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A Lapita-associated Skeleton from Natunuku, Fiji

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ABSTRACT. The fragmentary and generally poorly preserved remains of an approximately 3,000 year old skeleton found in association with Lapita cultural material at Natunuku, Fiji, are described. The skeleton, represented by diaphyseal fragments of the major limb bones, fragments of skull and other parts of the skeleton, isolated teeth and a partially edentulous mandible fragment, is that of an elderly (50 year old) male. The mandible is the best preserved bone in these remains. Stature is estimated to be 172 cm. The limb skeleton suggests that the individual is of moderately robust dimensions. Only minimal expressions of osteoarthritis are observed in these remains but opportunities for observations are limited. The teeth exhibit considerable wear and caries are present. The cause of death cannot be determined. There is no evidence that any of the human remains were burned or charred. Univariate comparisons of morphological details of the skeleton and associated teeth suggest Polynesian similarities such as tall stature, limb robusticity, small tooth crown diameters, and partial rocker jaw. Other aspects of skeletal morphology, limb proportions and the shapes of the leg bones, however, suggest Melanesian affinities. Multivariate analyses of mandibular measurements further suggest Melanesian affinities while similar analyses of a limited number of non-metric traits suggest Polynesian relationships. Until much larger and more representative samples of Lapita-associated skeletons become available, the biological origins of Polynesians, using the human palaeontological record from the Pacific, remains obscure.

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Contents

In 1967, Elizabeth Shaw (1967, 1975) excavated a single human skeleton at Natunuku VL1/1, a coastal site located between the villages of Ba and Tavua on the northwest coast of Viti Levu of the Fiji Islands (Fig. 1). Cultural material in the form of potsherds and shells are scattered throughout the site's six levels. The upper four contain material of several origins while the bottom two layers, Levels 5 and 6, have material restricted to the Lapita cultural complex (Green, 1979:33). The skeleton lay undisturbed in a crouched position in a shallow grave in Layer 5, its skull facing north. The earliest levels of the site and the skeletal remains have been dated to 1,590 ± 100 B.C. or 3,240 ± 100 years B.P. (Shaw, 1967 and personal communication, 1984). Green (personal communication, 1989) however, believes that the Natunuku burial, while early in the Fijian Lapita sequence, is probably not as early as the 1,500 B.C. date often assigned to it. Spriggs (personal communication, 1988) has further suggested, based on pottery style, that the Natunuku site is more likely to date to 1,000 B.C. rather than 1,500 B.C. Despite these reservations, the Natunuku skeleton is the earliest Lapita-associated skeleton thus far described. A complete archaeological report on the

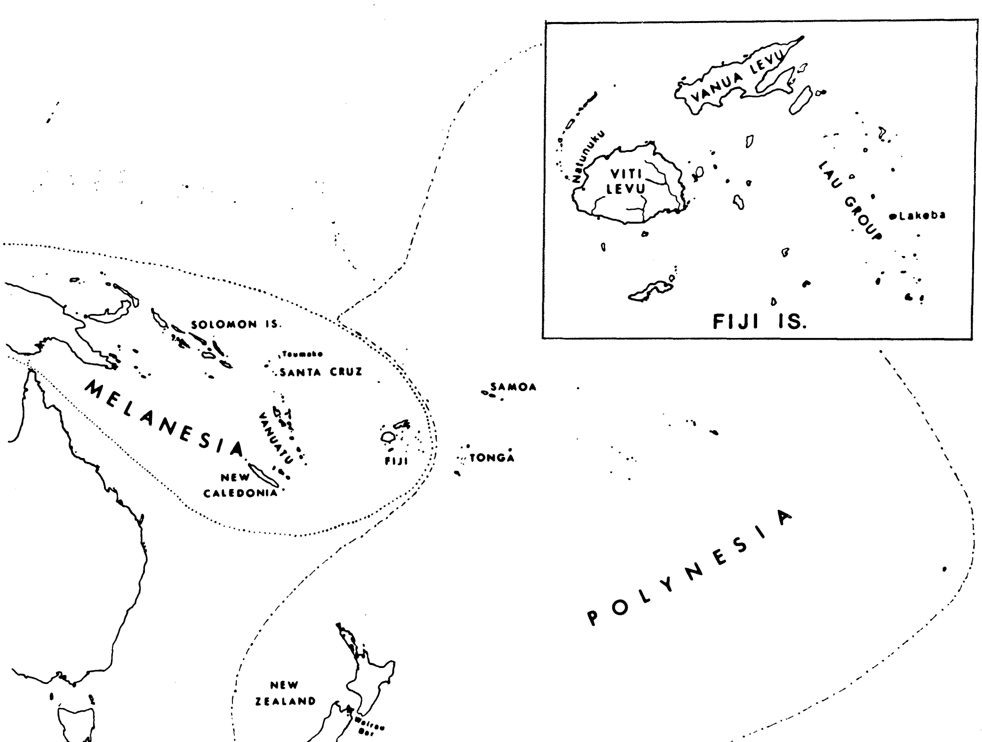

Fig.1. Map showing the location of the Natunuku site and several of the comparative samples.

Natunuku site has not been published.

The Natunuku skeleton was sent to the University of Hawaii in 1970 where it was described in an unpublished B.A. Honours thesis (Filler, 1971). Given the incomplete and preliminary nature of this study and the scarcity of Lapita skeletal remains in general, a re-investigation and re-analysis of the Natunuku skeletal remains was initiated in the early part of 1984 at the University of Hawaii. Since then, only the mandible fragment has been described (Pietrusewsky, 1985a, 1985b). The purpose of the present study is to provide a detailed description of the entire Natunuku skeleton, including an assessment of its age, sex and stature and a notation of the metric and non-metric features of the skull, teeth and infracranial skeleton. Observations of pathology and the results of univariate and multivariate comparisons of the Natunuku skeleton with other skeletal remains from the Pacific are further described.

Appendix A includes all tables referred to in the text.

Material

The human skeletal and dental remains from Natunuku are fragmentary and incomplete. The major bones and teeth of the Natunuku skeleton are shown in Fig. 2.

Except for a few hand phalanges and carpal bones, none of the bones are completely preserved. Judging from the weathered and brittle appearance of these remains, little of the bone's organic content has been preserved. Much of the cancellous bone is either eroded or missing.

During the study of the human remains, fragments of pottery, fish vertebrae, turtle and mammal bones were

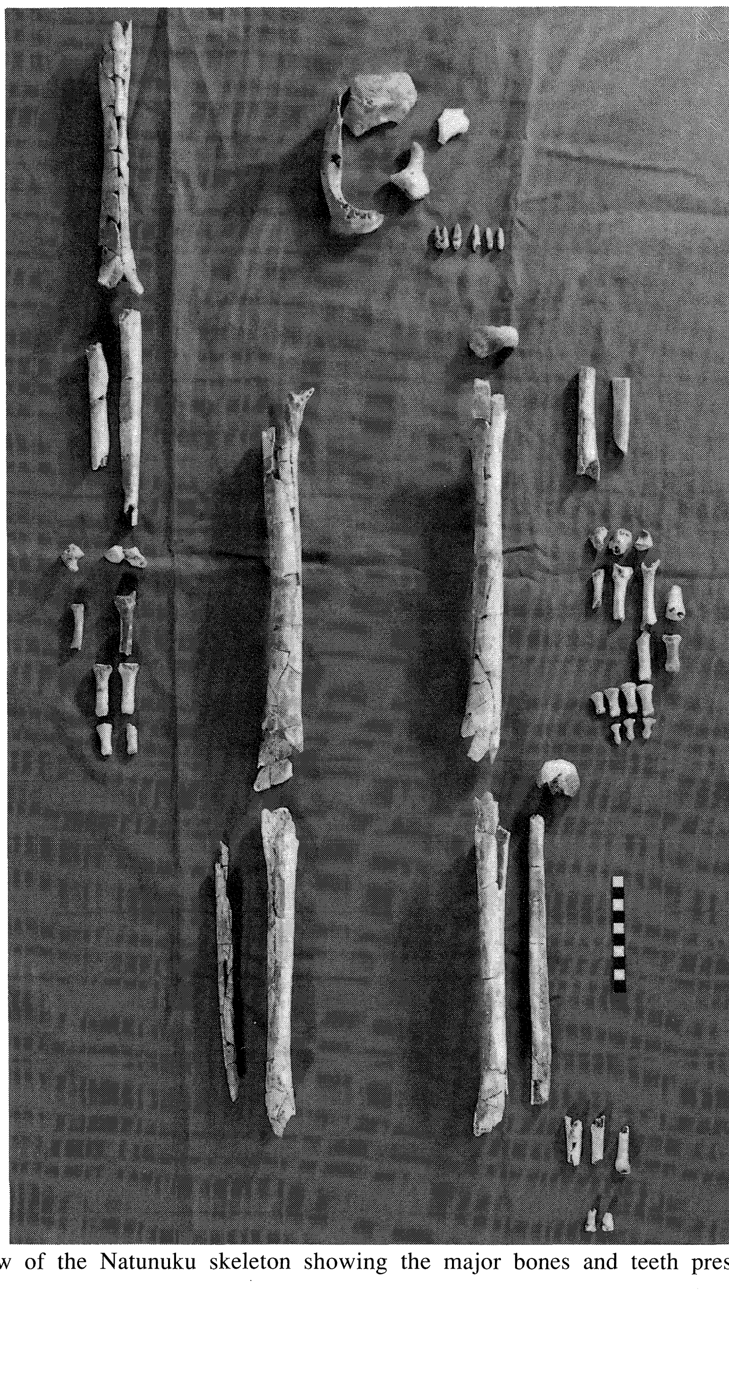

Fig.2. An overview of the Natunuku skeleton showing the major bones and teeth present.

identified. Some of the turtle and animal bones have been heated or burned. None of the human bone fragments have been burned as originally reported by Filler (1971). While some of the latter are dark in color, this condition seems to have been caused by post-depositional staining rather than charring.

A preservative which had been applied at the time of excavation retarded further disintegration of this fragile material. However, the preservative, dirt and other foreign particles adhering to most of these remains was not removed prior to Filler's initial reconstruction. In the present re-study, therefore, it was first necessary to remove the preservative and other impurities by immersing the remains, except the mandible fragment, in acetone for 24 hours. While effective in removing the preservative, this treatment further dissolved the adhesive originally used to mend the broken bones, thereby necessitating that these remains be reconstructed a second time. A two-part epoxy binding agent was used in this final reconstruction. Following this procedure, the majority of the diaphyseal shafts of the major limb bones and other parts of the skeleton were reconstructed.

Cranium

Except for two fragments of the occipital bone, a portion of the left zygomatic bone and a part of the frontal bone, most of the cranium is missing. The remaining cranial fragments are too small to permit further identification.

The occipital fragment, measuring approximately 71 mm by 53 mm, preserves a prominently developed inion process externally. Further identified are a portion of the external occipital crest and a small portion of the superior nuchal line. Internally, a portion of the groove for the superior sagittal sinus, the internal occipital crest and a portion of the groove for the transverse process are visible. The right groove is continuous with the groove of the superior sagittal sinus. The fragment is thick, measuring approximately 21 mm at the inion and 10 mm just superior to the external occipital protuberance.

