peninsular Malaysia (Leong Sau Heng 1991). North of Malaya they are known only from Ban Kao (south-central Thailand), where their nominal age of 4000 years BP specifically refers to the age of the deposit into which they had been interred as burial goods (Bellwood 1978:167-68). Thus, while Sørenson (1972) may be correct in deriving the tripods from mid-Holocene China, their point of entry would appear to have been the Isthmus of Kra, with subsequent dispersal both northward and especially southward.

Two other elements of the 'Ban Kao culture', pedestalled pots and finely polished stone adzes, were widespread across Mainland Southeast Asia by 4000–5000 years BP (Higham 2002; Nguyen et al. 2004). This spread probably included southern Thailand (Srisuchat 1993), whereas their appearance in Peninsular Malaysia evidently postdates 4000 years BP (Bulbeck 2004a). The situation with extended burials, reviewed in detail below, is probably similar. In contrast, barkcloth beaters, a sixth element, appear to have arrived earlier in Peninsular Malaysia—one was found in a preceramic context at Gua Madu (Matthews 1961:55–56)—than at Ban Kao, where additionally they were strangely made of pottery rather than stone (Bellwood 1978:168). North Vietnam, where stone barkcloth beaters were present by 4000–5000 years BP (Nguyen et al. 2004:183), is a possible source for the Malaya examples. Thus, while all of the elements listed above came together at Ban Kao, the archaeological evidence refutes any notion that the 'Ban Kao culture' was a discrete cultural package developed in south-central Thailand or transmitted *holus bolus* from there to Malaya.

See Table 1 (Malayan and Sumatran Late Pleistocene and Holocene assemblages in terms of Hoabinhian and other attributes), Table 2 (Prehistoric burial disposal modes in Malaya, along with main grave good associations) and Table 3 (Main Thailand and Peninsular Malaysia sites with extended burials, ordered approximately from north to south).

5 Holocene stature reduction – further evidence

Evidence that the prehistoric inhabitants of Malaya were taller than the Orang Asli has been previously reviewed on several occasions (Bulbeck 1996, 2003, 2005b), and these findings can now be supplemented with additional data recently available for Gua Cha (see Acknowledgements). For convenience, the methodology and detailed observations are placed in Appendix A, and only a summary of the evidence is presented in the main text. Collectively, these data show that, for both sexes (Tables 4 and 5), the Orang Asli on average have shorter limb bone lengths and stature than the Peninsula's prehistoric inhabitants, with frequent instances of non-overlapping ranges. Fibula length alone does not follow this pattern, which may be attributed to the very small number of complete prehistoric fibulae available for measurement (Appendix A). When Holocene size reduction is estimated, by expressing the difference between the early Holocene and Orang Asli averages as a percentage of the early Holocene average, the estimate hovers around 10% with a range between 7% and 18%.

Table 1: Malayan and Sumatran Late Pleistocene and Holocene assemblages in terms of Hoabinhian and other attributes. Asterisked radiocarbon dates are on freshwater shell.

Site/level	Dating	Shaped cores?	Retouched flakes?	Pointed wide-based cobbles?	Bifacially flaked cobbles?	Unifacially flaked cobbles?	Typological sumatraliths?	Characterisation of assemblage
Kota Tampan (Zuraina 1990, 2003)	c. 74,000 years ago	Yes	Yes	Yes	No	Yes	Yes	Cores and unifacially flaked cobbles, plus dominance of primary flakes
Lang Rongrien units 8–10 (Anderson 1990)	c. 27,000–>43,000 years BP	Yes	Yes	No	No	Yes	No	Core-based assemblage with retouched/utilised flakes
Bukit Bunuh (Mokhtar 2006)	c. 40,000 years ago	Yes	Yes	Yes	Yes	Yes	No	Variety of flaked cobbles plus dominance of primary flakes
Moh Khiew Level 1 (Chitkament 2006–07)	≥ 26,000 years BP	Yes	Not clear	No	No	Yes	No	Flakes from cores and unifacially flaked cobbles
Moh Khiew Level 2 (Chitkament 2006–07)	> 11,000 < 15,000 years BP	Yes	Many utilised	No	Yes	Yes	No	Unifacially and bifacially flaked cobbles with many utilised flakes
Gua Sagu spits 9–13 (Zuraina et al. 1998)	13,000–15,000 years BP	No	No	No	Yes	No	No	Flakes from bifacially flaked cobbles
Moh Khiew Level 3 (Chitkament 2006–07)	8000–11,000 years BP	Yes	Yes	No	Yes	Yes	No	Unifacially and (mainly) bifacially flaked cobbles with retouched flakes
Gua Gunung Runtuh (Zuraina et al. 1994)	<8000*–<13,000* years BP	Yes	Yes	Yes	Yes	Yes	Yes	Predominantly unifacially flaked cobbles and unmodified flakes
Gua Tenggek (Zuraina et al. 1998)	c. 3000–11,000 years BP	No	No	No	Yes	No	No	Flakes from bifacially flaked cobbles

Table 1: *continued*

Site/level	Dating	Shaped cores?	Retouched flakes?	Pointed wide-based cobbles?	Bifacially flaked cobbles?	Unifacially flaked cobbles?	Typological sumatraliths?	Characterisation of assemblage
Lang Rongrien units 5–6 (Anderson 1990)	8000–10,000 years BP	Yes	Yes	No	Yes	Yes	No	Diverse cores and flaked cobbles plus many primary flakes
Sakai Cave (Pookajorn 1996)	7500–10,000 years BP	Not clear	No	Not clear	Not clear	Yes	No	Unifacially flaked cobbles
Gua Teluk Kelawar (Zolkurnian 1998)	3000–10,000 years BP	No	Yes	Not clear	Yes	Yes	Yes	Flakes from unifacially and bifacially flaked cobbles
Gua Peraling layers 3–7 (Adi 2000)	5000–<12,000* years BP	No	Not clear	No	Yes	Yes	No	Flakes from unifacially and bifacially flaked cobbles
Gua Chawas spits 26–65 (Adi 2000)	4000–<12,000* years BP	No	Not clear	No	Yes	Yes	No	Flakes from unifacially and bifacially flaked cobbles
Gua Pandan Level 2 (Simanjuntak et al. 2006)	6500–9000 years BP	Yes	Yes	No	No	Yes	Yes	Hoabinhian and ‘Mousteroid’ components
Togi Ndrawa Level 3 (Forestier et al 2005; Wiradnyana 2008)	3000–9000 years BP	Yes	Yes	No	No	Yes	Yes	Poorly described; attributes noted here are provisional
Gua Kajang (Matthews 1961)	6000–9000 years BP	Yes	One utilised	No	Yes	Yes	Yes	Variable lithology and technology
Gua Bukit Taat (Nik Hassan et al. 1990)	3000–9000 years BP	No	Yes	No	Not clear	Yes	Yes	Flakes from unifacially flaked cobbles
Gua Sagu spits 2–8 (Zuraina et al. 1998)	1000–10,000 years BP	No	Yes	No	Yes	Yes	Yes	Flakes from bifacially flaked cobbles
Gua Teluk Kelawar B (Zolkurnian 1998)	3000–<10,000* years BP	No	Yes	No	No	No	No	Small assemblage of flakes and utilised cobbles
Gua Batu Tukang (Zolkurnian 1998)	3500–<9000* years BP	No	Yes	No	Yes	Yes	Yes	Flakes from a variety of cobble-based tools

Table 1: *continued*

Site/level	Dating	Shaped cores?	Retouched flakes?	Pointed wide-based cobbles?	Bifacially flaked cobbles?	Unifacially flaked cobbles?	Typological sumatraliths?	Characterisation of assemblage
Gua Singa (Azman 1998; Zuraina 1998)	<9000* years BP	No	Yes	No	Yes	Yes	Yes	Poorly described cobble-based industry
Gua Kerbau (Bulbeck 2003; Matthews 1961)	Early–late Holocene	No	Yes	No	Yes	Yes	Yes	Flakes from unifacially and bifacially flaked cobbles
Moh Khiew Level 4 (Chitkament 2006-07)	5500–7000 years BP	Yes	Yes	No	Yes	Yes	No	Unifacially and (mainly) bifacially flaked cobbles with retouched flakes
Gua Cha Layers 3–4 (Adi 1981)	3000–7000 years BP	No	Yes	No	Yes	Yes	No	Flakes from unifacially and bifacially flaked cobbles
Gua Kecil 14–32" (Dunn 1964)	c. 2000–c. 7000 years BP	No	Some utilised	No	Yes	Yes	Yes	Flakes from unifacially and bifacially flaked cobbles
Guar Kepah (Matthews 1961)	5–6000 years ago	Not reported	Not reported	No	Yes	Yes	Yes	Poorly described cobble-based industry
Gua Ngaum (Zolkurnian 1998)	c. 3000–<6000* years BP	No	Yes	No	Yes	Yes	Yes	Flakes from unifacially and bifacially flaked cobbles
Gua Baik (Callenfels and Noone 1938)	Mid–late Holocene	Not reported	Not reported	No	Yes	Yes	Yes	Ceramic Hoabinhian
Gua Bintong (Matthews 1961)	c. 5000 years ago	No	Yes	Yes	Yes	Yes	No	Flakes from unifacially and bifacially flaked cobbles

Table 2: Prehistoric burial disposal modes in Malaya, along with main grave good associations (see text).

Period	Flexed inhumations	Secondary disposals	Extended supine inhumations
Late Holocene Metal Phase	None recorded	Kuala Selinsing (composite canoe burial)	Gua Harimau 3, 5, 7? (bronze and glass grave goods) Kuala Selinsing (majority of burials—pottery and glass grave goods) Gua Peraling 1 (no grave goods) Gua Baik 94–96 (no grave goods)
Late Holocene Neolithic	Lang Rongrien 4 (with pedestalled pot)	Lang Rongrien 2, 3 (cordmarked pots) Gua Harimau 4, 6 (pottery) Gua Harimau 11, 95E (no grave goods) Gua Baik 98, 99 (no grave goods)	Other Lang Rongrien burials (pedestalled and cordmarked pots) Gua Harimau 1, 2, 8, 9, 10 (cordmarked pots) Gua Cha (most have pedestalled and/or cordmarked pots)
Middle Holocene	Moh Khiew 1 Gua Kerbau Gua Cha Gua Peraling 4 Gua Baik 583 (lowest layer) Gunung Cheroh (All lacking grave goods)	Gua Peraling 2, 3 Gua Cha Guar Kepah Gunung Cheroh (All lacking grave goods)	None recorded
Early Holocene	Gua Gunung Runtuh Gua Teluk Kelawar 1 Moh Khiew 2 Gua Kerbau (All lacking grave goods)	None recorded	None recorded

Table 3: Main Thailand and Peninsular Malaysia sites with extended burials, ordered approximately from north to south.

