SECTION I

INTRODUCTION

CHAPTER 1

OBJECTIVES AND STRUCTURE

1.1 INTRODUCTION AND ASSESSMENT OF VALUE

Why do humans differ? Of course the basic answer is that we differ because, apart from monozygotic twins, each of us carries a unique set of genes. Further, no two individuals ever develop in the same way because of environmental differences. This explains the variation between individuals, but what of variation between population groups? Why are some populations dark skinned and others fair, some stocky and others linear? The reasons behind such population differences have been of interest ever since secular thought was brought to bear on the matter.

The theme that the environment shaped the differences between human groups can be traced back to the writings of Aristotle and Hypocrates nearly two and half thousand years ago (Spencer 1997a, 1997b: 108; Agelarakis 1997). Their early observations were later to be confirmed, not only for humans, but also for all living creatures. The theory that a species can change over time due to the selection of phenotypes by the environment was recognized at roughly the same time by Charles Darwin and Alfred Wallace (Darwin 1859; Wallace 1876).

In particular, one aspect of the environment has come under scrutiny as an important selective factor in the variation of species - climate. The publications of Bergmann (1847) and Allen (1877) outlined an apparent congruence between ambient temperature and body size and shape in widespread animal species. These regularities, that are thought to relate to thermoregulation, have become known as Bergmann's and Allen's rules, and have spurred ongoing research into many animal species including humans, both present and past. The application of these "rules" to humans is the major focus of this thesis and it takes its place as part of this long-term and widespread research effort. The major advantage of this study is that the Australian Aboriginal populations involved observed a common way of life (hunter-fisher-gatherer), but lived under differing climatic conditions. Most other ecographic studies have involved populations pursuing a variety of socio-economic strategies. The use of this population sample may thus reduce some of the unexplained variation attributable to culture and economy that exists in these other studies.

This study hopes to contribute information pertaining to issues of human evolution and the human past. In a wider context, it may provide further insight into the causes of morphological variation in all hominid species, and more particularly to the questions surrounding the origins of modern humans. The results of this study may contribute evidence as to the causes (be they genetic or epigenetic) and tempo of climate adaptation.

In this way they may help to gauge the likelihood of the alternate propositions that the linear humans who appeared in Europe in the Upper Palaeolithic, and earlier in the Near East, were either recent migrants or the descendants of the indigenous Neandertal populations of these regions.

In a more localised sense it can provide information regarding the source of variation in Australian Aboriginal populations. Whilst it may give some indication of Aboriginal origins in a broad sense, it is more likely to provide a perspective on the events of the last ten thousand years, that saw marked socio-cultural changes and the movements of culture, languages and people across the Australian continent.

1.2 THEORETICAL BASIS AND SOME DEFINITIONS

To begin, it is stated that the theoretical paradigm of this thesis is strongly evolutionary, even adaptationist. The latter has become a term of disapprobation used against those who are seen to cling to an old-fashioned view that many of the differences we see distinguishing populations of modern humans from each other stem from evolutionary forces. Although I admit my viewpoint is somewhat adaptationist, I do not in any way dismiss the importance of stochastic, social and cultural forces in shaping modern human variation. Indeed these other evolutionary forces have clearly impacted on the results of this thesis. It is simply that I am investigating the data I have available, in order to test the hypothesis that certain aspects of human body morphology are the result of adaptation to climate.

This study has used the data collected by Joseph Birdsell in his expeditions to Australia during the 1930s and 1950s. He measured a large number of Aboriginal Australians of both mixed and unmixed ancestry. Only the latter have been used for this thesis. A number of other data collections of Aboriginal Australians have also been used. In the text they have been referred to as variously Aboriginal, Indigenous or Australian. When other ethnic groups are referred to they will be clearly distinguished.

The last definition refers to the use of the taxonomic term hominid, as a preference to the newer designation of hominin. The basis of the new taxonomic term, Hominin, stems from a re-interpretation of the Hominoid phylogeny that has taken place over a number of years (eg. Goodman 2001; Goodman *et al.* 1998; Groves 1986, 2001; Watson *et al.* 2001). However, as a general review of the recent palaeoanthropological literature demonstrates, this convention is not entirely accepted and, therefore, the older term will be used throughout this thesis. In any case, in this context it refers specifically to the phylogenetic lineage most closely related to the extant member of the genus *Homo*, than to the other the Hominoids.

1.3 AIMS OF THIS THESIS

The major aim of this thesis is to examine the evidence, positive or negative, for an effect of climate on human variation in Australia Aboriginal populations.

In doing so several interrelated questions will be posed:

1) Are the Aborigines measured by Birdsell an homogeneous or heterogeneous population?

2) Are the ecographic rules of Bergmann and Allen applicable to Australian Aborigines? If so, which climatic variables can be identified as the most important selective factors?

3) If heterogeneity is revealed can the results of this study provide answers as to its cause: (a) multiple migrations, (b) single founder population with divergence due to genetic adaptation to local environment, (c) stochastic processes.

As noted above, the thesis also aims to provide contextual information that may contribute to a better understanding of human evolution in general, and more specifically to modern human origins.

1.5 LIMITATIONS

The major limitation of this study is the data themselves, in particular issues relating to sampling and these problems have been addressed in the text. The other important issue is methodological. The methodology used in this study is based on correlation analysis. It is basic to the inferences made from any such study that correlation does not imply causation. Whilst experiments have shown that certain body phenotypes develop under different thermal conditions, the evidence that proves that climate is the direct selective force underlying the regularities observed by Bergmann and Allen is still unavailable. With our ever-deepening understanding of the genetic mechanisms of growth and development, such evidence may be accessible in the near future.

1.6 THESIS STRUCTURE

This thesis is divided into five sections and eleven chapters. They include Section I: Introduction (Chapter 1); Section II: Context (Chapters 2 and 3); Section III: Materials and Methods (Chapters 4 and 5); Section IV: Analysis (Chapters 6 through 9) and Section V: Discussion and Conclusion (Chapters 10 and 11).

Section 2 will examine the research context of this thesis. It will outline the history of

study into the ecographic rules and their application to humans and other animals. It will examine the validity of these rules through an examination of observational, statistical and experimental studies. It will also examine the possible causes underlying these apparent regularities. Finally it will examine the role that the ecographic rules have played in the interpretation of the hominid fossil record, particularly in the present argument surrounding the origins of modern humans.

The first chapter of Section 3 will document the sources of data for this study. The second chapter will discuss the statistical methods used to analyse this data set. The methods used include univariate analysis, bivariate and multivariate correlation and regression analysis, and principal components analysis.

Section 4 will document the results of the statistical analyses. Chapter 6 reports the descriptive statistics and the results of the univariate analysis. It will also report on issues relating to the integrity of the data and their suitability for use in statistical analyses. An analysis of variance (ANOVA) on all sample groups is included in order to assess the degree of heterogeneity in the population samples. Chapter 7 reports the results of the bivariate, partial and multiple stepwise regression analyses. In Chapter 8 the results of the principal component analyses on raw and size-corrected variables will be presented. In Chapter 9 the results stemming from the Aboriginal sample will be compared to a world sample gathered for this thesis.

In Chapter 10 of Section 5, there will be a discussion of the results in the light of previous research and in Chapter 11 conclusions will be presented.

SECTION II

CONTEXT

CHAPTER 2

HUMAN HISTORY AND ECOLOGY IN AUSTRALIA

2.1 INTRODUCTION

This chapter serves to provide the environmental, ecological and demographic background to this thesis. Given that adaptation to climate is the major focus of this research, it is pertinent to provide a brief overview of the Australian environment: its geography, climate and ecology, both present and past, as well as aspects of human ecology. This will be followed by a discussion of the evidence concerning the initial occupation of this continent by humans. This is an important consideration as the regions through which their ancestors travelled and the length of time they then spent within the environment of Australia is a factor in the degree of morphological adaptation they are likely to express.

2.2 THE AUSTRALIAN ENVIRONMENT

2.2.1 Present Geography and Climate

Australia is located in the Southern Hemisphere between latitudes 10° 41' S and 43°39' S and longitudes 113° 09'E and 153° 39'E. Approximately one-third of the continent lies within the tropics, with the remaining area lying within the sub-tropical or temperate zones. Due to the shape of the landmass (narrower latitudinally than it is longitudinally) seasonal variation is moderate, but it has more continentality than might be expected (Gentilli 1971: 35). It is also one of the most insolated continents.

Its physiographic features have been shaped by its location peripheral to the major areas of tectonic activity. The latter has produced a landmass without mountain ranges on the scale of the Alps, Andes, Rockies or Himalayas and with highly weathered topography and poor soils. This continent's latitude and lack of relief also accounts in part for its aridity. About 37% of Australia receives less than 250mm of rainfall annually, and another 31% above that receives between 250 and 500mm (Gentilli 1971: 144). As a result nearly 70% of the continent is defined as arid or semi-arid. The best and most reliably watered areas of the continent lie adjacent to the Great Dividing Range that runs nearly the entire length of the East Coast (Figure 2.1). These mountains act as a watershed for the west-to-east-running Southern Hemisphere weather systems and also trap the moisture from the on-shore east-coast winds. Springing from these ranges are the headwaters of many of the permanent river systems of the eastern half of the continent including Australia's largest river system, the Murray-Darling.

