THROUGH A GLASS DARKLY:

present and past land-use systems of Papuan sagopalm users

by

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Appendices
Precise modelling of flood patterns is contingent upon having information on a wide range of variables. These include hydraulic controls which are broadly stable over long periods, such as channel characteristics, drainage networks and basin morphology. One must also consider a series of transient controls, such as storm characteristics, vegetation interception, evaporation, infiltration and the water storage capacity of the basin (Rodda 1971: 164). As there are instances where the measures of many of these factors are unavailable, the description of flood patterns must frequently be based upon general hydrological principles and comparable studies for other areas.

Most, if not all, of the hydraulic controls operating in the Kikori River Basin have not been the subject of analysis. Certainly the most crucial evidence for modelling, long-term records of river flow, is not available. On the other hand, the climatic data and estimates of ground storage and runoff are available (McAlpine et al. 1975: 110; McAlpine 1979: pers. comm.). As the data base is incomplete, the flood pattern calculated for the Waira plain is intended to depict only the general order of magnitude of wet season flooding.

Plain Characteristics

As defined in this study the Waira plain is the alluvial reach of the Kikori River, on which Waira Village is situated, and is circumscribed by the 40 metre contour of the karst plateau lying along its margin (Fig. 1.1). In cross-section the plain's form is roughly that of a steep-sided dish and its area is 315 square kilometres.

The Kikori River bisects the plain from north to south. The Sirebi River enters from the east and joins the Kikori near the centre of the area. The Pinini Creek drains the northwestern portion of the plain and probably an area beyond the margin of the Waira plain. A limited area of the eastern karst border serves as the catchment for the Ario Creek. The drainage network throughout most of the plain
consists of small sinuous streams which carry some water during most of the year. Daily tidal fluctuations affect the water level in both of the major rivers.

The soil generally comprises alluvial clays. However, peat occurs in lowlying localities and fine gravel is often included in the clay matrix of river embankments. The soil horizons overlie limestone bedrock to a depth of from one to two metres (Loffler 1977: 57). The vegetation cover is primary swamp forest and lowland rain forest (Paijmans 1976: Fig. 22, 49-62).

**Estimation of River Flood Intensities**

The calculation of overbank flows accounts only for the contribution of the Kikori River. The effect of flooding from the Sirebi River, runoff originating in the plain's perimeter and tidal fluctuations are omitted. The formula used to compute the height of overbank flow is

\[ Q_f = \frac{(Q_m - Q_b) (n)}{A} \]  

where

- \( Q_f \) = river flood level (m);
- \( Q_m \) = mean annual flood (m\(^3\)/sec);
- \( Q_b \) = channel capacity (m\(^3\)/sec);
- \( n \) = the ratio of the flood flow to the mean annual flood;
- \( T \) = length of the rainless period following a storm (sec.)
- \( A \) = the area of the plain (m\(^2\)).

This equation simply expresses the effect of the overflow of a predictable quantity of liquid from a container of known volume. In other words, if a container (i.e. a river channel) is filled then any liquid which is subsequently put in the vessel will overflow. Therefore, if another container (i.e. the flood plain) is available to catch the excess then it will be filled to a depth which can be calculated by dividing the volume of the overflow by the second container's area and
then multiplying the quotient by the length of time such a discharge is maintained.

Using the 29 months of river flow records for the Kikori River gauging station at Kalam Village, which is situated at the head of the plain, the bankfull discharge of the Kikori River is estimated to be $4.61 \times 10^3 \text{ m}^3/\text{sec}$. The value for the mean annual flood is computed following the general principle that the channel capacity is filled by the 1.5 year flood. The actual level of discharge for the mean annual flood ($Q_m$) is derived by reference to the flood-frequency curve illustrated in Leopold, Wolman and Miller (1964: 64). Although their determination is based on studies conducted in the United States, the curve is likely to be applicable to the Waira setting because the contribution of Spring snow melt to the flood pattern of these American rivers is analogous to that of the intense wet season rainfall to the Kikori River. In absence of other more appropriate data their curve is used to predict the magnitude of flood discharge for various recurrence intervals. On this basis, the mean annual flood follows those values given in the cited study and are applied in determining the discharge rate ($Q$) of the 5, 10 and 50 year floods:

$$Q_5 = 8.06 \times 10^3 \text{ m}^3/\text{sec},$$
$$Q_{10} = 1.21 \times 10^4 \text{ m}^3/\text{sec},$$
$$Q_{50} = 1.44 \times 10^4 \text{ m}^3/\text{sec}.$$  

The length of the rainless periods between storms (Table 1.1) is computed on a weekly basis and is derived from an analysis of rainy and rainless periods for Kikori Station (McAlpine et al. 1975: 110). The assumption underlying the use of only rainless periods is that peak discharge usually occurs after a storm (Rodda 1971: 162).

**Basin Water Storage**

Before finalising the flood level throughout the Waira plain consideration must be given to the potential for excess water to accumulate in the soil horizons and to the runoff from rain falling within the plain. Figure 1.2 depicts the mean weekly soil moisture storage for the area (cf. Keig and McAlpine 1974 for a description of
the analytical method used to compute this information). With the exception of a brief period towards the end of the year, 150 mm of water (i.e. maximum ground water storage) is stored in the plain. Figure 1.3 is the plot of the mean weekly water surplus, smoothed by harmonic analysis. Since the ground water storage capacity of the plain remains filled during the entire wet season, the runoff figures are added to the weekly river flood level to derive the flood height (D) throughout the basin on an annual basis. When computing the weekly runoff during a period of 5, 10 or 50 year floods, point runoff is recalculated to compensate for an increase in rainfall in the plain. The percentage increase is derived from an analysis of the probability that rainfalls of a certain magnitude may occur (McAlpine et al. 1971: 66). Table 1.2 presents their findings. The upper quartile values indicated in the rows labelled 75, 90 and "highest" are used to estimate the runoff for the 5, 10 and 50 year floods respectively.

Wairi Plain Flood Levels

The formula now used to compute flood levels is

\[ D = (Q_w + Q_r) + \frac{(P_s - P_m)}{P_m} (Q_r), \]

where, 
\( D \) = flood depth (mm);
\( Q_w \) = weekly river flood level (mm);
\( Q_r \) = average weekly runoff (mm);
\( P_s \) = seasonal monthly precipitation (mm);
\( P_m \) = mean monthly precipitation (mm).

Table 1.3 lists the values for each of the variables used and the calculation of weekly flood levels. Two further assumptions are incorporated in the table. Firstly, the flood waters originating in the upper catchment of the Kikori River do not reach the Waira area until the fourth week after the beginning of the wet season. Secondly, water stored in the upper catchment continues to contribute to overbank flows in the Waira plain for three weeks after the end of the wet season.
I wish to acknowledge the assistance of G. Pickup (North Australian Research Unit, ANU) and J. McAlpine (Division of Land-Use, CSIRO). Both have permitted me to use their unpublished data. I sincerely thank M. Sullivan (Department of Anthropology and Prehistory, ANU) for guiding a novice through the hydrological literature and for providing much of the stimulus and encouragement which facilitated this analysis.
APPENDIX 2

DESCRIPTION OF FOUR EXPLOITED SAGOPALM STANDS

Informant reports during my first field season indicated not only that the Kairi employ sophisticated sagopalm management techniques but also that such measures are necessary to establish a vital stand of palms in the area. Direct verification was not possible within the study area because the people of Waira Village had no need to construct another palm stand. Although I did observe such an occurrence in a comparable setting just on the northern outskirts of Kikori Station, I still had no independent evidence to conclude that the stands near Waira were not natural. The resolution of this issue is most crucial because any determination I make concerning prehistoric land-use patterns must include the distributional characteristics of *Metroxylon* palms.

The use of vegetational transects and associated profile diagrams was suggested to me by Geoff Hope (Department of Geography, ANU) as an economical method by which to investigate this question. Transects provide an assessment of the range of variation within a stand, but it should be acknowledged that the results presented in this discussion are not a quantitative measure of stand variability.

Four sagopalm stands were studied, representing a range of usage histories. The margin of each stand, as defined by local informants, was surveyed by chain and compass. I then established a 200 m long baseline running from the edge toward the centre of a stand. Distance markers were placed at 5 m intervals. I next mapped the distribution of the following items which appeared within 5 m of either side of the line: *Metroxylon* palms, individual occurrences or clumps of palm suckers, plants of traditional economic importance and mature trees. I also measured the chest height circumference and height of individual tree and palm boles. The girth of plank trees with large plank buttresses was rarely gauged. The height of trees and palms was determined by sighting along the top of a rod of known height to the base of the tree's crown and then measuring my distance and that of the rod from the base of the tree. Using the mathematical ratio of
the sides of similar right triangles the height was easily calculated. Along each transect I made general notes on the density of lower story vegetation and the types of plants forming the ground cover. The local name for each sagopalm was recorded for three stands; the names of large trees were collected for all transects.

I did not have time to collect botanical specimens of the various types of trees appearing in the transects. However, Reg MacFadzean, a local sawmill proprietor, had made a botanical collection of desirable timber species and had obtained identifications from the Lae Herbarium (pers. comm. 1977). The tree species, listed in Table 2.1, have been tentatively identified using his cross-index of scientific names and local Kairi names.

I now describe the environmental setting, exploitation history and vegetation patterning for each transect. The exploitation history is a compilation of informant reports and evidence from historical documents.

**Nodoro Palm Stand**

The Nodoro palm stand is situated 2 km south of the Sirebi River and covers 14.9 ha (Fig. 2.1). The area in which this stand is situated is bounded on the east and south by the lower slopes of a karst plateau and on the west and north by several very large cone karst hills. The Hevere Creek, whose source is a nearby doline pond, runs through the palm stand. Several smaller streams which drain the karst plateau also flow into the general area of the stand but have no well defined outfall into the Hevere Creek, which eventually carries their waters out of the region.

The contact village site of Nodoro is located within 0.5 km of the stand, which served as the primary starch resource for the people living there. Nautama, the oldest man living at Waira, spent his early childhood at Nodoro Village and claims that the men's house there when he was born was the fifth successive *dubu* built at Nodoro. If the planting of the stand was closely followed by the first construction of Nodoro Village, I estimate a minimum age of 200 years for the stand.
In 1918 the people living at Nodoro resettled at Poialaviti, in compliance with the requests of Australian government officials. The shift in village site was swift and probably did not allow sufficient time to establish a new stand at Poialaviti. Presumably for at least the next 10 to 20 years, during which time the new stand reached maturity, women must have frequently walked the 4 km to the Nodoro stand to process starch.

Since approximately 1935, the stand has slowly dropped out of use. Its exploitation has probably diminished significantly since the founding of Waira Village. Today, palms are occasionally felled by hunters to serve as a lure for feral pigs. Family groups who infrequently camp in the area process starch from Nodoro palms.

Figure 2.2 illustrates the vegetation pattern along the surveyed transect (see also Plates 2.1, 2.2). The upper canopy is generally 30-35 m high with emergents reaching 50 m. Tree species present in the upper canopy include Areca sp., Ficus sp., Pandanus sp., Terminalia sp., and Elmerilla papuana. Lagerstromia sp., Dysoxylum sp., Pterocymbium sp. and Elmerilla papuana appear as emergents. The understory of well developed saplings is quite dense except between 60-80 m and from 160-200 m along the transect, at which localities Araceae (aroid lilies) replace swamp pandans as the dominant ground cover. Metroxylon palms occur irregularly along the transect and range between 15-28 m in height. Palm suckers appear in dense clumps usually situated very close to parent palms. Of particular note is the occurrence of the stump of a felled sagopalm at 75 and a sagopalm at 72 m which had lost its seeds.

Poialaviti Sagopalm Stand

This stand lies approximately 0.5 km inland from the bank of the Sirebi River opposite Waira Village (Fig. 2.1). The stand comprises 16.7 ha and is in a backwater swamp drained on the west by the Poiala Creek. Surface water run-off appears from my observations to be very slow. Wet season overbank flow would most certainly flood the area.

The planting of the Poialaviti palm stand was probably contemporaneous with the construction of the nearby village. The exploitation of the stand would have begun a minimum of seven years later with the maturation of the first suckers planted.
Plate 2.1  Nodoro swamp transect:  
20 - 40 m

Plate 2.2  Nodoro swamp transect:  
180 - 200 m
Since the abandonment of Poialaviti in 1961, this sagopalm stand has received progressively less attention. My field informants report that only palms in the western portion of the stand are currently exploited for starch. From my observations its use as a source of food for domesticated pig populations is its most important function today.

