PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

Recent Human Evolution in East Asia and Australasia

Peter Brown

Phil. Trans. R. Soc. Lond. B 1992 **337**, 235-242
doi: 10.1098/rstb.1992.0101

Recent human evolution in East Asia and Australasia

PETER BROWN

Department of Archaeology, University of New England, Armidale, New South Wales, Australia

SUMMARY

In both East Asia and Australasia arguments for evolutionary continuity between middle-late Pleistocene hominid populations and modern *Homo sapiens* are of long standing. In both regions, however, problems of chronological distribution, dating and preservation of hominid skeletal materials provide an effective barrier to extending regional sequences back to 'archaic' *Homo sapiens* or *Homo erectus*. The earliest securely dated modern *Homo sapiens* in East Asia are currently represented by Zhoukoudian Upper Cave at a minimum of 29 ka BP. In Australia skeletal remains of modern *Homo sapiens* have been dated to 26 ka BP, with archaeological materials at 38 to 50 ka BP. Late Pleistocene human skeletons from sites like Coobool Creek are morphologically and metrically outside the range of recent Australian Aboriginal populations. Similarly Liujiang and the Upper Cave crania can be distinguished from recent East Asian 'Mongoloids'. Evolutionary change within the Holocene needs to be taken into consideration when the evidence for regional evolutionary continuity is considered.

1. INTRODUCTION

Over the past 30 years the recent, late Pleistocene to mid-Holocene evolution of our species has been documented in increasing detail. In Australasia and East Asia osteological and dental research has focused on three separate, although interrelated, aspects of human evolution. These are the diversity of modern *Homo sapiens* populations (Pietrusewsky 1984; Wang 1986; Brown 1987; Li *et al.* 1991), the evolutionary relationships between these *H. sapiens* and earlier hominids from within, and outside, Asia (Weidenreich 1939*a*; Thorne & Wolpoff 1981; Wolpoff *et al.* 1984; Kaminga & Wright 1988; Wu 1988*a*, *b*) and change in skeletal and dental form during the Holocene (Zhang *et al.* 1982; Brace *et al.* 1984; Wu & Zhang 1985; Wang 1986; Brown 1987, 1989). Although the documentation of modern human variation is a continuing process, and there is general agreement as to the direction of post-Pleistocene evolution in both China and Australia, the origins and diversity of the first modern human populations is a topic of continued debate.

Evolutionary continuity between Pleistocene and recent human populations within China was first argued in detail by Weidenreich (1939*b*, 1943) and later developed, although with varying emphasis, by Coon (1962) and Wolpoff *et al.* (1984). Weidenreich's argument for evolutionary continuity rested on the identification of 'Mongoloid' skeletal characteristics in the Zhoukoudian *Homo erectus* remains and in modern northern Chinese. A persistent obstacle to expanding Weidenreich's 'Mongoloid' lineage has been the distribution, dating and preservation of the east Asian hominid skeletal remains. Although *H. erectus* and early *H. sapiens* (Dali, Maba, Jinniushan and Xujiayao) are reasonably well represented there are still substantial gaps in the Chinese hominid sequence (Chen & Zhang 1991). In particular the earliest examples of modern *H. sapiens* in China, Zhoukoudian Upper Cave, may only date to 10–13 ka BP (Wu & Zhang 1985; Hedges *et al.* 1988; Chen *et al.* 1989). There is also some debate over the 'Mongoloid' affinities of the crania from this locality (Weidenreich 1939*a*; Wolpoff *et al.* 1984; Wu & Zhang 1985; Kaminga & Wright 1988) which could undermine the east Asian regional evolutionary model.

For reasons of geographic proximity, rather than unequivocal archaeological or skeletal evidence, most researchers have focused on a possible Asian origin for the Australian Aborigines (Weidenreich 1945; Macintosh 1963; Birdsell 1967; Thorne 1977). The first person to have raised the possibility of a specific regional connection between fossil hominid skeletal material from Asia, Javan *Pithecanthropus*, and Australian Aborigines was Hermann Klaatsch (1908). This regional evolutionary sequence linking Indonesia and Australia was then further developed by Weidenreich (1946), Coon (1962) and Thorne & Wolpoff (1981). The argument for an Australasian evolutionary sequence also depends upon the identification of morphological and metrical osteological traits, which in combination, occur in the highest frequency in *Homo erectus* crania from Indonesia and terminal Pleistocene and recent Australians. Problems of temporal clustering of sites, inadequate chronological control, and poor preservation which occur in East Asia are also a feature of the Australasian sequence. The major differences between these two regions are that terminal Pleistocene *H. sapiens* are relatively common in Australasia (Thorne & Macumber 1972; Bowler *et al.* 1972; Bowler & Thorne 1976; Brown 1989), while if the Ngandong crania are considered to be *H. erectus* (Santa Luca 1980) then early *H. sapiens* comparable to Dali (Wu 1981) are not represented.

In both East Asia and Australasia the strength of

Phil. Trans. R. Soc. Lond. B (1992) **337,** 235–242
Printed in Great Britain

the evolutionary continuity model rests on the interpretation of several key skeletons. In China, while the 'Mongoloid' morphology of the mid-Holocene skeletal materials from Huaxian, Baoji, Hemudu and Banpo is clear (Wu & Zhang 1985; Wang 1986), the same cannot be said for the single reliably dated terminal Pleistocene locality, Zhoukoudian Upper Cave. Weidenreich (1939*a*), although committed to a regional evolutionary sequence, did no think that the Upper Cave skeletons were morphologically Chinese. This raises the possibility that 'Mongoloid' osteological traits, as represented in modern East Asians, were a Holocene development or that morphologically 'Mongoloid' people only moved into northern China during the Holocene. Recently a uranium-series date of 67 ka has been reported for the Liujiang skeleton from Guangxi in southeastern China (Wu 1988*a*, 1990). If the dated material and skeleton from Liujiang are contemporary then this provides the earliest evidence of modern *H. sapiens* in East Asia. Such an early date for a skeleton with 'Mongoloid' skeletal characteristics would also strengthen arguments for evolutionary continuity within southern China.