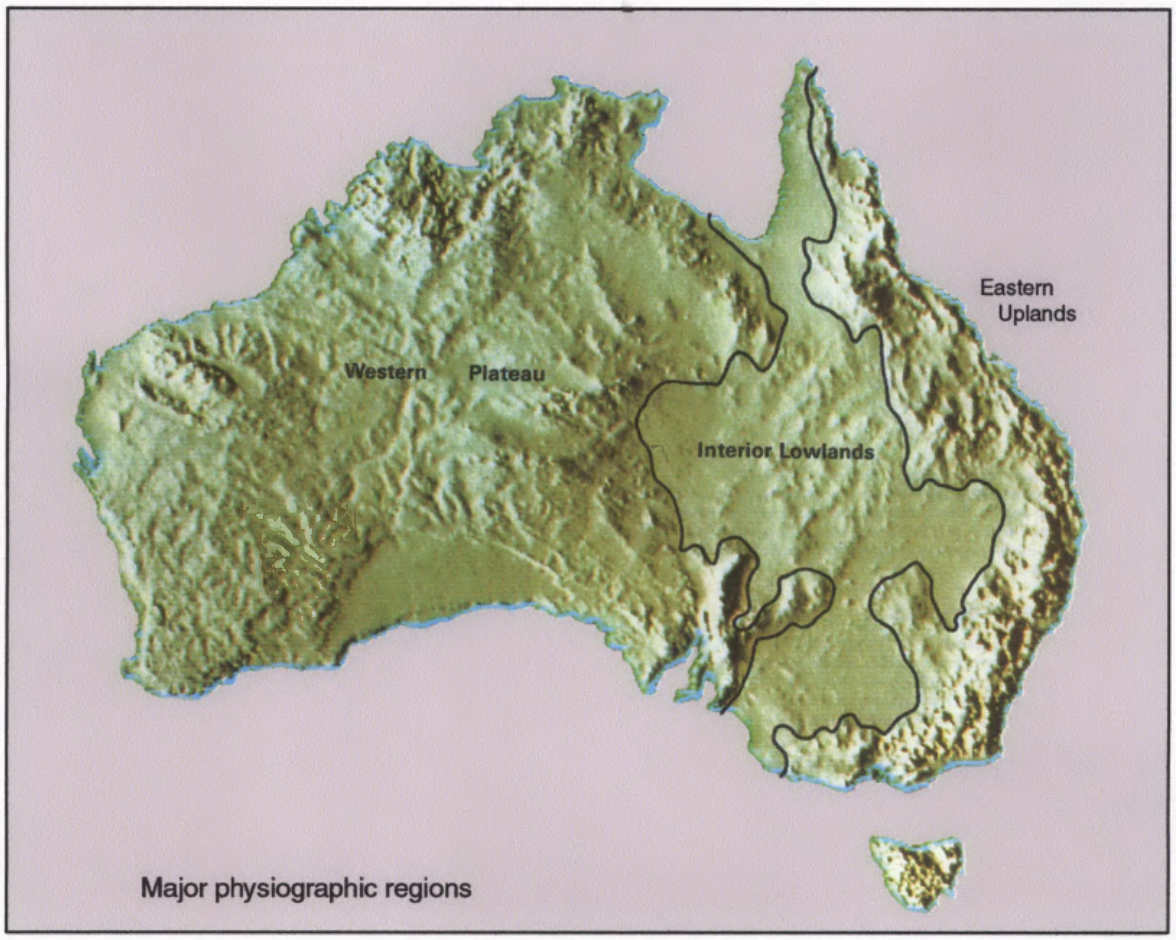


Figure 2.1: Major topographic features of Australia, taken from Atkinson 1984: 153.

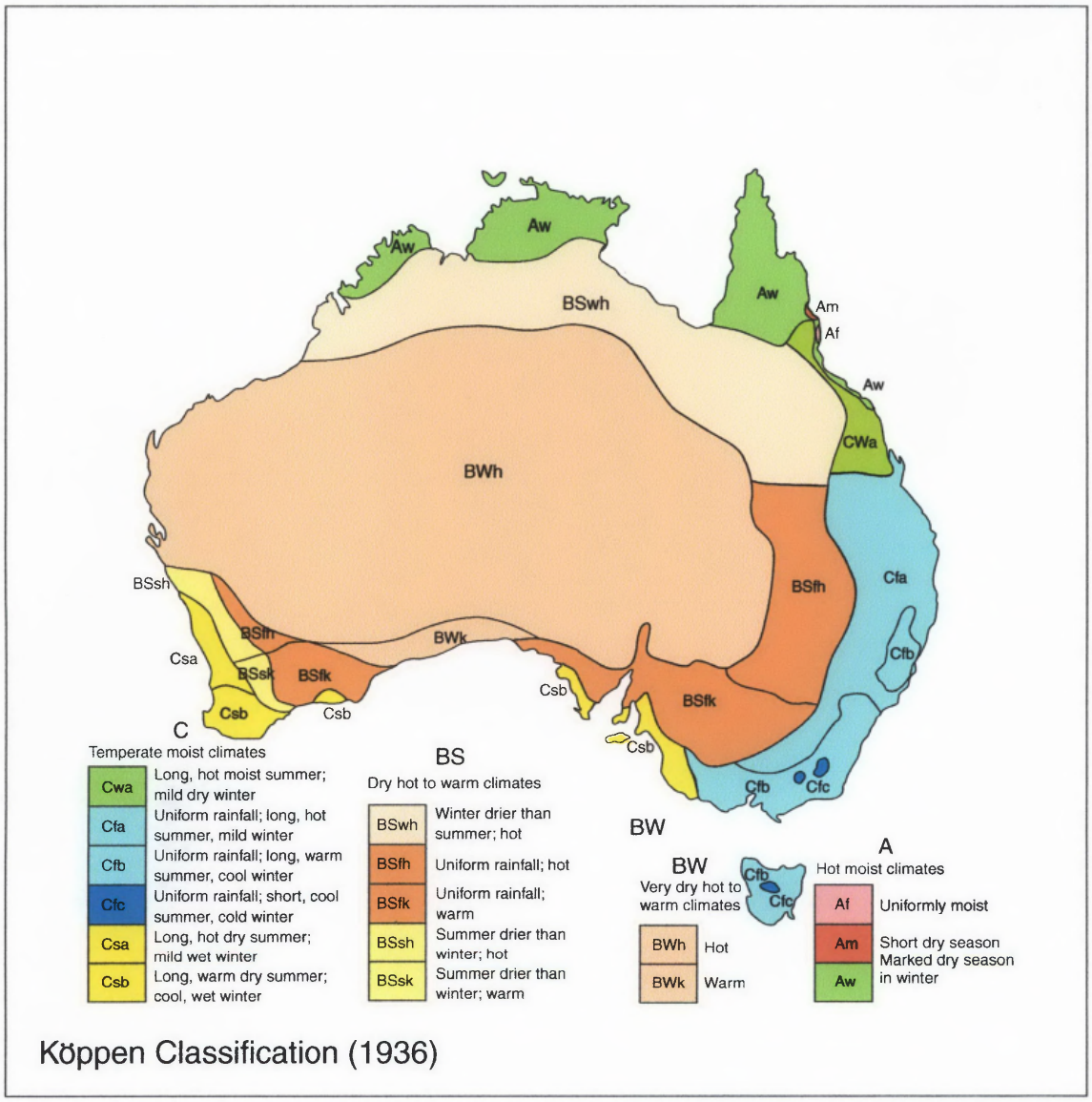


Figure 2.2: Köppen classification map of Australian climates, taken from Atkinson 1984: 169.