The vegetation pattern along the transect is illustrated in Figure 2.3 and Plates 2.3, 2.4. The upper canopy over the first 100 m is very open and includes only *Metroxylon* palms and *Terminalia* sp., which informants report were planted. The luxuriant ground cover in this area of the transect consists for the most part of Araceae, with grass and ferns dominating the first 20 m. Beyond 120 m the canopy is closed and trees, most of which appear to be immature, are very dense. Only swamp pandans occur as ground cover in this section of the transect.

*Metroxylon* palms usually range from 3-20 m in height; however, the two sagopals at the margin of the dense jungle reach unprecedented heights of 30 and 35 m. Large clumps of *Metroxylon* suckers occur between 5-10, 45-50, 65-75 and 105-110 m. The stumps of five felled sagopals are present along the transect. A pith processing platform which was used six months prior to the survey appeared just beyond the southern boundary of the transect at 40 m.

**Oboro Sagopalm Stand**

The Oboro sagopalm stand is located just inland from the Kikori River adjacent to the abandoned site of Oboro Village (Fig. 2.1). Its natural setting is similar to that of the Poialaviti stand with the exception that the area appears to be better drained. During none of my many visits there did I note long periods of standing water. Wet season flooding would affect the area.

The stand was first planted in the late 1930s/early 1940s, presumably not long before Oboro Village was established in 1941 (Chance 1941). Oral history suggests a pre-contact village was also located in the same area; therefore, the present-day stand may have been an expansion of a previously exploited stand. Today, the Oboro sagopalm stand covers 17.5 ha and is regularly exploited by members of Waira Village who originally lived at Oboro.
Plate 2.3  Poialaviti swamp transect: 40 m looking south along transect
Plate 2.4   Poialaviti swamp transect:
100 m looking north along transect

Plate 2.5   Waira swamp transect:
0 m looking north along transect
Figure 2.4 illustrates the vegetation pattern along the transect. Apart from the areas at the beginning (0-30 m) and end (165-200 m) of the transect, only *Metroxylon* palms form the upper canopy along the transect. The area at the beginning of the transect lies along the inland slope of the river levee. Here the upper canopy is 30-40 m high and consists of *Pometia* sp., *Caryota* sp. and *Pterocarpus indicus*. *Pometia* sp. and *Pterocarpus indicus* appear as emergents. *Elaeocarpus* sp. is the only identified tree genus occurring in the upper canopy toward the eastern end of the transect. Between 125-200 m there is a well developed lower story of young saplings, but these trees are never dense. Araceae form the dominant ground cover along the entire transect. Grass and ferns are also present from 40-80 and 140-160 m.

*Metroxylon* palms are very dense along most of the transect and are most usually 9-13 m in height. Palm suckers occur in large numbers between 45-115 m. The transect also includes the stumps of six felled sagopalms.

**Waira Sagopalm Stand**

The Waira sagopalm stand occupies 18.6 ha of generally low-lying ground adjacent to Waira Village (Fig. 2.1). It is drained on the east by Napara No. 1 Creek and on the south by Napara No. 2 Creek. The area in which the stand appears experiences seasonal droughts, when the water-table drops to 40-60 cm below ground surface. Although similar observations were not made for the three other sagopalm stands, I do not doubt that they too are affected by droughts. Wet season overbank flow invades the stand locality, but perhaps not to the same magnitude as at Oboro and Poialaviti since the river levee fringing the stand rises, on average, approximately 2.5 m above high tide. The observations I made of the soil horizons in the stand area suggest alluvial silts and clays from 30-50 cm deep overlying muck peats which extend well below.

The Waira stand was planted in approximately 1955 by Tovi Aupoae, who used the stand and the coconut plantation he also cultivated as an enticement for the Poialaviti villagers to resettle at Waira. Today, the stand is regularly exploited for palm sago, and this starch resource supplies the dietary needs for the majority of people living at Waira.
The vegetation pattern along the transect is illustrated in Figure 2.5 and Plates 2.5-2.7. The lower slope of the river terrace, upon which Waira Village is situated, is included in the first 10 m of the transect. In this area the villagers have planted *Syzygium* sp., *Terminalia* sp. and *Cocos nucifera*. The canopy from 10-110 m is open and generally consists only of *Metroxylon* palms. Araceae and grass are the primary types of ground cover in this area of the transect. Ferns also appear in the first 70 m. From 110-180 m the upper canopy is more closed and averages 25 m in height. Trees which form the canopy in this area include *Spondias* sp., *Dracontomelon* sp., *Xylocarpus* sp., *Pometia* sp., *Pandanus* sp. and *Terminalia* sp. Among the second story trees in this area are *Lagerstromia* sp., *Caryota* sp., *Ficus* sp., *Pterocyrum* sp. and *Dysoxylum* sp. A scattering of young saplings and a light ground cover of vines appear from 115-140 m. Araceae form the dominant ground cover between 140-180 m, with swamp pandans appearing in the last 20 m. A dense stand of bamboo occurs from 180-195 m.

The majority of *Metroxylon* palms appear from 5-110 m and their height range is 8-11 m. Palm suckers are dispersed throughout the length of the transect, but very few occur between 125-160 m. The isolated palm sucker at 136 m is reported to have been planted. Fourteen stumps of felled sagopalm occur within the surveyed area.

**Analysis**

To preface my analysis of the four vegetation transects I first describe the characteristics of the primary rain forest which occurs in a lowland alluvial plains environment in New Guinea. According to Paijmans (1976: 49-51) they are:

1. floristic diversity;
2. considerable variability in structure among all layers;
3. a rather open canopy which averages 30-35 m in height;
4. irregularly scattered emergents which attain a height of 50 m or more;
Plate 2.6  Waira swamp transect:  
50 m looking east of transect

Plate 2.7  Waira swamp transect:  
120 m looking north along transect
5. upper story tree species which always include *Pometia primata*, *Ficus* spp., *Alstonia scholaris* and *Terminalia* spp.;

6. a rather open lower tree story;

7. a variable cover and density of the shrub and and tall herb layer;

8. an irregular and patchy ground cover;

9. a common appearance of woody lianes, epiphytic climbers and climbing ferns.

These characteristics clearly demonstrate that, with the possible exception of the Nodoro sagopalm stand, the vegetation patterns of the stands are not those of a mature lowland closed forest. Although I failed to survey areas other than sagopalm stands, the reconnaissance transects conducted in the region by Grey (1959) describe a vegetation pattern which closely resembles that of a primary rain forest.

Richards (1959: 379-83) notes the general characteristics of a 'typical' secondary rain forest to be:

1. a low and even canopy;

2. a regular and uniform forest structure;

3. a restricted number of species present;

4. the predominance of light-demanding species;

5. the presence of species characterised by rapid growth, a short life span and efficient dispersal and propagation.

This characterisation best describes the vegetation pattern along most transects. While this evidence supports general field observations concerning the highly disturbed context in which most sagopalm stands occur, it does not provide conclusive evidence with regard to the necessity of human intervention in promoting a dense stand of *Metroxylon* palms.

Table 2.2 lists a number of the descriptive indices of *Metroxylon* palms growing along each transect. A comparison of individual attributes between stands illustrates differences which directly
correspond to the intensity of contemporary human exploitation. The density of discrete groupings ('clumps') of palm suckers and the number of suckers belonging to individual palms in the Nodoro and Poialaviti stands suggest that palm growth is closely related to the maintenance of the reproductive potential of individual plants. In both of these stands I observed a high degree of associability between sucker clumps and parent palm. As well as this, the density and average height of mature palms suggest that the palm communities in both stands are in stress due to competition from other plant species. By comparison, the Oboro and Waira *Metroxylon* palm communities evidence a more healthy state where palm regeneration regularly occurs.

Based on these findings it is my contention that the natural occurrence of *Metroxylon* palms within the environment of the research area is commonly characterised by isolated palms or small groups of palms widely dispersed throughout the rain forest. The vegetation pattern along the Nodoro transect most probably illustrates this situation. Casual human exploitation of *Metroxylon* palms (e.g. Poialaviti stand) promotes an increase in the localised density of palms but does not alone secure a competitive advantage for sagopals. Therefore, the occurrence of large and dense stands of *Metroxylon* palms, which are necessary to support a sedentary population in the area, requires the creation and maintenance of an environment in which the succession of other plant species is deflected by human intervention.

**Conclusion**

The contemporary distribution of *Metroxylon* palms in New Guinea includes many environments where local conditions do not directly favour the growth of dense and hardy palm stands. The human groups which largely subsist upon the starch exploited from such stands most usually consist of more than 30 adults and are relatively sedentary. Based upon the evidence presented above I am led to hypothesise that:

1. much of the present-day sagopalm distribution is anthropogenic;

2. persistent human exploitation and/or palm cultivation are responsible for the presence of contemporary stands.
These views represent a substantial reorientation of the commonly held attitude that sago users subsist upon the bounty of the land. If borne out by further work, it strengthens the case for a considerable antiquity for the exploitation of *Metroxylon* palms in New Guinea.
APPENDIX 3

WAIRA VILLAGE NON-SUBSISTENCE ACTIVITIES

The information in this appendix primarily centres upon the non-subsistence work activities which I monitored from 1 March to 15 June 1977. The record I kept only accounts for organised work activities which were usually conducted by groups of people; therefore, it omits the more casual or routine work tasks which frequently occur at an individual's house. To preface the major considerations of this appendix I describe in very general terms the daily work habits of the people living at Waira. This discussion is entirely based upon my experiences while living with John Tovi and his family over a period of roughly two months and upon the understanding which arises from an affiliation with a community of people.

In distinct opposition to the work habits of men, those tasks performed by women usually fall into a clear daily routine. By first light married women or their adolescent daughters have arisen to kindle their cooking fires and have begun the preparation of sago for the morning meal. Meat or fish not eaten during the previous night's dinner is reheated either directly on the coals or in sections of bamboo. However, since such left-overs are rarely available, leaf greens collected the previous day are steamed in bamboo and served with sago.

After the meal is cooked the woman tidies the kitchen and makes preparations for her daily work activity. Most, if not all, women belonging to a single household leave the village by eight o'clock to work in sago stands or gardens or to fish. With few exceptions, women do not return to the village until much later in the day. If a woman chooses not to work away from the village, she occupies the day mending clothes and repairing or making carrying bags. These tasks are usually performed in the company of other women. On the two occasions when new houses were under construction, women remained at home to plait mats of sagopalm leaf stem fibres which are used as wall partitions. When a house is ready to be roofed, most women of the village participate in the thatching.
Women begin the preparation of the evening meal immediately upon returning from activities conducted away from the village. Dinner is served at dusk and after its completion the kitchen area is set in order. Rubbish, which consists mainly of bamboo sections used to cook sago, is cast away into the river and left-over food is stored in a loft above the fire. The remainder of the evening and sometimes much of the night is spent chewing betel nut and conversing with family and friends.

The daily work activities of men are variable in their timing and thus appear very whimsical. Men usually spend brief periods of a few hours during the morning or late evening hunting or fishing away from the village. Longer trips directed toward these subsistence pursuits or major construction projects, such as canoe building, are most often initiated during the very early morning. It is not, however, uncommon for men to stay in the village for an entire day. On these occasions they may devote a considerable amount of time to refurbishing their hunting and fishing equipment or perhaps constructing replacement items. Card playing and lengthy discussions with their neighbours also occupy a portion of the time men spend in the village.

During the construction of a new house men are responsible for the task of collecting most of the building material. As well, they set the stilt foundation and build the shell. All of the heavy work is carried out by groups of men; however, the owner of the house may work alone while constructing the wall sections and roof.

MONITORED WORK ACTIVITIES

Peter's household

Over 80 percent of this household's non-subsistence work units are related to construction projects (Table 3.1). Over two-thirds of this total, as well as the majority of the time spent in komboki at Waeamu during April and early May, involves the building of a new canoe which was modified to accommodate the use of an outboard motor. Ape's assistance to Kororu's household in the construction of a permanent shelter at the Oboro bush locality accounts for the remaining construction work units.
Figure 3.1 portrays the percentage distribution of work units expressed areally. The graph comparing labour expenditure away from Waira and from the Waeramu sagopalm stand reiterates the pattern noted for subsistence activities. In other words, the vast majority of time spent in these activities is centred from the sagopalm stand. In this case 90 percent of labour expenditure occurs within 1 km, which is a considerable contraction of the distribution of subsistence activities.