The second largest cranial fragment, a nearly complete left zygomatic bone, preserves the frontal process including the articulation with the frontal bone, the entire orbital border and most of the maxillary border. The temporal process of this bone is only partially complete. A single zygomatico-facial foramen is visible externally. A zygomatico-orbitial foramen is further visible in the orbital surface of this bone. Both the marginal tubercle (located on the lateral surface of the frontal process) and the malar tuberosity (a slightly raised area for the origin of the zygomaticus minor muscle) are moderately developed. The two cranial fragments are shown in Fig. 3.

The third identifiable cranial bone fragment, measuring 35 mm by 27 mm, is from the frontal bone. The fragment preserves the zygomatic process, a portion of the orbital rim and adjoining regions of the squama from the left side of the frontal bone. The internal surface of this fragment is weathered revealing the inner diploic structure.

The remaining small fragments of skull are too fragmentary to permit further identification. Large areas of the vault region and especially the face are missing.

Mandible

The most complete bone of the skull is a reconstructed

Fig.3. Two cranial fragments from the Natunuku skeleton. The thick occipital bone fragment (on left) preserves a well-developed inion process. The fragment on the right is a nearly complete left zygomatic bone.

mandible fragment (see Figs 4-7) which preserves in its entirety the right body and a portion of the adjoining left mandibular body. The latter extends as far as the alveolus of the C/P3 region. The right ramus is missing the coronoid process and the articular head (condyle) of the mandible. The angle of the mandible forms a blunted projection which rests squarely on a level surface posteriorly. Anteriorly, the chin is raised warranting the designation partial 'rocker jaw'. The site for the attachment of the masseter muscle on the external surface of the left ramus is well developed. Externally, a well developed mental protuberance is preserved. Internally, the mental spine (genial tubercle) appears undamaged and single. Given its relatively complete nature, the perservative which was applied at the time of excavation was not removed prior to the present study.

The mandibular fragment is virtually edentulous, only the alveoli for the left canine and right lateral incisor indicate post-mortem tooth loss. The remaining alveoli exhibit complete or fairly advanced states of resorption.

Teeth

Five isolated teeth (Fig. 8) found in association with these

Fig.4. Superior view of the Natunuku mandible fragment.

Fig.5. Lateral (right) view of the Natunuku mandible. The mandible is classified as a partial 'rocker jaw'.

Fig.6. Internal lateral view of the Natunuku mandible fragment.

Fig.7. Inferior view of the Natunuku mandible fragment.

remains include a second (right?) molar from the upper dentition and both lateral incisors and the canines from the lower dentition. None of the lower teeth, however, convincingly fit any of the alveolar sockets preserved in the mandible fragment.

Infracranial Skeleton

The infracranial skeleton is represented by reconstructed shaft fragments of the right arm, left forearm, portions of both hands, lower limb bones and a few bones

Fig.8. Isolated teeth found in association with the Natunuku skeleton.

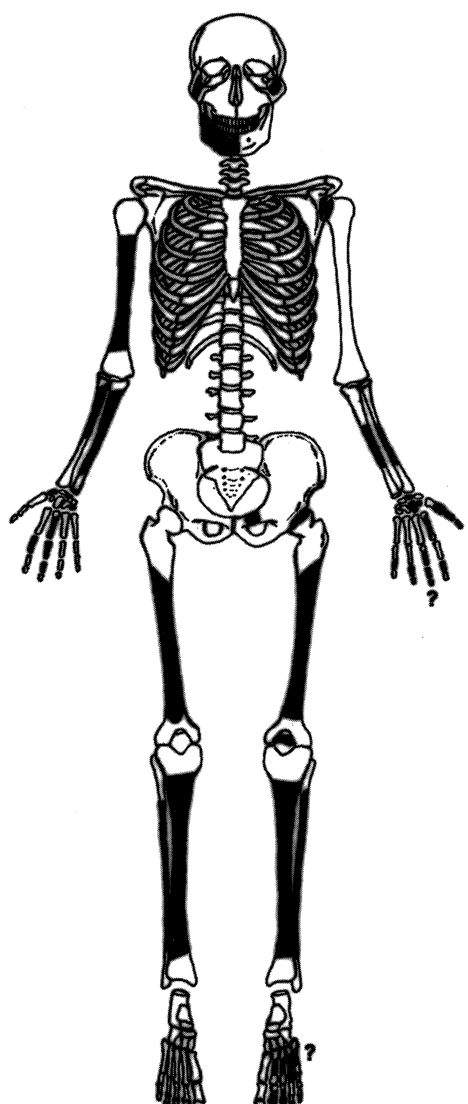

Fig.9. Skull and infracranial representation of the Natunuku skeleton. The darkened areas indicate the parts present.

from the left foot. The bones of the shoulder, thoracic and pelvic regions, except for fragments, are mostly missing. The articular ends of the major limb bones are represented by only a few fragments, none of which can be joined to the diaphyseal shaft fragments of these bones. Hand phalanges and carpal bones are the most complete bones represented in the infracranial skeleton. Skull and infracranial representation of the Natunuku skeleton is shown in Fig. 9. An inventory of the identifable skeletal fragments and teeth is given in Appendix A.

Methods

Age and sex determination follow criteria described in Anderson (1969), Brothwell (1981), and El-Najjar & McWilliams (1978).

Measurements recorded on the mandible and infracranial bones were made using an osteometric board, mandibulometer and sliding calipers. The measurements, indices and angles recorded on the mandible are given in Table 1. The measurements and indices recorded in the infracranial skeleton are explained in Table 2. Helios dial sliding calipers (pointed tips) were used to record the mesial-distal and bucco-lingual crown diameters of the teeth as defined by Moorrees (1957:80). Non-metric observations recorded on the mandible and teeth follow the author's previous work (Pietrusewsky, 1969a, 1969b). Estimation of the maximum lengths of limb bones follow methods explained in Steele (1970). Stature was estimated using formulae based on New Zealand Maori material described in Houghton *et al.* (1975). Where permitted, pathological involvement of bones and teeth were noted. Again, where observations were possible, osteoarthritis of the major articular surfaces of the infracranial skeleton was systematically recorded on an 0, +, ++, +++ basis indicating none, slight, medium and considerable amounts of osteoarthritic lipping, respectively. These categories of osteoarthritic lipping correspond most closely to those described by Brothwell (1981:146-151).

The Natunuku Skeleton

Age estimation. Given the relative incompleteness of these remains, including the absence of the symphysis pubis and the ends of the limb bones, age determination is based primarily on dental observations and the general size of the limb bones. The shafts of limb bones are of robust dimensions suggesting the individual is adult. Hand and foot bones further indicate adulthood but the absence of osteoarthritis in the latter suggests that the age may not be advanced. Four of the five isolated teeth, two mandibular lateral incisors and the two canines associated with the skeletal remains reveal advanced states of dental attrition in which the dentin is exposed suggesting this individual lived to old age (50+ years). The advanced states of alveolar resorption observed in the mandible fragment support this age determination.

Sex determination. Determination of sex was based on the size and robusticity of the infracranial skeleton. Virtually none of the pelvis is present, but the limb bones exhibit strong muscle markings. The existence of strong pilastering of the femur and a strongly developed deltoid tuberosity observed in the right humerus fragment suggest the individual is male. Estimated femur length approximates male Maori femora (Schofield, 1959). A prominently developed inion on the occipital bone further indicates these are the remains of a male.

Cranium. Only two measurements could be recorded in the cranial remains from Natunuku, both on the left zygomatic bone: Inferior Malar Length = 29 mm and Cheek Height = 26 mm. The latter is an estimate given the incompleteness of this bone.

Mandible. The measurements and mandibular indices recorded on the Natunuku mandible are presented in Table 3. Several of the measurements are estimates based on a reconstruction (traced on graph paper) of the missing portions of the mandible using the right side as a template. Using this reconstruction, the mandibular length, maximum bicondylar width and gonial breadth were estimated. The ramus height and mandibular notch breadth (measured on the left side) are the best approximations possible based on the portions of superior ramus present.

Later in this report, the results of multivariate comparisons of the Natunuku mandible with a number of Pacific mandible samples are presented. Here, univariate comparisons of measurements and non-metric observations recorded on the Natunuku and several Pacific samples are summarised. Comparative data for three indices are presented in Table 4.

Mandibular index. As measured by this index, the lower jaw is narrow or dolichognathic. A majority of Polynesian mandibles have broader dimensions. The values recorded for the Gilbert-Marshall Islands, Fiji and Gulf Province (Papua New Guinea) samples are most like the index value recorded for the Natunuku mandible.

Gonio-condylar index. The relatively high value obtained for this index indicates that the ascending rami of the Natunuku mandible are not very divergent. Again, of the values presented in Table 4, the Gilbert-Marshall Islands sample is closest to the value recorded for Natunuku. The ascending rami of Polynesian mandibles are generally more divergent.

Ramus index. This index, which is an approximation of the relative breadth of the ramus to its height, obtains a medium value indicating that the Natunuku ramus is neither especially elongated nor low. Compared with the other Pacific groups, this value is closest to those recorded for New Britain and Vanuatu although the observed variation in this index is not extreme.

The angle formed by the ramus relative to the horizontal plane is acute in the Natunuku mandible. The angle measured at the symphysis is equally low indicating a non-prognathic lower jaw.

Non-metric features. Non-metric features of the mandible include a single mental foramen on both sides. No bridging of the mylo-hyoid line is observed on the right side. The mandibular foramen on the right side is single. The lower border of the mandible is convex causing the mandible to 'rock' when it is deflected anteriorly from a resting position on a level surface. The mandible does not 'rock' when deflected posteriorly. A strong mandible angle and slight gonial eversion further warrant the designation 'partial rocker jaw'. A comparison of the non-metric traits recorded in the Natunuku mandible with three other Lapita-associated mandibles is presented in Table 5. The latter show a remarkable similarity in their non-metric variation.

Bridging of the mylo-hyoid line, multiple mandibular and mental foramina and mandibular tori are uniformily absent in all mandibles. All Lapita-associated mandibles are classified as partial 'rocker jaws'. The chin usually forms a bilateral prominence anteriorly.

A multivariate comparison of the non-metric observations recorded on the Natunuku mandible with other Pacific mandibles is presented later.

Dental status of mandible. The mandible fragment exhibits considerable alveolar resorption, especially in the posterior region. No teeth were found in the mandible at the time of this study. The socket for the right third molar, lost pre-mortem, exhibits a partially healed abscess. The remaining molars, premolars and the canine tooth from the same side were lost well in advance of the individual's death; their alveolar sockets have been completely resorbed. The socket for the right lateral incisor is still evident suggesting post-mortem loss of this tooth. The two central incisors and the left lateral incisor were lost not very long before the death of the individual and their sockets reveal the first stages of alveolar resorption. The socket for the left third molar exhibits less resorption. The socket for the left canine suggests that this tooth was lost post-mortem. The remaining portion of the mandible preserves a completely resorbed socket for the right first premolar (P3).

