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Bioarchaeological analysis of the Northern Moluccan excavated human remains

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Introduction

The Northern Moluccas form the northern apex of a triangle of small to medium-sized islands that extend to Sumba in the southwest and the Aru Islands in the southeast. These islands mark a rapid transition between indigenes with 'Melanesian' features to the east and inhabitants of predominantly 'Mongoloid' physical appearance to the north and the west. Summarising early physical anthropological research, conducted in a typological paradigm, Coon and Hunt (1965:180) wrote 'Some of the inhabitants are Negritos; others resemble Papuans. The Mongoloid element is minor'. Glinka (1981:103) emphasised the similarities between the populations across eastern Indonesia based on multivariate analysis of the recorded anthropometric data. He noted a predominantly dark brown skin colour, wavy to frizzy hair, a low incidence of epicanthic folds, low to medium stature, heads of narrow to medium breadth in shape with a very narrow forehead, and variable facial shape. Bulbeck et al. (2006) showed that recent crania from these islands have variable affinities, but predominantly with groups to the east of Wallace's Line, both 'Australoid' and Mongoloid, notably Tasmanians, Filipinos, New Britain Tolai, Guam Chamorros, and Hawaiians. The human remains excavated from the Northern Moluccas provide the opportunity to investigate whether this mixture of affinities also prevailed in prehistoric times.

Observations on the human remains also provide evidence on the palaeopathology of eastern Indonesians over the last two to three millennia. Oral pathology offers an insight into subsistence practices, while many diseases, especially those that stunt childhood growth, leave distinctive osteological markers. Some major diseases recorded during the nineteenth century in southeastern Indonesia include cholera, leprosy, malaria, sexually transmitted diseases, smallpox, and tuberculosis (Monk et al. 1997:493). In addition, two cultural practices, artificial cranial deformation and betel-nut chewing, are registered in the osteological assemblage.

Materials and methods

The researched materials include human burials dating to the last 2000–3000 years, excavated from rockshelters in the Northern Moluccas by the 'Archaeological Survey and Excavation in the Halmahera Islands, Moluccas, Indonesia' project (see Chapter 1). The identifiable individuals and unassigned remains are listed in Table 11.1. Weights were taken following cleaning and separation of associated materials that are not human bone and so may differ from the human bone weights provided in the excavation report chapters.

Table 11.1 Summary of human remains from the Northern Moluccan excavations.

Specimen	Island	Status	Weight (gm)	Estimated antiquity	Main composition	Burial mode
Golo LMN fragments	Gebe	Adults, 1 male	325	First millennium BCE?	Across skeleton	Disturbed primary extended?
Golo individual	Gebe	Male adult	1,834	2314–1415 cal. BP, ANU 11,818 on human bone	Whole skeleton	Primary extended
Tanjung Pinang 1	Morotai	Male subadult**	318	2684–1618 cal. BP, ANU 8439, apatite fraction**	Cranial	Secondary skull burial
Tanjung Pinang 2	Morotai	Male adult*	272.5	BCE/CE junction	Cranial	Secondary skull burial
Tanjung Pinang 3	Morotai	Male adult	268	BCE/CE junction	Cranial	Secondary skull burial
Tanjung Pinang 4	Morotai	Male adult*	163	BCE/CE junction	Cranial	Secondary skull burial
Tanjung Pinang 5	Morotai	Male teenager	316	BCE/CE junction	Cranial	Secondary skull burial
Tanjung Pinang 6	Morotai	Male adult*	345	BCE/CE junction	Cranial	Secondary skull burial
Tanjung Pinang 7	Morotai	Male adult	153	BCE/CE junction	Cranial	Secondary skull burial
Tanjung Pinang 8	Morotai	Male adult	360	BCE/CE junction	Cranial	Secondary skull burial
Tanjung Pinang 9	Morotai	Subadult	38.5	BCE/CE junction	Cranial	Secondary skull burial
Tanjung Pinang 10	Morotai	Male adult	69	BCE/CE junction	Cranial	Secondary skull burial
Tanjung Pinang unassigned	Morotai	Presumably from TP 1–10	1092	BCE/CE junction	Half cranial, half postcranial	From above?
Uattamdi 1	Kayoa	Male adult*	216	1932–1813 cal. BP, OxA 35,201 on human bone	Cranial	Secondary skull burial
Uattamdi 2	Kayoa	Adult/ subadult	35	BCE/CE junction	Cranial	Secondary skull burial
Uattamdi 3	Kayoa	Male adult	96	Recent	Cranial and postcranial	Secondary burial
Uattamdi 4	Kayoa	Infant	37	Recent	Mainly cranial	Secondary burial
Uattamdi 5	Kayoa	Subadult	45	Recent	Mainly cranial	Secondary burial
Uattamdi fragments	Kayoa	Infant to adult	107	First/second millennia CE	Across skeleton	Some from above Uattamdi burials?
Um Kapat Papo	Gebe	Female adult	32.5	First millennium CE	Cranial and postcranial	Secondary burials
Tanjung Tulang 1 to 3 (L5/M5/N5)	Morotai	Male adult, female adult, subadult	385	c. 1000 CE?	Cranial and postcranial	Secondary cremations
Tanjung Tulang 4 (E4/F6)	Morotai	Unsexed adult	38	c. 1000 CE?	Cranial and postcranial	Secondary cremations
Daeo 1 unassigned	Morotai	2 adults (at least 1 male), 1 subadult	347	c. 1000 CE?	Cranial and postcranial	Secondary burials, some cremation
Daeo 2 (1 to 4)	Morotai	5 adults and subadults	445	Recent	Cranial and postcranial	Secondary burials

* Identified as male from ancient DNA analysis, as also indicated on their anatomical criteria for Tanjung Pinang 1 and 6, and Uattamdi 1. Other sex assignments are based solely on anatomical criteria.

** Rachel Wood of the ANU Radiocarbon Facility comments that radiocarbon dates on apatite fractions tend to be too young, although by how much in this case is unknown. The unassigned bone submitted for ANU 8439 was collected in 1991 from the vicinities of Tanjung Pinang 1, 2, and 3.

Source: David Bulbeck.

The burial modes listed in Table 11.1 suggest a focus on secondary skull burials at approximately 2000 years ago, albeit complemented by the alternative burial treatment of a primary extended inhumation in Golo Cave at a similar time, followed later by secondary burials, including burial of cremated remains at around 1000 BP.

Treatment of the burial material included mechanical cleaning of the bones and teeth. Most of this was undertaken by the author, but in some cases by Kate Stockhausen (former PhD student in the School of Archaeology and Anthropology, ANU), and in some other cases by Jennifer R. Hull during her study of the Northern Moluccan faunal material for her BA Honours research in the same school. Additional treatment of the Golo extended burial involved soaking the bone in a 3 per cent solution of acetic acid for about 24 hours to weaken the calcium carbonate crust. The treated fragments were then soaked in several changes of water to leach any acetic acid from the bone, followed by drying in air, and mechanical cleaning of the residual calcium carbonate crust.

After cleaning, the human remains were separated from any associated faunal material. The human bone elements were identified with reference to standard human anatomy atlases and the reference human skeleton held at the School of Archaeology and Anthropology, ANU. Joins between bone fragments were effected (using Tarzan's Grip®) based on matching breaks, identification to the same element, and physical proximity in the excavated deposits. The effected joins facilitated additional element identifications. When reconstruction had proceeded as far as practical, an attempt was made to assign the remains to different individuals, considering biological clues such as likely age at death and, in the context of whether the elements are juvenile or adult, a male or female status based on general size and robustness. The attempted individuation was performed primarily on the cranial material, which dominates the burial assemblage at most of the sites.

Numerous measurements and anatomical observations were undertaken following a variety of systems that have been used in recording Oriental-Pacific human remains. Most of the original observations, which were used in assessing the likely age and sex of the identified individuals (and unassigned remains), were detailed in a series of unpublished reports to Peter Bellwood. Many of the observations in these reports serve no greater purpose than to produce the list of specimens and associated information in Table 11.1, and so are not replicated here.

These original observations include Stockhausen's identifications of loose teeth, most of which I was unable to relocate, from Uattamdi, Tanjung Tulang, Daeo 1, and Daeo 2. The observations also include my notes on the extent of closure of the cranial sutures, which, along with information on whether all of the permanent teeth had erupted and the extent of wear on the erupted permanent teeth, formed the basis for assessing the age at death of the individuated burials. Only occasionally was it possible to confidently link an individual's cranial and postcranial remains, and so to assess the biological age of an individual based on postcranial indicators such as the degree of epiphyseal union of the limb bones. However, my observations on the fragments of human bone that Jennifer R. Hull extracted from the Uattamdi faunal refuse are briefly summarised here.

The observations presented here include those of value for assessing biological affinities. A number of recorded measurements are dependent on the accuracy of the reconstructions, which involve a certain degree of judgement for tasks of any greater complexity than gluing together joining fragments. Some additional measurements further required the assumption of bilateral symmetry.

In terms of analytical methodology, the exploration of the individuals' biological affinities focuses on craniometrics. The measurements reported here are those defined by Howells (1973b), excluding radii and cranial fractions. This allows statistical comparison with the populations measured by Howells (1989) as well as six series from India measured by Pathmanathan Raghavan

(Bulbeck 2013). In addition, I recorded male and female crania with 'circumferential deformation' (Lindsell 1995) from Malekula Island, Vanuatu, Melanesia. This was to provide an appropriate 'Australoid' counterpart in the comparisons for the Golo cranium, which, as described below, has marked circumferential deformation. For each compared Northern Moluccan cranium, classification formulae for the comparative series were derived for the measurements available for the Moluccan specimen, allowing the specimen's probability of classification with each of the Howells' series/Malekula to be calculated. This exercise was performed in XLSTAT using discrimination function analysis, including the option to calculate canonical variates.

The affinities of the male Moluccan crania were also explored using the anatomical characters defined by Larnach and Macintosh (1966). The characters of relevance here are those that I have found to be consistently recorded by different observers and also useful in discriminating 'Indo-Malay' crania (recent Island Southeast Asia crania northwest of eastern Indonesia) from both Australian Aboriginal and Melanesian crania (Bulbeck 2013). The Boolean expressions evaluate as 'True' for Indo-Malay crania and 'False' for Australian crania (Table 11.2) and Melanesian crania (Table 11.3). Boolean formulae are used as these may allow the classification of crania to be undertaken, even if not all of the listed characters are extant.

Table 11.2 Boolean formulae classifying Indo-Malay and Australian male crania.

Type of formula	Indo-Malay expression (Australian expression is the logical opposite)	Correctly classified	
		Indo-Malays	Australians
1. Strongest discrimination	[(Glabella not large OR Supraorbital breadth not large) AND (Sagittal keel indistinct OR Naso-frontal articulation width narrow OR Parietal bossing prominent) AND Palate module −39] OR Cranial index ×75	113/117 (97%)	176/194 (91%)
2. All Indo-Malays	(Palate module −39 OR Cranial index ×75) AND (Glabella not large OR Median frontal ridge indistinct OR Sagittal keel indistinct)	117/117 (100%)	143/199 (72%)
3. All Australians	Cranial index ×75 AND [Orbital border sharp OR Phaenozygy absent OR (Naso-frontal articulation width narrow AND Transverse occipital torus absent)]	54/117 (46%)	210/210 (100%)

Source: David Bulbeck.

Table 11.3 Boolean formulae classifying Indo-Malay and Melanesian male crania.

Type of formula	Indo-Malay expression (Melanesian expression is the logical opposite)	Correctly classified	
		Indo-Malays	Melanesians
1. Strongest discrimination	Orbital border sharp OR Transverse occipital torus absent OR (Cranial index ×75 AND Palate module −39 AND Anterior nasal spine less than Broca 4)	83/112 (74%)	416/493 (84%)
2. All Indo-Malays	Cranial index ×75 OR [Palate module −39 AND (Orbital border sharp OR Supraorbital breadth not large OR Frontal curvature index >24.7)]	117/117 (100%)	200/492 (41%)
3. All Melanesians	(Orbital border sharp OR Transverse occipital torus absent) AND (Phaenozygy absent OR Parietal bossing prominent) AND [Cranial index ×75 OR (Frontal curvature index >24.7 AND Supraorbital breadth not large AND Supramastoid crest not slight)]	27/117 (23%)	525/525 (100%)

Note: Frontal curvature index is treated as a missing observation for the Malekula crania, owing to their circumferential deformation.

