8

Holocene site occupancy in Sulawesi

David Bulbeck

Abstract

This contribution presents an analysis of the number of Sulawesi sites (summed probability) occupied per 500-year interval between 10,000 and 0 BP, based on radiometric dates. The number of occupied sites was low between 10,000 and 4500 BP, ranging between 1 to 4 per half-millennium. There were subsequent increases in the number of occupied sites per half-millennium to 5–8 between 4500 and 2000 BP, 9–13 between 2000 and 1000 BP, and over 30 between 1000 and 0 BP. These figures would be consistent with a scenario of substantial population increases at around 4500, 2000 and 1000 BP. However, care should be exercised in making a literal interpretation of these figures. For instance, with respect to the 4500–2500 BP period, the number of closed sites was highest during 4500–3500 BP and the number of open-air sites highest during 3500–2000 BP. Also, the large number of documented sites dating to the last millennium BP reflects a particular focus of Sulawesi archaeological research on sites related ethnohistorically to the Bugis and other major ethno-linguistic divisions in South Sulawesi.

Keywords: Sulawesi Holocene, site occupancy, summed probabilities, closed sites, open-air sites

Introduction

The increased availability of radiometric determinations from archaeological sites has encouraged archaeologists to use these dates as a proxy measure for population levels in times past. Peros et al. (2010) and Williams (2012) outline the history and growing popularity of this approach, and its respective application to North America and Australia—two continents for which there are large numbers of radiocarbon dates from archaeological sites. The statistical basis for their analysis is to calibrate the dates, distribute the resulting calibrated probabilities across brief intervals and to sum the probabilities for each of the analytical intervals, followed by correction of the calculated numbers for factors such as the increasing probability of taphonomic loss of archaeological deposits with age and the perturbations inherent in the calibration curve (Peros et al. 2010; Williams 2012). While these two studies used the results to construct a scenario of continent-level changes in population size following initial colonisation, the same basic approach has been applied to more targeted research questions, such as the nature of the demographic transition in Europe following the early to mid-Holocene introduction of agriculture (Downey et al. 2014).

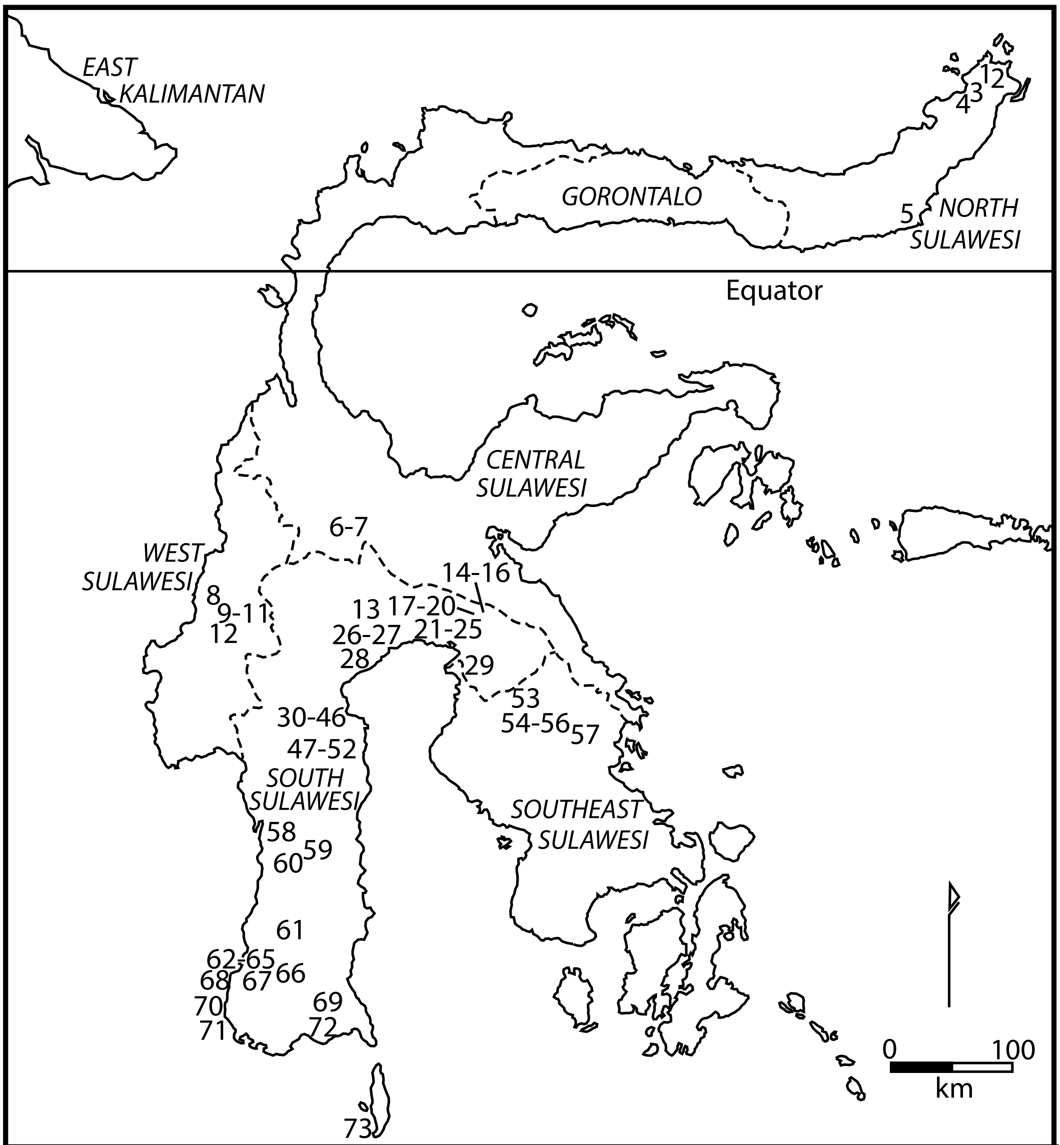
One pointed criticism of this approach is the possibility of a particularly intensive program of obtaining radiometric dates from certain sites compared with others, resulting in a biased representation of the periods of site occupancy represented by the intensively studied sites

(Hiscock and Attenbrow 2016). Examples of Sulawesi sites represented by large numbers of radiometric determinations include the Gua Talimbue cave site in Southeast Sulawesi and the Minanga Sipakko open site in West Sulawesi. A solution to this objection is to employ the determinations to estimate the probabilities of site occupancy per specified interval (here, half-millennium intervals BP), and to sum these probabilities as an estimate of the number of occupied sites per interval. Then, in fact, there would arguably be a reversal in the bias; specifically, that a certain interval at a given site represented by a single unsupported date may be as prominent (up to 100% occupancy probability) as another interval at the same site represented by multiple confirmatory dates (see Discussion). Also, there remains the potential objection of bias in the types of sites focused on, although this issue can be addressed by examining the research programs covered by the radiometric determinations and is open to correction in the future as novel research programs are initiated.

A particularly thorny issue is which determinations to accept for analysis. My general approach here is to include dates if clearly from an archaeological context, and to reject dates only if there are positive reasons for their rejection. The justifications for this approach include: (1) to allow the inclusion of dates back to the 1970s for sites that have not since been re-excavated; (2) to incorporate dates processed in Indonesia for excavations undertaken by Indonesian archaeologists without foreign collaboration; and (3) to avoid subjective decisions of dates' acceptability—for instance, whether they 'fit' the excavator's expectations based on dates obtained from other sites or even the same site. In accord with this last point, when a date is rejected the decision is made whether or not the date is compatible with the *a priori* expectation of the dated material's radiometric determination. For instance, the median Carbon-14 date of 7170 BP from basal Ulu Leang 2 (ANU 1606, Table A8.1) is entirely compatible with the Carbon-14 dates obtained from higher in the site's deposit, but the large standard error of 600 years makes the determination useless for pinning down the probabilities of the 'real age' by half-millennium intervals BP (cf. Spriggs 2003).

Table A8.1 in Appendix A lists the radiometric dates from Sulawesi rejected for the purposes of the present analysis and the reasons for their rejection. In the future, when the archaeology of Sulawesi is better documented, it may be feasible to impose stricter criteria on the acceptance of radiometric determinations—for instance, to exclude any Carbon-14 dates that are not Accelerator Mass Spectrometry (AMS) dates—and to still have a sufficiently large sample of dated sites to produce a robust scenario of Holocene site occupancy patterns. For present purposes, analytical time intervals of 500 years (Bulbeck 2014) are employed to accommodate the motley assemblage of accepted determinations with alternatively wide and tightly defined standard errors (Tables A8.2–A8.6).

Note that Sulawesi in this contribution is defined to include the main body of the island and any immediately offshore islands (Figure 8.1). The Sangihe and Talaud island chains, while politically part of Sulawesi, lie approximately halfway from North Sulawesi to Mindanao in the Philippines and so are not considered here to be geographically part of Sulawesi.



1: Woloan
2: Tatelu
3: Paso
4: Teling
5: Mansiri
6: Pokekea
7: Entovera
8: Pantara'an
9: Minanga Sipakko
10: Kamassi
11: Palemba
12: Sakkarra
13: Timo'oni
14: Sukoyu
15: Pontanoa Bangka
16: Nuha
17: Lemogola
18: Rahampu'u 1
19: Pandai Besi
20: Matano bore
21: Turungang Damar
22: Manu Manue
23: Katue
24: Bola Merajae
25: Salabu
26: Pinanto
27: Sabbang Loang
28: Arateng
29: Gua Andomo
30: Tampang Allo
31: Marimbunna Tikala
32: Londa
33: Lombok Borik
34: Buntu Pune
35: Marante Tondon
36: Lalanbai Sarira
37: Lalik Manuk
38: Tambolang Ba'lele
39: Limbong
40: Ke'te Kesuk
41: Allak Angin-Angin
42: Lo'kok Pongdadu
43: Se'pon Marinding
44: Pangki Mangke'pek
45: Palak Tokkek
46: Potok Tengan Kando
47: Tok Sempa
48: Kaluppini
49: Puang Leoran
50: Marengok Papaling
51: Buttu Mila
52: Liang Datu
53: Gua Lampetia
54: Gua Talimbue
55: Gua Mo'o hono
56: Gua Sambangoala
57: Gua Tengkorak
58: Bulubangi
59: Allangkanangnge ri Latanete
60: Tinco Tua
61: Mallawa
62: Gua Pasaung
63: Ulu Leang
64: Leang Burung
65: Leang Karassak
66: Gua Batti
67: Lamuru
68: Bayoa 1
69: Bonto-Bontoa
70: Galesong
71: Sanrabone
72: Batu Ejayya
73: Leang Batu Tunpa

Figure 8.1: Sites in Sulawesi that have yielded accepted radiometric determinations.

Source: Tables A8.2–A8.7.

Hypotheses on changes in Sulawesi past population sizes

An overall scenario of population size increases in ISEA is posited by Brandão et al. (2016) from their analysis of mitochondrial DNA haplogroups found in recent ISEA populations. They infer low population sizes during the Pleistocene, followed by a 19-fold increment, which commenced around 10,500–8000 years ago, and a further 70-fold increment starting at around 4000 years ago. They relate the first of the inferred population expansions to the early Holocene stabilisation of sea levels in ISEA following the drastic rises of sea levels during the terminal Pleistocene. The second population expansion is related to the immigration of Austronesian speakers from Taiwan into ISEA (where the great majority of indigenous languages are Austronesian) commencing at around 4500 BP, and probably involved increasing numbers of both the genes introduced by immigrant Austronesians and the autochthonous genes established in ISEA prior to the Austronesian incursion.

The first of the inferred population expansions is not directly tested in this study but one reason for starting the analysis at 10,000 BP is the scarcity of ISEA radiometric dates relating to the terminal Pleistocene—for instance, to my knowledge there are just two radiometric determinations for Sulawesi with a median age between 20,000 and 10,000 BP, both from the single site of Gua Talimbue (O'Connor et al. 2014). In contrast, as we shall see, the millennia after 10,000 BP are consistently represented by radiometric determinations, compatible with the persistence of sustainable population sizes.