Site	Location	Earliest extended burials	Other burial modes	Characterisation of burial goods
Ban Chiang (Higham & Thosarat 1998; Bulbeck 2004c)	Khorat Plateau, northeast Thailand	c. 4300 BP (Neolithic; dates on rice chaff)	Flexed burials; foetus/infant jar burials (till 3500 BP)	Pedestalled and other ceramic vessels, accompanied by bronze ornaments and weapons after 3500 BP, plus iron weapons after 3000 BP
Non Nok Tha (Bayard 1996–97; Higham & Thosarat 1998)	Khorat Plateau, northeast Thailand	c. 4000 BP (Neolithic; dates on rice chaff)	Secondary burials early in the sequence	Pedestalled and other ceramic vessels, occasionally accompanied by bronze bracelets, axes and moulds (3500–3000 BP), as well as polished stone adzes, grindstones, shell jewelry and hematite
Ban Na Di (Higham & Thosarat 1998)	Khorat Plateau, northeast Thailand	c. 3000 BP (Bronze Age; rice present)	Infant jar burials (Iron Age)	Rich assemblage of ceramics (vessels and figurines), shell jewelry, marble and other stone jewelry, and iron items (by 2400 BP)
Ban Non Wat (Higham & Thosarat 2006)	Mun Valley, central Thailand	c. 4000 BP (Neolithic; rice present)	Jar burials including infants and a seated, crouched adult	Decorated ceramic vessels, shell ornaments, pig offerings
Ban Lum Khao (Higham 2002)	Mun Valley, central Thailand	c. 3400 BP (Bronze Age; rice present)	Infant jar burials	Ceramic vessels (some pedestalled), figurines and spindle whorls, accompanied by shell ornaments, polished stone adzes, marble bangles and bronze fragments (ending 2500 BP)
Non Pa Wai (Higham 2002; Pigott et al. 2006)	Chao Phraya Plains, central Thailand	c. 4000 BP (Neolithic; rice, especially after 3500 BP)	Not documented	Ceramic vessels (some pedestalled), polished stone adzes and shell jewelry, with copper axes and moulds, a copper fishhook and ochre after 3500 BP
Non Mak La (Higham & Thosarat 1998; Higham 2002; Pigott et al. 2006)	Chao Phraya Plains, central Thailand	c. 3800 BP (Neolithic; rice, especially after 3500 BP)	Infant jar burials	Ceramic vessels and ornaments of shell, greenstone and marble
Ban Tha Kae (Higham 2002)	Chao Phraya Plains, central Thailand	c. 3800 BP (Neolithic)	Not documented	Ceramic vessels (some pedestalled), polished stone adzes and shell jewelry (Neolithic to Bronze Age), with bronze jewelry, iron tools and weapons, and glass and stone ornaments during the Iron Age
Khok Charoen (Higham 2002; Bulbeck lab. notes)	Chao Phraya Plains, central Thailand	2853 $\pm$ 33 years BP (Wk-15038), i.e. c. 3000 BP	Not documented	Ceramic vessels including pedestalled pots, shell and stone jewelry, polished stone adzes, and a bronze ring found with one burial studied by Sood Sangvichien

Table 3: *Continued*

Site	Location	Earliest extended burials	Other burial modes	Characterisation of burial goods
Ban Phu Noi (Higham 2002)	Chao Phraya Plains, central Thailand	Bronze Age	Not documented	Ceramic vessels (some pedestalled); jewelry of shell, ivory, marble and chlorite; and a polished stone adze (no bronze)
Khok Phanom Di (Higham & Thosarat 1998; Higham 2002)	South coastal Thailand	c. 4000 BP (Neolithic; rice throughout sequence)	None	Ceramic vessels (some pedestalled) and anvils and shell jewelry, along with shell knives, bone fishhooks and harpoons, ivory ornaments, and polished stone adzes and hoes (no bronze, ending 3500 BP)
Nong Nor (Boyd et al. 1998)	South coastal Thailand	3100 BP (Bronze Age; rice first appears)	Preceded by Neolithic jar burials including a seated, crouched adult	Pedestalled and other pottery vessels; jewelry of shell, bronze, tin, marble and semi-precious stone; and copper implements (ending 2700 BP)
Ban Kao (Sørenson & Hatting 1967; Bulbeck 2004d)	South-central Thailand	< 4000 BP (Neolithic)	One flexed burial	Ceramic vessels including pedestalled and tripod pots; jewelry of stone, bone and shell; polished stone adzes; polished stone adzes; barbed bone points; ivory disks; iron adzes (postdating 2500 BP)
Lang Rongrien (Anderson 1990, 2005)	Peninsular Thailand	Estimated 3000–5000 BP (Neolithic)	Flexed and secondary burials	Ceramic vessels including pedestalled pots, shell bracelet, polished stone adze; burials sometimes in log-lined coffins
Gua Harimau (Chia & Zolkurnian 2005 – see text)	Peninsular Malaysia	3500 BP (Neolithic)	Secondary burials including tooth burials	Ceramic vessels including pedestalled pots, shell jewelry, barkcloth beaters, and late in the sequence a glass bead and two bronze axes and moulds
Gua Cha (Sieveking 1954; Bulbeck 2000)	Peninsular Malaysia	c. 3000 BP (Neolithic)	Preceded by Hoabinhian flexed and secondary burials	Ceramic vessels including pedestalled pots, shell jewelry and spoons, nephrite and marble bracelets, polished stone adzes, and a barkcloth beater
Kuala Selinsing (Bellwood 1997; Bulbeck 1998)	Peninsular Malaysia	2000 BP (Iron Age; rice present)	Canoe burial with bones from multiple skeletons	Ceramic vessels, glass and stone beads; burials sometimes in canoes

Table 4: Average male maximum limb bone lengths (in mm) and estimated/recorded stature (in cm), taken from Appendix A

Period	Femur length	Tibia length	Fibula length	Humerus length	Radius length	Ulna length	Stature
Early Holocene	451.5*	395*	–	324*	277*	285*	169*
Middle Holocene	454	355	331.5	321	255*	263*	166
Late Neolithic	434	360	310	320.5*	243*	275*	159
Early Metal Phase	438	362	–	316*	227.5	238	162
Orang Asli	406	342	325	290	226	242	154
Holocene reduction	10 %	13 %	–	10 %	18 %	15 %	9 %

* Mutually exclusive range with the Orang Asli.

Table 5: Average female maximum limb bone lengths (in mm) and estimated/recorded stature (in cm), taken from Appendix A

Period	Femur length	Tibia length	Fibula length	Humerus length	Radius length	Ulna length	Stature
Early Holocene	433*	340*	–	316*	247*	271*	163.5*
Middle Holocene	419*	308	313	298*	222*	262*	158
Late Neolithic	384	327	321	277	–	232	156
Early Metal Phase	397	–	–	278	227*	–	156
Orang Asli	380	317	313	262	206	229	143
Holocene reduction	12 %	7 %	–	17 %	17 %	15 %	13%

* Mutually exclusive range with the Orang Asli.

Male stature estimates suggest three phases of stature reduction. Gua Gunung Runtuh, suspected to be the oldest male skeleton from Malaya, has limb bone lengths consistent with a taller population than the Gua Cha Hoabinhian burials, which dominate the middle Holocene sample. The middle Holocene burials appear to have been taller on average than the late Neolithic (extended burial) and Early Metal Phase males who, in turn, tended to be taller than Orang Asli males. Humerus and radius lengths are consistent with this trend even if the pattern of steady reduction is less obvious for the other limb bone lengths (Table 4). The scenario of steady stature reduction over three phases is also consistent with the female data on stature and femur, humerus and ulna lengths (Table 5).

Based on the available data, an estimate of around ten percent reduction in stature between the early Holocene and the Orang Asli is strongly supported for both sexes, and appears to have been a process that occurred throughout the Holocene. Several mechanisms can be proposed as pressures selecting for this body size reduction, all of them directly or indirectly related to the warm, humid conditions that prevailed during the Holocene. First, according to Bergmann's Rule, a smaller, leaner physique would have assisted thermal regulation in these conditions (Gilligan & Bulbeck 2007). Secondly, small stature could have assisted with the procurement of tropical rainforest resources, whether these be foraged foods or produce collected for trade, which are distributed sparsely (both horizontally and vertically) in an environment where profuse undergrowth hampers

mobility (Bulbeck 2003). Thirdly, dietary breadth and access to high-quality protein appear to have decreased over time for all Orang Asli groups. In the case of foragers, this dietary shift can be seen in the increase of arboreal species relative to ungulates in the rockshelter faunal refuse (Bulbeck 2003) and, with farming groups, it can be seen in the increasing reliance on low-protein root crops (Fix 2002).

Osteological evidence of the selection pressures favouring reduced stature includes the high proportion of the Gua Cha and Guar Kepah teeth affected by macroscopic dental enamel hypoplasia. This condition registers a temporary cessation to childhood growth, whether due to illness, malnutrition or some other physiological stress, and the child's approximate age at which growth was arrested can be gauged from which teeth and/or crown segments were affected (Hillson 1996). The Gua Cha crown segments involved particularly reflect pronounced stresses on physical growth during mid-childhood, while at Guar Kepah the third molars were most affected, which indicates stresses hindering the growth spurt of adolescence (Bulbeck 2005a, 2005b). These observations may reflect selection pressures operating directly against unfettered childhood growth, or (following the model of Migliano et al. 2007) monitor high childhood mortality rates, and hence, selection pressures for females' younger onset of reproduction and (indirectly) their smaller body size.

6 Other relevant studies in physical anthropology

The question of Orang Asli origins is central to the view developed by Coon (1962) and Howells (1973a) in which the foraging populations of Southeast Asia, whether pre-Neolithic or represented by ethnographically recorded Negritos, belong to the Australo-Melanesian 'race'. This term covers the indigenous populations from Tasmania to Melanesia, bordering along eastern Indonesia with 'Mongoloid' populations, which are found across Polynesia, Micronesia, the New World and, apart from isolates such as Negritos and the Ainu, eastern Asia (Bulbeck et al. 2006). Bellwood, in numerous publications (for example, 1978, 1992, 1997), has adumbrated a scenario in which Mongoloid farmers, who originated in South China, expanded across Southeast Asia during the Neolithic, and introduced the proto-versions of Southeast Asia's indigenous languages. Purportedly, the Mongoloids' agricultural economy gave them a crucial demographic advantage over the Australo-Melanesian foragers who were either absorbed or driven into isolated refuges.

The above-mentioned works by Bellwood, and Coon and Howells before him, cited studies on ancient Southeast Asian skeletal remains that inferred an Australo-Melanesian status on the grounds of generally large teeth, robust cranial morphology, squat facial skeleton and elongated braincase. However, as contended by Bulbeck (1981) and Storm (1995), none of these features unambiguously distinguish between Australo-Melanesian and Mongoloid populations. Further, the late Holocene trend amongst Southeast Asians towards smaller teeth, more gracile crania, narrower facial skeleton and broader braincase could be explained in local evolutionary terms, either as adaptations to an agricultural subsistence (Bulbeck 1981) or to the humid heat of the Holocene (Storm 1995).

Studies on dental morphology, which covers traits such as shovelled incisors, had suggested that all *H. sapiens* in Southeast Asia, regardless of antiquity, belonged to a single population complex, labelled 'sundadont' by Turner (1990; Turner & Eder 2006). However, Turner based this conclusion on an 'Early Southeast Asian' sample which was dominated by Neolithic and Early Metal Phase teeth, and so would be expected to be similar to recent Southeast Asian teeth even according to Bellwood's scenario of a

Neolithic Mongoloid immigration (Bulbeck 2000). The finding which contradicts Bellwood's scenario is that the Neolithic teeth from Gua Cha appear more Australo-Melanesian than sundadont, which suggests that any China-based migration of Mongoloids across Southeast Asia would appear to have occurred within the last 2000 years (Bulbeck 2000). In this chapter I will test this suggestion against the dental anthropological data provided by Matsumura & Hudson (2004), who interpret their data as supporting Bellwood's Neolithic migration scenario. Their data are crucial in this regard, because they include an analysis of dental metrical shape—that is, the relative size of tooth diameters to each other, with the confounding factor of overall tooth size removed—as well as dental morphology. In addition, I accept the analysis by Matsumura et al. (2008) of the transitional Neolithic/Bronze Age cemetery population of Man Bac, in North Vietnam. That study assigned the majority of the individuals to a Mongoloid population with its origins in China, but also identified a minority component of residual Australo-Melanesians. My point here is that, since North Vietnam abuts South China, any China-derived influences on Southeast Asians should have appeared relatively early there, and so Man Bac represents the earliest possible time for when Southeast Asia more widely could have been affected.