Except for the aforementioned alveolar erosion observed in the third molar socket, there is little evidence of abscessing in the mandible fragment. However, given the resorption of the alveolar sockets, opportunities for observing periodontal disease in the mandible fragment were few.

Isolated teeth. The root and particularly the cervical regions of the five isolated teeth found in association with the skeletal remains of this individual exhibit a reddish-brown stain. Small amounts of calculus (tartar) formation at or below the cemento-enamel junction are further observed in these teeth.

As mentioned earlier, the state of alveolar resorption in the mandible suggests that the left canine and right lateral incisor were probably lost post-mortem. None of the isolated teeth, however, were found to fit convincingly any of the existing mandibular alveolar sockets. It is therefore not known for certain if any of the isolated teeth belong to this skeleton. Given that the anterior teeth are more greatly worn than the single molar tooth, two individuals may be represented.

Individual observations of the teeth follow:

7| The enamel portion of this tooth is slightly worn. Interproximal caries are observed on the mesial surface of the crown just superior to the crown/root junction and at the cervix on the lateral (buccal) side of the tooth. The molar cusp pattern in this tooth is +5.

3| Advanced attrition of this tooth's distal occlusal surface produces an uneven (oblique) wear pattern which exposes the dentin. Such unequal wear has sometimes been observed to occur in advanced stages of dental attrition (Brothwell, 1981:72). No caries are observed in this tooth.

2| The occlusal surface of this tooth is evenly worn well into the dentin. There is a small interproximal cervical caries on the mesial surface.

|2 The dental attrition seen in this tooth mirrors that observed in the incisor from the opposite side. Again, small interproximal cervical caries are evident on the mesial surface.

|3 As was observed in the other canine, this tooth exhibits uneven wear exposing the dentin. The tooth has no caries.

Measurements recorded on the isolated teeth are presented in the Table 6.

Some comparative data recorded on Asian and Pacific samples are presented in Tables 7 to 9. Crown diameters of the Natunuku teeth are similar to Asian and Polynesian teeth.

Infracranial skeleton. Measurements recorded on the infracranial remains for the Natunuku skeleton are presented in Table 10. Infracranial indices and estimations of stature are presented in Table 11. Some comparative data recorded on a number of Pacific Island samples are given in Table 12.

Humerus. The right humerus fragment extends approximately from the region of the deltoid tuberosity to the supratrochlear region, its closest approximation is Steele's humerus shaft segment-2 (Steele, 1970). The fragment is of robust dimensions, an observation that is supported by the high value obtained for the index of robustness. The diaphysis displays little or no flattening.

The humeral-femoral index is low indicating that arm length is proportionately shorter than leg length. In this instance, the Natunuku skeleton approaches the mean values recorded for Nebira and Tonga.

Radius and ulna. These bones are represented by shaft fragments from both forearms. The bones are too incomplete and fragmentary, however, for maximum lengths to be determined. The shaft diameters of these bones suggest an individual of robust proportions.

Femur. Extensive reconstruction yielded the major shaft fragments of both femora, they approximate Steele's shaft fragment-3. The mid-shaft region of both femora display strong pilastric development, indicating a strongly developed linea aspera. The values of this index exceed all values presented in Table 12 except the one recorded for Fiji. Further, there is no flattening (platymeria) in the subtrochanteric region of the Natunuku femora as is typical of Polynesian thigh bones. The shapes of the Natunuku femora are most like those in the Nebira sample. Natunuku femur robustness is most like that recorded for the Fiji, Nebira and the Marquesas samples. While the femoral shafts appear bowed (see Fig. 10), low values were obtained for the bowing index.

Strong pilastric development and missing extremities are at least partially responsible for the results obtained here.

Tibia. The tibial shafts display little or no flattening (platymeria) at the level of the nutrient foramina. Table 12 indicates that the Natunuku tibiae are the least flattened of all the samples compared and that they are most like the Nebira tibiae. The tibia (lower leg) length expressed as a

Fig.10. Femoral shaft fragments (right and left) from Natunuku.

percentage of the femur (thigh) length (Crural index) is proportionately greater in the Natunuku skeleton than in any of the other Pacific groups compared. This proportion is again closest to those reported for Fiji and Nebira.

Non-metric features. Given the highly fragmentary and incomplete condition of the infracranial skeleton, no observations of the non-metric characteristics are possible.

Stature. Using formulae devised by Houghton *et al.* (1975), living stature is estimated to be approximately 172.4 cm or 5 feet 8 inches. The formulae used are given in Table 11. Compared with other male Pacific groups, the skeleton from Natunuku is closest to the stature estimated for a number of Polynesian groups.

Pathology. Descriptions of dental pathology were presented in the section on dentition. Given the incomplete and fragmentary nature of these remains, systematic recording of pathological involvement in the infracranial skeleton is limited. Almost none of the extremities of the major limb bones are preserved. Evidence of osteoarthritis in the carpal and metacarpal bones, some of the best preserved bones, is minimal or nonexistent. Other abnormalities, such as bowing of the lower limb bones, is discussed in the section dealing with the infracranial skeleton. The cause of death cannot be determined.

Multivariate Comparisons

In this section the results of multivariate comparisons using metric and non-metric traits recorded on mandibles are presented.

Mandibular measurements. The detailed results of two separate multivariate comparisons, which utilise measurements recorded on the Natunuku mandible fragment, a Lapita-associated mandible from Lakeba in the Fiji Islands, and several other prehistoric and near-contemporary mandible samples from Polynesia, Micronesia, and Melanesia are presented in an earlier paper (Pietrusewsky, 1985b). The results of this earlier investigation are briefly reviewed here to allow comparisons with the results obtained through univariate and multivariate comparisons of other aspects of the Natunuku skeleton.

Multivariate procedures [Mahalanobis' Generalised Distance (Mahalanobis, 1936) and stepwise discriminant function analysis (Dixon & Brown, 1979)] applied to seven mandible measurements recorded on seven male samples are discussed first. The means of the seven measurements for these samples and their provenance are presented in Table 13.

The diagram of relationship which results from a cluster analysis of the d-squared results is shown in Fig. 11. The two Lapita-associated mandibles from Natunuku and Lakeba form a loose association. Additionally, very close associations between prehistoric Wairau Bar and near-contemporary New Zealand Maori and between the prehistoric Tongan and Namu samples is indicated in this diagram. Further clarification of these relationships is presented in the next diagram, Fig. 12, which summarises the results of stepwise discriminant function analysis. Natunuku and Lakeba are closest to the Namu and Tongan samples, all of which are well separated from the samples in

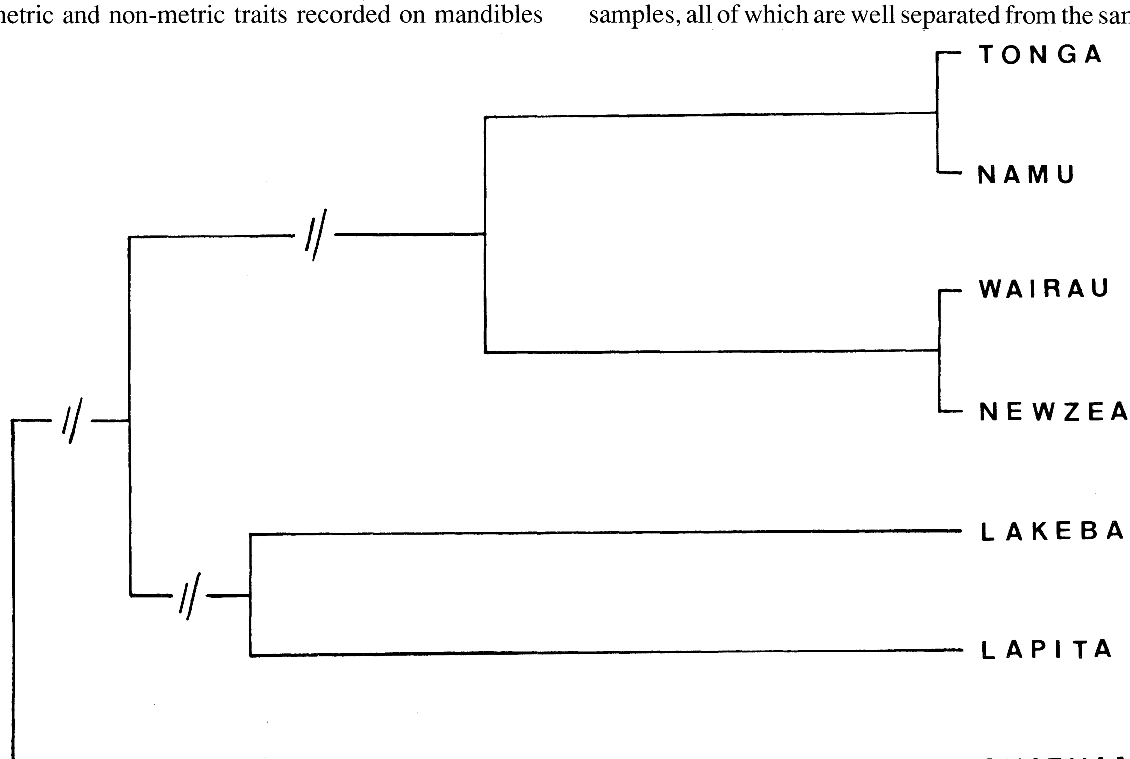

Fig.11. Diagram of relationship of d-squared results for 7 male samples using 7 mandible measurements.

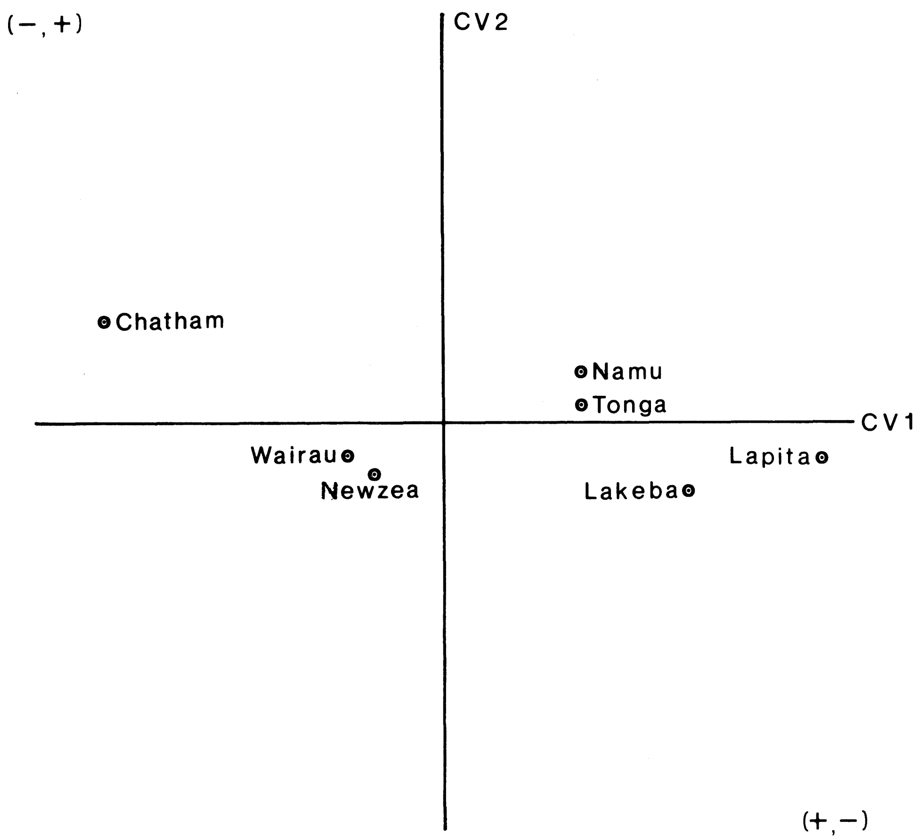

Fig.12. Plot of 7 male means on the first and second canonical variables using 7 mandible measurements (stepwise discriminant function analysis).

