Murray River Societies in Australia through the Lens of Bioarchaeology

Judith Littleton, Sarah Karstens, and Harry Allen

The Oxford Handbook of the Archaeology of Indigenous Australia and New Guinea
Edited by Ian J. McNiven and Bruno David

Subject: Archaeology, Archaeology of Australia Online Publication Date: Apr 2021
DOI: 10.1093/oxfordhb/9780190095611.013.33

Abstract and Keywords

The Murray River Valley was one of the most densely occupied areas of inland Australia during the Holocene. Unlike other areas of Australia, the record of burials and human remains dominates archaeological narratives of this area’s Aboriginal experience. In this article, we review bioarchaeological evidence from the region. In addition to mortuary remains, also discussed in this article are evidence from human morphological variation, palaeopathology, and diet. While the valley is often treated as a single region, Aboriginal communities who lived along the Murray shared aspects of economic and cultural systems but also demonstrated diversity and local trajectories. Rather than a single grand narrative the valley’s bioarchaeological evidence shows variation which is the product of multiple local factors.

Keywords: mortuary practices, bioarchaeology, palaeopathology, morphological variation, Aboriginal burial places, southeastern Australia, stable isotope analysis, non-metric variation

Introduction

The Murray River Valley was identified by Birdsell (1953) as one of the few inland areas in Australia that did not conform to a regular correlation between annual rainfall and the density of Aboriginal linguistic groups. The supply of water and its associated resources meant that this was a high-population region with much linguistic diversity distributed along the river and its tributaries. This contrast to the surrounding country and to the general correlation in the inland between population density and annual precipitation defined the Murray River Valley as a distinct region. Subsequent archaeological and anthropological analyses have often emphasised that riverine unity. In this article, we evaluate the unity of Murray River societies in the Holocene period, exploring the tension between regional and local perspectives.

This article focusses on the bioarchaeological record because, unlike other areas of Australia, the record of burials and human remains dominates the archaeological narratives of the Murray River Aboriginal experience. The perspective here is an integrated one, where the study of burial practices and the human remains contained within burial sites are brought together within a framework that includes natural history, observations of Aboriginal ethnography, and where possible, other archaeological studies. Different aspects of bioarchaeological analysis (mortuary remains, morphological variation, palaeopathology, and diet) are also discussed in detail.

The Murray River as a Human Environment

The Murray River is Australia’s longest river (2500 km). As it flows from the Snowy Mountains to the sea, it passes through a number of ecological–physiographic regions (Figure 1): Highlands, Riverine, Central Murray Mallee, Gorge, and the Coastal Lakes and Estuary sections (MacKay & Eastburn, 1990) (Table 1). For most of this course, the Murray flows roughly east to west until it reaches Morgan in South Australia, where it turns southward towards Lake Alexandrina and the sea. For the greater part of its course, the river moves from an area of higher rainfall (800 to 1200 mm per annum) in the Highlands to a much lower rainfall regime (200 to 400 mm per annum) on the plains through a succession of vegetation zones.

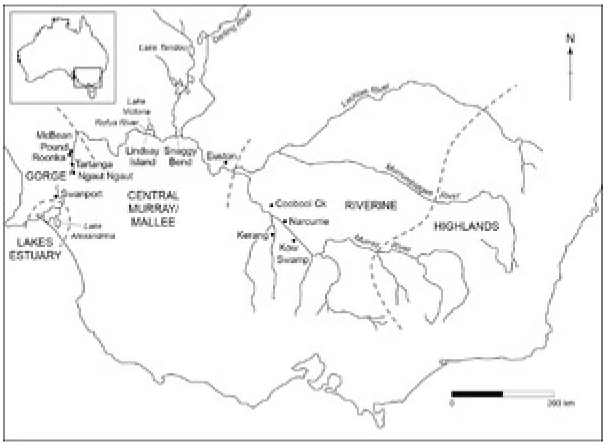

Figure 1. Map of the Murray River Valley and major tributaries, with the physiographic regions identified along with sites mentioned in the text.

Table 1. Murray River Sections (List of Murray River Distances, *Wikipedia*, available from: https://en.wikipedia.org/wiki/List_of_Murray_River_distances; MacKay & Eastburn, 1990).

Murray River Major Divisions		**Section**	
Upper	Mt Kosciusko to Corowa (450 km)	Highland—Headwaters	
Middle	Corowa to Wakool River (810 km)	Riverine	
Lower	Wakool River to the River Mouth (1300 km)	Mallee	Wakool River to Overland Corner (860 km)
		Gorge	Overland Corner to Mannum (280 km)
		Coastal lakes and Estuary	Mannum to the Coorong (160 km)

While rainfall is spread over the entire year, summers are hot and evaporation is high, whereas winters are cooler with lower evaporation. This rainfall distribution gives the Murray River Valley an effective Mediterranean climate, with most growth in the natural vegetation occurring during the winter and spring months (Laut et al., 1977a, 1977b; MDBA, 2020).

While much of the Murray Basin is semiarid, the river itself was highly productive in terms of water and food for local Aboriginal communities (Allen, 1972; Humphries, King, & Koehn, 1999; Lawrence, 1968; Walker, Sheldon, & Puckridge, 1995). Before the river was controlled through locks and dams, much of its productivity was determined by annual rises associated with spring snowmelt on the mountains and winter and spring water entering the Murray via tributaries, with Aboriginal subsistence varying with the ecological conditions of different river sections (Table 1).

Aboriginal people used the entire Murray River to hunt, trap, net, and gather waterfowl, fish, shellfish, aquatic and swamp plants, crustaceans, amphibians, and mammals. On the adjacent plains, they collected a variety of plant foods and organized hunts of large, medium, and small mammals using spears and spearthrowers, fire drives, and nets (Allen, 1972). Observing these economic similarities, Pardoe (1995: 704) found a pattern of regional coherence along the entire river, excluding the Highlands. Certainly, communities invested in nets, traps, and weirs to harvest fish and waterfowl in a manner that was common along its central and lower reaches. Large and small bark canoes were ubiquitous, evidenced today by numerous old 'scarred trees'—that is, trees revealing the removal of large sections of bark (Edwards, 1972).

This pattern of similar resource reliance begs two questions. First, was this riverine economy equivalent along the river from the Riverine section down to the sea? Second, was this mode of production distinct from that used in other areas of Australia? Lawrence (1968: 85) defined participants in a riverine economy as groups that 'spent at least some seasons of the year in continuous settlement on the rivers, and whose economy … showed some specialization in the collection of riverine foods'. In a comparison of Aboriginal lifeways, Keen (2004) found strong similarities in the organization of production across Australia. Similarly, McCarthy (1957) observed that Aboriginal material culture and economy everywhere showed hunting, fishing, and collecting, with variations depending on local circumstances and seasons. Certainly, Murray River Aboriginal people made considerable use of nets, traps, and weirs to harvest fish, and they developed specialized long nets stretched across waterways anchored to trees on adjacent banks to capture large numbers of waterfowl. However, as Satterthwait (1987) and Kelly (2014) point out, the use of large nets for hunting and fishing, and traps and weirs for harvesting fish, was widespread, and what we see in the Murray Valley was the adaptation of generally available material culture to particular circumstances.

Depending on how Aboriginal tribal-linguistic groups are defined, more than 20 Aboriginal groups occupied territories along the Murray River (Table 2). Peterson (1976) noted a correlation between high Aboriginal populations and river productivity along the Murray, but he also observed that there was a different language group along every 50 km or so of river frontage. He considered that ease of communication along the river should have brought Aboriginal groups closer together. However, the evidence is that the closest cultural and linguistic ties were with related tribal groups away from the river rather than with immediate riverine neighbours. For example, in a series of papers, Pardoe has attempted to draw multiple factors (landscape, ecology, human biological and social information, population, and productivity) into an evolutionary model to explain this cultural and linguistic diversity (see references in Pardoe 2006). Noting that the greatest ecological contrast was between the river valley and the surrounding semiarid plains, Pardoe contrasted the open boundaries and gene flow between the river and its hinterland with marked divisions along its course, which he links with processes of social exclusion and competition over resources. Pardoe interprets the presence of long-term cemeteries as markers of land ownership.

However, in addition to ecology, historical factors are relevant in explaining diversity along the Murray. The distribution of language groups along the river (Table 2) suggests that Upper Murray languages were once continuous along its length. The movement of Kulin speakers from Victoria, and of Bagandji speakers from New South Wales, towards highly productive river frontage territory has disrupted this pattern and created a diverse cultural and linguistic landscape. Other studies show both continuities and discontinuities along the river, such as the common nature of burial locations but with distinctive local mortuary practices (e.g., Littleton & Allen, 2020). Hercus (2010: 170) describes the Murray corridor as a 'language cross-roads', quoting A.L.P. Cameron that most Aboriginal people there could speak two or three languages and could understand even more. Hercus further noted that these tribes shared a common social system, which facilitated intermarriage across linguistic lines at the same time that linguistic diversity was emphasized. Such studies emphasize both relatedness and diversity.

Table 2. Tribal-linguistic units and language groups along the course of the Murray River from the headwaters to the sea (data after Hercus, 1986, 2010). Note that the orthography of Aboriginal tribal names is highly variable.