In Australasia it is the terminal Pleistocene collections from the southeastern Australian sites of Coobool Creek and Nacurrie (Brown 1989, 1992*a*), Kow Swamp (Thorne & Macumber 1972; Thorne 1976), Willandra Lakes (Bowler *et al.* 1972; Bowler & Thorne 1976; Thorne 1984; Wolpoff 1991) and Keilor (Wunderly 1943; Brown 1987) which are crucial to the regional continuity argument. It is these sites in combination which are important, as there has been continued debate over the significance of morphological and metrical variation in terminal Pleistocene Australia (Thorne 1977; Habgood 1986; Brown 1987; Webb 1989; Pardoe 1991). Most recently the literature has contained references to an as yet undated and undescribed cranial vault, WLH-50 (Flood 1983; Thorne 1984), which has been directly connected with the Indonesian Ngandong crania (Stringer & Andrews 1988; Wolpoff 1991).

2. REGIONAL CHRONOLOGY OF MODERN *H. SAPIENS*

(*a*) *Australasia*

The earliest, widely accepted, evidence for human occupation in Australia is a radiocarbon date of 39 500 ± 2300–1800 BP (SUA-1500) for charcoal associated with stone artifacts from the Upper Swan in Western Australia (Pearce & Barbetti 1981). More recently Roberts *et al.* (1990*a*) have argued on the basis of themoluminescence dates from the Malakunanja II rockshelter that human occupation in Australia may predate 50 ka. However, Hiscock (1990) has expressed concern over the extent of the discrepancy between the radiocarbon and TL dates, and stratigraphic association of the artifacts. Roberts *et al.* (1990*b*) have defended their original assessment of the age of Malakunanja II.

Although there are an increasing number of archaeological sites which are older than 30 ka BP, few radiometrically dated late Pleistocene human skeletal remains have been recovered from Australia. The oldest positively dated human skeleton is the Lake Mungo 1 cremation dated to 24 700 ± 1270 BP (ANU-618A) (Bowler *et al.* 1970; Bowler *et al.* 1972). Bowler & Thorne (1976) have argued, on the basis of geomorphological criteria and stratigraphic association with Lake Mungo 1, that the extended burial Lake Mungo 3 may be in the order of 28–32 ka BP in age. Morphological comparisons have suggested to some people (Flood 1983; Thorne 1984; Wolpoff 1991) that at least one of the undated Willandra Lakes specimens, WLH-50, is considerably older than Lake Mungo 1. Kow Swamp (Thorne & Macumber 1972; Thorne 1976) is bracketed by radiocarbon dates on shell from the grave of KS5 of 13 000 ± 280 BP (ANU-1236) and on bone apatite from KS9 to 9590 ± 130 BP (ANU-532) (Thorne 1975). Morphologically and metrically similar skeletons to those from Kow Swamp were collected from the nearby sites of Coobool Creek and Nacurrie (Brown 1989, 1992*a*). Unfortunately the skeletons from both of these locations are without archaeological provenance and have proved difficult to date due to contamination from a gelatin based preservative. A ^{234}U/^{230}Th date of 14 300 ± 1000 (LLO-416) has been obtained for bone from Coobool Creek 65 (Brown 1989) and uncontaminated bone from Nacurrie 1 has recently been AMS dated to 11 440 ± 160 BP (NZA-1069) (Brown 1992*a*). The Keilor skeleton (Brown 1987) is dated to 12 000 ± 100 BP (NZ-1327).

Skeletal materials from southeast Asia with some claim to being examples of early modern *H. sapiens* are the deep skull from Niah Cave in Borneo (Brothwell 1960; Kennedy 1977), Wadjak I and II from Java (Dubois 1922) and Tabon from the Philipines (Fox 1970). The Niah cave juvenile cranium, which is poorly preserved, has been radiocarbon dated on the basis of charcoal associated with the cranium at 39 820 ± 1012 BP (GrN-1339) (Oakley *et al.* 1975). Wolpoff (1980) is sceptical of the contemporaneity of the dated material and human skull, but an earlier review of the excavation reports by Kennedy (1977) supports the original date. The Wadjak cave crania, although undated, have on the basis of perceived morphological similarities with prehistoric Australian Aboriginal crania been considered to be of late Pleistocene age (Dubois 1922; Weidenreich 1945). This is not upheld by an analysis of the associated fauna which contains few extinct species and is considered to be broadly recent in age (Theunissen *et al.* 1990). The Tabon frontal and mandible are poorly preserved (Macintosh 1978), but are radiocarbon dated by association to 23 ka BP (Fox 1970).

(*b*) *East Asia*

Two recent articles (Wu & Wang 1985; Chen & Zhang 1991) have presented detailed reviews of the dating and distribution of the major Middle and late Pleistocene hominid localities in China. Although a consensus is being reached on the age of *H. erectus* and early *H. sapiens* in east Asia, the first appearance of modern *H. sapiens* continues to be problematic. Fossilized remains of modern *H. sapiens* have been recovered from relatively few late Pleistocene contexts in China (Wu & Zhang 1985). Specimens which combine a reasonable state of preservation, with information on provenance, and claims of a Pleistocene antiquity are Liujiang (Wu 1959) and Zhoukoudian Upper Cave 101, 102 and 103 (Weidenreich 1939; Wu 1960, 1961; Kaminga & Wright 1988). The Liujiang skeleton, consisting of a cranium and limited postcranial material was discovered in a cave at Tongtianyan, Guangxi, in 1958 by people collecting fertilizer. Liujiang was initially described by Wu (1959) with Wu & Zhang (1985) providing additional comparative anatomical information. The *Ailuropoda–Stegodon* fauna found in association with Liujiang were interpreted as being of Middle Pleistocene age but the contemporaneity of the fauna and the human skeletal materials has not been established. Wu (1959) did not support a Middle Pleistocene age for the human skeletal materials arguing that the morphology of the cranium suggested a more recent date. Recently a Uranium series date of $67\,000^{+6000}_{-5000}$ has been reported for Liujiang (Wu 1988*a*; Wu 1990). However, the stratigraphic relationship of the dated stalactite layer and the human skeletal materials can not be confirmed (Chen & Zhang 1991).