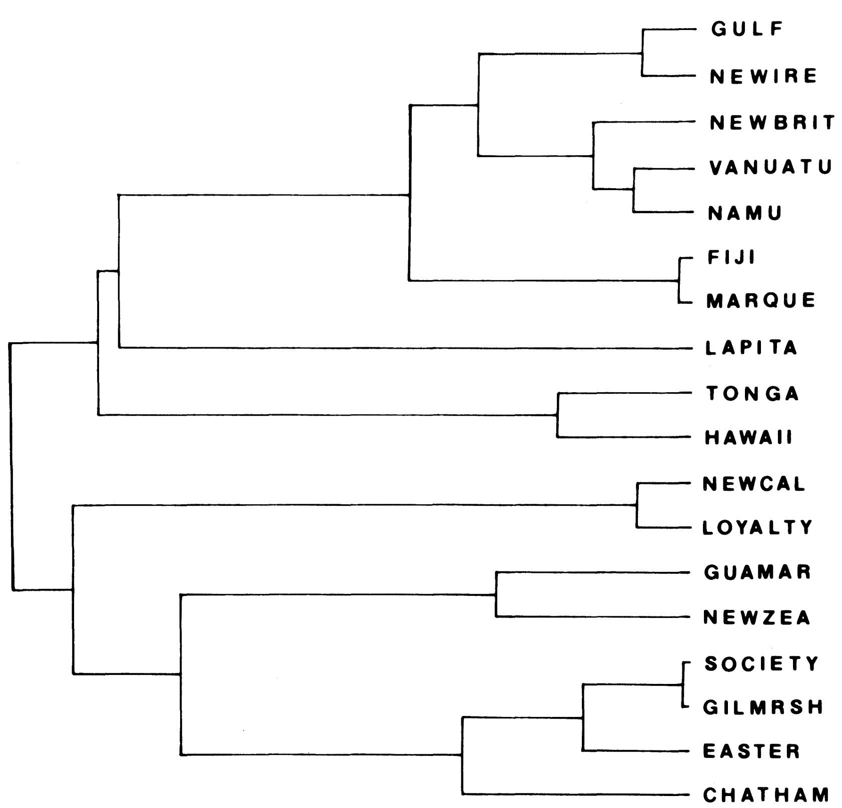

Fig.13. Diagram of relationship of d-squared results for 18 male samples using 5 mandible measurements.

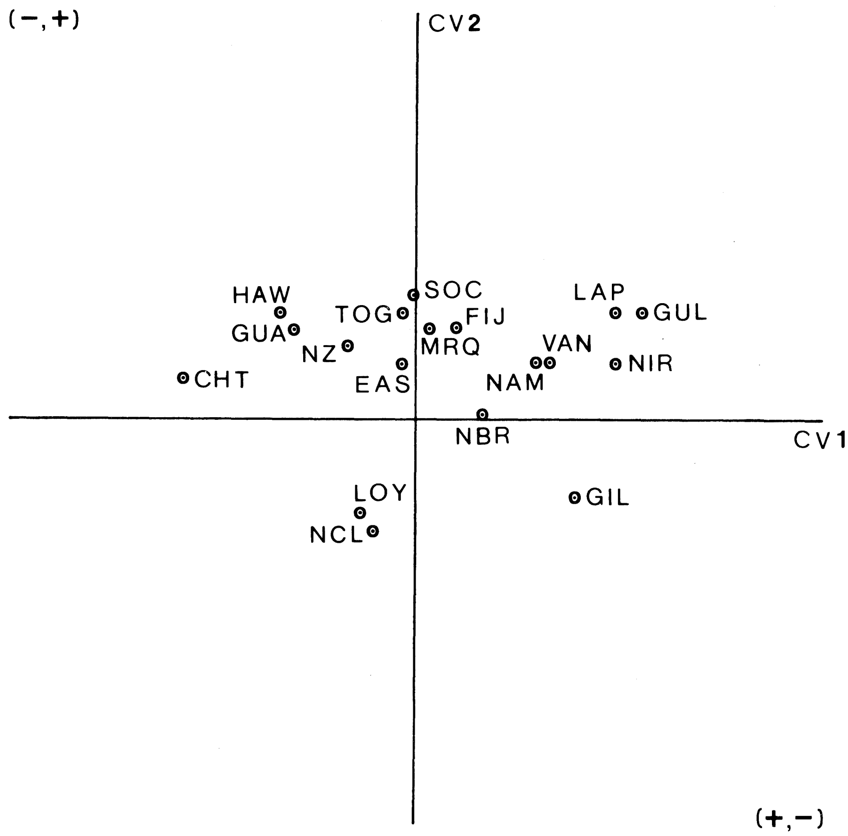

Fig.14. Plot of 18 male means on the first and second canonical variables using 5 mandible measurements (stepwise discriminant function analysis).

western Polynesia.

In the second analysis the same multivariate procedures are applied to five mandibular measurements recorded on eighteen male samples. With the exception of Natunuku, Tonga and Namu, the samples are not well dated, the majority represent near-contemporary specimens found in museums located in Europe, Australia, New Zealand and Hawaii. The sample sizes and means for the five mandible measurements recorded for these groups are presented in Table 14.

A cluster analysis of Mahalanobis' d-squared values is presented in Fig. 13. The main separation in this diagram is between a basically Polynesian-Micronesian constellation and a Melanesian cluster. Natunuku, while somewhat peripheral, associates with the Melanesian subdivision. Multiple discriminant function analysis (Fig. 14) reiterates this separation and underscores Natunuku's proximity to the Melanesian grouping. Two samples from eastern Melanesia, the Loyalty Islands and New Caledonia, form a separate isolate unrelated to any of other samples included in the analysis.

Non-metric traits. In this section, multivariate procedures are applied to three non-metric mandibular traits. The non-metric observations which were recorded on the Lapita-associated mandibles and a number of Pacific and Asian groups are presented in Table 15. With the exceptions given in Table 15, these data are taken from Pietrusewsky (1984). Using a computer program written by Molto (1980), the Mean Measure of Divergence statistic, or MMD, (Green & Suchey, 1976) is applied to non-metric traits as an alternative means for assessing group relationships. Six separate applications, representing various partitions of the larger data set, were made. Using an unweighted pair-group clustering technique, diagrams of relationship based on the MMD results are constructed using a computer program written by Dr Jim Archie of the University of Hawaii. The results of each distance analysis are presented separately.

Seven male samples, three non-metric traits. This analysis, which applies the MMD statistic to three non-metric traits recorded on seven male samples, most nearly approximates the samples used in the multivariate analysis of seven mandible measurements presented earlier. The diagram of relationship of these results (a cluster analysis of the MMD Scores) is shown in Fig. 15.

The two Lapita-associated samples from Natunuku and Lakeba form a separate cluster in this diagram. Namu and Tonga occupy the most peripheral positions. The relatively high incidence of non-rocker jaw in the Namu sample is chiefly responsible for the isolation of this sample. The Wairau Bar sample similarly occupies a marginal position in this diagram.

Eighteen male samples, three non-metric traits. This

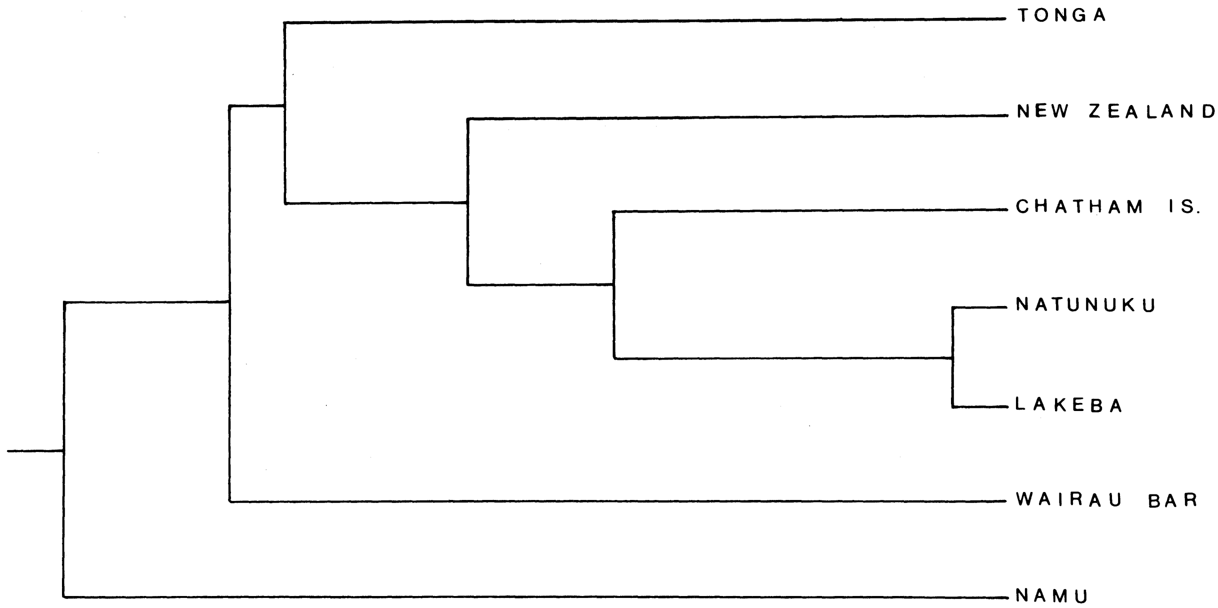

Fig.15. Diagram of relationship of Mean Measure of Divergence (MMD) results for 7 male samples based on 3 mandibular non-metric traits.