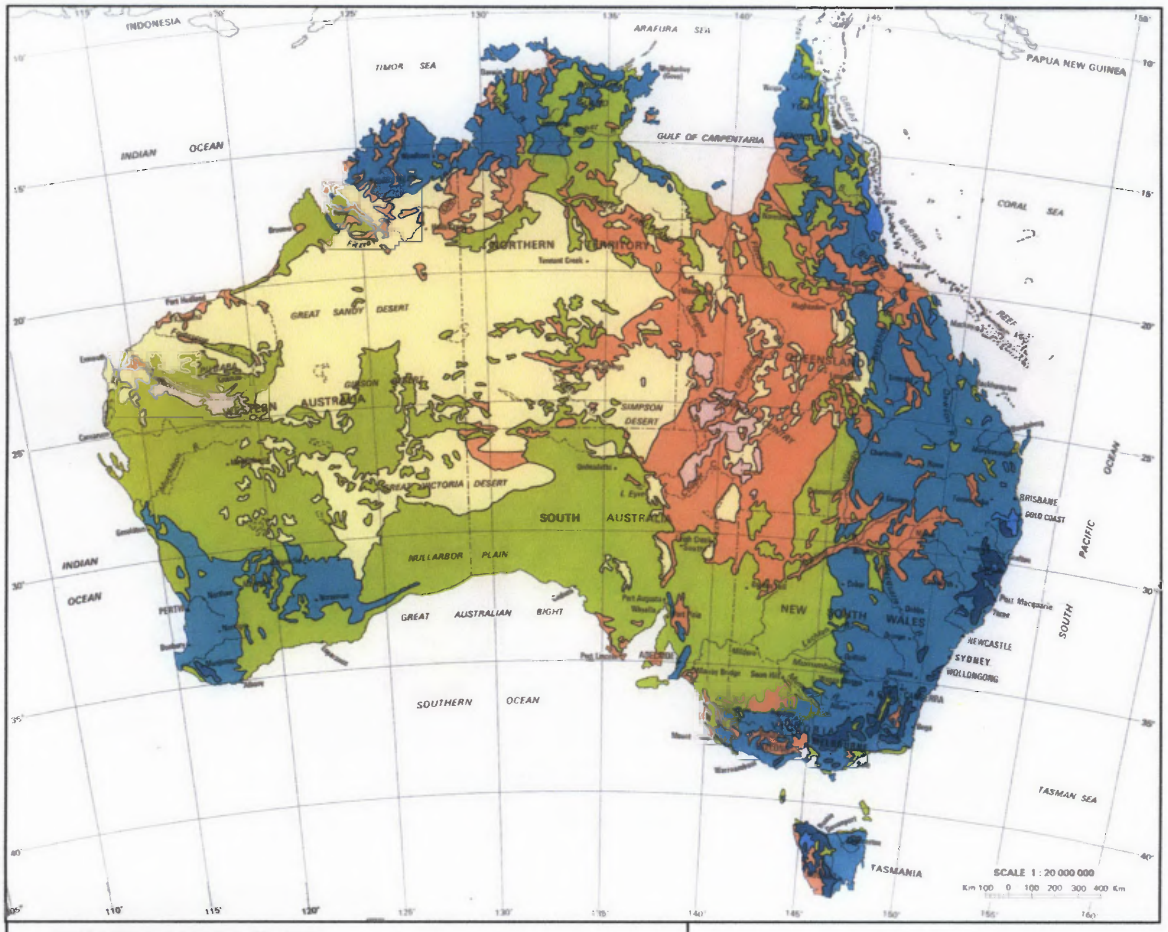
Although Australia has many other great rivers, those found in the north of the continent are dependent on the monsoon rains and many cease to flow during the dry-season. Seasonality of rainfall is an important factor in the patterning of environment in Australia. In the north, summer is the period of the heaviest rainfalls and in the south the mid-latitude frontal depressions bring rain in winter.

The distribution of climate types in Australia is illustrated in Köppen's Classification system (Köppen 1936) (Figure 2.2). This diagram demonstrates that summers all over Australia are warm to hot, and that very few areas are extremely cold in winter. Only in the mountains of the southeast and in some areas of Tasmania do areas of permanent winter snows exist. Although most of the continent experiences summers with relatively low humidity, this is not true of the more northerly sections of the eastern seaboard, or the tropical north, where the combination of heat, summer rainfall and high humidity can cause severe heat discomfort to humans (Archer & Fox 1984; Atkinson 1984; Gentilli 1971; Kirk 1981).

2.2.2 Flora and Fauna

The variety and abundance of vegetation within a region is the result of a number of interconnected factors, including but not confined to, temperature, moisture balance, insolation, seasonality and soil type. Given Australia's generally dry and warm climate the majority of the continent is covered by arid and semi-arid floral species such as grasses and low woody scrub. In the better-watered areas of the north, east and southwest, there were at one time extensive areas of open eucalypt woodlands with small patches of tall forest and rainforest, but much of this has since been cleared for grazing and agriculture (Figure 2.3). Perhaps the most unique aspect of Australia's flora is its tolerance to fire, with many species requiring the actual presence of flame or smoke for germination (Archer & Fox 1984; Atkinson 1984; Kirk 1981).

The nature of the Australian fauna is to a great degree the result of the deep, sea barrier (known as the Wallace Trench) that has isolated the continent from the rest of the world for last 50 million-years following the break-up of the super-continent Gondwanaland. After a voyage to Southeast Asia in the 1850s, Alfred Wallace noted that there was a clear demarcation between the ranges of the Eurasian type fauna (with its placental mammals) and the Australian fauna (with its marsupial mammals). This line, or rather zone, of demarcation (Wallace's Line or Wallacea) runs from south of the Philippines, southeast of Borneo and separates the Indonesian islands of Bali and Lombok (Wallace 1876). Wallacea encompasses the Moluccas, Sulawesi and the Lesser Sunda Islands and is a region where the Eurasian and Australian faunas are not clearly demarcated with some animals managing to cross into the Wallacian zone (eg Macaques in Sulawesi). Few placental mammals ever bridged the entire gap to enter Australia and New Guinea.



NATURAL VEGETATION
This map depicts the broad patterns of natural vegetation before significant modification by Europeans.

TALL FOREST
Trees > 30m; cover 10%-70%, dominated by eucalypts.

CLOSED FOREST
Trees 10m to > 30m; cover > 70%, formerly known as rainforests
Occur in fertile soils with rainfall > 1200 mm, eucalypts absent.

LOW FOREST
Trees 10m-30m; cover 10%-70%. Dominated by very large range of eucalypts. In drier areas brigalow, mulga & cypress displace eucalypts.

SCRUB
Trees and woody shrubs < 10m; cover 10%-70%. As mapped the group includes saltbush, bluebush shrublands, coastal heaths, the alpine complex above the tree line and areas of non-eucalypt closed forest.

HUMMOCK GRASSES
Mound-like grasses < 1m; cover 10%-30%. Shrubs, when present, <10%, typicall Acacia sp.. Typical grass: porcupine grass ('spinifex'). Dominant only in sand plain and sand-ridge deserts.

TUSSOCK GRASSES AND GRAMINOIDS
Grass and grass-like forms < 1m; cover 10%-70%. Shrubs, when present, < 10%, typically saltbush, bluebush and compositae.

FORBS
Herbaceous plants; cover < 10%. Stony desert areas dominated by the non-woody saltbushes, everlastings and bassia burrs.

Figure 2.3: Vegetation of Australia, taken from Atkinson 1984: 154.

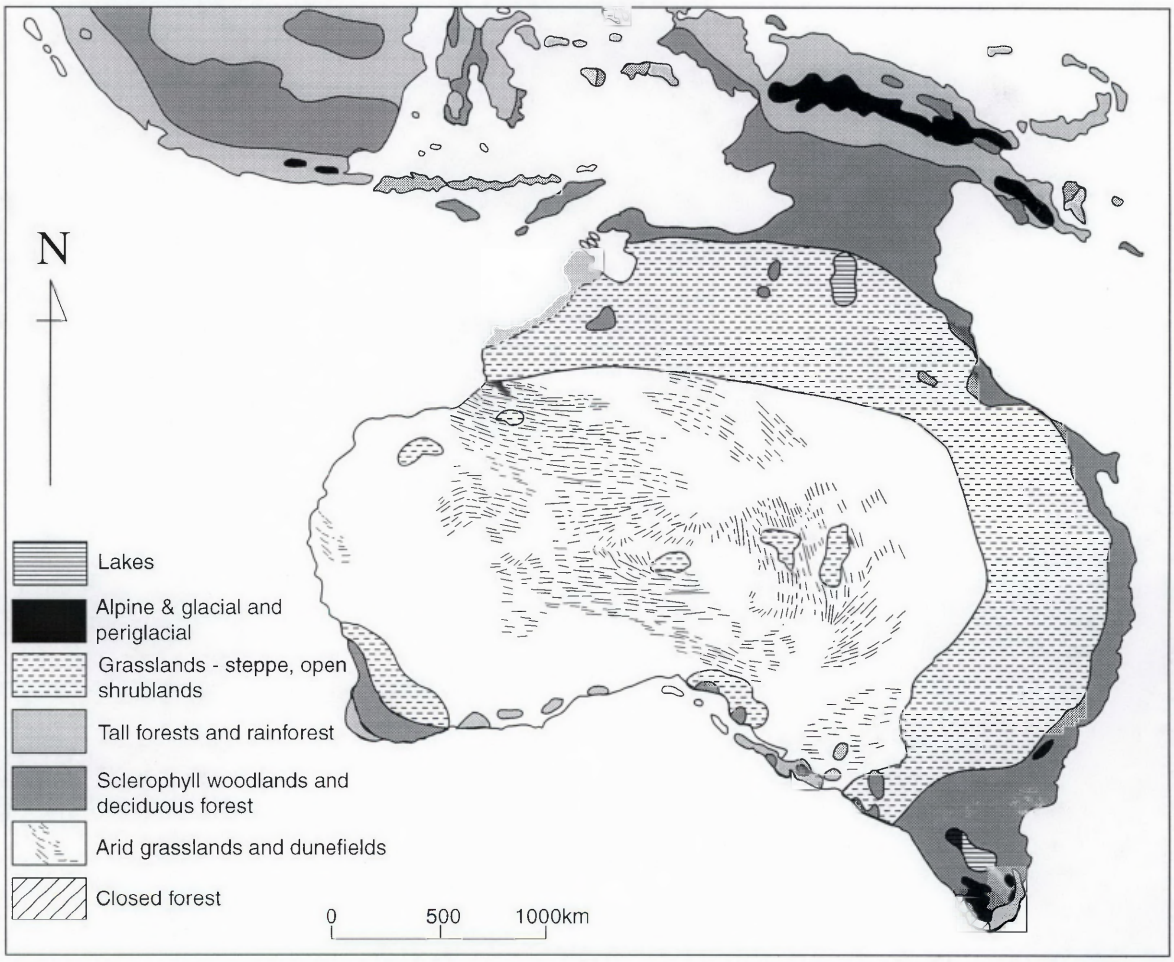


Figure 2.4: Australia during the last glacial maximum, adapted from Mulvaney and Kamminga 1999: 115)

Those that did manage the journey were small, such as rodents and bats, and are thought to have rafted or flown across the water gaps, a feat not accomplished by larger mammals without human assistance.