A stronger claim for terminal Pleistocene antiquity can be established for the Upper Cave at Zhoukoudian. The Zhoukoudian Upper Cave skeletons were excavated in 1933 and 1934, with the archaeological assemblage discussed by Pei (1935, 1939) and the human skeletal materials briefly described by Weidenreich (1939). The fauna recovered from the lower chamber of the cave suggested to Pei that the deposits were of late Pleistocene age and this was subsequently confirmed by a series of radiocarbon dates (Wu & Zhang 1985). Conventional ^{14}C dates on non-human bone provided dates of 10 175 ± 360 BP (ZK-136-0-4) for the upper part of the cave and 18 340 ± 410 BP (ZK-136-0-2) for the basal layers. Wu & Wang (1985) argue that the older date is for a layer well below the human occupation and the archaeological deposits are closer to 10 ka. More recent AMS dates, again on non-human bone, range in age from 13 200 ± 160 BP (OXA-891) to 33 200 ± 2000 BP (OXA-190) (Hedges *et al.* 1988, 1992; Chen *et al.* 1989), with a suggested age of 29–24 ka BP for the cultural layers. Unfortunately, the published accounts of the excavation contain insufficient information to be certain of the stratigraphic relationships between the human burials and the dated faunal material. It is unclear whether the burials are contemporaneous with the deposition of layer 4 or had been interred from a higher layer. In contrast to the uncertainties surrounding Chinese terminal Pleistocene skeletons, collections of mid-Holocene skeletal material are extensive. Wu & Zhang (1985) provide a list of the major Neolithic sites which range in age from 7000 to 3000 years BP and a discussion of geographic variation and diachronic change in skeletal morphology.

3. RECENT HUMAN EVOLUTION

(*a*) *Australasia*

Morphological and metrical comparison of terminal Pleistocene, mid-Holocene and recent Australian Aboriginal crania and dentitions have highlighted the

Table 1. *Comparison of orofacial and cranial dimensions in the terminal Pleistocene Australian Aboriginal male sample with those in the two Holocene male Aboriginal groups using Student's t-test (mm)*

	terminal-Pleist.[a]			mid-Holocene[b]			late-Holocene[c]		
	n	$\bar{x}$	s.d.	*n*	$\bar{x}$	s.d.	*n*	$\bar{x}$	s.d.
cranial length[d]	23	195.8	7.57	11	191.7[e]	7.10	29	190.3[e]	5.60
cranial height[d]	18	140.7	5.07	7	136.1[e]	3.76	28	129.8[e]	4.93
endocranial volume / ml	19	1404.9	96.96	—	—	—	23	1271.5[e]	92.95
supraorbital breadth	31	117.2	4.98	9	107.8[e]	2.48	29	110.2[e]	2.94
thickness at bregma[d]	21	10.7	2.32	4	10.7	1.70	24	7.8[e]	1.09
frontal angle / deg.[d]	17	140.3	3.75	7	136.4[e]	3.89	26	137.1[e]	3.42
occipital angle / deg.[d]	14	118.6	3.63	3	115.3	9.61	24	117.6	5.05
bi-zygion	9	144.1	4.85	9	136.3[e]	5.26	24	136.5[e]	2.93
nasion-nasospinale	22	54.5	3.18	10	50.8[e]	2.65	29	51.7[e]	2.56
nasospinale-prosthion	23	20.8	3.40	10	18.8	3.36	28	16.5[e]	2.42
nasal breadth	26	29.3	1.82	11	27.9[e]	2.25	25	26.4[e]	1.35
orbital height	26	31.2	2.49	10	33.3[f]	2.86	29	34.1[f]	2.33
orbital breadth	26	43.4	3.46	9	44.4	2.65	25	43.9	1.18
alveolar length	22	64.9	2.42	10	61.8[e]	4.31	29	61.5[e]	3.15
symphyseal height	25	39.2	2.94	8	34.2[e]	4.16	15	32.3[e]	2.87

[a] Coobool Creek, Nacurrie, Keilor, Cohuna, Lake Mungo and Kow Swamp.
[b] Barham, Roonka and Keera Station.
[c] Swanport.
[d] Crania which previous research indicates are artificially deformed are excluded from sample.
[e] Mean value significantly less than terminal Pleistocene mean, $p < 0.05$.
[f] Mean value which is significantly greater than terminal Pleistocene mean, $p < 0.05$.

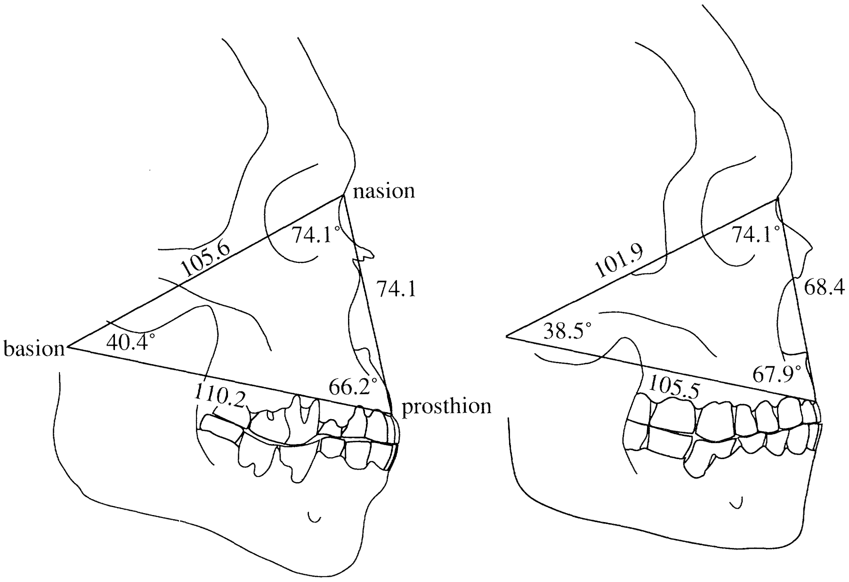

Figure 1. Comparison of mean facial dimensions (mm) in male terminal Pleistocene (left) and late Holocene Australian Aboriginal crania (right).