The second of the inferences by Brandão et al. (2016) would predict an increase in occupied sites starting at around 4000 BP. However, as explicitly noted by the authors, this would not rule out major steps in population size (and numbers of occupied sites) at later times. For instance, my research into the early historical archaeology of Southwest Sulawesi has led me to postulate watersheds in population size growth at approximately 2000 BP and 750 BP (Bulbeck 2010).

Materials and methods

This study accepts radiometric determinations of Holocene age (Tables A8.2 to A8.6) from 73 archaeological sites in Sulawesi. As shown in Figure 8.1, large swathes of Sulawesi remain undocumented for their archaeological chronology, including all of Gorontalo Province, almost all of Central Sulawesi Province and the southern four-fifths of Southeast Sulawesi Province. Even in South Sulawesi, which is the province with by far the best documented archaeology, there are large gaps in the geographic coverage. Accordingly, there is ample scope for future archaeological research to test the scenario of Holocene site occupancy generated here from the currently available data.

The available radiometric determinations are characterised in terms of the class of dated material, site aspect and site use (detailed in Bulbeck 2014, 2016). The seven dated material classes in order of precedence are 'Ceramic' (including dates from charcoal extracted from ceramic objects), 'Boat' (including boat-shaped coffins), 'Human bone', 'Marine shell', 'Charcoal', 'Animal matter' and 'Plant matter'. The 'Ceramic' and 'Boat' classes are of particular interest for dating these important developments in Sulawesi's prehistoric technology. The site aspect categories in order of precedence are 'Closed', 'Monumental' (megalithic sites in the context of this study), 'Maritime' (no examples for Sulawesi), 'Marine shell midden', 'Freshwater shell midden' and 'Open' (where none of the preceding applies). The site usage categories in order of precedence are 'Mortuary', 'Ceremonial' (for ritual contexts lacking strong evidence of a mortuary association), 'Industrial', 'Transport' (no examples for Sulawesi), 'Gardening' (especially charcoal probably related to forest clearance) and 'Habitation' (where none of the preceding applies).

Site occupancy is analysed in terms of the probability of occupation during any 500-year interval between 10,000 and 0 cal BP. The Carbon-14 (including AMS) dates were calibrated using the OxCal 13 internet program (Bronk Ramsey 2013). The program includes a capacity to distribute the 100% probability of the date's antiquity across five-year intervals, allowing these probabilities to be summed to 500-year intervals cal BP. The calibration of these dates did not include any correction factor for southern hemisphere determinations, in view of the proximity (within 6°) of all of the dated sites to the equator (Figure 8.1). The small number of accepted determinations that required a marine reservoir correction factor or that were a luminescence date were modelled as normal distributions in order to be assigned to 500-year intervals (cal) BP. (Note that in the Results and Discussion sections, the terminology 'BP' is used instead of 'cal BP', so as to incorporate luminescence dates, which do not require calibration.)

For the sake of explanation, we can use the Mallawa determinations, which are all dates on 'Charcoal' from 'Habitation' usage in an 'Open' site aspect (Table A8.6). The calibrated date probabilities span the 10 half-millennia between 5000–4500 cal BP and 500–0 cal BP. As these are the probabilities of occupation, their complements equate to the probabilities that the date does not document any occupation during the half-millennium in question. The product of the complements equates to the probability that none of the dates document occupation during the said half-millennium, and so the complement of the product equates to the joint probability of occupation at the site during the said half-millennium. This mathematical procedure (grounded in classical probability theory) caps the probability of occupation during any half-millennium to 1 (100%), whilst allowing multiple dates that relate to a half-millennium to be used in consort to increase the overall probability of site occupation, up to a maximum of 1 (Table 8.1).

Table 8.1: Occupation probabilities of Mallawa by half-millennium cal BP.

Date	5–4.5 k BP	4.5–4 k BP	4–3.5 k BP	3.5–3 k BP	3–2.5 k BP	2.5–2 k BP	2–1.5 k BP	1.5–1 k BP	1–0.5 k BP	0.5–0 k BP	Sum
P3G-06	0.001	0.273	0.718	0.008							1.0
P3G-06			0.001	0.137	0.704	0.158					1.0
ANU 11276				0.054	0.535	0.395	0.016				1.0
Wk-20380					0.016	0.971	0.013				1.0
ANU 11274						0.004	0.968	0.028			1.0
ANU 11275									0.973	0.027	1.0
Joint probability	**0.001 (1)**	**0.273 (2)**	**0.718 (3)**	**0.190 (4)**	**0.865 (5)**	**0.985 (6)**	**0.969 (7)**	**0.028 (8)**	**0.973 (9)**	**0.027 (10)**	–

(1) 1–(1–0.001). (2) 1–(1–0.273). (3) 1–((1–0.718)*(1–0.001)). (4) 1–((1–0.008)*(1–0.137) *(1–0.054)). (5) 1–((1–0.704)*(1–0.535)*(1–0.016)). (6) 1–((1–0.158)*(1–0.395)*(1–0.971) *(1–0.004)). (7) 1–((1–0.016)*(1–0.013)*(1–0.968)). (8) 1–(1–0.028). (9) 1–(1–0.973). (10) 1–(1–0.027).

Source: Authors' analysis.

Figure 8.2 presents a graphical view of the Mallawa example, using the 95.4% (two standard error) probability curves generated using Bronk Ramsey (2013). These curves do not cover the 100% probabilities captured in Table 8.1, and so the chronological ranges they cover are narrower (compare, for instance, the Wk-20380 results in Figure 8.2 and Table 8.1), but they are still useful for illustrating the computation procedure. Now, the 500-year period between 2500 and 2000 BP covers the entire 95.4% probability (in fact, 97.1%) for the Wk-20380 determination, but there are three other determinations (P3G-06 (second), ANU 11276, ANU 11274) whose true calendrical date may also fall between 2500–2000 BP. Do these other determinations substantially increase the probability, compared with relying just on Wk-20380, for occupation at Mallawa during 2500–2000 BP? Simply summing the probabilities for the four determinations (Table 8.1) would produce a probability greater than 100%, which is a mathematical impossibility. Instead, following the statistically correct method outlined above, we find that the four determinations together do indeed produce a somewhat greater probability (98.5%) of Mallawa's occupation during 2500–2000 BP compared with just relying on Wk-20380 on its own.

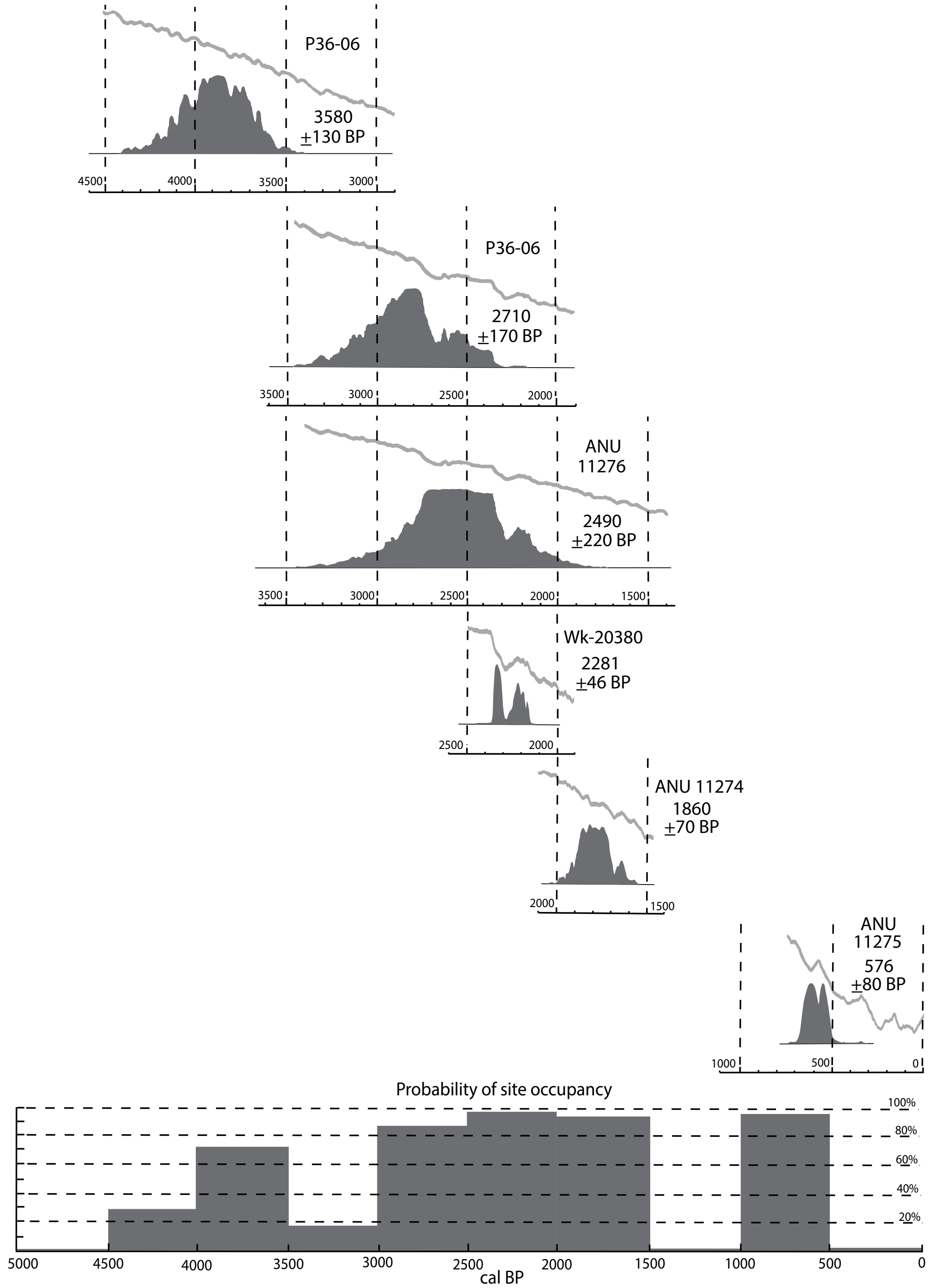


Figure 8.2: Mallawa radiocarbon dates' 95.4% probability distributions and related calibration curves related to the probability of site occupancy by 500-year cal BP intervals.

Sources: Bronk Ramsey (2013) output histograms (redrawn); Table 8.1.

Figure 8.2 illustrates an additional benefit of using 500-year intervals compared with attempting to generate granular curves of radiometric dating incidences (as done by Peros et al. (2010) and Williams (2012)). The peaks and troughs in the radiocarbon calibration curve often fall comfortably inside a 500-year interval, and so have minimal impact on the probability that a determination would relate to a given interval compared with the adjacent intervals. For instance, the trough at around 2300 BP is clearly reflected in bimodal calibration curves for ANU 11276 and Wk-20380 during the 2500–2000 BP interval (Figure 8.2), but the two modes are aggregated when the probability of 2500–2000 BP occupation at Mallawa is calculated (Table 8.1). Accordingly, the risk is neutralised of producing apparent patterns of occupation intensity that are a product of the radiocarbon calibration curve (as discussed by Bamforth and Grund 2012), and any need to accommodate for this effect is minimised.

The 73 sites with accepted determinations are independent entities, and so their joint probabilities of occupancy by half-millennium can be summed to estimate the probable number of Sulawesi sites occupied for each half-millennium. Take the example of four sites each with a 0.25 probability of occupancy during a given half-millennium, producing a summed probability of one occupied site. In reality, the number of occupied sites could be between zero and four, with the following probabilities:

0 sites: 1 * (0.75*0.75*0.75*0.75) = 0.316
1 site: 4 * (0.25*0.75*0.75*0.75) = 0.422
2 sites: 6 * (0.25*0.25*0.75*0.75) = 0.211
3 sites: 4 * (0.25*0.25*0.25*0.75) = 0.047
4 sites: 1 * (0.25*0.25*0.25*0.25) = 0.004

The modal probability is one occupied site. Also, while there is a greater probability of zero than two–four occupied sites, this is offset by the possibility of several sites more than 1 occupied site as represented by the probabilities for three and for four occupied sites.