Figure 3 shows the inter-population relationships indicated by the dental morphology distances published by Matsumura & Hudson (2004, Table 7). It differs from the hierarchical dendrogram published by Matsumura & Hudson (2004, Fig. 5) in that the branches have been swivelled so as to seriate the populations, in as orderly a manner as the dendrogram structure allows, along the single major axis of biological variation (see Bulbeck 2000, 2006 on seriated dendrograms). At one end of this axis is a cluster of 'sinodont' groups (cf. Turner 1990) such as Mongolians, Iron Age to recent Japanese, and Neolithic to recent Chinese, and, at the far end, Sakhalin Ainu and the two Bronze/Iron Age Southeast Asian samples (Dong Son in North Vietnam, and Leang Codong in Sulawesi). At the other extreme are the two pre-Neolithic cum Neolithic Southeast Asian samples (from Vietnam/Laos and Flores/Malaya) plus Andaman Islanders, all of which Matsumura & Hudson (2004) consider to be Australo-Melanesian. However, based on where Australian Aborigines and New Britain fall in the seriated order, an Australo-Melanesian status would also apply to 'Mid-Holocene Thailanders' (represented by middle/late Holocene teeth from Ban Kao, Non Nok Tha and Khok Phanom Di), plus the Jomon of pre-Iron Age Japan, as well as recent Hokkaido Ainu, Amami-Okinawa Islanders and Indochinese. That is, the data fail to distinguish Australo-Melanesians from numerous non-Australo-Melanesian populations of eastern Asia, and if any label could be applied to such a diverse grouping it would have to be non-sinodont.

To the degree that we can rely on the dental morphology data in Matsumura & Hudson (2004), evidence for population incursion into Southeast Asia from China would be dated as of 800 BCE, when the Dong Son culture commenced (Nguyen et al. 2004). Further, any such incursion would have affected only some (for example Thais, Dayaks and Sunda Islanders), not all recent Southeast Asians, and certainly not Neolithic/Bronze Age Southeast Asians, given that 'Mid-Holocene Thailanders' cluster with Australian Aborigines and New Britain Melanesians. Additionally, the 'Austroasiatic corridor' described above would have been established at a time when populations along its entire length had a non-sinodont dental morphology. For this reason, there would be little point in looking to dental morphology for evidence of Neolithic/Bronze Age population movement or gene flow along the Mekong valley.

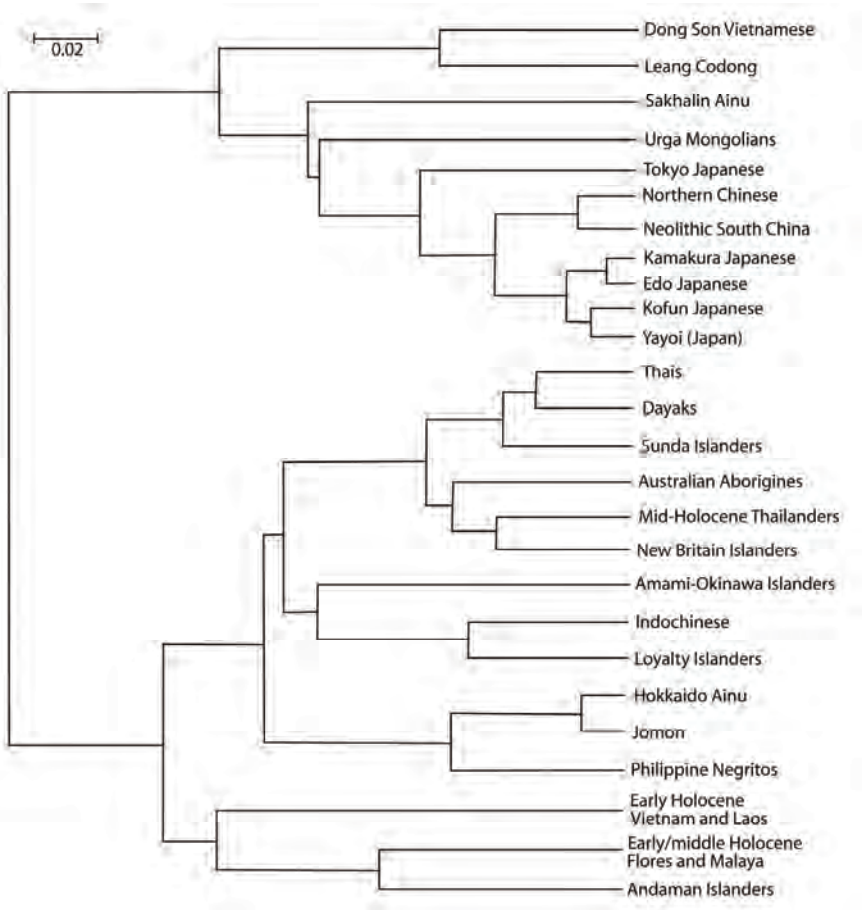

Figure 3: Seriated dendrogram (average linkage clustering) of dental morphology distances in Matsumura and Hudson (2004) (Correlation coefficient between the seriated order and a perfect seriation = 57.6%).

Figure 4 shows the seriated dendrogram derived from the dental metric shape distances published by Matsumura & Hudson (2004, Table 5). It suggests two useful improvements on the interpretation that those authors provide of their results. First, the cluster at the bottom of the dendrogram, which they characterise as Australo-Melanesian (including early Southeast Asians), also includes all their samples of Jomon and Ainu, who are indistinguishable from Australo-Melanesians in this analysis. To facilitate discussion, let us label this cluster 'non-Mongoloid', and the other cluster 'Mongoloid'. Secondly, the modern populations which seriate the farthest from the non-Mongoloids are Southeast Asians (here including Philippine Negritos), not Northeast Asians. Thus, whatever explanation might be advanced for the Mongoloid status of recent Southeast Asians in this analysis, genetic input from Northeast Asia might appear to fall short of the mark. Fortunately, as will now be seen, an explanation is possible from considering the point that three Bronze/Iron Age East Asian samples in the study (Dong Son, Anyang and Yayoi) are three of the five most Mongoloid samples (at the very top of Figure 4).

The Dong Son teeth are very distinctive from the Bac Son and Da But teeth (Figure 4) which both represent the Neolithic inhabitants of coastal North Vietnam. This would imply some level of post-Neolithic population incursion into North Vietnam by a people related to Bronze Age Chinese (as represented by Anyang). Similar population expansion from early historical China is evidently represented by Yayoi (with Japanese being the result of Yayoi/Jomon hybridisation), and may also be represented by the Bronze Age Mongolian

sample from Chifeng. Neolithic South China may well be a deep source for the transition to a 'hyper-Mongoloid' dental metrical shape across recent Southeast Asia, but its archaeologically attested effects date no earlier than the late Bronze Age (the age of Dong Son), or perhaps the Neolithic/Bronze Age transition at the far north of Southeast Asia (Man Bac, in North Vietnam). What clearly cannot be found in the dental metrical shape analysis of Matsumura & Hudson (2004), or in any currently available osteological data, is evidence for a Neolithic population expansion from China across Southeast Asia.

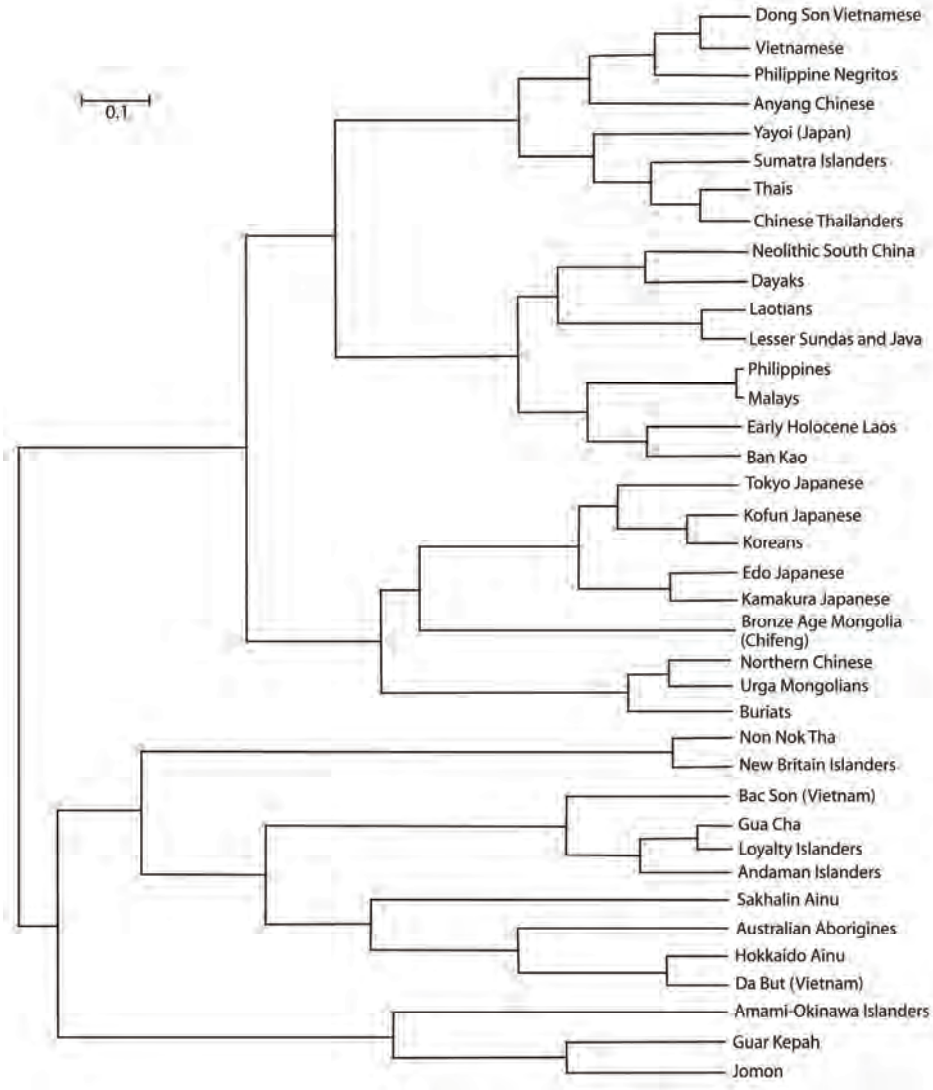

Figure 4: Seriated dendrogram (average linkage clustering) of dental metrical shape distances in Matsumura & Hudson (2004) (Correlation coefficient between the seriated order and a perfect seriation = 65.8%).

Intriguingly, as noted by Matsumura & Hudson (2004), their sample of 'Early Holocene Laos' teeth differs from most other prehistoric Southeast Asians in being metrically Mongoloid. They attempt to explain away this result by proposing that their sample possibly includes some Neolithic teeth, thereby obscuring the true non-Mongoloid status of the early inhabitants of Laos. However, there are a number of problems with this rationalisation. First, based on the available accelerator mass spectrometry dates from the remains (Demeter 2006), the time period covered by the Laos burials spans the Late

Pleistocene (Tam Hang, 15,700 years BP) to middle Holocene (Tamp Pong, 5400 years BP)—not early to late Holocene, as Matsumura and Hudson would wish. Secondly, were they justified in allowing for the presence of two distinct populations in the 'Early Holocene Laos' collection, this should be evident from other studies of these remains. What we find instead is that all ten early Laos crania studied by Demeter (2006) fell neatly into a single (C2) cluster. Thirdly, even if Neolithic remains have been caught up in Matsumura and Hudson's 'Early Holocene Laos' sample, evidence that Southeast Asia's Neolithic inhabitants were characterised by Mongoloid dental metrics is yet to be adduced.

