Houghton, Philip, 1989. Watom: the people. *Records of the Australian Museum* 41(3): 223–233. [30 November 1989].

doi:10.3853/j.0067-1975.41.1989.144

ISSN 0067-1975

Published by the Australian Museum, Sydney

Records of the Australian Museum (1989) Vol. 41: 223–233. ISSN 0067 1975

Watom: the People

PHILIP HOUGHTON

Department of Anatomy, University of Otago
P.O. Box 913, Dunedin, New Zealand

ABSTRACT. The human material from the Reber-Rakival Lapita site on Watom Island has been analysed. Eight adults and a two year old child are defined in addition to scattered adult material. Mean age at death of the adults, comprising two females and six males, was about 30 years. Mean stature of three males was 1,784 mm, and that of a female was 1,659 mm. Long bones were moderately robust, and bowed to accommodate a considerable musculature. One substantially-complete mandible showed Polynesian 'rocker' characteristics, and it is probable that two adult mandibular fragments shared this morphology. Another substantially-complete mandible, though very robust, did not show this form. The morphology of this group displays the large-bodied characteristics of oceanic voyagers and small-island dwellers. Statistical analyses of mandibular and dental metric data support the morphological evidence of affinities with prehistoric Polynesians of rather later date.

HOUGHTON, P., 1989. Watom: the people. Records of the Australian Museum 41(3): 223–233.

Material

This paper discusses the human remains from locality SAC at Reber-Rakival on Watom Island.

The human remains were recovered from Rectangles I, III and IV, during two separate excavations, in 1966 and in 1985 (Specht, 1968; Green & Anson, 1987; see also Green, Anson & Specht. this volume). The 1966 excavation identified three individuals from Rectangle I. The 1985 excavation identified a further five individuals from Rectangles III and IV, and in addition recovered an amount of dispersed human bone from Rectangle IV. The material thus comprised the incomplete remains of eight individuals recognised at excavation, and mixed material from Rectangle IV that could neither be clearly assigned to any of the recognised individuals, nor ascribed to another single person. In addition, remains of another discrete individual from Rectangle I were identified in the laboratory.

In general the remains are incomplete and broken, and the bone, having been exposed to the fluctuations of tidal sea water through the soil, is poorly preserved.

Methods

Ageing was done by standard biological criteria of maturation or degeneration. However, the very scanty skeletal representation means that for most individuals the age estimate is only an informed guess. The bone was unsuitable for histological methods of ageing. Sexing was based on pelvic morphology wherever possible, and was supplemented by citrate analysis (Dennison, 1979), which allowed sexing of all adults. Stature was assessed from overall lengths of long bones, or segments of bone. Two sets of estimates were made, using the formulae of Trotter (1970) derived for white Americans, and those of Houghton *et al.* (1975) for Polynesians. Standard metric data were obtained from long bones and mandibles, and the occurrence of certain morphological characters was noted. Shape and size of teeth were recorded. Cortical thicknesses of second metacarpals were assessed from radiographs. All material was examined for evidence of bony or dental pathology. Multivariate statistics (Penrose Size and Shape) were applied to mandible and tooth data to investigate possible biological relationships of the group.

Findings

Individual findings are detailed in the census, Appendix A.

Age. The estimates are set out in Table 1, together with the method used. With the exception of the young child, all were adults, with an average age at death probably a little over 30 years.

Table 1. Age of Watom individuals, and criteria used in assessment.

Individual	Age (years)	Criteria
1	mature adult	full epiphyseal union
2	20	left fifth metacarpal shows a fusing epiphysis
3	25-30	rounded tooth roots, minimal joint degeneration
4	30+	degeneration of lumbar vertebrae
5	30+	slight lipping of vertebral bodies, and costo-chondral junction
6	mature adult	full epiphyseal union
7	25+	mature bone
8	25+	vertebral lipping
child	2	length of tibial diaphysis

Sex. Table 2 gives the sex of the individuals and the gross morphology used to establish this. Citrate assay supported the gross assessments. There were two women and six men in the group.

Table 2. Sex of Watom individuals, and morphological criteria; all estimates were supported by citrate analysis (Dennison, 1979).

Individual	sex	morphological criteria
1	female	pelvis
2	female	nil
3	male	pelvis
4	male	pelvis
5	male	pelvis
6	male	general size and morphology
7	male	nil
8	male	nil

Skeletal morphology and measurements. *(a) Crania.* An attempt was made to reconstruct the cranial fragments of individual 3 but postmortem distortion rendered this impossible. The only data obtained were the median sagittal arcs for frontal (106 mm), parietal (107 mm) and occipital (88 mm) bones.

(b) Mandibles. For individuals 3 and 6 fairly complete reconstruction of the mandible was achieved. Two further incomplete bones were recovered from the scattered Rectangle IV material. The bones were robust, with strong basal portions and particularly for individual 6 a very broad and high ramus. The mandible of individual 3 (Fig.1) was of an unequivocal rocker form, the two incomplete bones were probably of this form (Fig.2), while the mandible of individual 6 (Fig. 3) was not of the rocker form. Standard metric data on the two more complete bones are set out in Table 3.

(c) Infracranial skeleton. Few bones were intact and observations were limited. The long bones generally were

Fig.1. Reconstructed mandible of individual 3.