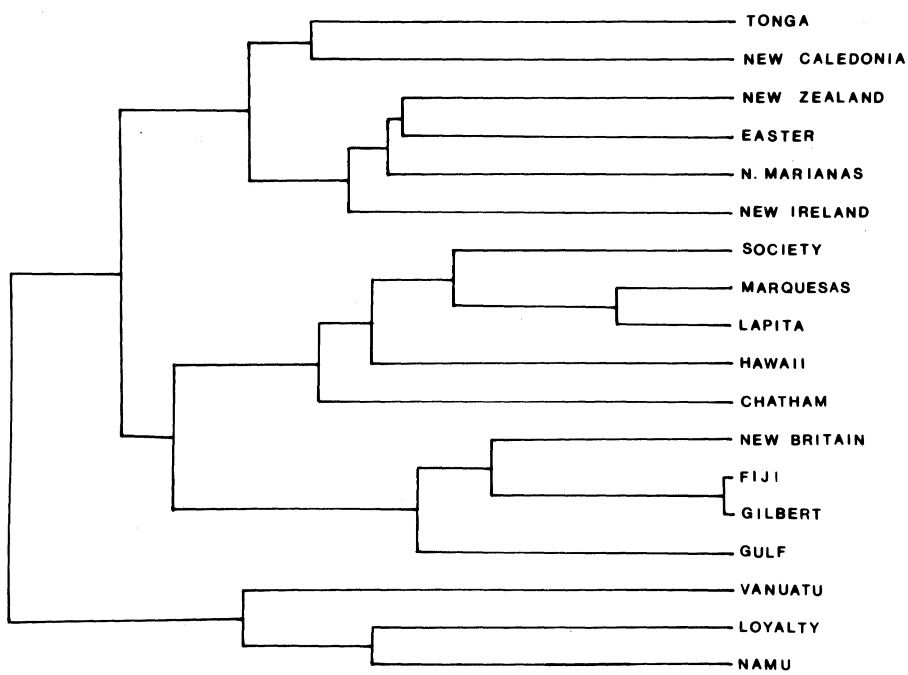

Fig.16. Diagram of relationship of Mean Measure of Divergence (MMD) results for 18 male samples based on 3 mandibular non-metric traits.

comparison most nearly approximates the samples analysed in the larger metric analysis. The diagram of relationship is given in Fig. 16. The Lapita sample falls within a cluster containing samples from eastern Polynesia and is closest to the prehistoric Hane Dune (MUH-1) sample from Uahua, Marquesas. The groups which are next closest to this cluster, containing the Natunuku mandible, are New Britain, Fiji, Gilbert-Marshall and Gulf. No recognisable patterning among the remaining samples is evident. Samples from eastern Melanesia (Vanuatu, Loyalty, Namu and New Caledonia) occupy isolated positions in the diagram. Inspecting the original MMD values (not shown) identifies the Gilbert-Marshall sample as the one closest to the Lapita sample.

Eight male samples, three non-metric traits. The results of applying the MMD statistic to non-metric traits recorded on eight male samples is given in Fig. 17.

The Lapita and Marquesas (Hane Dune) sample form a close association which, in turn, attracts samples from eastern and marginal Polynesia. Tonga and Fiji represent a western division.

Ten male samples, three non-metric traits. In this analysis, Lapita mandibles are compared with Melanesian samples.

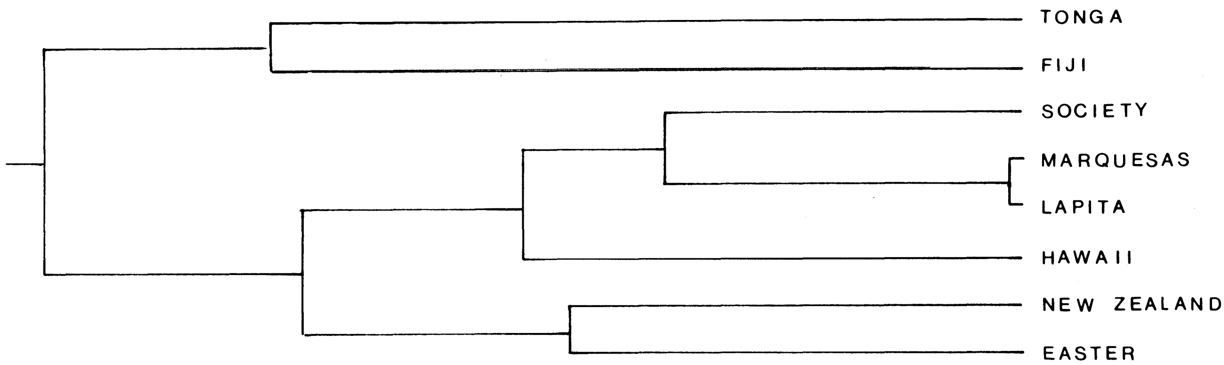

Fig.17. Diagram of relationship of Mean Measure of Divergence (MMD) results for 8 Polynesian male samples based on 3 mandibular non-metric traits.

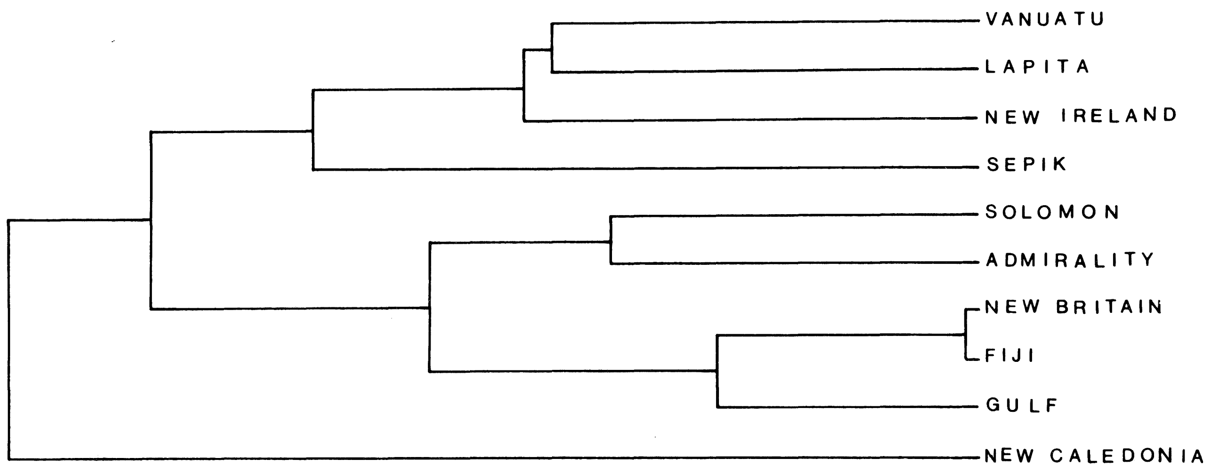

Fig.18. Diagram of relationship of Mean Measure of Divergence (MMD) results for 10 male Melanesian samples based on 3 mandibular non-metric traits.

The diagram of relationship is presented in Fig. 18. The Lapita sample falls within a cluster which contains, with the exception of Vanuatu, samples from western Melanesia. Inspection of the MMD results (not shown) further reveals that the samples nearest to the Lapita sample are Solomon, Gulf, Sepik, New Ireland and Admiralty. The samples from eastern Melanesia are the most removed from the Lapita sample.

Ten male samples, three non-metric traits. The results of applying the Mean Measure of Divergence statistic to three non-metric traits recorded on the Lapita mandibles and nine corresponding samples from South-east Asia and East Asia are presented in Fig. 19. Lapita mandibles are found to cluster with samples which are largely of island South-east Asian origin. The groups closest to the Lapita sample are the Philippines, Borneo and Sulu.

Twenty six male samples, three non-metric traits. Finally, including all the samples used in the previous three analyses, the MMD statistic is applied to 26 male samples. The diagram of relationship based on the MMD scores is presented in Fig. 20. In this representation, the Lapita and Hane Dune (Marquesas) samples form a close connection. Other samples which demonstrate an affinity to the Lapita sample, as interpreted by this diagram and inspection of the MMD values (not shown) include the Society Islands, Hawaii, Sepik and Gulf. With the exception of New Caledonia, New Britain and Fiji, the remaining samples form three groupings which are equidistant from the cluster containing the Lapita-associated mandibles.

Discussion and Conclusions

Despite the incompleteness and variable preservation of the 3,000-3,500 year old Lapita-associated skeleton from Natunuku and the limitations of using a single specimen, comparing this material with other prehistoric and near-contemporary inhabitants of the Pacific allows some tentative conclusions regarding biological relationship and Polynesian ancestry.

The relatively tall (172 cm or 5 feet 8 inches) stature and the robustness of the Natunuku appendicular skeleton is consistent with a Polynesian physical pattern (Houghton,

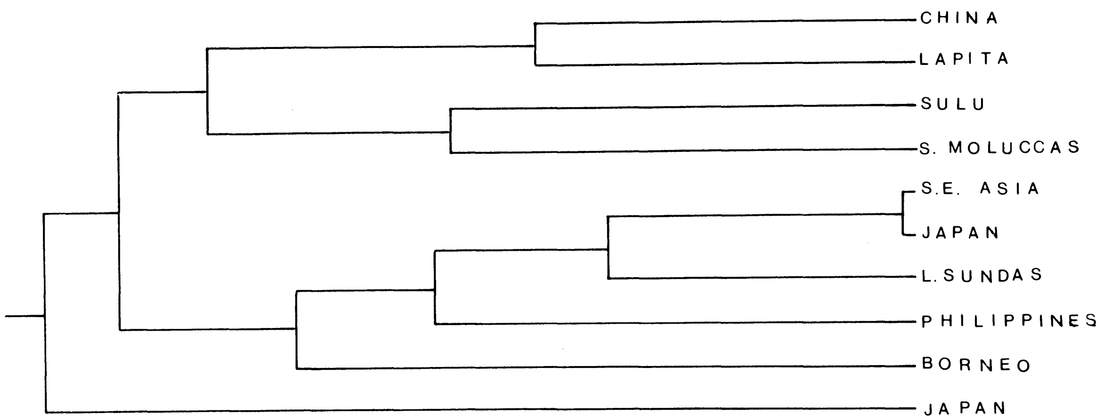

Fig.19. Diagram of relationship of Mean Measure of Divergence (MMD) results for 10 male samples based on 3 mandibular non-metric traits.