The procedure outlined above can also be undertaken as separate exercises for the site aspect categories, site usage categories and dated material classes (see Results).

Because the site occupancy levels are modest in scale, reaching a maximum of 33 occupied sites for any 500-year interval (see below), no attempt is made to formally correct the calculated site numbers for potential biases such as site taphonomic loss. Instead, these potential biases will be considered at an intuitive level in the Discussion.

Results

The clearest introductory overview of Sulawesi Holocene site occupancy is provided by considering site aspect. All of the sites have a single aspect except for the large Tinco Tua site (Kallupa et al. 1989), which has 'Monumental' and 'Open' aspects (Table A8.6), computed separately. Also, in view of the hierarchy of site aspect categories, the two overarching aspects are **closed** sites and **open-air** sites (covering all sites that are not closed).

The site aspect graph (Figure 8.3) shows continuous use of closed sites in Sulawesi covering the last 10,000 years BP, including a mid-Holocene spike for the 4500–3500 BP period, followed by a second, more pronounced spike after 2000 BP. This second spike predominantly reflects the use of closed sites for depositing human remains over the last couple of millennia BP, as will become evident when the site usage categories are considered.

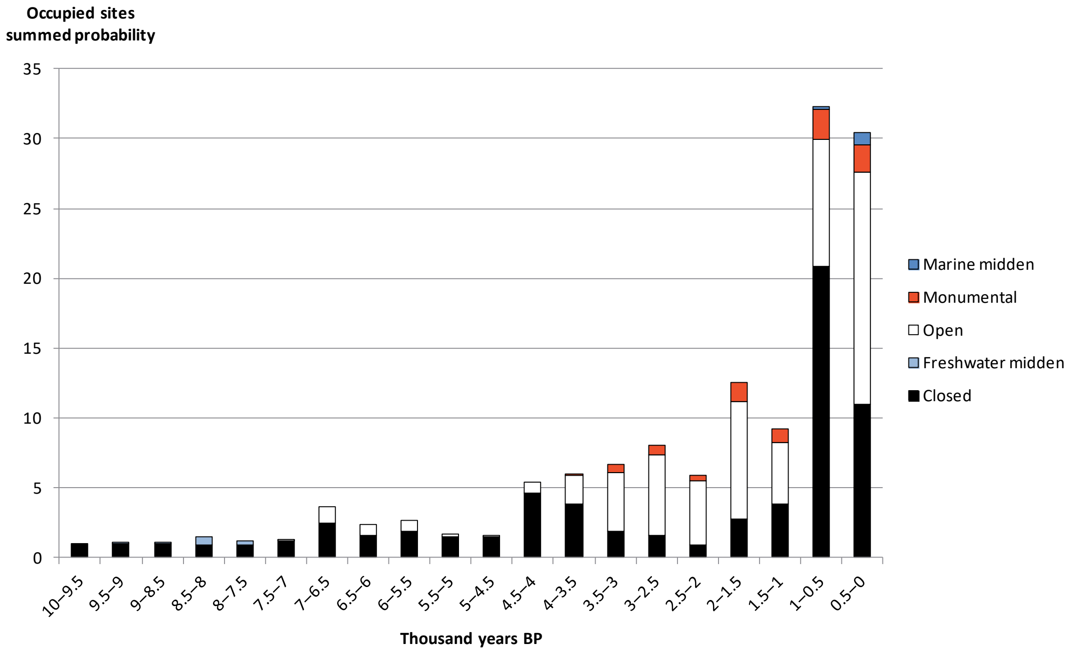


Figure 8.3: Sulawesi sites summed probabilities by site aspect.
Source: Author's data.

Shell middens make just a miniscule contribution to Sulawesi's archaeological chronometry, even though the Paso freshwater shell midden (3 in Figure 8.1) is the oldest open-air site in Sulawesi. The single dated marine shell midden, named Salabu (25 in Figure 8.1), has a very high probability of dating to the <500 years BP interval. 'Open' sites make a detectable contribution to Sulawesi site occupancy levels during the 7000–5500 BP interval and then with increasing impact from 4500 BP onwards. They are joined by 'Monumental' (megalithic) sites from 2500 BP onwards, present with sufficient regularity to propose 2500 BP as an approximate inception date for Sulawesi's widespread megalithic tradition(s).

When site usage is considered, we see that the 'Habitation' category accounts for all of the radiometric determinations up to 3500 BP, and the great majority of radiometric determinations till as recently as 2500 BP (Figure 8.4). The 'Ceremonial' category (notably for open-air sites) is consistently represented for the period between approximately 3000 BP and the present, along with the 'Mortuary' category (for both closed and open-air sites) after 2500 BP. The late Holocene dating for these site usage categories reflects the availability of accepted radiometric determinations rather than the limitations of Sulawesi's early to middle Holocene inhabitants for a symbolic capacity. Uranium-series dates obtained for parietal paintings in the Maros karsts document an age range of c. 40,000–18,000 years BP for a symbolic propensity in Sulawesi *Homo sapiens*; unfortunately, direct dates are yet to be published for the very large body of Sulawesi rock paintings that are not covered by the collaroid speleothems that allowed the above-mentioned late Pleistocene dates to be obtained (Oktaviana et al. 2016). Similarly, the mid-Holocene date for a burial from Leang Burung 1 (ANU 6175 in Table A8.1) is fully consistent with the burial's preceramic stratigraphic context, but the determination was obtained from the human bone apatite fraction and so is sadly not reliable enough for inclusion in the present study.

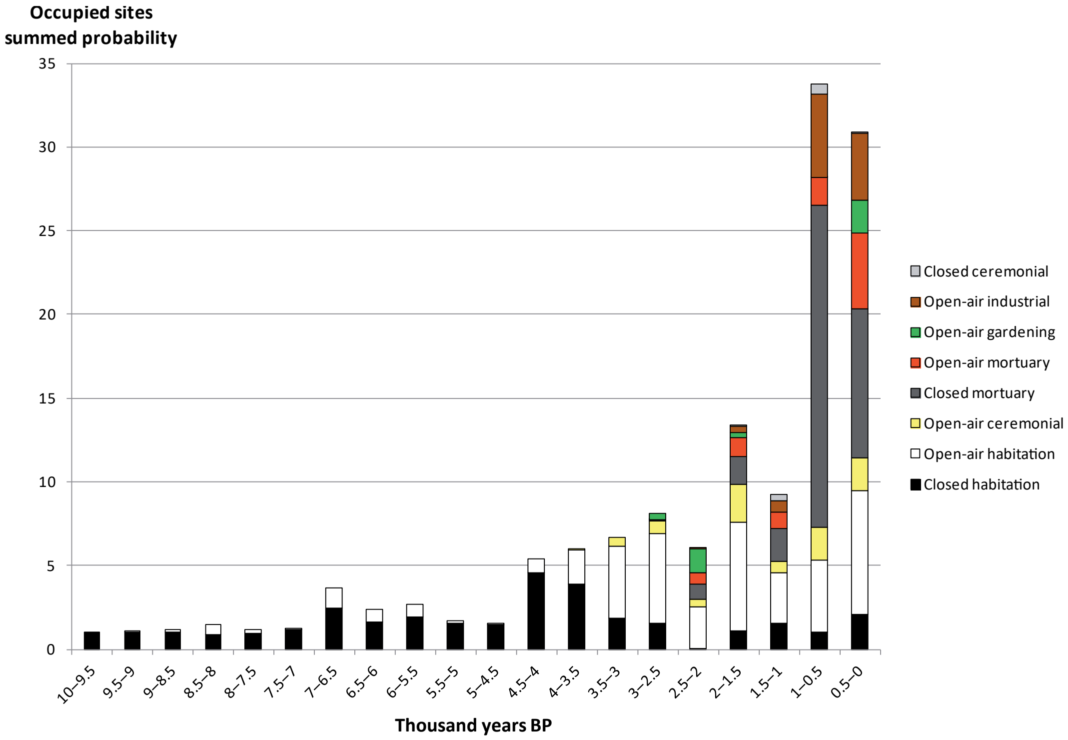


Figure 8.4: Sulawesi sites summed probabilities by site usage.
Source: Author's data.

However, there are two examples of site usage categories whose late Holocene representation is more reasonably taken at face value. One is the 'Gardening' category, convincingly documented for 2500–2000 BP, which can be interpreted as a minimum estimate for when farming activities allowed the establishment of permanent kampong settlements in Sulawesi (e.g. Anggraeni et al. 2014). The second is the 'Industrial' category, in particular ironworking for which Sulawesi (*sula besi* = 'island of iron') received its name. The industry appears to have originated by around 1500 BP and to have been in full operation throughout the last millennium BP (Figure 8.4).

Until approximately 2500 BP, the available radiometric determinations reflect the exclusive or predominant of closed sites for habitation rather than mortuary disposals, but this relationship switches after 2500 BP, especially during the last millennium BP when dates on mortuary disposals in closed sites make up the single largest site usage category.

The graph for dating material (Figure 8.5) shows the exclusive reliance on charcoal both for closed and open-air sites until c. 5000 BP. Animal matter as a dating material appeared in closed sites during the 5th millennium BP and in open-air sites from around 3500 BP to the present. The ceramic category is convincingly represented in open-air sites during 3000–2500 BP and in open-air and closed sites (in combination) during 2000–500 BP. This is direct evidence for a minimum date of 3000 BP for the appearance of pottery in Sulawesi.

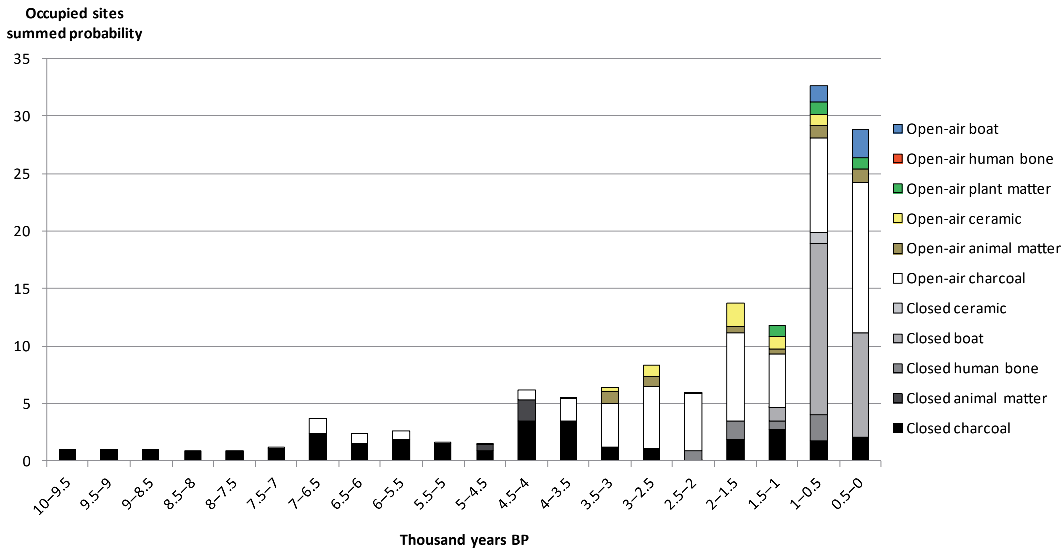


Figure 8.5: Sulawesi sites summed probabilities by dating material.
Source: Author's data.