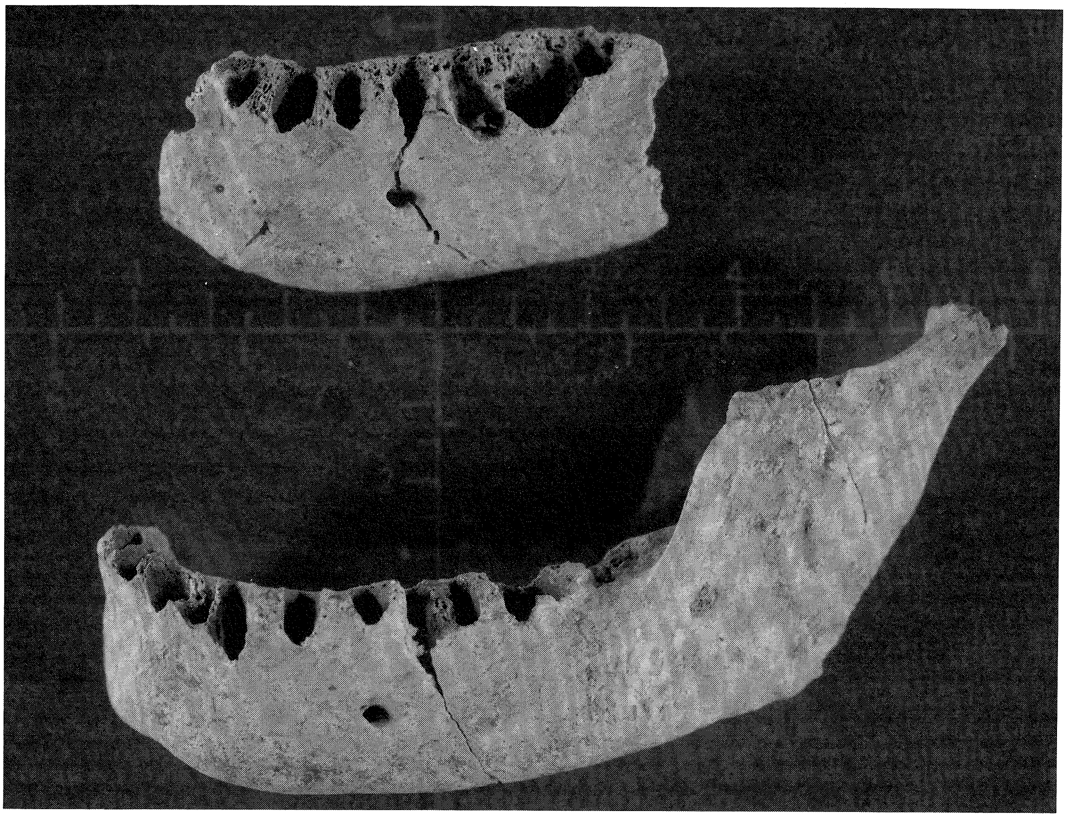

Fig.2. Two mandibular fragments from Rectangle IV. It is probable that both were of 'rocker' morphology.

Fig.3. Reconstructed mandible of individual 6.

robust, and bowed to accommodate a considerable musculature. Metric data are in Appendix A.

Stature was estimated from the lengths of long bones . Table 4 gives stature in millimetres of the four assessable individuals using both white American equations (Trotter, 1970) and Polynesian equations (Houghton *et al.*, 1975). The Polynesian equations gave the female a stature of 1659 mm and a mean for the males of about 1784 mm. The white American equations gave a stature of 1,720 mm for the female and a mean of 1,750 mm for the three males. This lesser mean still marks them as a tall group. However, the much tighter range of estimates from the three arm bones of individual 6 using the Polynesian equations suggest that these more accurately mirror the body proportions of the individual, and thus are more appropriate for stature estimate. A similar pattern is suggested with the other

Table 3. Mandibular measurements in millimetres of individuals 3 and 6; definitions follow Morant (1936).

Individual	3	6
bicondylar breadth	141	120
bigonial breadth	109	98
condylar length	–	24
ramal breadth	43	45
ramal height	60	72
symphyseal height	35	31
body height	33	29
body length	106	100
mandibular angle	112	95

individuals, where the radius of individual 2 gives a higher stature estimate with the white American equation than with the Polynesian; and the humerus of individual 5 gives a higher estimate with the Polynesian equation.

Two male second metacarpals were X-rayed for cortical structure. These gave standardised thicknesses (Nordin's score; Barnett & Nordin, 1961) of 52.5 and 51.0.

Dentition. The material was limited to the near-complete dentitions of individuals 3 and 6, and two isolated teeth.

(a) morphology. The recorded features are set out in Table 5, together with dental pathology.

(b) metric data for individuals 3 and 6 are given in Table 6.

Pathology. *(a) Skeletal.* Two lesions were identified. (i) A lesion was present in the upper shaft of the left femur of individual 6 (Fig.4). The appearance of this suggests a periostitis, a localised and essentially superficial bone infection secondary to an overlying soft tissue lesion. Radiology supports this diagnosis, showing minimal involvement of the deeper cortex and no encroachment on the medullary cavity. Neither in appearance nor site does this lesion suggest yaws.

(ii) A proximal hand phalanx from individual 3 showed expansion of the proximal end and pathological antero-posterior bowing of the whole shaft (Fig.5). Radiology showed a rather thin structure to the proximal expansion, but some thickening of the involved distal cortex. The general appearance is suggestive of a chronic granulomatous infection, of which yaws is a possibility.

(b) Dental (Table 5). Pathology here was limited to a moderate degree of alveolar erosion in individual 3 and a rather lesser degree in individual 6. The assumption is that the overlying pathology was periodontal disease. There was no enamel hypoplasia, caries, advanced attrition, or staining suggestive of betel chewing.

Distance analyses. Penrose Size and Shape statistic was applied to mandibular metric data, utilising five and seven dimensions and comparative data from other

Table 4. Stature in millimetres, derived from White American equations (Trotter, 1970) and Polynesian equations (Houghton *et al.*, 1975). Long bone lengths are given; see text for further comment.