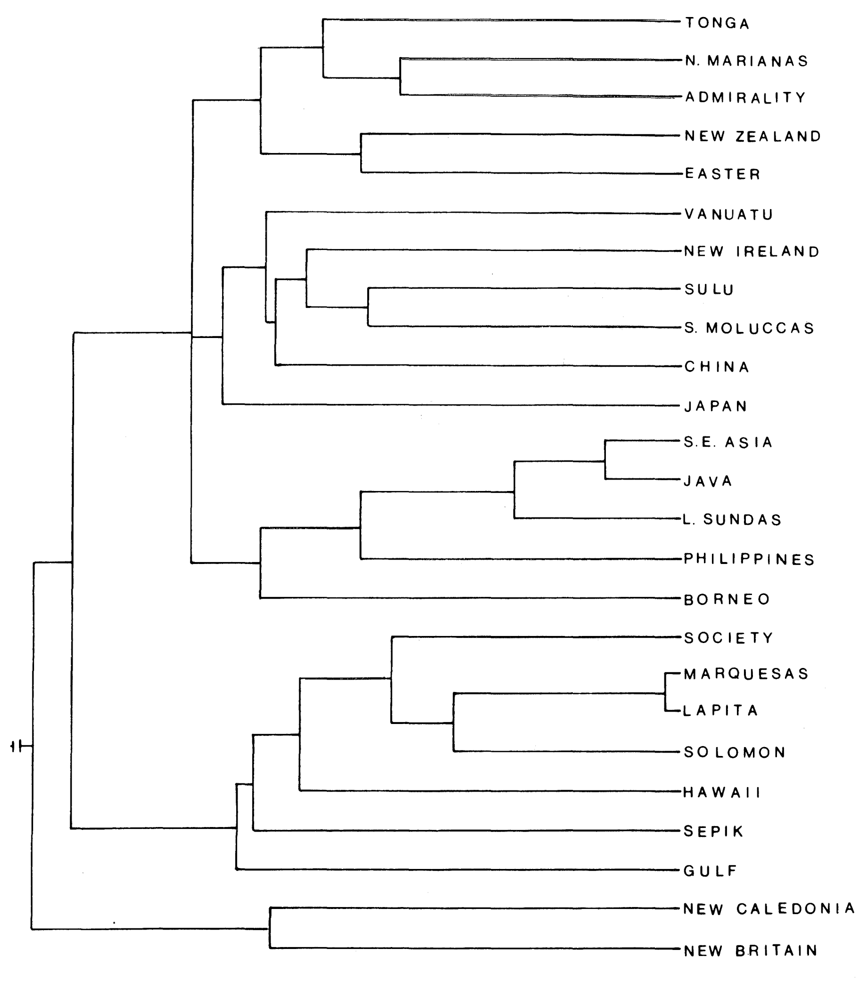

Fig.20. Diagram of relationship of Mean Measure of Divergence (MMD) results for 26 male samples based on 3 mandibular non-metric traits.

1980: 67-78). Other aspects of the Polynesian physical form such as relatively short legs and bowing of the limb bones are not observed in the Natunuku skeleton. In fact, the size, shape and relative proportions of the Natunuku lower limb bones are closest to Melanesian samples such as Fiji and Nebira. Of the Polynesian groups compared in Table 12, the Marquesas is most like Natunuku. Much of our knowledge of the Polynesian limb skeleton is based on New Zealand Maori material (Schofield, 1959; Houghton, 1980) which, as the comparative data used in the present study indicate, may not be entirely typical of Polynesians. This seems to be particularly true for the shape (platymeric index) of the femur's shaft which is considerably flattened in the New Zealand Polynesian femur but is of more rounded proportions in other parts of Polynesia. This is also true of the Natunuku femur shaft which is most like Tongan and New Guinea femora.

Further, the strong pilaster development observed in the Natunuku femora is not consistent with the Polynesian pattern. In this respect, Natunuku is again closest to Fiji. Femur robustness in the Natunuku skeleton is most like that recorded for Fiji, Nebira and the Marquesas. While the femoral shafts of the Natunuku skeleton appear to be bowed, this is not reflected in the values obtained for the bowing index. The shapes of the tibial shafts in the Natunuku skeleton again are most like the values obtained for Nebira, a sample from coastal Papua New Guinea.

The crown diameters of the five isolated teeth found in association with the Natunuku skeleton are most like those recorded for Polynesian and East Asian groups (Brace & Hinton, 1981). Unfortunately, the marked attrition found in the teeth prevents comment on the non-metric features of the dentition.

Finally, there is the mandibular fragment, one of the most complete bones of the Natunuku skeleton. Univariate comparisons of metric and non-metric features of this bone indicate that the Natunuku mandible is most like the Lapita-associated mandibles from Tonga and Lakeba and to Polynesians, in general. There is a uniform absence of multiple mental foramina and bridging of the mylo-hyoid line in all Lapita-associated mandibles examined. The presence of a partial rocker jaw condition is further representative of these mandibles.

Unlike Polynesian mandibles, however, the Natunuku mandible is of small dimensions and univariate comparisons place it with mandibles from the Marshall-Gilbert and Fiji Islands. The edentulous condition of the specimen undoubtedly accounts for some of its smallness, particularly the height of the mandible body.

The most extensive comparisons, which involve the application of multivariate procedures to metric and non-metric traits recorded in mandibles, again suggest that there is a basic uniformity among the Lapita mandibles from Fiji and western Polynesia. However, slightly different patterns of relationship are found when multivariate procedures are applied to metric and non-metric variation recorded in the Lapita-associated mandibles and a larger number of Pacific and circum-Pacific samples. Metrically, Lapita mandibles are most like those from Melanesia, especially Gulf, New Ireland, Vanuatu and Fiji, while the results based on multivariate analyses of a limited number of non-metric traits suggest Polynesian affinities. Both sets of results, however, do allow for some intermediate placement of the Lapita mandibles with respect to both Melanesia and Polynesia. For example, the Marquesas, Tonga and Hawaii samples are members of a larger cluster which further contains the Natunuku mandible in Fig. 13 (the results based on measurements). Likewise, despite the overall affinity with Polynesian groups in the non-metric analysis, these same results further indicate that Gulf and New Ireland are about as close to Lapita mandibles as New Zealand and Easter Island.

Earlier conclusions (Pietrusewsky, 1985b), which were based solely on the application of multivariate procedures to mandibular measurements, may warrant reconsideration. In this earlier study, because of the great attraction of the Natunuku mandible to Melanesian samples and its dissimilarity with Polynesian mandible samples, it was argued that it was impossible to derive Polynesians from Melanesians. This view runs counter to the evidence from archaeology which now suggests that the Lapita culture developed indigenously in the Bismarck Archipelago region in north-western Melanesia (e.g. Spriggs, 1984). It is, however, supported by a wealth of evidence from previous studies in physical anthropology (e.g. Howells, 1970, 1973, 1979; Pietrusewsky, 1983, 1984; Serjeantson, 1984; Katich & Turner, 1974; Turner, 1982; Brace & Hinton, 1981) and, more recently, by papers presented at the Micronesian Archaeological Conference held on Guam in 1987 (Brace, n.d.; Howells, n.d.; Turner, n.d.; Pietrusewsky, n.d.). These latter include studies of anthropometric data, cranial variation, genetic data and dentitions of Pacific peoples, all of which identify Polynesians as being genetically uniform and unrelated to Melanesians.

The present study, which examines a single skeleton, cannot completely rule out the possiblity that Polynesians could have developed out of Melanesians. Multivariate analyses of mandible measurements and features of the lower limb skeleton argue against such a derivation, while other aspects of the Natunuku skeleton's morphology, notably stature, skeletal robustness, tooth size, and the non-metric features of the mandible suggest a Polynesian likeness. The Natunuku skeleton, the oldest and most complete skeleton associated with the Lapita culture thus far discovered, cannot, by itself, settle the question of Polynesian origins. As this study clearly demonstrates, additional Lapita-associated skeletons from the Pacific are required for understanding of Polynesian biological origins.

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Appendix A

Table 1. List of mandibular measurements, indices & angles.

	Abbrev	Measurement	Reference
1.	MANDLNTH	Mandibular length (superior)	Olivier, 1969
2.	INFMANDL	Inferior length	Martin -68
3.	ALVEOLGT	Alveolar length	Trinkaus, 1978-BCAB
4.	BICONDWD	Bicondylar width (max. breadth)	Martin -65
5.	MIDCONDW	Bicondylar articular breadth	Trinkaus, 1978-BCAB
6.	CORONBTH	Bicoronoid breadth	Martin -65(1)
7.	BIGONIAL	Bigonial breadth	Martin -66
8.	BICANBTH	Bicanine external breadth	Trinkaus, 1978-CEB
9.	FRMOLBTH	Bimolar-1 external breadth	Trinkaus, 1978-M1EB
10.	THMOLBTH	Bimolar-3 external breadth	Trinkaus, 1978-M3EB
11.	SYMPHYHT	Symphyseal height	Martin -69
12.	MENFORHT	Mental foramen height	Martin -69(1)
13.	CANINEHT	Canine height: at C/P3	Trinkaus, 1978-CHC
14.	MOLARHGT	Molar height: at M1/M2	Martin -69(2)
15.	SYMPHYBT	Symphyseal breadth	Trinkaus, 1978-CBS
16.	MENFORBH	Mental foramen breadth	Martin -69(3)
17.	CANINEBH	Canine breadth: at C/P3	Trinkaus, 1978-CBC
18.	MOLARBTH	Molar breadth: at M1/M2	Trinkaus, 1978-CBM
19.	RAMUSHGT	Ramus height	Martin -70
20.	RAMUSBTH	Ramus breadth	Martin -71
21.	MANDNOTB	Mandibular notch breadth	Martin -71(1)
22.	CONDYLGT	Condyle length	Brown, 1982-I100
23.	CONDYBTH	Condyle breadth	Brown, 1982-I101
24.	PMMOLARL	P3-M1 length	Brown, 1982-I103
25.	MOLARLGT	M1-M2 length	Brown, 1982-I104

Index or Angle	Source
Mandibular = total length/bicondylar breadth	Olivier, 1969
Gonio-condylar = bigonial breadth/bicondylar breadth	Olivier, 1969
Ramus = ramus breadth/ramus height	Olivier, 1969
Mandibular angle = gonial angle formed by ramus on horizontal plane	Olivier, 1969
Symphyseal angle = most acute angle between the horizontal plane and chin	Olivier, 1969
Index of robustness = maximum thickness/body height at mental foramen	Olivier, 1969

Table 2. List of infracranial measurements and indices.

	Source
Humerus	
Maximum length	M-1*
Maximum diameter at mid-shaft	M-5
Minimum diameter at mid-shaft	M-6
Maximum diameter at deltoid	M-6a
Shaft circumference	M-7a
Radius	
Proximal sagittal diameter	M-5
Proximal transverse diameter	M-4
Shaft circumference	M-5(5)
Ulna	
Dorsoventral diameter	M-11
Transverse diameter	M-12
Femur	
Maximum length	M-1
Anterior-posterior diameter-subtroch.	M-10
Medio-lateral diameter-subtroch.	M-9

Table 2 (cont'd).

	Source
Femur	
Anterior-posterior diameter-midshaft	M-6
Medio-lateral diameter-midshaft	M-7
Bowing	Schofield (1959:95)
Tibia	
Maximum length	M-1a
Anterior-posterior diameter-nut. for.	M-8a
Medio-lateral diameter-nut. for.	M-9a
Anterior-posterior-midshaft	M-8
Medio-lateral diameter-midshaft	M-9
Patella	
Thickness	M-3
Lunate	
Maximum length	M-1
Maximum breadth	M-2
Maximum height	M-3
Trapezium	
Maximum thickness	T-1**
MC-1 articular breadth	M-4
MC-1 articular height	M-5
Trapezoid	
Maximum length	M-1
Maximum breadth	M-2
Maximum height	M-3
Hamate	
Maximum height	M-3
Articular length	M-1
MC-4/5 articular breadth	M-8
Capitate	
Articular length	M-4
Maximum breadth	M-2
Maximum height	M-3
Hand Phalanges	
Length	M-1
Height	M-2
Breadth	M-3

Humeral index of robustness = circum./max length x 100	Olivier, 1969:227
Humeral diaphyseal index = min/max diam. x 100	Olivier, 1969:227
Crural index = tibia/femur x 100	Olivier, 1969:269
Humeral-femoral = humerus/femur x 100	Olivier, 1969:262
Femoral index of robustness = trans + A-P midshaft diam./length x 100	Olivier, 1969:262
Platymeric index = A-P/trans. diam. x 100 (subtroch.)	Olivier, 1969:263
Pilastric index = A-P/trans. diam. x 100 (midshaft)	Olivier, 1969:263
Tibial thickness index = trans./A-P diam. (midshaft)	Olivier, 1969:272
Platycnemic index = trans./A-P diam. (nut. for.)	Olivier, 1969:271

* Martin & Saller (1957) number
** Trinkaus (1978)

Table 3. Measurements and indices recorded in Lapita mandible fragments (in mm.).