<table>
<tr><th colspan="2">Murray River Section</th><th>Language Group</th><th>Aboriginal Tribe/Linguistic Unit</th></tr>
<tr><td colspan="2" rowspan="3">Highlands—Headwaters</td><td rowspan="4">Upper Murray</td><td>Dhudhuroa</td></tr>
<tr><td>Djilamatong</td></tr>
<tr><td>Bangeran</td></tr>
<tr><td colspan="2" rowspan="5">Riverine</td><td>Yorta Yorta</td></tr>
<tr><td rowspan="3">Kulin</td><td>Berabaraba</td></tr>
<tr><td>Wemba Wemba</td></tr>
<tr><td>Wadi Wadi</td></tr>
<tr><td>Upper Murray</td><td>Dadi Dadi</td></tr>
<tr><td colspan="2" rowspan="8">Mallee</td><td rowspan="2">Kulin</td><td>Madi Madi</td></tr>
<tr><td>Latje Latje</td></tr>
<tr><td>Upper Murray</td><td>Nari Nari</td></tr>
<tr><td rowspan="2">Bagandji</td><td>Gureingi</td></tr>
<tr><td>Marawara</td></tr>
<tr><td rowspan="5">Upper Murray—Meru</td><td>Ngintait</td></tr>
<tr><td>Yirawirung</td></tr>
<tr><td>Ngawait</td></tr>
<tr><td>Mallee</td><td>Gorge</td><td>Ngaiawang</td></tr>
<tr><td>Gorge</td><td>Lakes</td><td>Nganguruku</td></tr>
</table>

Lakes Estuary	Lower Murray	Ngarrindjeri

Murray River Sections

While most commentators consider the Murray to be a unified entity, there is considerable variation in its ecology, physiology, and in the timing of Aboriginal occupation and response across the sections identified in Table 1.

The Highlands was an area of medium to high relief, with narrow, fast-flowing streams and eucalypt forest and woodlands. Aboriginal populations were probably small and of low density, with the people highly mobile. The rivers and forests also probably had medium- to low-subsistence potential for Aboriginal hunter-gatherers using fire, spears, and digging sticks. Archaeological evidence for this section is sparse, with some concentration of activity (e.g., stone artefacts) on river flats and mid-latitude valleys. Excavated sites are few, with intermittent dates of occupation beginning c. 25,000 years ago and increased usage in the past 3000 years (Frankel 2017: 179).

The Riverine Plain was created by the Pleistocene Lachlan, Murrumbidgee, and Murray Rivers, where prior streams carried a bedload of sand and gravels and more recent ancestral streams carried clays. It is an area of braided river channels, floodplains, backplains, swamps, lakes, and lunettes, with riparian gum forests, open woodlands, and extensive areas of saltbush and grasslands (Hill, De Decker, von der Borch, & Murray-Wallace 2009; NSW Government, n.d.; Pels 1964). This plain was a productive resource zone, especially during spring when floods overtopped the banks of the many streams to create swamps which lasted through the summer period and into the autumn. These waters carried many fish, turtles, and freshwater crayfish, and, most importantly, bulrush (*Typha* spp.), which was collected and cooked in ground ovens to provide farinaceous carbohydrate in immense quantities (Gott 1999). Archaeological evidence for use of these resources lies in the many earthen mounds situated along the course of the rivers and major creeks, many of which have been mapped and excavated. These mounds are the product of using baked clay in ovens over the past 5000 years, with the result that the mounds themselves became elevated camping places above the floodwater levels (Frankel 2017; Martin 2011). A useful by-product of bulrush was the fibre in its rhizomes. The intensive chewing of this fibre for string used in the manufacture of nets, baskets, bags, and other implements has left distinctive wear marks on the teeth of Aborigines from this area (Pardoe 1995: 708). Aboriginal populations in this area were large and of high density, and, at least seasonally, semi-sedentary. Human burials are common in both the mounds and source bordering dunes along the creeks.

In the Central Murray Mallee section, the river moves into a semiarid area dominated by Quaternary dunefields and a floodplain that is between 5 and 25 km wide. Here the Murray River features narrow riparian gum forests along its banks, and mallee woodlands, saltbush, and grasslands on the adjacent plains (Bowler & Magee 1978; Laut et al.

1977b). The slow-flowing and sinuous nature of the river, together with the uniformity of its sediments, means that the Central section is characterized by multiple channels, cut-offs, oxbow lakes, and billabongs that fill when the river floods at overbank stage. As with the Riverine section, this flooding creates highly productive wetlands and swamps. To the north of the Murray within the sand dune belt of southwest New South Wales, the Pleistocene Willandra Lakes have archaeological sites dating to 45,000 BP, while occupation at Lake Tyrrell to the south of the Murray in northwest Victoria goes back 30,000 years (Hiscock 2008; Richards, Pavlides, Walshe, Webber, & Johnston 2007). Along the Murray corridor, archaeological remains consist of freshwater mussel shell middens and areas of multiple heat retainer hearths dating back 15,000 years (Prendergast, Bowler, & Cupper 2009). These ages have been extended by research on the Calpurnum floodplain and Pike cliffs, both close to Renmark on the Murray River. Westell et al. (2020) report single dates on freshwater mussel middens from Pike floodplain back to c. 30,000 BP, with a further spike in dates at about 15,000 BP, slightly later than the final drying period of the Willandra Lakes system (Gillespie 1997: 243). In their totality, dates from these locations indicate human occupation of the Murray corridor intermittently in the Late Pleistocene and probably continuously through the Holocene. Multiple human burials in the Central Murray are often present on remnant dunes rather than earth mounds (Pardoe 1995). One interesting innovation for the sand dune country is the use of shovel-shaped wooden implements to dig animals such as rat-kangaroos out of their burrows (Massola 1959). Plant processing stones, including seed grindstones, are common near creeks.

The nature of the river changes again as it enters a region dominated by limestones overtopped by sands. In the Gorge section, the river channel narrows from c. 5–10 km wide in the Mallee to c. 2–3 km and flows through a trench 30 m below the level of the surrounding drylands. As a result, the area of wetlands in the Gorge section is less than half of that in the Mallee section (Walker & Thoms 1993: 112). Along the river there are riparian forest and swamplands, while on the adjacent Murray Plains there is dry Mallee woodland, open shrubland, and saltbush. The presence of limestone cliffs changes the nature of the archaeology. The Gorge section saw some of the earliest archaeological excavations in Australia at the rockshelter sites of Ngaut Ngaut (Devon Downs), Tungawa (Fromm's Landing 2 & 6), and McBean's Pound, which provided insights into some aspects of the Aboriginal economy between c. 3000 and 7000 years ago (Allen n.d.; Frankel 2017: 85–89). Both Paton (1983) and Smith (1978) note differences between the ethnographic observations of Aboriginal life on the river and the archaeological evidence from the rock shelters. This, however, is likely to be the result of a bias in both the ethnography and archaeology. A review of the economic evidence from these excavations and surveys along the river revealed differing patterns of exploitation, where multiple resource zones, including the Murray Plains, the riverbanks, and the river itself were used (Allen n.d.) (Table 3). The open, stratified midden site of Tartanga Island, dating to 7000 BP, reveals that quantities of fish were harvested. The greatest deficiency comes from the poor preservation of plant remains where ethnographic observations note the use of *Typha* and other aquatic plants. In his survey, Paton (1983) found little archaeological evidence in the dry country away from the river, although ethnographic recordings indicate that the Murray Plains were utilised to hunt kangaroos, wallabies, and rat kangaroos.

Table 3. Summary of economic remains from excavated-survey archaeological sites in the Gorge Section of the Murray River noting the environments exploited and probable means of capture (after Allen n.d.).

Site Type—Resource Type	**Large Mammals**	**Small to Medium Mammals**	**Water and Bush Rats Possums**	**Fish, Turtles Crayfish, Shellfish**	**Qaterfowl**	**Vegetables**
Environment and method of capture	Murray Plains, spear hunting	Murray Plains, nets and fire drives, spear hunting	Riverbanks and water's edge, collecting	Riverbanks and river channel, collecting	Creeks and watercourses, Net and spear hunting	Riverbanks and swamps, collecting
Shelters, Ngaut Ngaut and Tungawa 2 & 6	Present	Major	Major	Major	Present	Present?
Shelters McBean's Pound	Present	Major	Major	Major	Present	Present?
Fishing Camp, Tartanga Island	Major			Major	Present	Present?

Shore Middens, Roonka area			Present	Major	Present	Present?

Finally, the river enters its lowermost reaches, the estuary and lakes, before it enters the sea at the Coorong. This final section of the Murray is a more humid environment than the semiarid sections of the river's course. The economy and material culture of Aboriginal people here demonstrate a combination of river and coastal adaptations (Berndt, Berndt, & Stanton 1993; Frankel 2017; Mackay & Eastburn 1990). Again, the archaeological signature of this area varies with the ecology and physiography, consisting of freshwater mussel middens dating between 8000 and 350 BP, and marine shellfish and other coastal foods at the estuary and river mouth (Wilson, Fallon, & Trevorrow 2012).

In the discussion that follows, most attention will be given to the Riverine Plain, the Central Murray Mallee, and the Gorge sections, as these are the areas we are most familiar with and where we have carried out most of our research.