Individual	White American	Polynesian	Bone length
2 (female)	1720	1659	right radius 247
3 (male)	1750	1798	right femur 477 (est)
5 (male)	1720	1753	left humerus 331
	1715	1767	right fibula 372(est)
6 (male)	1780	1800	left humerus 350
	1860	1809	left ulna 307
	1875	1805	both radii 285
Male mean	1750	1784	

Table 5. Dental morphology and pathology.

Individual		3	6
shovel-shaped	I1	nil	nil
incisors	I2	nil	trace
maxillary molar	M1	D4	D4
crown morphology	M2	D4	D4-
	M3	?	D3
Carabelli cusp		nil	nil
mandibular molar	M1	?5	?4
crown morphology	M2	+5	+4
	M3	+4	+5
protostylid		nil	nil
third molars	All erupted in both individuals, but 28 and 38 hypoplastic in Individual 3.		
calculus		slight	slight
alveolar erosion		moderate	slight
caries		nil	nil
enamel hypoplasia		nil	nil

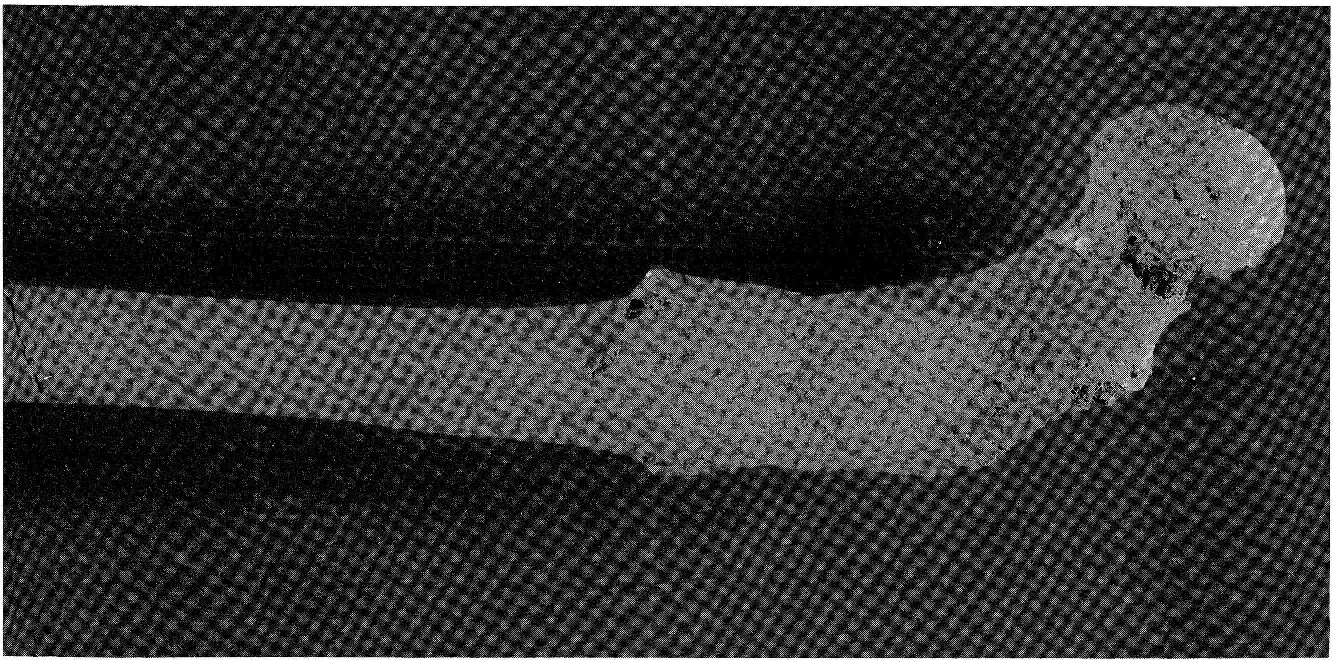

Fig.4. Proximal end of left femur, The thickening of the upper shaft is superficial and probably secondary to overlying soft-tissue infection.

Table 6. Watom tooth dimensions in millimetres; the FDI classification is used.

Maxillary								
Individual	Quadrant 1							
	11	12	13	14	15	16	17	18
	length							
3	9.5	8.1	8.8	8.0	7.3	11.6	11.4	
6	9.1	7.2	8.0	6.4	6.2	10.0		8.2
	breadth							
3	7.8	7.2	8.8	10.1	9.2	12.1	12.6	
6	7.8	6.4	8.5	9.9	9.9	12.2		11.3
	Quadrant 2							
	21	22	23	24	25	26	27	28
	length							
6	9.0	7.2	7.9	6.5	6.0	10.0	9.5	8.0
	breadth							
6	7.4	6.7	8.5	10.0	9.9	12.2	12.0	10.7
Mandibular								
Individual	Quadrant 3							
	31	32	33	34	35	36	37	38
	length							
3	5.8				8.5	12.5	12.5	12.2
6	5.2	6.2	6.7	6.5	6.7	10.7	10.5	11.3
	breadth							
3	6.0				9.7	11.8	11.9	10.7
6	5.7	6.1	8.2	7.8	8.0	10.5	10.0	9.9
	Quadrant 4							
	41	42	43	44	45	46	47	48
	length							
3			6.4	7.8	8.9	12.7	13.0	12.2
6	5.3	6.2	6.8	6.2	6.5	10.7	10.3	11.0
	breadth							
3			8.0	8.5	9.2	11.8	11.0	10.0
6	5.7	6.2	8.0	7.9	8.0	10.3	10.0	9.8