Because of the isolation of the continent the original human colonists of Australia would have encountered many unfamiliar animals among which were the large marsupial fauna. The majority of these "megafauna" subsequently became extinct prior to the end of the last glaciation (Archer & Fox 1984). The cause or causes of these extinctions, be they human or environmental, are still being debated (Archer 1984; Flannery 1990; Horton 1980; Merrilees 1968).

2.2.3 Climate Change in the Quaternary

Given that the bulk of the human data analysed in this thesis are recent (measured on living subjects) and thus very broadly represents late Holocene patterns of variation it would seem incongruous to be discussing Pleistocene climatic conditions. However, archaeological evidence clearly demonstrates that Aboriginal people have occupied this continent for at least 40,000 years and possibly longer (see below), a time period that covers the significant climatic changes of the last glacial maximum (about 25 - 15 kya). Thus we have a scenario of a population (possibly of common origin - although that remains to be proven) occupying the continent over a great time-span during which the climate changed dramatically. It can therefore be argued that some of the recent morphological variation seen in the Aboriginal population is due, in part, to adaptations to ancient environments and so a discussion of these past climates is valid.

At the time of initial colonisation the climate of Australia was generally cooler and moister than present day conditions (Colhoun 1991). Dated sites around Australia indicate that prior to the last glacial maximum virtually all regions and habitats were colonised, the exceptions being the more difficult habitats such as the cold tableland and alpine zones, the tropical rainforest and the sandy deserts (Jones 1989; Mulvaney & Kamminga 1999; White & O'Connell 1982). Thus, about 25kya the climate became markedly colder and drier, with temperatures dropping by as much as 10 degrees Celsius (°C), rainfall decreasing by as much as half and sea levels dropping to 150 meters below present day levels. In the southern regions evidence suggests it was also much windier. The maximum period of cold and arid conditions was between 20 and 16kya. Cool and relatively dry conditions continued until about 12kya when temperatures and rainfall increased to above present-day averages, a period lasting about 5,000 years, subsequent to which conditions reached present-day averages (Colhoun 1991).

Not all areas of Australia were affected similarly. North Queensland became much drier and cooler whereas coastal New South Wales and the southwest corner of Western Australia suffered relatively little change (Colhoun 1991: 8-11; 38). However, the interior of the continent became much drier, colder and in the south, windier. The arid and semi-

arid zones stretched near, or even to the coast in the north, west and south (Colhoun 1991: 50). The extent of the aridity at the last glacial maximum is highlighted by the presence of dune fields in northeastern Tasmania (Colhoun 1991: 25) (Figure 2.4).

The changes in water regime were followed by changes to the floral and the faunal communities. There was an expansion of true desert and vast areas of the inland became arid grass and shrub lands. With the lowering of sea levels two major areas of land became exposed, the Gulf of Carpentaria and Arafura Sea became a vast wooded, swampy plain (Nix & Kalma 1972) surrounding Lake Carpentaria, and Bass Strait became the Bassian Plain. New Guinea, Australia and Tasmania, along with numerous small islands became linked together into a single large continent known as Sahul. At the height of the last glacial maximum rainforest, both tropical and temperate, was almost completely replaced by more open forest communities and the extent of alpine and cold temperate habitats, such as steppe, also increased in the south and east (Mulvaney & Kamminga 1999: 179-180). To the human inhabitants of Australia these environmental changes must have undoubtedly presented behavioural and physical challenges to which they had to adapt.

2.2.4 Human Ecology in Australia

Evolution cannot be separated from the environmental context in which it occurs. Although other factors have undoubtedly played a part in human evolution, it is within the environment that humans live and reproduce. One of the principal elements of the environment is the climate, with rainfall, temperature and sunshine mediating the distribution of economic resources, predators and disease organisms.

The ultimate origin of the genus *Homo* was in tropical Africa and humans have adapted to hot conditions primarily through the mechanism of evaporative heat loss (sweating). The moisture that is lost from the body during this process has to be replaced and, as a result, humans are particularly dependent on adequate drinking water to survive (Newman 1970; Weiner 1973; Wheeler 1992a). In an arid continent like Australia access to water is the major constraining factor on the distribution of humans. Birdsell estimated that it was the availability of rainfall that determined both tribal densities per unit area of land and the absolute areas which tribes occupied (Birdsell 1953). The areas of abundant water resources tended to have the highest densities of people and the smallest tribal territories (Birdsell 1953).

The presence or absence of rainfall and standing water has also been argued to mediate human social relations and behaviour within Australia. Peterson has defined major culture areas in Aboriginal Australia based predominantly on the various drainage basins and the different habitats they contain (Peterson 1976). Veth has argued that the late Pleistocene oscillations in climate during the last glacial maximum (particularly the reduction in available water) led to changes in settlement patterns, economy, technology and demography (Veth 1989). Pardoe (1995: 709) has noted that areas rich in resources

tend to lead to heightened competition and closed inter-group relationships based on exclusion, whereas in areas of less predictable resource availability more open and inclusive social relationships predominate. These inter-group relationships in turn affect the evolution of the populations involved by helping or hindering gene flow between groups, causing breeding isolates to form or disintegrate and perhaps even leading to localised extinctions.

It has been suggested by Clive Gamble (1993), based on Robert Kelly's work (Kelly 1983), that given our evolutionary history the optimum hunter-gatherer habitats are temperate grasslands and tropical savanna (in other words open country with high biomass), add "-fisher" to the mix and this would also include access to riverine, lacustrine and marine habitats. Whilst there is relatively little true grassland in Australia today, it was more extensive during the last glacial maximum (Mulvaney & Kamminga 1999: 115), and there have always been large areas of fairly open forest that would have been further opened up, and extended in range, through firestick farming (Jones 1969; Tindale 1959; cf. Flannery 1990). Add to this the extensive lake systems that existed prior to the onset of the last glaciation, the riverine systems and a vast, resource-rich coastline, it becomes clear that much of Australia was prime habitat for human hunter-fisher-gatherers.

Certain habitats, however, are more difficult for humans. True desert with very little and unpredictable rainfall is marginal or uninhabitable and there are other habitats, although abundant in water, which are also sub-optimal for human life. These include closed forest, where many food resources are high in the forest canopy and difficult for humans to access, and areas of severe winter cold, where specialised adaptations, either cultural (shelter, clothing and food storage) and/or morphological and physiological, are needed to survive. That these ecosystems may have been difficult for Aborigines is seen in the archaeological evidence which indicates a late (mid Holocene) and/or seasonal occupation of such habitats (Bowdler 1981; McBryde 1976; Horsfall 1987 cited in Cosgrove 1996c; cf. Cosgrove 1996c) who argues for a deep antiquity for rainforest occupation in Australia). It should be noted, however, that some of this lack of evidence of occupation, particularly in the rainforest may, in fact, be the result of problems with archaeological visibility and/or poor preservation conditions.

This late occupation of some ecosystems leads onto a consideration of the post-glacial maximum period when climatic conditions ameliorated. In particular the mid- to late Holocene (6000 BP onwards) was a period of dramatic change in Aboriginal demography, society and culture as witnessed in the archaeological record. The upsurge in the number of occupation sites and the amount of artefacts found at sites has led some archaeologists to argue for a population increase during this period (Lourandos 1983, 1985; Mulvaney & Kamminga 1999: 267-272).

But also of interest is the evidence supplied by linguistics. One of the curious features

of Aboriginal languages is their geographic distribution. Of the estimated 250 distinct Aboriginal languages, 85 per cent belong to a single language family - the Pama-Nyungan. This language family covers almost 7/8ths of the continent. The non-Pama Nyungan languages, comprising of another 9 language families, are confined to the far northwest of the continent (Mulvaney & Kamminga 1999). There is disagreement as to the origins of the distribution of Pama-Nyungan. On the one hand, Dixon sees it as the result of long term cultural diffusion, with the language spreading without wholesale population movement (Dixon 1980). Such a scenario has also been put forward by Evans and Jones (Evans & Jones 1997). On the other hand McConvell has argued that it was a movement of people and language (McConvell 1996; McConvell and Laughren 1996). He expressed the opinion that entire

> "languages do not and cannot diffuse through space save in the mouths of (some of) their speakers. It is impossible to imagine a scenario in which a semiotic system as complex as a natural language could be thus transmitted by diffusion alone" (McConvell 1996: 128).

Analysing the linguistic similarities between dialects within Pama-Nyungan, and in particular the Nyungic dialects, he has put forward the hypothesis that the Nyungic language separated from the proto-Pama-Nyungan near the Gulf of Carpentaria, in the north of Australia, about 6000 - 5000BP. From about 4000 - 3000BP Nyungic speaking populations moved south and west, with the final element of the expansion into the Western Desert occurring after 2000BP (Figure 2.5). If there were such vast and recent movements of people within Australia there should be evidence of this in the biological record. This issue will be examined later in the present study.