Source: David Bulbeck.

As a test of the effectiveness of these formulae for classifying recent eastern Indonesian male crania, we would predict the resulting classifications to straddle the Indo-Malay and Australian/Melanesian reference samples. This is indeed found to be the case, based on a small available sample of six recent male eastern Indonesians recorded by the author (Table 11.4). For instance, while four of the six crania (three from Flores and one from Solor) are more probably Indo-Malay than Australian or Melanesian, even these crania would lie within the Melanesian range of variation, and another cranium (Gua Nempong) has a distinctly Australoid cranial morphology.

Table 11.4 Results from application of the Boolean formulae in Tables 11.2 and 11.3 to a sample of six recent eastern Indonesian male crania.

Formula	Flores, Hamy 4-1-6 09.929; Solor, MacLeay 84.45	Flores, Hamy 4-1-3 09.928, Flores, Hamy 4-1-4 09.926	Timor, MacLeay 84.42	Flores, Gua Nempong
2.1	Indo-Malay	Indo-Malay	Indo-Malay	Australian
2.2	Indo-Malay	Indo-Malay	Indo-Malay	Australian
2.3	Indo-Malay	Australian	Australian	Australian
3.1	Indo-Malay	Indo-Malay	Melanesian	Melanesian
3.2	Indo-Malay	Indo-Malay	Indo-Malay	Melanesian
3.3	Melanesian	Melanesian	Melanesian	Melanesian

Note: The Hamy expedition specimens were recorded at the Musée de l'Homme, Paris.

Source: David Bulbeck.

Multivariate metrical comparisons of the mandible from the Golo extended burial were undertaken based on the measurements presented in Table 11.8 (below). Table 11.5 lists the 107 mandibles from South Asia, Island Southeast Asia, and Melanesia recorded for the same measurements. The non-Melanesian sample sizes are small and so the comparisons treated the specimens as ungrouped individuals. The comparisons included principle components analysis, using the default settings on XLSTAT, and *k*-means clustering, performed using SAS EG. The latter analysis employed full seed replacement, as this minimises the differences in assignment of individuals to groups between different runs (Laszlo and Mukherjee 2007), with the number of clusters set at six to correspond to the six groups in Table 11.5. Also, the number of iterations was set at 20 (six iterations proved to be sufficient to satisfy the convergence criterion).

Table 11.5 Individual specimens and groups included in the mandibular metrical comparisons.

Individual/group	Group sample size	Details
Liang Lemdubu	N/A	c. 18,000-year-old female from Aru (Bulbeck 2005)
Watinglo	N/A	c. 10,000-year-old male from Papua New Guinea's north coast (Bulbeck and O'Connor 2011)
Liang Momer E	N/A	'Mesolithic' male from Flores
Liang Toge	N/A	c. 4000-year-old female from Flores
Eastern Indonesian males	7	Melolo, Sumba (2); Gua Nempong, Flores; Golo; 3 ethnographic (museum) specimens
Melanesian males	44	New Britain (19), New Ireland (1), Malekula (2), coastal Papua New Guinea including Motupore Island (22)
Melanesian females	26	New Britain (9), coastal Papua New Guinea including Motupore Island (17)
Indo-Malay males	15	Leang Buidane, Talauds (1); South Sulawesi (8); Singapore Malays (6)
Indo-Malay females	2	Provenanced only as 'Indonesia'
South Asians	9	Six males and three females from Andhra Pradesh and Sri Lanka, grouped due to minimal sexual dimorphism

Note: Unpublished data except where otherwise indicated. Criteria for sexing mandibles explained in Bulbeck and O'Connor (2011).

Source: David Bulbeck.

The available sample sizes of teeth are small, and so aggregated observations on dental metrics and oral pathology are presented in their own section towards the end of this paper. My original reports include tooth lengths and breadths recorded at the cemento-enamel junction, which can usually be taken even on very worn teeth (Snell 1949), as well as the maximum lengths and breadths that I recorded wherever interstitial wear or other effects on the teeth had not significantly reduced the dimensions available for recording. These latter observations are re-presented here to allow comparison between the Northern Moluccan burials and recorded Oriental-Pacific populations. The comparative statistic employed is Brace's (1976, 1980) 'summed tooth area', which provides a useful summary of tooth size, even though it is affected by the sexual composition and extent of interstitial wear of the available sample.

Occlusal tooth wear was recorded following Smith's (1984) system, and oral pathology following Patterson's (1984) system, with his different classes aggregated into major categories to allow condensation of the relevant information. Observations on the morphology and location of macroscopic linear enamel hypoplasia are also condensed into noting their presence at the cervical, medium, or occlusal third of the affected tooth. This is to allow an assessment of whether they probably reflect systemic arrests to childhood growth, registered by most or all of the teeth whose enamel should have been forming at the same age, or just a localised interruption to enamel formation (Hillson 1996).

Signs of pathology were also recorded on the cranial vault and other bones, based on the criteria described by Aufderheide and Rodríguez-Martin (1998).

Finally, a Penrose (1954) size and shape analysis, which separates these two components of Pearson's 'Coefficient of Racial Likeness', was undertaken on the lengths of the Golo limb bones. Penrose's statistic was chosen as a simple multivariate statistic whose conditions for application require only sample sizes, means, and standard deviations, which describes the form of most of the useful comparative data to which I have access. These (male) data come from Abe (1955), Inabe (1955), Mizoguchi (1957), and Sendo (1957) for Japanese; Genet-Varcin (1951, no standard deviations provided) for Aeta Negritos; Bergman and The (1955) for Javanese; Sarasin (1916–22) for New Caledonians and Loyalty Islanders; and Davivongs (1963a), van Dongen (1963), and Rao (1966) for Australian Aborigines.

The human remains from Golo Cave, Gebe

The oldest excavated human remains from the Northern Moluccas may be the Golo fragments from the LMN Squares. The basis for this inference is their weathered to very weathered appearance (Fig. 11.1), contrasting with the generally less weathered appearance of the extended burial, which has been directly dated to 2314–1415 cal. BP (ANU 11818). The LMN remains include fragments from two or more individuals, including what appears to be the proximal shaft of a male humerus. The inference of two individuals is based on the discrepancy between the maxilla and mandible fragments in their oral pathology and the degree of wear on the molars. The limb bone shaft fragments are quite large, especially after re-joining of adjacent segments, which suggests they may derive from disturbed primary burials rather than secondary burials.

Figure 11.1 Reconstructed limb bone fragments from Golo LMN Squares.
Source: David Bulbeck.

The Golo primary burial (Fig. 11.2) is directly radiocarbon dated to 1900±190 BP (ANU 11818), which calibrates to 2314–1415 BP at 95.4 per cent (Table 1.1). It is an adult male, with a stature when alive of around 163 cm, and an age at death of around 40 (30–50) years suggested by the dental remains (detailed towards the end of this chapter). Apart from the individual's poor state of oral health, and mild porotic hyperostosis on its extant frontal towards the midline, no signs of pathology were observed on the remains. The individual's male status is indicated by its (left) pelvic morphology—for instance, its large vertical acetabulum diameter of 56.5 mm and the small width and depth of its greater sciatic notch of 41.5 mm and 25 mm respectively (cf. Davivongs 1963b)—as well as its robust cranial morphology and large mandible.

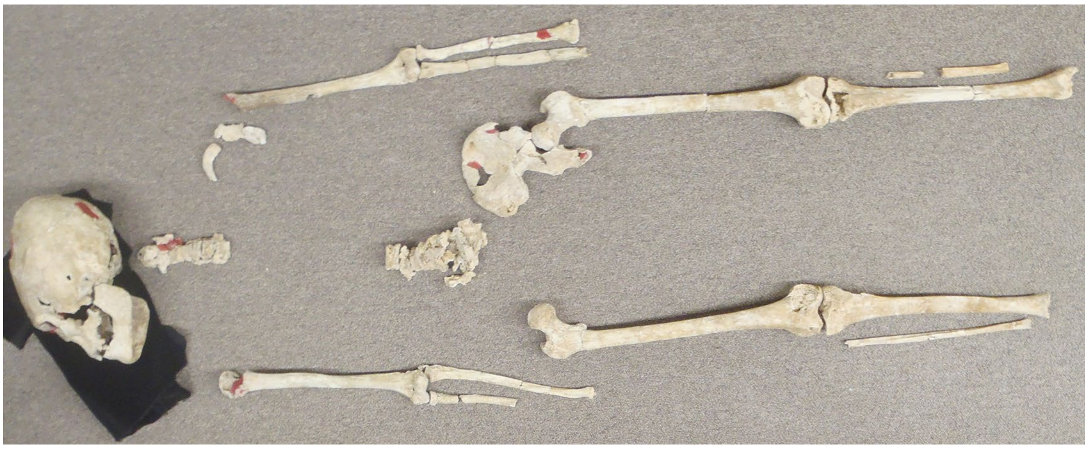

Figure 11.2 Golo extended burial after reconstruction (excluding the right pelvis, sacrificed for direct radiocarbon dating).
Source: David Bulbeck.

The Golo extended burial cranium

The extended burial has an artificially flattened frontal bone (Fig. 11.3), as registered by its small nasion-bregma subtense (more than one standard deviation below the mean recorded for any Howells' series). Other craniometric peculiarities include a very large bregma-lambda subtense, more than four standard deviations above the mean recorded for any Howells' series, associated with a vertex (highest point on the cranial vault in the Frankfort horizontal plane) that lies well posterior to bregma, producing a basion-vertex height of 156 mm, much larger than the basion-bregma height of 133 mm. Technically, the Golo individual shows circumferential erect deformation, which would have involved some sort of binding around the front and the back of its head during childhood, preventing the growing brain from filling out in these directions (Lindsell 1995).

Craniometrically, the Golo cranium clearly classifies with Malekula. Two sets of measurements were entered, the first excluding the measurements that could be taken only by assuming symmetry (Table 11.6), and the second including those measurements. In both cases, Golo registered a 100 per cent probability of being classified as Malekula. Significantly, none of the crania from the Howells' series would have been classified as Malekula. The only crania other than Golo to be classified as Malekula were the Malekula crania themselves: 16/18 (89 per cent) in the first analysis and 17/18 (94 per cent) in the second analysis. Inspection of the discriminant functions shows that a small frontal subtense and large parietal subtense—measurements both directly affected by head binding—were important for securing a 'Malekula' classification. That is, the classification obtained for the Golo cranium simply reflects this cultural practice, without of course implying that Golo might not have registered Melanesian craniometrics even in the absence of cranial deformation.

Figure 11.3 Left lateral view of the cranium from the Golo extended burial.
Source: David Bulbeck.

The observable anatomical features (Larnach and Macintosh 1966) relevant to assessing the biological affinities of the Golo cranium are presented in Table 11.7. An additional measurement required to fill the table is the palate length, which is 70 mm, to produce a palate module of 43.8 when multiplied by external palate breadth. Note that the cranium's strongly receding frontal, registered by its frontal curvature index of 15.5 (188*FRS/FRC), is not included in Table 11.7, as this shape aspect clearly reflects cultural modification rather than genetic ancestry.

The Golo cranium would be classified as Australian on all three Boolean formulae that distinguish between Indo-Malay and Australian crania, and as Melanesian on all three Boolean formulae that distinguish between Indo-Malay and Melanesian crania. Accordingly, its anatomy lies outside of the recorded range of recent Indo-Malays and entirely within the range of recent 'Australoids'.

Table 11.6 Measurements (in mm) defined by Howells (1973b) recorded on the Golo cranium.