The three dating materials restricted to the last 2000 years BP on current documentation are the 'Human bone', 'Plant matter' and 'Boat' categories. The boat category, constituted by dates on boat-shaped coffins, is represented at a modest number of closed sites for the 1500–1000 BP interval and then a large number of closed sites and moderate number of open-air sites for the last millennium BP. These boat dates are maximum estimates of antiquity because the samples generally derive from the bark and/or outer tree-rings, and so more closely reflect the date when the tree was a sapling rather than when it was felled for making into a coffin. For instance, in his discussion of the dates from the Enrekang coffins (47–52 in Figure 8.1), Duli (2013) noted that the dates on *Elmerillia celebica* (Dandy) wood were systematically several centuries older than the dates on *Vitex cofassus* (Reinwald) wood, and so proposed that the c. 600 to 700 cal BP dates on *E. celebica* wood should be interpreted as maximally 500 to 550 cal BP in terms of the Enrekang coffins' age.

Accordingly, although it is not possible to formally accommodate the 'old wood effect' impacting on the boat-shaped coffins' age, it is fully possible that all of these coffins would correctly date to the last millennium BP, and that the number of them that are <500 BP in age is at least equal to the number with a true antiquity of 1000–500 BP. The implied effects on the overall pattern of site occupancy over time would be to increase the degree to which the 1500–1000 BP interval is less well represented than the 2000–1500 BP interval, but also to even up the 1000–500 BP and 500–0 BP histogram heights.

Discussion

Taphonomic effects may have had some impact on the results. For instance, the slightly lower site occupancy recorded between 10,000–7000 BP compared with 7000–4500 BP, and the fact that the only open-air site for the former period is a freshwater shell midden, may reflect greater taphonomic loss or burial of early Holocene sites. Also, the greater variability of late Holocene dating materials compared with early to mid-Holocene materials may partly reflect disintegration of older samples to the status of 'Charcoal', although two of the late Holocene material categories (the 'Ceramic' and 'Boat' categories) would appear to reflect late Holocene technological innovations. Overall, a generally increased visibility of open-air sites between the 4500–4000 and 500–0 BP intervals (Figure 8.3) would have had some impact on site occupancy levels, even if difficult to quantify.

On the other hand, any impact of calibration effects would be debatable. For instance, these effects should exaggerate the 2500–2000 BP occupancy level compared with 3000–2500 BP (Williams 2012:582), but the results actually suggest a slight dip during 2500–2000 BP. As observed in the earlier discussion for Figure 8.2, late Holocene dips and troughs in the calibration curve appear to be accommodated by this study's 500-year BP intervals and, as for the early Holocene, site numbers by 500-year interval are uniformly small.

Overall, the proposition by Brandão et al. (2016) of a 70-fold population increase in ISEA commencing at around 4000 years ago appears to be broadly confirmed by the sustained increase in Sulawesi site occupancy levels documented to have begun at around 4500 BP. Yet the interpretation is complicated by the observation that the increased site occupancy levels initially spiked for closed habitation sites, but these levels declined after 4000 BP as occupancy levels of open-air sites and closed mortuary sites came to the fore (Figure 8.4). This increased occupancy of sites other than closed habitation sites may be a more fitting counterpart to the population increase posited by Brandão et al. (2016).

The transition from mainly closed habitation sites to mainly open-air sites between 4500 and 2000 BP, during a period when overall site occupancy levels appear to have remained stable, is intriguing but difficult to explain. Explanation is difficult because the sites concerned are located in mutually exclusive areas. The critical closed sites are located in South and Southeast Sulawesi (specifically, 54–56, 62–65 and 72 in Figure 8.1), compared with the critical open-air sites in North and West Sulawesi plus a single South Sulawesi site (Mallawa, lying to the north of the South Sulawesi closed habitation sites). A simplistic explanation would entertain a desertion of the closed sites whose former occupants migrated to the locations where open-air sites have been documented. But the distances involved are large, and most authorities today would link the growth of open-air sites to the incursion of Austronesian speakers from the Philippines (e.g. Simanjuntak 2008; Anggraeni et al. 2014). In addition, even if the increase in open-air sites after 3500 BP can be linked to the greater visibility of Austronesian settlements compared with pre-Austronesian forager campsites, this would not explain the apparent decline in closed habitation sites after 4000 BP.

Accordingly, it may seem more reasonable to propose that the Malayo-Polynesian (Austronesian) incursion led to disturbances to the environment or transformations of the social landscape that diminished the attractiveness of habitation of closed sites. However, to test this proposition, relevant data would be required from open-air sites in the locations where we have the closed sites and closed sites where we have the open-air sites. This may be a strategic priority for future research on Sulawesi's late Holocene archaeology, which may also test whether the currently recorded 4500–4000 BP peak in closed habitation sites (Figure 8.4) is an artefact of sampling or a firm result to be reckoned with.

The author's proposition of a population increase with the advent of the Early Metal Phase at around 2000 BP, based on my review of the archaeological evidence from South and West Sulawesi (Bulbeck 2010), is confirmed for Sulawesi generally in terms of site occupancy levels. Documented occupancy levels were higher throughout the 2nd millennium BP than at any earlier stage. Also, the site usage categories were variable, including the evident addition of local industrial (ironworking) sites at some point during the millennium. However, there is no sign of increased site occupancy levels during the millennium, whether or not we literally interpret the apparent dip in these levels during the 1500–1000 BP interval compared with the 2000–1500 BP interval.

The author's proposition of a population increase at around 750 BP (Bulbeck 2010) is also confirmed by the high site occupancy levels, in excess of 30 per 500-year interval, throughout the 1st millennium BP. In this case, the majority of the avalanche of site dates were obtained through projects that aimed to elucidate the early history of specific ethnographic-cum-historical situations as recorded for South Sulawesi: Bulbeck's (1992) study of the origins of the Macassar empire; Bulbeck and Caldwell's (2000) investigation into the origins of ironworking associated with the rise of the Bugis kingdom of Luwu; and the projects by Duli (2012, 2013) to date the coffins stored in caves by the Tana Toraja and Enrekang ethnic groups. This point raises the possibility that the observed leap in site occupancy levels reflects a c. 1000-year time depth for most of the archaeological sites that can be encountered from following up on ethnohistorical reports (oral and/or written).

However, it is also the case that most of South Sulawesi and the lowland stretches of West Sulawesi were well populated as of c. 500 BP (e.g. Andaya 1981), and in the case of Macassar and its immediate hinterland, the number of archaeological sites combined with historical records suggests a population increase from around 60,000 people in the 14th century AD to 170,000 in the 17th century AD (Bulbeck 1992). The urban and dense rural populations recorded for much of southwestern Sulawesi at this time reflects the combination of widespread wet-rice agriculture, cultivation of numerous ancillary crops on generally fertile soils and intensive trade (Bulbeck 1992; Bulbeck et al., this volume), which may not have applied generally across Sulawesi. The significant number of Indian cotton *patola* traded to Central Sulawesi, with AMS dates of c. 600 BP and later (Table A8.1), possibly suggests similar developments there to those documented for southwestern Sulawesi; unfortunately, these *patola* lack any archaeological context. In short, the documented peak in site occupancy levels during the last millennium BP relates specifically to South Sulawesi, and the extent to which it could be generalised across Sulawesi would be a matter for future research.

One topic for discussion is the impact of radiometric determinations that fall outside of the main concentration of dates, which can be addressed by considering these determinations for the Minanga Sipakko and Kamassi sites (9 and 10 in Figure 8.1). At both sites, multiple dates refer to the 3500–2500 BP 'Neolithic' period, resulting in a probability of occupancy of 100% for 3500–3000 BP and over 75% for 3000–2500 BP. However, the accepted determinations also point to probable earlier occupancy, as early as 7000–6500 BP (80% probability for Kamassi), 4500–4000 BP (56% probability for Minanga Sipakko) and 4000–3500 BP (100% probability for Minanga Sipakko). No suggestion is being made here that the Neolithic in Sulawesi necessarily dates to earlier than 3500 BP; instead, that the excavation of these sites recovered evidence for pre-Neolithic occupancy at riverside locations ideal for habitation.[1]

The Kamassi site contributes to the intriguing suggestion of a minor, isolated peak in occupancy levels of open sites (and therefore sites overall) between 7000–5500 BP (Figure 8.3). But the apparent 5500–4500 BP dip probably reflects sampling error, as suggested by the significant number of 'Maros points' recorded as surface finds in Southwest Sulawesi. A Toalean type (see footnote 1), these hollow-based, denticulated projectile points are dated from closed sites to 5000–3500 BP (Bulbeck 2004). Accordingly, if they could be dated, the open sites with Maros points may counteract any 5500–4500 BP dip in occupancy levels. A case in point is Pammangkulang Batua, on the bank of a major river (the Je'ne'berang, just south of the Lamuru site; 67 in Figure 8.1), where 422 stone artefacts including two Maros points were collected. Unfortunately, the site would be unsuitable for excavation, not only because the stone artefacts'

1 The decision by Anggraeni et al. (2014) to reject these early dates, based on the lack of 'Toalean' tool types in the excavated deposits, is without foundation, because the Toalean was restricted to the Southwest Sulawesi peninsula, as documented by Bulbeck (2004:154; see also the papers in this volume by Hasanuddin and by O'Connor et al.).

original context was apparently a thin soil covering the local conglomerates, but also because they were subsequently disturbed to the surface through quarrying of the site's conglomerates (Pasqua 1995).

In general, the recovery of open-air pre-Neolithic sites in stratified context is a confronting task for archaeologists in the face of the 'twin taphonomic terrors' of wholesale erosion of the site or its burial deep beneath overburden deposit. Certainly, pre-Neolithic open habitation are drastically under-represented by their small number of available dates, even after acceptance of the examples from Minanga Sipakko and Kamassi.

Conclusion

The radiometric dates from Sulawesi sites accepted for this study suggest persistent but low levels of site occupancy between 10,000 and 4500 BP, followed by dynamic change during the late Holocene. Site occupancy levels stepped up during the 4500–2000 BP period, and again during the 2000–1000 and 1000–0 BP periods. Habitation occupancy of closed sites peaked during the 4500–4000 BP interval, but declined in later times as the occupancy of open-air sites for habitation and other purposes, and (after 2000 BP) the use of closed sites for mortuary purposes, became increasingly evident. Dating material analysis indicates a minimum age of 3000 BP for the presence of ceramics in Sulawesi, while site aspect analysis and site usage analysis suggest a minimum age of 2500 BP for gardening activities and the inception of megalithic practices in Sulawesi, respectively. Other important developments in Sulawesi for which dating evidence is available include ironworking by 1500 BP and the production of boat-shaped coffins (after allowing for the potential 'old wood effect' in these coffins) by 1000 BP.

Remembering that the synopsis presented here is based on just 73 sites, and that the accepted dates include many that were obtained before AMS dating became standard practice, we should treat the results of this study as a hypothesis for future testing as archaeological outreach across Sulawesi is extended and the recovery of strongly rigorous radiometric determinations becomes more entrenched.

Acknowledgements

The author thanks two anonymous referees for their valuable comments on the originally submitted version of this manuscript.

Author biography

David Bulbeck Department of Archaeology and Natural History, School of Culture, History and Language, College of Asia and the Pacific, The Australian National University, Canberra, Australia

References

Andaya, L.Y. 1981. *The Heritage of Arung Palakka: A History of South Sulawesi (Celebes) in the Seventeenth Century*. Verhandelingen van het Koninklijk Instituut voor Taal-, Land- en Volkenkunde 91. The Hague: Martinus Nijhoff.

Anggraeni. 2012. The Austronesian Migration Hypothesis as seen from Prehistoric Settlements on the Karama River, Mamuju, West Sulawesi. Unpublished PhD thesis, School of Archaeology and Anthropology, The Australian National University, Canberra.

Anggraeni. 2016. *The development of Neolithic-Palaeometallic pottery with a special reference to the Karama Valley, West Sulawesi*. Presentation at 'The Archaeology of Sulawesi – An Update', Makassar, Sulawesi, 31 January – 2 February.