Mortuary Practices

Information on burial practices along the Murray River comes from diverse archaeological sources (Table 4), together with ethnohistoric accounts of specific funerals and monuments observed by Europeans and generalized accounts of normative practice (Meehan 1971; Littleton 2007). Each of these sources is biased in some way: the archaeological survey has a greater potential to identify groups of burials rather than single burials; archaeological finds are biased towards better preserved remains that may result in systematic age biases; and ethnohistoric accounts are more frequently of extended burial rituals. Nevertheless, all forms of burial have been recorded along the Murray Valley: simple inhumations, delayed compound burials, bundle burials, and cremations. The resulting pattern highlights change over time as well as a complex of shared ideas and practices, with considerable spatial and temporal variability.

Table 4. Major surveys and published excavations of Aboriginal burials along the Murray River. The number of burials is indicative only. For a more detailed list, see Littleton (1999).

Fieldwork Type	Number of Burials	Source
Surveys		
Riverine Plain	c. 80	Bonhomme (1990)
Murray-Darling	166	Pardoe (1985, 1988a, 1988b, 1989, 1993) (number excludes Darling River sites)
Mildura Region	176	Clarke & Hope (1985)
Murray-Murrumbidgee	406	Littleton (1997, 1999)
Lake Victoria	304	Littleton, Johnston, & Pardoe (1994)
Katarapko	25	Dowling (1989)
Excavations		
Kow Swamp	c. 40	Thorne et al. (1972)
Robinvale	11	Bowdler (1983)
Chowilla	100	Blackwood & Simpson (1973)
Roonka	142+	Pretty (1977)
Tartanga	3	Hale & Tindale (1930)
Ngaut ngaut (Devon downs)	4	Hale & Tindale (1930)
Tailem Bend	3	Pretty (1967)

Tungawa 2 & 6 (Fromm's Landing)	3	Mulvaney, Lawton, & Twidale (1964)
Swanport	c. 160	Stirling (1911)

Even if the population of the Murray remained at only 3000 people for 10,000 years, there would be conservatively one million burials along the Murray River. Not all of these burials would survive, but in this part of Australia where the custom was to bury the dead and not disturb them, and where the soil is calcareous and conducive to good preservation of bone, the discovery of burials on survey and in excavation is inevitable. The intensity of pastoral occupation causing ground disturbance and erosion has increased the likelihood of burial exposure.

While there are Pleistocene human remains from the Willandra Lakes and the Lachlan River (Pietsch et al. 2019), the oldest remains currently found on the Murray River are those from Coobool Creek, Narcurrie, and Kow Swamp. Precise dating of these remains (now reburied following repatriation) is difficult to determine (Brown 1989; Pardoe 1988a; Stone & Cupper 2003). However, based on the clustering of dates from a small number of burials and shared morphology, it is commonly accepted that the oldest burials date to the Late Pleistocene/Early Holocene (c. 15,000–9000 BP).

The Coobool Creek remains, like those from Kow Swamp, suggest that a significant number of burials occurred within a constrained area.[1] Elsewhere along the Murray, beginning around 9000–5000 BP (Roonka, Chowilla 17, Chowilla 16B, and Barham), burials begin to appear in greater numbers and in areas of higher density (Blackwood & Simpson 1973; Daley 1986; Littleton, Petchey, Walshe, & Pate 2017).

What distinguishes these groups of burials from isolated interments is their presence on particular landforms (generally, source bordering dunes along the Murray River), the density of burials (often more than 1/100 square metres in exposed sites) within restricted areas, exclusivity of use, and formality in the layout of burials. Pardoe (1988a) argued that these burial groupings operated as formal cemeteries serving to symbolise the link between corporate groups and land, following the linkage proposed by Saxe (1970) and Goldstein (1981). In this interpretation, cemeteries are used exclusively by particular descent groups.

The difficulty that arises with the cemetery concept is establishing how burial grounds were used and by whom. Work on the Riverine Plain between the Murrumbidgee and Murray Rivers demonstrates that many clustered burials largely occur in groups of between 3 and 20, with the same characteristics of high density, exclusivity of use, and formal patterns of burial. Within a single area, however, several clusters of burials with different burial orientations and positions may exist (Littleton 2002). The same variability occurs within individual sites (e.g., at Roonka—Pretty 1977) and within adjacent cemeteries (e.g., East Nanyah versus Gecko Island at Lake Victoria—Littleton & Allen 2007).

An alternative argument to groups of burials at high density acting as cemeteries of exclusive territoriality is that clusters of burials represent the accumulation of different processes over time (Littleton & Allen 2007). Places for burial have persistence both in physical terms through the marking of graves but also over a longer period by being recognised as appropriate places for burial. The variability of burials within and between sites suggests that often more than one group uses a particular location. Whether this use is successive or contemporary is unclear.

The burial site of Roonka provides some clues to the cemetery question (Pretty 1977). The earliest burial on the site is radiocarbon dated by charcoal to c. 9000 BP. In the lower level of the site, burials are predominantly males and children. In the upper levels, there are much greater numbers of adult females, and the range of burials has increased, including supine extended burials, flexed burials with people buried on either their right or left side, and a small group of prone burials. All of these groups tend to have preferred orientations although the most frequent position is an extended burial with the head to the northwest. From the dates there is little evidence of successive use and more evidence for synchronous variability (Littleton, Petchey, Walshe, & Pate 2017). This variability could suggest that, rather than burial grounds being exclusive to one social or territorial grouping (i.e., a cemetery), by the Late Holocene multiple burying groups were being incorporated within a single locale. While this is the possible sequence at Roonka, it is not necessarily the same sequence at all burial grounds up the river.

The Roonka site, along with other evidence, still leaves unanswered the questions of who forms the burying group, as well as how many people and what the linkage between them is. The number of burials at any one site is very low relative to past population sizes (e.g., even with an estimated 10,000 burials over 6000 years at Lake Victoria, that is only one or two burials per generation; see Littleton, Johnston, & Pardoe 1994). One way to test underlying demographic models is to progress from the archaeological record and reconstructions of site formation processes to modelling the possible parameters of the contributing population. But the record of burials reflects more than economics and social organisation. Underlying how people bury their dead are ontological issues of what it means to be human, relationships between the living and the dead, and associations between the dead and land. The Murray River corridor is an area of both shared ideas and distinct regional variability. With the exception of the mouth of the Murray, primary burial predominated, with relatively few secondary burials (in the form of bundled burials or platform exposures). The exception is the frequently delayed burials of children, which commonly occur with a single adult (Littleton & Allen 2007). Both of these burial practices extend over a wide region, suggesting shared ideas of the relationship between children and death.

Burial monuments as documented in the ethnohistoric record demonstrate regional variability (Littleton & Allen 2020; Meehan 1971). The areas of greatest variation are the major junctions, for example, at the Murray-Darling, which were at the periphery of several groups or reflective of one group with multiple influences in the mid-nineteenth century and therefore key points of interaction (Taçon 2013). This regional distribution lacks hard boundaries.

In terms of burial, the Murray River was an area with internal variability, but it was linked by underlying interaction and some shared practices of temporal and regional depth. Whether this internal diversity is emphasised as exclusivity between neighbours or inclusivity reflecting clinal variation depends both on the marker that is being analysed and on our ability to establish the underlying demographic and economic relationships.

Morphology

Human biological variation results from the interaction of the biological, ecological, economic, and social worlds. Different analyses of human remains capture the interaction of the biological and the social at varying temporal scales, from the lifetime of the individual (e.g., deliberate tooth removal or avulsion) to the pattern of gene flow occurring over thousands of years (e.g., cranial nonmetrics) and potentially longer term adaptation to the environment (e.g., cranial morphology).

Human remains from the Murray River Valley clearly reflect change over time. Brown's (1989) analysis of the Coobool Creek late Pleistocene remains demonstrates that both crania and teeth were significantly larger and more robust than those in the larger collection of presumed Holocene remains. The difficulty is of course that only the Riverine Plain is represented in this analysis. Conceivably, the same morphology seen in this region was present among people all down the river, but sample sizes are insufficient to be certain. Moreover, people at Coobool Creek and Kow Swamp were actively modifying heads in a way that would help to construct and signal distinctions between groups. The modified crania with their elongated, sloping foreheads would have been a distinctive marker of people from this area (Pardoe 2006).

Later remains from the same area do not show evidence of cranial deformation. However, patterns of gene flow indicated by studies of cranial metric (Pietrusewsky 1979) and nonmetric (discontinuous variants of morphology assumed to be the result of genetic inheritance patterns—Pardoe 1995) characters suggest continuities in the morphological distinctiveness of the Murray Valley and surrounding regions. As a whole, the Murray Valley populations, when considered as broad clusters (e.g., Murray Valley, Roonka, Swanport), are most similar to neighbouring groups in Victoria and South Australia and fit easily into a broad southeastern Australian pattern (e.g., Pietrusewsky 1979).

At a larger scale, however, Pardoe's (1984) analysis of more than 2500 individual human remains from across Australia emphasises greater intraregional diversity among the Murray River groups compared to the rest of the continent. Effectively, the river serves as a conduit for gene flow, but it does not negate relationships with hinterland populations (often represented by smaller sample sizes from a significantly larger geographic region).