Measurement	Acronym	Value	Comments
Glabello-occipital length	GOL	187	Dependent on accuracy of reconstruction
Nasio-occipital length	NOL	187.5	Dependent on accuracy of reconstruction
Basion-nasion length	BNL	81	Dependent on accuracy of reconstruction
Basion-bregma height	BBH	133	Dependent on accuracy of reconstruction
Maximum cranial breadth	XCB	120	Symmetry assumed to take measurement
Maximum frontal breadth	XFB	110	Symmetry assumed to take measurement
Bistephanic breadth	STB	104	
Biauricular breadth	AUB	113.5	
Minimum cranial breadth	WCB	71	Symmetry assumed to take measurement
Biasterionic breadth	ASB	124	Exceeds XCB (measured above the supramastoid crests)
Basion-prosthion length	BPL	93	Dependent on accuracy of reconstruction
Nasion-prosthion height	NPH	67	
Nasal height	NLH	49.5	Dependent on accuracy of reconstruction
Orbit height, left	OBH	35	
Orbit breadth, left	OBB	39.5	
Bijugalia breadth	JUB	112.5	
Nasal breadth	NLB	31	Dependent on accuracy of reconstruction
Palate breadth, external	MAB	62.5	
Mastoid height	MDH	30	Left side
Mastoid breadth	MDB	15.5	Left side
Bimaxillary breadth	ZMB	96	Symmetry assumed to take measurement
Zygomaxillary subtense	SSS	36.5	Symmetry assumed to take measurement
Bifrontal breadth	FMB	103	Symmetry assumed to take measurement
Nasio-frontal subtense	NAS	15	Symmetry assumed to take measurement
Biorbital breadth	EKB	102	Symmetry assumed to take measurement
Cheek height, left	WMH	20	
Supraorbital projection	SOS	13.5	
Foramen magnum length	FOL	32.5	Dependent on accuracy of reconstruction
Nasion-bregma chord	FRC	116	Dependent on accuracy of reconstruction
Nasion-bregma subtense	FRS	18	Dependent on accuracy of reconstruction
Bregma-lambda chord	PAC	115	Dependent on accuracy of reconstruction
Bregma-lambda subtense	PAS	38	Dependent on accuracy of reconstruction
Lambda-opisthion chord	OCC	114	Dependent on accuracy of reconstruction
Lambda-opisthion subtense	OCS	33	Dependent on accuracy of reconstruction

Source: David Bulbeck.

Table 11.7 Relevant anatomical observations of the Golo extended burial cranium.

Character	Observation	Binary value (Tables 10.2 and 10.3)
Maximum supraorbital breadth	110 mm	Large
Parietal bossing	Absent	Not prominent
Palate module	43.8	Large
Cranial index (100*XCB/GOL)	64.2	<75 (Narrow)
Phaenozygy	Present	Not absent
Transverse occipital torus	Medium	Present
Malar orbital border	Trace rounding	Not sharp
Anterior nasal spine	Broca 2	Less than Broca 4
Supramastoid crest	Large (left)	Not slight

Source: David Bulbeck.

The Golo extended burial mandible

The measurements taken on the Golo mandible (Fig. 11.4) are presented in Table 11.8. The measurements' loadings on Principal Components (PC) 1 to 3 in the PC analysis are presented in Table 11.9. PC 1, accounting for 45 per cent of variance, reflects size, as is usually found in PC analysis of biometric data (Joliffe 2002). PCs 2 and 3 are the main shape variables, both having an eigenvalue above 1, and respectively accounting for 19 per cent and 10 per cent of variance. A high score on PC 2 marks mandibles with a tall corpus while a low score marks mandibles with a broad corpus. In the case of PC 3, a high score reflects mandibles that are broad posteriorly in relation to corpus breadths and a low score reflects mandibles that are posteriorly narrow in relation to corpus breadths.

Figure 11.4 Superior view of the mandible from the Golo extended burial.

Source: David Bulbeck.

Table 11.8 Measurements on the Golo mandible included for analysis.

Measurement	Acronym	Golo value	Measurement source
Symphysis height	h1	33.5	Morant 1936
Chin height	M69	34	Bräuer 1988
Corpus height at mental foramen	M69(1)	29.5 (left)	Bräuer 1988
Corpus thickness at mental foramen	M69(3)	14 (left)	Bräuer 1988
Breadth between mental foramena	zz	53.5	Morant 1936
Corpus height between first and second molars	CHe	28	Brown 1989; Storm 1995
Corpus thickness between first and second molars	CTh	16	Brown 1989; Storm 1995
Interobliqual breadth	IOB	82.5	Jacob 1967a
Gnathion-gonion length	gngo	96.5 (left)	Morant 1936
Inferior breadth between gonia	gogo	88	Morant 1936
Outer breadth between gonia	w2	93.5	Morant 1936
Minimum ramus breadth	rb′	37	Morant 1936

Source: David Bulbeck.

Table 11.9 Loadings of the measurements for PC 1 to 3 in the Golo mandible PC analysis.

Measurement	PC 1	PC 2	PC 3
Symphysis height	0.259	0.468	0.014
Chin height	0.263	0.458	0.010
Corpus height at mental foramen	0.302	0.371	−0.021
Corpus thickness at mental foramen	0.252	−0.225	−0.468
Breadth between mental foramena	0.313	−0.179	−0.179
Corpus height between first and second molars	0.332	0.278	−0.112
Corpus thickness between first and second molars	0.214	−0.323	−0.381
Interobliqual breadth	0.316	−0.131	0.022
Gnathion-gonion length	0.336	−0.131	0.105
Inferior breadth between gonia	0.290	−0.239	0.542
Outer breadth between gonia	0.309	−0.242	0.484
Minimum ramus breadth	0.251	−0.138	−0.238

Source: David Bulbeck.

The Golo mandible scores 2.63 on PC 1. This is within the range recorded for other eastern Indonesian males (0.87 to 4.13) and Melanesian males (–2.04 to 5.41) and similar to the terminal Pleistocene male from Watinglo in Papua New Guinea (2.83). It lies above the range obtained for Indo-Malay males (–1.12 to 1.90), Indo-Malay females (–3.43 to –3.14), Melanesian females (–4.92 to 2.53), and South Asians (–5.57 to –3.15). In terms of size, the Golo mandible is quite large (and male), which is more typical of eastern Indonesian and Melanesian males than any of the other comparative series.

Figure 11.5 plots the analysed mandibles' scores on a two-dimensional plot with PCs 2 and 3 represented by the two axes. As shown there, Indo-Malay mandibles tend to have high negative to low positive scores on both PCs, Melanesian mandibles tend to have low negative to high positive scores on both PCs, while eastern Indonesian and South Asian mandibles tend to be intermediate in both respects. The Golo mandible falls within the large central area of overlap between the different series. Its shape is not diagnostic in terms of Asia-Pacific population affinities.

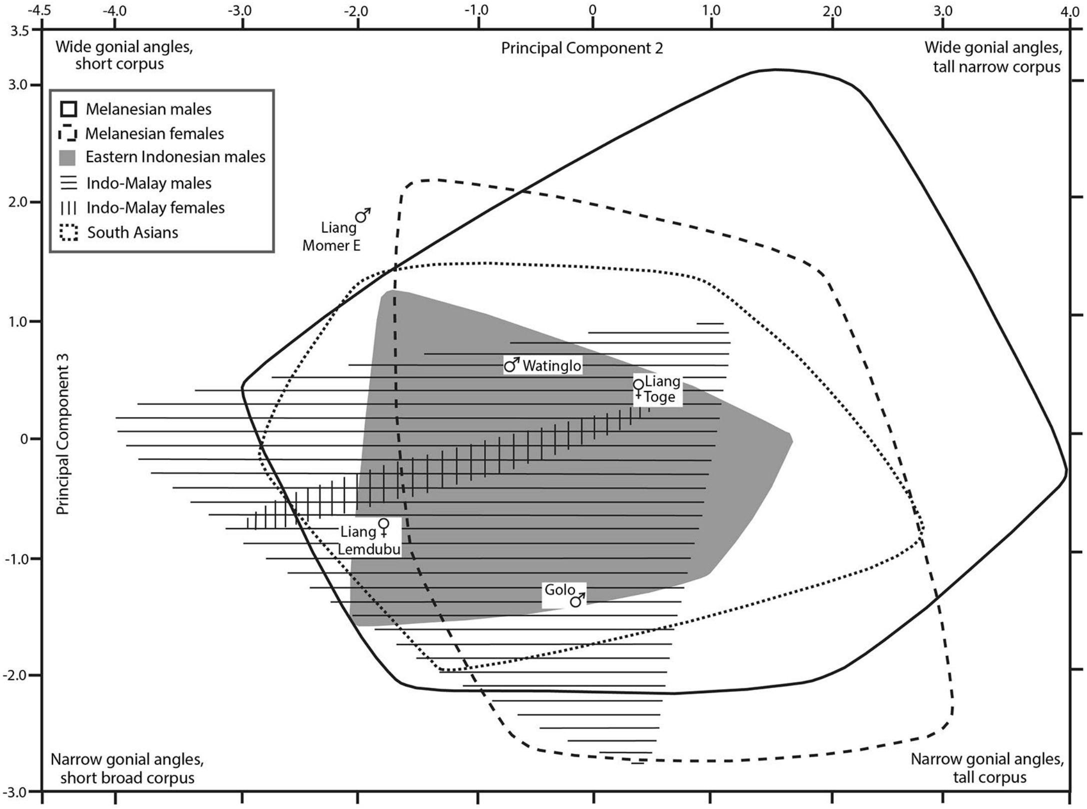

Figure 11.5 Mandibular metrical analysis, two-dimensional plot of PC 2 and 3.

Source: David Bulbeck.

Figure 11.6 plots the means of the six *k*-means clusters, which combine both size and shape in the same analysis. The implications of Figure 11.6 are summarised in Table 11.10, which also presents the membership of the six clusters. Assignment of the mandibles to the six clusters is far from random, as represented by the asterisked probability in the last column of Table 11.10. To calculate that probability, the number of combinations with the discovered membership, or a more extreme membership, was placed in the numerator, and the total number of combinations (whereby the 107 mandibles could be assigned to the six discovered clusters, 6.124 multiplied by 10 to the power of 71) was placed in the denominator. For instance, cluster 4 contained four eastern Indonesian mandibles, including Golo. The number of combinations in which this cluster of 23 mandibles could have included 4 to 7 of the eastern Indonesian mandibles is 2.278

multiplied by 10 to the power of 70. This number, divided by the total number of combinations, comes to less than 0.05, demonstrating a statistically significant over-representation of eastern Indonesian males in cluster 4 (at the conventional $p<0.05$ confidence level).

Cluster 4 also has a strong representation of Melanesian male mandibles, although not strong enough to be statistically significant. However, the probability that cluster 4 would include both four or more eastern Indonesian males and 12 or more Melanesian males is very low, 0.0019. Accordingly, *k*-means clustering would assign the Golo mandible to a cluster dominated by eastern Indonesian and Melanesian males.

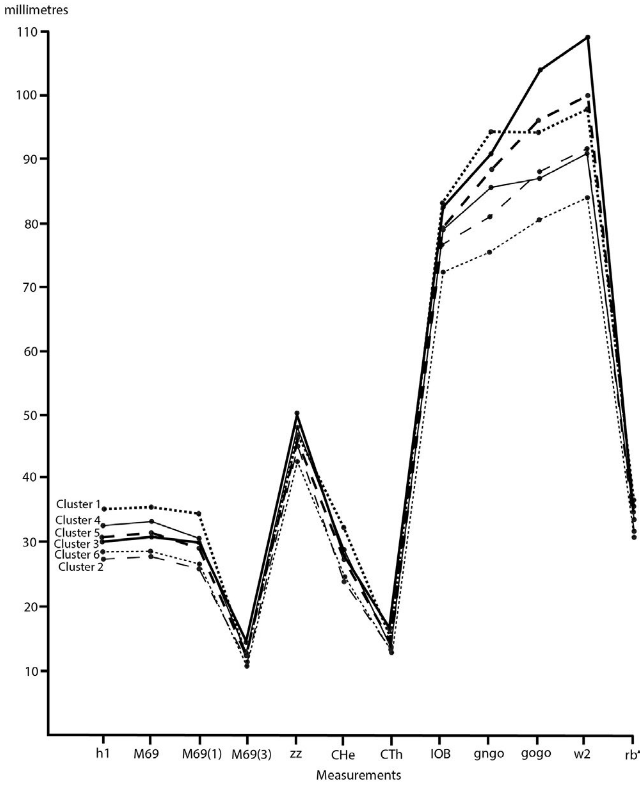

Figure 11.6 Mean mandibular measurements for clusters 1 to 6 identified by *k*-means analysis.