Although the Neolithic Ban Kao teeth cluster with 'Early Holocene Laos' in Figure 4, along with other 'Mongoloids', this reflects a specific similarity between the early Holocene inhabitants of Laos and middle/late Holocene populations along the Mekong valley. Pietrusewsky (2006) found early Laos crania to be virtually indistinguishable from Ban Chiang crania, while Matsumura (2005) also found Ban Kao to be similar to early Laos in its craniometrics (as well as its dental metrics). In addition, Non Nok Tha is closer to early Laos and Ban Kao in its dental metrical shape (Matsumura & Hudson 2004, Fig. 2) than my Figure 4 would suggest. These comparisons all suggest an ancestor-descendant (or perhaps uncle-nephew) relationship between the early Laos and middle/late Holocene Thailand populations.

Osteological analysis accordingly offers strong support for the Mekong Austroasiatic dispersal route proposed by Sidwell and Blench (this volume). The populations involved appear non-Mongoloid in some analyses; for example, in its dental morphology, Ban Kao is most similar to Melanesians from New Britain (Matsumura 2005), and the early Laos teeth also presumably have a non-sinodont dental morphology (Figure 3). However, in other analyses they appear Mongoloid; for example, the Ban Chiang and Khok Phanom Di crania cluster together as marginally East Asian (Pietrusewsky 2006), and the Mongoloid dental metrics of the early inhabitants of Laos has been demonstrated above. These populations' ambivalently 'Mongoloid' status nonetheless distinguishes them from the Guar Kepah and Hoabinhian/Neolithic Gua Cha samples, which all consistently show 'non-Mongoloid' tendencies regardless of the analysis (Figures 3 and 4, and see below).

Matsumura (2005) found that the inhabitants of Malaya would appear to have remained Australo-Melanesian till as late as the Early Metal Phase, based on the close similarity between Gua Harimau and Gua Cha in tooth size and shape. This finding is broadly compatible with the results of comparisons between prehistoric Malaya and Orang Asli osteology. Considering dental morphology, Rayner & Bulbeck (2001) show that the Semang join a cluster made up of New Guinea and European/North African samples, whereas the Aboriginal Malays (Temuan and Semelai) and Temiar Senoi are intermediate between this cluster and sundadonts, albeit closer to the latter. In their dental morphology, the Hoabinhian and especially Neolithic/Early Metal Phase samples are closer to the Temiar than any other Orang Asli population, a result interpreted as placing the immediate biological ancestry of the Semang to the north of where most of Peninsular Malaysia's prehistoric human remains have been found (Bulbeck & Lauer 2006). However, when the Guar Kepah and Gua Cha Neolithic teeth are analysed separately, the former appear equally similar to both Aboriginal Malays and the Temiar (Bulbeck 2005a), even if the distinctive Temiar affinity of the latter is attested (Bulbeck 2005b). Dental metrical analysis, on the other hand, finds the Semang to be very close to all male prehistoric Peninsular Malaysia teeth (except those from Guar Kepah) in terms of shape, but of course not size (the Semang have much smaller teeth, in line with their reduced body size). The mixed-sex Guar Kepah sample, on the other hand, clusters with Khok Phanom Di in terms of dental metrical shape and emerges as more 'Mongoloid' than any Orang Asli (Bulbeck

et al. 2005). To combine these results with those of Matsumura & Hudson (2004) (see Figure 4), both prehistoric Malayan and Orang Asli teeth would be characterised as non-Mongoloid in their metrical shape.

In their craniometrics, the three Orang Asli divisions resemble each other in having small crania, a braincase which is modally of middling shape (but varying from narrow to broad), and a short face and broad nasal aperture but tall orbits (Bulbeck & Lauer 2006). Compared to non-Malaya populations, approximately equal numbers resemble Andamanese, Mongoloid Southeast Asians and Africans, with no suggestions of a difference between the divisions except perhaps a specific likeness between Aboriginal Malays and Andamanese (Table 6). Andamanese and Southeast Asian affinities are not found amongst prehistoric Malay Peninsula crania, which instead resemble the crania of Africans, Tasmanians, New Britain Melanesians, and Mongoloid populations in Easter Island and the New World (Bulbeck & Lauer 2006), as well as the Orang Asli. The main shape changes over time—narrowing of the face and nose, and slight broadening of the braincase—may be related to reduction in cranial size, which finally resulted in a proportion of Orang Asli crania metrically similar to recent Andamanese and other Southeast Asians. Certainly, there appears to have been a trend towards less robust crania over time, which can be attributed to cranial- and, ultimately, body-size reduction (Bulbeck & Lauer 2006).

In summary, the osteology of the Orang Asli indicates that their ancestry predominantly lies with Malaya's prehistoric inhabitants, reaching back to the Hoabinhian. However, there are also indications of genetic input from beyond Malaya that has contributed to the Orang Asli, and especially the Senoi and Aboriginal Malay, gene pool. This overall picture is consistent with the genetic distances in Lie-Injo (1976), which, when analysed, show that his Semang, Senoi and Aboriginal Malay samples all seriate together, notwithstanding a Mongoloid-leaning tendency shown by the Senoi (consistent with the findings of Saha et al. 1995) and especially Aboriginal Malays (Bulbeck 1996). The incorporation of extra-Malaya genes in the Orang Asli gene pool would be expected from their linguistic affinities and absorption of mortuary and technological innovations. In addition, as emphasised by Rambo (1988), all Orang Asli populations tend to show a diversity of physical appearances which crosses the three divisions. Whether due to recent 'mixed marriages' (Schebesta & Lebzelter 1928; Noone 1939) or earlier conjugal relations, this observation points to a network of gene flow that has linked all Orang Asli populations (see also Fix this volume).

Mitochondrial DNA (mtDNA) analysis is particularly useful here because it allows for a particulate view on a population's composition, based on its maternal lineages. This approach frees the analysis from the broad-brush classification of groups into macro-populations, which, as we have seen above, leads to a confusing array of terms (Australo-Melanesian, Mongoloid, non-Mongoloid, sundadont, sinodont, non-sinodont) in trying to extract useful information from the complex realities of how groups may resemble or differ from each other depending on the traits being considered (Bulbeck et al. 2006). This approach further releases the analysis from the assumption of episodic prehistoric change (as in Bellwood's Mongoloid migration scenario). The phylogeographical approach detailed by Oppenheimer (2003, this volume) additionally allows donor and recipient regions to be identified, as well as estimation of the time of arrival of a maternal lineage at its recipient destination.

Table 6: Classifications of Orang Asli crania relative to the Howells (1973b) populations using Fordisc 2.0 (Ousley & Jantz 1994). The crania's tribal affinities are from Evans (1937:269) for the Siong Semang and otherwise from Bulbeck (1996), while their Fordisc classifications are from Bulbeck (2004b)

Orang Asli group	**Andaman Islanders**	**Sub-Saharan Africans**	**Southeast Asians**	**Miscellaneous**	**Number tested**
Kensiw/Kintaq (Maniq)		1 Dogon, 2 Bushman	1 Atayal, 1 Philippines	2 Ainu, 1 Santa Cruz	8
Jahai	1	1 Teita, 1 Zulu	1 Atayal	1 Zalavar (Hungary)	5
Menriq	1				1
Lanoh	1				1
Semang	**3**	**5**	**3**	**4**	**15**
Temiar	2		2 Atayal		4
Semai		2 Teita, 1 Dogon, 1 Zulu		1 Easter Island	5
Jah Hut			1 Atayal		1
Senoi	**2**	**4**	**3**	**1**	**10**
Aboriginal Malays (Jakun)	**2**				**2**

7 Mitochondrial DNA analysis

Limited studies on Orang Asli mtDNA were first published by Ballinger et al. (1992), Melton et al. (1995), Oota et al. (2001) and Zainuddin & Goodwin (2003). The study by Hill et al. (2006) has the advantages of extensive sampling of the Orang Asli (three Semang, one Senoi and two Aboriginal Malay groups) as well as Malay populations in Sumatra, which is the likely homeland of the Melayu Malays. As detailed by Hooker (2003), the Melayu sequentially established an early historical capital at Palembang in Sumatra, a medieval capital at Tumasik in Singapore, and their capital at Melaka in the fifteenth century CE.

Hill et al. (2006) identified a small number of haplogroups, particularly well represented among the Semang, which would appear to reach back to the Late Pleistocene dispersal of *Homo sapiens* from Africa along the northern rim of the Indian Ocean to Australia (Oppenheimer 2003; cf. Lahr & Foley 1998). The majority of haplogroups, however, were found to have a terminal Pleistocene to Holocene time depth in Malaya, contrasting with the Late Pleistocene age of their root type elsewhere in Southeast Asia. Hill et al. (2006) related these introduced haplogroups to the Hoabinhian, (late) Neolithic, Malayic and Melayu cultural horizons. Some review of their conclusions may be warranted in light of subsequently published research on Island Southeast Asian mtDNA haplogroups by Hill et al. (2007), which has far better sampling of populations across the region than any preceding study on the topic, and in light of the detailed review of Malaya's archaeology presented here.

Two ancient haplogroups with their root type concentrated amongst the Orang Asli are M21 and R21 (Table 7). Their much lower representation in Sumatra or among the Melayu rules out a Sumatran source. Their cultural counterparts are the core- and cobble-based stone tool assemblages which led to Malaya's 'bifacial Hoabinhian' by 15,000 years ago

(Table 1). The very rare M22 haplogroup may come under the same rubric even though it is a feature of the Temuan, based on present data, whereas the M21 and R21 haplogroups characterise the Semang more than other Orang Asli groups (Table 7).

Both the R9b and N9a6 haplogroups are traced by Hill et al. (2006) to LGM ancestral types in Indochina, and have a stronger representation amongst the Orang Asli (especially Aboriginal Malays) than anywhere in Sumatra, other parts of Island Southeast Asia (Table 7) or Thailand (Hill et al. 2007). However, their hypothesised arrival in Malaya with the introduction of the Hoabinhian (Hill et al. 2006) is contradicted by archaeological evidence for the predominantly local development of the Malayan Hoabinhian. R9b has a disjunct distribution with concentrations in (1) northern Vietnam and central Thailand, and (2) amongst the Temuan and Semelai living to the south of any of the Peninsula's recorded Hoabinhian sites (cf. Oppenheimer this volume with my Figure 1). One likely scenario explaining this distribution would posit a terminal Pleistocene dispersal of R9b from northern Vietnam (then host to Hoabinhian and Bacsonian industries) or central Thailand to central-western Sundaland, and its northward retreat (associated with an undocumented stone tool industry) into southern Malaya as postglacial sea levels rose (Figure 5).

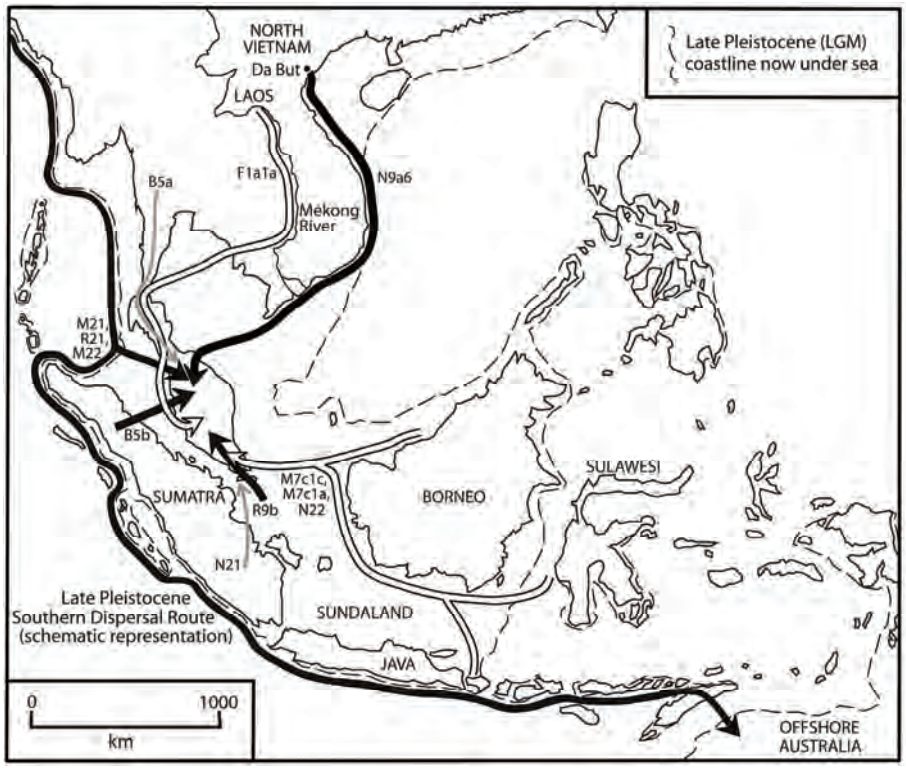

Figure 5: Hypothesised routes of entry of Orang Asli mtDNA haplogroups into the Malay Peninsula.