Oboro landholding unit

Over 80 percent of the labour expended in non-subsistence activities by the households of Kororu and Lanagae consists of construction projects (Table 3.2). Approximately two-thirds of this total is related to Kororu's household constructing a kombati shelter in the Oboro bush. The majority of the remaining work units result from the construction of Lanagae's new "motor canoe". It is important to note that for a small percentage of the time Kororu's household assisted Peter and Kirokoe in the labour-intensive task of "turning" their partially completed canoes so that the bow was properly directed toward a direct course to the nearest source of flowing water.

The remaining non-subsistence work units are equally divided among fetching and carrying firewood, drinking water and bamboo for cooking on the one hand and duties involved in Kororu's tending his infant son while Perese processed sago.

Figure 3.2 illustrates the areal distribution of non-subsistence work activities. For this landholding unit 95 percent of the labour expenditure in these pursuits occur within 1 km of the primary sagopalm stand. A comparison of the distribution of labour from the village with that from the sagopalm stand supports the deductions made for subsistence activities.

Poialaviti landholding unit

This is the only group within the village actively engaged in cash cropping. This activity comprises 5 percent of the labour expended in non-subsistence tasks observed over the study period. During my stay in Waira this group's cash income was supplemented by wages paid to its members who assisted me in my work. In the following account of
non-subsistence activities I do not include the 185 man-days devoted to such work.

Approximately 70 percent of all monitored non-subsistence activities are directed toward canoe construction (Table 3.3). More than 46 percent of the time spent in such tasks is related to the production of canoes for the two men who returned to Waira in March after working on copra plantations near Port Moresby. The remaining time represents the building of a canoe adapted for an outboard motor whose construction I contracted in November 1976.

Figure 3.3 describes the areal distribution of non-subsistence activities for this group. More than 90 percent of labour expended in such tasks occur within 1 km of Waira Village and this group's primary sago stand.

SUMMARY

The areal distribution of non-subsistence activities for each landholding unit demonstrates a very strong orientation toward the site of a group's primary sagopalm stand. This result substantiates observations of the patterning of subsistence activities.

It is difficult to assess whether the emphasis upon canoe construction represents a frequently reoccurring activity or a series of events particular to the recording period. The dry season is clearly the most advantageous period for this activity and it is doubtful that canoe construction at this time of the year would conflict with other major work activities, such as the development of new garden plots. Therefore, there may be some yearly replacement of canoes by individual men. On the other hand, outboard motors are very desirable commodities and it would appear that recent cash flow into the village is being directed toward purchasing them. This could well explain the emphasis on canoe building at the time of my research there.
APPENDIX 4

KOMBATI ACTIVITY PATTERNS

The following information was gathered while I lived in kombati near the Herekuna rock shelter, which I was excavating at the time. My daily work load prohibited my accompanying the people and making direct field observations. Instead, I interviewed the kombati inhabitants during lunch and evening meals. The daily work activities were recorded in the same manner as the more detailed study I conducted at Waira Village (see pp. 47-50).

The kombati was situated along the southern bank of the Hevere Creek and consisted of four open-sided huts (Plate III-25), three of which were constructed when I began major excavations at Herekuna in February 1977. Each structure consisted of two parallel rows of 50-75 cm high side roof posts with two or three 1.5 m centre posts supporting the ridge pole. Two layers of leaves comprised the thatch roof. The underlayer was made of broad Araceae leaves which were tightly interwoven into a sapling lattice. On top of this was laid a thick layer of palm fronds, which were also used to cover the shelter floor. A maximum of two to three man-hours was devoted to shelter construction.

The impetus prompting this kombati residence was my excavation of the Herekuna shelter. I originally thought the company would include only my work force of three men and John's family; therefore, the night prior to our departure I set out provisions of rice and tinned meat and fish. The next morning when I arrived at the Waira canoe landing I learned from John that the stores had been returned to my cupboard because they were not needed: "Only a white man would take food to a free market!" My increduality was quickly laid to rest with the swelling of our company to 13 men and women. It soon became clear that excavation had now assumed only an ancillary role at the kombati. As I now cast my mind back over these events and the time during which I lived in kombati, I have no doubt that my preoccupation with archaeology inhibited my full appreciation of a truly unique experience during my research.
The provisions taken into the bush included two small bundles and two bags of sago, which weighed approximately 35-45 kg, and several coconuts, which were eaten en route to Herekuna. All of the men carried their bows, and John took his shot-gun along as well. Three of the women brought their sago chopping implements and most had a fishing line and hooks stored in their carrying bags.

We arrived at the kombati at 1400 hours on 19 March. We returned to Waira at roughly the same time three days later, when I concluded excavations at Herekuna. The second day we were joined by three other women.

Table 4.1 lists the labour expenditure for each work activity. Hunting and fishing comprise 70 percent of the time spent in all activities. The participation by men and women in these activities is roughly equivalent. This result is rather surprising, since an additional 34 work units were expended by married men assisting me with excavations. Subsistence activities of particular note include the use of fish poison at the Hevere doline pond by a group of three women on 20 March (see pp.37-38) the collecting of sago grubs on three separate occasions and the gathering of pith from a sagopalm which had already produced seed (see p. 83).

While at kombati the people exploited ten resource localities. The Nodoro sagopalm stand and the Hevere doline pond were each visited more than twice as often as any other area. Together they were the focus of 50 percent of the total labour expenditure. Activities conducted at the Nodoro palm stand include sago processing, hunting, collecting, gathering and fetching firewood. People hunted and fished at the Hevere pond locality.

Figure 4.1 is a one-dimensional representation of the areal distribution of all work activities. All utilised resource localities occur within a 1.5 km radius of the kombati and the distribution of labour is roughly equivalent for each 0.5 km zone. The individual occurrences of work tasks drops dramatically from 31 for the inner zone to 7 for the outer.
The daily subsistence returns are listed in Table 4.2. The captured animal food evidences a strong bias toward aquatic resources. This orientation is further supported by the fact that no terrestrial fauna was procured when men went out only to hunt. With the exception of palm starch, plant food, all of which was obtained from wild or feral resources, comprises only a very small percentage of returns.
APPENDIX 5

WAIRA VILLAGE FOOD RETURNS AND GENERAL HEALTH

The information reported in this appendix was collected while I monitored village work activities between 1 March and 15 June 1977 (see pp. 47). With two exceptions this evidence only denotes the presence or absence of items belonging to general food categories among the returns of daily work activities. The numbers of game types (e.g. pig, cassowary, wallaby, canopy birds, ground-dwelling birds, etc.) killed and brought back to the villages were recorded. The numbers of aquatic fauna (i.e. fish, prawns, shellfish, etc.) were generally reported according to individual number by my informants up to 20 items. Catches exceeding this fell into a category they termed "plenty". Since I never asked the people to stipulate the actual number of items which were included in their reports of a plentiful catch, I assume for purposes of analysis that a minimum of 15-20 items is indicated by "plenty". At no time did I attempt to weigh any group of food items brought back to the village.

In Figures 5.1-5.9 I describe the occurrence of different food items in the returns of daily work activities of individual work groups for each village household (see pp. 23-24). Table 5.1 summarises this information by daily household occurrence for plant and animal foods. With regard to plant food this analysis highlights the importance of semi-cultivated and gardened green vegetables in the diet of Waira villagers. Furthermore, palm sago is clearly demonstrated to be the starch staple. Among animal foods aquatic resources occur approximately five times more frequently than the remaining faunal resources. Fish appear in roughly the same frequency as all other animal foods. Moreover, the catch of fish over the sample period indicates that on one day in six every member of a single household had at least one fish to eat.

From very general personal observations I conclude that malnutrition is not a serious component influencing the health of adults or juveniles living at Waira. However, I do not judge the general health of the villagers to be particularly good. At least
once every fortnight someone came to me seeking medicine and evidencing very obvious symptoms of malaria. Skin fungus was noted in a very advanced stage of development in at least two adult males and two juveniles. The presence of such on any individual had very serious repercussions for adolescent and adult males and females because these people were judged by the Kairi as socially unsuitable for marriage.

There is a history of premature death for young adults (R. MacFadzean 1977: pers. comm.). Since many deaths are judged by the Kairi to be the result of sorcery, individuals do not seek European medical assistance; therefore, many people are buried before an autopsy is made. While I was in the village a young woman died. My unqualified diagnosis is that she suffered from a peptic ulcer. Within a year after I left the village three individuals died (U. Kirokæ 1978: pers. comm.). They were Nautama, Kororu and Perese. Nautama was born prior to the first Australian government patrols to the area. While I lived in the village he was often sick with respiratory illnesses; therefore, he very probably died of pneumonia. Kororu and his wife Perese were approximately 35 and 25 years old and in a very good state of health when I left Waira. Their deaths, which came as a grievous shock to me, were reportedly due to sorcery.
# APPENDIX 6