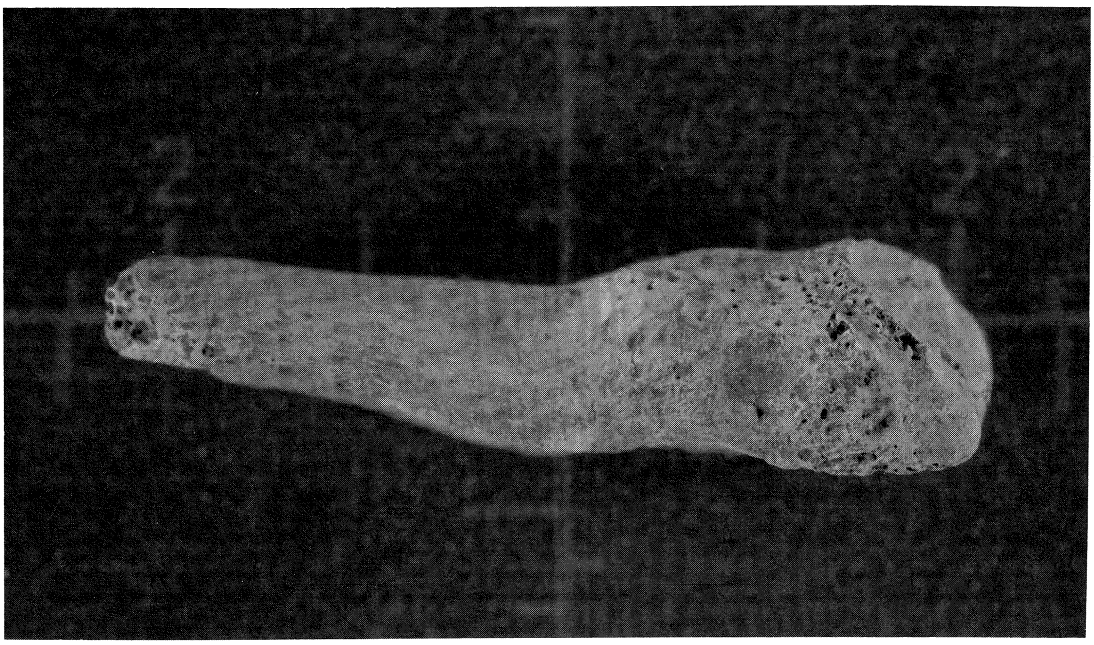

Fig.5. Proximal hand phalanx of individual 3 showing a chronic granulomatous reaction with expansion of the proximal end and ventral bowing of the shaft.

populations. The results are set out in Tables 7 and 8, and graphically for the five-dimensional analysis in Fig.6.

Table 7. Penrose analysis on seven mandibular measurements.

Group	Size	Shape	C.R.L
Watom	0.00	0.00	0.00
New Zealand	0.02	1.68	1.70
Hawaii	0.00	1.93	1.93
Namu	0.19	1.76	1.95
Tonga	0.04	2.13	2.17
Africa	0.53	3.50	4.03
Sarawak	0.61	4.14	4.75

Table 8. Penrose analysis on five mandibular measurements

Group	Size	Shape	C.R.L.
Watom	0.00	0.00	0.00
New Zealand	0.20	1.12	1.32
Hawaii	0.55	0.82	1.37
Tonga	0.96	0.62	1.58
Namu	1.22	0.87	2.09
New Britain	1.23	0.87	2.10
Vanuatu	2.34	0.79	3.12
Africa	2.93	1.28	4.20
Nebira	3.31	0.93	4.24
Sarawak	3.68	0.79	4.47

A similar analysis was carried out on the dentition. These results are given in Table 9 and Fig.7.

Discussion

Health and biological affinities are discussed.

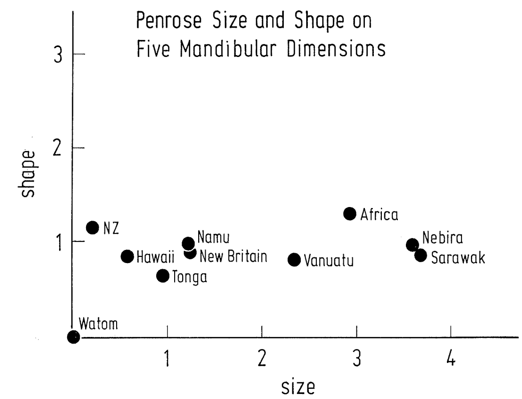

Fig.6. Penrose Size and Shape analysis on five mandibular dimensions from Watom Individuals 3 and 6. The comparative groups are described in Appendix B. HPNG = Highland Papua New Guinea.

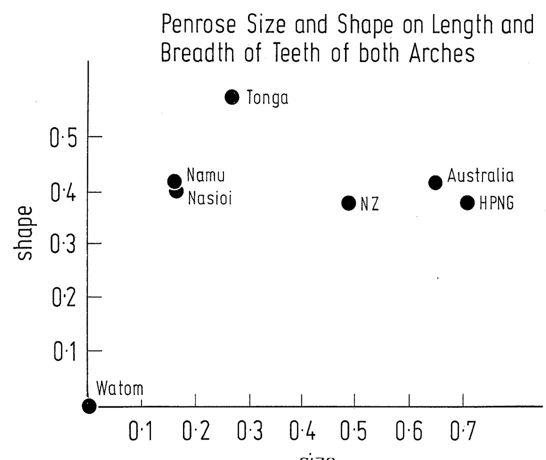

Fig.7. Penrose Size and Shape analysis on tooth dimensions of individuals 3 and 6. The comparative groups are described in Appendix C. HPNG = Highland Papua New Guinea. NZ = New Zealand.