Thus the effects of climate, both directly and indirectly, can be seen as a major influence on human ecology and ultimately evolution both biological and behavioural. This is not to suggest, of course, that the other major factors affecting human evolution are unimportant.

2.3 EARLY OCCUPATION HISTORY

2.3.1 Introduction

When did humans arrive in Australia and where did they come from? Given that this thesis is examining the possible causes for human variation in Australia these factors must be taken into consideration. The first factor is time. How long have humans lived within the Australian environment? In evolutionary terms it matters if they have been here fifty years or fifty thousand years, both in terms of the selective and stochastic processes of evolution. The second factor is space - where did the first Australians come from? Their geographic origins also relate to genetic origins.

2.3.2 Indigenous History

For its indigenous inhabitants, Australia has been home since the Dreamtime creation (Flood 1990: 10). For some groups oral history records that this land was the site of their creation by ancestral spirits, for others their ancestors travelled here from afar (Flood 1990: 19). Because of this, the theory that humans evolved elsewhere and migrated to this continent cannot be entertained within the cosmological traditions of some Aboriginal Australians and thus western science has come into conflict with indigenous views of existence. It is not the place of this thesis to debate the merits of either side of this argument. It can only be restated here that the theoretical context for this research is tied to the western scientific paradigm of evolution.

2.3.3 Theories on Aboriginal Origins

Ever since Europeans first encountered Australia's indigenous inhabitants they have theorised as to their origins. The same questions asked then are still being asked now and with as little success. Where did they come from? When and how did they get here? Are they descended from a single colonising event or from multiple events? Despite the ever-increasing bodies of evidence accumulated by anthropologists, linguists, archaeologists, biological anthropologists and geneticists, we are still no nearer to definitively answering these questions. All that can be done is to document the evidence we now possess.

2.3.3.1 Dating the occupation: Archaeological evidence

The history of archaeological discovery relating to the antiquity of Aboriginal occupation can be found in any basic text of Australian archaeology and will not be recounted here, except to underscore how it has affected views about the origins of Aboriginal people. Although it had already been suggested, by workers such as Mahony (Mahony 1943) and Birdsell (Birdsell 1941, 1949), that humans arrived in Australia during the Late Pleistocene, it was not until radiocarbon dating was developed in the late 1950s that the true time depth of human occupation in Australia was revealed.

Up until about 1990 radiocarbon dates suggested that human occupation did not stretch beyond about 40kya. Singh and his co-workers (Singh & Geissler 1985; Singh *et al.* 1981) had, at one time, suggested a much earlier date, of around 125kya, based on a comparison of sediment cores from Lake George in NSW with deep sea cores. The authors attributed a dramatic rise in charcoal density and a change from fire-sensitive to fire-resistant floral species in zone F of the lake core, to the advent of Aboriginal fire-stick farming at this early date. The early estimate for the age of zone F was discounted, largely because it was out of step with other data, particularly the complete absence of any archaeological evidence of human occupation at this time (Mulvaney and Kamminga 1999). Wright was to confirm these doubts when he radiocarbon dated the upper levels of the core, and through extrapolation, estimated zone F to be only about 60,000 years old (Wright 1986).

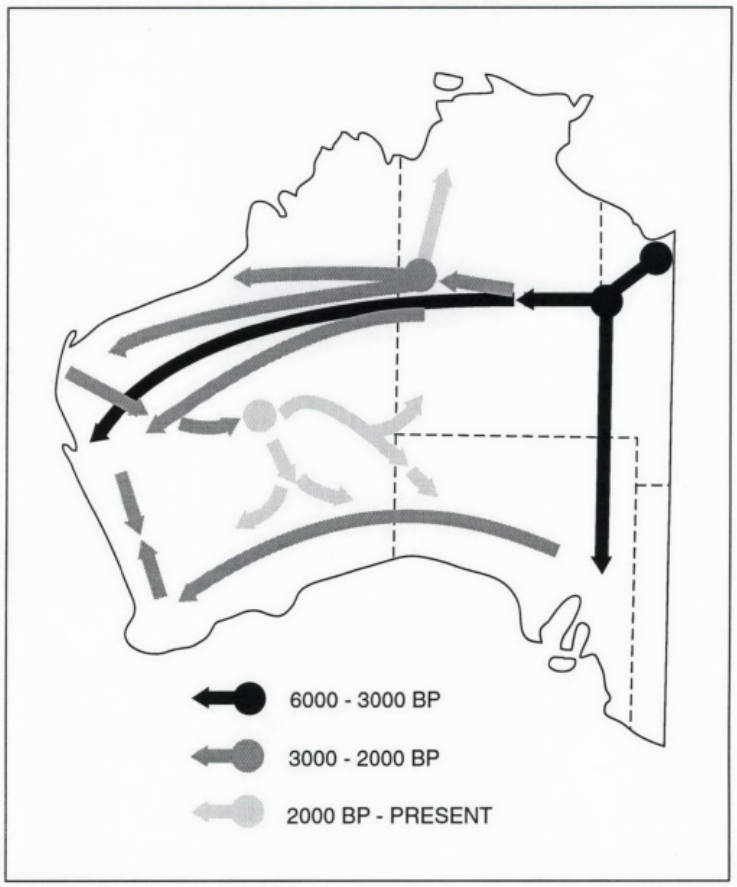


Figure 2.5: Pama-Nyungan language expansion, after McConvell 1996: 129, Figure 3.

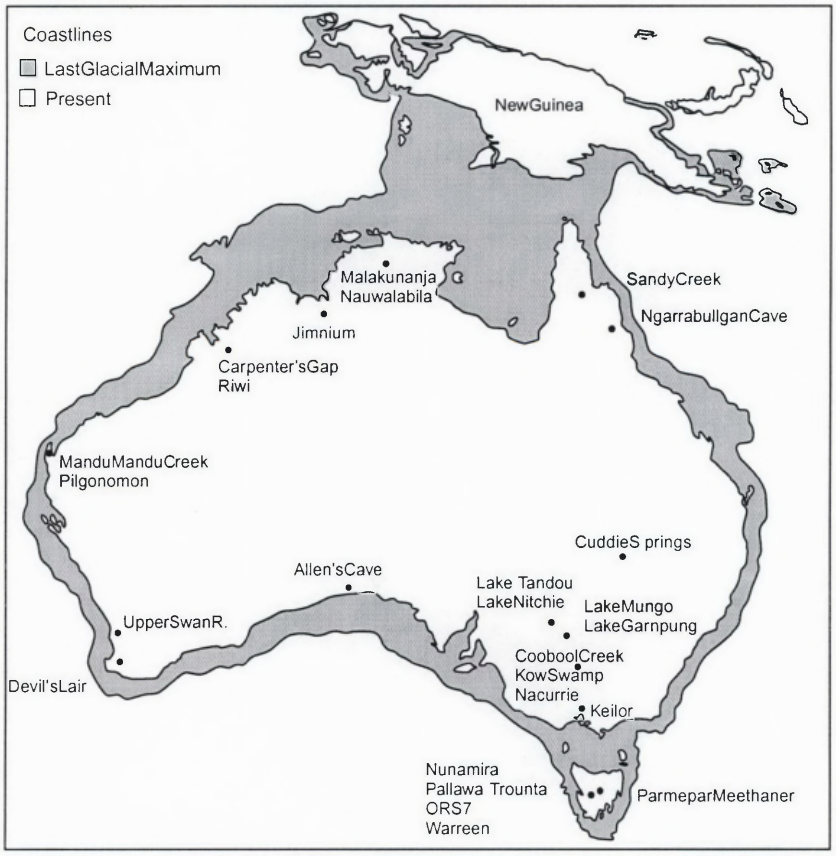


Figure 2.6: Human occupation and fossil sites mentioned in the text.

Yet the very limitations of radiocarbon dating (with an upper limit of about 50,000 years) have made it impossible to rule out an earlier occupation of Australia. Indeed, a date of around 50 to 60 kya for the initial occupation was considered likely, largely due to the known sea level changes in the Quaternary, with a low sea level just prior to 60 kya (Chappell 1993 cited in Mulvaney and Kamminga 1999: 106).

Table 2.1: Earliest dates for archaeological sites in Australia, adapted from Table 2 in O'Connell and Allen 1998: 141.

Site	Location	Dating method*	Oldest date at site (ka BP)	Reference
Malakunanja	Arnhem Land, NT	TL	61	Roberts *et al.* 1990
Nauwalabila	Arnhem Land, NT	TL	60.3	Roberts *et al.* 1994
Devil's Lair	Southwest WA	C14(AMS)	45	Turney et al. 2000
		C14	32.8	Dortch 1984
Carpenter's Gap	West Kimberley, WA	C14	39.7	O'Connor 1995
Allen's Cave	Nullarbor Plain, SA	OSL	39.8	Roberts *et al.* 1996
Upper Swan River	Southwest WA	C14	39.5	Pearce & Barbetti 1981
Keilor	South VIC	C14	38.8	Smith & Sharp 1993
Lake Arumpo	West NSW	C14	38.5	Clark 1986 cited in O'Connell & Allen 1998
Ngarrabullgan	South Cape York, Qld	C14	>37.2	David *et al.* 1997
		OSL	34	
Lake Tandou	West NSW	C14	~36	Clark 1986 cited in O'Connell & Allen 1998
Cuddie Springs	Central NSW	OSL	~35	Furby 1995
		C14	32	
Warreen	Southwest Tasmania	C14	35	Allen 1996
Parmerpar Meethaner	Central Tasmania	C14	34	Cosgrove 1995
Lake Mungo	West NSW	C14	32	Clark 1986 cited in O'Connell & Allen 1998
Lake Garnpung	West NSW	C14	32	Clark 1986 cited in O'Connell & Allen 1998
Sandy Creek	South Cape York	C14	32	Morwood *et al.* 1995
Mandu Mandu Creek	Cape Range Peninsular, WA	C14	~32	Morse 1993
Pilgonomon	Cape Range Peninsular, WA	C14	31.8	Morse 1993
Nunamira	Southwest Tasmania	C14	30.8	Cosgrove 1996a
ORS 7	Southwest Tasmania	C14	30.8	Cosgrove 1996b
Pallawa Trounta	Southwest Tasmania	C14	30	Stern & Allen 1996

* Radiocarbon dates are uncalibrated: calibrated dates would be about 4-5ky older.