Measurement	Natunuku	Tonga	Lakeba #1	Lakeba #2
MANDLNTH	108*	–	–	–
INFMANDL	68	–	64	–
ALVEOLGT	71	54.8*	–	–
BICONDWD	114*	124	–	–
MIDCONDW	–	–	–	–
CORONBTH	–	100*	–	–
BIGONIAL	100*	109*	–	–
BICANBTH	37	31.8	–	–
FRMOLBTH	–	54.9	–	–
THMOLBTH	–	68*	–	–
SYMPHYHT	26	27.5*	28	30
MENFORHT	19	24.6**	28	32
CANINEHT	22	29.1	29	32
MOLARHGT	–	27.2	28	29
SYMPHYBT	14	–	14	13
MENFORBH	11	–	11	11
CANINEBH	12	–	10	9
MOLARBTH	13	–	13	13
RAMUSHGT	60*	–	–	–
RAMUSBTH	33	41	31	–
MANDNOTB	37*	–	–	–
CONDYLGT	–	–	–	–
CONDYBTH	–	–	–	–
PMMOLARL	–	–	15	14
MOLARLGT	–	–	18	–
Index, Angle				
Mandibular	94.7	–	–	–
Gonio-condylar	87.7	–	–	–
Ramus	55	–	–	–
Mandibular angle	97°	89°	–	–
Symphyseal angle	72°	–	–	–
Robustness	63	–	–	–

* estimated measurements.
** Spennemann (1985:14) reports a value of 15.2 mm for this measurement while the value given here is his premolar height.

Table 4. Mandibular indices for a number of Pacific groups.

Group	Mandibular Index	Gonio-Condylar Index	Ramus Index
Natunuku	94.7	87.7	55.0
Tonga	87.3	80.1	56.4
Namu	82.6	80.6	52.3
Wairau Bar	90.6	70.8	56.0
New Zealand	82.0	83.4	53.0
Chatham Is.	83.0	88.5	52.9
Society Is.	89.2	81.3	58.9
Marquesas	91.8	83.8	57.2
Easter Is.	86.1	79.2	63.8
Hawaii	85.7	82.7	54.0
Fiji	94.0	83.9	57.6
Gilbert/Marshall	94.7	87.0	57.5
Guam	88.7	85.1	58.2
Gulf, PNG	93.8	82.4	50.9
New Britain	90.6	83.0	54.8
New Ireland	92.0	81.5	53.0
New Caledonia	–	82.6	60.2
Loyalty	–	85.0	60.6
Vanuatu	–	80.4	54.9
China	–	83.6	55.9
South-east Asia	–	82.9	55.9
Thailand	–	82.7	53.4
Mongolia	–	85.4	55.4
Java	83.0	82.7	54.0
Sulu	–	83.2	54.6
Western Australia	94.5	83.4	53.5

Table 5. A comparison of non-metric traits recorded in Lapita-associated mandibles.

	Natunuku	Lakeba[1] #1	Lakeba[1] #2	Tonga[2]
Mandibular torus	absent	absent	absent	–
Mylohyoid groove-R	no bridge	no bridge	–	no bridge
Mylohyoid groove-L	–	–	–	–
Mandibular foramen-R	single	single	–	single
Mandibular foramen-L	–	–	–	–
Mental foramen-R	single	single	–	single
Mental foramen-L	–	–	single	single
Rocker jaw	anterior	anterior	anterior	anterior*
Chin form	MBA**	BA***	BA	–

[1]Observations recorded by the author on two Lapita-associated mandibles from Lakeba of the Lau Group, Fiji Islands (#1 = cast of right mandible fragment, #2 = left mandible fragment).
[2]Observations recorded by Spennemann (1985) on Burial AK from Shell Midden To.1, Pea, Tongatapu.

* According to Spennemann (1985:19) the lower jaw is 'rocker' but not of the extreme category.
** median-bilateral-angle.
*** bilateral-angle.

Table 6. Natunuku tooth measurements (in mm).

	Mesial	Mesial-distal	Buccal-lingual
Maxillary	Right M2	10.1	12.3
Mandibular	Right C	6.5	7.7
Mandibular	Right I2	5.5	6.2
Mandibular	Left I2	5.7	6.2
Mandibular	Left C	7.3	7.9

Table 7. Mesiodistal and buccolingual crown diameters of permanent mandibular canine teeth for males (in mm).

Sample/size	Side	Mesiodistal	Buccolingual	Source
Natunuku	R	6.50	7.70	(present study)
(n=1)	L	7.30	7.95	
Hawaii (n=24)		7.15	8.32	(Snow, 1974:93)
China (n=209)		7.31	7.89	(Moorrees, 1957)
Japan (n=146)		7.00	7.70	(Moorrees, 1957)

Table 8. Mesiodistal and buccolingual crown diameters of permanent mandibular lateral incisors for males (in mm).

Sample/size	Side	Mesiodistal	Buccolingual	Source
Natunuku	R	5.55	6.15	(present study)
(n=1)	L	5.70	6.15	
Hawaii (n=23)		6.11	6.82	(Snow, 1974)
China (n=187)		6.15	–	(Moorrees, 1957)
Japan (n=136)		6.00	–	(Moorrees, 1957)

Table 9. Mesiodistal and buccolingual crown diameters of permanent maxillary second molar teeth for males (in mm).

Sample/size	Mesiodistal	Buccolingual	Source
Natunuku (n=1)	10.10	12.30	(present study)
Tongan Lapita* (n=1)	12.30	10.90	(Spennemann, 1985:28)
New Zealand Maori (n=21)	10.19	11.98	(Dennison, 1979:125)
Hawaii (n=25)	10.69	12.09	(Snow, 1974:93)
Japan (n=142)	9.80	11.60	(Moorrees, 1957)
China (n=76)	9.36	11.00	(Moorrees, 1957)

* the two measurements as reported by Spennemann would appear to be reversed.

Table 10. Infracranial measurements recorded in the Natunuku skeleton.

	Right	Left
Humerus		
Shaft segment-2 length (Steele, 1970)	215	–
Max. length (M-1)[1]	(290.7)[2]	–
Max. diameter mid-shaft (M-5)	22	–
Min. diameter mid-shaft (M-6)	20	–
Max. diameter deltoid (M-6a)	26.5	–
Shaft circumference (M-7a)	73	–
Radius		
Prox. sagittal diam. (M-5)	15	–
Prox. trans. diam. (M-4)	13	–
Shaft circumference (M-5(5))	45	–
Ulna		
Dorsoventral diameter (M-11)	12.5	–
Transverse diameter (M-12)	19.0	–
Femur		
Shaft segment-2 length (Steele, 1970)	250	253.0
Max. length (M-1)	(444.0)	(446.6)
Anterior posterior diam.-subtroch. (M-10)	26	26
Medio-lateral diam.-subtroch (M-9)	32	32
Anterior-posterior diam.-midshaft (M-6)	32	31
Medio-lateral diam.-midshaft (M-7)	25	25
Bowing (Schofield, 1959:95)	9	7
Tibia		
Shaft segment-3 length (Steele, 1970)	187	–
Maximum length (M-1a)	(393.9)	–
Anterior-posterior diam.-nut. for. (M-8a)	36	34
Medio-lateral diam.-nut. for. (M-9a)	23	23
Anterior-posterior -midshaft (M-8)	33	31
Medio-lateral diam.-midshaft (M-9)	22	20
Patella		
Thickness (M-3)	–	19
Lunate		
Maximum length (M-1)	1.96	1.95
Maximum breadth (M-2)	1.35	1.35
Maximum height (M-3)	2.01	2.05
Trapezium		
Maximum thickness (T-1)[3]	–	1.23
MC-1 articular breadth (M-4)	–	1.75
MC-1 articular height (M-5)	–	2.47
Trapezoid		
Maximum length (M-1)	1.35	–
Maximum breadth (M-2)	1.62	–
Maximum height (M-3)	1.98	–
Hamate		
Maximum height (M-3)	–	2.65
Articular length (M-1)	–	2.01
MC-4/5 articular breadth (M-8)	–	1.31
Capitate		
Articular length (M-4)	2.33	–
Maximum breadth (M-2)	1.39	–
Maximum height (M-3)	1.77	—

Table 10 (cont'd).

	Hand Phalanges Proximal			
	Left thumb	# 1	# 2	
Length (M-1)	3.15	4.25	4.34	
Height (M-3)	0.67	0.67	0.66	
Breadth (M-2)	0.99	1.04	1.01	
		Middle		
	# 1	# 2	# 3	# 4
Length (M-1)	2.79	2.87	2.56	1.89
Height (M-3)	0.51	0.66	0.55	0.41
Breadth (M-2)	0.83	0.88	0.86	0.72
		Distal		
	# 1	# 2	# 3	
Length (M-1)	1.91	1.95	1.83	
Height (M-3)	0.39	0.36	0.36	
Breadth (M-2)	0.54	0.50	0.41	

[1]Measurements defined in Martin & Saller (1957).
[2]Values within parentheses indicate measurements were estimated from shaft fragments-see text.
[3]Measurement described in Trinkaus (1978).

Table 11. Infracranial indices* and stature** for the Natunuku skeleton.

	Right	Left
Humeral index of robustness (at deltoid)	25.1	–
Humeral diaphyseal index	90.9	–
Crural (tibia-femur) index	88.7	–
Femur-humeral index	65.5	–
Femoral index of robustness	13.3	12.8
Pilastric index	128.0	124.0
Platymeric index	81.2	81.2
Bowing (femur) index	1.5	2.0
Tibial thickness index	66.7	64.5
Platycnemic index	63.9	67.6

*See Table 2 for explanation.

**Stature Estimation using Houghton *et al.* (1975:333) equations:
(1)2.137(444.0) - 5.184(10) + 830.7 ± 31.4 mm = 1727.7 ± 31.4 mm. or approx. 5'8"
(2)2.210(393.9) - 5.247(10) + 978.6 ± 9.4 mm = 1796.6 ± 9.4 mm. or approx. 5'10"
(4)1.782(290.7) - 7.339(10) + 1226.4 ± 56.8 mm = 1671.0 ± 56.8 mm. or approx. 5'6"

Table 12. A comparison of infracranial indices and stature for a number of Pacific groups.