## LISTING OF ARCHAEOLOGICAL SITES IN KIKORI KAIRI CENSUS DIVISION

<table>
<thead>
<tr>
<th>Site Name</th>
<th>Geographical location</th>
<th>PNG site no.</th>
<th>Type of site</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abikomate</td>
<td>7°12'S, 144°14'E</td>
<td>OCZ</td>
<td>cave</td>
<td>ossuary</td>
</tr>
<tr>
<td>Aetemate</td>
<td>7°13'S, 144°14'E</td>
<td>not yet assigned</td>
<td>rock shelter</td>
<td>shellfish on surface</td>
</tr>
<tr>
<td>Amaho</td>
<td>7°16'S, 144°9'E</td>
<td>ODC</td>
<td>rock shelter</td>
<td>shellfish, human bone, shell artefacts to 10 cm</td>
</tr>
<tr>
<td>Bagelma</td>
<td>7°18'S, 144°11'E</td>
<td>ODL</td>
<td>open</td>
<td>see thesis discussion</td>
</tr>
<tr>
<td>Eke</td>
<td>7°20'S, 144°16'E</td>
<td>not yet assigned</td>
<td>rock shelter</td>
<td>only shellfish to 10 cm</td>
</tr>
<tr>
<td>Emehemate</td>
<td>7°15'S, 144°13'E</td>
<td>ODB</td>
<td>rock shelter</td>
<td>European artefacts to 10 cm; shellfish to 70 cm</td>
</tr>
<tr>
<td>Haku</td>
<td>7°17'S, 144°12'E</td>
<td>OCT</td>
<td>cave</td>
<td>ossuary; surface shellfish scatter</td>
</tr>
<tr>
<td>Hemaro</td>
<td>7°16'S, 144°9'E</td>
<td>ODE</td>
<td>rock shelter</td>
<td>ossuary</td>
</tr>
<tr>
<td>Herekuna</td>
<td>7°15'S, 144°13'E</td>
<td>OCY</td>
<td>rock shelter</td>
<td>see thesis discussion</td>
</tr>
<tr>
<td>Hevereho</td>
<td>7°14'S, 144°14'E</td>
<td>OCV</td>
<td>rock shelter</td>
<td>shellfish to 10 cm</td>
</tr>
<tr>
<td>Ibira</td>
<td>7°14'S, 144°12'E</td>
<td>ODK</td>
<td>open</td>
<td>see thesis discussion</td>
</tr>
<tr>
<td>Kabarebu</td>
<td>7°13'S, 144°14'E</td>
<td>OQ</td>
<td>rock shelter</td>
<td>shellfish to 30 cm</td>
</tr>
<tr>
<td>Kaebate</td>
<td>7°16'S, 144°12'E</td>
<td>not yet assigned</td>
<td>cave</td>
<td>shellfish on surface</td>
</tr>
<tr>
<td>Kapoyoni</td>
<td>7°16'S, 144°12'E</td>
<td>ODX</td>
<td>rock shelter</td>
<td>ossuary</td>
</tr>
<tr>
<td>Kulupuari</td>
<td>7°17'S, 144°11'E</td>
<td>ODI</td>
<td>open</td>
<td>see thesis discussion</td>
</tr>
<tr>
<td>Kumuri</td>
<td>7°20'S, 144°15'E</td>
<td>not yet assigned</td>
<td>rock shelter</td>
<td>shellfish to 20 cm</td>
</tr>
<tr>
<td>Liaeyu</td>
<td>7°19'S, 144°11'E</td>
<td>not yet assigned</td>
<td>open</td>
<td>surface scatter of weathered pot sherds</td>
</tr>
<tr>
<td>Laro</td>
<td>7°13'S, 144°14'E</td>
<td>ODA</td>
<td>rock shelter</td>
<td>shellfish to 70 cm</td>
</tr>
<tr>
<td>Mampaui</td>
<td>7°17'S, 144°11'E</td>
<td>ODR</td>
<td>open</td>
<td>see thesis discussion</td>
</tr>
<tr>
<td>Navekari</td>
<td>7°16'S, 144°24'E</td>
<td>not yet assigned</td>
<td>rock shelter</td>
<td>shellfish, shell artefact, chipped stone to 25 cm</td>
</tr>
<tr>
<td>Old Mati Village</td>
<td>7°20'S, 144°12'E</td>
<td>ODM</td>
<td>open</td>
<td>post-contact village; shellfish and Motuan pottery to 20 cm</td>
</tr>
<tr>
<td>Orao</td>
<td>7°21'S, 144°14'E</td>
<td>not yet assigned</td>
<td>cave</td>
<td>shellfish, flying fox bones, fire hearths on surface</td>
</tr>
<tr>
<td>Ouloubomoto</td>
<td>7°16'S, 144°13'E</td>
<td>OCS</td>
<td>rock shelter</td>
<td>see thesis discussion</td>
</tr>
<tr>
<td>Pote</td>
<td>7°15'S, 144°15'E</td>
<td>OCK</td>
<td>rock shelter</td>
<td>sparse stone artefacts and shellfish to 50 cm</td>
</tr>
<tr>
<td>Rupo</td>
<td>7°15'S, 144°8'E</td>
<td>ODF</td>
<td>rock shelter</td>
<td>see thesis discussion</td>
</tr>
<tr>
<td>Tumuyakea</td>
<td>7°14'S, 144°14'E</td>
<td>OCU</td>
<td>rock shelter</td>
<td>shellfish to 25 cm</td>
</tr>
<tr>
<td>Ukerau</td>
<td>7°13'S, 144°14'E</td>
<td>OCR</td>
<td>rock shelter</td>
<td>shellfish dense to 30 cm</td>
</tr>
<tr>
<td>Urapo</td>
<td>7°16'S, 144°10'E</td>
<td>ODD</td>
<td>rock shelter</td>
<td>shellfish, animal bone, pottery and European artefacts to 15 cm</td>
</tr>
<tr>
<td>Waira</td>
<td>7°14'S, 144°12'E</td>
<td>ODT</td>
<td>open</td>
<td>see thesis discussion</td>
</tr>
<tr>
<td>Watoreke</td>
<td>7°14'S, 144°14'E</td>
<td>OCW</td>
<td>rock shelter</td>
<td>shellfish to 50 cm; stone artefacts to 10 cm</td>
</tr>
</tbody>
</table>
APPENDIX 7

TECHNIQUES OF SITE SURVEY AND EXCAVATION AND PROCEDURES OF ARTEFACT ANALYSIS

SURVEY AND EXCAVATION

Informant reports served as my only guide for locating sites. Probabilistic sampling techniques, such as those described by Mueller (1974) and Plog (1976), were judged inapplicable. As the research area had not previously been the subject of archaeological investigations the visibility, abundance and clustering characteristics of archaeological data was unknown; therefore, an efficient and effective sampling procedure could not be designed. Also, since probabilistic sampling may be ineffective in discovering rare or highly clustered archaeological remains (Schiffer et al. 1978), sites potentially important to the interpretation of the region's prehistory could have been missed.

During the first field season, February - May 1976, my archaeological reconnaissance focused upon the area's limestone caves and rock shelters, of which I visited 29 (see Appendix 6 for a listing of archaeological sites). Initially each site was assessed using three criteria: the presence of surface finds, the amount of floorspace occurring within the dripline and the soil moisture content. If any of these factors lent support to the possible habitation of the site, I tested the locality to determine the depth and composition of any archaeological deposits.

The exploration method employed was to core the deposits with a trowel to a depth of approximately 70 cm. Changes in the stratigraphy were carefully noted and finds appearing in different soil horizons were bagged separately. Since most of the sites visited were either rock shelters or shallow caves, three "hand tests" were usually excavated: one near the back wall, another toward the middle of the site and the last outside the dripline. All the material was hand sorted. The majority of sites had either no archaeological material or only shell debris to a depth of 20 - 25 cm and were not considered for further testing.
At four of the five localities having substantial deposits, I dug at least one 50 x 50 cm test pit to determine if a full scale excavation was warranted. I removed the deposits in 20 cm spits, if there were no noticeable breaks in either the natural or cultural horizons. All excavated material was sifted through a 6 mm (¼ in) sieve.

During the first field season the Mampaiu open site was discovered in the present-day village of Kopi (Fig. VI-1). Following up informant reports of pottery and chipped stone debris occurring in the village, I surveyed the stratigraphic sections in the walls of house drains and other disturbed areas at Kopi. After a quick inspection, I concluded the greatest concentration of archaeological material was situated along a river levee in the southern portion of the village. I excavated a 1 x 1 m test pit in this area using 10 cm spits. Two more test pits were dug, one on the lower slope of the ridge and the other at the margin of the village green lying to the north. Again I used a 6 mm sieve.

I returned to the area in October 1976 to begin an eight month field season, during which all but a month was devoted to archaeological investigations. I first expanded my original reconnaissance area to include the karst escarpment north of the Ivi River (Fig. II-1). Four rock shelters were surveyed and tested in the same manner as those found during the first season. None of the sites proved to contain more than a shallow scattering of shell. The reported location of a pre-contact village was also visited but not tested because no surface deposits were discovered beneath the dense ground cover.

As the area surrounding Waira and Kopi villages now seemed to have the greatest potential for locating sites, I directed my efforts to this region for the remainder of my stay in the field. Over the next seven months I visited and tested two more rock shelters; their cultural deposits were inconsequential. I also surveyed nine open sites where surface finds were reported or where my informants claimed that there had once been a village. If there was only a light scattering or no surface debris, I tested the area by excavating several 50 x 50 cm test pits with a spade. Only one such locality, Waira, was judged to warrant a full-scale excavation. At sites where there was extensive cultural material exposed I tested the area using 1 x 1 m pits.
and, when required, removed material in 20 cm spits. Only the Kulupuari and Bageima open sites were excavated further. When initially testing any open site all material was hand sorted.

At all localities where I conducted a major excavation I was assisted by at least one member of the group who claimed ownership of the site and two or three men from Waira Village, whom I trained as excavators while in the field. While my confidence in their diligence was never disproved, the amount of work I sought to complete, the limitations imposed by the remoteness of some sites and the high rainfall of the area forced me to employ expeditious excavation methods.

The size of excavation units varied between and sometimes within each site. The physical nature of sites and the information sought in excavating any specific portion of a site did not allow uniformity. For example, the large number of economically useful plants (e.g. coconut and betel nut palms, banana, etc.) at Kulupuari greatly restricted the area available for excavation. At Herekuna evidence of a substantial layer of roof-fall, detected during my first testing of the site, prompted me to excavate a single large area to gain access to the lower levels of the site.

During my test excavations of all the major sites I was able to identify only two natural stratigraphic horizons, which always graded ever so slightly from one to the other. Therefore, I generally chose to excavate in arbitrary levels. All finds of significance (cultural features, ground stone axes, sago choppers and large rim sherds in the cave/shelter sites) were recorded three dimensionally. I used both 3 mm (1/8 in) and 6 mm sieves at all sites but never in conjunction with one another in processing the same spoil. This unfortunate circumstance arose as a result of my mistaken assumption that four sieves were an adequate supply for a long field season and my inability to secure replacements quickly from Port Moresby. I did attempt wet sieving with a 3 mm sieve and fine-meshed tea strainer at Rupo, but since the results obtained did not justify the time involved, I discontinued this technique half-way through my work there.
METHODS OF ARTEFACT ANALYSIS

The archaeological material recovered during my excavations is substantial, but not great in number with respect to any particular class of artefact. Therefore, I have elected only to describe the finds and not attempt to discover archaeological types. Each of the analytical procedures discussed below applies to the finds from all sites.

The processing of archaeological material began while I was still in the field. With the exception of faunal remains, finds from each excavation unit were washed, sorted into major artefact categories (e.g. pot sherds, chipped stone, shell etc.) and rebagged. Field labels were discarded only after two permanent tags were made. An embossed plastic label was placed inside each bag and a waxed linen tag with all pertinent information written in permanent black ink was stapled to the outside.

All archaeological finds were shipped to Port Moresby. During my stay there I further sorted the pottery, weighed and counted the cooking stones and weighed the shellfish debris from Herekuna. These items comprise the bulk by weight of all archaeological finds. Shipping costs prevented me from taking the entire collection to Canberra for analysis; therefore, it was necessary to process at least a portion of these large collections. All material shipped to Canberra was accessioned upon arrival and prior to further analysis.

I now discuss in detail the procedures employed to describe the major artefact categories.

Pottery

Pot sherds were first sorted into groups corresponding to their location on an individual vessel: body sherds, near-rims and rim sherds. The weight and number of sherds in each category were recorded. All sherds whose area did not exceed $6 \text{ cm}^2$ (roughly the area of a 20c coin) were removed from each grouping, counted and weighed. These pottery fragments were excluded from further analysis because the information they provide is usually ambiguous. Body sherds were divided into plain, decorated and weathered categories, and the maximum thickness of each sherd was recorded to the nearest 0.1 mm.
Near-rim and rim sherds were first segregated by vessel type, jar or bowl. All sherds from these categories which were recovered from a single site were laid out together on a table in order to identify sherds belonging to the same vessel. When direct joins were found the portion of the vessel present was reconstructed. If sherds from different excavation units were matched, the reconstructed rim was assigned to that unit from which the greatest contribution by area was made (following Specht 1969: 73). Rim sherds recovered from Kulupuari were further sorted into two groups based on the presence/absence of two of the three following criteria:

(i) at least 5 percent of the vessel's rim represented;

(ii) a minimum of 2 cm of the vessel's body occurring below the neck (for jars) or shoulder (for bowls) directly associated with a rim;

(iii) an unweathered surface.

The qualitative and quantitative ceramic attributes which I selected for the analysis of rim sherds closely follow those used by Irwin (1977: Table 4.1, 90). There are some minor differences in the categories of decorative techniques and vessel form some of which are more similar to those described by Allen (1972: 102) and Vanderwal (1973: 64-5). Table 7.1 lists the qualitative attributes I chose for rim sherd analysis. The figures to the right of most attribute categories serve as a schematic illustration of each. Since I use generally standardised descriptive categories, I refrain from discussing each in detail. However, the decorative techniques listed do require further explanation.

There are five techniques of tooled decoration in the ceramic collection I excavated. Incision is the cutting or pressing of lines into the surface of unfired vessels (Sheppard 1957: 195-96). In my analysis incision refers only to an unbroken line whose production may have necessitated the removal of the tool used from the vessel's surface while the pot was re-oriented in order to continue the line. This distinction is made to differentiate incision from gash incision, which is a short line cut by a quick stroke of the tool. Gouge excision
is the removal of a portion of the clay fabric. The same effect can be produced by a large number of closely spaced gash incisions which displace the unfired clay. In order to avoid confusion in my identification of decorative techniques such occurrences are classed as gouge excision. Punctation and perforation appear infrequently among the sherds analysed. The former is simply the imprint of a tool, the latter a hole running through the fabric of the vessel wall.

Table 7.2 presents my breakdown of tooled decorative elements and illustrates the most common forms of decoration associated with each category. I first divide the decorative elements according to their geometric form: straight line, curvilinear line, rectangular figure, circular figure and triangular figure. Further segregation is first based on the variations these forms exhibit within my pottery collection. The final distinction is made on the primary decorative technique used to create the individual decorative elements.

The design motifs produced by combining these decorative elements are in turn extremely complex and generally individualistic in character. Therefore, in discussing design motifs I describe only the major trends within the collection and for illustrative purposes generally reproduce those designs which occur in the greatest number for each category of vessel form.