Anggraeni, T. Simanjuntak, P. Bellwood and P. Piper. 2014. Neolithic foundations in the Karama valley, West Sulawesi, Indonesia. *Antiquity* 88(341):740–756. doi.org/10.1017/S0003598X00050663 (accessed 5 June 2018).

Azis, N., C. Reepmeyer, G. Clark, Sriwigati and D.A. Tanudirjo. 2018. Mansiri in North Sulawesi: A new dentate-stamped pottery site in Island Southeast Asia. In S. O'Connor, D. Bulbeck and J. Meyer (eds), *The Archaeology of Sulawesi: Current Research on the Pleistocene to the Historic Period*, pp. 191–206. Canberra: ANU Press.

Bamforth, D.B. and B. Grund. 2012. Radiocarbon calibration curves, summed probability distributions, and early Paleoindian population trends in North America. *Journal of Archaeological Science* 39(6):1768–1774. doi.org/10.1016/j.jas.2012.01.017 (accessed 5 June 2018).

Barnes, R. and M.H. Kahlenberg (eds). 2010. *Five Centuries of Indonesian Textiles: The Mary Hunt Kahlenberg Collection*. Munich: Delmonico Books.

Bellwood, P. 1976. Archaeological research in Minahasa and the Talaud Islands, Northeastern Indonesia. *Asian Perspectives* 19(2):240–288.

Brandão, A., K.K. Eng, T. Rito, B. Cavadas, D. Bulbeck, F. Gandini, M. Pala, M. Mormina, B. Hudson, J. White, T.-M. Ko, M. Saidin, Z. Zafarina, S. Oppenheimer, M.B. Richards, L. Pereira and P. Soares. 2016. Quantifying the legacy of the Chinese Neolithic on the maternal genetic heritage of Taiwan and Island Southeast Asia. *Human Genetics* 135(4):363–376. doi.org/10.1007/s00439-016-1640-3 (accessed 5 June 2018).

Bronk Ramsey, C. 2013. *OxCal 4.2 manual.* RC.arch.ox.ac.uk/oxcal/Oxcal.html (accessed 3 November 2016).

Bronson, B. and I. Glover. 1984. Archaeological radiocarbon dates from Indonesia: A first list. *Indonesia Circle* 12(34):37–44. doi.org/10.1080/03062848408729585 (accessed 5 June 2018).

Bulbeck, F.D. 1992. A Tale of Two Kingdoms: The Historical Archaeology of Gowa and Tallok, South Sulawesi, Indonesia. Unpublished PhD thesis, School of Archaeology and Anthropology, The Australian National University, Canberra. www.oxis.org/theses/bulbeck-1992.pdf (accessed 5 June 2018).

Bulbeck, D. 2004. Divided in space, united in time: The Holocene prehistory of South Sulawesi. In S.G. Keates and J.M. Pasveer (eds), *Quaternary Research in Indonesi*a, pp. 129–166. Modern Quaternary Research in Southeast Asia, Volume 18. Leiden: A.A. Balkema.

Bulbeck, D. 2010. Uneven development in Southwest Sulawesi, Indonesia during the Early Metal Phase. In B. Bellina, E.A. Bacus, T.O. Pryce and J.W. Christie (eds), *50 Years of Archaeology in Southeast Asia: Essays in Honour of Ian Glover*, pp. 153–169. Bangkok: River Books.

Bulbeck, D. 2014. The chronometric Holocene archaeological record of the southern Thai-Malay Peninsula. *International Journal of Asia Pacific Studies* 10(1):112–162.

Bulbeck, D. 2016. The Neolithic Gap in the Southern Thai-Malay Peninsula and its implications for Orang Asli prehistory. In K. Endicott (ed.), *Malaysia's Original People: Past, Present and Future of the Orang Asli*, pp. 123–152. Singapore: NUS Press.

Bulbeck, D., F.A. Aziz, S. O'Connor, A. Calo, J.N. Fenner, B. Marwick, J. Feathers, R. Wood and D. Prastiningtyas. 2016. Mortuary caves and the dammar trade in the Towuti-Routa region, Sulawesi, in an Island Southeast Asian context. *Asian Perspectives* 55(2):148–183. doi.org/10.1353/asi.2016.0017 (accessed 5 June 2018).

Bulbeck, D. and I. Caldwell. 2000. *Land of Iron: The Historical Archaeology of Luwu and the Cenrana Valley. Results of the Origin of Complex Society in South Sulawesi Project (OXIS)*. Hull: Centre for South-East Asian Studies, University of Hull. www.oxis.org/books/land-of-iron.pdf (accessed 5 June 2018).

Bulbeck, D. and I. Caldwell. 2008. *Oryza sativa* and the origins of kingdoms in South Sulawesi, Indonesia: Evidence from rice husk phytoliths. *Indonesia and the Malay World* 36(104):1–20. doi.org/10.1080/13639810802016117 (accessed 5 June 2018).

Bulbeck, D., I. Caldwell, S. Druce, B. Hakim and C. Macknight. 2018. Imported tradeware ceramics and their relevance for dating socio-political developments in South Sulawesi, with special reference to the Allangkanangnge ri Latanete site. In S. O'Connor, D. Bulbeck and J. Meyer (eds), *The Archaeology of Sulawesi: Current Research on the Pleistocene to the Historic Period*, pp. 269–286. Canberra: ANU Press.

Bulbeck, D. and M.A. Fadillah. 2000. The context of the carnelian beads from Bonto-Bontoa, Bantaeng, South Sulawesi. *Walennae* 3(1):44–48.

Bulbeck, D. and B. Hakim. 2005. The human fossil cranium from Leang Batu Tunpa, Selayar, Sulawesi Selatan. In D.W. Utomo, Hasanuddin, B. Hakim and A.F. Uma (eds), *Menguak Tabir Kehidupan Masa lalu dan kini*, pp. 71–84. Makassar: Balai Arkeologi Makassar.

Bulbeck, D. and Nasruddin. 2002. Recent insights on the chronology and ceramics of the Kalumpang site complex, South Sulawesi, Indonesia. *Bulletin of The Indo-Pacific Prehistory Association* 22:83–100.

Bulbeck, D., M. Pasqua and A. Di Lello. 2000. Culture history of the Toalean of South Sulawesi, Indonesia. *Asian Perspectives* 39(1–2):71–108. doi.org/10.1353/asi.2000.0004.

Downey, S.S., E. Bocaege, T. Kerig, K. Edinborough and S. Shennan. 2014. The neolithic demographic transition in Europe: Correlation with juvenility index supports interpretation of the summed calibrated radiocarbon date probability distribution (SCDPD) as a valid demographic proxy. *PLoS ONE* 9(8):e105730. doi.org/10.1371/journal.pone.0105730 (accessed 5 June 2018).

Druce, S., D. Bulbeck and I. Mahmud. 2005. A transitional Islamic Bugis cremation in Bulubangi, South Sulawesi: Its historical and archaeological context. *Review of Indonesian and Malaysian Affairs* 39(1):1–22.

Duli, A. 2012. Budaya Keranda Erang di Tana Toraja. Unpublished PhD thesis, Centre for Archaeological Research Malaysia, Universiti Sains Malaysia, Kuala Lumpur.

Duli, A. 2013. The mandu coffin: A boat symbol of ancestral spirits among the Enrekang people of South Sulawesi. *Review of Indonesian and Malaysian Affairs* 47(1):115–138.

Fakhri. 2016. Situs Rampi: Masa persebaran arca batu dan hubungannya dengan di wilayah situs terdekat (Rampi sites: The dispersion age of stone statue and the connection between nearest site areas). *Walennae* 14(1):23–36. walennae.kemdikbud.go.id/index.php/walennae/article/view/38 (accessed 27 October 2018).

Fakhri. 2018. Vertebrate fauna from Gua Sambangoala, Southeast Sulawesi. In S. O'Connor, D. Bulbeck and J. Meyer (eds), *The Archaeology of Sulawesi: Current Research on the Pleistocene to the Historic Period*, pp. 153–170. Canberra: ANU Press.

Fakhri, Suryatman, B. Hakim and R. Sardi. 2015. Exploration of prehistoric sites in the Karama watershed, West Sulawesi, Indonesia. *Journal of Indo-Pacific Archaeology* 39:18–25. journals.lib.washington.edu/index.php/JIPA/article/view/14786/12489 (accessed 5 June 2018).

Glover, I. 1978. Survey and excavation in the Maros district, south Sulawesi, Indonesia: The 1975 field season. *Bulletin of The Indo-Pacific Prehistory Association* 1:60–103.

Glover, I.C. 1981. Leang Burung 2: An upper Palaeolithic rock shelter in South Sulawesi, Indonesia. In G.-J. Bartstra and W.A. Casparie (eds), *Modern Quaternary Research in Southeast Asia*, pp. 1–38. Modern Quaternary Research in Southeast Asia, Volume 6. Rotterdam: A.A. Balkema.

Glover, I. 1997. Southeast Asia. In S. Hooper (ed.), *Robert and Lisa Sainsbury Collection*, pp. 214–217. Ipswich: University of East Anglia.

Guy, J. 1998. *Woven Cargoes: Indian Textiles in the East*. London: Thames and Hudson.

Hakim, B., M. Nur and Rustam. 2009. The sites of Gua Pasaung (Rammang-Rammang) and Mallawa: Indicators of cultural contact between the Toalian and Neolithic complexes in South Sulawesi. *Bulletin of The Indo-Pacific Prehistory Association* 29:45–52. doi.org/10.7152/bippa.v29i0.9476 (accessed 5 June 2018).

Hasanuddin. 2015. Kebudayaan Megalitik di Sulawesi Selatan dan Hubungannya dengan Asia Tenggara. Unpublished PhD thesis, Centre for Archaeological Research Malaysia, Universiti Sains Malaysia, Kuala Lumpur. www.oxis.org/theses/hasanuddin-2015.pdf (accessed 5 June 2018).

Hasanuddin. 2018. Prehistoric sites in Enrekang Kabupaten, South Sulawesi. In S. O'Connor, D. Bulbeck and J. Meyer (eds), *The Archaeology of Sulawesi: Current Research on the Pleistocene to the Historic Period*, pp. 171–190. Canberra: ANU Press.

Higham, T., C. Bronk Ramsey, F. Brock, D. Baker and P. Ditchfield. 2007. Radiocarbon dates from the Oxford AMS system: Archaeometry datelist 32. *Archaeometry* 49(Supplement s1):S1–S60. doi.org/10.1111/j.1475-4754.2007.00363.x (accessed 5 June 2018).

Hiscock, P. and V. Attenbrow. 2016. Dates and demography? The need for caution in using radiometric dates as a robust proxy for prehistoric population change. *Archaeology in Oceania* 51(3):218–219. doi.org/10.1002/arco.5096 (accessed 5 June 2018).

Kallupa, B., D. Bulbeck, I. Caldwell, I. Sumantri and K. Demmanari. 1989. *Survey Pusat Kerajaan Soppeng 1100–1986* [*Survey of the Capital of Soppeng Kingdom 1100–1986*]. Final Report to the Australian Myer Foundation, Privately published in Canberra, ACT. www.oxis.org/books/soppeng-1986.pdf (accessed 5 June 2018).

Kirleis, W., J. Müller, C. Kortemeier, H. Behling and S. Soeghondo. 2012. The megalithic landscape of Central Sulawesi, Indonesia: combining archaeological and palynological investigations. In M.L. Tjoa-Bonatz, A. Reinecke and D. Bonatz (eds), *Crossing Borders in Southeast Asian Archaeology: Selected Papers from the 13th International Conference of the European Association of Southeast Asian Archaeologists, Berlin, 2010,* pp. 199–220. Singapore: NUS Press.