distinctiveness of the Pleistocene materials from Kow Swamp, Coobool Creek and Nacurrie (Thorne & Macumber 1972; Pietrusewsky 1979; Brown 1987, 1989). At a general level terminal Pleistocene crania can be distinguished by greater overall size, with significantly larger endocranial volumes than recent crania from the same region (table 1). This size distinction also extends to the orofacial skeleton, post cranial skeleton, and to a lesser degree, tooth dimensions (Brown 1992*b*). More detailed consideration of morphological differences between terminal Pleistocene and recent crania is complicated by the presence of artificially deformed crania at Coobool Creek, Kow Swamp and Nacurrie (Brothwell 1975; Brown 1981, 1989). Fortunately most of the crania from these locations have not been deformed and the deformation process does not appear to have significantly influenced facial dimensions (Brown 1989). The terminal Pleistocene cranial vaults can be distinguished by their greater length, height and breadth dimensions, thicker vault bone, more receding frontal squama and greater supraorbital breadth (table 1).

Morphological features associated with general robusticity, including the median sagittal ridge, supramastoid and mastoid crests, occipital torus and supraorbital region are generally more prominent. Although true supraorbital tori are present in low numbers (Brown 1989), the supraorbital trigones reduce laterally and are distinct from those in Ngandong. Terminal Pleistocene Australian facial skeletons are dominated by the functional requirements of a large dentition (Brown 1992*b*). Mean orofacial dimensions in terminal Pleistocene males are significantly greater than those in the Holocene (table 1 and figure 1), with the only exceptions being for the height and breadth of the orbit. Facial prognathism, particularly subnasally, is greater with increased facial height and palate length dimensions influencing the angles of the facial triangle (figure 1). By the middle of the Holocene a reduction in tooth size, and associated alveolar support, results in a significantly shorter and less prognathic face.

Although the terminal Pleistocene average is for larger overall size and morphological robustness, there is considerable variation, both metrically and morphologically, in the undeformed male and female crania. Areas of the cranium which are particularly variable include the angle and curvature of the frontal bone, development of median ridge and prebregmatic eminence, facial prognathism, supraorbital morphology which ranges in males from a true torus to minimal development of the lateral trigone and superciliary components, the angle and curvature of the occipital bone, morphology of the occipital torus and lambdoidal region and cranial vault thickness (Brown 1987, 1989). This variation has implications for the regional evolutionary continuity model as it effects many of the clade features cited by Thorne and Wolpoff (1981).

Groves (1989) and Bräuer (1989) have emphasized that many of Thorne & Wolpoff's (1981) traits occur singly, and in combination, in hominids outside the Australasian region, with the parietal breadth, frontal flatness, prebregmatic eminence and prognathism characters best considered as primitive retentions. Several of the traits are sexually dimorphic in Australian Aboriginal crania (frontal flatness, prognathism, tooth size, prebregmatic eminence, location of minimum frontal breadth, location of parietal breadth and malar eversion) and some have undergone significant change in the early Holocene (prognathism, tooth size, frontal flatness, frontal and parietal breadths). Pronounced prognathism and large posterior tooth size, which are functionally related, appears to be a particularly poor regional characteristic as people in most parts of the world had large teeth and relatively prognathic faces during the late Pleistocene (Brace & Mahler 1971; Carlson 1976; Frayer 1977, 1984; Smith

1982; Calcagno 1986; Smith *et al.* 1986; Brown 1987, 1992*b*).

Most surprisingly, Thorne & Wolpoff (1980) seem to assume that terminal Pleistocene Australians were a fairly homogenous group and are suitably represented by Kow Swamp (Thorne & Macumber 1972) and the undated Cohuna cranium. This runs contrary to a series of earlier publications by Thorne (1976, 1977) in which he argued the complete opposite. Variation in Pleistocene Australia was interpreted as being so great that it could most readily be explained by the migration of two morphologically distinct founder populations. On the evidence so far published the earliest group of immigrants, and those temporally less removed from the Indonesian hominids, are represented by the Lake Mungo 1 and 3 skeletons (Bowler *et al.* 1970; Bowler *et al.* 1972; Bowler & Thorne 1976). The Lake Mungo materials, along with Keilor, were excluded from Thorne & Wolpoff's (1981) regional comparison. In retrospect this may have been because the morphology of these crania did little to support their chosen hypothesis. Their characteristics include the following: facial skeletons relatively orthognathic, dentitions of moderate size, frontal bones very curved, bregmatic eminence not present, and maximum parietal breadths not located in an inferior position.