The introduction of the N9a6 haplogroup to Malaya, on the other hand, dates to the same age as the early Neolithic, not only in Malaya but also in North Vietnam. Every characteristic of Malaya's early Neolithic is echoed at North Vietnam's Bacsonian and/or Dabutian sites (Table 8), which suggests a linked introduction of the N9a6 haplogroup and the Neolithic from North Vietnam to Malaya. Archaeologically, the Bacsonian makes the best comparison with Malaya's early Neolithic, but osteologically Guar Kepah and Da But are particularly similar. Guar Kepah compares well with both Bac Son and Da But in tooth size (Matsumura & Hudson 2004, Fig. 3), and particularly well with Da But in terms of

tooth shape (Figure 4), elongated cranial form and Ainu/Jomon-like dental morphology (cf. Bulbeck 2005a and Matsumura 2005). N9a6 is also sporadically present in Island Southeast Asia (Table 7), which correlates with the status of the Da But culture as the likely source for pre-Austronesian Neolithic introductions to Island Southeast Asia, apparently reflecting coastal Vietnam's access to mid-Holocene sailing technology (Bulbeck 2008). Haplogroup N9a6 is therefore inferred to mark a maritime link between coastal Vietnam and Malaya at around 6000 BP (Figure 5).

Sumatraliths have a restricted chronological and geographical presence in Malaya, and probably source to early Holocene Sumatra. Their introduction to Malaya should find its biological echo in an mtDNA lineage more notable in Sumatra (retained there even after the island's colonisation by Austronesian speakers) than elsewhere in Island Southeast Asia (where sumatraliths are lacking). The B5b lineage, which is essentially a Semang-related lineage in Malaya (Table 7), fits the bill. The ancestral type is found in eastern Indonesia and otherwise in Sumatra; more specifically, it is found in Medan (Hill et al. 2006), near Sumatra's concentrated zone of Hoabinhian shell middens (Heekeren 1972). Although Hill et al. (2006) avoid proposing a specific time depth for the arrival of the B5b lineage in Malaya, their data would be consistent with an early Holocene date (see also Oppenheimer this volume).

The F1a1a haplogroup, on the other hand, is well represented at locations along the Mekong valley (see Oppenheimer this volume) as well as among the Senoi. As discussed above, the early inhabitants of Laos appear to have been a suitable biological precursor for Thailand's late Neolithic to Bronze/Iron Age populations. In combination with the Mekong route for early Austroasiatic dispersal (Sidwell & Blench, this volume), these points confirm the inference by Hill et al. (2006) of an association with the (late) Neolithic of Mainland Southeast Asia and the introduction of Austroasiatic to Malaya. However, in that case, the virtual absence of F1a1a from southern Thailand (Oppenheimer this volume) would contrast with its high frequencies amongst the Austroasiatic-speaking Temiar Senoi and the Nicobar Islanders immediately north of Sumatra (Prasad et al. 2001). This line of argument would contradict Bellwood's (1978, 1993) vision of south Thailand's 'Ban Kao culture' as the immediate source of early Austroasiatic speakers in Malaya, and instead imply that they had immigrated overseas across the Gulf of Siam (Oppenheimer, this volume; my Figure 5). Entry into Malaya may have been via the Isthmus of Kra, where tripods arrived at about the same time (see above), and which subsequently acted as a major node in a late prehistoric interaction sphere that extended across the South China Sea (Bellina-Pryce 2009).

Hill et al. (2006) also drew attention to three haplogroups, M7c1c, N22 and N21, with middle to late Holocene antiquity in Malaya, where they particularly characterise Aboriginal Malays (Table 7). The M7c1c and N22 haplogroups possibly arrived from southern Island Southeast Asia east of Sumatra. They are reasonably associated with early Austronesian maritime networks. The linguistic echo is Benjamin's (2002) detection of Malayic (proto-Malay) lexical items among southern Aboriginal Malay groups, while the archaeological marker is southern Malaya's red pottery and early watercraft (see below). The M7c1a haplogroup may also belong here given its trace presence amongst the Semelai (Hill et al. 2006) and geographically closest, external presence in Taiwan and Borneo (Hill et al. 2007).

Haplogroup N21, however, evidently has origins in Sumatra (Hill et al. 2007) although its absence from the Melayu (Table 7) points to a means of introduction separate from the Melayu immigration. The restriction of N21 to Palembang (within Sumatra), the old Srivijaya capital, suggests its introduction via influence that Srivijaya had exerted on

proto-historical Malaya. B5a may also have entered Malaya at this time from south-central Thailand where it is present at concentrated frequencies (Fucharoen et al. 2001). B5a is recorded as root types amongst the Batek and Temiar, and amongst the Melayu and in Sumatra both as root types and a derived lineage otherwise characteristic of Austroasiatic speakers in Indochina (Hill 2005). Northern Malaya was evidently influenced by the early Buddhist Dvaravati civilization of central Thailand, which is traditionally associated by scholars with Mon speakers (Indrawooth 2004). Influences include such aspects as Buddhist votive tablets recorded from the Isthmus of Kra to Gua Chawas, and the monumental architecture, Sanskrit inscriptions and replete Hindu-Buddhist imagery of the Bujang Valley/Sungei Mas state (Bulbeck 2004b). Dvaravati influence on northern Malaya (Benjamin 1987) would explain the introduction of B5a lineages to the Orang Asli, excluding Aboriginal Malays, as well as to the Melayu whose expansion took them well north of the present-day Malaysia-Thailand border.

The signature of haplogroups introduced by the Melayu Malays to the Peninsula would be a significantly more pronounced presence amongst the Melayu, both in the Peninsula and in their Sumatra homeland, than amongst the Orang Asli. The M* unclassified lineages (Hill et al. 2006) particularly fit the bill, but there are also numerous haplogroups recorded at low frequencies amongst the Peninsula and Sumatra Melayu, which do not appear to have been transmitted to the Orang Asli. These include the B4a*, B4b, B4c, E1, E2, F1a*, F1a3, M7b1, M45, M46, N*, R9* and Y2 haplogroups, all of which had dispersed across Island Southeast Asia at various times following the LGM (Hill et al. 2007 and references therein).

The present re-analysis of the mtDNA haplogroup data leads to the chronological schema summarised in Table 9. To assist interpretation, we may assume that a group's socio-political marginalisation and/or geographical isolation are marked by its apparent inability to recruit wives from an immigrant group (represented by novel haplogroups) even if the immigrants recruited wives from the marginalised group. As shown in Table 9, over half of the Semang female gene pool dates back to the Late Pleistocene, and virtually all of the remainder dates to around the first half of the Holocene. On that basis, the Semang would appear to have been marginalised from the late Neolithic onwards. The Senoi, to judge by the Temiar, would appear to be closely linked to the late Neolithic developments that led to the marginalisation of the Semang. Approximately half of the Temiar female gene pool can be ascribed to late Neolithic immigrants to Malaya, even if the other half has local roots dated to between the Late Pleistocene and early/mid-Holocene. The Temiar, in turn, appear to have become marginalised in early historical times (Table 9).

The Aboriginal Malays evidently represent a tradition of staying abreast with changing circumstances, as around 20% of their female gene pool dates to the Late Pleistocene, 30% to the early Holocene, 20% to late prehistoric times and 25% to the early historical period. However, they were marginalised with the establishment of the Melayu as Malaya's dominant population. The Melayu clearly mark a major expansion of an immigrant population, with 50% of their female gene pool attributable to their Sumatra-based migration, and 40% reflecting the recruitment of wives from the Orang Asli and Dvaravati-associated groups further north.

Table 7: mtDNA haplogroups recorded in Malaya, based on Hill et al. (2006, 2007). 'Dominant' means frequencies above 40%; 'strong' means frequencies between 11% and 40%; 'slight' means presences of 10% or less. Antiquity estimates are approximations; where Hill et al. (2006) provide the standard error (S.E.) for their estimate of a lineage's arrival in Malaya, antiquity is shown as one S.E. range.

Haplogroup	**Semang presence**	**Temiar Senoi presence**	**Aboriginal Malay presence**	**Melayu presence**	**Representation in Sumatra**	**Representation in central/ eastern Island Southeast Asia (crISEA)**	**Source**	**Antiquity in source**	**Antiquity in Malaya**
M21	All 3 (strong to dominant) + Ten'en	Slight	Slight	Slight	Virtually absent	Sporadic slight presence	Ancient Sunda	57 ka	57 ka
R21	All 3 (slight to dominant)	Strong	Absent	Slight	Absent	Absent	Ancient Sunda	60 ka	60 ka
M22	Absent	Absent	Temuan (strong)	Absent	Absent	Absent	Ancient Sunda	63 ka	63 ka (?)
R9b	Absent	Absent	Strong	Slight	Absent to slight	Absent	Indochina	19 ka	6–12 ka
N9a6	Jahai (strong)	Slight	Slight to strong	Slight	Absent to strong	Borneo, Java, Sulawesi (trace)	Indochina	Similar to above	3–8 ka
B5b	Batek (dominant), Menriq (slight)	Absent	Absent	Slight	Medan (strong)	Absent to slight	Sumatra	35 ka	Holocene
F1a1a	Absent	Dominant	Slight	Slight	Absent to strong	Slight (widespread)	Indochina	9 ka	≤7 ka
M7c1c	Absent	Absent	Semelai (strong)	Slight	Absent to strong	Slight to strong	crISEA	8 ka	Mid-Holocene
N22	Absent	Absent	Temuan (strong)	Absent	Absent	Sulawesi (slight)	crISEA	Unclear	Mid/late Holocene
N21	Absent	Absent	Strong	Slight	Slight (Palembang)	Sporadic slight presence	Sumatra	30 ka (ISEA)	Late Holocene
B4*	Absent	Absent	Semelai (slight)	Absent	Absent	Sporadic slight presence	Thailand? (see text)	Unassessed	Late Holocene
M*	Absent	Slight	Slight	Strong	Strong everywhere	Slight to strong	crISEA	Late Pleistocene	Late Holocene
B5a	Slight	Slight	Absent	Strong	Absent to strong	Absent to slight	crISEA	9 ka	Late Holocene
Various (see text)	Absent	Absent	Absent	Slight	Slight to strong	Absent to strong	crISEA	Variable	Late Holocene

Table 8: Comparisons between the early Neolithic of Malaya (this chapter) and North Vietnam (abstracted from Nguyen et al. 2004; Nguyen 2005; Bower et al. 2006)