	Natunuku	Fiji(1)	New Guinea (2) Nebira	Tonga (3)	Marquesas (4)	Hawaii (5) Anaehoomalu	Hawaii (6) Mokapu	New Zealand (7)	Easter Island (8)
Crural index	88.7	84.2	84.0	83.5	82.0	84.0	82.1	82.4	83.7
Pilastric index	128.0	133.7	121.0	116.9	122.2	115.0	119.2	116.7	115.8
Platymeric index	81.2	94.5	82.0	84.8	76.5	71.0	71.6	65.0	72.7
Femoral index of robustness	13.3	13.1	13.5	12.6	13.3	14.6	12.4	12.4	12.0
Platycnemic index	63.9	66.7	65.0	66.1	69.4	66.0	66.8	–	71.8
Humeral-femur index	65.5	72.5	70.0	70.3	72.9	72.0	72.5	71.8	71.2
Stature	172.7	169.0	167.0	176.0	174.0	172.7	172.0	171.0	173.0

[(1) Weber (1934); (2) Pietrusewsky (1976); (3) Pietrusewsky (1969a); (4)Pietrusewsky (1976); (5) Pietrusewsky (1971); (6) Snow (1974); (7) Houghton (1980); Schofield (1959); (8) Murrill (1968)]

*for the purposes of this table stature estimates were standardised using formula no. 1 in Houghton *et al.* (1975).

Table 13. Means and standard deviations for seven mandibular measurements recorded in seven male samples (mm).

		INFMANDL		SYMPHYHT		SYMPHYBH		MENFORBH	
Group*	(n)	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
TONGA	13	65.00	6.28	30.00	2.48	14.08	1.75	11.62	0.77
WAIRAU	7	64.71	4.92	34.14	2.73	14.57	0.98	12.42	1.13
CHATHAM	6	65.33	4.84	37.67	1.86	16.50	1.22	12.83	0.75
LAKEBA	1	64.00		28.00		14.00		11.00	
NAMU	14	64.21	4.06	30.14	2.25	14.21	1.89	10.71	1.86
NATUNUKU	1	68.00		26.00		14.00		11.00	
NEWZEA	23	64.39	5.43	33.74	2.68	14.22	1.93	12.35	1.67

n = number of mandibles

* TONGA = 'Atele Mound Burials (1200 B.P. - 390 ± 110 yrs. B.P.) excavated by Davidson (1969) on Tongatapu, Tongan Islands; WAIRAU = Wairau Bar, South Island, New Zealand (1150 A.D. - 1450 A.D.); CHATHAM = Moriori mandibles from the Chatham Is. preserved in Dunedin; LAKEBA = cast of right Lapita-associated mandible fragment (500 B.C.) from Lakeba, Lau Group, Fiji Is. excavated by Best (1977); NAMU = skeletal remains dated between 1000 and 1600 yrs A.D. from Taumako Is., Duff Is. excavated by F. Leach; NEWZEA = Maori material preserved in Dunedin.

		CANINEBH		MOLARBH		RAMUSBTH	
Group	(n)	Mean	S.D.	Mean	S.D.	Mean	S.D.
TONGA	13	11.85	0.69	13.31	1.65	36.92	4.57
WAIRAU	7	12.57	1.51	14.71	0.76	38.57	1.72
CHATHAM	6	12.33	1.21	13.67	1.75	38.00	2.61
LAKEBA	1	10.00		13.00		31.00	
NAMU	14	11.43	1.65	12.50	2.24	35.14	3.78
NATUNUKU	1	12.00		13.00		33.00	
NEWZEA	23	12.13	1.58	14.43	1.75	36.65	3.70

n = number of mandibles

Table 14. Means and standard deviations for five mandibular measurements recorded in 18 male samples.

		BIGONIAL		SYMPHYHT		RAMUSHGT		RAMUSBTH		BICONDWD	
Group*	(n)	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
GULF	12	94.0	3.4	29.6	4.5	62.1	7.6	31.6	2.4	114.1	5.4
NEWBRIT	37	98.5	5.7	31.1	3.8	67.0	5.8	36.7	3.2	118.7	5.7
NEWIRE	9	93.4	7.8	29.7	3.8	62.8	5.9	33.3	3.5	114.6	4.9
NEWCAL	30	99.0	8.2	33.3	3.5	69.1	5.2	41.6	3.0	119.8	5.5
VANUATU	35	95.2	4.9	29.9	3.3	63.6	4.6	34.9	2.7	118.4	5.3
LOYALTY	21	101.1	6.1	33.4	2.6	67.5	5.3	40.9	3.5	118.9	4.5
FIJI	8	99.5	6.6	31.6	1.8	60.9	2.7	35.1	2.3	118.6	4.8
NAMU	9	96.8	4.7	29.4	2.0	66.9	7.1	35.0	4.1	120.1	3.7
GUAMAR	24	106.5	7.2	32.8	4.4	65.0	6.0	37.8	3.3	125.2	8.2
TONGA	16	100.5	7.6	30.4	2.3	64.4	7.3	36.3	3.6	125.4	9.2
SOCIETY	14	99.0	5.2	32.5	2.0	60.4	7.7	35.6	3.1	121.7	6.1
MARQUE	9	100.0	4.7	32.4	2.5	61.7	3.9	35.3	4.2	119.4	6.7
EASTER	14	96.9	4.8	31.6	4.0	60.3	6.0	38.5	4.3	122.4	4.4
NEWZEA	33	103.1	5.7	34.1	2.7	68.3	6.5	36.2	3.5	123.6	8.0
CHATHAM	10	110.7	6.0	36.6	2.3	72.5	2.5	38.0	2.4	126.7	5.1
HAWAII	30	103.3	5.5	33.0	3.3	64.9	5.8	37.9	3.9	128.8	7.2
NATUNUKU	1	100.0	–	26.0	–	60.0	–	33.0	–	114.0	–
GILMARSH	7	96.0	7.7	30.9	2.5	64.4	4.6	37.0	2.9	110.4	2.5

n = sample size

* GULF = Gulf District, Papua New Guinea; NEWBRIT = New Britain; NEWIRE = New Ireland; NEWCAL = New Caledonia; VANUATU = Vanuatu (New Hebrides); LOYALTY = Loyalty Is.; FIJI = Fiji Is.; NAMU = Namu, Taumako Is., Duff Group; GUAMAR = Guam, Saipan and Tinian Is.; TONGA - 'Atele prehistoric burial mounds on Tongatapu, Tongan Is.; SOCIETY = Tahiti and Tuamotu Is.; MARQUE = Marquesas Is.; EASTER = Easter Is.; NEWZEA = New Zealand Maori; CHATHAM = Chatham Is., Moriori; HAWAII = Mokapu, Oahu, Hawaiian Islands; GILMARSH = Gilbert and Marshall Is.

Table 15. Frequency of occurrence of three non-metric mandibular traits for 31 male samples[1].

	Mylo-hyoid bridging		Multiple mental foramina		Rocker jaw	
	n/N		n/N		n/N	
Lapita[2]	0/3	.00	0/5	.00	4/4	1.00
Tonga[3]	5/36	.14	3/36	.08	11/18	.61
Society	2/46	.04	3/46	.07	21/23	.91
New Zealand	3/27	.11	5/28	.18	12/14	.86
Chatham Is.[3]	2/16	.12	2/16	.12	8/8	1.00
Easter Is.	3/32	.09	7/34	.21	14/17	.82
Marquesas[4]	3/23	.13	1/25	.04	12/12	1.00
Wairau Bar[3]	0/19	.00	0/25	.00	11/12	.87
Hawaii	5/90	.06	2/92	.02	40/46	.87
Tinian-Saipan	2/22	.09	4/24	.17	7/10	.70
Gilbert-Marshall[5]	0/12	.00	0/12	.00	6/6	1.00
Namu[3]	0/20	.00	1/20	.05	4/10	.40
Vanuatu	0/16	.00	1/34	.03	11/17	.65
New Caledonia	7/59	.12	11/59	.19	15/30	.50
Loyalty[6]	1/56	.02	6/56	.11	8/28	.29
Solomon Is.	2/42	.05	4/42	.10	18/19	.95
Admiralty	2/29	.07	4/30	.13	9/13	.69
New Ireland	1/43	.02	5/44	.11	14/18	.78
New Britain	16/129	.12	25/130	.19	35/65	.54
Gulf District	1/132	.01	10/126	.08	59/61	.97
Sepik	0/33	.00	3/34	.09	15/17	.88
Fiji[5]	8/26	.31	0/13	.00	10/13	.77
China	2/37	.05	5/74	.07	27/37	.73
Japan	0/104	.00	12/104	.12	35/52	.67
S.E. Asia	4/112	.04	9/114	.08	42/67	.63
Philippines	2/24	.08	1/24	.04	10/12	.83
Sulu	2/32	.06	2/34	.06	13/17	.76
S. Moluccas	0/26	.00	4/26	.15	8/12	.67
Lesser Sundas	0/30	.00	4/34	.12	12/17	.71
Borneo-Celebes	10/90	.11	7/92	.08	40/45	.89
Java	5/148	.03	13/148	.09	55/74	.74

[1] Except for those cases indicated below, these data are taken from Pietrusewsky (1984).
[2] This sample combines data on the Lapita-associated mandibles presented in Table 5.
[3] These samples correspond to those used in the multivariate analysis of mandibular measurements (Pietrusewsky, 1985b).
[4] This sample consists solely of mandibles from the prehistoric Hane Dune site described by the author (Pietrusewsky, 1976).
[5] Data recorded on Fijian mandibles are from Pietrusewsky (1969a).
[6] These samples are taken from Pietrusewsky (1977).

Appendix B

Inventory of major human bone fragments identified in the Natunuku material.

Skull
- Right mandibular fragment
- Right zygomatic bone fragment
- Frontal fragment (left side)
- Occipital bone fragment

Dentition
- 5 isolated teeth (upper right M2, lower right and left C, right and left I2)

Thorax
- Fragment of left scapula (glenoid cavity)
- Rib fragments
- Vertebrae fragments

Right arm
- Humerus shaft
- Radius: proximal end of shaft
- Ulna shaft fragment

Right hand
- Carpals: hamate, lunate, triquetrum
- Metacarpals: MC-3 (proximal end missing)
- Phalanges: 2 proximal (for MC-2 and 3); 2 middle (for MC-3 and 4)

Left arm
- Humerus: small fragment from head region
- Radius: distal shaft
- Ulna: distal shaft

Left hand
- Carpals: capitate, trapezium, lunate
- Metacarpals: MC-1 (distal fragment); MC-2 (extremities missing); MC-3 (distal extremity missing)
- Phalanges: proximal and distal phalanges for thumb; one proximal fragment (for MC-3); 4 middle phalanges (for MC 2-5); 2 distal phalanges (for MC 3 and 4).

Pelvis
- small fragments

Right leg
- Femur: shaft fragment
- Tibia: shaft fragment
- Fibula: shaft fragment

Left leg
- Femur: major shaft fragment and small head fragment
- Tibia: major shaft fragment
- Fibula: major shaft fragment
- Patella: fragment