From the dates presented in Table 2.1 (as illustrated in Figure 2.6), it can be seen that the earliest evidence for occupation is located in northern Australia (Malakunanja II and Nauwalabila in Arnhem Land) and are luminescence dates of between 50 000 and 60 000 BP (Roberts *et al.* 1990; Roberts *et al.* 1994). An OSL date of 116-176 BP at Jimnium was published in 1996 (Fullagar *et al.* 1996), however it was later found to be the result of contamination with the true date of human occupation at the site being Holocene (Roberts *et al.* 1998; Roberts *et al.* 1999). The other early thermoluminescence dates have also been

challenged (Bowdler 1990; Bowdler 1991; Hiscock 1990; O'Connell & Allen 1998).

Recent research has revealed the difficulties inherent in luminescence dating which include contamination by decaying rock-fall, incomplete bleaching and the difficulty in determining dose rates (see Gillespie & Roberts 2000; O'Connell & Allen 1998). O'Connell and Allen have further questioned the older luminescence dates on the grounds of the way in which the dates bracket site formation events (changes in sedimentation rates) and poor reporting of the excavations (O'Connell & Allen 1998: 134-137). They have challenged all dates beyond 40kya, arguing that the methodology of AMS radiocarbon dating is reliable enough that if the human occupation of Australia truly occurred in the period between 40,000 and 50,000 years ago, this would have shown up by now in archaeological investigations (O'Connell & Allen 1998: 141-142). As if in answer to this challenge the site of Devil's Lair, located in the extreme southwest of the continent, has recently yielded AMS occupation dates of between 48-50 BP (CAL) (Turney I. 2000).

However problematic the evidence for initial occupation is, it is certain that by between 30 and 20 thousand years ago the majority of Australia had been colonised, including the semi-arid areas (Mulvaney & Kamminga 1999; O'Connell & Allen 1998). However, following this first expansion of humans across the continent, Veth has shown that the increase in aridity caused by the last glacial maximum led to the withdrawal of people from the expanding arid zone into refuges with reliable water and food resources (eg. coast, rivers and uplands). When conditions improved during the Holocene these semi-arid areas were repopulated (Veth 1989).

As mentioned above, the available evidence suggests that on the mainland one of the last habitats to be colonised was the cold up-lands. The exception seems to be the highland areas of Tasmania's southwest, where rock shelters record continuous occupation during the last glacial maximum, an occupation which ceases about 13kya when temperatures rose and the uplands were recolonised by temperate rainforest (Flood 1990: 323; Mulvaney & Kamminga 1999: 181-182). One of the oldest sites in Tasmania is at Parmerpar Meethaner Rock Shelter, near Cradle Mountain in the central north. Occupied from about 34kya to only a few hundred years ago (Mulvaney & Kamminga 1999: 188-189), it is sited close to where a glacier flowed during the last glacial maximum. It may well have been only seasonally occupied, but even today conditions in the area can become treacherously cold even at the height of summer. This argues that the Tasmanians, despite a less complex material culture than mainland Aborigines (Flood 1990: 326), were able to successfully adapt to cold-climate conditions.

2.3.3.2 Dating the occupation: Fossil evidence

Although there is an ever-increasing body of archaeological evidence for the period between 40,000 and 30,000 BP and beyond, there is only one example of fossil human remains representing this period, Lake Mungo 3 (also known as Willandra Lakes

Hominid 3) and its dating is far from settled. The skeleton was originally dated to between 28,000 and 30,000 BP through the stratigraphic association of a dated section of the Mungo unit thought to correspond with the burial layer (Bowler & Thorne 1976). Recently Alan Thorne and his collaborators have published direct dates of c. 62±6ky BP for these remains, based on a combination of ESR (dental enamel), U-Series (bone shavings) and OSL (sediments) dating methods (Thorne *et al.* 1999). This date, and the inferences drawn from it, have been challenged on a number of fronts (see Bowler & Magee 2000; Brown 2000b; Gillespie & Roberts 2000): the major criticism being as, Gillespie and Roberts point out, that it is unlikely that the remains can be older than the sediments in which they are buried. The age of the level in which the remains were found (just below the Upper/Lower Mungo boundary) is estimated to be between 40,000 and 43,000 BP with a maximum range of 38000 to 46,000 BP (Gillespie & Roberts 2000). The disposition of the burial (see Figure 2 in Bowler and Thorne 1976: 130) clearly demonstrates that it was primary and undisturbed supporting Gillespie and Roberts' estimate for the age of LM-3. Moreover, the fact that it is a burial, and therefore intrusive, indicates that it is younger than the level in which it is buried. As Gillespie and Roberts (2000) conclude 'no change is warranted to the existing chronology, and [we] caution against accepting the new ages as reliable until such time as the dating uncertainties are resolved.'

This uncertainty leaves the Lake Mungo 1 (LM-1) female as the oldest securely dated skeleton found in Australia. Although it is possible that LM-3 is older, this is still to be proven beyond dispute. The dates for LM 1 in conventional (uncalibrated) radiocarbon years, ranges from *circa* 24ky BP (28ky CAL) to around 16 - 17ky BP (20ky CAL): the latter date being more likely on technical grounds according to Gillespie (1997).

The dating evidence reported in Tables 2.1 and 2.2, highlights the problems facing physical anthropologists researching Aboriginal origins. Whilst there is ample archaeological evidence for an occupation beginning about 40,000 BP or earlier, the human fossil record for this period is tentatively represented by a single skeleton of uncertain date and sex (Brown 2000b; *cf* Thorne & Curnoe 2000).

The vast majority of skeletal remains found in Australia have been dated to within the last 10,000 years and cannot be assumed *a priori* to closely represent their ancestors of 40 to perhaps 60 thousand years, and many human generations ago. Indeed, the degree of diachronic change in the last 10,000 years has been sufficient to clearly separate the earlier more robust Aboriginal populations from their smaller, less robust recent ancestors when they are compared in multivariate analyses (Brown 2000a: 115-119).

Table 2.2: Securely dated human remains in Australia prior to 10,000 BP (radiocarbon dates are uncalibrated).

Site	Location	Dating method	Material dated	Date, ka,BP (c14 CAL)	Reference
Lake Mungo, WLH-3	SW NSW	TIMS, GSU, ESR.	Bone and tooth enamel	50.7 - 78*	Thorne *et al.* 1999
		OSL	Sediment of Mungo unit	40-43	Gillespie & Roberts 2000
		C14	Shell and Charcoal	28-30	Bowler & Thorne 1976
Lake Mungo, WLH-1	SW NSW	C14	Insolubles	24.7**(28.5)	Bowler *et al.* 1972
		C14	Humic acid	25.1 (28.9)	Webb 1989: 7;
		C14	Humic acid	24.8 (28.5)	Gillespie 1997: 248
		C14	Insolubles	16.9 (19.8)	
Lake Mungo, WLH-9	SW NSW	C14	Insolubles	15.8 (18.4)	Webb, 1989: 7; Gillespie 1997: 248
Lake Garnpung, WLH-44	SW NSW	C14	Humic acid	18.6***(21.8)	Webb, 1989: 7;
				c. 14 (15-16)	Gillespie 1997: 248
Lake Nitchie South	SW NSW	C14	Charred collagen	15.3# (17.8)	Macintosh & Larnach 1976: 122
Coobool Creek 65	SW NSW	U/Th	Bone	14.3	Brown 1989: 5
Lake Garnpung, WLH-50	SW NSW	TIMS/ GSU	Bone	11.1-15.8	Simpson & Grün 1998
		ESR	Bone	c.30	Caddie et al. 1987
Lake Tandou (cremation)	W NSW	C14	Charred collagen	12.5# (14.5)	Allen 1972; Hope I. 1983
Keilor	VIC	C14	Collagen	12.0# (14)	Brown 1987
Lake Garnpung, WLH-24	SW NSW	C14	Insolubles	11.9 (13.7)	Webb, 1989: 7; Gillespie 1997: 248
Lake Garnpung, WLH-23	SW NSW	C14	Insolubles	11.7 (13.5)	Webb, 1989: 7; Gillespie 1997: 248
Nacurrie 1	SW NSW	C14	Collagen	11.4# (13.2)	Brown 1994
Lake Garnpung, WLH-122	SW NSW	C14	Insolubles	11.1 (12.7)	Webb, 1989: 7;
			Humic acid	16.5 (19.3)	Gillespie 1997: 248
Kow Swamp 1	VIC	C14	Apatite	10.07 (11.7)	Thorne & Macumber 1972: 317

*Contentious date. ** These are Stage 1 insolubles that are now known to be mostly humic acid (Gillespie 1997: 245). Humic acid and apatite dates are subject to contamination and are unreliable. *** Lake Garnpung WL44 has a date of about 18.6kya BP. Webb (1989: 7) states that this date came from the insoluble fraction, however Gillespie (1997 and personal comment) who carried out the dating, notes that the fraction was in fact fully soluble and thus was humic acid. Its true age is probably one to three thousand years older than the other Lake Garnpung skeletons, ie. 15-16ka BP calibrated (Gillespie personal comment) or about 14ka BP, uncalibrated. # It is likely that the dated fractions contained humic acid.