Criterion	Malaya early Neolithic	North Vietnam early Neolithic comparison
Chronology	6000 BP (cf. age of N9a6, 5500 BP)	Dabutian (6500–4500 BP) a better fit than the Bacsonian (11,000–7000 BP)
Pottery	Cordmarked	Cordmarked in the Bacsonian; fibre-impressed and later cordmarked in the Dabutian
Polished/ ground stone tools	Incompletely polished (mainly ground edges)	Edge-ground axes in the Bacsonian and early Dabutian; more extensively polished in the late Dabutian
Site type	Rockshelters and large middens	Rockshelters (Bacsonian) and large middens (Dabutian)
Plant cultivation	Arboriculture	Possible simple plant cultivation (Bacsonian); gardens, including rice consumption by 5000 BP (Dabutian)
Burials	Secondary	Bacsonian (secondary, sprinkled with ochre) a better fit than the Dabutian (flexed)
Human osteology	Non-Mongoloid (Guar Kepah)	Dabutian a better match than Bacsonian (see text)

Table 9: Combined haplogroup frequencies excluding the unclassified B*, B4* (mislabelled B4a), M* and N* haplogroups (taken from Hill et al. 2006) amongst the Orang Asli and Melayu Malays

Time of establishment in Malaya	Semang			Senoi	Aboriginal Malays		Melayu Malays
	Batek	Jahai	Menriq	Temiar	Semelai	Temuan	
Late Pleistocene (M21, R21, M22)	0.52	0.82	0.94	0.45	0.13	0.27	0.07
Early Holocene (R9b, B5b, N9a6a)	0.45	0.18	0.06	0.06	0.30	0.33	0.05
Late prehistoric (F1a1a, M7c1c, N22, M7c1a)	0.00	0.00	0.00	0.43	0.22	0.12	0.14
Early historical (N21, B5a)	0.03	0.00	0.00	0.02	0.31	0.15	0.12
Melaka period (other haplogroups)	0.00	0.00	0.00	0.00	0.00	0.00	0.51

8 A synthesis of the evidence

Using Table 9 as a framework, we can now synthesise the biological and cultural evidence on Malaya's population history. Following the colonisation of Malaya by *Homo sapiens*, which the archaeological evidence would place before 74,000 years ago (see above) but which the mtDNA clock may place as late as 55,000 years ago (Macaulay et al. 2005; Hill et al. 2006; Soares et al. 2009), the region's inhabitants appear to have remained

in isolation, or at least unaffected by major population incursions, for tens of millennia. The descendants of these original *H. sapiens* colonists are well represented in the female gene pool of all Orang Asli groups, especially the Semang (Table 9). Archaeological remains dating to the LGM are yet to be certified, but this can be attributed to a coastal and lowland orientation of the inhabitants. The introduction of the R9b and B5b haplogroups to the Aboriginal Malays and Semang, respectively, can be related to lowland inhabitants' inland retreat as sea levels rose at the end of the Pleistocene. Early Holocene human remains, which include the flexed Moh Khiew 2, Gua Gunung Runtuh and Gua Teluk Kelawar burials, attest to full-sized people over ten percent taller than the average Orang Asli of ethnographic (British colonial) times.

There is considerable archaeological evidence for an early Neolithic phase in Malaya dated to c. 5000–6000 years ago, linked to the early Neolithic of North Vietnam. In southern Thailand, the early Neolithic is represented by pottery and polished stone tools at several mid-Holocene sites, as well as phytolith evidence for intensified arboriculture. Similarly, the Guar Kepah teeth reveal betel-nut chewing and, based on the high dental caries rate, evidence for high levels of carbohydrate consumption (Bulbeck 2005a). Extension of the early Neolithic to Malaya's remote hinterland is represented by early pottery, edge-ground cobble tools and haematite-coated burials at Gua Peraling. The N9a6 haplogroup, with its origins in Indochina, can be linked to the widespread early Neolithic given that it is recorded amongst all of the Semang, Senoi and Aboriginal Malays (Table 7). The flexed and secondary burials dated to c. 5000 years ago from numerous sites indicate a population of smaller body size than their early Holocene ancestors, probably reflecting biological adaptation to Malaya's equatorial humidity.

The Aslian homeland is parsimoniously located in the vicinity of central-western Pahang and southern Selangor (Figure 1) as this is the area of maximum diversity of the Aslian languages (Bulbeck 2004a:377). This homeland would also be consistent with an Austroasiatic association of the F1ala haplogroup, as it is present amongst the Semelai, Temuan and Jakun to the south as well as the Semai and Temiar to the north (Hill et al. 2006). Neolithic extended burials were interred at Lang Rongrien, Gua Harimau and Gua Cha (and, as argued above, presumably in association with Jenderam Hilir and Nyong), while pollen and palynological evidence is consistent with slash and burn agriculture having been established by 4000 years BP in both southern Thailand and Singapore. The Neolithic Gua Cha burials show clear evidence of arboriculture in the guise of betel-nut stained teeth, plus recourse to cooking in pots by those suffering from poor oral health, and a higher carbohydrate component—possibly honey and forest fruit—in their diet (Bulbeck 2005b). A mixed forager-farmer economy and semi-sedentary lifestyle, similar to that of the Ceq Wong (see Burenhult et al., this volume), would appear to have spread north and south from the Aslian homeland. Wives from resident foraging groups (with or without an arboriculture component) were evidently absorbed by these land-hungry colonists, but without reciprocal spouse exchange to the foragers who were losing access to optimal patches of land.

There is no reason to doubt the cultural and biological discreteness of the main Semang groups, whose traditional ranges extended in a chain from the Ten'en of southern Thailand, across the border to the Kensiw/Kintaq, Jahai, Menriq and Batek of northern and central Peninsular Malaysia (Figure 1). Biologically the Jahai, Menriq and Batek form a discrete group in their mtDNA haplogroup frequencies (Hill et al. 2006) and dental metrics (Bulbeck et al. 2005), and they are also homogeneous in their dental morphology (Rayner 2000) and craniometric affinities (Table 6). With respect to their culture, not only are these Northern Aslian groups linguistically related but also they traditionally foraged the

rainforest in nuclear family groups equipped with blowpipes, iron blades and digging sticks as their main tools. All of this evidence looks very much like a population expansion, the only conceivable objection being that foragers are not supposed to expand. Any other interpretation would posit the unparsimonious scenario of multiple switches to a Northern Aslian language along a chain of closely related people. A scenario of population expansion, on the other hand, would require only one such switch, by a rainforest forager group in contact with early Northern Aslian speakers somewhere between south Thailand and central Peninsular Malaysia, followed by expansion along a lowland rainforest corridor that may have been barely inhabited (almost all of Malaya's Hoabinhian sites lie west of the Semang groups discussed here), aided by acquisition of the blowpipe (Bulbeck 2003). The lack of haplogroups postdating 5000 years ago amongst the studied Semang groups could accordingly be explained by their geographic isolation as well as their socio-political marginalisation.

Having explained the ethnographic distribution of the Northern Aslian Semang, we can turn to the late Neolithic archaeological record to their west to investigate Central Aslian cultural evolution. The Central Aslian speakers due north of the Aslian homeland include the Lanoh and Semnam Negritos as well as Semai and Temiar Senoi. Unfortunately, osteological differences between the c. 4000 BP populations of Thailand and of Malaya, and between the Orang Asli divisions, are too subtle to conclusively assess any osteological sample (for example, Neolithic Gua Cha) as mainly Indochina-derived versus indigenous, or as more Semang- than Senoi-related. Nonetheless, the impression we obtain from the archaeological data is the co-existence of complementary traditions. Gua Harimau, with its minimal habitation evidence, would appear to have been a burial site used by a sedentary population in the vicinity (proto-Semai?). Gua Baik and Gua Kerbau, on the other hand, testify to continuous occupation by foragers (proto-Lanoh/Semnam?) who obtained pottery, iron and other manufactured goods through trade. Finally, Neolithic Gua Cha combines fine grave goods and possible evidence for local manufacture of polished stone adzes (Sieveking 1954) with a predominantly foraging and arboricultural economy (as noted above). This suggests a frontier colony, probably proto-Temiar (Benjamin 1987:118), where old and new traditions were seamlessly combined, especially given the site's status as a focus for the local population both before and during the Neolithic. Despite the material prosperity reflected in the Gua Harimau and Gua Cha grave goods, stature reduction evidently continued between the middle and late Holocene (Tables 4–5). Indeed, Malaya's late Neolithic inhabitants appear to have been shorter than their contemporaries at Ban Kao (Bulbeck 1996:46), Ban Chiang, Non Nok Tha, Ban Na Di, Ban Lum Khao, Khok Phanom Di and Nong Nor in Thailand (Higham 2002:165); the Malaya male average (159 cm) is the shortest recorded, while the female average (156 cm) sits comfortably within the Thailand range of averages (152–157 cm).

Dunn (1964) noted the presence of red-slipped pottery in the upper 14 inches at Gua Kecil, which he interpreted as reflecting late Neolithic or Early Metal Phase influence. Red pottery is also recorded in the early excavation reports from Kota Tongkat and Gua Sagu but not from any sites to their north (Matthews 1961). Red-slipped pottery is one of the markers of Austronesian linguistic expansion (Bellwood 1997; Bulbeck 2008), and so its occurrence in Peninsular Malaysia suggests an Austronesian association. As red-slipped pottery evidently appeared late in the Malaya sequence, and in the vicinity of Gua Kecil southwards (where Aboriginal Malays, both Southern Aslian and Malayic, are located), an association with the introduction of haplogroups M7c1c, N22 and M7c1a appears likely. While the prehistoric archaeology of southern Peninsular Malaysia is scanty, a new type of site—featuring boat remains recovered from waterlogged coastal deposits—dates as of c.

2000 years BP at the sites of Pontian, Kelang and Sungei Lang (Bulbeck 2003). Boat transport is vital in southern Malaya where the rivers are often navigable up to their headwaters and provide natural ports where they debouch (Gianno & Bayr 2009).

Iron Age remains that are probably linked to an Austronesian presence occur to the immediate west of Gua Kecil. The Perak/Selangor foothills include four main locations with stone slab graves which resemble the central Java slab graves with their extended burials and mortuary goods (Bellwood 1997:290). These slab graves cross Temuan and lowland Semai territory (Figure 1). The lowland Semai are the only Orang Asli group numbered amongst Malaya's peasantry (Benjamin 1985). The lowland Semai probably provided a labour pool and agricultural produce to the local elite, who had been attracted by these foothills' tin, gold and high-quality iron ore, and may have been Austronesian speakers (Bulbeck 2004b). Minerals exploited in the Perak foothills may have been exported through the entrepot of Kuala Selinsing to the immediate west (Leong Sau Heng 2000). Kuala Selinsing, which features canoe burials plus pottery decorations particularly similar to those from the 2000-year-old maritime trading site of Sembiran in Bali (Bulbeck 2006), adds to the picture of a maritime proto-historical influence from Island Southeast Asia on southern and coastal Malaya. However, Southern Perak seems to mark the northern limit of this early Austronesian influence, for the associated M7c1c, N22 and M7c1a haplogroups did not travel as far north as Temiar territory (Table 7).

Specific parallels between the proto-historical archaeology of Malaya and Sumatra are sparse. For instance, the megaliths of Iron Age Sumatra are far more diverse than Malaya's, and the slab graves in these two regions have very different architecture (see Hoop 1932). Nonetheless, interaction between these two landmasses which flank the Melaka Strait, so critical to Southeast Asia's maritime trade, is undoubted. Malaya's importance as a source for natural resources, which evidently included tin as well as forest products, is clear from its many early historical toponyms. Inscriptions in Old Malay located in Singapore and Nakhon Si Thammarat, respectively at the immediate south and north of Malaya, suggest that Srivijaya exerted an influence on the southern lowlands and eastern seaboard of Malaya (Bulbeck 2004b). Malaya's fragmentary Dong Son bronze drums, recovered from Kelang on the southwest coast, Terengganu on the east coast, and the upper reaches of the Tembeling River (which debouches on the east coast), may well reflect a shared maritime trade route with South Sumatra where further Dong Son drums, including their depiction in megalithic statues, have been found (see Bellwood 1997). An additional similarity involves the ceremonial bronzes with incised designs found at Kelang and Kampung Pecu in southern Malaya (shaped like bells) and the southern half of Sumatra (shaped like flasks). These observations can explain the presence of the N21 haplogroup, which evidently reflects a connection between Aboriginal Malays and Sumatra prior to the Melayu immigration to Malaya.