The undated WLH-50 calvaria (Flood 1983; Thorne 1984; Stringer & Andrews 1988; Wolpoff 1991), recovered from a deflating land surface in the Garnpung/Laghur Lake region, has been argued to be morphologically intermediate between middle Pleistocene Indonesian hominids and late Pleistocene Australians (Stringer & Andrews 1988; Wolpoff 1991). Features cited in support of this include the thickness of the vault, morphology of the frontal, inion prominence, occipital torus morphology and position of maximum cranial breadth. Vault thickness in WLH-50 does not comply with the pattern in Asian *H. erectus* or early *H. sapiens*. In these middle-late Pleistocene hominids the vaults are preferentially thickened at the parietal eminence and asterion but not particularly thick elsewhere (Brown 1992*c*). WLH-50 is uniformly thick (Brown 1989), with extremely thin tabular bone and greatly expanded diploë, and without preferential thickening basally or at the parietal eminence. Both Brown (1989) and Webb (1990) have suggested that vault thickness in WLH-50 is pathological. Other unusual aspects of WLH-50 are its extreme size and parietal curvature, with maximum cranial breadth in a basal position. Overall cranial shape has little in common with Ngandong. The vault is long, but also extremely high and supraorbital development is minimal for an Aboriginal cranium of this size. The morphology of the inion, lambdoid and occipital torus regions are not unusual for an Aboriginal male cranium and are unlike Ngandong.

(*b*) *East Asia*

The Zhoukoudian Upper Cave crania were briefly described by Weidenreich (1939) prior to being lost, along with the Locality 1 *Homo erectus* materials, in 1941. Fortunately good quality casts were made of the originals and these have been widely studied ever since (Kaminga & Wright 1988). Weidenreich's description of the Upper Cave crania, 101, 102 and 103, concentrated on determining their racial affinities. The male cranium 101 was argued to have European Upper Palaeolithic features, the female 102 supposedly resembled an artificially deformed Melanesian, and the female 103 an Eskimo. Weidenreich's (1939) interpretation of the racial affinities of the Upper Cave crania was challenged by Wu (1960, 1961) who, after correcting Weidenreich's assignment of the 104 mandible to the 102 cranium, could find no reason to exclude them from the 'Mongoloids'.

More recently a principal components analysis involving 33 dimensions and a comparative sample of 26 recent human populations concluded that there is 'nothing especially Mongoloid about the 101 cranium in terms of its shape' (Kaminga & Wright 1988: 751). Interpretation of the principal components indicated that Upper Cave 101 did not have the Mongoloid characteristics of relatively great cranial height, cheek height and orbital height, as well as having a vault which was too long and a frontal which was too broad (table 2). The distinctions they draw are correct but rather than indicating that 101 is not a 'Mongoloid' it just indicates that 101 is not a modern 'Mongoloid'. The metrical and morphological features which distinguish 101 from mid-Holocene and recent Chinese crania are similar to those which distinguish terminal Pleistocene and mid-Holocene crania in other parts of the world. Terminal Pleistocene crania tend to be longer, with great supraorbital breadth, low rectangular orbits, deeper facial skeletons which are generally more prognathic and have larger dentitions than their mid-Holocene counterparts (tables 1 and 2, Figures 1 and 2). The remarkable thing about Upper Cave 101 is that it goes against the normal terminal Pleistocene pattern with facial prognathism, and presumably palate and tooth dimensions, which are close to the modern Chinese mean (figure 2). Whatever has been selecting for 'Mongoloid' facial characteristics appears to have been doing so for a long period of time.

The remaining East Asian specimen to be considered is Liujiang (Wu 1959; Wu & Zhang 1985). Liujiang has been described as having a mixture of 'Mongoloid' and 'Australoid' characters, with 'Australoid' perhaps best interpreted as a synonym for greater than average robusticity. Compared with modern southern Chinese male crania Liujiang has a vault which is long and low, a short and broad face with low rectangular orbits and a low frontal angle (table 2). Alveolar dimensions, tooth size, nasal breadth and vault thickness dimensions all fall close to the modern male mean. The supraorbital region has a glabella and superciliary ridges which are prominent relative to modern Chinese and there is a pronounced occipital bun. 'Mongoloid characteristics' include a shovel shaped central incisor, shallow prenasal fossa, congenitally absent third molars and an anterolateral surface of the frontal process which is rotated forwards (Wu and Zhang 1985).

The major area of uncertainty surrounding Liujiang is not its 'Mongoloid' morphology, which seems

Table 2. *Comparison of orofacial and cranial dimensions of male modern southern and northern Chinese using Student's t-test and values for Upper Cave 101, Liujiang and a combined mid-Holocene sample (mm)*

	South China[a]			North China[b]					Mid-Holocene[c]
	n	$\bar{x}$	s.d.	*n*	$\bar{x}$	s.d.	101	Liujiang	$\bar{x}$
cranial length	38	181.7	7.5	37	175.5[d]	5.7	204	191	181.6
cranial height	38	141.1	5.0	37	136.2[d]	3.9	136	135	142.1
endocranial volume / ml	37	1499.7	130.5	37	1369.7[d]	94.9	1500	1540	1510.0
supraorbital breadth	39	104.6	4.0	37	102.4[d]	3.5	108	106	—
thickness at bregma	38	7.6	1.4	37	6.4[d]	1.3	—	7	—
frontal angle / deg.	38	137.1	4.9	37	136.4	4.6	—	129	—
occipital angle / deg.	39	117.4	3.6	36	119.2	9.6	109	122	—
bi-zygion	38	133.4	4.9	36	131.8	4.8	143	(134)	135.6
nasion-nasospinale	39	54.0	3.4	37	55.1	2.7	58	46	53.8
nasospinale-prosthion	35	19.4	2.4	35	18.7	2.2	18	20	19.0
nasal breadth	38	26.1	2.1	37	25.2	2.1	32	25	27.4
orbital height	39	33.7	2.1	37	36.2[e]	1.9	34	27	33.2
orbital breadth	39	40.3	1.9	37	40.3	1.7	45	41	42.5
alveolar length	34	53.2	2.9	34	51.4[d]	3.2	57	54	—
symphyseal height	36	35.1	3.1	34	33.7[d]	2.6	—	—	34.4

[a] Collection of Department of Anatomy, University of Hong Kong.

[b] Collection of I.V.P.P., Beijing.

[c] Mid-Holocene mean calculated from Neolithic data in Wu & Zhang (1985) with deformed crania excluded.