Painting and slipping are often tenuous attributes to include in ceramic analysis. In many instances, such as on small sherds, discrimination between the two is impossible. On sherds with weathered surfaces neither can be identified and for this reason Irwin (1977: 98) omits slipping from his analysis. There are, however, sufficient examples in my collection for which painting and slipping can be identified and differentiated and this warrants their inclusion in the pottery analysis. Here, painting denotes the application of colouring to a discrete area of the vessel's surface. It is usually distinguished by a line of extinction between painted and unpainted areas. Slipping is the colouring of an entire surface of a pot. Appliqué, the addition of clay to a pot's surface for purposes of design, stands apart from other decorative techniques because it appears only on a single rim sherd.
The quantitative attributes used in analysis are as follows:

1. orifice diameter (after Shepard 1957: 253);
2. percentage of rim present (after Egloff 1979: 42);
3. orientation angle (after Poulsen 1972: 14-15);
4. inclination angle (after Poulsen 1972: 15-17);
5. rim length;
6. rim thickness A (after Specht 1969: 79);

The orifice diameter of a rim sherd was measured by aligning the exterior surface at the lip to a series of concentric arcs of a known radius. Calculations were made to the nearest centimetre. The percentage of the rim present was estimated to the nearest percent using the rays superimposed over the arcs at 5 percent intervals. In determining the orientation or rim angle and the inclination or rim/body angle I followed the procedures defined by Poulsen (1972: 14-17). Measurements were made using a piece of plexiglass upon which 10° rays were etched. Each angle was estimated to the nearest 5°.

Rim length, the distance from the lip to the neck, was estimated to the nearest 0.1 mm. In order to ensure consistency in my observations the length of jar rims was measured either along the interior surface or, on very convex rims, along the chord of the arc described by the curvature of the rim. The length of composite or shouldered bowl rims was calculated on the exterior surface. On direct bowl rims, which have no neck, the inclination angle and rim length were not measured.

Following Specht (1969: 79) two rim thickness measurements were taken. The first, rim thickness A, was made close to the lip on parallel-sided rims or at the point of greatest thickness on other rims. Rim thickness B was measured just below the neck on jars or shoulders on bowls. Both thickness calculations were estimated to the nearest 0.1 mm.

On near-rim sherds which could not be directly associated with a rim, I noted the following attributes: location of decoration, decorative technique, inclination angle and rim thickness B. While not analysed with the same rigour as rim sherds, near-rim sherd
observations provided a useful means of determining the full range of variability within a collection.

Chipped stone artefacts

The chipped stone material was first sorted into five categories: debitage, non-utilised cores, retouched and/or edge-altered flakes, utilised cores and chipped stone tools. Each of these groups was next subdivided according to stone type, which was determined by the type of cortex present. With few exceptions chert is the only stone material in my archaeological collections. Contemporary stone knappers living in the research area identify two major sources for the material they use.

The first occurs in the region bounded by the Sireru River on the north, the Sirebi River to the west, and the Kuru River and Sire Creek on the south (Fig. II-1). Gravel banks appear along all the waterways draining this region and the cherts used today in the manufacture of sago choppers are found in the water-worn stones collected from these gravel banks. These cherts may have originated from eroded conglomerates underlying the volcanic landforms (Mackenzie 1979: pers. comm.) or from silicified tuffs (P. Hughes 1979: pers. comm.). In further discussion I term chert derived from this first region as "volcanic chert". In doing such I am only distinguishing the source area and not the manner in which the material originated.

The second source area for cherts is the karst country which occurs along the middle reaches and headwaters of the Omati River (Fig. II-1). According to my informants chert may be found in isolated limestone boulders throughout this region. To distinguish this source from the first mentioned I term this material "limestone chert". It is readily identified by its limestone cortex.

I further denote a special category of "limestone" chert which I call wasá following local terminology. This material is black to steel grey in colour and is only found in exposed seams in one or two limestone caves located west of the present-day village of Baina near the headwaters of the Keivi Creek (Fig. II-1). Although I never visited the cave, the interviews I conducted throughout the area from Kikori Station to Lake Kutubu and at Baina leave no doubt as to the
general location of the stone source. Wasá is still the most highly prized material for stone knapping and sago choppers fashioned at Baina from this type of chert are currently traded to the Foi living at Lake Kutubu, the Foe living along or near the upper reaches of the Hegigio River and to the Omati, Ikobe and Kairi peoples living south of Baina (Fig. II-1). As well, I was told that wasá sago choppers were sold at the Kikori market to people from the coastal villages of the Kikori/Purari delta.

**Debitage**

My analysis of debitage primarily consisted of counting and weighing each specimen. Weights were recorded to the nearest 0.5 g. If an item weighed less than 0.5 g, I noted the weight to the nearest 0.1 g. I also estimated the percentage of cortex present using the categories listing in Table 7.3.

**Non-utilised cores**

These artefacts were individually weighed to the nearest 0.5 g. The amount of cortex present was also estimated. Following Jones (1971: 240, 244, 245) I further distinguished between single, multiple and discoidal platform cores.

**Altered flakes**

Edge-altered flakes and retouched flakes with or without evidence of edge alteration form a single category of chipped stone artefacts. The attributes chosen for analysis are listed in Table 7.3. In general I follow the edge-analysis techniques described by White (1969). Some modifications are derived from the work of Peterson (1974: 15-70) or as a result of my initial handling of the material. For reasons of clarity I distinguish between those attributes pertaining to the entire flake, which I call the support structure, and those of the altered edge.

Eight attributes of the support structure were noted.

1. The type of stone used was identified.
2. A rough estimate of the amount of cortex present on each flake was made.
3. The maximum length and width were measured by placing the ventral flake surface on a piece of graph paper and delimiting the smallest rectangle which circumscribed the flake. The longest side was recorded as the flake length.

4. Thickness was taken as the greatest distance between the ventral and dorsal surfaces as defined by an imaginary line running at right angles to the ventral surface. The area of the bulb of percussion was excluded when measuring thickness. All three linear measurements were estimated to the nearest 0.5 mm.

5. The weight of each altered flake was recorded to the nearest 0.5 g.

6. The orientation angle is the acute angle formed between the measured length and the line along which the flake was removed. The direction of flake removal was determined from the position of the bulb of percussion, the alignment of ripples on the ventral surface and the location of the negative fracture scar resulting from step or hinge flake fractures at the distal end of the flake. In cases where this information was not present no measurement was made. The orientation angle was calculated to the nearest 10°. This attribute serves as a measure of the level of standardisation in the production of flakes which have no retouch or severe alteration of form due to use.

7. Lastly, I noted if the flake had been retouched. In this study I define retouch as any major alteration of the original flake form. I therefore, exclude any edge alteration which may be the result of use.

An altered edge is defined in this study as a length along the intersection of two surfaces (planes) of stone, one or both of which surfaces bear modification other than retouch. The criteria used to determine the limits of the altered edge are those used by
White (1969: 24). For each edge a number of attributes was noted.

1. The location of the altered edge on the flake was noted. The terminology of flake morphology I use is that suggested by Leach (1969: 49-51).

2. The length of the altered edge was measured to the nearest 0.5 mm.

3. The edge angle was taken at the point where the two planes either side of the altered edge formed the most acute angle. The edge angle was measured to the nearest degree using a goniometer.

4. The profile of the edge was described using the following categories (after Jones 1971: Fig. 30): very convex, convex, straight, wavy, concave and very concave.

Finally, I observed the macroscopic and microscopic alterations of the edge, each in turn. Macroscopic alterations are modifications of the original flake edge and adjacent surfaces which can be observed visually and need a magnification of no more than 10 x to determine the type of alteration present. Conversely, microscopic alteration is a modification visible only with magnification of the flake edge and its form is rarely discernible at less than 10 x magnification. I make these distinctions because the terms retouch and use-wear are ambiguous and assume the identification of the manner in which an edge is altered.

I described four attributes for both macroscopic and microscopic edge alteration.

1. The location of the modification was noted.

2. The type(s) of alteration were recorded. Step, hinge and feather flaking were distinguished by the type of terminal fracture of the distal end of the flake scar: right angle for step flaking, concoidal or rounded for hinge flaking and tapering for feather flaking (see Cotterell and Kamminga 1977: 12-14 for further discussion). The removal of small "bites" from the edge was
categorised as nibbling. On thin-edges I was never certain that this type of alteration was attributable to other factors such as the flake's production or post-depositional disturbance (i.e. trampling underfoot). Polish was identified by the glass-like sheen on the altered edge and adjacent surfaces.

3. The angle formed between the line of the edge and the direction of flake removed from the altered edge was estimated by eye and recorded in one of three $30^\circ$ groupings.

4. The last attribute considered was the percentage of the edge which had been modified. My calculations consisted of a rough visual estimate which were assigned to broad categories.

*Edge-altered cores*

These artefacts were analysed in the same manner as altered flakes, with the exception of a measurement of thickness. As with non-utilised cores I also distinguished between single, multiple and discoidal cores.

*Chipped stone tools*

The last class of chipped stone artefacts is restricted to those specimens with a distinct morphology and/or a specialised pattern of use-wear. Sago choppers are the most numerous chipped stone tool recovered. Since they have not been described before I devised the following method. Analytical attributes were identified through my own observations of the contemporary manufacture and use of stone sago chopper and through consultation with R. Jones (Department of Prehistory, ANU) during the initial stages of inspecting the archaeological finds.

Twelve attributes of sago choppers were recorded for analysis.

1. The first three: stone type, percentage of cortex present and specimen weight are attributes consistently noted for all chipped
stone artefacts. My recording method did not alter from that described above.

2. The distance between the working face and the poll was measured as the length. As most sago choppers are conical in form, length corresponds to the geometric height of a cone.

3. Two maximum width measurements were taken, the first at the working face [W1] and the second at 0.5 cm from the poll or conical apex [W2].

4. The area of the working face was recorded to the nearest square millimetre.

5. The perimeter of the working face was measured to the nearest 0.5 mm.

6. The maximum angle formed between the working face and the lateral surface (i.e. the edge angle) was noted to the nearest degree using a goniometer.

7. The maximum depth of step flake scars beginning at the working face and continuing down the lateral surfaces was measured to the nearest 0.5 mm.

8. Two characteristics of the use-polish present were noted. The maximum occurrence of use-polish along the lateral surfaces away from the working face was measured to the nearest 0.5 mm. The percentage of use-polish present on the working face was recorded using the following categories: 
   <10%, <30%, <50%, <75% and ≤100%.

9. After completing the first descriptive phase I computed the value of the taper index. This figure was arrived at by dividing the difference between the two width measurements by the length and then multiplying the positive quotient value by 10.
Ground Stone Tools

This artefact grouping is largely comprised of axe-adzes. Following White (1972: 6) I chose not to distinguish between these two functional classes of stone tools. There are three factors relevant to my collection which support this decision. Firstly, the total number of axe-adzes recovered from my excavations is small and the majority of specimens is not complete. Possible variation within the sample therefore cannot be resolved by recourse to a statistical test. Secondly, microscopic examination of the working edge of specimens revealed the general absence of use striations and thus critical evidence which Semenov (1964: 123-6) employs to differentiate axes from adze. Lastly, no hafts were found in any archaeological site.

Two distinct procedures were followed during the first stage of axe-adze analysis. The form of each specimen was described using the attribute categories suggested by Lampert (1972). Table 7.4 lists the attributes employed in my analysis. Although Lampert's method is directed primarily at the analysis of planilateral axes, I found it most useful in describing axe-adzes of any typological form. It will be noted that I have not used all of Lampert's attributes. I chose not to include his "index" of ratios of primary measurements because few of my specimens are complete.

The second procedure was to submit my collection for stone sourcing. J. Chappell (Department of Biogeography and Geomorphology, ANU) and I. Hughes (Human Sciences Program, ANU) conducted the first analysis. After their inspection of the specimens they concluded that there are two general stone types present. The first is metamorphised material typical of the Highlands stone axe quarries (cf. Chappell 1966). The second is material of volcanic origin for which no previous analysis had been made. With the assistance of M. Campion (Department of Biogeography and Geomorphology, ANU), 12 axe-adzes from the volcanic grouping were thin-sectioned. These specimens were then given to D. Mackenzie (Bureau of Mineral Resources, Canberra) for sourcing. In Appendix 11 he presents his findings.