The Aboriginal Malays are diverse in terms of (1) their coastal versus hinterland orientation, (2) the manner in which their local economy balances swidden agriculture with the collection and trade of forest produce, (3) their strategies for dealing with local Melayu dominance, and (4) the distinction between Southern Aslian and Malayic speakers (Benjamin 2002; Gianno & Bayr 2009). Their Melayu-like physical appearance (Martin 1905; Cole 1945; Rambo 1988) is a main reason why Aboriginal Malays have been treated as a single ethnological bloc. The presumption of biological homogeneity is supported by the close resemblance between the Malayic-speaking Temuan and Aslian-speaking Semelai in their dentition (Rayner & Bulbeck 2001; Bulbeck et al. 2005) and mtDNA lineages (Hill et al. 2006). The ethnographically recorded short stature of Aboriginal

Malays (Appendix A) is true of the Malayic-speaking Temuan and Jakun as well as the Aslian-speaking Besisi (Martin 1905:233–234).

To judge by the historical land-use strategies of the Semelai (Gianno & Bayr 2009), the Aboriginal Malays would have experienced selection pressures favouring small stature owing to a traditional focus on nutrient-poor root crops and a proclivity to seek out primary rainforest when communities resettle or break off. In addition, the Semelai and many other Aboriginal Malays were targeted by the Melayu as sources of slaves as fervidly as were the Semang and Senoi 'Sakai' groups (Benjamin 2002; Hooker 2003; Gianno & Bayr 2009). Slave raiding in particular drove the Orang Asli into marginal and/or isolated terrain beyond the reach of the Melayu who increasingly commandeered Malaya's habitat most conducive to population growth (Bulbeck 2004b). The Melayu were the last pre-colonial episode in a late Holocene population history characterised by new arrivals who absorbed a significant part of their female gene pool from the previously established denizens, and no doubt contributed to the indigenous gene pool through various acts of fathering, but kept their women away from the populations which they had displaced.

9 Summary

Over 50% of the Semang gene pool, as represented by the mtDNA of three Northern Aslian groups, has Late Pleistocene roots that reach back to Malaya's colonisation by *Homo sapiens*. However, it would be a mistake to think of the Semang as the barely changed relics from those early days. The Pleistocene occupants inhabited a cooler drier environment, particularly during the LGM, and were oriented toward the lowlands on or near the coast. Also, all three studied Semang groups have mtDNA haplogroups whose time of introduction to Malaya is dated to around the early Holocene. At that time, based on the available human remains, Malaya's inhabitants differed from the Semang in being taller and having larger teeth, more robust crania, broader faces and more elongated braincases. As discussed elsewhere (Bulbeck 2003), rockshelter sites bear witness to habitation across Malaya by the early Holocene, in contrast to the evidence for a sporadically distributed Pleistocene population.

To explain how full-sized people could have dispersed across Malaya just as the rainforest expanded, and maintained a viable foraging strategy in an environment where selection pressures for reduced body size would have exerted their influence, a model was developed in which ungulates (well represented in the faunal refuse) were the target of intercept hunting along well-maintained forest trails (Bulbeck 2003). Keeping the forest at bay would have been assisted by the tree-felling functionality of Hoabinhian cobble tools, including sumatraliths which appeared during the early Holocene. However, the most dramatic changes to affect the immediate ancestors of the Semang occurred later, with the arrival of the blowpipe and iron, and the loss of prime terrain to more settled populations. While the Lanoh and Semnam appear to represent an adaptation involving complementary co-habitation with swidden farmers, the Northern Aslian Semang evidently staged a late Holocene population expansion along a sparsely inhabited corridor of lowland rainforest within central Malaya's interior.

The archaeological evidence suggests two Neolithic phases in Malaya, neither of them sourced to Ban Kao, which instead should be viewed as merely a sister branch of Malaya's late Neolithic. Malaya's early Neolithic, documented at Guar Kepah and particularly at various southern Thailand sites, is associated in this study with the Da But culture of North Vietnam. Genetic evidence for a mid-Holocene population incursion comes from the N9a6a haplogroup, present amongst the Jahai and Temiar as well as Aboriginal Malays.

The advent of arboriculture by the mid-Holocene, indicated by phytolith and osteological evidence, as well as cordmarked pottery and lightly polished cobble tools are all aspects of Malaya's early Neolithic.

A late Neolithic immigration from the Mekong delta region, associated with the introduction of extended burials, pedestalled pots, and by association the F1a1a haplogroup and proto-Aslian, then set the scene for trenchant differentiation between Orang Asli populations in competition for the same terrain. Evidence for slash-and-burn agriculture by 4000 years ago, which included rice within the repertoire of crops, comes from northern Malaya (phytolith evidence, and the Sakai Cave Neolithic rice grains), central Malaya (open-air settlements, and a proto-Aslian term for rice), and Singapore (increased charcoal deposition). The F1a1a haplogroup, which strongly characterises the Temiar Senoi, appears not to have been picked up by any Northern Aslian groups although it occurs among Aboriginal Malays. It is likely that early Aslian-speaking communities with a mixed economy dispersed widely across western and southern Malaya, more or less as proposed by Bellwood (1997), but their impact in the north and south was masked by proto-historical developments (Benjamin 1987). Accordingly the Temiar, whose ethnographic location sits virtually in the centre of Malaya, provide the clearest genetic signal we have for a late Neolithic Austroasiatic incursion. Nonetheless they can hardly be treated as a 'Neolithic fossil' as they subsequently evolved culturally, for instance, replacing pottery with bamboo containers (Benjamin 1987:118) and practising tree burials as well as extended inhumations (this chapter).

Following the Neolithic, Mainland Southeast Asia apparently had minimal genetic influence on the Orang Asli, apart from the Dvaravati-associated introduction of the B5a haplogroup. However, Dunn's (1964) documentation of red-slipped pottery late in the Gua Kecil sequence correlates with genetic evidence for the Iron Age incursion of haplogroups from Island Southeast Asia (east of Sumatra) affecting the Aboriginal Malays. Boat remains dating as of 2000 years BP in southern Malaya further point to a maritime Austronesian influence whose linguistic traces include the local Malayic dialects. Subsequent maritime connections between southern Malaya and southern Sumatra are indicated by loose archaeological parallels between these two regions, as well as by the Sumatra-derived N21 haplogroup found amongst Aboriginal Malays.

Overall, the female gene pool of Aboriginal Malays appears to reflect these populations' active participation in the growth of long-distance maritime trade, to which Malaya contributed metals (especially tin) and forest produce, during the first millennium CE. Maritime trade polities were also established in central and northern Malaya, but the female gene pools of the Semang and Senoi were barely affected by these developments. While these latter groups participated in the technological advances of the Common Era, as for instance in the wide-scale replacement of stone tools with iron implements, they were kept at a distance through socio-political marginalisation (combined in many cases with geographic isolation)—a fate that befell all Orang Asli with the expansion of the Melayu across Malaya after c. 1300 CE.

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Appendix A Detailed tables of limb bone length calculations and compilations, and stature estimates.

This study utilises maximum limb-bone lengths estimated from their segments, which is necessary to make use of the often-fragmentary nature of the limb bones from sites in Malaya (Table A1). Such length estimation can be performed for the femur, tibia and humerus following the methodology of Steele & McKern (1969), who calculated the regressions between the lengths of these bones and their segments amongst Mesoamericans. Although Steele (1970) performed a similar regression exercise for American Whites and Blacks, the Mesoamerican-based study is relied on here, for two reasons. Firstly, Steele (1970) combined two of the humerus segments recognised by Steele and McKern (1969), but these segments need to be recognised separately to apply the technique to certain fragmentary prehistoric humeri from Malaya. Secondly, as with all correlation coefficient regression exercises the method has the weakness of 'regression to the mean', which means that the resulting estimates will tend to approach the mean values of the population being regressed to. Since the limb bones used in these studies are on average longest for American Blacks, intermediate for American Whites and shortest for Mesoamericans (Steele & McKern 1969; Steele 1970), the resulting estimates also follow this order, sometimes to only a minor degree but sometimes with major discrepancies. We do not know the average lengths of the limb bones of prehistoric Malaya populations, but in using the segments to help estimate these lengths we should adopt the shortest resulting estimates. This is to ensure that we are not creating a spurious difference between the Orang Asli (short people, represented by complete limb bones) and their prehistoric forerunners (represented mainly by limb bone fragments) through our choice of methodology, but that as far as possible we use a methodology consistent with the 'null hypothesis' of no reduction in limb-bone length over time (see Tables A2 and A3).

Living stature of prehistoric Malayans can be estimated from limb-bone lengths and/or extended skeleton length (Tables A4 and A5). This study uses the Javanese regression formulae relating limb bone lengths (maximum lengths in the case of the humerus, ulna and fibula) to corpse length as Javanese are the population geographically closest to Malaya for whom such formulae are available (Bergman & The 1955). After people die, their corpse extends slightly, and so 2 cm is subtracted from corpse length to estimate living stature (Snell 1949). Skeleton length is slightly shorter than corpse length, owing to the loss of soft tissue, and so can be used as a direct estimate of living stature. Anthropometric data on Orang Asli living stature are taken from sources compiled during the British colonial era, rather than post-colonial surveys (for example Wagenseil 1967; Fix 2002) which would be affected by secular effects on growth associated with the various socio-political programs of the Malaysian state, such as the forced settlement of the more mobile of the Orang Asli.

Table A1: Maximum limb bone lengths estimated from segment lengths (mm), author's measurements

Specimen	Sex	Limb bone	Segment(s)	Length	Estimated limb-bone length
Gua Teluk Kelawar [1]	♀	Femur	2 & 3 (L)	242, 86	433.2 ± 5.1
Gua Teluk Kelawar [1]	♀	Humerus	1 & 2 (L)	31, 64	315.5 ± 8.3
Gua Peraling 4 [2]	♀	Humerus	2 & 3 (L)	59.6, 169	290.0 ± 4.7
Gua Kerbau Box No. 4 [3]	♂	Humerus	3, 4 & 5 (L)	192, 21, 18	339.3 ± 8.5
			3, 4 & 5 (R)	198, 25, 18	349.7 ± 8.5
			2 & 3 (L)	240, 74	428.3 ± 7.5
Gua Cha 1 [3]	♂	Femur	2 (R)	222	417.4 ± 13.1
			2, 3, 4 & 5 (R),	64, 156, 30, 19	306.7 ± 2.6
Gua Cha 1 [3]	♂	Humerus	3 & 4 (L)	164, 28	312.9 ± 9.2
Gua Cha H10 [3]	♂	Femur	3 (R)	89	448.5 ± 16.7
Gua Cha S6 [3]	♂	Humerus	3 & 4 (L)	198, 19	327.5 ± 9.2
Gua Cha S7 [3]	♂	Femur	4 (R)	39	456.3 ± 15.6
Gua Cha H5 [3]	♀	Femur	2 & 3 (L)	217, 94	416.2 ± 5.1
Gua Cha H12 [3]	♂	Humerus	2, 3, 4 & 5 (R)	70, 168, 19, 14	303.9 ± 2.6
Gua Cha H8 [3]	♀	Tibia	2 & 3 (L)	53, 131	308.0 ± 6.4
Gua Cha H8 [3]	♀	Humerus	3 (L), 4 & 5 (R)	176, 18, 15	296.0 ± 6.9
Gua Cha H9 [3]	♂	Humerus	4 (R)	15	301.0 ± 12.3
Guar Kepah B289 [4]	♀	Femur	1 (R), 2 (L)	74, 221	422.4 ± 5.1
Guar Kepah B296 [4]	♂	Humerus	4 (L)	28	324.4 ± 12.3
Guar Kepah B321 [4]	♂	Humerus	4 (R)	29	326.2 ± 12.3
Guar Kepah C82 [4]	♂	Humerus	4 & 5 (R)	27, 18	330.1 ± 11.6
Gua Cha H11 [3]	♂	Tibia	1, 2 & 3 (L)	32, 50, 136	327.5 ± 8.3
Gua Cha A3 [3]	♀	Humerus	3 & 4 (L)	146, 25	288.0 ± 9.2
Gua Harimau 1 [3]	♂	Femur	2 & 3 (L)	236, 103	455.4 ± 7.5
Gua Harimau 1 [3]	♂	Humerus	3 (R)	166	306.0 ± 9.8
Kuala Selinsing 7 [3]	♂	Tibia	3 (R)	165	366.3 ± 13.8
Kuala Selinsing 8 [3]	♂	Femur	2, 3 & 4 (R)	254, 90, 40.5	451.9 ± 5.8

(1) Bulbeck & Zuraina 2007; (2) Bulbeck & Adi 2005; (3) Author's measurements (see also Acknowledgments). (4) Bulbeck 2005a, modified here by combining Guar Kepah B289 left and right measurements to estimate femur length.