[d] Mean value significantly less than southern Chinese mean, $p < 0.05$.

[e] Mean value which is significantly greater than South China mean, $p < 0.05$.

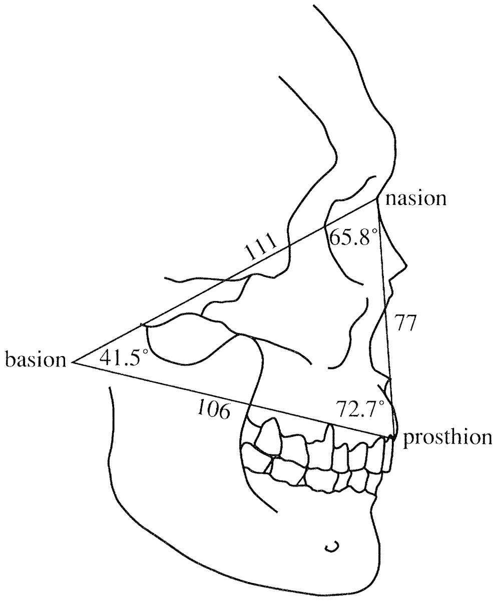

Figure 2. Comparison of facial dimensions (mm) in Upper Cave 101 (left) with the modern southern Chinese male mean.

fairly uncontroversial, but its age. Multivariate comparisons (direct discriminant analysis and cluster analysis) of Liujiang with modern northern and southern Chinese males, Neolithic males and Upper Cave 101 will, depending upon which variables are selected, link Liujiang most closely with the southern Chinese or Neolithic samples. Upper Cave 101 is invariably at a greater distance from the modern and Neolithic samples than Liujiang. Features which suggest an early Holocene, or terminal Pleistocene, age for Liujiang are the relatively great length of the cranium, prominent occipital bun, low cranial height relative to cranial length, and low and rectangular orbits. Features which appear inconsistent with a date of 67 ka BP, particularly if Liujiang is a male, are the relatively small facial height, minimal alveolar and tooth dimensions, low orbits, and a supraorbital and occipital torus development which would be slight for a late Pleistocene female.

4. CONCLUSION

In both East Asia and Australasia the skeletal remains of terminal Pleistocene *H. sapiens* have morphological and metrical features which leave little doubt that they are ancestral to people living in the same regions during the mid to late Holocene. In other words there is clear evolutionary continuity during the Holocene. The available skeletal materials from both East Asia and Australia are, however, too limited to extend this evolutionary continuity back to the middle Pleistocene. There are a common set of features which distinguish terminal Pleistocene *H. sapiens* from their mid-Holocene counterparts in most parts of the world. These features are not as evident in the East Asian terminal Pleistocene remains, but the sample is extremely small. Post-Pleistocene reductions in dental and skeletal mass, and associated changes in craniofacial morphology, should be taken into consideration when the evidence for regional evolutionary continuity is examined. The earliest directly dated example of modern *Homo sapiens* from the East Asian and Australasian regions, which has not been the subject of dispute, is Lake Mungo I dated to 24 000 ka BP.

I would like to thank Dr C. Stringer and the Royal Society for inviting me to contribute to the Discussion Meeting on the origin of modern humans and the impact of chronometric dating. The following individuals and institutions granted me access to human skeletal materials in their care. Dr N. Jablonski, formerly Department of Anatomy, University of Hong Kong; Mr G. Pretty, South Australian Museum; Mr P. Gordon, Australian Museum; Dr R. Vanderwal, Museum of Victoria; Dr A. Thorne, Australian National University; the late Professor L. Ray, Professor G. Ryan and Dr G. Kenny of the Department of Anatomy, University of Melbourne and Professor Wu Xinzhi, Associate Professor Dong Xingren and Associate Professor Wu Maolin of the Institute of Vertebrate Paleontology and Paleoanthropology, Academia Sinica. Without their help this research would not have been possible.

REFERENCES

Birdsell, J.B. 1967 Preliminary data on the trihybrid origin of the Australian Aborigines. *Arch. Phys. Anthropol. Oceania* **2**, 100–155.

Bowler, J.M., Jones, R., Allen, H. & Thorne, A.G. 1970 Pleistocene human remains from Australia: a living site and human cremation from Lake Mungo, western New South Wales. *World Archaeol.* **2**, 39–60.

Bowler, J.M. & Thorne, A.G. 1976 Human remains from Lake Mungo: Discovery and excavation of Lake Mungo III. In *The Origin of the Australians* (ed. R. L. Kirk & A. G. Thorne), pp. 127–138. Canberra: Australian Institute of Aboriginal Studies.

Bowler, J.M., Thorne, A.G. & Polach, H. 1972 Pleistocene man in Australia: age and significance of the Mungo skeleton. *Nature, Lond.* **240**, 48–50.

Brace, C.L. & Mahler, P.E. 1971 Post-Pleistocene changes in the human dentition. *Am. J. phys. Anthrop.* **34**, 191–204.

Brace, C.L., Shae, X.-Q. & Zhang, Z.-B. 1984 Prehistoric and modern tooth size in China. In *The origins of modern humans* (ed. F. H. Smith & F. Spencer), pp. 485–516. New York: Alan R. Liss.

Bräuer, G. 1989 The evolution of modern humans: a comparison of the African and non-African evidence. In *The human revolution: behavioural and biological perspectives on the origins of modern humans* (ed. P. Mellars & C. Stringer), pp. 123–155. Princeton University Press.

Brothwell, D. 1975 Possible evidence of a cultural practise affecting head growth in some late Pleistocene East Asian and Australasian populations. *J. archeol. Sci.* **2**, 75–77.

Brothwell, D.R. 1960 Upper Pleistocene Human Skull from Niah Caves. *Sarawak Mus. J.* **9**, 323–349.

Brown, P. 1981 Artificial cranial deformation: a component in the variation in Pleistocene Australian Aboriginal crania. *Archaeol. Oceania* **16**, 156–167.