The final analysis of the axe-adze collection collates from attributes and stone sources.
Miscellaneous Artefacts

Cooking stone

Cooking stones and their fragmentary heat spalls are readily distinguished by stone type. M. Worthing (Department of Geology, UPNG) identified this material as volcanic lavas and tuffs. Such stones occur in gravel banks situated in the upper drainage of the Sirebi River, but I have also observed it to be present in gravel banks along the Kikori River between the mouth of the Iehe Creek and Baina Village (Fig. II-1). In processing cooking stones I only counted and weighed the material from each excavation unit.

Iron stone, pumice, and haematite. Artefacts belonging to these categories were counted and weighed. They comprise a small percentage of the total artefacts recovered and are not the subject of analysis beyond noting.

Shell and Bone Artefacts

A variety of shell artefacts was recovered during my excavation. In analysing this material I identified the type of shell used, the areas modified and the portion of the original shell remaining.

Few bone artefacts were found. Each specimen was described as to the class of animal, the body part used and areas of modification. I have refrained from describing the use of bone artefacts except when the archaeological context or manner of alteration suggest a very specific function.

Human Bone

With the exception of two skulls recovered from Kulupuari and Rupo, all human bone was bagged with animal bones during excavation. The human remains were segregated during the initial sorting of the faunal material and given to A. Thorne (Department of Prehistory, ANU) for analysis. His findings are presented in Appendix 17.
Faunal Remains

Shellfish

While in the field I collected specimens representative of almost the complete range of bivalves and gastropods which occur in the study area and were reported by my informants to be edible. For most types of shellfish I calculated the shell to live weight ratio. Upon my return to Australia I sought the assistance of P. Coleman (Australian Museum) to provide the taxonomic names of the specimens.

The amount of shell material excavated from Rupo and Ouloubomoto was not great; therefore, the entire collection from these sites was shipped to Canberra for analysis. The shell debris recovered from Herekuna was, however, substantial. Only 20 percent by weight of the material from each excavation unit was sent to Canberra.

Prior to sorting and weighing all shell debris was washed. To ensure the removal of dirt lodged in gastropod shell spirals, each sample was placed in a fine-meshed container and suspended in a of warm soapy water. Air was fed into the tank from just below the mesh container and the water was agitated for 30 minutes to an hour. The shell material was then dried, sorted into types and weighed.

Animal bones

The excavated animal bone was shipped to Canberra without prior processing in the field. Since most of this material was very friable it was first dried. The dirt still adhering to the bone was then removed with dental picks. The identification of all animal bones was made by K. Aplin in consultation with other faunal experts. In Appendix 13 he describes the analytical methods he employed.

To assist in the identification of the archaeological animal bones I assembled a collection of specimens while in the field. This material was collected by the people of Waira during their fishing and hunting expeditions.
Approximately 13 kg of pottery was recovered from Kulupuari (Table 8.1). After the initial sorting the collection was reduced by 91 percent (or 60 percent by weight) so that only sherds greater than 6 cm$^2$ were retained for detailed analysis. The reader is directed to Appendix 7 (pp.4.26-4.29) for a discussion of the quantitative and qualitative attributes used in the analysis of each sherd category.

Techniques of manufacture

Based on a visual inspection of the collection I conclude the jar vessels were shaped using a paddle-and-anvil technique. The prominent rounded depressions appearing on a number of jar rim sherds are indicative of the potter holding an anvil against the interior surface while constructing a vessel. The interior neck and shoulder areas of jar rims also show signs of tool-smoothing and scraping. These methods of surface finish generally follow the final shaping of the vessel (O. Rye 1979: pers. comm.).

Bowls were formed using a completely different, but as yet unidentified, process. There are no anvil marks on the interior of bowl rim sherds. Also, greater attention is paid to the smoothing and possibly burnishing of bowl surfaces on this type of vessel.

The tooled decoration of all vessels occurred after the clay had hardened, but before the pot was fired. This is indicated by the absence of clay ridges along the margins of tool impressions (O. Rye 1979: pers. comm.). Tooled decorations appear only on surfaces which were first painted or slipped. The alteration or removal of coloured areas on the pottery by tool impressions is a major decorative technique on rim sherds. This effectively changes the figure-ground perception of the executed decoration (see Fig. VI-16d). While complicating the analysis of decoration, this technique produces highly embellished and attractive designs. Furthermore, it attests
to the skill of the potters to produce a wide range of designs from a standard repertoire of decorative techniques.

**Rim sherd analysis**

A total of 711 rim sherds was excavated at Kulupuari. Most are small and many are badly weathered. Since most of the ceramic attributes I nominate for analysis cannot be determined for these rim sherds, I have chosen to consider only large rims for formal analysis (see Appendix 7: A.29 for a discussion of the criteria used to select the rim sherd sample).

To test the validity of the assumption that the sample of rims adequately characterises the entire population of rims, the F and Student's t-tests were applied. Tables 8.2 - 8.4 list the descriptive statistics of the quantitative attributes for the sample and the remaining group of rims. The total number of sherds noted in these tables do not correspond to the total number of sherds excavated because rims that could not be assigned to a specific category of vessel are omitted. Table 8.5 presents the values of the statistical tests. This evidence supports the acceptance of the null hypothesis that the sample of rims selected is not significantly different from the rims excluded from formal analysis.

The rim sample is now used to assess the major trends within the collection. The following section identifies the variability present by analysing the remaining rim sherds and near-rim sherds.

**Everted jar rims**

The sample contains 68 rims belonging to this vessel category. Table 8.6a is a breakdown of everted jar rims into the various rim and lip shape categories. Figure VI-11 illustrates the range of forms in each major grouping. Most everted vessels have straight rims and rounded lips. Rim profiles are evenly distributed between those with a parallel form and those with a gradual reduction in rim thickness. Several everted rims are very convex, with a few having a "rounded" form. Table 8.6b lists the distributional characteristics of the quantitative attributes. Most closely approximate a normal curve. However, the thickness measurement taken
on the rim is highly skewed toward smaller values and the distribution curve is very sharply peaked.

All everted jars included in the sample are decorated (Tables 8.7, 8.8; Fig. VI-12, VI-13). Approximately two-thirds of the rim sherds are painted and over 50 percent of the painted rims have bands of colouring occurring at a minimum of two distinct localities on the vessel surface. The interior rim, lip and shoulder are the most frequently used loci for painting. A horizontal band(s) of colouring is a common decorative motif. When present on the interior rim or lip the band appears to be continuous. Only a few sherds retain a large portion of the shoulder area; therefore, I am uncertain of the behaviour of painting motifs applied there. A few specimens do, however, exhibit a truncation of painted bands on the shoulder. One rim sherd possesses horizontal and vertical bands of paint appearing in this area.

The application of colouring also occurs on specific areas of everted jar rims, the interior rim and/or lip being the most common loci. Twenty-five percent of the sampled rims have a solid coloured surface beginning near the lip and continuing to the sherd break at the shoulder. This may or may not be evidence of the slipping of the exterior surface of everted jars.

Dark red colouring appears on all but four rim sherds. Of the sherds decorated with different coloured paints, one has two distinct bands of yellowish brown colouring applied to the interior neck and down the interior surface. The black colouring on the interior surface of another sherd is followed by two separate bands of brown colouring on the interior rim and lip and also on the exterior body. Another has the same pattern of painting with the exception that it has red colouring applied to the exterior body. The remaining sherd with a black coloured interior exhibits red paint extending from the interior rim to the exterior shoulders. Red colouring is only reported for other Papuan pottery collections of a comparable age; therefore, to ensure the accuracy of my observations I have consulted with O. Rye, who has confirmed the presence of other than red pigments.

Tooled decoration (Table 8.8) appears on only 14 everted rim sherds and in all cases except for one sherd with a weathered exterior is in direct association with a coloured surface. Five
rim sherds have tooled decoration occurring on one area of the vessel: three on the interior rim, two on the shoulders. Three other sherds have decoration covering the entire area from the exterior rim to the shoulder. The remaining rim sherds exhibit decoration on the interior rim and exterior surface. Decoration begins on the exterior rim of only two such sherds; on the rest, tooled decoration extends from near the neck downward along the exterior surface.

Straight line figures are the most frequent decorative element used and appear at all the decorative locations. Incised plain parallel lines are the most common decorative mode, but only once does this decorative element appear by itself. Usually incised parallel lines occur with triangular figures and form a saw-tooth decorative motif. In general, all decorative elements present on everted rims are combined without regard for the repetition of standard motifs and, therefore, the tooled designs are remarkably individualised.

**Straight jar rims**

The 24 rim sherds comprising this sample show considerable diversity in the combination of rim and lip forms used (Table 8.9a; Fig. VI-11). The quantitative measures of rim and vessel form indicate notable uniformity within the sample (Table 8.9b). The distribution curve of these attributes is more consistently peaked at the mean than would be expected for a normal distribution. This indicates a distinctive characteristic of this sample of straight jars.

All straight jar rims are decorated with surface colouring (Table 8.10; Fig. VI-14), the major trend being to colour more than one area. Fifty percent of the rims have a solid band of colouring from near the lip to the sherd break at the shoulder. Again a distinction between exterior surface painting or slipping cannot be made. Horizontal bands of paint occur on a few sherds and the painted areas correspond with the pattern observed for everted jar rims. There is only one example of the use of a colouring other than red. Black paint is applied to the interior neck and the body area below. Red colouring begins on the interior rim and continues to the exterior shoulder.
Only four straight jar rims are decorated with tooled designs (Table 8.11). Two examples possess decoration covering the exterior rim through to the shoulder areas. Straight line decorative elements appear most frequently. The decorative motifs on all four rims are unique to each specimen.

Simple composite bowls

This vessel category is represented by 45 rim sherds in the pottery sample. Table 8.12a lists the number of rims occurring within each rim and lip form grouping (see also Fig. VI-15, VI-16). Rims with a straight rim course comprise approximately one half of the sample. Almost 75 percent of the rims are parallel in profile. Rounded lip forms appear in roughly the same frequency.

Table 8.12b describes the distributional characteristics of the quantitative attributes. With the exception of the orientation and inclination angles, the measurements of all attribute categories approximate a normal distribution. The two angle measures have very low kurtosis values. This suggests that there is considerable variability in the form of simple composite bowls.

Simple composite bowls are distinct from the previously discussed vessel categories as they are definitely slipped (Table 8.13). The colouring of both interior and exterior surfaces occurs on 20 rim sherds. Of the remaining sherds 14 have an interior slip, 8 do not and 3 sherds are too weathered for painting or slipping to be detected. The colouring of one area of the vessel appears on 5 rims and in all cases is confined to the exterior rim. Red colouring is used as both a paint and a slip on all but three sherds. Two sherds have brown colouring. On one specimen this is applied as an interior slip, on the other as an exterior rim paint. Black colouring occurs on one rim, but it has no definite locus because it is intermixed with red colouring on both interior and exterior surfaces.

All simple composite bowl rims in the sample are tool decorated (Table 8.14; Fig. VI-15, VI-16). The exterior rim of all sherds is decorated. Exterior rim decoration extends to include the shoulder on 3 sherds and the body on 2 others. Of the 40 remaining 5 also have lip decoration. Straight line decorative elements comprise 50 percent of the total number of elements used. Triangular
figures occur in over 25 percent of instances. On 26 rim sherds these two categories of decorative elements are combined to produce a saw-tooth motif. The hatching of parallel lines (e.g. Fig. VI-15a), regardless of the figure they form, is the other dominant motif and is found on 17 sherds.

Two other characteristics of simple composite bowls can be distinguished. The first is alteration of primary design motifs along the vessel rim (see Fig. VI-16b). This is evidenced on only a few specimens whose original rim has been largely reconstructed. On some the change is sufficiently different to warrant a typological segregation of decoration on different parts of the rim. Therefore, if one were working with small rim sherds and categorising this collection on the basis of decoration alone, the chances of making a faulty classification would be high.

The second characteristic partially follows from the first. I here refer to what I term "intermediate" and "closure" designs (see Fig. VI-16a, b, c). An intermediate design is a distinctive decorative element or motif which is notably different from those appearing to either side. A closure design establishes a distinct break marking the end of a decorated area on the vessel. Both serve to segregate lengthy decorative motifs occurring along the course of a particular rim. Intermediate and closure designs appear in the sample of simple composite bowls, but as many of the sherds are small it is not only difficult to identify these design elements but also almost impossible to distinguish between the two.