The same pattern occurs in Pleistocene groups; this suggests that the linear (riverine) patterning is of long standing (Pardoe 1984, 2006). Differentiation between Murray groups suggests shorter marriage distances, possible in situations of higher population density. Following Tindale's (1974) distribution of linguistic groups along the Murray, the pattern of greater gene flow between neighbours along the river than with more dispersed populations behind emerges. The extent to which groups interact may result in a pattern consistent with territorial exclusion where there is less gene flow between neighbouring groups than expected given population sizes (Pardoe 1994).

Pardoe's cranial nonmetric analysis (1984) is based on the sample mean, which has the effect of concealing the degree of diversity within each sample. Pardoe's (2006: fig. 2) later analysis demonstrates how, with more than one sample from a single region, there is potentially greater diversity within a 'linguistic group' than between groups, suggesting that while the overall structure of the river corridor dominating gene flow may hold over time, more diverse local processes are occurring. Along the river there are points with marked heterogeneity. The nonmetric analysis demonstrates that the river served to structure relationships, but it does not suggest that a simple model of cultural exclusion explains the Holocene pattern of variation—there is both regional and temporal variation.

While most work has focussed on cranial characteristics, postcranial morphology among Murray Valley human remains has also been studied (Bennett 1995; Hill, Durband, & Walshe 2016, Hill et al. 2020; Macho & Freedman 1987; Pardoe 2006). Similar to cranial morphology, characteristics of the postcrania respond to patterns of gene flow and adaptation to both local and developmental circumstances. Most recently, international studies of long bone shape have revealed a relationship to patterns of mobility and work (Ruff 2008; Stock & Pfeiffer 2001). It is argued, for example, that populations who undertake high rates of walking and running produce (on average) femurs with a more oval than circular cross-section. Hill, Durband, and Walshe (2016) have used this correlation to examine changes over time at Roonka, dividing the sample into pre- El Niño Southern Oscillation (ENSO) period (pre-c. 4000 BP, characterised as warmer and wetter) and post-ENSO period (post-c. 4000 BP) individuals. They argue that the post-ENSO subsample has more oval femoral midshafts indicative of greater mobility (Hill, Durband, & Walshe 2016), particularly among females who also show less asymmetry in development of their upper limbs compared to males (Hill et al. 2020). The temporal difference is interpreted as indicative of a trend towards a more diverse diet and the incorporation of 'high handling cost' foods into the diet. The difficulty is that, if use of the burial ground has changed over time, then it is not clear that the two samples originate from the same population in the sense that early use may be biased away from younger males and females, and it is known that patterns of mobility and of work vary by age. Nevertheless, the analysis points to the need to interrogate patterns within samples, which may reveal more fine-grained local changes.

The overarching picture of populations in the Murray Valley is that of biological relatedness held together by patterns of gene exchange. These patterns change over time, and we have relatively little sense of how they vary between areas of the Murray Valley. Some places such as the Murray-Darling junction have marked degrees of diversity, which serve to reflect a major interaction zone. The comparative analysis of large undated samples provides an underlying pattern, but that needs to be tested using multiple techniques (including isotope analyses such as strontium and oxygen) and differing types of dated samples.

Palaeopathology

Human remains reflect the accumulation of life stresses up to the point of death. The interpretation of a person's past life from their remains—an osteobiography—is a window into a very specific event or point of time (e.g., the Mallee Cliffs burial—Pardoe 1988b). While such individual descriptions provide insight, they also incorporate ambiguity due to the nature of archaeological and osteological evidence, as the reinterpretation of a woman from Roonka demonstrates (Littleton & Wallace 2019). These biographies start to build a picture of past life. As they are compared and patterns emerge, both the full range of variability and the relationship between disease, stress, economy, and ecology can be analyzed.

Multiple studies have been done of disease and injury in past human remains from the Murray River (Green 1982; Littleton 2005; Pretty & Kricun 1989; Prokopec 1979; Robertson 2003; Sandison 1973), but Webb's (1989, 2009) analysis of museum collections of human remains in the early 1980s is the most extensive regional comparison. With the exception of late Pleistocene/early Holocene remains (e.g., Kow Swamp) and the remains from Swanport (Stirling 1911), the majority of the Murray Valley remains analyzed originated from the George Murray Black Collection. These were largely undated remains presumed to date primarily from the Mid- to Late Holocene. Beyond biases inherent to an archaeological record (differential preservation, differential burial), the collection was affected by an expressed preference on the part of institutions for particular remains (pathologized, unusual, crania versus postcrania) (Robertson 2007). Most have now been repatriated to traditional owners of the area where the remains originated, though unprovenanced remains continue to be an issue (Pickering 2015; Russell 2010).

The conditions analyzed by Webb (1989) were primarily nonspecific indicators of stress (cribra orbitalia, linear enamel hypoplasia, Harris lines, bone infection) and trauma. The underlying premise of palaeopathological analysis was at the time that high rates of such markers upon human remains reflected poor human health. Most notably, Webb found very high rates of cribra orbitalia among children and adults from the Murray samples—particularly his Riverine Plain sample (which he termed central Murray)—and a fairly high frequency of linear enamel hypoplasia. Comparative analysis with frequencies elsewhere in the world suggested that rates of cribra were much higher and comparable to Middle Mississipian (Illinois, USA) rates for children, pointing to a startling similarity between sedentary maize agriculturalists (Cohen & Armelagos 1984a, 1984b) and Aboriginal people residing in the Riverine Plain (the highest rates were recorded at Kerang). The parallel prompted Webb to suggest that the Murray in general, but his Riverine Plain in particular, was ‘an infectious environment’ inhabited by populations existing at high population density (Webb 1989: 147).

However, the patterns of infection and trauma in the central Murray are not consistent with an interpretation of a stressed, dense population. Dense, sedentary populations tend to experience relatively high rates of nonspecific infection, as wounds heal slowly and pathogens are easily transmitted between individuals. Similarly, interpersonal violence is often assumed to be greater in stressed populations who are competing over resources. Neither of these conditions occurs at higher frequency in the Riverine Plain area (Pardoe, Allen, & Jones 2014; Webb 2009).

Analytical ambiguities in interpreting signs of disease in human remains need to be taken into account. A pivotal article written by Wood, Milner, Harpending, and Weiss (1992) points to the osteological paradox: skeletal samples are not unbiased indicators of the once living but instead comprise nonsurvivors who potentially include the most frail and the most common age group. Furthermore, ‘better health makes for worse skeletons’. Conditions that show in the human skeleton are generally a response to chronic conditions, and that response is more likely in a person with a healthy immune system. Acutely ill individuals or individuals unable to mount an immune response are more likely to die before any signs of disease are seen upon the skeleton. Robertson (2003) tackled these issues in relation to interpretation of cribra orbitalia in the Murray region and concluded that the rates recorded among human remains from this area may be overestimated due to temporal mixing and biased collecting practices.

An example of this issue of representation is seen in the analysis of linear enamel hypoplasia in Murray River populations. Both Green (1982) (Rufus River) and Smith (2016) (Roonka) have recorded linear enamel hypoplasia. They both document virtually ubiquitous hypoplasic defects among individuals. However, as Smith and Littleton (2019) show, most people have very few defects, and these defects are not associated with a greater chance of dying. In other words, childhood stressors are present, but the majority of individuals experienced those stressors at defined periods of childhood and survived.

People living on the Murray River existed within an ecology different from elsewhere in Australia. However, this is not a single environment, and not all indicators of disease and injury show a consistent picture. Comparison of the rates of cribra orbitalia from Roonka with the collections studied by Webb shows a startling variation. Rates of cribra orbitalia at Roonka are less than half those recorded in the Riverina area (Webb’s Central Murray) and significantly less than those at the Rufus River (Figure 2). Over the space of 40 years, even using the same criteria, it is impossible to be assured that there is no difference in recording. But that cannot account for the entire disparity between the two samples—there is significant regional variation.

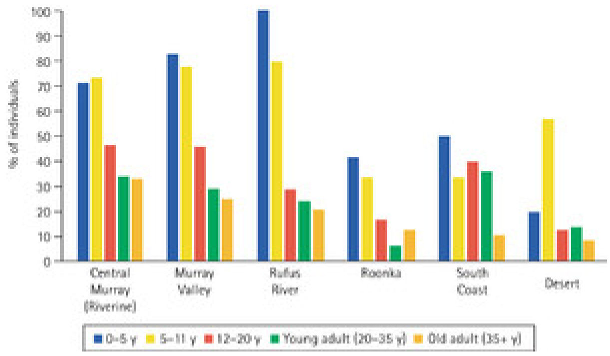

Figure 2. A comparison of the rates of cribra orbitalia between a single site, Roonka, and the relevant regional groupings of Webb (1989).

The rates of disease among human remains along the Murray is clearly a product of particular regional ecologies, but interpreting those rates requires careful consideration of the chronology of the samples. For example, Roonka covers a period (with gaps) between 9000 and 150 BP, including six postcontact individuals who clearly spent at least part of their lives in a rapidly changing ecology. In addition, the samples used in these analyses are not populations; rather, they are samples of human remains from particular sites. The ethnographic record clearly points to different burial locales, depending on an individual's age and gender (Littleton 2007). As such, these samples cannot be treated unproblematically as a palaeodemographic record representative of entire communities. Finally, in order to understand particular lesions, it is necessary to identify the local stressors, the severity of the lesion, and whether it had healed or was active at the time of death?