Source: David Bulbeck.

Table 11.10 Characterisation of the six *k*-means clusters in the mandibular metrical analysis.

Cluster	Metrical description	Composition	Asterisked probability
1	Tall anterior corpus, long corpus	4 Melanesian males*	0.0263
2	Small mandibles especially on anterior corpus heights	7 Melanesian males, 12 Melanesian females*, 1 Indo-Malay male, 1 Indo-Malay female, 2 South Asians	0.0002
3	Wide mandibles especially across gonial angles	Watinglo, Liang Momer E, 4 Melanesian males, 1 Melanesian female, 2 eastern Indonesian males, 1 Indo-Malay male	–
4	Comparatively large except across gonial angles	12 Melanesian males, 5 Melanesian females, 4 eastern Indonesian males*, 2 Indo-Malay males	0.0372
5	Comparatively large (on all measurements)	Liang Lemdubu, Liang Toge, 16 Melanesian males, 2 Melanesian females, 1 eastern Indonesian male, 11 Indo-Malay males*	0.0002
6	Small mandibles especially across gonial angles	1 Melanesian male, 6 Melanesian females, 1 Indo-Malay female, 7 South Asians*	0.0000

See text for an explanation of asterisked probability.

Source: David Bulbeck.

The Golo extended burial limb bone lengths

The limb bones of the Golo postcranial skeleton are largely complete, allowing them to be measured for their lengths as also recorded for several populations surrounding eastern Indonesia. The Golo measurements used in the analysis are presented in Table 11.11, and the square roots of the Penrose size and shape distances are presented in Table 11.12. The analysis of the square roots of the size distances is simple because they are additive, and so can be expressed in terms of the distance from the group with the shortest (or longest) limb bones. The analysis of the square roots of the shape distances was performed by finding the resultant average-linkage dendrogram and seriating the dendrogram (see Bulbeck 2013 for a detailed account of seriated dendrograms). The results of the analysis are presented in Figure 11.7.

Table 11.11 Golo limb bone measurements used in the Penrose analysis.

Measurement	Martin number	Golo's value (mm)	Comments
Femur oblique length	M2	423 (right)	Complete (left side 424 mm)
Tibia lateral condyle-malleolar length	M1	354 (right)	Complete
Fibula maximum length	M1	352.5 (right)	Estimated from the available shaft length of 267 mm
Humerus maximum length	M2	304 (left)	Complete
Radius physiological length	M2	227.5 (left)	Complete
Ulna maximum length	M1	262 (left)	Complete

Note: Martin's measurements defined by Bräuer (1988).

Source: David Bulbeck.

Table 11.12 Square roots of Penrose size (bottom-left half-matrix) and shape (top-right half-matrix) distances for limb bone lengths of Golo and the comparative Oriental-Pacific groups.

	Aeta	Loyalty Islanders	Golo	Javanese	Australians	New Caledonians	Japanese
Aeta	–	0.195	0.221	0.170	0.245	0.352	0.445
Loyalty Islanders	1.835	–	0.103	0.155	0.179	0.214	0.329
Golo	1.308		–	0.129	0.115	0.192	0.286
Javanese	0.963			–	0.100	0.224	0.293
Australians	2.068				–	0.164	0.214
New Caledonians	1.713					–	0.141
Japanese	0.361						–

Note: Golo and compared groups arranged in the seriated order for the shape distances. Size distances other than those presented can be calculated with reference to the Aeta distances (for instance, the distance between Loyalty Islanders and Golo = 1.835 – 1.308 = 0.527).

Source: David Bulbeck.

The Golo limb bone lengths are shorter than the averages recorded for the comparative southwest Pacific groups, but longer than the averages recorded for the comparative East Asian groups, especially the Aeta Negritos, who have the shortest limb bones. In terms of shape distances, Golo clusters with Loyalty Islanders and otherwise seriates adjacently to Javanese (who cluster with Australians). Golo is very different from Japanese both in terms of its longer limb bones and their different shape (Fig. 11.7). Index analysis, which is at best an approximation of the metrical drivers of the multivariate results, shows that Golo has long distal limb bones compared to its femur and humerus lengths, and a short humerus compared to its femur length (Table 11.13), contrasting with Japanese in these respects.

Bergman and The (1955) have published regression formulae for the estimation of Javanese male stature from their limb bone lengths. The similarity of Golo to Javanese in their limb bone proportions (Table 11.13) allows these formulae to be applied to Golo. The resulting estimates for Golo vary between 162 cm (fibula) and 165 cm (ulna), indicating the Golo male had a stature of around 163 cm when alive. This would fall just within the range of means of 154–163 cm recorded for living eastern Indonesian males (Keers 1948).

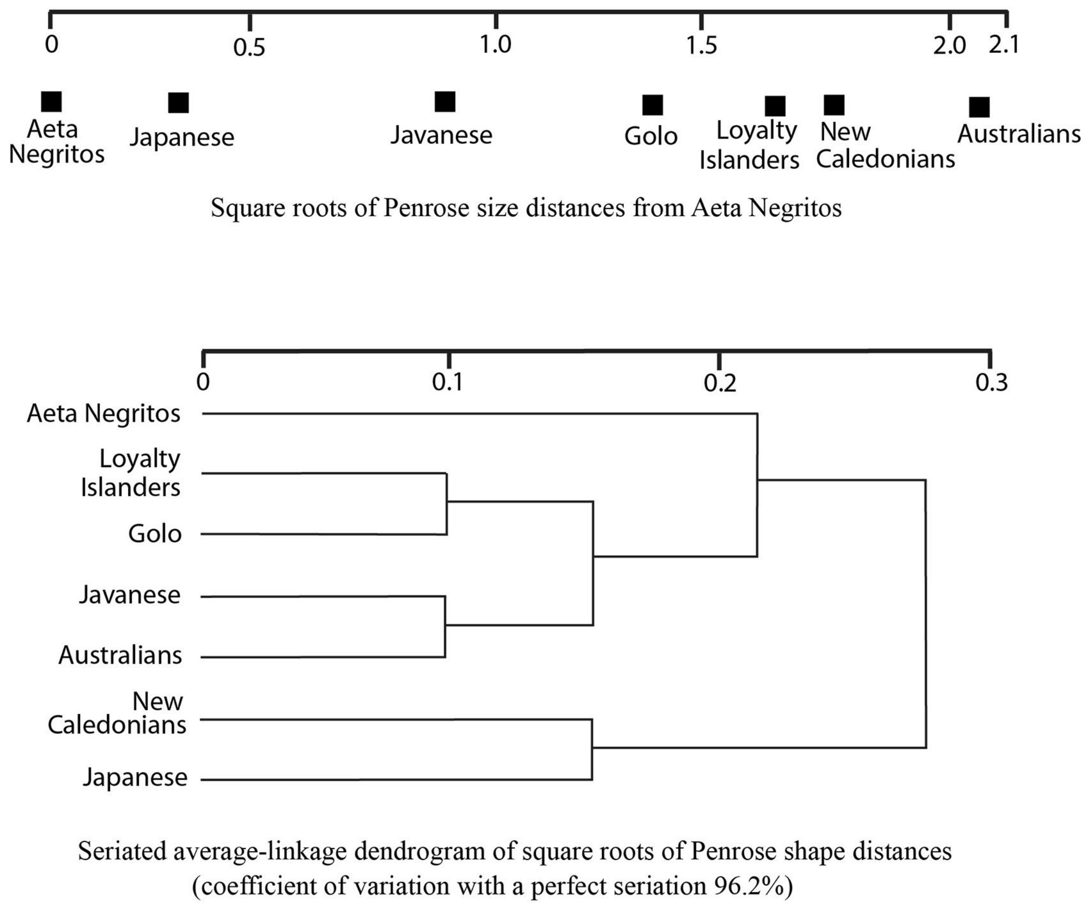

Figure 11.7 Graphical representation of metrical comparison of Golo with six Oriental-Pacific male groups.
Source: David Bulbeck.

Table 11.13 Golo and comparative group limb bone indices based on mean measurements.

Index	Aeta	Loyalty Islanders	Golo	Javanese	Australians	New Caledonians	Japanese
Femur:tibia	84.6	86.8	83.7	83.9	84.9	84.2	79.6
Femur:fibula	81.8	84.8	83.3	82.4	83.4	82.3	80.1
Humerus:radius	75.6	75.1	74.8	75.3	76.0	72.8	70.4
Humerus:ulna	85.8	86.7	86.2	84.6	85.2	84.0	80.1
Femur:humerus	71.7	72.3	71.9	71.5	72.1	72.7	73.6

Source: David Bulbeck.

The human remains from Tanjung Pinang, Morotai

Nearly 85 per cent of the Tanjung Pinang (TP) human remains are cranial. Ten individual crania ranging in their age at death from their teens to young adulthood (30s) could be distinguished (Table 11.14). Initially, two of the adults (TP2 and TP6) were sexed as female based on their gracile anatomy, but ancient DNA analysis in Leipzig has identified them as male, and so the crania in the collection are predominantly and perhaps entirely male (Table 11.1).

The mandibular and postcranial remains are highly fragmentary or, if complete, are small elements such as carpals and tarsals. Almost every postcranial element is represented with only the clavicle, trapezoid, navicular, medial cuneiform, and intermediate cuneiform apparently absent from the nearly 600 gm of postcranial material. The postcranial assemblage includes male adult, possibly female adult (as adjudged from anatomical attributes), and subadult specimens, and was excavated in essentially the same spits as the cranial remains.

Thus, the mortuary rituals at Tanjung Pinang appear to have focused on the secondary disposal of defleshed male crania accompanied by a random assortment of non-cranial fragments and small elements. Presumably, the deceased were treated to preliminary burial or exposure to the elements at another location, before retrieval of the cranium (along with incidentally collected bone) for final burial at Tanjung Pinang.

Cranium TP1 has been directly dated to 2090±180 BP (ANU-8439) which calibrates to 2684–1618 BP at 95.4 per cent (Table 1.1). The other TP burials would also date to around 2000 years ago, as discussed in Chapter 3.

Table 11.14 Cranial thicknesses (mm) recorded on the Tanjung Pinang vaults.

Location	TP1	TP2	TP3	TP4	TP5	TP6	TP7	TP8	TP10
Mid-frontal squama						9.5	6		
Bregma	7.5	7		7.5	7	9.1	6.5		
Vertex	–	8							
Euryon	8	7		5.1	6	8.4	7	8.1	
Parietal bone	10		Quite thick						10
Lambda	11	9		7.8	5	8.9	7		

Note: TP1 to TP3 had their cranial vault thicknesses measured only at the anatomical landmarks documented by Brown et al. (1979) for Australian Aborigines, and otherwise noted impressionistically (TP3). The 10 mm parietal thickness for TP1 was recorded on a cranial vault fragment (Square F2 25–30 cm depth) that may be attributable to TP1.

Source: David Bulbeck.

Crania TP1, TP5, TP6, TP9, and TP10 all have slight to mild *cribra orbitalia* on their extant orbits, taking the form of recovery scars in the case of the adults. The orbital roofs were not preserved for TP2, TP3, TP4, or TP7. Unusually thick cranial bone was recorded for TP1, TP6, TP8, and TP10, although not for TP2, TP3, TP4, TP5, or TP7, whose cranial vault thicknesses approximate the averages recorded for Australian Aborigines (Table 11.14). TP5 also displays mild porotic hyperostosis on its frontal and upper parietal bones, and TP6 and TP7 on their upper parietal bones, while TP4 has three fistulas attributable to osteitis on its left parietal. Unfortunately, observations for porotic hyperostosis on the parietal and occipital bone of TP1 to TP3 had not been undertaken at the time these remains were returned to Jakarta. In conjunction with the frequent occurrence of macroscopic linear enamel hypoplasia on the teeth, as detailed towards the end of this chapter, the buried remains point to chronic childhood anaemia as a morbidity that afflicted the Tanjung Pinang population (cf. Aufderheide and Rodríguez-Martin 1998).