Table 9. Penrose analysis of tooth dimensions.

Group	Size	Shape	C.R.L.
Watom	0.00	0.00	0.00
Nasioi	0.16	0.40	0.56
Namu	0.15	0.42	0.57
Tonga	0.27	0.58	0.85
Maori	0.49	0.38	0.87
Australian	0.65	0.42	1.07
PNG	0.71	0.38	1.09

Health. The mean age at death of the adults is unremarkable for prehistory and with the unreliability inherent in this small and fragmented series allows no conclusions to be drawn. The stature data indicate not only a genetic potential for tallness (see below), but also a reasonable diet and general environment during the growth period. The rather low Nordin's score on two individuals does suggest that stature was achieved somewhat at the expense of bone robusticity and that at times during the growth period there might have been some dietary inadequacy. Recent well-nourished groups give a Nordin's score in the 57–63 range; prehistoric Namu is 57 and prehistoric New Zealand 53 (Houghton, 1980). The teeth show no transverse lines or other enamel hypoplasia. The general conclusion is that these people lived in a fairly favourable environment. It is possible that yaws existed amongst them.

Biological affinities. In view of the significance of Lapita ware in current theories of Pacific settlement and Polynesian origins, preliminary comment is necessary on the model used here regarding human relationships within the Pacific, and the settlement of Polynesia. In tersest form the model states that the dominant settlement of Polynesia was from Island Melanesia, by a group that was part of the human population of that geographic region; that is, they were not in transit through Melanesia from more distant parts. This model was originally adopted as appearing biologically valid and being the most parsimonious of the possibilities. Polynesians, considering their wide geographic distribution, show a remarkable biological homogeneity (Houghton, 1980). This homogeneity strongly suggests origin from a rather small founding group. Melanesians, by contrast, in terms of both body morphology and the numerous tissue polymorphisms that now are measurable, show great biological diversity. Indeed the term melanesian is a geographical statement, being someone living within Melanesia; it cannot be a fairly closely-defined biological statement as can the term 'Polynesian'. To settle Polynesia with a group evolved from one of the varied populations of Island Melanesia makes the simplest plausible thesis, requiring least voyaging (though the distances are formidable enough) and no long transits through (purportedly) genetically alien territory. Recently this model has been supported by two very different forms of analysis. Firstly, gene mapping is now starting to reveal some unique relationships between human groups in Melanesia and Polynesia (e.g. Hill *et al.*, 1985, 1987; Trent *et al.*, 1985). Secondly, the distinctive Polynesian morphology has been demonstrated to be a crucial selective adaptation to the particular conditions of the oceanic environment, and an inappropriate form for the environment further west (Houghton, in press). The latter study demontrates that the Polynesian body form evolved within the Pacific.

This model may be contrasted with the lingering view that "...as physical human beings, the Polynesians simply could not have emerged from any eastern Melanesian population; they are just too different genetically. Skulls and the living agree" (Howells, 1973: 234). The gene mapping results dispose of this argument *vis-a-vis* the living. Regarding skulls, much craniological data used in distance studies has been obtained from museum collections of indeterminate temporal provenance, but in general dating to late prehistory or the protohistoric period. Yet the time dimension is actually crucial, and it simply is not valid to compare data from ill-defined collections of recent crania from widely separated parts of the Pacific and its rim, and claim biological significance for the results. Indeed, in these studies biological justification for the measurements used is usually entirely lacking. On the statistical side, very small samples and incomplete matrices often violate the premises on which multivariate statistical theory rests. For valid comparison, adequate samples from well excavated and dated sites from prehistory are needed. Fortunately these are starting to emerge; e.g. Davidson & Leach (in preparation), Best (1987). In the meantime, the comparative groups used here fall far short of the ideal, but in Appendices B and C they are described, and their selection and the measures used are justified as far as possible. There may be other suitable comparative groups of which I am unaware.

The model used here is examinable against data from relevant groups. It is desirable to have a model, for the inexorable (and often contradictory) outpourings of data and dendrograms that emerge from the fusion of craniometric data, multivariate statistics and computer power, have the potential to illustrate inductive method at its worst.

Comment is also necessary on the statistics, here confined to the use of Penrose's Size and Shape, a refinement of Pearson's original Coefficient of Racial Likeness (CRL). The CRL has had a bad press, and regularly is dismissed as inadequate because it does not allow for correlation between variables. For that reason, the Mahalanobis D^2 has swept the field. Yet the concept of functionally-significant uncorrelated variables within a biological structure is a difficult one, which its proponents need to explain. Anyway, the use of CRL or one of its derivatives receives support from a statistician:

> D^2 differs fundamentally from the other two distance measures because it eliminates redundant variables and the others do not....Both DD and CRL increase when adding a variate that is completely correlated with those already included, but D^2 remains unaltered. Now it seems to me that the human mind distinguishes between different groups or populations *because* there are correlated characteristics within the postulated groups.

To quantify this idea, some measure of distance such as DD or CRL is necessary; D^2 will not do, because of the way it eliminates correlations. When populations have been established, D^2 becomes useful and is essential when building up discriminant functions. These two aspects of distance must be distinguished and carefully considered.....(Gower, 1972).

In turn, it seems to me that this has been one of the problems in using osteometric data in distance studies. Groups from different sites or regions have been considered to be biologically distinct, whereas the first statement can only be that they are geographically distinct. For initial analysis, CRL or its Penrose elaboration seems most appropriate. It is also my feeling that progress in this difficult field depends on a deeper analysis of the biology of the particular situation, rather than increasing refinement of statistical method. Statistical analyses properly belong as addenda to quite complex biological considerations. The biological validity of the data are all-important, and no amount of manipulation of irrelevant data will produce anything of worth (see Rhoads (1984) for more on this theme).