Analysis of pathology highlights significant regional differences along the Murray River that are a response to differing subsistence patterns and stressors. There are some striking similarities; for example, linear enamel hypoplasia at Rufus and Roonka is very similar and resembles the historical patterns observed at Yuendummu in central Australia (Smith 2016). There are, however, striking differences, particularly in the level of heterogeneity between different samples. The Riverine Plain samples analyzed by Webb (1989) are surprisingly homogeneous, and there is also a reflection of this similarity in some of the dental wear analysis discussed below. The questions then are what are these samples and who do they represent? Detailed contextualised analysis of particular groups of individuals can clarify those patterns and give a clearer idea of both spatial and temporal variation.

Dietary Analyses

Bioarchaeological studies of diet also highlight the nature of variability along the Murray River, indicating that rather than there being a single dietary pattern common to Murray River societies, the types of resources utilised and their relative proportions varied along the length of the river. There is also evidence of dietary variation between individuals buried within a site. However, it is likely that both inter- and intrasite dietary variation is greater than the existing data suggests. This variation is a result of the limitations of certain methods, the nature of the archaeological record on the Murray River, and a focus on population rather than individual-level analyses.

A number of factors may contribute to dietary variation along the Murray River corridor. As discussed earlier, the ecology of the Murray River and its relationship to the surrounding landscape changes as it travels westward from its headwaters in the Great Dividing Range to Lake Alexandrina at its mouth. Such changes also resulted in changes in available resources and in the abundance and seasonality of those resources. Analysis of dental wear patterning suggests regional variation in resource exploitation, particularly in relation to seeds, tubers, and potentially molluscs (Brown 1978; Littleton, Scott, Mcfarlane, & Walshe 2013; Molnar, Richards, Mckee, & Molnar 1989; Richards 1984). For example, while heavy molar wear is seen in all groups analyzed along the river, remains from around Euston also had a flat plane of wear on the anterior and central teeth, a pattern not seen in people from Mildura to the Rufus River (Littleton, Scott, Mcfarlane & Walshe 2013; Molnar, Richards, Mckee, & Molnar 1989). Suggestions regarding the difference in wear planes include a greater reliance on tubers such as the rhizomes of *Typha* on the Riverine Plain, seed-grinding practices in the Central Murray/Mallee, or the greater diversity of ecological zones within the Central Murray/Mallee region (Littleton, Scott, Mcfarlane, & Walshe 2013; Molnar, Richards, Mckee, & Molnar 1989). A number of factors other than diet can impact dental wear patterning. however, and while Molnar, Richards, Mckee, and Molnar (1989) rule out the role of tooth size as an underlying case of variation in wear patterns between groups, nonmasticatory tooth use such as processing fibres, and variability in facial robusticity and occlusal loading are potential additional contributing factors that require further investigation. In addition, Littleton, Scott, Mcfarlane, and Walshe (2013) demonstrate that the use of population averages in analysing dental macrowear can obscure significant differences between individuals. Indeed, analyses of dental wear by age and sex show marked intragroup variability, but notably also that the specific patterns of age- and sex-related wear change by location (see Littleton 2017; Littleton, Scott, Mcfarlane, & Walshe 2013; Richards 1984; Smith, Prokopec, & Pretty 1988). So even when dental wear is uniformly severe, its patterning reflects not just ecological zones and the available resources but also differences in economic organisation between those zones.

As Figure 3 demonstrates, stable isotope analyses of the remains from Roonka and Swanport also show inter- and intrasite variability in diet (Owen 2004; Pate 1998b, 1998c; Pate & Owen 2014). At both sites, the majority of individuals have isotopic signatures that indicate they were relying primarily on local foods from the Murray River and adjacent Mallee, specifically C3 plants (i.e., those plants that produce a 3-carbon compound during photosynthesis as opposed to a 4-carbon compound, particularly temperate shrubs, trees, and some grasses), freshwater fish and shellfish, and terrestrial animals feeding on C3 plants, but the relative proportions of each of these food sources appears to differ between the sites. The demographic makeup of the respective samples may influence these results, however, as there is also evidence for intrasite variation in diet consistent with cultural practices such as age- and/or gender-restricted foods and division of labour. Differences in the $\delta^{15}N$ values of individuals at Swanport suggest that men were eating foods from higher trophic levels (e.g., large freshwater fish and terrestrial animals) than women, as were adults when compared to nonadults less than 16 years of age (Owen 2004; Pate & Owen 2014). At Roonka, on average, nonadults and adult females had $\delta^{13}C$ values that were ~0.7‰ more negative than those of adult males. This finding suggests that the diets of children and women contained more $\delta^{13}C$-depleted foods such as aquatic and terrestrial plants and freshwater shellfish than men's diets (Pate 1998b).

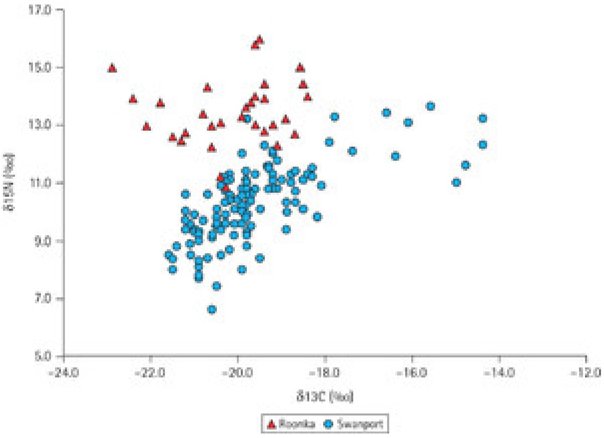

Figure 3. Stable carbon and nitrogen isotopic signatures of individuals from Roonka (n = 32)

(Source: Pate 1998b)

and Swanport (n = 121)

(Source: Owen 2004).

Dietary reconstructions along the Murray River using stable isotope analysis are, however, highly complex and a number of factors can limit or impact interpretation of data. These and other isotopic analyses of individuals from the Roonka and Swanport sites (e.g., Hobson & Collier 1984; Pate 1995a, 1995b, 1997a, 2000, 2017) have focussed primarily on stable carbon and nitrogen isotopes in bone collagen. In addition to issues of collagen preservation and diagenesis, which are limiting factors (see Pate 1997b, 1998a, 1998c) often skewing samples towards more recent remains, the isotopic values of collagen reflect primarily the protein component of diet rather than total diet (Krueger & Sullivan 1984) and are an average of an individual's diet over the last decades of their life (Eriksson & Liden 2013; Katzenberg 2007; Price 2015; Sealy, Armstrong, & Schrire 1995). Furthermore, within a freshwater environment there are multiple potential sources of carbon and factors that can influence carbon fractionation. Thus, the isotopic signatures of fish being consumed can vary depending on when (season) and where the fish are caught (Cartwright 2010; Hardy, Krull, Hartley, & Oliver 2010; Hecky & Hesslein 1995; Katzenberg & Weber 1999; Zohary, Erez, Gophen, Berman-Frank, & Stiller 1994). Studies have also shown that $\delta^{13}C$ values in terrestrial C3 plants at the base of food chains can vary based on aridity (O'Leary 1988; Pate & Krull 2007). As Pate (2017) emphasises, as a result of all of these factors, continued analysis of ecological and isotopic data on the food sources available in the vicinity of the riverine zone is vital to improving our understanding of isotopic variability in populations along the Murray River.

Despite these limitations, it is clear that a simple classification of Murray River societies as having a 'riverine diet' is insufficient. While the river undoubtedly plays a significant role in shaping diet, this blanket term ignores the nuances of the variation in diet both between and within Murray River societies. Instead, as the bioarchaeological evidence indicates, discussions of diet and subsistence practices along the Murray River need to be contextualised within a specific local environment. Ongoing analysis of archaeological material, as well as modern flora and fauna, continues to add to our understanding of the variability of the environment, particularly food resources both within and between specific locales along the Murray River. Currently, the role of time in contributing to variation in diet is difficult to assess due to the limited dating evidence for many of the human remains from the Murray Valley. However, technological improvements, particularly in the areas of isotopic analysis and radiocarbon dating, are now allowing for analysis of a wider range of sample types, including in cases where preservation had previously been an issue. Such improvements in the understanding of local ecologies, dating, and analysis of dietary indicators from different time periods within an individual's lifespan (e.g., comparison of isotopic signatures in bone collagen and dental enamel, or the calculation of age-related dental wear gradients) have also led to an increased emphasis on taking an individual-up rather than regional-down approach to dietary research on the Murray River. As a result of these factors, future bioarchaeological studies of diet on the Murray River may more accurately assess the role of time in contributing to dietary variability as well as the true extent of inter- and intragroup variability in diet.

Themes and Debates

This review of the bioarchaeology of the Riverine Plain to the Murray gorge has identified the unifying factors between Murray River societies but has not seen the Murray as a unity. The Murray is both a shared cultural area and heterogeneous—culturally, ecologically, and biologically. While the river served as a conduit for gene flow, people maintained relatively porous boundaries with hinterland groups (as evidenced in linguistic, nonmetric skeletal, burial, and dietary analyses). Populations along the river shared a dependence on riverine resources, but they also had differing emphases (as seen in different proportions of food types and stable isotopes).