The Tanjung Pinang crania

Cranial measurements taken with a sufficient degree of accuracy for multivariate analysis are presented in Table 11.15. The classificatory probabilities of the analysed Tanjung Pinang crania are presented in Table 11.16. If the most likely classification is with an Oriental-Pacific series, this is the only classification shown, but if the most likely classification is with a series from some other part of the world, but there is also an Oriental-Pacific classification that is more probable than any other, this secondary classification is also shown.

Table 11.15 Measurements[a] in mm recorded on the Tanjung Pinang crania.

Acronym	TP1	TP2	TP3	TP4	TP5	TP6	TP7	TP8
GOL	–	173[b]	–	–	162.5[c]	170[d]	–	184[e]
NOL	–	–	–	–	162.5[f]	–	–	183[g]
BNL	–	–	–	–	–	–	–	98[h]
BBH	–	131	–	–	–	–	–	–
XCB	–	129[i]	–	125[i]	125	134.5[j]	–	137[k]
XFB	112	115[i]	–	122[i]	106	120[i]	–	–
STB	112	109[i]	–	117[i]	106	117[i]	110[i]	–
ZYB	–	–	140[i]	–	125[l]	134[m]	–	137[k]
AUB	–	115[i]	130[i]	115[i]	105[i]	109	–	132
WCB	–	–	80[i]	–	–	–	–	75
ASB	–	101 [i]	120[i]	99[i]	97.5[n]	100	96[i]	117
BPL	–	–	–	–	–	–	–	109[h]
NPH	64[h]	–	–	–	63	58[h]	–	66
NLH	49	–	–	–	51	–	–	51
OBH	34.5	–	–	–	35	–	–	37
OBB	40.5	–	–	–	40[o]	–	–	40
JUB	117[h]	–	120[i]	–	115	–	120[i]	119
NLB	29.5	–	26[i]	–	23	26	25[p]	25
MAB	63.5	–	64[i]	–	60	59	63[p]	68
MDH	–	22	24	27[o]	–	23[o]	–	31
MDB	–	14	10.6	10	13	13	–	16.3
ZMB	98	–	–	–	87	–	94[i]	112
SSS	23	–	–	–	21	–	–	29
FMB	102	–	–	–	93	–	110[i]	96
NAS	15	–	–	–	12	–	–	22
EKB	101	–	–	–	97	–	108[i]	100
DKS	10	–	–	–	15[o]	–	–	13
DKB	22	–	–	–	22[h]	23	–	25
NDS	10	–	–	–	–	–	–	7
WNB	9	–	–	–	10	–	–	11
SIS	3	–	–	–	2	–	–	3
IML	–	–	–	–	33	–	38	38
XML	–	–	–	–	48	–	57	58
MLS	–	–	–	–	8	–	10	10
WMH	23	–	21[o]	–	21	25	23.5	23
SOS	7	–	–	–	2.5	–	–	5
GLS	2.5	–	–	–	2	–	–	4[p]
FRC	112	–	–	–	110	96[h]	–	–
FRS	23	17[p]	–	–	22	–	–	–
PAC	–	114	–	115[d]	104	–	117	–
PAS	–	28	–	–	23	–	25.5	–

(a) Most acronyms are detailed in Table 11.6. Other acronyms include ZYB (bizygomatic breadth), DKS (dacryon subtense), DKB (interorbital breadth), NDS (naso-dacryal subtense), WNB (least nasal breadth), SIS (simotic subtense), IML (inferior malar length), XML (maximum malar length), MLS (malar subtense), and GLS (glabella projection).

(b) Minimum estimate.

(c) Midpoint of 160–165 mm estimate.

(d) Dependent on accuracy of reconstruction.

(e) Midpoint of 182–186 mm estimate.

(f) Midpoint of 161–164 mm estimate.

(g) Midpoint of 181–185 mm estimate.

(h) Measured following estimation of the exact location of one of the anatomical points required for the measurement's definition.

(i) Symmetry assumed to take measurement.

(j) Midpoint of 133–136 mm estimate.

(k) Midpoint of 136–138 mm estimate.

(l) Midpoint of 120–130 mm estimate.

(m) Midpoint of 132–136 mm estimate.

(n) Midpoint of 95–100 mm estimate.

(o) Taken on right side.

(p) Approximate estimate, allowing for some missing bone.

Source: David Bulbeck.

Table 11.16 Classification results from discriminant function analysis of Tanjung Pinang crania.

Specimen	Most similar Oriental-Pacific series[a]	Classificatory Probability	Most similar series (if not Oriental-Pacific)	Classificatory Probability
TP 1[b]	Philippines	0.198	Dogon, Africa	0.266
TP2	Tolai	0.262	Tamil, South India	0.296
TP3	Atayal, Taiwan	0.095	Berg, Europe	0.648
TP4	None	0.000	Kannada, South India	0.738
TP5	Andamanese	0.982	NA	–
TP6	Andamanese	0.351	NA	–
TP7	Tolai, New Britain	0.502	NA	–
TP8[c]	Malekula	0.001	Santa Cruz, America	0.980

(a) Except for TP4, an Oriental-Pacific series is either the most probable or second most probable classification.

(b) Essentially identical results were obtained from the analysis that excluded NPH and JUB.

(c) In the analysis that excluded the estimated measurements, Santa Cruz was still by far the most probable classification, with Hawai'i the most likely Oriental-Pacific classification (0.006).

Source: David Bulbeck.

As shown in Table 11.16, two of the Tanjung Pinang crania would be classified as Andamanese. However, one of these (TP5) is a teenager and may not have retained Andamanese-like craniometrics into adulthood. The only other classification with an Oriental-Pacific series was with a Melanesian series (TP7). Five of the Tanjung Pinang crania would be classified with series distributed widely across the world, including India, Africa, Europe, and the New World. The last is a Mongoloid classification, in which context it is worth noting that the TP1 adolescent also has a reasonable probability of being classified as male Filipino.

Overall, particularly in the context of the small sample size of Tanjung Pinang crania and their incomplete nature, there is not a clear difference between the craniometric affinities of the Tanjung Pinang crania and those of recent eastern Indonesians. With the latter, 36 per cent would be classified with southwest Pacific series and 42 per cent with Mongoloid series, with Andamanese affinities otherwise prominent too (Bulbeck et al. 2006).

Only five of the (male) Tanjung Pinang crania have a sufficient suite of the Larnach and Macintosh (1966) characters intact for any of the Boolean expressions in Tables 10.2 and 10.3 to be evaluated. Table 11.17 presents the relevant observations and Table 11.18 summarises the results of the evaluation of the Boolean expressions. As TP1 and TP5 are adolescent, the results suggest that the Tanjung Pinang crania retained a cranial anatomy similar to that of Indo-Malays until adolescence. TP6 may have retained an Indo-Malay anatomy into adulthood, whereas TP2 and TP8 lean towards an Australoid cranial anatomy, similar in this respect to the Golo individual.

Table 11.17 Relevant anatomical observations of the Tanjung Pinang crania and their binary evaluation in terms of Tables 11.2 and 11.3.

Character	TP1	TP2	TP5	TP6	TP8
Glabella development	Martin 3 (small)	–	Martin 2 (small)	–	Martin 3 (small)
Maximum supraorbital breadth	109 mm (large)	–	101 mm (small)	–	105 mm (small)
Sagittal keeling	–	Trace (indistinct)	Absent (indistinct)	Absent (indistinct)	–
Naso-frontal articulation width	13 mm (broad)	–	11.9 mm (broad)	14.6 mm (broad)	10.7 mm (broad)
Parietal bossing	Slight (not prominent)		Slight (not prominent)	Slight (not prominent)	Absent (not prominent)
Palate module	c. 35.6 (small)[(a)]	–	33.6 (small)[(b)]	c. 35.4 (small)[(c)]	42.2 (large)[(d)]
Median frontal ridge	Trace (indistinct)	Absent (indistinct)	Trace (indistinct)	Trace (indistinct)	–
Cranial index (100*XCB/GOL)	–	−74.6 (<75, narrow)	76–78 (×75, not narrow)	c. 79 (×75, not narrow)	73–76 (not assessable on whether <75)
Transverse occipital torus	Large (present)	Small (present)	–	–	–
Malar orbital border	Rounded (not sharp)	–	Unrounded (sharp)	Rounded (not sharp)	Flattened (not sharp)
Phaenozygy	–	–	–	–	Marked (present)
Anterior nasal spine	Broca 3 or less (less than Broca 4)	–	Broca 2 (less than Broca 4)	–	Broca 1 (less than Broca 4)
Frontal curvature index	20.5 (Non-bulging, −24.7)	Low, visual estimate (Non-bulging, −24.7)	–	Low, visual estimate (Non-bulging, −24.7)	–
Supramastoid crest	–	Slight (slight)	Slight (slight)	Medium (not slight)	Medium (not slight)

(a) Relies on an estimate of c. 56 mm for palate length in addition to the Table 11.15 MAB value.

(b) Relies on a 56 mm measurement for palate length in addition to the Table 11.15 MAB value.

(c) Relies on an estimate of c. 60 mm for palate length in addition to the Table 11.15 MAB value.

(d) Relies on a 62 mm measurement for palate length in addition to the Table 11.15 MAB value.

Source: David Bulbeck.

Table 11.18 Implications of evaluation of the Boolean formulae in Tables 11.2 and 11.3 for the Tanjung Pinang crania.

Formula	TP1	TP2	TP5	TP6	TP8
2.1	Formula cannot be evaluated	Formula cannot be evaluated	More likely Indo-Malay than Australian	More likely Indo-Malay than Australian	Formula cannot be evaluated
2.2	Within the Indo-Malay range of variation	Formula cannot be evaluated	Within the Indo-Malay range of variation	Within the Indo-Malay range of variation	Formula cannot be evaluated
2.3	Formula cannot be evaluated	Within the Australian range of variation	Outside the Australian range of variation	Formula cannot be evaluated	Within the Australian range of variation
3.1	Formula cannot be evaluated	Formula cannot be evaluated	More likely Indo-Malay than Melanesian	Formula cannot be evaluated	Formula cannot be evaluated
3.2	Formula cannot be evaluated	Formula cannot be evaluated	Within the Indo-Malay range of variation	Within the Indo-Malay range of variation	Formula cannot be evaluated
3.3	Within the Melanesian range of variation	Within the Melanesian range of variation	Formula cannot be evaluated	Formula cannot be evaluated	Within the Melanesian range of variation
Inference	All affinities possible	Could be Australoid	Indo-Malay	Could be Indo-Malay	Could be Australoid

Source: David Bulbeck.

The human remains from Uattamdi 1, Kayoa

Figure 11.8 Uattamdi 1 cranial bones illustrating their thickness and porotic hyperostosis.
Source: David Bulbeck.

Five individuals were recognised amongst the Uattamdi human remains, two comprising slightly weathered bone (Uattamdi 1 and 2), and three comprising bone of fresh appearance (Uattamdi 3 to 5). Uattamdi 1 has been directly dated to 1915±27 BP (1932–1813 cal. BP), and Uattamdi 2, which is the other well-represented cranium from the excavation, probably dates to about the same time. On the other hand, Uattamdi 3 to 5 would appear to be later burials interred at the site.

Uattamdi 1, an adult male, is represented by a very peculiar posterior braincase. The maximum cranial breadth (assuming symmetry) is estimated to measure 160 mm, over 20 mm broader than any of the Golo or Tanjung Pinang crania. The cranial bone is very thick, up to 15.6 mm at inion, 12.2 mm at (right) euryon, 10 mm at lambda and 9.2 mm at (left) stephanion. Advanced porotic hyperostosis covers both surfaces of the vault, including a trabecular pattern of pinprick impressions externally and craters of up to

20 mm diameter internally (Fig. 11.8). A section of the left parietal has been cut out and this reveals thickened diploe that make up around 80 per cent of the thickness of the cranial bone, although the diploic trabeculae themselves are rather sparse and much of the diploe comprises solid bone. This lack of diploic coarsening would be unusual for anaemic sufferers except for those whose condition is caused by thalassaemia (Aufderheide and Rodríguez-Martín 1998:348; Tayles 1999:187 ff.), and this may be the appropriate diagnosis for Uattamdi 1 despite the lack of a 'hair-on-end' appearance of the diploic bone (cf. Aufderheide and Rodriguez-Martín 1998:347).