O'Connor, S., F.A. Aziz, B. Marwick, J. Fenner, B. Prasetyo, D. Bulbeck, T. Maloney, E.S. Pierre, R. Whitau, U.P. Wibowo, B. Hakim, A. Calo, Fakhri, M. Husni, Hasanuddin, A.A. Oktaviana, D. Prastiningtyas, F.Z. Campos, and P.J. Piper with an appendix by A.A. Oktaviana and Suryatman. 2014. *The Archaeology of Sulawesi: A Strategic Island for Understanding Modern Human Colonization and Interactions Across our Region*. Final Report to Indonesia's Bureau of Research and Technology, Department of Archaeology and Natural History, The Australian National University, Canberra and Department of Prehistory, Indonesia's National Centre for Archaeological Research and Development, Jakarta.

O'Connor, S., D. Bulbeck, P.J. Piper, F. Aziz, B. Marwick, F. Campos, J. Fenner, K. Aplin, Fakhri, Suryatman, T. Maloney, B. Hakim and R. Wood. 2018. The human occupation record of Gua Mo'o hono shelter, Towuti-Routa region of Southeastern Sulawesi. In S. O'Connor, D. Bulbeck and J. Meyer (eds), *The Archaeology of Sulawesi: Current Research on the Pleistocene to the Historic Period*, pp. 117–152. Canberra: ANU Press.

Oktaviana, A.A., D. Bulbeck, S. O'Connor, B. Hakim, Suryatman, U.P. Wibowo, E. St Pierre and Fakhri. 2016. Hand stencils with and without narrowed fingers at two new rock art sites in Sulawesi, Indonesia. *Rock Art Research* 33(1):32–48.

Pasqua, M. 1995. Mid–Late Holocene Toalean Sites in South Sulawesi: A Technological Analysis. Unpublished BSc Honours thesis, Centre for Archaeology, University of Western Australia, Perth.

Peros, M.C., S.E. Munoz, K. Gajewski and A.E. Viau. 2010. Prehistoric demography of North America inferred from radiocarbon data. *Journal of Archaeological Science* 37(3):656–664. doi.org/10.1016/j/jas.2009.10.029 (accessed 5 June 2018).

Simanjuntak, T. 2008. Austronesian in Sulawesi: Its origin, diaspora, and living tradition. In T. Simanjuntak (ed.), *Austronesian in Sulawesi*, pp. 215–251. Jakarta: Center for Prehistoric and Austronesian Studies.

Simanjuntak, T. 2010. Penutur dan budaya Austronesia. In N. Harkantiningsih, T. Simanjuntak and E.S. Hardiati (eds), *Arkeologi Indonesia Dalam Lintasan Zaman*, pp. 41–71. Jakarta: Pusat Penelitian dan Pengamban Arkeologi Nasional.

Simanjuntak, T., M.J. Morwood, F.S. Intan, I. Mahmud, K. Grant, N. Somba, B. Akw and D.W. Utomo. 2008. Minanga Sipakko and the Neolithic of the Karama River. In T. Simanjuntak (ed.), *Austronesian in Sulawesi*, pp. 57–75. Jakarta: Center for Prehistoric and Austronesian Studies.

Spriggs, M. 2003. Chronology of the Neolithic transition in Island Southeast Asia and the Western Pacific: A view from 2003. *The Review of Archaeology* 24(2):57–80.

Storm, P., R. Wood, C. Stringer, A. Bartsiokas, J. de Vos, M. Aubert, L. Kinsley and R. Grün. 2013. U-series and radiocarbon analyses of human and faunal remains from Wajak, Indonesia. *Journal of Human Evolution* 64(5):356–365. doi.org/10.1016/j.jhevol.2012.11.002 (accessed 5 June 2018).

Williams, A. 2012. The use of summed radiocarbon probability distributions in archaeology: A review of methods. *Journal of Archaeological Science* 39(3):578–589. doi.org/10.1016/j.jas.2011.07.014 (accessed 5 June 2018).

Yuniawati, D.Y. 2006. *Kubur Batu Waruga di Sub-Etnis Tou' Mbulu Sulawesi Utara*. Jakarta: Pusat Penelitian dan Pengembangan Arkeologi Nasional.

Appendix A: Sulawesi radiometric determinations

Table A8.1: Rejected Sulawesi Holocene radiometric determinations (oldest to youngest determinations): Radiocarbon dates unless otherwise specified.

Site/ Location	Date	Dating material	Laboratory code	Reference	Reason for rejection
Ulu Leang 2	8995±50 BP	Freshwater shell	GRN-8647	Bronson and Glover 1984	Freshwater shell date in karstic environment
Ulu Leang 2	8785±45 BP	Freshwater shell	GRN-8291	Bronson and Glover 1984	Freshwater shell date in karstic environment
Paso	7530±450 BP	Charcoal	ANU 1517	Bellwood 1976	Standard error in excess of 400 years
Ulu Leang 2	7170±600 BP	Charcoal	ANU 606	Glover 1978	Standard error in excess of 400 years
Gua Mo'o hono	6855±32 BP (AMS)	Freshwater shell	D-AMS 001620	O'Connor et al. this volume	Freshwater shell date in karstic environment
Gua Mo'o hono	6808±28 BP (AMS)	Freshwater shell	D-AMS 001618	O'Connor et al. this volume	Freshwater shell date in karstic environment
Gua Mo'o hono	6531±28 BP (AMS)	Freshwater shell	D-AMS 001619a	O'Connor et al. this volume	Freshwater shell date in karstic environment

Site/ Location	Date	Dating material	Laboratory code	Reference	Reason for rejection
Kamassi	6498±25 BP (AMS)	Phytoliths	NZA 34860	Anggraeni 2012	Experimental dating material
Leang Burung 1	4880±480 BP	Charcoal	ANU 1264	Bulbeck et al. 2000	Standard error in excess of 400 years
Gua Mo'o hono	4730±36 BP (AMS)	Freshwater shell	D-AMS 001616a	O'Connor et al. this volume	Freshwater shell date in karstic environment
Gua Mo'o hono	4718±26 BP (AMS)	Freshwater shell	D-AMS 001624a	O'Connor et al. this volume	Freshwater shell date in karstic environment
Gua Mo'o hono	4702±29 BP (AMS)	Freshwater shell	D-AMS 001617	O'Connor et al. this volume	Freshwater shell date in karstic environment
Leang Burung 1	4610±220 BP	Human bone apatite	ANU 6175	Bulbeck et al. 2000	Bone apatite fraction
Kamassi	4282±25 BP (AMS)	Phytoliths	NZA 34861	Anggraeni 2012	Experimental dating material
Kamassi	4282±20 BP (AMS)	Phytoliths	NZA 34896	Anggraeni 2012	Experimental dating material
Gua Mo'o hono	4202±31 BP (AMS)	Freshwater shell	D-AMS 001615	O'Connor et al. this volume	Freshwater shell date in karstic environment
Ulu Leang 2	4000–3000 years ago	Pottery (thermo-remnant magnetism)	Not stated	Glover 1978	Date's probability by half-millennium BP can't be estimated
Mansiri	414±380 BC	Sediment (OSL)	X6841	Azis et al. this volume	Suspected incomplete bleaching/no cultural association
Gua Mo'o hono	1690±25 BP (AMS)	Freshwater shell	D-AMS 001614	O'Connor et al. this volume	Freshwater shell date in karstic environment
Gua Mo'o hono	1568±21 BP (AMS)	Freshwater shell	D-AMS 001622a	O'Connor et al. this volume	Freshwater shell date in karstic environment
Mansiri	AD 725±195	Sediment (OSL)	X6839	Azis et al. this volume	Suspected incomplete bleaching
Gua Mo'o hono	1103±21 BP (AMS)	Freshwater shell	D-AMS 001612	O'Connor et al. this volume	Freshwater shell date in karstic environment
Gua Lampetia	AD 900±120	Burial jar cover (OSL)	UW2871	Bulbeck et al. 2016	Older of two dates for same object
Talaborong	920±170 BP	Human bone apatite	ANU 5924	Bulbeck 1992	Bone apatite fraction
Leang Burung 1	660±200 BP	Human bone apatite	ANU 6173	Bulbeck et al. 2000	Bone apatite fraction
Leang Burung 1	640±240 BP	Human bone apatite	ANU 6174	Bulbeck et al. 2000	Bone apatite fraction
Toraja region	650±40 BP (AMS)	Cotton patola	OxA-6482	Guy 1998	Ethnographic object
Toraja region	580±40 BP (AMS)	Cotton patola	OxA-6481	Guy 1998	Ethnographic object
Bulubangi	570±60 BP	Human bone	ANU 11852	Druce et al. 2005	Dating facilities not set up for human bone
Poso	630–470 cal BP	Cotton patola	Not stated	Barnes and Kahlenberg 2010	Ethnographic object
Sulawesi	550±40 BP (AMS)	Cotton patola	OxA-5769	Guy 1998	Ethnographic object
Toraja region	539±64 BP (AMS)	Cotton patola	NZA-8090	Guy 1998	Ethnographic object
Saukang Boe	450±220 BP	Human bone apatite	ANU 5923	Bulbeck 1992	Bone apatite fraction
Poso	531–323 cal BP	Cotton patola	Not stated	Barnes and Kahlenberg 2010	Ethnographic object
Minahasa	510–310 cal BP	Cotton patola	Not stated	Barnes and Kahlenberg 2010	Ethnographic object

Site/ Location	Date	Dating material	Laboratory code	Reference	Reason for rejection
Sulawesi	410±23 BP (AMS)	Cotton patola	OxA-13343	Higham et al. 2007	Ethnographic object
Palu	466–287 cal BP	Cotton patola	Not stated	Barnes and Kahlenberg 2010	Ethnographic object
Sulawesi	384±24 BP (AMS)	Cotton patola	OxA-13297	Higham et al. 2007	Ethnographic object
Sulawesi	355±40 BP (AMS)	Cotton patola	OxA-6484	Guy 1998	Ethnographic object
Sulawesi	295±55 BP (AMS)	Cotton patola	OxA-6587	Guy 1998	Ethnographic object
Tana Toraja	346– ~170 cal BP	Cotton patola	Not stated	Barnes and Kahlenberg 2010	Ethnographic object
Central Sulawesi	230±40 BP (AMS)	Cotton patola	OxA-6483	Guy 1998	Ethnographic object
Pontanoa Bangka	50±60 BP (AMS)	Cotton	OZE644	Bulbeck and Caldwell 2000	Larger standard error than Oxford Laboratory redating for same sample
Rahampu'u 1	Modern	Charcoal	ANU 11075	Bulbeck and Caldwell 2000	No reason to suspect pre-1950 antiquity
Katue	Modern	Charcoal (AMS)	OZD846	Bulbeck and Caldwell 2000	No reason to suspect pre-1950 antiquity
Sabbang Loang	Modern	Charcoal (AMS)	OZE129	Bulbeck and Caldwell 2000	No reason to suspect pre-1950 antiquity
Marante Tondon	Modern	Boat (coffin)	Beta-274723	Duli 2012	No reason to suspect pre-1950 antiquity
Allangkan-anangnge ri Latanete	Modern	Charcoal (AMS)	Wk-17743	Bulbeck et al. this volume	No reason to suspect pre-1950 antiquity
Petta Balubue	Modern	Burnt cranial bone	ANU 5928	Kallupa et al. 1989	No reason to suspect pre-1950 antiquity
Bayoa 1	Modern	Boat (coffin)	ANU 5926	Bulbeck 1992	No reason to suspect pre-1950 antiquity
Batu Ejjaya 2	Modern	Charcoal	ANU 606	Bronson and Glover 1984	No reason to suspect pre-1950 antiquity

Note: Reasons for dates' rejection explained in Bulbeck (2014), except for 'experimental dating material' (Anggraeni 2012), bone apatite fraction (Storm et al. 2013), 'incomplete bleaching of dated sediment' (Azis et al., this volume) and 'ethnographic object' (rather than archaeological status of dated object), which are added here.

Table A8.2: Accepted Holocene radiometric determinations from North and Central Sulawesi (all Carbon-14).