Brown, P. 1987 Pleistocene homogeneity and Holocene size reduction: the Australian human skeletal evidence. *Archaeol. Oceania* **22**, 41–71.

Brown, P. 1989 *Coobool Creek: A morphological and metrical analysis of the crania, mandibles and dentitions of a prehistoric Australian human population.* Terra Australis 13. Canberra: Department of Prehistory, Australian National University.

Brown, P. 1992*a* Human skeletons. In *The Encyclopedia of Aboriginal Australia* (ed. D. Horton). Canberra: Australian Aboriginal Studies Press. (In the Press.)

Brown, P. 1992*b* Post-Pleistocene change in Australian Aboriginal tooth size: dental reduction or relative expansion? In *Human craniofacial variation in the Pacific* (ed. T. Brown & S. Molnar), pp. 33–52. Adelaide: University of Adelaide.

Brown, P. 1992*c* Cranial vault thickness in Asian *Homo erectus* and modern *Homo sapiens*. *Courier Forschungsinstitut Senckenberg*. (In the Press.)

Calcagno, J.M. 1986 Dental reduction in Post-Pleistocene Nubia. *Am. J. phys. Anthrop.* **70**, 349–363.

Carlson, D.S. 1976 Temporal variation in prehistoric Nubian crania. *Am. J. phys. Anthrop.* **45**, 467–484.

Chen, T., Hedges, R.E.M. & Yuan, Z. 1989 Accelerator radiocarbon dating for the Upper Cave of Zhoukoudian. *Acta Anthrop. Sin.* **8**, 216–221.

Chen, T. & Zhang, Y. 1991 Palaeolithic chronology and possible coexistance of *Homo erectus* and *Homo sapiens* in China. *World Archaeol.* **23**, 147–154.

Coon, C.S. 1962 *The origin of races*. New York: Knopf.

Dubois, E. 1922 The proto-Australian fossil man of Wadjak, Java. *Koninklijke Akademie van Wetenschappen te Amsterdam.* **B23**, 1013–1051.

Flood, J. 1983 *Archaeology of the dreamtime*. Sydney: Collins.

Fox, R. 1970 *The Tabon Caves. Archaeological explorations and excavations on Palawan Island, Philippines.* Manila: National Museum of the Philippines.

Frayer, D.W. 1977 Metric dental changes in the European Upper Paleolithic and Mesolithic. *Am. J. phys. Anthrop.* **46**, 109–120.

Frayer, D.W. 1984 Biological and cultural change in the European late Pleistocene and early Holocene. In *The origin of modern humans* (ed. F. H. Smith & F. Spencer), pp. 211–250. New York: Alan R. Liss.

Groves, C.P. 1989 A regional approach to the problem of the origin of modern humans in Australasia. In *The human revolution* (ed. P. Mellars & C. Stringer), pp. 274–285. Princeton University Press.

Habgood, P.J. 1986 The origin of the Australians: a multivariate approach. *Archaeol. Oceania* **21**, 130–137.

Hedges, R.E.M., Housley, R.A., Law, I.A., Perry, C. & Hendy, E. 1988 Radiocarbon Dates from the Oxford AMS System: *Archaeometry* Datelist 8. *Archaeometry* **30**, 291–305.

Hedges, R.E.M., Housley, R.A., Bronk, C.R. & Van Klinken 1992 Radiocarbon dates from the Oxford AMS system: *Archaeometry* Datelist 14. *Archaeometry* **34**, 141–159.

Hiscock, P. 1990 How old are the artefacts in Malakunanja II? *Archaeol. Oceania* **25**, 122–124.

Kaminga, J. & Wright, R.V.S. 1988 The Upper Cave at

Zhoukoudian and the origins of the Mongoloids. *J. hum. Evol.* **17**, 739–767.

Kennedy, K.A.R. 1977 The deep skull of Niah: An assessment of twenty years of speculation concerning its evolutionary significance. *Asian Perspect.* **20**, 32–50.

Klaatsch, H. 1908 The skull of the Australian Aboriginal. *Rep. Path. Lab. Lunacy Dept., New South Wales* **1**, 43–167.

Li, Y., Brace, C.L., Gao, Q. & Tracer, D.P. 1991 Dimensions of Face in Asia in the Perspective of Geography and Prehistory. *Am. J. phys. Anthrop.* **85**, 269–279.

Macintosh, N.W.G. 1963 Origin and physical differentiation of the Australian Aborigines. *Aust. Nat. Hist.* **14**, 248–252.

Macintosh, N.W.G. 1978 The Tabon Cave mandible. *Arch Phys. Anthrop. Oceania.* **13**, 143–159.

Oakley, K.P., Campbell, B.G. & Molleson, T.I. 1975 *Catalogue of fossil hominids.* London: British Museum of Natural History.

Pardoe, C. 1991 Competing paradigms and ancient human remains: the state of the discipline. *Archaeol. Oceania* **26**, 79–85.

Pearce, R.H. & Barbetti, M. 1981 A 38,000-year-old archaeological site at Upper Swan, Western Australia. *Archaeol. Oceania* **16**, 173–78.

Pei, W. 1935 A preliminary report on the Late Palaeolithic Cave of Choukoutien. *Bull. Geol. Soc. China* **13**, 327–358.

Pei, W. 1939 On the Upper Cave Industry. *Palaeont. Sin* **D9**, 1–141.

Pietrusewsky, M. 1984 Metric and non-metric cranial variation in Australian Aboriginal populations compared with populations from the Pacific and Asia. *Occ. Papers Hum. Biol.* **3**, 1–113.

Roberts, R.G., Jones, R. & Smith, M.A. 1990*a* Thermoluminesence dating of 50,000 year-old human occupation site in northern Australia. *Nature, Lond.* **345**, 153–156.