Uattamdi 2 consists of 11 cranial vault fragments from Square E9 spit B1. It is clearly a distinct individual from Uattamdi 1 as shown by the much thinner cranial vault (6.2 mm at asterion, and 7.7 mm in the vicinity of the sagittal suture), open cranial sutures, and duplication of the right postero-inferior parietal corner.

Uattamdi 3 is identified on the basis of the apparently adult fragments from Squares C4–C5, C5 spit B3, E4 spit B3, E4–E5 and E6. The parts of the skeleton represented are the right temporal, left parietal (probably), vertebral column, ribcage, left and right hands, and left and right feet. The same individual may also be represented by at least some of the adult fragments extracted by Jennifer R. Hull when she separated the human material from the Uattamdi faunal material. These adult remains include cranial vault, teeth, a hyoid bone, fragments from the entire vertebral column, ribs, scapula, humerus, radius, ulna, carpals, metacarpals, manual extremities, tibia, tarsals, metatarsals, and pedal phalanges—virtually the entire skeleton from head to toe.

Uattamdi 4 was initially recognised on the basis of apparently infantile remains from the frontal, right posterior parietal, and right temporal, from E4 spit B3, C5 spit B3 and C4–C5. The same individual may be represented by the infantile human remains extracted by Jennifer R. Hull from the Uattamdi faunal material. These include six deciduous teeth, an unfused mandibular symphysis fragment, two vertebra centra with the vertebral processes completely unfused, and miniature extremity bones present as shafts without either the base or the head attached.

Uattamdi 5 is recognised on the basis of apparently subadult but non-infantile fragments from the spits labelled as lower A and A1, comprising a partial occipital and abutting posterior parietals, additional parietal bone, and an upper rib. The remains from non-infantile children extracted by Jennifer R. Hull include the incompletely formed buds to a first molar and a third molar, a fragment from a very small superciliary region with active porotic hyperostosis on the orbital roof, and a very small sesamoid bone.

The consistently small specimens extracted by Jennifer R. Hull were recovered from all Uattamdi squares. Some were in bags that were unlabelled, or labelled only in general terms. Together they constitute 78 specimens weighing 107 gm. The generally fresh (and unburnt) condition of the bone, and the general similarity of the assemblage to the collections of highly fragmentary remains suspected to date to the Common Era from other Northern Moluccan sites (including betel-nut staining on all of the permanent anterior teeth), suggest that these Uattamdi fragments would date to the first and/or second millennia BP. This is despite these fragments' recovery from as deep as 55–60 cm. While at least some of these specimens may relate to Uattamdi 3 to 5, additional secondarily buried individuals may also be represented.

Other sites

The human remains from Um Kapat Papo, Gebe

The Um Kapat Papo human remains include a tooth, cranial vault fragments, and postcranial fragments from spits 1 and 2 of the P9 Square. Much of the postcranial skeleton is represented including the vertebral column, forearms, carpals, metacarpals, manual phalanges, patella, tibia, fibula, tarsals, metatarsals, and pedal phalanges. Some of the small bones are complete, but the larger elements are consistently represented by small fragments. The lack of duplication of any element, and the consistency with which the remains could be attributed to an adult female (epiphyses fused wherever present, small apparent size of the original bones), suggest that only one individual is represented. The fresh to quite fresh appearance of the bone, and its stratigraphic location at the same level or above the c. 2000 BP date on marine shell from the site, suggest a second millennium BP dating.

The human remains from Tanjung Tulang, Morotai

Figure 11.9 Fragments assigned to the Tanjung Tulang 2 adolescent.
Source: David Bulbeck.

Four individuals, Tanjung Tulang 1 to 4, are recognised amongst the human material excavated from the site. Tanjung Tulang 1 to 3 include an adult male (the larger adult), an adult female (the smaller adult) and a subadult represented amongst the L5/M5/N5 material (Fig. 11.9), while Tanjung Tulang 4 is an unsexed adult excavated in the E4 and F6 squares. The great majority of the human remains are burnt or singed (96 per cent by weight), and this indicates that the site was reserved for the secondary burial of cremated human remains. This use of the site apparently preceded its habitation phase, associated with the deposition of shellfish and small amounts of Sambiki Tua–type pottery, given that the main concentration of human remains was stratified beneath the major concentration of shell and pottery (see Chapter 3).

From the weathered condition of most of the bone, I would estimate the Tanjung Tulang burials date to around 1000 years ago. Similarity in age to the Tanjung Pinang burials is suggested by the dominance of cranial material (slightly over 50 per cent) in the identified Tanjung Tulang remains, the wide-scale representation of the postcranial skeleton (ribs, vertebrae, clavicle, scapula, humerus, radius, ulna, trapezoid, lunate, hamate, proximal and medial manual phalanges, pelvis, femur, tibia, fibula, talus, navicular, medial cuneiform, metatarsals, and proximal and distal pedal phalanges), and the extant status of most of the postcranial elements either as small fragments or small complete bones.

The cranial vault appears generally thick, up to 11.2 mm along the coronal suture and 11.5 mm on the occipital. Further, one of the F6 cranial vault fragments has holes on the interior surface with a 'punched out' appearance, which is suggestive of multiple myeloma (cf. Aufderheide and Rodríguez-Martín 1998). A subadult, orbital roof fragment from N5 has porotic *cribra orbitalia*, indicative of active anaemia (cf. Webb 1982). Further information on the health status of the buried Tanjung Tulang individuals might have been available if I had been able to relocate the upper left lateral incisor, upper right lateral incisor, upper right first premolar, three upper first molars, upper right second molar, lower right lateral incisor, lower canine, lower left second molar and lower left third molar mentioned in Kate Stockhausen's notes, in addition to the left second lower premolar (detailed below).

The human remains from Daeo 1, Morotai

As described in Chapter 3, Daeo 1 appears to be a disturbed site with human remains (around 350 gm) distributed throughout most of the excavated deposit, to a depth of 30–35 cm. Conceivably, the activity of burying the deceased at the site could have been a contributing factor to the disturbance of the deposit. Despite the small quantity of excavated human material, virtually the entire skeleton is represented, more or less in the expected proportions (with only the pelvic girdle missing). The assemblage consists of small fragments and a few small, complete bones, indicating the secondary burial of previously defleshed corpses. There are both fused and unfused epiphyses in the assemblage, and an unworn, lower fragmentary molar (first or second), demonstrating the representation of both adult and subadult individuals. Further, the adult postcranial material includes some extremity bones and fragments that appear to be male in their dimensions. Most of the fragments have a weathered appearance, with only small quantities recorded as burnt or as fresh, suggesting an age of perhaps 1000 years ago for the mortuary assemblage.

The recorded remains are too fragmentary to provide any biologically useful information. Information of this nature might have been possible if it had been possible to relocate the 28 human teeth identified by Kate Stockhausen in her notes. Her identifications include three upper right central incisors, indicating a minimum number of three individuals represented in the Daeo 1 assemblage.

The human remains from Daeo 2, Morotai

The description in Chapter 3 of the stratigraphy of Daeo 2 refers to a thin veneer of ceramic period burial activity on the top. This description accords well with the fresh appearance that characterises 96 per cent of the identified human bone from the site, and which indicates a first millennium BP dating for the burials. Over half of the identified bone is cranial and it includes some of the very small, delicate bones such as the palatine and concha bones. This strong representation of cranial bone suggests secondary burial of previously defleshed corpses, with a possible focus on skull burials. The postcranial material, which covers the entire skeleton apart from the pelvic girdle, includes both adult and subadult fragments and small bones (such as carpal bones). The extant cranial sutures are variably closed and fully open.

A lateral incisor in a mandible fragment was available for recording, as detailed below. In addition, the notes made by Kate Stockhausen refer to 42 teeth, which I was unable to relocate. These teeth include five upper right central incisors and five upper left lateral incisors, indicating a minimum number of five individuals represented amongst the Daeo 2 burial remains.

Northern Moluccan tooth size and morphology

Table 11.19 presents the summed average tooth area for the recorded Northern Moluccan teeth, calculated from the average tooth lengths and breadths provided in Tables 11.20 and 11.21. The summed average tooth area is the sum of the products of the average mesio-distal length and bucco-lingual breadth of each tooth class (Brace 1976). Ideally, the summed average tooth area would be based on all of the tooth classes. However, the Northern Moluccan remains that I recorded exclude any lower central incisors with measurable diameters or any lower third molars (Tables 11.20 and 11.21) so these could not be included in the calculation.

Table 11.19 Northern Moluccan summed tooth area (square millimetres), with Indo-Malaysian and Melanesian comparisons (bisexual samples except where otherwise specified).

Series	Summed tooth area (excluding lower third molars and lower central incisors)	Summed tooth area (excluding all third molars and lower central incisors)	Data source
Northern Moluccas	1229	1127	This chapter
Temperate Australians (excluding Sydney)	1230–1354	1114–1223	Brace 1980 (8 series)
New Guinea Highland males	1279	1168	Doran and Freedman 1974
Tasmanians	1262	1134	Brace 1980
Loyalty Islands	–	1117	Matsumura and Hudson 2005
Tropical Australians	1121–1226	1006–1103	Brace 1980 (7 series)
Sydney Australians	1195	1082	Brace 1980
Prehistoric Flores	1193	1075	Jacob 1967a
New Britain	1164	1056	Snell 1938
Nasioi, North Solomons	1157	1058	Bailit et al. 1968
Leang Buidane, Early Metal Phase Sulawesi	1159	1054	Bulbeck 1981
Leang Codong, Early Metal Phase Sulawesi	1136	1029	Jacob 1967a
Temiar Senoi, Malaysia	1135	1029	Bulbeck et al. 2005
Borneo 'Dayaks'	–	1025	Matsumura and Hudson 2005
Gilimanuk, Early Metal Phase Bali	1120	1014	Jacob 1967b
Batawi, Java	1105	1003	Snell 1938
Andaman Islanders	–	1003	Matsumura and Hudson 2005
Sumatrans	–	1001	Matsumura and Hudson 2005
Javanese	1087	997	Brace 1976
Melayu Malay males	1092	990	Bulbeck et al. 2005
Aboriginal Malays, Malaysia	1077	983	Bulbeck et al. 2005
Semang, Malaysia	1071	976	Bulbeck et al. 2005
Motupore Island, Papua New Guinea	1045	958	Brown 1978
Philippine Negritos	–	939	Matsumura and Hudson 2005
Tagalogs	–	880	Yap Potter et al. 1981

Source: David Bulbeck.

In addition, some of the comparative sources for average tooth lengths and breadths of recent Indo-Malaysian and Melanesian populations do not include data for third molars. Accordingly, Table 11.19 additionally presents the Northern Moluccan summed average tooth area for the dentition excluding both upper and lower third molars as well as the lower central incisors. The Northern Moluccan values are compared with the corresponding values for prehistoric (mid to late Holocene) Flores teeth, teeth from other prehistoric sites in Indonesia dating to the last two millennia BP, as well as teeth of recent Indo-Malaysians, Melanesians, Australians, and Tasmanians (see Table 11.19 for sources).

The comparative data show that the available Northern Moluccan teeth are large, with a summed tooth area that would fall within the Australian range of variation. The Northern Moluccan tooth area exceeds that recorded for tropical and Sydney-region Australians, although it is smaller than the tooth area recorded for temperate Australians (outside of the Sydney region) and Tasmanians. The Northern Moluccan tooth area is also larger than that of every comparative non-Australian series, with the single exception of New Guinea Highland males. Even this (modest) difference could be readily attributed to sexual dimorphism, because males generally exceed females from the same population in their average tooth sizes (e.g. Bulbeck 1981), and the Northern Moluccan sample includes some females notwithstanding its predominantly male composition (Table 11.1). Other series with quite large teeth include Loyalty Islanders, prehistoric Flores and, to a lesser degree, New Britain, Solomon Islanders, and the Early Metal Phase teeth from Leang Buidane in the Talaud Islands. At the other end of the scale, the smallest teeth are shown by the Semang and Philippine Negritos, the coastal Papua New Guinea sample from Motupore Island, and Philippine Tagalogs. The Motupore Island sample shows that not all Melanesians can be distinguished from Indo-Malaysians on the basis of larger teeth.