With that background, and in the light of the biological model set out above, comment is possible on the results. The large body build dominates the findings. While the limitations of the sample must be continually born in mind, the mean male stature of 1784 mm is exceptionally tall for a prehistoric group, and the female also is tall. The tallest individual has rather gracile infra-cranial bones relative to the others, but all show bony evidence of a well-developed musculature. This large body phenotype, inappropriate to the land-dominated tropical environment to the west, places the Watom people firmly with other large-bodied ocean voyagers and small-island dwellers, whose most evident living representatives are the Polynesians.

The mandibular analysis using five dimensions (which each express some major structural and functional component) gives closest relationship with two eastern Polynesian groups, then Tonga, and Namu. The dental analysis places Namu practically as close as the recent Melanesian Nasioi, with Tonga and New Zealand a little further away. Care is particularly needed in interpreting these dental data, or indeed any craniofacial data, for they are profoundly influenced by total body form and environment (Houghton & Kean, 1987). The changing biomechanics of the mandible with changing body size contributes to a negative allometric relationship with the dentition; that is, teeth get relatively smaller with increase in overall body size. Thus, although individuals may show teeth of rather similar dimensions it does not follow that close biological affinities are indicated; similarity in size between teeth of large and small-bodied individuals may reside not in some specific and autonomous genetic control of tooth size common to both groups, but may be a metric coincidence reached through different influences. With these caveats, it may be said that together, these analyses support the thesis of affinities both with groups now regarded as Polynesian or having Polynesian associations (Namu), and with recent Island Melanesian groups.

The chord measurements obtained from the vault bones of individual 6 merit comment. It is known that the proportions of the three major vault bones differ between different parts of Oceania; for example Polynesians tend to have a rather long frontal bone whereas some groups from New Guinea show an opposing tendency (Wagner, 1937). The biological basis of these differences is still uncertain. It may relate to underlying cranial base morphology. More probably it simply reflects overall head length, the parietal bone contribution dominating as the vault elongates. The Watom fronto-parietal index of 100.00 falls between the recent Polynesian values of around 96–97, and recent values from Island Melanesia of around 105–106. The parieto-occipital index of 82.2 is very low, and may contain some element of distortion of the bones. The Polynesia value for this ratio usually lies in the 93–94 region, and those from geographic Melanesia in the high eighties. However, the only values lower than 82 recorded by Wagner (1937) are in two small series from Fiji and Vanuatu, suggesting an eastern Melanesia/western Polynesia affinity. But despite the space spent on these cranial dimensions it should be appreciated that the weightier conclusions derive from the stature data, and the mandibular and dental analyses.

My conclusion is that the morphology of the Watom people is fully compatible with that to be expected, on biological grounds, of oceanic voyagers and small-island dwellers, and thus of the earliest settlers of western Polynesia. While synthesis of biological and cultural (and linguistic) findings must always proceed with great caution, claims that the Polynesians derive from the creators of the Lapita culture of the western Pacific are supported by this analysis of the human material from the Reber-Rakival site. From this body form, within Polynesia successive episodes of genetic drift would readily have allowed the more extreme eastern Polynesian morphology to be derived. This body form of course remained totally appropriate to the oceanic environment.

References

Anderson, A.J., 1978. Archaeological explorations on 'Ata Island, Tonga. Bulletin of the Royal Society of New Zealand 17: 1–21.

Bailit, H.L., S.J. De Witt & R.A.Leigh, 1968. The size and morphology of the Nasioi dentition. American Journal of Physical Anthropology 28: 271–288.

Barnett, E. & B.E.C. Nordin, 1961. The radiological diagnosis of osteoporosis: a new approach. Clinical Radiology 11: 166–174.

Barrett, M.J., T. Brown & M.R. Macdonald, 1963. Dental observations on Australian aborigines: mesiodistal crown diameters of permanent teeth. Australian Dental Journal 8: 150–155.

Barrett, M.J., T. Brown, G. Arato & I.V. Ozols, 1964. Dental observations of Australian aborigines: buccolingual crown diameters of deciduous and permanent teeth. Australian Dental Journal 9: 280–285.

Best, S., 1987. Sigatoka dune burials (Site VL 16/1). Unpublished preliminary report.

Bulmer, S., 1979. Prehistoric ecology and economy in the Port Moresby region. New Zealand Journal of