Another serious problem lies in the restricted distribution of the Australian Pleistocene fossil evidence with the vast majority being confined to the continent's southeast. Whilst there are (or at least were, as many museum collections have been repatriated) collections of skeletal material from around Australia, these represented recent populations and were often poorly provenanced. This lack of evidence has not only hampered research into Aboriginal origins, but also the study of diachronic change and human evolution over this time period in Australia. Consequently the studies of evolution in Australian populations have been limited to the southeast (eg. Brown 1987, 1989, 1992b; Pardoe 1995;

Pietrusewsky 1979), and this is a very small window through which to view the human past in Australia.

A further challenge to palaeoanthropologists lies in the identification of likely ancestor populations for the Aborigines in Southeast Asia and southern China. Over the years "Australoid" features, or affinities, have been attributed to a number of fossils from this region. One putative ancestral group comes from Indonesia. Arguing within the multi-regional paradigm, Wolpoff, Thorne and their co-workers have identified a "unique combination" of cranio-facial traits they argue provide evidence of a direct phylogenetic link between the so-called robust late Pleistocene/early Holocene Australians and Indonesian *Homo erectus* (Thorne & Wolpoff 1981, Wolpoff 1995; Wolpoff *et al.* 1984; Wolpoff *et al.* 2001). Indeed Wolpoff sees Indonesia as a 'significant source for Aboriginal Australians' (Wolpoff 1995): 749). The dating of all the early Indonesian hominid material is problematical as most of the hominid fossils are poorly provenanced and none are directly dated (for a review see Wolpoff 1995), however the dates are approximate enough to suggest that the multiregional theory would necessitate the retention of a suite of features for a least one million years (Hyodai *et al.* 1993, Morwood *et al.* nd) and possibly longer (Swisher *et al.* 1994).

Morphological similarities have also been drawn between the Ngandong calvaria and the robust Australians (mostly recently in Wolpoff *et al.* 2001) and whilst the Ngandong hominids may have lived later in the Pleistocene, again their dating is uncertain. Swisher produced a date of 27,000 BP, based on associated faunal remains (Swisher *et al.* 1996), however more recent direct dating by non-destructive gamma-ray spectrometry, suggests they are older than 200 kya (Yokoyama *et al.* 1998). Swisher's date, even if correct, would place the Ngandong population too late to be considered an 'ancestor' of Aboriginal people. The earlier dates, however, put them in the right place and time to be considered a stage along the multiregional route to modern human populations in Australia. Alternatively, as might be argued by the proponents of the 'Out of Africa' theory, they could merely be an evolutionary dead end - the last gasp of Indonesian *Homo erectus*, wiped out or absorbed as the ancestors of modern Australians colonised Southeast Asia.

The other major contenders for an Australian ancestor from SE Asia are the deep Niah skull found in cave deposit in Borneo (Brothwell 1960; Kennedy 1977) and the Wadjak skulls from Java (Dubois 1922). Niah is a distorted, juvenile cranium that has been indirectly radiocarbon dated to close to 40kya (39, 820 ±1012 year BP: Oakley *et al.* 1975). Wolpoff however, notes the presence of Holocene burials in the cave and implies that the skull is sourced from an intrusive burial and not associated with the dated charcoal (Wolpoff 1995: 748). Moreover, morphological studies have linked this cranium, not with Australia, but with Asia (Wu 1987).

Wadjak 1, initially thought to be thought to be Pleistocene in age (Dubois 1922) is a reasonably well-preserved skull and was considered by Weidenreich to be a twin of

Keilor (Weidenreich 1945). Subsequently it has been morphologically and chronologically reassessed (Storm 1995; Storm & Nelson 1992; Theunissen *et al.* 1990) and found, as Wolpoff has admitted, to "hold little relevance" to the question of Australian origins (Wolpoff 1995: 748).

At least two fossils from East Asia have also come under scrutiny as representing possible ancestral groups. Coon (1962) suggested that Liujiang, a well-preserved skull of undetermined sex (Brown 2000a: 113; contra Wu 1959) from the Guangxi Zhuang region of southern China, had Australoid characteristics. Some years later Thorne (Thorne & Raymond 1989 46) was also to suggest a link between Liujiang and the Aboriginal fossils from the Willandra Lakes he terms gracile. He also included the female cranium from Ziyang (Sichuan Province, southwest China). Unfortunately for Thorne both the dating of these fossils and the studies into their morphological affinities has undermined his position. Neither Liujinag nor Ziyang are directly dated. Although there is a Uranium-series date of 67,000 +6000 -5000 (Wu 1988) for Liujiang, the relationship of the dated layer and the fossil is uncertain (Chen & Zhang 1991). Brown (2000a: 111) maintains that at "present it must be said that the Liujiang skeleton remains undated". Further, a statistical analysis conducted by Brown indicates that Liujiang's morphological affinities do not lie with modern or Pleistocene Aboriginal populations as might be expected if Liujiang represented an ancestral type (Brown 2000a: 115, Figure 3: it should be noted that due to poor preservation neither Mungo 1 nor 3 were included in this analysis). As for Ziyang, contradicting Thorne's description of the cranium as "delicate"(Thorne & Raymond 1989): 27), Wolpoff asserts that it is small, but robust (Wolpoff 1995: 742). Its age is also uncertain with the reported radiocarbon dates of either 39-36 kya or 7kya highlighting the poor provenancing of the fossil (Wolpoff 1995: 742). Indeed even if the early date is correct, it still leaves Ziyang too young to be considered a direct ancestor for Aboriginal Australians.

2.3.3.3 Aboriginal Affinities in Time and Space

The debate over Aboriginal origins has always centred on two major questions. 1) From where did the ancestors of the Aborigines originate? 2) Was there a single founding event or was there more than one major migration?

These questions are inexorably linked and the answers to them have depended on the interpretation of the variation found in Indigenous Australians, past and present. The important questioning being - is the variation seen within Aboriginal populations too great to be the result of evolution within a single founder population? This is a simple question with no easy answer.

The first question has traditionally been investigated through comparison with populations outside Australia using a range of evidence and methodologies. Initially anatomical variation from living and skeletal populations was examined along with

comparisons of culture and linguistics and such analyses are still relevant. With scientific advances came the analysis of gene products (beginning with blood antigens), gene markers and more recently base sequences. The quantitative methodologies used to analyse this data have ranged from simple morphological comparison to sophisticated multivariate statistical techniques.

Some early explorers such as William Dampier likened Aboriginal people to black Africans (Dampier 1697), however 18th Century observers such as James Cook (Wharton 1893) and Joseph Banks (Beaglehole 1962) recognized that the resemblance was superficial. Not only were they physically unlike Africans (apart from their dark skin colouring), but the mainland Aborigines in particular, were distinct from the peoples of New Guinea, Southeast Asia and the Pacific (see Brown 1997). The Aborigines seemed to be unique and they were often designated as one of the major races - Australian or Australoid - a rather nebulous group that could also include Melanesians and even southern Indians (Coon 1962; Howells 1937). But the situation was confused by the apparent differences between the Tasmanians and the mainland peoples. In particular their tightly curled head hair elicited comparison with Melanesians or Negritos (Howells 1973a; Huxley 1870; Topinard 1872). For the mainland Aborigines other contenders for affiliation were as far-flung as the Ainu of northern Japan and certain tribes in India (Birdsell 1941, 1949, 1967, 1977, 1993; Huxley 1870; Topinard 1872). The most parsimonious course - on the basis of geographic proximity alone - would be to look for evidence of Aboriginal origins in certain of the Melanesian groups to the north of Australia. This does not, however, answer the question of where the ancestors of Australians or indeed the older strata of Melanesians originated.

The links with Melanesia have been borne out by numerous multivariate studies using craniometric (eg. Brace & Hunt 1990; Giles 1976; Howells 1973a, 1976, 1989, 1997; Pietrusewsky 1983, 1984, 1990) and genetic data (eg. Brinkman *at al.* 1996; Cavalli-Sforza, *et al.* 1994; Kirk 1976, 1981; Nei & Roychoudhury 1993; Serjeantson 1989; Van Holst Pellekaan *et al.* 1998; cf. Redd & Stoneking 1999). But another thing is also clear: despite their similarities there are also striking differences, particularly genetically. Melanesians are a genetically, linguistically and culturally diverse people (Houghton 1996: 136-140), so much so that Houghton considers Melanesia a geographical not biological region (Houghton 1996: 139). Even though Melanesians and Australians share a common ancestry it now seems clear that continued gene flow into Melanesia, the relative isolation of Australia for the last 8,000 years combined with inter-regional micro-evolution have all combined to create the differences between the populations.