In summary, keeping in mind that the Northern Moluccan sample is small in size and irregular in its composition, we may conclude that the available data suggest large teeth, as otherwise shown by Australians, some recent Melanesian groups, and the prehistoric Flores sample.

The dental sample size is too small to propose a population affinity for the Northern Moluccan remains based on the dental morphological traits described by Scott and Turner (1997). The few observations that could be made suggest intra-population variability. For instance, with reference to the breakpoint for upper incisor shovelling in Scott and Turner (1997), the unassigned lateral incisor from Tanjung Pinang would be 'shovelled' whereas all of the other Northern Moluccan incisors would be 'unshovelled'.

Northern Moluccan tooth wear and betel-nut staining

The rate of tooth wear shown by the Northern Moluccan dental remains can be described as moderate. Around one-third of the recorded teeth are lightly worn (Table 11.22), characterised by enamel polishing or at most the creation of small dentine pools (Smith wear classes 1 to 3). However, most of these teeth either come from subadults (e.g. TP1, TP5, and TP9) or were found amongst unassigned dental remains that are suspected to include subadults. As for the adult individuals, TP3 and TP6 also have lightly worn teeth, potentially reflecting their status as young adults, whereas TP8 and especially the Golo extended burial have more heavily worn teeth. Accordingly, TP8 and the Golo individual may have died in their middle age, although compelling independent evidence for this inference is not available (for instance, the Golo extended burial is unfortunately missing its pubic processes, whose surface morphology would otherwise serve as a useful marker of biological age). It might also be noted that the tooth wear on the Golo individual is very irregular across the dentition (discussed below).

Betel-nut staining was characteristic of the Northern Moluccan anterior teeth, which are more prone than the cheek teeth to becoming stained through habitual betel-nut (*Areca catechu*) chewing. It was observed on the teeth assigned to the Golo extended burial, and on the permanent anterior Uattamdi teeth. Betel-nut staining was also observed on the extant teeth of TP1, TP2, and TP7, the anterior teeth (back to the first premolar or first molar) of TP3, TP5, TP6, and TP8, and the unassigned lateral incisor from Square J2 5–10 cm depth. The only evidence for a TP individual who was unaffected by betel-nut staining is provided by the suspected juvenile, lower left canine from Square J2 10–20 cm (TP9). Finally, the left lateral lower incisor from Daeo 2 has a strong betel-nut stain, while the second upper molar from Um Kapat Papo has a pinkish wash, though it is not diagnostic of betel-nut staining.

Northern Moluccan oral pathology

The available observations on oral pathology (Tables 11.23–11.25) suggest a difference between the Tanjung Pinang remains, characterised by sound oral health, and the Golo remains, marked by poor oral health. The TP teeth show no cases of caries, and only one case of ante-mortem tooth loss, while periodontal disease was recorded as either absent (including TP8, with its moderate tooth wear) or mild (affecting the TP5 teenager and the TP7 adult). All of these pathological traits are more developed with the available Golo material. Incipient caries was recorded on 1/3 of the unassigned Golo teeth, while 11/22 of the teeth and tooth sites from the extended burial show incipient to highly advanced caries. Similarly, ante-mortem tooth loss was recorded on 2/6 of the unassigned Golo tooth sites and 7/31 of the recordable tooth sites from the extended burial. In addition, mild periodontal disease was recorded at 5/6 of the unassigned Golo tooth sites, while mild to pronounced periodontal disease was recorded at 11/30 of the recordable tooth sites from the extended burial.

The Golo individual would have had a poorly functioning dentition at the time of death. About half of the molars had been lost ante-mortem, and the molars that remained jutted into the empty spaces left by their missing counterparts. The anterior teeth and premolars are much less affected by oral disease, but their wear pattern is uneven, with about half reduced to dentine stubs and the other half showing moderate wear. The individual had presumably used his teeth to puncture his food rather than grind it through lateral jaw excursions (as would be associated with a helicoidal occlusal plane), and probably had a diet that included both tough items and a high carbohydrate content (cf. Hillson 1996:237–239, 267, 283).

The limited available sample sizes would suggest that a diet high in carbohydrates was more a feature of the Golo than the Tanjung Pinang population. Unfortunately, too few tooth sites could be recorded from any of the other sites to assess how they might compare with Golo and Tanjung Pinang.

Table 11.20 Recorded mesio-distal diameters on Northern Moluccan permanent teeth (mm).

Tooth	GO	GE	TP1	TP2	TP3	TP5	TP6	TP7	TP8	TP9	TPU	UAT	UKP	TT4	Average
L I^1						10.3	9.7								9.6
R I^1					9.1							8.4			
L I^2											7.3				6.5
R I^2											5.7				
L $\underline{C}$				8.8		9.3									8.5
R $\underline{C}$					9.0		7.9					7.4			
L P^1						8.2	7.85		7.5			7.3			7.8
R P^1					8.1		7.8		7.8						
L P^2			8.0			8.1			6.7						7.5
R P^2			8.1		7.5	7.1			7.2						
L M^1						11.7	10.1		10.6			10.4, 13.2			11.2
R M^1		12.1			12.4	11.1	10.3	10.4	10.8						
L M^2						9.5	10.0		10.3				10.1		9.9
R M^2						9.6	9.5		10.5						
L M^3							7.6		9.2			8.3, 9.7			9.0
R M^3	9.05				10.2		8.1		9.7						
R I_2				5.9								6.6			6.25
L C										6.9					7.5
R C			8.0									6.5, 8.7			
L P_1		7.7													7.7
L P_2			7.1											7.0	7.05
R M_1	13.2														13.2
R M_2	12.4								11.2						11.8

GO: Golo LMN fragments; GE: Golo extended burial; TP: Tanjung Pinang, including TPU for Tanjung Pinang unassigned; UAT: Uattamdi; UKP: Um Kapat Papo; TT4: Tanjung Tulang 4.

Source: David Bulbeck.

Table 11.21 Recorded bucco-lingual diameters on Northern Moluccan permanent teeth (mm).

Tooth	GO	GE	TP1	TP2	TP3	TP5	TP6	TP7	TP8	TP9	TPU	UAT	UKP	TT4	DA2	Average
L I^1						7.5	7.8									7.7
R I^1					8.1							7.5, 7.7				
L I^2		7.9									6.9					6.6
R I^2											5.0					
L $\underline{C}$				8.8		9.9										8.8
R $\underline{C}$					9.1		8.2					7.8, 8.8				
L P^1						11.7	9.6		10.0			9.5				10.1
R P^1					10.5		9.2		10.4							
L P^2		10.6	10.6			10.8			9.4			8.7				10.1
R P^2			10.7		9.9	10.0			9.8							
L M^1						13.8	11.6		12.3			11.6, 12.2				12.2
R M^1		12.8			12.1		11.6	11.4	12.3							
L M^2						12.8	11.9		12.5				11.4			11.9
R M^2						10.3	11.55		12.6							
L M^3							11.3		11.3							11.3
R M^3	12.0				12.5		10.8		11.2			10.3, 10.9				

Tooth	GO	GE	TP1	TP2	TP3	TP5	TP6	TP7	TP8	TP9	TPU	UAT	UKP	TT4	DA2	Average
L I$_2$															6.2	6.4
R I$_2$				7.0								6.1, 6.2				
L C										8.1						8.2
R C			8.9									7.2, 8.7				
L P$_1$		8.4														8.4
L P$_2$			8.7											7.9		8.3
R M$_1$	12.5															12.5
R M$_2$	12.5								10.7							11.6

GO: Golo LMN fragments; GE: Golo extended burial; TP: Tanjung Pinang, including TPU for Tanjung Pinang unassigned; UAT: Uattamdi; UKP: Um Kapat Papo; TT4: Tanjung Tulang 4; DA2: Daeo 2.

Source: David Bulbeck.

Table 11.22 Recorded tooth wear (Smith's classes) on Northern Moluccan teeth.

Tooth	GO	GE	TP1	TP2	TP3	TP5	TP6	TP7	TP8	TP9	TPU	UAT	UKP	TT4	DA2
L I^1		8				3	4								
R I^1		7			2							2, 4			
L I^2		4									2				
R I^2		5									3				
L $\underline{C}$		8		4		3									
R $\underline{C}$		6			2		3					3, 5			
L P^1		8				3	3		5			1			
R P^1		8			2		3		6						
L P^2		6	2			3			4			5			
R P^2		8	1			3			4						
L M^1		4				3	3		5			1, 2			
R M^1		4			3	3	3	4	4						
L M^2		–				2	3		3				3		
R M^2		8				2	3		4						
L M^3		–					2		4			1, 3			
R M^3	2	–			1		2		4						
L I$_1$		6													
R I$_1$		8													
L I$_2$		7													5
R I$_2$		8		4								1, 4			
L C		5								2					
R C		5	2									1, 4			
L P$_1$		4													
R P$_1$		8													
L P$_2$		–	2											2	
R P$_2$		8													
R M$_1$	5	–													
R M$_2$	4	8							5						

GO: Golo LMN fragments; GE: Golo extended burial; TP: Tanjung Pinang, including TPU for Tanjung Pinang unassigned; UAT: Uattamdi; UKP: Um Kapat Papo; TT4: Tanjung Tulang 4; DA2: Daeo 2.

Source: David Bulbeck.

Table 11.23 Recorded caries (not recorded for teeth missing on the basis of unknown aetiology or teeth reduced to stubs) on Northern Moluccan teeth.

Tooth	GO	GE	TP1	TP2	TP3	TP5	TP6	TP7	TP8	TP9	TPU	UAT	UKP	TT4	DA2
L I^1		–				N	N								
R I^1		N			N							N, N			
L I^2		N									N				
R I^2		N									N				
L $\underline{C}$		–		N		N									
R $\underline{C}$		N			N		N					N, N			
L P^1		–				N	N		N			N			
R P^1		–			N		N		N						
L P^2		N	N			N			N			N			
R P^2		–	N		N	N			N						
L M^1		M				N	N		N						
R M^1		I			N	N	N	N	N			N, N			
L M^2		P				N	N		N				N		
R M^2		M				N	N		N						
L M^3		P					N		N			N, N			
R M^3	N	–			N		N		N						
L I_1		N													
L I_2		N													I
R I_2		N		N								N, I			
L C		N								N					
R C		N	N									N, N			
L P_1		N													
L P_2		–	N											N	
L M_1		P													
R M_1	I	P													
L M_2		P													
R M_2	N	M							N						
L M_3		P													
R M_3		P													

N = none; I = Incipient; M = massive; P = presumed cause of tooth loss. GO: Golo LMN fragments; GE: Golo extended burial; TP: Tanjung Pinang, including TPU for Tanjung Pinang unassigned; UAT: Uattamdi; UKP: Um Kapat Papo; TT4: Tanjung Tulang 4; DA2: Daeo 2.

Source: David Bulbeck.

Table 11.24 Recorded ante-mortem loss at Northern Moluccan tooth sites.

Tooth site	GO	GE	TP1	TP3	TP5	TP6	TP7	TP8	DA2
L I^1		N			N	N		N	
R I^1		N		N		N		N	
L I^2		N			N	N		N	
R I^2		N				N		N	
L $\underline{C}$		N			N	N		N	
R $\underline{C}$	N	N		N	X	N		N	
L P^1		N			N	N		N	
R P^1	N	N		N		N		N	
L P^2		N	N		N	N		N	

Tooth site	GO	GE	TP1	TP3	TP5	TP6	TP7	TP8	DA2
R P^2	X	N	N	N	N	N		N	
L M^1		N			N	N		N	
R M^1	X	N		N	N	N	N	N	
L M^2		X			N	N		N	
R M^2		N		N	N	N		N	
L M^3		X				N		N	
R M^3		–		N		N		N	
L I_1		N							
R I_1		N							
L I_2		N							N
R I_2		N							
L C		N							
R C		N	N						
L P_1		N							
R P_1		N							
L P_2		N	N						
R P_2		N							
L M_1		X							
R M_1	N	X							
L M_2		N							
R M_2	N	X			N				
L M_3		X							
R M_3		X							

X = lost ante-mortem; N = not lost ante-mortem. GO: Golo LMN fragments; GE: Golo extended burial; TP: Tanjung Pinang; DA2: Daeo 2.