Other bowl forms

Four complex composite bowl rims and two direct bowl rims are also present in the sample (see Fig. VI-17). The first is distinguishable from the other form of composite bowl because of its pronounced shoulder carination and the multiple orientation angles of its rim. Direct bowl rims are distinct as they lack a well defined shoulder and the rim is a continuation of the vessel body.

The rim course of all complex composite bowl forms found within the sample is convex. Rim profiles include parallel, thickening and thinning forms, with the last appearing on two rims. Three rims have round lip forms, the last a flattened shape. The orifice diameter
of only two specimens was measured; the values are 29 and 50 cm. The orientation angle formed by the lower portion of these two rims is 20° inverted (-20°); the uppermost orientation angle is +20° and +30°. These measures on the other two rims are -20/0° and -10/0° respectively. The inclination angle values are 210, 240, 230 and 220 degrees. The rim length and thickness measures, in centimeters, for each are: 2.85/1.10/0.70; 3.10/0/85/0.40; 2.70/0.85/0.55; 4.70/0.75/0.75.

Three complex composite bowl rim sherds are slipped with red colouring on both vessel surfaces. The other has slip on the interior with paint applied to the exterior rim and shoulder. All rims are highly embellished with tool decoration on the exterior rim area. This decoration continues onto the body on two rims; interior rim decoration appears on the remaining two rim sherds. The three major tooled decorative techniques occur on three specimens. The decorative elements are varied, but single line and triangular figure are most prominent. On three sherds these elements are combined to create a saw-tooth decorative motif.

The two direct bowl rims have distinct form attributes and measurements. For convenience I describe each in the following list:

- Rim course: straight; concave
- Rim profile: parallel; parallel
- Lip shape: round; round
- Orifice diameter: 24 cm; 16 cm
- Orientation angle: 0°; -5°

The absence of some measures is attributable to this vessel form having no distinct shoulders.

The decoration of each direct bowl rim sherd is also unique. The first listed is only painted. A band of red colouring is applied to the lip and upper portion of the vessel exterior. Lower down on the same surface paint again appears and continues downward to the sherd break. The other rim sherd (Fig. VI-17c) is slipped on both surfaces with red colouring. Tooled decoration occurs from the lip downward on the exterior surface and the highly decorative design changes around the rim's course. As well, three distinct "intermediate designs" are present. Saw-tooth and hatched parallel decorative motifs predominate.
Variation within pottery collection

The Kulupuari pottery collection has been characterised through a detailed analysis of what may be called "good rims". The task now is to detect any notable variation. To accomplish this the remaining rim sherds and the collection of near-rim sherds are examined. The discussion of each vessel category follows the same order as that above.

Everted jars

The combinations of rim and lip form attributes differ little from those illustrated in the sample (Table 8.6a). Other combinations occur, but they are never represented on more than two sherds. The percentage of total rims with a very convex rim course increases significantly against those with convex forms. Rims with thin profiles increase by approximately 25 percent. Round lip forms continue in the same frequency.

As the orifice diameter and orientation angle measurements for the rim sherd sample and the remaining rims show no statistical difference (Table 8.5), they are not considered further. With regard to the other attributes, the skewness and kurtosis values for the remainder of the everted jar rims are as follows:

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inclination angle</td>
<td>0.52</td>
<td>0.56</td>
</tr>
<tr>
<td>Rim length</td>
<td>0.34</td>
<td>0.22</td>
</tr>
<tr>
<td>Rim thickness A</td>
<td>1.29</td>
<td>3.68</td>
</tr>
<tr>
<td>Rim thickness B</td>
<td>0.82</td>
<td>0.61</td>
</tr>
</tbody>
</table>

The comparison of these figures with those of the sampled rims (Table 8.6b) demonstrates that the distributional curves of each are similar. The curve of the inclination angle measurements is not as peaked among "non-sampled" rims and perhaps indicates that a normal distribution more accurately characterises this attribute among the everted jar rims from Kulupuari. The highly significant difference between the two groupings of sherds relative to rim length and thickness of the rim just below the neck (Table 8.5) is now demonstrated
to be contingent upon the different mean values. The significance of a 2 mm difference for rim length and a 1 mm for the thickness measure cannot be properly assessed without the use of multivariate analysis. Although, Irwin (1977: 207-215) concludes that differences of the same order in the thickness of plain body sherds are critical markers of change through time, I hesitate to claim the same in the absence of a long sequence of pottery deposition and without first assessing the effect of measurement error.

Colouring is present on 148 sherds not included in the sample. All other rims have badly weathered surfaces which prohibited the identification of applied colour. Among the sherds with colouring, 107 specimens have no evidence of weathering. Fifty percent of these sherds are coloured from the interior neck/interior rim to the shoulder area. The occurrence of this colouring motif is considerably more frequent than that observed in the everted jar rim sample. Since colouring continues to the sherd break, no distinction can be made between the painting or slipping of the exterior surface. The painting of more than one distinct area of the vessel appears on only 15 unweathered sherds. The dominance of this painting motif as evidenced in the rim sample is therefore contradicted. The use of colouring, other than red, is again noted, but its occurrence continues to be rare.

Tooled decoration appears on 13 percent of the remaining everted jar rims, as compared to 20 percent of the sample sherds. Twenty-three rims (75 percent) are decorated on the interior rim and on 9 rims this area serves as the only locus of tool decoration. Parallel line decorative elements (single line category) frequently occur on the interior rim and in most instances have triangular figures in direct association. The exterior rim and vessel area below is decorated on 10 sherds. On 10 others decoration begins in the neck/shoulder area. Incised parallel lines are the uppermost decorative element on 85 percent of sherds with exterior surface decoration. Various decorative elements appear below and most design motifs are particular to single rim sherds.
Straight jar rims

Among the remaining sherds there are 141 rims of this vessel category. Unlike rim sherds in the sample, rims with a straight course, parallel profile and round lip dominate the groupings of qualitative form attributes, occurring on one in three rims. Rims with a straight course, thickening profile and a complex flat lip appear in 16 percent of the sherds. As rims with these form attributes do not occur among the sample rims, this is a considerable alteration in the conclusions arising from the first analysis of straight jar rims.

The quantitative measures of form for the two groups of straight jar rims are shown not to be statistically different (Table 8.5), with the exception of the two thickness measures. Distributional characteristics of these attributes for the remaining rims are:

<table>
<thead>
<tr>
<th></th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rim thickness A</td>
<td>0.99</td>
<td>0.08</td>
</tr>
<tr>
<td>Rim thickness B</td>
<td>0.47</td>
<td>-0.17</td>
</tr>
</tbody>
</table>

By comparing these values with those for the sample group (Table 8.9b) it is apparent that the difference relates to the clustering of measurements about the mean. In the sample group kurtosis values suggest a tight distribution, whereas the remaining sherds exhibit a distribution which approaches normality. Because the number of sample sherds is small, I assume that a normal distribution of these measures to be more representative of the entire collection of straight jar rims.

Approximately 80 percent of the rims in this group have weathered surfaces and only a third of these sherds show any evidence of colouring. The remaining 31 rims are all coloured. Thirty percent of these rims are painted only on the lip. With the exception of five sherds with colouring appearing on the interior rim and lip, all other rims are coloured with a solid band running from the interior rim to the sherd break at the shoulder. One rim has colouring appearing on all vessel surfaces. Unlike sherds from the sample group there is no evidence of the painting of several discrete areas. These observations suggest greater variability in the colouring of straight jar vessels than was noted in the rim sample.
Sixteen straight jar rims are further decorated with tooled designs. Except on weathered sherds, tool decorations only occur on coloured surfaces. Six rims have only one locus of decoration, either the lip or interior rim. Fifty percent of the rims have decoration beginning on the exterior rim and continuing to the shoulder area; two of these rims are further decorated on the interior rim or lip. Tooled designs occur on the neck/shoulder area of only 2 sherds. A combination of straight line and triangular decorative elements is the most frequently used design motif.

Jar near-rims

Up until this point this class of sherd has not formed a part of analysis because without a vessel lip no determination of a particular sherd's vessel category can be made. A total of 389 jar near-rims representing a minimum of 371 jar vessels comprise this artefact sample. The last figure results from additional sherd reconstruction during the final stage of analysis. In the following discussion this value (371) is used in all calculations.

The inclination angle was determined for only 21 sherds. The mean value is 123° with a standard deviation of 16°. This figure falls roughly half-way between the mean values for everted and straight jar rims (Table 8.2, 8.3), indicating that a contribution from each category of jar may be present in the collection of near-rims. The body thickness (measurement B) was measured on 283 sherds. The mean value is 0.7 cm with a standard deviation of 0.12. This value compares well with the figures calculated for the "remainder" sample of both everted and straight jar rims (Table 8.2, 8.3).

In the preceding discussions of surface colouring on jar rims a high occurrence of colouring was noted beginning near the lip and continuing down the exterior surface to the sherd break. To determine whether this evidence is indicative of surface slipping or painting I conducted a detailed analysis of exterior surface colouring on jar near-rim sherds. Of the 185 sherds with an unweathered surface 70 percent are painted. Fifty-five near-rims are of sufficient size to identify decorative motifs. Parallel painted bands occur on more than half. On the remaining 75 near-rims exterior surface painting is identified by a clear line of extinction between painted and unpainted surfaces. On 50 percent of these sherds painting ends
on the shoulder. Twenty-eight sherds exhibit an extinction line at the neck; painting ceases on the body of the remaining 9 sherds.

Painting or slipping is indeterminable on 55 jar near-rim sherds. Of these, 37 sherds are of sufficient size to suspect that colouring may have extended from the rim to the body. Tooled decoration occurs on 15 sherds. Therefore, the decoration of the exterior surface of jars by slip colouring alone appears on a maximum of 22 near-rims, or 12 percent of coloured jar near-rims. Thus, the slipping of the exterior surface of jars is rare.

Simple composite bowls

Eighty-seven rims comprise the remaining sherds belonging to this vessel category. Straight and concave rim comes with a parallel profile and rounded lip are again frequent rim and lip forms. However, other straight rims with differing rim profiles and lip forms increase considerably against concave rims with the result that the former group now accounts for 78 percent of all rims, as opposed to 15 percent for the latter.

Inclination angle, rim length and the thickness of the rim are shown in Table 8.5 to be quantitative attributes of form evidencing dissimilarity between the two groupings. The skewness and kurtosis values for these measures among the remaining sherds are:

<table>
<thead>
<tr>
<th></th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inclination angle</td>
<td>0.57</td>
<td>-0.52</td>
</tr>
<tr>
<td>Rim length</td>
<td>0.51</td>
<td>0.17</td>
</tr>
<tr>
<td>Rim thickness A</td>
<td>0.38</td>
<td>0.74</td>
</tr>
</tbody>
</table>

While the distribution curve for measurements of the sample rims' inclination angle produces a very flattened curve (Table 8-12b), the curve for the remaining rims approaches normality. The difference between the mean values for the two groupings is approximately 10° (Table 8.4). These results are difficult to reconcile without more detailed analysis. However, since the upper and lower stratigraphic samples for this measure of simple composite bowls reveal no statistical difference (Table VI-5), I must conclude this difference between the two groupings possibly suggests the occurrence of discrete groupings within this vessel category.
The significant difference of rim length between the two groupings (Table 8.5) is attributable to the disparity of the mean values (Table 8.4). As with everted jar rims, it is difficult to assume that a statistical difference predicted upon such a small measured distance, in this case 3 mm, is a sufficient basis to define variability between the two groups. With regard to the rim thickness measurements there is no question of their similarity because both distributions approach that of a normal curve and there is no real difference in the mean values. The question as to whether or not the null hypothesis should be rejected centres upon the F-test and the significant difference between the two groups rests only on the difference of variance which is minimal.

Almost 50 percent of the rims in this group have badly weathered surfaces and consequently no colouring has survived. Of the remaining sherds 37 show no sign of weathering and all are coloured. Twenty-three rims are interior slipped. Thirteen of these sherds have colouring applied as a slip to the vessel's exterior surface. The exteriors of 7 more rims have a solid band of colour covering the rim area but ending at the shoulder or just below on the body area. This pattern of colouring the surface of simple composite bowls is consistent with that noted for the sample rims. However, the colouring of discrete areas occurs on 3 rims. All exhibit two horizontal bands of paint, the uppermost running from the interior rim/lip to exterior rim and the other from the lower portion of the exterior rim to the shoulder.