The nature of the archaeological record in this region has determined what narratives are drawn. The visibility and survivorship of differing site types, processes of site formation, and the degree of chronological and temporal control, all structure the available data. Particularly in relation to bioarchaeological work, the difference between a sample and a population needs to be remembered. This very partial record is a collection of samples from different locales, not a grouping of populations.

Nevertheless, the integration of the archaeological and bioarchaeological records gives a closer view of the tension between unity and diversity along the Murray River. Developing techniques (e.g., strontium analysis, aDNA, proteomics) all provide new ways of testing existing models and of addressing new questions (e.g., migration, division of labour, the role of different age groups, the structuring of social groups).

Our studies of Murray River peoples concur with the genetic studies by Van Holst Pellekaan, Liu, and Wilton (2010) showing that Darling River peoples were long standing. There are differences between the Pleistocene human remains and the more recent material, but within the Holocene period there appear to be few major changes, with variations the product of multiple and local factors. To a degree, this patterning is at odds with older archaeological interpretations that considered changes in populations, or in cultures, to be the norm. Considerable further work needs to be done in integrating the bioarchaeology with the archaeology and ecology of the region and in considering the implications of differing findings.

However, underlying these differences is the need for joint projects with Aboriginal communities which address Aboriginal priorities as well as scientific priorities. Nondestructive techniques and recording are always a first step. Future work is not going to be driven by existing collections but from surveys and from individual or small groups of burials exposed through erosion or in the course of development. That places responsibilities on those recording not only to collect and store data in accordance with Aboriginal communities' wishes but also to show how building detailed interpretations in the future is going to depend upon those individual records. Working with the dead entails a sense of long-term obligation as well as a relationship with the dead themselves and with their descendent communities. In this respect, while repatriation has been ongoing, return of human remains does not negate relationships and responsibilities between the institutions and individuals involved and the receiving communities.

The bioarchaeological work done to date along the Murray Valley has been driven by a regional comparative and primarily economic/subsistence focus. It is in the comparison of rates of disease or genetic diversity between the River and elsewhere that the narrative has been drawn. Detailed and contextualised studies of dated burials and individuals serve as a way both to test these grand narratives and to parameterise them—specifically, to define the extent of sedentism, mobility, or exclusivity. These detailed studies can also incorporate a wider range of perspectives, including focus beyond the economic to the social and cultural practices that made the Murray Valley a shared cultural area with significant internal heterogeneity.

Acknowledgments

This work was undertaken in collaboration with, and the permission of, the River Peoples of the Murray and Mallee Inc. We acknowledge and thank the Ngaiwaing, the Traditional Owners of Roonka, and the Ngaiwait, Nganguruku, Ngingtait, Eraweirung, Ngaralte, and Ngarkat. It is undertaken with ethical clearance from the UAHPEC committee, University of Auckland (010311). Thanks to Caitlin Smith and Ashley McGarry for their editorial help. The research was funded by the Royal Society of New Zealand Marsden Fund (14-UOA-19). Seline McNamee, Anthropology, School of Social Sciences, University of Auckland, drew the maps.

References

Allen, H. (n.d.). Archaeological evidence for Aboriginal foraging in the Gorge section of the Murray River. Typescript. The University of Auckland, Auckland.

Allen, H. (1972). *Where the crow flies backward: Man and land in the Darling Basin* (PhD thesis). Australian National University, Canberra.

Bennett, C. M. (1995). *Morphology of the major limb bones of South Australian Aborigines* (PhD thesis). La Trobe University, Melbourne.

Berndt, R. M., Berndt, C. H., & Stanton, J. (1993). *A world that was: The Yaraldi of the Murray River and lakes, South Australia*. Carlton: Melbourne University Press.

Birdsell, J. B. (1953). Some environmental and cultural factors influencing the structuring of Australian Aboriginal populations. *The American Naturalist*, *87*(834), 171–207.

Blackwood, R., & Simpson, K. (1973). Attitudes of Aboriginal skeletons excavated in the Murray Valley region between Mildura and Renmark, Australia. *Memoirs of the National Museum of Victoria*, *34*, 99–150.

Bonhomme, T. (1990). Report on burials and sandmining in the Riverine Plain. Report to NSW National Parks and Wildlife Service, Sydney.

Bowdler, S. (1983). Archaeological investigation of a threatened Aboriginal burial site near Robinvale, on the Murray River, Victoria. Report to the Murray Valley Aboriginal Co-operative, Euston, Victoria.

Bowler, J. M., & Magee, J. W. (1978). Geomorphology of the Mallee Region in semi-arid Northern Victoria and Western New South Wales. *Proceedings of the Royal Society of Victoria*, *90*, 5–26.

Brown, P. (1989). *Coobool Creek*. Terra Australis 13. Canberra: Department of Prehistory, Australian National University.

Brown, P. (1978). *The ultrastructure of dental abrasion: Its relationship to diet* (BA Honours thesis). Australian National University, Canberra.

Cartwright, I. (2010). The origins and behaviour of carbon in a major semi-arid river, the Murray River, Australia, as constrained by carbon isotopes and hydrochemistry. *Applied Geochemistry, 25*, 1734–1745.

Clarke, P., & Hope, J. (1985). Aboriginal burials and shell middens at Snaggy Bend and other sites on the Central Murray River. *Australian Archaeology*, *20*, 68–89.

Cohen, M. N., & Armelagos, G. J. (1984a). Disease and death at Dr Dickson's Mounds. *Natural History*, *9*, 12–8.

Cohen, M. N., & Armelagos, G. J. (Eds.). (1984b). *Paleopathology at the origins of agriculture*. New York: Academic Press.

Daley, C. (1986). *The Barham skeletons* (MA thesis). The University of Sydney, Sydney.

Dowling, P. (1989). *Violent epidemics* (MA thesis). Australian National University, Canberra.

Edwards, R. (1972). *Aboriginal bark canoes of the Murray Valley*. Adelaide: Rigby.

Eriksson, G., & Liden, K. (2013). Dietary life histories in Stone Age Northern Europe. *Journal of Anthropological Archaeology*, *32*(3), 288–302.

Frankel, D. (2017). *Between the Murray and the sea: Aboriginal archaeology in south-eastern Australia*. Sydney: Sydney University Press.

Gillespie, R. (1997). Burnt and unburnt carbon: Dating charcoal and burnt bone from the Willandra Lakes, Australia. *Radiocarbon*, *39*(3), 239–250.

Goldstein, L. (1981). One-dimensional archaeology and multi-dimensional people: Spatial organization and mortuary analysis. In R. Chapman, I. Kinnes, & K. Randsborg (Eds.), *The archaeology of death* (pp. 53–70). Cambridge: Cambridge University Press.

Gott, B. (1999). Cumbungi, Typha species: A staple Aboriginal food in southern Australia. *Australian Aboriginal Studies 1999*/1, 33–50.

Green, M. K. (1982). *A review of enamel hypoplasia and its application to Australian prehistory* (BA Honours thesis). Australian National University, Canberra.

Hale, H. M., & Tindale, N. B. (1930). Notes on some human remains in the lower Murray Valley, South Australia. *Records of the South Australian Museum*, *4*, 145–218.

Hardy, C. M., Krull, E. S., Hartley, D. M., & Oliver, R. L. (2010). Carbon source accounting for fish using combined DNA and stable isotope analysis in a regulated lowland River Weir pool. *Molecular Ecology*, *19*, 197–212.

Hecky, R. E., & Hesslein, R. H. (1995). Contributions of benthic algae to lake food webs as revealed by stable isotope analysis. *Journal of the North American Benthological Society*, *14*(4), 631–653.

Hercus, L. (2010). Aboriginal people and languages of the Murray River in the 1850s. In H. Allen (Ed.), *Australia: William Blandowski's Illustrated Encyclopaedia of Aboriginal Australia* (pp. 169–173). Canberra: Aboriginal Studies Press.

Hercus, L. (1986). *Victorian languages: A late survey.* Pacific Linguistics Series B No 77. Canberra: Australian National University.

Hill, E. C., Durband, A. C., & Walshe, K. (2016). Risk minimization and a late Holocene increase in mobility at Roonka Flat, South Australia: An analysis of lower limb bone diaphyseal shape. *American Journal of Physical Anthropology*, *161*(1), 94–103.

Hill, E. C., Pearson, O. M., Durband, A. C., Walshe, K., Carlson, K. J., & Grine, F. E. (2020). An examination of the cross-sectional geometrical properties of the long bone diaphyses of Holocene foragers from Roonka, South Australia. *American Journal of Physical Anthropology*, *172*, 682–697.

Hill, P. J., De Decker, P., von der Borch, C., & Murray-Wallace, C. V. (2009). Ancestral Murray River on the Lacepede Shelf, southern Australia: Late Quaternary migrations of a major river outlet and strandline development. *Australian Journal of Earth Sciences*, *56*(2), 135–157.

Hiscock, P. (2008). *Archaeology of ancient Australia.* London: Routledge.

Hobson, K. A., & Collier, S. (1984). Marine and terrestrial protein in Australian Aboriginal diets. *Current Anthropology*, *25*(2), 238–240.

Humphries, P., King, A. J., & Koehn, J. D. (1999). Fish, flows and flood plains: Links between freshwater fishes and their environment in the Murray-Darling River system, Australia. *Environmental Biology of Fishes*, *56*, 129–151.