Source: David Bulbeck.

Table 11.25 Recorded periodontal disease at Northern Moluccan tooth sites.

Tooth site	GO	GE	TP1	TP2	TP5	TP6	TP7	TP8	TP10	DA2
L I^1		N			M	N		N	M	
R I^1		N		N	M	N		N	M	
L I^2		N			M	N		N	M	
R I^2		M			M	N		N	M	
L $\underline{C}$		N			M	N		N	M	
R $\underline{C}$	M	M		N	M	N	M	N	M	
L P^1		N			N	N	M	N	M	
R P^1	M	N		N	–	N	M	N	M	
L P^2		N	N		N	N	M	N	M	
R P^2	M	N	N	N	N	N	M	N	M	
L M^1		M			N	N	M	N	N	
R M^1	M	N		N	N	N	M	N	N	
L M^2		M			N	N		N		
R M^2		N		N	N	N		N	N	
L M^3		M				N		N	N	
R M^3		–		N		N		N		
L I_1		N								
R I_1		N								

Tooth site	GO	GE	TP1	TP2	TP5	TP6	TP7	TP8	TP10	DA2
L I_2		N								N
R I_2		N								
L C		N								
R C		N	–							
L P_1		N								
R P_1		N								
L P_2		–	–							
R P_2		N								
L M_1		P								
R M_1	M	P								
L M_2		P								
R M_2	N	P								
L M_3		P								
R M_3		P								

N = None, apart from expected age-related degeneration; M = Mild, for instance, advanced dehiscences; P = Pronounced, for instance, alveolar abscesses. GO: Golo LMN fragments; GE: Golo extended burial; TP: Tanjung Pinang; DA2: Daeo 2.

Source: David Bulbeck.

Northern Moluccan general health (see also Chapter 12)

One line of insight into general health is to examine the teeth for macroscopic lines of dental linear enamel hypoplasia (LEH). These lines potentially reflect interruptions to tooth formation during childhood development. LEH was recorded on a high proportion of the Northern Moluccan teeth; for instance, all of the upper lateral incisors and first and second molars, and more than half of the upper central incisors, canines, premolars, and third molars (Table 11.26).

Further, LEH formation may reflect systemic interruptions to growth, but to have confidence in drawing that inference, observable LEH should match across different teeth that would have been forming at about the same time (Hillson 1996). Applying that criterion, we would infer that five of the eight Tanjung Pinang individuals had experienced an interruption to childhood growth. In the case of TP3, this would have occurred at a very young age, in the order of 1 year old. In the case of TP5, it would have occurred on two occasions, at the ages of around 2 years old and 6 years old. In the case of TP6, it would have occurred on three occasions, at the ages of around 2 years old, 5 years old and 12 years old. Finally, the TP1 and TP8 subadults may also have experienced an interruption to growth, respectively at approximately 6 years and 12 years of age. Susceptibility to LEH may have been increased at the time of weaning, but, if so, there is insufficient regularity in the inferred ages for LEH formation to suggest the modal age at which weaning had occurred.

With three of the five Tanjung Pinang individuals, there is evidence to relate their LEH to chronic childhood anaemia. These individuals are TP6 (*cribra orbitalia*, thick cranial bone, and porotic hyperostosis), TP1 (*cribra orbitalia* and thick cranial bone, porotic hyperostosis status unknown), and TP5 (*cribra orbitalia* and porotic hyperostosis, albeit lacking thick cranial bone). However, the same diagnosis is less convincing for TP8, which has thick cranial bone but not the other two markers, and TP7, which displays no anaemic markers. Finally, it may be noted that the TP2 and TP7 do not display either LEH or any signs of chronic childhood anaemia.

The Uattamdi assemblage resembles Tanjung Pinang in its inclusion of a proportion of individuals with osteological signs of anaemia. Although this was the case with only one of the five Uattamdi crania, the condition of this specimen (Uattamdi 1) is extreme, with a possible diagnosis of genetically determined thalassaemia. The observation of active *cribra orbitalia* on a fragmentary, juvenile orbital roof from Uattamdi confirms the case that childhood anaemia afflicted some proportion of the local population. A similar conclusion may apply to Tanjung Tulang, whose fragmentary remains included an orbital roof with active *cribra orbitalia*, examples of thick cranial vault, and a specimen with what may be advanced porotic hyperostosis.

The status of the Golo individual is ambiguous in terms of his general health prior to dying middle-aged, as the only sign of anaemia involves faint traces of porotic hyperostosis. Unfortunately, the Um Kapat Papo and Daeo assemblages are too fragmentary and/or limited in their quantity of cranial vault to provide a reliable indication of the existence or otherwise of anaemia in the populations that they represent.

Table 11.26 Macroscopic linear enamel hypoplasia observed on the Northern Moluccan teeth.

Tooth	GO	TP1	TP2	TP3	TP5	TP6	TP7	TP8	TP9	TPU	UAT	UKP	TT4	DA2	Occurrence
L I^1					I, C*	I									4/6
R I^1				O							N, N				
L I^2										I					2/2
R I^2										C					
L $\underline{C}$			C		I										4/5
R $\underline{C}$				O		C					N				
L P^1					O, C*	I		N			C				4/7
R P^1				N		I		N							
L P^2		C			C			N							4/7
R P^2		C		N	C			N							
L M^1					I	C		I			C, C				9/9
R M^1				O	I	I	C	C							
L M^2					I	I		I				I			7/7
R M^2					I	I		I							
L M^3						I		I			I				5/7
R M^3	N			N		I		I							
L I_2														N	2/4
R I_2			C								N, C				
L C									O, I, C*						1/3
R C		N									N				
L P_2		C													1/2
R P_2													N		
R M_1	N														0/1
R M_2	N							O, C*							1/2
Match?	N/A	Yes	No	Yes	Yes	Yes	N/A	Yes	No	No	Possible	N/A	N/A	N/A	44/62

N = none; O = occlusal third of tooth; I = middle third of tooth; C = cervical third of tooth. * = Multiple lines on single tooth. No observations available on many of the teeth including those from the Golo extended burial. GO: Golo LMN fragments; TP: Tanjung Pinang, including TPU for Tanjung Pinang unassigned; UAT: Uattamdi; UKP: Um Kapat Papo; TT4: Tanjung Tulang 4; DA2: Daeo 2.

Source: David Bulbeck.

Discussion

Affinities with southwest Pacific populations emerge repeatedly from the comparative analysis of the Northern Moluccan human remains. Tooth size resembles that of Australians and certain Melanesian groups (those with relatively large teeth). Craniometrically, the Malekula series from Vanuatu provides a very close match for the Golo extended burial (though this may be attributable to their shared feature of cranial deformation), and the Tolai series from New Britain provides a reasonable match for one of the Tanjung Pinang crania (TP2). In terms of cranial anatomy, the Golo cranium would be classified as either Australian or Melanesian rather than Indo-Malaysian. Metrically, the Golo mandible falls with a cluster dominated by Melanesian as well as eastern Indonesian males. Finally, the Golo limb bone proportions are most closely approached by Loyalty Islanders.

On the other hand, there would be insufficient evidence to infer a difference between Northern Moluccans and recent eastern Indonesians in their biological affinities. As for tooth size, it is undocumented for recent eastern Indonesians, and the prehistoric Flores remains recorded by Jacob (1967a) resemble the Northern Moluccan assemblage in their summed tooth area. Further, as also shown by a fair proportion of recent eastern Indonesians, the Tanjung Pinang crania include four specimens with Andamanese and 'Mongoloid' Southeast Asian craniometric affinities, even if this is more a feature of the subadults (TP1 and TP5) than the adults (true only of TP3 and TP6). As for cranial anatomy, recent eastern Indonesian males resemble Golo/Tanjung Pinang in terms of including specimens with variably Indo-Malay and southwest Pacific affinities. The mandibular metrical cluster that includes Golo is more focused on eastern Indonesians than Melanesians. Finally, recent Javanese are also very similar to Golo in their limb bone proportions, which suggests that the same may be true of recent eastern Indonesians too.

The ubiquitous presence of betel-nut staining on the recorded, permanent anterior teeth from the Northern Moluccas indicates the cultivation of betel-nut palms by 2000 BP. The poor state of oral health shown by the Golo teeth and jaws indicates a high carbohydrate component in the local diet, which may well have involved sago, an important staple today across the Northern Moluccan lowlands (Monk et al. 1997:687–689). Even though the oral health shown by the Tanjung Pinang dental arcades is generally sound, they exhibit a moderate rate of dental wear similar to that recorded for Golo. This would be more consistent with a diet that includes a substantial component of agricultural produce and/or sago (which need not be cultivated even in places where it is a staple; Ellen 2011) than the tough, fibrous diet of most hunter-gatherers. In summary, the Northern Moluccan human remains would point to the presence of arboriculture in the region for the 2000 or so years that they cover.

The Northern Moluccan human remains show a susceptibility to chronic anaemia, and in this respect are similar to the Neolithic burials from Khok Phanom Di, Thailand, which date to c. 2000–1500 BCE. The five Northern Moluccan subadults represented by their orbital roofs all exhibit active *cribra orbitalia*, similar to the rate of 77 per cent recorded for Khok Phanom Di children aged between 1 and 14 years old at death (Tayles 1999:161). Two of the four Northern Moluccan adults represented by their orbital roofs exhibit *cribra orbitalia* scars, higher than the 5 per cent recorded at Khok Phanom Di (Tayles 1999:191). Unusually thick cranial bone was recorded for one of two TP subadults, three of nine TP adults, and one Uattamdi adult, while porotic hyperostosis was observed for the Golo extended burial, one of the TP subadults, two of the six TP adults, and one Uattamdi adult. Similarly, a cranial vault thickness in excess of 7 mm was recorded for one of 16 subadults and 37 of 44 adults from Khok Phanom Di, associated in at least one case with porotic hyperostosis (Tayles 1999:187, 220–221). Tayles (1999:278–280, 319–320) accepts that malaria was endemic at Khok Phanom Di, possibly associated with thalassaemia or a functionally similar genetic mutation that confers immunity in its heterozygous

expression but is severely debilitating in its homozygous expression. A similar inference would also apply to the Northern Moluccas, particularly in view of the prevalence of malaria recorded for the region during the nineteenth century.

Cranial deformation, as documented for the Golo extended burial, has been recorded for many Austronesian-speaking populations. However, the technique recorded for Sarawak, Sulawesi, the Philippines, Tahiti, and Hawai'i is fronto-occipital, rather than the circumferential deformation recorded for southern New Britain, the Solomons, and the Malekula of Vanuatu. On a broader scale, circumferential deformation occurred sporadically across Africa and Eurasia throughout the Holocene, and was also widespread across the tropical Americas after approximately 2000 BCE (Lindsell 1995). Accordingly, the circumferential deformation of the Golo cranium is suggestive of a link with Austronesian-speaking groups in Melanesia, although it may also be the result of an independently developed local custom.

Conclusions

The human remains from the Northern Moluccan excavations date from approximately 2000 years BP to the late second millennium CE. They register the practice of arboriculture throughout this period, notably *Areca catechu* (betel-nut) palms but probably also sago (to the degree it was cultivated rather than harvested 'wild'). Chronic anaemia afflicted a substantial proportion of the population, probably associated with endemic malaria. The biological affinities of the skeletal remains lie predominantly with southwest Pacific populations, although they cannot be clearly distinguished from recent eastern Indonesians in this regard. Living stature can be estimated for the 2000-year-old burial from Golo, Gebe, and at 163 cm it lies at the upper limit of the range of means recorded for recent eastern Indonesian males. The great majority of the burials are secondary, notably skull burials during the first millennium CE and secondarily buried cremations at around 1000 CE. The Golo individual, however, is distinct in being a primary inhumation, and also in displaying marked circumferential deformation, as recorded ethnographically for some Austronesian speakers in Melanesia.

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