Site	Date BP	Laboratory code	Dated material	Site aspect	Site use	Reference
Woloan	1540±140	Not stated	Charcoal	Monumental	Mortuary	Yuniawati 2006
Woloan	1260±80	Not stated	Human bone	Monumental	Mortuary	Yuniawati 2006
Woloan	1180±80	Not stated	Human bone	Monumental	Mortuary	Yuniawati 2006
Tatelu	2070±140	Not stated	Animal bone	Monumental	Mortuary	Yuniawati 2006
Tatelu	850±140	Not stated	Charcoal	Monumental	Mortuary	Yuniawati 2006
Paso	7360±310	ANU 1518	Charcoal	Freshwater shell midden	Habitation	Bellwood 1976
Teling	3100±210	Not stated	Charcoal	Open	Habitation	Simanjuntak et al. 2008
Teling	2770±120	Not stated	Charcoal	Open	Habitation	Simanjuntak 2010
Mansiri	3035±35 (AMS)	S-ANU 40031	Charcoal	Open	Habitation	Azis et al. this volume
Mansiri	2494±20 (AMS)	Wk-44605	Charcoal	Open	Habitation	Azis et al. this volume

Site	Date BP	Laboratory code	Dated material	Site aspect	Site use	Reference
Mansiri	2469±20 (AMS)	Wk-44610	Charcoal	Open	Habitation	Azis et al. this volume
Pokekea	1251±31 (AMS)	ErL-10584	Plant matter	Monumental	Ceremonial	Kirleis et al. 2012
Pokekea	1197±30 (AMS)	ErL-10585	Plant matter	Monumental	Ceremonial	Kirleis et al. 2012
Pokekea	949±45 (AMS)	ErL-10584	Plant matter	Monumental	Ceremonial	Kirleis et al. 2012
Pokekea	890±30 (AMS)	ErL-10584	Plant matter	Monumental	Ceremonial	Kirleis et al. 2012
Entovera	2890±120	Not stated	Charcoal	Monumental	Ceremonial	Simanjuntak 2010
Entovera	2460±120	Not stated	Charcoal	Monumental	Ceremonial	Simanjuntak 2010

Table A8.3: Accepted Holocene radiometric determinations from West Sulawesi (all Carbon-14).

Site	Date BP	Laboratory code	Dated material	Site aspect	Site use	Reference
Pantara'an 1	2850±50 (AMS)	ANU 9707	Ceramic	Open	Habitation	Anggraeni et al. 2014
Pantara'an 1	2505±25 (AMS)	ANU 9438	Ceramic	Open	Habitation	Anggraeni et al. 2014
Pantara'an 1	277±30 (AMS)	Wk-25697	Charcoal	Open	Gardening	Anggraeni 2012
Minangka Sipakko	2810±50 (AMS)	OZE-132	Animal matter (bone)	Open	Habitation	Bulbeck and Nasruddin 2002
Minangka Sipakko	2570±110	P3G-97	Charcoal	Open	Habitation	Simanjuntak 2008
Minangka Sipakko	4950±180	P3G-05	Charcoal	Open	Habitation	Simanjuntak et al. 2008
Minangka Sipakko	3690±160	P3G-05	Charcoal	Open	Habitation	Simanjuntak et al. 2008
Minangka Sipakko	3446±51 (AMS)	Wk-14561	Charcoal	Open	Habitation	Anggraeni et al. 2014
Minangka Sipakko	3343±46 (AMS)	Wk-17981	Charcoal	Open	Habitation	Anggraeni et al. 2014
Minangka Sipakko	3082±50 (AMS)	Wk-14562	Charcoal	Open	Habitation	Anggraeni et al. 2014
Minangka Sipakko	2996±41 (AMS)	Wk-14564	Charcoal	Open	Habitation	Anggraeni et al. 2014
Minangka Sipakko	2881±46 (AMS)	Wk-14563	Charcoal	Open	Habitation	Anggraeni et al. 2014
Kamassi	5830±140	P3G	Charcoal	Open	Habitation	Anggraeni 2012
Kamassi	3345±40 (AMS)	ANU 36406	Marine shell*	Open	Habitation	Anggraeni et al. 2014
Kamassi	3225±40 (AMS)	ANU 36406	Animal matter (freshwater shell)	Open	Habitation	Anggraeni et al. 2014
Kamassi	3140±30 (AMS)	ANU 35128	Animal matter (freshwater shell)	Open	Habitation	Anggraeni et al. 2014
Kamassi	2700±150 (AMS)	Geolabs-411	Charcoal	Open	Habitation	Anggraeni et al. 2014
Kamassi	1620±30 (AMS)	ANU 35126	Animal matter (freshwater shell)	Open	Habitation	Anggraeni et al. 2014
Palemba	1720±30 (AMS)	Beta-360430	Ceramic	Open	Habitation	Anggraeni 2016
Sakkarra	2047±40 (AMS) #	S-ANU 39336-2	Charcoal	Open	Habitation	Fakhri et al. 2015
Sakkarra	2000±40 (AMS) #	S-ANU 39336-1	Charcoal	Open	Habitation	Fakhri et al. 2015

*Calibrated using Marine 0.914c, applied correction factor for marine reservoir effect delta R 89±70 (Borneo), assuming 50% marine contribution.

#Standard error back-calculated from median age BP and 95% calibrated range provided by Fakhri et al. (2015).

Table A8.4: Accepted Holocene radiometric determinations from South Sulawesi north and east of the southwest peninsula (all Carbon-14).

Site	Date BP	Laboratory code	Dated material	Site aspect	Site use	Reference
Timo'oni	1854±25 (AMS)	Wk-39675	Charcoal	Monumental	Ceremonial	Fakhri 2016
Timo'oni	1850±25 (AMS)	Wk-39676	Charcoal	Monumental	Ceremonial	Fakhri 2016
Timo'oni	1823±25 (AMS)	Wk-39677	Charcoal	Monumental	Ceremonial	Fakhri 2016
Sukoyu	2070±50	ANU 11271	Charcoal	Open	Gardening	Bulbeck and Caldwell 2000
Sukoyu	830±70	ANU 11272	Charcoal	Open	Industrial	As above
Pontanoa Bangka	1520±70	ANU 11107	Charcoal	Open	Industrial	As above
Pontanoa Bangka	1010±60	ANU 11108	Charcoal	Open	Industrial	As above
Pontanoa Bangka	152±33 (AMS)	OxA-10457	Plant matter (cotton)	Open	Mortuary	Higham et al. 2007
Nuha	960±70	ANU 11105	Charcoal	Open	Industrial	Bulbeck and Caldwell 2000
Nuha	130±50	ANU 11278	Charcoal	Open	Industrial	As above
Lemogola	120±70	ANU 11277	Charcoal	Open	Industrial	As above
Rahampu'u 1	5680± 130	ANU 11802	Charcoal	Open	Habitation	As above
Rahampu'u 1	1400± 110	ANU 11801	Charcoal	Open	Habitation	As above
Rahampu'u 1	1000±40 (AMS)	OZE646	Ceramic	Open	Habitation	As above
Rahampu'u 1	430±120	ANU 11077	Charcoal	Open	Industrial	As above
Rahampu'u 1	400±60	ANU 11080	Charcoal	Open	Industrial	As above
Rahampu'u 1	350±70	ANU 11074	Charcoal	Open	Industrial	As above
Rahampu'u 1	310±90	ANU 11076	Charcoal	Open	Industrial	As above
Rahampu'u 1	310±90	ANU 11079	Charcoal	Open	Industrial	As above
Pandai Besi	480±130	ANU 11083	Charcoal	Open	Industrial	As above
Pandai Besi	410±70	ANU 11084	Charcoal	Open	Industrial	As above
Matano bore	2350± 140	ANU 11104	Charcoal	Open	Gardening	As above
Turungang Damar	350±70	ANU 11353	Charcoal	Open	Habitation	As above
Manu Manue	170±70 (AMS)	OZD848	Charcoal	Open	Habitation	As above
Katue	1850±40 (AMS)	OZE581	Charcoal	Open	Habitation	As above
Katue	1810±40 (AMS)	OZD847	Charcoal	Open	Habitation	As above
Katue	1100±50 (AMS)	OZD845	Charcoal (carbonised shell)	Open	Habitation	As above
Katue	370±35 (AMS)	OZE580	Charcoal	Open	Gardening	As above
Bola Merajae	1980±90 (AMS)	OZD843	Charcoal	Open	Habitation	As above
Bola Merajae	1870±40 (AMS)	OZE579	Charcoal	Open	Habitation	As above
Bola Merajae	1260±60 (AMS)	OZD844	Charcoal	Open	Habitation	As above
Bola Merajae	660±70	ANU 11356	Charcoal	Open	Habitation	As above
Bola Merajae	310±40 (AMS)	OZE578	Charcoal	Open	Habitation	As above
Salabu	400±60 (AMS)	Wk-7336	Animal (dentine)	Marine shell midden	Habitation	As above
Pinanto	390±90	ANU 11355	Charcoal	Open	Habitation	As above
Sabbang Loang	2020± 140	ANU 11106	Charcoal	Open	Mortuary	As above
Sabbang Loang	1990± 200	ANU 11273	Charcoal	Open	Mortuary	As above
Sabbang Loang	1910±70 (AMS)	OZD850	Ceramic	Open	Habitation	As above
Sabbang Loang	1780±50 (AMS)	OZD851	Ceramic	Open	Habitation	As above
Sabbang Loang	1750±50 (AMS)	OZD852	Ceramic	Open	Habitation	As above
Arateng	450±60	ANU 11109	Boat (coffin)	Open	Mortuary	As above

Site	Date BP	Laboratory code	Dated material	Site aspect	Site use	Reference
Gua Andomo	1000±25 (AMS)	SANU 34619	Human bone	Closed	Mortuary	Bulbeck et al. 2016
Tampang Allo	1070±50	Beta-281928	Boat (coffin)	Closed	Mortuary	Duli 2012
Marimbunna Tikala	1130±50	Beta-287186	Boat (coffin)	Closed	Mortuary	Duli 2012
Londa	1000±40	Beta-274728	Boat (coffin)	Closed	Mortuary	Duli 2012
Lombok Borik	930±40	Beta-274725	Boat (coffin)	Closed	Mortuary	Duli 2012
Buntu Pune	810±50	Beta-281927	Boat (coffin)	Closed	Mortuary	Duli 2012
Marante Tondon	800±50	Beta-287188	Boat (coffin)	Closed	Mortuary	Duli 2012
Lalanbai Sarira	780±60	Beta-294688	Boat (coffin)	Closed	Mortuary	Duli 2012
Lalik Manuk	710±40	Beta-294684	Boat (coffin)	Closed	Mortuary	Duli 2012
Tambolang Ba'lele	660±40	Beta-294687	Boat (coffin)	Closed	Mortuary	Duli 2012
Lalik Manuk	640±50	Beta-287183	Boat (coffin)	Closed	Mortuary	Duli 2012
Limbong	570±50	Beta-287189	Boat (coffin)	Closed	Mortuary	Duli 2012
Allak Angin-Angin	510±50	Beta-287187	Boat (coffin)	Closed	Mortuary	Duli 2012
Lombok Borik	400±50	Beta-274726	Boat (coffin)	Closed	Mortuary	Duli 2012
Ke'te Kesuk	400±50	Beta-274726	Boat (coffin)	Closed	Mortuary	Duli 2012
Marimbunna Tikala	390±50	Beta-287185	Boat (coffin)	Closed	Mortuary	Duli 2012
Lo'kok Pongdadu	360±50	Beta-294686	Boat (coffin)	Closed	Mortuary	Duli 2012
Lombok Borik	360±50	Beta-281929	Boat (coffin)	Closed	Mortuary	Duli 2012
Se'pon Marinding	360±40	Beta-294685	Boat (coffin)	Closed	Mortuary	Duli 2012
Pangki Mangke'pek	350±60	Beta-294689	Boat (coffin)	Closed	Mortuary	Duli 2012
Tampang Allo	310±40	Beta-274727	Boat (coffin)	Closed	Mortuary	Duli 2012
Palak Tokkek	280±40	Beta-274724	Boat (coffin)	Closed	Mortuary	Duli 2012
Potok Tengan Kando	240±40	Beta-287184	Boat (coffin)	Closed	Mortuary	Duli 2012
Tok Sempa	790±50	Beta-274731	Boat (coffin)	Closed	Mortuary	Duli 2013
Kaluppini	790±50	Beta-274732	Boat (coffin)	Closed	Mortuary	Duli 2013
Marengok Papaling	700±40	Beta-274729	Boat (coffin)	Closed	Mortuary	Duli 2013
Puang Leoran	700±40	Beta-274730	Boat (coffin)	Closed	Mortuary	Duli 2013
Buttu Mila	570±40	Beta-274733	Boat (coffin)	Closed	Mortuary	Duli 2013
Liang Datu	470±40	Beta-274734	Boat (coffin)	Closed	Mortuary	Duli 2013

Table A8.5: Accepted Holocene radiometric determinations from Southeast Sulawesi (all Carbon-14 unless otherwise stated).