In order to explain the variation between Australians and Tasmanians, and also between recent and fossil mainland groups, scenarios involving multiple migrations and hybridisation have been put forward (Birdsell 1941, 1949, 1967, 1977, 1993, 1939; Freedman & Lofgren 1979; Huxley 1870; Thorne 1971, 1972, 1976, 1977, 1980, 1984; Thorne

& Macumber 1972; Tindale & Birdsell 1941; Topinard 1872, Wunderly 1943). The earlier studies such as those of Huxley, Topinard, Fenner and Wunderly were conducted within a scientific paradigm that saw variation in modern humans being the result of the mixing of "pure races". Echoes of this paradigm can also be found in Thorne's work.

Birdsell's early research, too, was conducted within such a paradigm. He argued that the Aborigines were the descendants of three separate migrations, related to, in order of entry, Southeast Asian Negritos, the Ainu of Japan and the Veddoid populations of southern India. Some research effort has been put into examining Birdsell's tri-hybrid theory using both craniometrics and genetics, yet successive studies found virtually no evidence to tie Australians with any of his proposed founder groups (Boyd 1963; Hanihara 1993; Kirk 1976; Omoto & Misawa 1976; Simmons 1973; but see Prokopec & Sedivy 1976 on dermatoglyphics). A more detailed discussion of Birdsell's work will be presented in the following chapter.

The catalyst of so much debate over Aboriginal origins, the possibility of a distinct origin for the Tasmanians, was examined by Pardoe (1991). Analysing non-metric traits using multivariate analysis he found that his Tasmanian sample represented an isolated outlier of the Aboriginal populations of the southeast mainland Pardoe 1991: 6-7). His results, however, are somewhat weakened by the fact that many of the collections of Tasmanian crania housed in Museums around the world may be not be Tasmanian at all, but rather merely designated Tasmanian because they fitted a supposed type.

Although the concepts of racial typology and race mixing began to lose its currency from the 1950s, the idea that gene flow was responsible for the temporal and spatial variation seen in Aboriginal people persisted. As mentioned in the previous section, Alan Thorne, basing his theory on fossil evidence, has argued for a di-hybrid mix, which included the archaic hominid populations of Indonesia and modern humans from southern China. The idea that Indigenous Australians are descended either in part or in total from the archaic hominids of Indonesia is a tenet of the multiregional or regional continuity theory of human evolution. This theory states that regional populations of archaic humans evolved into the *Homo sapiens* populations found in those regions (Coon 1962; Thorne & Wolpoff 1981; Weidenreich 1939, 1943; Wolpoff, *et al.* 1984). It was Herman Klaatsch who first contended that modern Aboriginal Australians owe some of their genome to the *Pithecanthropines* of Indonesia (Brown 1997; Klaatsch 1908). This theory was later expanded upon by Franz Weidenreich who not only saw morphological continuity between the Javan *erectines* and Australians and Melanesians, but also between the Chinese *erectines* and modern Chinese populations (Weidenreich 1939, 1943). The hypothesis of Indonesian origins is supported, according to its proponents, by a suite of morphological features in Late Pleistocene Australians that can be traced back to their Middle Pleistocene ancestors from Southeast Asia. The shared features include thick vault bones, a long flattened frontal without a distinct supraorbital sulcus, strong,

continuous browridges, posterior position for the minimum frontal breadth, prebregmatic eminence, large prognathous face, rugged, rounded cheekbones positioned in an anterolateral direction, a rolled edge on the lower margin of the orbits, a malar tuberosity, flat nasal floor and large postcanine teeth (Frayer *et al.* 1993; Thorne & Wolpoff 1981). It has been pointed out, however, that the so-called clade features can be also found in other archaic groups (Bräuer 1989; Groves 1989; Habgood 1989, 1992; Lahr 1994, 1996), although the multiregionalists have countered by saying it is the combination of features that is significant, not the isolated features themselves (Frayer *et al.* 1993; Habgood 1989, 1992).

As mentioned above, in the case of Australia Alan Thorne has argued for two major migrations: the first a group with genetic ties to Indonesian *Homo erectus* (the robust group, typified by Kow Swamp) and a second, later migration of modern *Homo sapiens* from southern China (the gracile group, typified by Lake Mungo 1 and 3) (Thorne *et al.* 1999; Thorne 1971, 1972, 1976, 1977, 1980, 1984; Thorne & Macumber 1972; Thorne & Wolpoff 1981). Thorne's theory, based on the assumption that the cranially robust fossils represent a separate lineage to the gracile fossils, has always suffered from a severe dating problem: namely that all the "archaic" fossils are much younger in time than the "modern" ones and this would have entailed a long period of coexistence of these groups without intermixing. It is telling that Wolpoff, although a long-time collaborator with Thorne has remained unconvinced by his di-hybrid theory of Aboriginal origins (Wolpoff 1995: 751).

Yet what is clear is that there is no evidence for a close phylogenetic link between modern Australian, and Indonesian and Chinese populations, either in terms of craniometrics or genetics (eg. Brown 2000a; Cavalli-Sforza *et al.* 1994; Howells 1973a, 1973b, 1989, 1997), but given the time depths involved (c. 40,000 years) and clear evidence for quite recent, large scale population movements in this region (Bellwood 1978; Houghton 1996), this would be an unlikely finding in any case (Brown 2000a).

An alternative view to Thorne's, interprets the variation existing in Australia as being due to the normal processes of genetic differentiation of a single founder population spread over considerable time and space (Abbie 1968; Brown 1987, 1989, 2000b; Habgood 1986; Howells 1937; Lahr 1996; Macintosh 1963; Turner 1884). Although, as can be seen from the references cited above, it is a theory with a considerable history, it has more recently become allied to the 'Replacement' or 'Out of Africa' hypothesis of modern human origins, although it is certainly not synonymous with it (eg Habgood 1992). The Replacement theory sees modern humans as evolving about 200 - 100kya, most likely in Africa, and thence moving out to replace - with or without admixture - the archaic populations of the Old World (Bräuer 1989; Stringer & Andrews 1988; Stringer 1992).

It is possible that in the future the analysis of "fossil" DNA may help to solve the puzzle of Aboriginal origins. There has yet to be any such investigation into the Southeast

Asian hominids, as has been conducted on the Feldhofer and Mezmaiskaya Neandertals (Krings *et al.* 1999; Ovchinnikov *et al.* 2000) and, more recently, on Lake Mungo 3 (Adcock *et al.* 2001a). As a result specific genetic evidence linking the relevant Indonesian or Chinese fossils to the Australian material is lacking. Whilst initial studies into MtDNA variation within fossil and living Aboriginal groups hints at the possibility of multiple founder groups (Adcock *et al.* 2001a; Redd & Stoneking 1999; Van Holst Pellekaan *et al.* 1998), further work is necessary before the results of these studies can be placed in their true context (for instance see Adcock *et al.* 2001b, Cooper *et al.* 2001). This is all the more pertinent given the results of recent Y chromosome studies that may support a single founder population (Underhill *et al.* 2001).

Another issue, related to the question of Aboriginal origins, is the extent of variation in the mainland Aborigines: were they relatively homogeneous or heterogeneous? Some physical anthropologists have claimed that there is little if any morphological variation present in Indigenous Australian populations (eg Abbie 1968, 1976; Parsons & White 1976). However, ongoing research has demonstrated that Aboriginal peoples were not the same everywhere, either in time or space. Not only did they clearly differ in aspects of culture (eg. regional differences in art, stone tools types and dietary preference (Flood 1990; Mulvaney & Kamminga 1999), they also differed morphologically. Various studies of recent crania have found north-south and east-west clines (or distinctions) in cranio-facial shape (Freedman 1964; Giles 1976; Larnach and Macintosh 1966; Pardoe 1991; Pardoe 1994; Pietrusewsky 1990; Van Holst Pellekaan 1990) although results tend to vary depending on factors of sampling, variable choice and analytical methodology. Diachronic change in skeletal morphology has also been demonstrated by Brown (1981b, 1987, 1989, 1992a, 1992b). He conclusively demonstrated that there had been a significant reduction in body size and skeletal robusticity in the populations of the Southeast during the Holocene. Brown considered this an adaptation to the increasing temperature of the Holocene climate Brown 1987: 62), however Pardoe has linked it to population pressure combined with deteriorating environmental conditions (Pardoe 1995: 703).

It is somewhat frustrating that despite over 300 years of inquiry, and an ever-increasing database, the only consensus about Aboriginal origins is that they must have come from or through Asia, almost certainly used some type water-craft to reach Australia and arrived here around 40,000, and perhaps up to 60,000 years ago. The Aboriginal people are most like the Melanesian populations to the North but they are also genetically, physically, culturally and linguistically distinct from them. Still missing, and crucial to solving this long-term puzzle, is sufficient well-preserved and securely dated fossil evidence from the time period between 100,000 and 40,000 BP in Southeast Asia and Australia. Only when (or indeed if) such evidence is uncovered can the competing hypotheses regarding the late Pleistocene occupation of Australia by humans be confidently tested.