Archaeology 1: 5–27.
Davidson, J., 1969. Archaeological excavations in two burial mounds at 'Atele, Tongatapu. Records of the Auckland Institute and Museum 6: 251–286.
Davidson, J. & B.F. Leach, in preparation. Excavations on Taumako, Solomon Islands.
Dennison, K.J., 1979. Citrate estimation as a means of determining the sex of human skeletal material. Archaeology and Physical Anthropology in Oceania 14: 136–143.
de Villiers, H., 1968. The skull of the South African negro. Witwatersrand University Press, Johannesberg. xvii + 342 pp.
Doran, G.A. & L. Freedman, 1974. Metrical features of the dentition and arches of populations from Goroka and Lufa, Papua New Guinea. Human Biology 46: 583–594.
Gower, J.C., 1972. Measures of taxonomic distance and their analysis. pp. 1–24. **In** (J.S. Weiner & J. Huizinga, eds). The Assessment of Population Affinities in Man. Clarendon Press, Oxford.
Green, R.C. & D. Anson, 1987. The Lapita site of Watom: new evidence from excavations in 1985. Man and Culture in Oceania 3 (special issue): 121–132.
Hill, A.V.S., D.K. Bowden, R.J. Trent, D.R. Higgs, S.J. Oppenheimer, S.H. Thein, K.N. Mickleson, D.J. Weatherall & J.B. Clegg, 1985. Melanesians and Polynesians share a unique alpha-thalassemia mutation. American Journal of Human Genetics 37: 571–580.
Hill, A.V.S., B. Gentile, M. Bonnardot, J.Roux, D.J. Weatherall & J.B.Clegg, 1987. Polynesian origins and affinities: globin gene variants in eastern Polynesia. American Journal of Human Genetics 40: 453–463.
Houghton, P., 1980. The First New Zealanders. Hodder and Stoughton, Auckland. 156 pp.
Houghton, P., in press. The adaptive significance of Polynesian body form. Annals of Human Biology.
Houghton, P., The People of Namu. Unpublished report.
Houghton, P., B.F. Leach & D.G. Sutton, 1975. The estimation of stature of prehistoric Polynesians in New Zealand. Journal of the Polynesian Society 84: 325–326.
Houghton, P. & M.R. Kean, 1987. The Polynesian head: a biological model for *Homo sapiens*. Journal of the Polynesian Society 96: 223–242.
Howells, W.W., 1973. The Pacific Islanders. Charles Scribner's Sons, New York. xvi + 299 pp.
Hughes, D.R., 1963. A study of a series of mandibles from the Mulu cave, Sarawak. Journal of the Royal Anthropological Institute 93: 235–240.
Morant, G.M., 1936. A biometric study of the human mandible. Biometrika 28: 84–122.
Rhoads, J.G., 1984. Improving the sensitivity, specificity, and appositeness of morphometric analyses. pp. 247–259. **In** (G.N. van Vark & W.W. Howells, eds). Multivariate Statistical Methods in Physical Anthropology. Reidel, Dordrecht.
Snow, C.E., 1974. Early Hawaiians. The University Press of Kentucky, Lexington. 179 pp.
Specht, J., 1968. Preliminary report of excavations on Watom Island. Journal of the Polynesian Society 77: 117–134.
Trent, R.J., K.N.P. Mickleson, T. Wilkinson, J. Yakas, R. Black, M. Dixon, A.W. Liley & H. Kronenberg, 1985. Alpha globin gene rearrangements in Polynesians are not associated with malaria. American Journal of Hematology 18: 431–433.
Trotter, M., 1970. Estimation of stature from intact long bones. pp. 71–83. **In** (T.D.Stewart, ed.). Personal Identification in Mass Disasters. Smithsonian Institution, Washington D.C..
Wagner, K., 1937. The craniology of the Oceanic races. Skrifter utgitt av Det Norske Videnskaps-Akademi i Oslo, Oslo. 193 pp.

Accepted August 14, 1989

Appendix A. Census

Individual 1.
Age: mature adult
Sex: female
Material: scanty and fragmented. No skull. A solitary left maxillary canine, but this cannot be assigned to the person with certainty. Fragments of most upper limb bones. Atlas and axis, and bodies of three other cervical vertebrae; fragments of lower vertebrae. Pelvic fragments and upper 60% of right femur. Several foot bones, especially tarsals.

Individual 2.
Age: mature adult
Sex: female
Material: no skull or teeth. An almost intact right radius, lacking only the styloid process (estimated maximum length 247 mm); otherwise material is limited to fragments of forearm bones, tibiae and femora, and a few pieces of vertebrae.
Comment: When estimating stature, 10 mm was added to the measured length of right radius to allow for the missing styloid process.

Individual 3.
Age: 25–30 years
Sex: male
Material: crushed and distorted cranium. Largely intact (reconstructed) mandible. Nineteen teeth present. Some scapula and humeral fragments. Three intact cervical vertebrae and fragments of lower vertebrae. Pelvic fragments. Right femur missing only upper end (estimated maximum length 477 mm), and shaft fragments of all other major leg bones. Some foot bones.
Pathology: there is moderate erosion of the alveolar bone of both jaws. A proximal hand phalanx shows involvement by some chronic granulomatous condition, with expansion of the proximal end and general bending of the shaft; the gross and X-ray appearance is compatible with but not diagnostic of yaws.
Comment: I retain a residual suspicion that this individual could be female. This is based on the rather equivocal pre-auricular grooves of the pelvis, and on the small cranial measurements. If female, she is particularly tall and robust, and the general comments on stature for the group are reinforced. Nordin's score for the second metacarpal is 52.5.

Individual 4.
Age: 30+ years
Sex: male
Material: there are fragments of vertebrae, clavicle,

humerus, pelvis, femur, and a few hand and foot bones. Overall representation is minimal. An upper left third molar cannot with certainty be assigned to this person. In addition there are upper limb fragments of a more gracile individual, probably female.

Individual 5.
Age: 30+ years
Sex: male
Material: complete left humerus of maximum length 331mm; shaft of right humerus; left clavicular fragment; scanty fragments of all vertebral regions; pelvic fragments; almost intact right fibula, of estimated maximum length 372mm; some hand and foot bones.

Individual 6.
Age: mature adult
Sex: male
Material: skull, malars and supraorbital margin, substantial left temporo-parietal fragment, and many lesser pieces; largely complete (reconstructed) mandible; complete dentition except for right maxillary second molar; intact left humerus (350 mm), left ulna (307 mm) and both radii (both 285 mm), with fragmentary representation of all other upper limb bones. Radio-humeral ratio of 0.81. Hip fragments, and largely complete femora and tibiae, though insufficient for stature estimates. Some fibula fragments, and foot bones.
Pathology: there is a lesion of the upper shaft of the left femur, probably a periostitis secondary to overlying soft tissue infection; this is not typical of yaws, though this aetiology cannot be excluded.
Comment: despite (or because of) the stature, the long bones of this individual are rather gracile. The Nordin's score of 51 is rather low in comparison with contemporary well-nourished groups who have values above 57.