Site	Date BP	Laboratory code	Dated material	Site aspect	Site use	Reference
Gua Lampetia	890±100	UW2870 (OSL)	Ceramic	Closed	Mortuary	Bulbeck et al. 2016
Gua Talimbue	8735±38	D-AMS 004042	Charcoal	Closed	Habitation	O'Connor et al. 2014
Gua Talimbue	8526±42	D-AMS 004040	Charcoal	Closed	Habitation	O'Connor et al. 2014
Gua Talimbue	8191±33	D-AMS 004039	Charcoal	Closed	Habitation	O'Connor et al. 2014
Gua Talimbue	7961±39	D-AMS 004038	Charcoal	Closed	Habitation	O'Connor et al. 2014
Gua Talimbue	6506±38	D-AMS 004037	Charcoal	Closed	Habitation	O'Connor et al. 2014
Gua Talimbue	6127±31	D-AMS 004036	Charcoal	Closed	Habitation	O'Connor et al. 2014
Gua Talimbue	5973±30	D-AMS 004035	Charcoal	Closed	Habitation	O'Connor et al. 2014

Site	Date BP	Laboratory code	Dated material	Site aspect	Site use	Reference
Gua Talimbue	5740±36	D-AMS 004034	Charcoal	Closed	Habitation	O'Connor et al. 2014
Gua Talimbue	3923±30	D-AMS 004032	Charcoal	Closed	Habitation	O'Connor et al. 2014
Gua Talimbue	3843±29	D-AMS 004031	Charcoal	Closed	Habitation	O'Connor et al. 2014
Gua Talimbue	3800±28	D-AMS 004033	Charcoal	Closed	Habitation	O'Connor et al. 2014
Gua Talimbue	3767±29	D-AMS 004029	Charcoal	Closed	Habitation	O'Connor et al. 2014
Gua Talimbue	3733±29	D-AMS 004030	Charcoal	Closed	Habitation	O'Connor et al. 2014
Gua Talimbue	3726±33	D-AMS 004041	Charcoal	Closed	Habitation	O'Connor et al. 2014
Gua Talimbue	3372±27	D-AMS 004028	Charcoal	Closed	Habitation	Bulbeck et al. 2016
Gua Talimbue	1710±20	SANU 40418	Human bone	Closed	Mortuary	Bulbeck et al. 2016
Gua Talimbue	347±26	D-AMS 004027	Charcoal	Closed	Habitation	Bulbeck et al. 2016
Gua Mo'o hono	5618±29	D-AMS 001627	Charcoal	Closed	Habitation	O'Connor et al. this volume
Gua Mo'o hono	5461±29	D-AMS 001625	Charcoal	Closed	Habitation	O'Connor et al. this volume
Gua Mo'o hono	5460±32	D-AMS 001621	Charcoal	Closed	Habitation	O'Connor et al. this volume
Gua Mo'o hono	5371±28	D-AMS 001619	Charcoal	Closed	Habitation	O'Connor et al. this volume
Gua Mo'o hono	5214±32	D-AMS 001626	Charcoal	Closed	Habitation	O'Connor et al. this volume
Gua Mo'o hono	3905±26	D-AMS 001616	Charcoal	Closed	Habitation	O'Connor et al. this volume
Gua Mo'o hono	3870±40	SANU 10573	Animal matter (tooth)	Closed	Habitation	O'Connor et al. this volume
Gua Mo'o hono	3865±29	D-AMS 001624	Charcoal	Closed	Habitation	O'Connor et al. this volume
Gua Mo'o hono	3452±26	D-AMS 001623	Charcoal	Closed	Habitation	Bulbeck et al. 2016
Gua Mo'o hono	450±24	D-AMS 001622	Charcoal	Closed	Habitation	Bulbeck et al. 2016
Gua Sambangoala	4923±30	D-AMS 001993	Charcoal	Closed	Habitation	Fakhri this volume
Gua Sambangoala	4802±26	D-AMS 001994	Charcoal	Closed	Habitation	Fakhri this volume
Gua Sambangoala	4766±31	D-AMS 001991	Charcoal	Closed	Habitation	Fakhri this volume
Gua Sambangoala	4482±28	D-AMS 001992	Charcoal	Closed	Habitation	Fakhri this volume
Gua Sambangoala	3925±29	D-AMS 001989	Charcoal	Closed	Habitation	Fakhri this volume
Gua Sambangoala	3883±29	D-AMS 001990	Charcoal	Closed	Habitation	Fakhri this volume
Gua Sambangoala	3297±29	D-AMS 001988	Charcoal	Closed	Habitation	Fakhri this volume
Gua Tengkorak	7239±36	D-AMS 009676	Charcoal	Closed	Habitation	Ugo Zoppi pers. comm.
Gua Tengkorak	7139±35	D-AMS 009675	Charcoal	Closed	Habitation	Ugo Zoppi pers. comm.

Table A8.6: Accepted Holocene radiometric determinations from the South Sulawesi southwest peninsula (all Carbon-14).

Site	Date BP	Laboratory code	Dated material	Site aspect	Site use	Reference
Bulubangi	270±140 BP	ANU-11853	Charcoal	Open	Mortuary	Druce et al. 2005
Allangkan-anangngeri Latanete	955±30 (AMS)	Wk-19966	Animal matter (marine shell)*	Open	Habitation	Bulbeck et al. this volume
Allangkan-anangngeri Latanete	820±60	ANU 11352	Animal matter (marine shell)*	Open	Habitation	Bulbeck and Caldwell 2008
Allangkan-anangngeri Latanete	752±34 (AMS)	Wk-17818	Charcoal	Open	Industrial	Bulbeck et al. this volume
Allangkan-anangngeri Latanete	364±25 (AMS)	Wk-29737	Charcoal	Open	Mortuary	Bulbeck et al. this volume
Tinco Tua	762±30 (AMS)	Beta-324215	Charcoal	Monumental	Ceremonial	Hasanuddin 2015
Tinco Tua	380±30 (AMS)	Beta-324216	Charcoal	Open	Habitation	Hasanuddin 2015
Tinco Tua	320±30 (AMS)	Beta-324217	Charcoal	Monumental	Ceremonial	Hasanuddin 2015
Mallawa	3580± 130	P3G-06	Charcoal	Open	Habitation	Simanjuntak 2008
Mallawa	2710± 170	P3G-06	Charcoal	Open	Habitation	Simanjuntak 2008
Mallawa	2490± 220	ANU 11276	Charcoal	Open	Habitation	Bulbeck 2004

Site	Date BP	Laboratory code	Dated material	Site aspect	Site use	Reference
Mallawa	2281±46	Wk-20380	Charcoal	Open	Habitation	Hakim et al. 2009
Mallawa	1860±70	ANU 11274	Charcoal	Open	Habitation	Bulbeck 2004
Mallawa	576±80	ANU 11275	Charcoal	Open	Habitation	Bulbeck 2004
Gua Pasaung	6026±70 (AMS)	Wk-20381	Charcoal	Closed	Habitation	Hakim et al. 2009
Ulu Leang 1	5740± 230	ANU 394	Charcoal	Closed	Habitation	Bulbeck et al. 2000
Ulu Leang 1	4390± 110	PRL-231	Charcoal	Closed	Habitation	Bulbeck et al. 2000
Ulu Leang 1	4050±90	HAR-1734	Charcoal	Closed	Habitation	Bulbeck et al. 2000
Ulu Leang 1	3550± 130	PRL-230	Charcoal	Closed	Habitation	Bulbeck et al. 2000
Ulu Leang 1	1490± 210	SUA-1080	Charcoal	Closed	Habitation	Bulbeck et al. 2000
Leang Burung 1	3420± 400	ANU 390	Charcoal	Closed	Habitation	Bulbeck et al. 2000
Leang Burung 1	2820± 210	ANU 391	Charcoal	Closed	Habitation	Bulbeck et al. 2000
Leang Burung 1	2260±90	ANU 6173	Human bone collagen	Closed	Mortuary	Bulbeck et al. 2000
Leang Burung 1	1660± 190	ANU 6174	Human bone collagen	Closed	Mortuary	Bulbeck et al. 2000
Leang Burung 1	1160± 200	ANU 6172	Human bone collagen	Closed	Mortuary	Bulbeck et al. 2000
Leang Burung 2	1665±80	T-9096	Charcoal	Closed	Habitation	Glover 1981
Leang Burung 2	1275± 5	Not stated	Charcoal	Closed	Habitation	Glover 1981
Leang Karassak	2690±60 (AMS)	Wk-3823	Charcoal	Closed	Habitation	Bulbeck et al. 2000
Leang Karassak	370±50 (AMS)	Wk-3824	Charcoal	Closed	Habitation	Bulbeck et al. 2000
Gua Batti	2928±26 (AMS)	Wk-30264	Charcoal	Closed	Habitation	Oktaviana et al. 2016
Lamuru	340±70	ANU 5922	Boat (coffin)	Open	Mortuary	Bulbeck 1992
Bayoa	270±120	ANU 5927	Boat (coffin)	Open	Mortuary	Bulbeck 1992
Bonto-Bontoa	170±55	OZE-130	Charcoal	Open	Gardening	Bulbeck and Fadillah 2000
Galesong	1910±90 (AMS)	Oxford	Ceramic	Open	Ceremonial	Glover 1997
Near Galesong	1640±70 (AMS)	Not stated	Ceramic	Open	Ceremonial	Glover 1997
Bayoa, Sanrabone	780±80	ANU 5564	Boat (coffin)#	Open	Mortuary	Bulbeck 1992
Batu Ejayya 1	4430±50 (AMS)	Wk-5464	Marine shell*	Closed	Habitation	Bulbeck et al. 2000
Batu Ejayya 1	4370±70 (AMS)	Wk-5465	Marine shell*	Closed	Habitation	Bulbeck et al. 2000
Batu Ejayya 1	920±275	ANU 392	Charcoal	Closed	Ceremonial	Bulbeck et al. 2000
Leang Batu Tunpa	500±33 (AMS)	Wk-15438	Human bone (dentine)	Closed	Mortuary	Bulbeck and Hakim 2005

*Calibrated using Marine 0.914c, applied correction factor for marine reservoir effect delta R 89±70 (Borneo), assuming 50% marine contribution.

#80 years subtracted from calibrated date to allow for 80 countable tree rings ('old wood effect') between radiocarbon-dated wood sample and tree heart.

This text is taken from *The Archaeology of Sulawesi: Current Research on the Pleistocene to the Historic Period*, edited by Sue O'Connor, David Bulbeck and Juliet Meyer, published 2018 by ANU Press, The Australian National University, Canberra, Australia.

doi.org/10.22459/TA48.11.2018.08