Roberts, R.G., Jones, R. & Smith, M.A. 1990*b* Stratigraphy and statistics at Malakunanja II: reply to Hiscock. *Archaeol. Oceania* **25**, 125–129.

Santa Luca, A.P. 1980 *The Ngandong fossil hominids.* New Haven: Department of Anthropology Yale University.

Smith, P. 1982 Dental reduction: Selection or drift? In *Teeth: form, function, and evolution* (ed. B. Kurten), pp. 366–379. New York: Columbia University Press.

Smith, P., Wax, Y., Adler, F., Silberman, D. & Heinic, G. 1986 Post-Pleistocene changes in tooth root and jaw relationships. *Am. J. phys. Anthrop.* **70**, 339–348.

Stringer, C.B. & Andrews, P. 1988 Genetic and fossil evidence for the origin of modern humans. *Science, Wash.* **239**, 1263–1268.

Theunissen, B., De Vos, J., Sondaar, P.Y. & Aziz, F. 1990 The establishment of a chronological framework for the hominid-bearing deposits of Java; A historical survey. In *Establishment of a geologic framework for paleoanthropology* (ed. L. F. Laporte), pp. 39–54. Boulder: Geological Society of America.

Thorne, A.G. 1975 Kow Swamp and Lake Mingo. Ph.D. thesis, University of Sydney.

Thorne, A.G. 1976 *Morphological contrasts in Pleistocene Australians.* Canberra: Australian Institute of Aboriginal Studies.

Thorne, A.G. 1977 Separation or reconcilliation? Biological clues to the development of Australian society. In *Sunda and Sahul* (ed. J. Allen, J. Golson & R. Jones), pp. 187–204. London: Academic Press.

Thorne, A.G. 1984 Australias human origins – how many sources? *Am. J. phys. Anthrop.* **63,** 227.

Thorne, A.G. & Macumber, P.G. 1972 Discoveries of Late Pleistocene man at Kow Swamp. *Nature, Lond.* **238**, 316–319.

Thorne, A.G. & Wolpoff, M.H. 1981 Regional continuity in Australasian Pleistocene hominid evolution. *Am. J. phys. Anthrop.* **55**, 337–349.

Wang, L. 1986 Secular change and geographic variation in Chinese Neolithic and modern inhabitants: a statistical study of cranial metric traits. *Acta Anthrop. Sin.* **5**, 243–258.

Webb, S. 1989 *The Willandra Lakes Hominids.* Canberra: Department of Prehistory, Australian National University.

Webb, S. 1990 Cranial thickening in an Australian hominid as a possible palaeoepidemiological indicator. *Am. J. phys. Anthrop.* **82**, 403–412.

Weidenreich, F. 1939*a* On the earliest representatives of modern mankind recovered on the soil of East Asia. *Bull. Nat. Hist. Soc. Peking.* **13**, 161–174.

Weidenreich, F. 1939*b* Six lectures on Sinanthropus and related problems. *Bull. Geol. Soc. China.* **19**, 1–110.

Weidenreich, F. 1943 The skull of *Sinanthropus pekinensis*: a comparative study of a primitive hominid skull. *Palaeont. Sin.* **D10**, 1–485.

Weidenreich, F. 1945 The Keilor skull: a Wadjak type from south-east Australia. *Am. J. phys. Anthrop.* **3**, 225–236.

Weidenreich, F. 1946 *Apes, giants, and man.* Chicago University Press.

Wolpoff, M.H. 1980 *Paleoanthropology.* New York: Alfred A. Knopf.

Wolpoff, M.H. 1991 Theories of Modern Human Origins. In *Continuity or replacement? Controversies in Homo sapiens evolution* (ed. G. Bräuer & F. H. Smith), Rotterdam: A. A. Balkema.

Wolpoff, M.H., Wu, X.-Z. & Thorne, A.G. 1984 Modern *Homo sapiens* origins: a general theory of hominid evolution involving the fossil evidence from east Asia. In *The origins of modern humans* (ed. F. H. Smith & F. Spencer), pp. 411–484. New York: Alan R. Liss.

Wu, R. 1959 Human fossils found in Liukiang, Kwangsi, China. *Gu Jizhuidongwu yu Gu Renlei* **1**, 97–104.

Wu, X. 1960 On the racial type of Upper Cave Man of Choukoutien. *Gu Jizhuidongwu yu Gu Renlei* **2**, 141–149.

Wu, X. 1961 Study of the Upper Cave Man of Choukoutien. *Verteb. Palasiat.* **3**, 181–211.

Wu, X. 1981 A well-preserved cranium of an archaic type of early *Homo sapiens* from Dali, China. *Scientia Sin.* **24**, 530–539.

Wu, X. 1988*a* The relationship between upper Palaeolithic human fossils of China and Japan. *Acta Anthrop. Sin.* **7**, 235–238.

Wu, X. 1988*b* Comparative study of early *Homo sapiens* from China and Europe. *Acta Anthrop. Sin.* **7**, 292–299.

Wu, X. 1990 The evolution of humankind in China. *Acta Anthrop. Sin.* **9**, 312–322.

Wu, X. & Wang, L. 1985 Chronology in Chinese Palaeoanthropology. In *Palaeoanthropology and palaeolithic archaeology in the People's Republic of China* (ed. R. Wu & J. W. Olsen), pp. 29–68. London: Academic Press.

Wu, X. & Zhang, Z. 1985 *Homo sapiens* remains from Late Palaeolithic and Neolithic China. In *Palaeoanthropology and palaeolithic archaeology in the People's Republic of China* (ed. R. Wu & J. W. Olsen), pp. 107–133. London: Academic Press.

Wunderly, J. 1943 The Kilor fossil skull: anatomical description. *Mem. Nat. Mus. Victoria.* **13**, 57–69.

Zhang, Z., Wang, L. & Ouyang, L. 1982 Physical patterns of Neolithic skulls in China in view of cluster analysis. *Verteb. Palasiat.* **20**, 72–80.