Katzenberg, M. A. (2007). Stable isotope analysis: A tool for studying past diet, demography and life history. In M. A. Katzenberg & S. R. Saunders (Eds.), *Biological anthropology of the human skeleton* (pp. 411–441). Hoboken, NJ: John Wiley & Sons.

Katzenberg, M. A., & Weber, A. (1999). Stable isotope ecology and palaeodiet in the Lake Baikal region of Siberia. *Journal of Archaeological Science*, *26*(6), 651–659.

Keen, I. (2004). *Aboriginal economy and society: Australia at the threshold of colonisation.* Melbourne: Oxford University press.

Kelly, D. (2014). *Archaeology of Aboriginal fish traps in the Murray–Darling basin, Australia* (Honours thesis). Charles Sturt University, Wagga Wagga.

Krueger, H. W., & Sullivan, C. H. (1984). Models for carbon isotope fractionation between diet and bone. *Stable Isotopes in Nutrition*, *258*, 205–220.

Laut, P., Heyligers, P. C., Keig, G., Loffler, E., Margules, G., & Scott, R. M. (Eds.). (1977a). *Environments of South Australia. Province 1. South East.* Canberra: CSIRO Division of Land Use Research.

Laut, P., Heyligers, P. C., Keig, G., Loffler, E., Margules, G., & Scott, R. M. (Eds.). (1977b). *Environments of South Australia. Province 2. Murray Mallee.* Canberra: CSIRO Division of Land Use Research.

Lawrence, R. (1968). *Aboriginal habitat and economy.* Occasional Paper 6, Department of Geography, School of General Studies. Canberra: Australian National University.

Littleton, J. (1997). *Burial sites on the Hay Plain*. Report to the Australian Institute of Aboriginal and Torres Strait Islander Studies, Canberra.

Littleton, J. (2005). Data quarrying in the Western Riverina: A regional perspective on postcontact health. In I. Macfarlane, M-J. Mountain, & R. Paton (Eds.), *Many exchanges: Archaeology, history, community and the work of Isabel McBryde* (pp. 199–218). Aboriginal History Monograph 11. Canberra: Aboriginal History Inc.

Littleton, J. (2017). Dental wear and age grading at Roonka, South Australia. *American Journal of Physical Anthropology*, *163*(3), 519–530.

Littleton, J. (1999). East and west: Burial practices along the Murray River. *Archaeology in Oceania*, *34*(1), 1–14.

Littleton, J. (2002). Mortuary behaviour on the Hay Plain: Do cemeteries exist? *Archaeology in Oceania*, *37*(3), 105–122.

Littleton, J. (2007). Time and memory: Historic accounts of Aboriginal burials in south-eastern Australia. *Aboriginal History*, *31*, 103–121.

Littleton, J., & Allen, H. (2007). Hunter-gatherer burials and the creation of persistent places in southeastern Australia. *Journal of Anthropological Archaeology*, *26*(2), 283–298.

Littleton, J., & Allen, H. (2020). Monumental landscapes and the agency of the dead along the Murray River, Australia. *World Archaeology*, *52*(1), 120–132.

Littleton, J., Johnston, H., & Pardoe, C. (1994). *The Lake Victoria lakebed survey*. Report to NSW National Parks and Wildlife Service, Sydney.

Littleton, J., Petchey, F., Walshe, K., & Pate, F. D. (2017). A preliminary redating of the Holocene Roonka burials, south-eastern Australia. *Archaeology in Oceania*, *52*(2), 98–107.

Littleton, J., Scott, R., Mcfarlane, G., & Walshe, K. (2013). Hunter-gatherer variability: Dental wear in South Australia. *American Journal of Physical Anthropology*, *152*, 273–296.

Littleton, J., & Wallace, S. (2019). Ambiguity in the bioarchaeological record: The case of “euthanasia” at Roonka, South Australia. *Bioarchaeology International*, *3*(2), 103–117.

Macho, G., & Freedman, L. (1987). *A re-analysis of the Andrew A. Abbie morphometric data on Australian Aborigines.* Occasional Papers in Human Biology No. 4. Canberra: Australian Institute of Aboriginal Studies.

Mackay, N., & Eastburn, D. (Eds.). (1990). *The Murray.* Canberra: Murray Darling Basin Commission.

Martin, S. (2011). Palaeoecological evidence associated with earth mounds of the Murray Riverine Plain, south-eastern Australia. *Environmental Archaeology*, *16*, 162–172.

Massola, A. (1959). Wooden shovels of the Aborigines of south-east Australia. *Mankind*, *5*, 289.

McCarthy, F. (1957). Habitat, economy and equipment of the Australian Aborigines. *Australian Journal of Science*, *19*, 88–96.

MDBA (Murray-Darling Basin Authority). (2020). Climate. Accessed at **https://www.mdba.gov.au/discover-basin/landscape/climate**, 12 February 2020.

Meehan, B. (1971). *The form, distribution and antiquity of Australian Aboriginal mortuary patterns* (MA thesis). University of Sydney, Sydney.

Molnar, S., Richards, L., Mckee, J., & Molnar, I. (1989). Tooth wear in Australian Aboriginal populations from the river Murray Valley. *American Journal of Physical Anthropology, 79*(2), 185–196.

Mulvaney, D. J., Lawton, G. H., & Twidale, C. R. (Eds.). (1964). Archaeological excavation of Rock Shelter No. 6, Fromm's Landing, South Australia. *Proceedings of the Royal Society of Victoria*, *77*(2), 479–516.

New South Wales Government. (n.d.). Riverina Landforms. Accessed at **https://www.environment.nsw.gov.au/bioregions/Riverina-Landform.htm**, 28 February 2020.

O’leary, M. H. (1988). Carbon isotopes in photosynthesis. *Bioscience*, *38*, 328–336.

Owen, T. D. (2004). *Of more than usual interest: Bioarchaeological analysis of Aboriginal skeletal material from southeastern South Australia* (PhD thesis). Flinders University, Adelaide.

Pardoe, C. (1989). Archaeology of the western Lindsay Island meander scroll. Unpublished report. Australian Institute of Aboriginal and Torres Strait Islander Studies, Canberra.

Pardoe, C. (2006). Becoming Australian: Evolutionary processes and biological variation from ancient to modern times. *Before Farming*, *1*, 1–21.

Pardoe, C. (1994). Bioscapes: The evolutionary landscape of Australia. *Archaeology in Oceania*, *29*(3), 182–190.

Pardoe, C. (1988a). The cemetery as symbol. The distribution of prehistoric Aboriginal burial grounds in southeastern Australia. *Archaeology in Oceania*, *23*(1), 1–16.

Pardoe, C. (1988b). The Mallee cliffs burial (Central River Murray) and population-based archaeology. *Australian Archaeology, 27*, 45–62.

Pardoe, C. (1984). *Prehistoric human morphological variation in Australia* (PhD thesis). Australian National University, Canberra.

Pardoe, C. (1995). Riverine, biological and cultural evolution in southeastern Australia. *Antiquity*, *69*(265), 696–713.

Pardoe, C. (1985). Variation in mortuary patterning along the Darling River. Unpublished report. Australian Institute of Aboriginal and Torres Strait Islander Studies, Canberra.

Pardoe, C. (1993). Wamba Yadu, a later Holocene cemetery of the Central Murray River. *Archaeology in Oceania*, *28*, 77–84.

Pardoe, C., Allen, M. W., & Jones, T. L. (2014). Conflict and territoriality in Aboriginal Australia: evidence from biology and ethnography. In M. W. Allen & T. L. Jones (Eds.), *Re-examining a Pacified past: Violence and warfare among hunter-gatherers* (pp. 112–132). Walnut Creek, USA: Left Coast Press.

Pate, F. D. (2000). Bone chemistry and palaeodiet: Bioarchaeological research at Roonka Flat, Lower Murray River, South Australia 1983–1999. *Australian Archaeology*, *50*, 67–74.

Pate, F. D. (1997a). Bone chemistry and paleodiet: Reconstructing prehistoric subsistence-settlement systems in Australia. *Journal of Anthropological Archaeology*, *16*, 103–120.

Pate, F. D. (1997b). Bone collagen diagenesis at Roonka Flat, South Australia: Implications for isotopic analysis. *Archaeology in Oceania*, *32*, 170–175.

Pate, F. D. (1998a). Bone collagen preservation at the Roonka Flat Aboriginal burial Ground: A natural laboratory. *Journal of Field Archaeology*, *25*, 203–217.

Pate, F. D. (1998b). Bone collagen stable nitrogen and carbon isotopes as indicators of past human diet and landscape use in southeastern South Australia. *Australian Archaeology*, *46*, 23–29.

Pate, F. D. (2017). Diet, mobility and subsistence-systems in the late Holocene lower Murray River basin of South Australia: Testing models of Aboriginal seasonal mobility and sedentism with isotopic and archaeological data. *Journal of the Anthropological Society of South Australia*, *41*, 123–171.

Pate, F. D. (1995a). Palaeodietary inferences from bone collagen stable carbon isotopes at Roonka Flat, South Australia. *Australian Archaeology*, *40*, 57.

Pate, F. D. (1998c). Stable carbon and nitrogen isotope evidence for prehistoric hunter-gatherer diet in the lower Murray River Basin, South Australia. *Archaeology in Oceania*, *33*, 92–99.