Table A2: Male limb bone lengths and estimates (mm), maximum length except where otherwise specified

Period	Specimen	Femur	Tibia	Fibula	Humerus	Radius	Ulna
Early Holocene	Gua Gunung Runtuh [1]	449, 454	395		323, 325	277	285
Middle Holocene	Gua Kerbau Box No. 4 [2]	474, 480			339, 350		≥260
Middle Holocene	Gua Bintong 1 [3]	470 est.					
Middle Holocene	Gua Cha 1 [4]	417, 428	355 est.	345 est.	307, 313	248	266.5
Middle Holocene	Gua Cha H10 [2]	448.5					
Middle Holocene	Gua Cha S6 [2]	448 est.			327.5		
Middle Holocene	Gua Cha S7 [2]	456				254	
Middle Holocene	Gua Cha H9 [2]			318	301	262 est.	
Middle Holocene	Gua Cha H12 [2]				304		
Middle Holocene	Guar Kepah B296 [5]				324		
Middle Holocene	Guar Kepah B321 [5]				326		
Middle Holocene	Guar Kepah C82 [5]				330		
Late Neolithic	Gua Cha H11 [2]	413.5	327.5, 342	310 est.			
Late Neolithic	Gua Cha H4 [2]		385 est.				275
Late Neolithic	Gua Cha B2 [2]					243 est.	
Late Neolithic	Gua Cha H1 [2]				335		
Late Neolithic	Gua Harimau 1 [2]	455			306		
Iron Age	Gua Baik 94 [6]					217	238
Iron Age	Kuala Selinsing 2 [7]	423, 426	357, 358			238	
Iron Age	Kuala Selinsing 7 [2]		366		317, 317.5		
Iron Age	Kuala Selinsing 8 [2]	452			315		
Orang Asli	Semang (n = 1–3) [8]	424.0 (411.5–432)	362.8 (345–374.5)	363.5	303.3 (302–305.5)	236.0 (231–240)	250.8 (249.5–252)
Orang Asli	Senoi (n = 1–2) [9]	378.5 (368, 389)	311 (299, 323)	305.5 (299, 312)	263.5 (249.5, 277.5)	209.8 (202, 217.5)	228 (222, 234)

(1) Matsumura & Zuraina 1999, excludes lengths of atrophied left forearm bones. (2) Author's measurements (see also Table A1). Note that the total right tibia length of Gua Cha H11 is 334 mm. (3) Duckworth 1934. (4) Bulbeck 2005b, amended where appropriate to apply Mesoamerican regression formulae (see Table A1). (5) Bulbeck 2005a (see also Table A1). (6) Snell 1949. (7) Harrower 1933; tibia lengths are total lengths. (8) Author's measurements for the Pangan Semang (Duckworth Laboratory) combined with the measurements from Schebesta & Lebzelter (1926); averages of left and right limb bones shown. (9) Martin (1905); averages of left and right limb bones shown.

Table A3: Female limb bone lengths and estimates (mm), maximum length except where otherwise specified

Period	Specimen	Femur	Tibia	Fibula	Humerus	Radius	Ulna
Early Holocene	Moh Khiew 2 (1)					247	271
Early Holocene	Gua Teluk Kelawar (2)	433	340 est.		316		
Middle Holocene	Moh Khiew 1 (1)				308		
Middle Holocene	Gua Peraling 4 (3)				290		
Middle Holocene	Gua Cha H5 (4)	416					
Middle Holocene	Gua Cha H8 (4)		308		296	222	
Middle Holocene	Gua Cha H6 (4)			313			262
Middle Holocene	Gua Cha H7 (4)						262 est.
Middle Holocene	Guar Kepah B289 (5)	422					
Late Neolithic	Gua Cha B8 (6)	384	325, 329	320, 322	265, 268		232
Late Neolithic	Gua Cha A3 (4)				288		
Iron Age	Kuala Selinsing 1 (7)	394, 400			278	227	
Orang Asli	Semang (n = 1–4) (8)	386.6 (373.5–395)	322.3 (313–334)	318.3 (309–330)	267.4 (265–269)	214.2 (211–219.5)	243.5
Orang Asli	Senoi (n = 1–2) (8)	388.3 (383, 393.5)	309.8 (300, 319.5)	306.3 (302, 310.5)	269.8 (269, 270.5)	205.8 (197.5, 214)	221.8 (211.5, 232)
Orang Asli	Aboriginal Malay (8)	338			228	185	

(1) Bulbeck 2003. (2) Bulbeck & Zuraina 2007 (see also Table A1). (3) Bulbeck & Adi 2005 (see also Table A1). (4) Author's measurements (see also Table A1). (5) Bulbeck 2005a (see also Table A1). (6) Trevor & Brothwell 1962; tibia lengths are total lengths; the published left ulna length of 265 mm is excluded as it replicates the left humerus length and is clearly in error. (7) Harrower 1933, re-sexed as female based on the author's study of the skull; humerus length is total length. (8) Martin (1905), averages of left and right limb bones; the Jakun Aboriginal Malay humerus length is total length.

Table A4: Estimates of male living stature in cm

Period	Specimen	Stature	Method
Early Holocene	Gua Gunung Runtuh [1]	169	Regression formulae (skeleton length affected by lordosis)
Mid-Holocene	Gua Kerbau Box No. 4 [2]	172	Regression formulae (average of 171 cm femur and 173 cm humerus estimates)
Mid-Holocene	Gua Bintong 1 [3]	169	Regression formula (using Duckworth's 465 mm minimum femur length estimate)
Mid-Holocene	Gua Cha S6 [4]	168	Regression formula (humerus length)
Mid-Holocene	Gua Cha 1 [4]	166	Regression formulae (average of 164 cm humerus and 168 cm femur estimates)
Mid-Holocene	Gua Cha S7 [4]	166	Regression formula (allowing 448 mm for femur physiological length)
Mid-Holocene	Gua Cha H10 [4]	164	Regression formula (allowing 440 mm for femur physiological length)
Mid-Holocene	Gua Cha H12 [4]	162	Regression formula (humerus length)
Mid-Holocene	Gua Cha H9 [4]	158	Regression formulae (average of 154.4 cm femur and 161 cm humerus estimates)
Mid-Holocene	Guar Kepah C82 [4]	169	Regression formula (humerus length)
Mid-Holocene	Guar Kepah B321 [4]	167	Regression formula (humerus length
Mid-Holocene	Guar Kepah B296 [4]	167	Regression formula (humerus length
Late Neolithic	Gua Cha H1 [4]	171	Regression formula (humerus length)
Late Neolithic	Gua Cha H4 [5]	165	Skeleton length (169 mm would be estimated based on ulna length)
Late Neolithic	Gua Cha B9 [5]	164	Skeleton length
Late Neolithic	Gua Cha H13 [5]	158	Skeleton length
Late Neolithic	Gua Cha B2 [5]	157	Skeleton length
Late Neolithic	Gua Cha B7 [5]	155	Skeleton length
Late Neolithic	Gua Cha H11 [4]	155	Regression formulae (average of 157 cm tibia and 153 cm fibula estimates)
Late Neolithic	Gua Cha B1 [5]	152	Skeleton length
Late Neolithic	Gua Harimau 1 [6]	160	Skeleton length (162 cm would be the estimate based on humerus length)
Late Neolithic	Gua Harimau 9 [7]	155	Skeleton length
Iron Age	Kuala Selinsing 7 [4]	165	Regression formulae (humerus lengths)
Iron Age	Kuala Selinsing 8 [4]	165	Regression formula (humerus length)
Iron Age	Kuala Selinsing 2 [4]	162	Regression formulae (tibia lengths)
Iron Age	Gua Baik 94 [4]	155	Regression formula (ulna length)
Orang Asli	Semang [8]	154	Anthropometry (range 142–164 cm)
Orang Asli	Senoi [9]	153	Anthropometry (range 138–166 cm)
Orang Asli	Aboriginal Malays [9]	154	Anthropometry (range 139–164 cm)

(1) Matsumura & Zuraina 1999, who provide femur and radius physiological lengths and tibia total length, as used by Bergman & The (1955), as well as the maximum lengths shown in Table A2. The estimate employed is the median estimate from the different limb bones (which range from 166 cm using the femur to 175 cm using the radius). (2) Based on author's measurements, including right femoral physiological length. (3) See Duckworth 1934:165. (4) Based on measurements in Table A2. (5) Sieveking 1954. (6) Chia & Zolkurnian (2005). (7) Measured from Chia & Zolkurnian 2005:Fig. 18.5. (8) Bulbeck 1996. (9) Martin 1905:232–234.

Table A5: Estimates of female living stature in cm

Period	Specimen	Stature	Method
Early Holocene	Moh Khiew 2 (1)	167	Regression formula (ulna measurement)
Early Holocene	Gua Teluk Kelawar (2)	160	Regression formulae
Mid-Holocene	Moh Khiew 1 (1)	165	Regression formula (humerus measurement)
Mid-Holocene	Gua Peraling 4 (1)	157	Regression formula
Mid-Holocene	Gua Cha H7 (1)	163	Regression formula
Mid-Holocene	Gua Cha H8 (1)	157	Regression formula (humerus measurement)
Mid-Holocene	Gua Cha H5 (1)	156	Regression formula (allowing 408 mm for femur physiological length)
Mid-Holocene	Gua Cha H6 (1)	156	Regression formulae (average of 163 cm ulna and 149 cm fibula estimates)
Mid-Holocene	Gua Kajang (3)	155	General comparison
Mid-Holocene	Guar Kepah B289 (4)	153	Regression formulae
Neolithic	Gua Cha A3 (1)	156.5	Regression formula
Neolithic	Gua Cha B8 (5)	155	Skeleton length (150 cm would be estimate based on limb bone lengths)
Iron Age	Kuala Selinsing 1 (6)	156	Regression formula
Orang Asli	Semang (7)	143	Anthropometry (range 135–152 cm)
Orang Asli	Senoi (8)	143	Anthropometry (range 132–156 cm)
Orang Asli	Aboriginal Malays (8)	143	Anthropometry (range 131–155 cm)

(1) Based on measurement in Table A3. (2) Bulbeck & Zuraina 2007 (see also Table A3). (3) Duckworth 1934:154. (4) Bulbeck 2005a. (5) Sieveking 1954. (6) Harrower 1933:203–204. (7) Bulbeck 1996. (8) Martin 1905:232–234.

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