Individual 7.
Age: mature adult
Sex: male
Material: this is minimal; a right femoral shaft, otherwise wide but very scanty and fragmented skeletal representation.

Individual 8.
Age: 25+ years
Sex: male
Material: minimal, the main representation being shaft fragments of both tibiae and fibulae, and many foot bones.
Comment: although close to individual 1 excavated in 1965, these are clearly different people.

Child.
Age: two years.
Material: cranial fragments; an incisor that cannot certainly be assigned to this individual; shaft fragments of all upper limb long bones; rib fragments; complete left tibial diaphysis (155 mm) and left femoral diaphysis, with some epiphyseal fragments of the latter.
Comment: this individual was contained under 'miscellaneous bones' and seems not to have been identified at excavation. It may not belong to SAC locality (see Green, Anson & Specht, this volume).

Rectangle IV material.
A small and chaotic amount of largely adult material that I can neither fit with the discrete individuals nor sensibly relate within the rectangle. Fragments of two adult mandibles are present.

Appendix B. The mandibular comparative material.

(i) Measurements. The definitions are those of the Biometric School (Morant, 1936). The seven used here I consider to express some basic functional parameters. The bicondylar width gives a guide to the width of the cranial base, a fundamental skull template. The bigonial width contains some of the same information and also an indication of lower facial width. Ramal breadth particularly relates to the degree of development of the masticatory muscles, while ramal height gives an idea of the height of the nasal airway (and thus overall body size) and is also influenced by cranial base angle, another fundamental base parameter. Mandibular angle contains much the same elements of information as ramal height. Mandibular length gives an idea of the overall anterior projection of the facial skeleton. Symphyseal height gives an indication of the height of the basal component of the bone anteriorly (the alveolar contribution is fairly constant between groups) and this in turn is related to the pattern of growth of the bone, with relationships to such measurements as mandibular angle and ramal height.

(ii) Comparative series. Included here is comment on the environment of the group (which strongly influences phenotype) and the justification for using the group in the analysis.

Namu. A series of 13 drawn from material excavated by B.F. Leach and J. Davidson in 1977 on Taumako, a Polynesian outlier of the southern Solomons. The material is dated to about A.D.1200–1400. Although this group suffered severely from yaws, nutrition was good during their developmental years, with development of a robust body form (Houghton, unpublished report). The series was used as an example of an eastern Melanesian (in geographic terms) morphology.

Hawaii. A series of 125 (Snow, 1974) from Mokapu, probably dating to the late prehistoric. Included as an example of eastern Polynesian morphology.

Nebira. A series of 10 individuals from a lowland New Guinea site, some 20 km inland from Port Moresby, dated to about A.D.1500 (Bulmer, 1979). These are small, gracile people who were almost certainly existing in a region of endemic malaria. Their mandibular phenotype will have been influenced by this poor environment. Included to represent a New Guinea group from prehistory. Adequate representation by one group of course is unrealistic, and the environmental conditions make it a poor example; but I could find no other discrete group. The placing of this group in the analysis is probably most uncertain.

New Zealand. Unpublished data from 126 individuals, measured by the author. The material is drawn from the whole country, and largely belongs to the late prehistoric – say A.D.1600–1800. The limited gene pool that seems to be represented in the New Zealand skeletal phenotype justifies the use of a group with fairly wide geographic spread. In general, nutrition was fairly good for these people. Like Hawaii, the group was chosen to represent eastern Polynesian morphology, with the hope that the analysis would place the two groups fairly close together.

Tonga. Data on 16 individuals, largely from material excavated at 'Atele (Davidson, 1969), and dated to about A.D.1200. These were generally robust, healthy people. Used as an example of western Polynesian morphology from prehistory.

Sarawak. These data are on a series of 12 from Mulu cave (Hughes, 1963). Their date in prehistory is uncertain, but the series was used to provide some representation from that region. There is no information on the health of the group.

Africa. These data are from a recent series of 488 individuals from South Africa (de Villiers, 1968), and were introduced to test the ability of the statistical method to distinguish such an exotic group. There is no information on the health of the group.

Appendix C. The dental comparative material.

Namu. See under Appendix A. The dental data are from 70 individuals, measured by the author.

New Zealand. See under Appendix A. The dental data are on 30 individuals.

Tonga. A very small series of four individuals from the late prehistoric period (Anderson, 1978). Bone robusticity suggests that nutrition and environment were good. Unpublished data by the author.

Highland Papua New Guinea. Data obtained from casts on a series of 32 contemporary males from Goroka in the eastern Highlands region (Doran & Freedman, 1974). I have no information on nutrition and environment, although the authors comment that the group were 'in close contact with urbanization'. The group was used to provide comparative data from the region, but the contemporary nature of the material is a disadvantage.

Nasioi. Contemporary data from casts of 60 individuals of the Nasioi people on Bougainville (Bailit *et al*. 1968). Nutritional and environmental status unknown. Again, the dating is a disadvantage.

Australian. Data from casts of 41 individuals of the Wailbri (Walpiri) tribe, living 'under settlement conditions' at Yuendumu, South Australia (Barrett *et al*. 1963, 1964). Casts taken between 1950 and 1960. Environment and nutrition unstated but probably not very good. This group was introduced to provide a recognised extreme in size of dentition.