Pate, F. D. (1995b). Stable carbon isotope assessment of hunter-gatherer mobility in prehistoric South Australia. *Journal of Archaeological Science*, *22*, 81–87.

Pate, F. D., & Krull, E. (2007). Carbon isotope discrimination by C3 pasture grasses along a rainfall gradient in South Australia: Implications for palaeoecological studies. *Quaternary Australasia*, *24*(2), 29–33.

Pate, F. D., & Owen, T. D. (2014). Stable carbon and nitrogen isotopes as indicators of sedentism and territoriality in late Holocene South Australia. *Archaeology in Oceania*, *49*, 86–94.

Paton, R. C. (1983). *An analysis of Aboriginal subsistence in the lower Murray District, South Australia* (BA Honours thesis). Australian National University, Canberra.

Pels, S. (1964). The present and ancestral Murray River system. *Australian Geographical Studies*, *2*(2), 111–119.

Peterson, N. (1976). The natural and cultural areas of Aboriginal Australia: A preliminary analysis of population groupings with adaptive significance. In N. Peterson (Ed.), *Tribes and boundaries in Australia* (pp. 50–71). Canberra: Australian Institute of Aboriginal Studies.

Pickering, M. (2015). Rewards and frustrations: Repatriation of Aboriginal and Torres Strait Islander ancestral remains by the National Museum of Australia. *International Handbooks of Museum Practice*, *3*, 455–478.

Pietrusewsky, M. (1979). Craniometric variation in Pleistocene Australian and more recent Australian and New Guinean populations studied by multivariate procedures. *Occasional Papers in Human Biology*, *2*, 83–123).

Pietsch, T., Kemp, J., Pardoe, C., Grün, R., Olley, J., & Wood, R. (2019). A multi-method approach to dating the burial and skeleton of Kiacatoo Man, New South Wales, Australia. *Journal of Quaternary Science*, *34*(8), 662–673.

Prendergast, A. L., Bowler, J. M., & Cupper, M. L. (2009). Late Quaternary environments and human occupation in the Murray River Valley of northwestern Victoria. In A. Fairbairn, S. O'Connor, & B. Marwick (Eds.), *New directions in archaeological science* (pp. 55–74). Terra Australis 28. Canberra: Australia National University ePress.

Pretty, G. (1967). Rescue excavation of an Aboriginal grave, Tailem Bend, South Australia. *South Australian Naturalist*, *41*, 77–80.

Pretty, G. L. (1977). The cultural chronology of the Roonka Flat: A preliminary consideration. In R. Wright (Ed.), *Stone tools as cultural markers* (pp. 288–331). Canberra: Australian Institute of Aboriginal Studies.

Pretty, G. L. & Kricun, M. E. (1989). Prehistoric health status of the Roonka population. *World Archaeology*, *21*(2), 198–224.

Price, T. D. (2015). An introduction to the isotopic studies of ancient human remains. *Journal of the North Atlantic*, *7*, 71–87.

Prokopec, M. (1979). Demographical and morphological aspects of the Roonka population. *Archaeology and Physical Anthropology in Oceania*, *14*(1), 11–26.

Richards, L. C. (1984). Principal axis analysis of dental attrition data from two Australian Aboriginal populations. *American Journal of Physical Anthropology*, *65*(1), 5–13.

Richards, T., Pavlides, C., Walshe, K., Webber, H., & Johnston, J. (2007). Box Gully: New evidence for Aboriginal occupation of Australia south of the Murray River prior to the last glacial maximum. *Archaeology in Oceania*, *42*, 1–11.

Robertson, S. (2003). *A critical evaluation of the application of cribra orbitalia in Australian archaeology as a correlate of sedentism* (BA Honours thesis). Australian National University, Canberra.

Robertson, S. (2007). Sources of bias in the Murray Black collection: Implications for palaeopathological analysis. *Australian Aboriginal Studies 2007*(1), 116–127.

Ruff, C. B. (2008). Biomechanical analyses of archaeological human skeletons. In M. A. Katzenberg & S. R. Saunders (Eds.), *Biological anthropology of the human skeleton* (2nd edition, pp. 183–206). New York: Wiley-Liss.

Russell, L. (2010). Reflections on Murray Black’s writings. In S. Faulkhead & J. Berg (Eds.), *Power and passion: Our people return home* (pp. 56–63). Melbourne: Koorie Heritage Trust Inc.

Sandison, A. T. (1973). Palaeopathology of human bones from Murray River region between Mildura and Renmark, Australia. *Memoirs of the National Museum of Victoria*, *34*, 173–174.

Satterthwait, L. (1987). Socioeconomic implications of Australian Aboriginal net hunting. *Man*, *22*, 613–636.

Saxe, A. (1970). *Social dimensions of mortuary practices* (PhD thesis). University of Michigan, Ann Arbor, Michigan.

Sealy, J., Armstrong, R., & Schrire, C. (1995). Beyond lifetime averages: Tracing life histories through isotopic analysis of different calcified tissues from archaeological human skeletons. *Antiquity*, *69*(263), 290–300.

Smith, C. (2016). *Dental enamel hypoplasia at Roonka flat: A record of hunter-gatherer variability* (MA thesis). The University of Auckland, Auckland.

Smith, C. B., & Littleton, J. (2019). Enamel defects at Roonka, South Australia: Indicators of poor health or the osteological paradox? *Australian Archaeology*, *85*(2), 139–150.

Smith, M. (1978). A note on the fauna from Devon Downs shelter. *Australian Archaeology*, *8*, 19–21.

Smith, P., Prokopec, M., & Pretty, G. (1988). Dentition of a prehistoric population from Roonka Flat, South Australia. *Archaeology in Oceania*, *23*(1), 31–36.

Stirling, E. C. (1911). Preliminary report on the discovery of native remains at Swanport, River Murray: With an inquiry into the alleged occurrence of a pandemic among the Australian Aboriginals. *Transactions of the Royal Society of South Australia*, *35*, 4–46.

Stock, J. T., & Pfeiffer, S. K. (2001). Linking structural variability in long bone diaphyses to habitual behaviors: Foragers from the southern African later Stone Age and the Andaman Islands. *American Journal of Physical Anthropology*, *115*(4), 337–348.

Stone, T., & Cupper, M. L. (2003). Last Glacial Maximum ages for robust humans at Kow Swamp, southern Australia. *Journal of Human Evolution*, *45*(2), 99–111.

Taçon, P. S. (2013). Interpreting the in-between: Rock art junctions and other small style areas between provinces. *Time and Mind*, *6*(1), 73–80.

Thorne, A. G., & Macumber, P. G. (1972). Discoveries of late Pleistocene man at Kow Swamp, Australia. *Nature*, *238*(5363), 316–319.

Tindale, N. B. (1974). *Aboriginal tribes of Australia: Their terrain, environmental controls, distribution, limits, and proper names*. Canberra: Australian National University Press.

Van Holst Pellekaan, S., Liu, P., & Wilton, A. (2010). Genetic heritage in the Darling River Aboriginal peoples captures ancient presence and post-contact survival. *Before Farming*, *4*, 1–17.

Walker, K. F., & Thoms, M. C. (1993). Environmental effects of flow regulations on the Lower Murray River, Australia. *Regulated Rivers Research and Management*, *8*, 103–119.

Walker, K. F., Sheldon, F., & Puckridge, J. T. (1995). A perspective on Dryland River ecosystems. *Regulated Rivers Research and Management*, *11*, 85–104.

Webb, S. (2009). *Palaeopathology of Aboriginal Australians: Health and disease across a hunter-gatherer continent*. Cambridge: Cambridge University Press.

Webb, S. (1989). *Prehistoric stress in Australian Aborigines: A palaeopathological study of a hunter-gatherer population*. Oxford: BAR International Series 490.

Westell, C., Roberts, A., Morrison, M., Jacobsen, G., & the River Murray and Mallee Aboriginal Corporation (2020). Initial results and observations on a radiocarbon dating program in the Riverland region of South Australia, *Australian Archaeology*, doi: 10.1080/03122417.2020.1787928.

Wilson, C., Fallon, S., & Trevorrow, T. (2012). New radiocarbon ages for the Lower Murray River, South Australia. *Archaeology in Oceania*, *47*, 157–160.

Wood, J. W., Milner, G. R., Harpending, H. C., & Weiss, K. M. (1992). The osteological paradox: Problems of inferring prehistoric health from skeletal samples. *Current Anthropology*, *33*(4), 343–370.

Zohary, T., Erez, J., Gophen, M., Berman-Frank, I., & Stiller, M. (1994). Seasonality of stable carbon isotopes within the pelagic food web of Lake Kinneret. *Limnology and Oceanography*, *39*(5), 1030–1043.

Notes:

(1) Coobool Creek remains were collected in 1949 and 1950 by George Murray Black. It is the c. 70 remains from 1950 that are heavily carbonate encrusted and morphologically distinct from more recent remains (see Brown, 1989; Pardoe, 1988a).

Judith Littleton

Department of Anthropology, University of Auckland

Sarah Karstens

Department of Anthropology, University of Auckland

Harry Allen

Harry Allen, Associate Professor of Archaeology, Department of Anthropology, and coordinator of the Faculty of Arts Graduate programme in Museums and Cultural Heritage, University of Auckland, New Zealand.