The decoration of the exterior rim with tooled designs is a prominent feature of these sherds. Decoration of the lip appears on 7 rims. On 6 sherds exterior rim decoration continues onto the vessel body, but the frequency of body decoration is difficult to assess because most rims are broken at or near the shoulder. Only 3 simple composite bowl rim sherds lack tooled decoration. Straight line decorative elements comprise 60 percent of all decorative elements on these rims. Incised or gash incised parallel lines occur in 3 out of 4 instances. The next most popular decorative element is triangular figures (27 percent). Infilled triangular forms appear in 50 percent of these occurrences. These two decorative elements are combined to produce a saw-tooth decorative motif on half of the rims.
Hatched line motifs occur on 38 percent of rims. Another popular motif is the addition of gash incised parallel lines to either single or parallel incised lines (e.g. Fig. VI-15b, e). This "fringe" motif occurs on 12 percent of the rims. The tooled decoration of rims in group shows no major differences from that noted for the sample rims.

Other bowl forms

Two complex composite bowl rims and 11 direct bowl rims are included among the remaining rims. Both composite bowl sherds have a convex rim course and round lip; rim profiles are parallel and thinning. Since both rims are small, all the quantitative attributes of form could not be measured; however, those calculated conform to the range noted among the sample rims. Both rims are weathered, so the presence or absence of colouring could not be determined. The erosion of the surface of one rim is so great as to obliterate any tooled decoration, if it were present. The other sherd has gash incised lines on the interior rim and other forms of single line figures on the exterior rim.

Eighty percent of the direct bowl rims have a concave rim course. A thickened rim course and round lip forms also occur on 80 percent of rims. Table 8.15 describes the quantitative form attributes of these rim sherds. Surface colouring is present on all except one unweathered specimens. Five sherds exhibit interior and exterior slipping. Two other sherds are coloured on the interior and exterior rim, but since both are broken a few centimetres below the lip, a distinction between slipping and painting cannot be made. Two weathered sherds have interior slipping. Tooled decoration appears on the exterior rim of all sherds. The lip of two rims is decorated with tooled designs. Single line figures occur on all but one rim sherd. Triangular figures are used on 7 rims to produce a saw-tooth motif.

Bowl near-rims

Since direct bowl forms have no distinct shoulder, their near-rims are difficult to distinguish from decorated body sherds. Therefore, only near-rim sherds from composite bowls form this sherd grouping.
As with jar near-rims the inclination angle and the thickness of the vessel body just below the shoulder are the only quantitative attributes of vessel form which are measurable. The mean values of the 42 near-rim sherds for which the inclination angle could be determined is 222°; the standard deviation is 11°. These values are comparable with that calculated for the "remainder" group of simple composite bowls (Table 8.4). The body thickness measurements, made on 65 near-rims, exhibit a higher proportion of thicker sherds than is expected from the values described for both groups of simple composite bowl rims (Table 8.4). Twenty-four percent near-rims have a thickness in excess of 7.2 mm or one standard deviation from the mean of bowl rim sherds. Also of note is the presence of strongly carinated shoulders on 4 near-rims.

Decoration appearing on bowl near-rims is generally consistent with that described for bowl rims. More than half of the 37 sherds with unweathered surfaces evidence both interior and exterior slipping. Twenty-four percent have interior slipping with only the exterior rim coloured. Tool decoration occurs on all but 3 near-rims. Sawtooth motifs are again frequent, appearing on approximately 30 percent of the unweathered sherds.

Body sherds

Of the three categories of body sherds only plain and decorated sherds are considered in this discussion. The descriptive statistics of the thickness measures for the two groups are as follows:

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>X</th>
<th>s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plain</td>
<td>1,000</td>
<td>0.51</td>
<td>0.14</td>
</tr>
<tr>
<td>Decorated</td>
<td>434</td>
<td>0.57</td>
<td>0.14</td>
</tr>
</tbody>
</table>

(Student's t = 7.456)

The high t-test value excludes the possibility that the two are derived from the same population. In the discussion on manufacturing techniques I noted that jar and bowl vessels were constructed by different techniques. The distinction between plain and decorated body sherds may be evidence of this difference.
A close examination of the decorated body sherds provides some support for this conclusion. Colouring is present on 413 sherds. The remaining sherds are weathered but have tool decoration. Thirty percent coloured sherds have pigment covering the entirety of both surfaces. Another 20 percent are coloured only on the interior surface. Since the colouring of jar interiors is rare I assume that 50 percent of the coloured body sherds come from bowls. The remaining 50 percent are coloured exclusively on the exterior surface; 30 percent of these are clearly painted. The other 20 percent cannot be assigned to either major category of vessel. I may, therefore, conclude that there is at least a strong trend for coloured body sherds to belong to bowls.

Before ending this discussion I note two unique pottery specimens which appear in the collection. The first is a nearly complete strap handle (Fig. VI-17d). All of its surface is coloured and its exterior is ornately decorated. The other is a tool decorated sherd which is the sagging base of a vessel. While neither is represented elsewhere in the collection, they both provide further evidence of the highly decorative nature of the vessels represented at Kulupuari.

CHIPPED STONE ARTEFACTS

The reader is directed to Appendix 7 (pp. 432-437) for a discussion of the qualitative and quantitative attributes used in analysis.

Debitage

This category contains all chipped stone flakes which lack retouch or edge alteration. Table 8.16 indicates the distribution of debitage at Kulupuari by percentage of total weight for each stone type. Although there is no clear trend for the occurrence of various stone types, a slight increase with depth in the quantity of "limestone chert" is evidenced in the three major excavations: Pits ONOE, 3N3W and 6NOE.
Table 8.17 describes the occurrence of original cortex on debitage associated with each major phase of site occupation. Although most debitage flakes retain little or no cortex, the proportion with cortex covering more than 10 percent of the flake surface is sufficient to suggest that whole cores arrived at Kulupuari during both phases.

Non-utilised cores

"Volcanic chert" cores occur most frequently, by weight, throughout the site (Table 8.18). The stratigraphic appearance of cores in the three major pits again suggests two phases of deposition. Table 8.19 describes the occurrence of cortex on non-utilized cores.

Edge-altered Flakes

Following the depositional trends noted for the two previous categories of chipped stone artefacts I first examine the edge-altered flakes recovered from the upper and lower stratigraphic units of Pits ONOE, 3N3W, ad 6NOE. The descriptive statistics for the quantitative attributes of each sample (Table 8.20) demonstrates a significant difference between altered flakes according to their depositional context. Those associated with the most recent phases of site occupancy are small, thin and more "blade-like" in form. Ceramic phase altered flakes are larger, more chunky and very square in plan. Figure 8.1 graphically displays the difference between the two samples. Two aspects of these illustrations are worthy of note. Firstly, only 9% of altered flakes in the lower sample have a length less than 2.5 cm, as opposed to 48% in the upper sample. Secondly, variation in flake length and in the angle of the altered edge is considerably more restricted during the early than in the later phase.

The difference between the two samples, however, fades if the qualitative attributes are compared (Table 8.21). The frequency of retouch, which is unifacial in all instances, is roughly equal. As well, the sums of the percentages of macroscopic step and hinge flake edge alteration, which may be compatible with other observes' definition of retouch, differ only marginally. The position of the altered edge on the flake and the location of the altered surfaces are similar between samples.
The most striking qualitative distinction between samples is the strong orientation of recent flake implements toward microscopic edge alteration, which again reflects the difference in robustness between the two groups. Attributes relating to the presence of use-polish also differ between samples. Among flake implements found in the lower stratigraphic units polish occurs only along the lateral margins and usually appears on both dorsal and ventral surfaces. Edge-altered flakes belonging to the upper sample have polish only on the dorsal surface of lateral and/or distal flake margins.

Twenty-four other flake implements were recovered from an additional 12 excavation units. No clear determination can be made concerning their temporal provenance because the number of implements belonging to any unit is small. However, from inspection it seems likely that the majority of these flakes has a greater affinity with the more recent phase of site habitation. Tables 8.22 and 8.23 list the quantitative and qualitative attributes of the remaining flakes.

So far I have refrained from employing the well-worn categories of stone tool analysis, such as scraper, awl, drill point, burin, etc. I chose to do so for two reasons. Firstly, these categories generally assume the identification of tool use (but cf. Allen 1978) and this is a logical impurity I wish not to introduce into my primary analysis of data. Secondly, the description of flake implements in terms of gross morphological attributes alone, ignores important evidence which may allow prehistorians to understand New Guinea stone tool collections in terms other than "crude" or "amorphous" (cf. White 1977 for further discussion).

To facilitate comparison I define three primary categories of flake implements for the Kulupuari collection: side-altered, end-altered and multiple-edge altered flakes. From these groups I further segregate those flakes with steeply altered edges or a rounding of the vertex (the point where a flake's lateral margins meet at its distal end). I do not attempt to refine my categorisations into functional groups, but I do posit a general correspondence with what other observers identify as scrapers or drill points. The high occurrence of step and feather flake edge alteration and the large number of implements whose edges are modified by flakes removed perpendicular to the course of the edge support the identification of scraping tools in the Kulupuari sample. The presence of flakes with a rounded vertex and
unifacial alteration of the dorsal crest immediately adjacent (Fig. VI-20b) supports the identification of drill points.

Table 8.24 describes the distribution of flake implement categories during the two major phases of site occupation. Here a previously unnoted distinction between samples is identified. Whereas flake implements recovered from the lower excavation units generally have an even distribution among the three primary categories, those associated with the recent phase of site habitation tend to be side-altered implements. This is accompanied by a significant decrease in the occurrence of multiple edge-altered flakes. Implements with steep edge alteration or vertex rounding comprise only a small percentage of the total number of edge-altered flakes and their appearance remains constant between site habitation phases.

To assess the Kulupuari flake implements it is again necessary to examine the Nebira 4 (Allen 1972) and Oposisi (Vanderwal 1973, 1978) artefact collections, both of which correspond in age with the early phase at Kulupuari. The only Papuan collection comparable in age to that of the recent habitation period is the one described for Mailu (Irwin 1977: 312-14). Unfortunately, Irwin's analysis of chipped stone implements is unavailable so I only consider the earliest Kulupuari assemblage.

The flake implement assemblages recovered from Nebira 4 and Oposisi bear little similarity to those of a comparable age at Kulupuari. The Nebira 4 collection is characterised as a diversified suite of small flake and core tools (Allen 1972: 109, 116). Side altered flake implements occur most frequently at Nebira 4; however, tool forms identified as awls, fabricators, drill points and burins are represented in more than 21 percent of the flake implements associated with each of Allen's archaeological horizons (1972: Table 7). The mean weight of utilised flakes and retouched flakes at Nebira 4 is 1.5 and 2.1 gm, respectively. The mean weights of these chipped stone categories for each stratigraphic unit rarely deviates more than 30 percent from these values (1972: Table 6). The identification of fabricators at Nebira 4 further highlights the differences between the collections. Not one chipped stone flake from Kulupuari has both proximal and distal end alteration. Assuming fabricators to be a by-product of a chipped stone reduction sequence which includes bipolar flake removal, there is reason to suggest some technological
disparity between the two assemblages. While Allen provides no
detailed quantitative description of the Nebira 4 flake implements,
there is no doubt that his material and the temporally comparable
assemblage from Kulupuari are indeed different.

The utilised flakes from Oposisi are also small in size,
ranging from 3.3-5.7 gm, but this collection of flake implements
generally lacks the specialised tool categories observed at Nebira 4
(Vanderwal 1973: Table VII-2). The mean values of the length, width
and length/width ratio of utilised flakes occurring in each of
Vanderwal's archaeological zones (1973: Tables VII-4, VII-7)
indicate that these artefacts are smaller, narrower and more "blade­
like" than those from Kulupuari. The "length of utilization" of
the altered edge or "length" edge (Vanderwal 1973: 122; Table VII-7)
is given, but due to the ambiguity of the terminology comparison
with the length of altered edges of Kulupuari flake implements is
impossible.

Vanderwal identifies a major category of chipped stone
artefacts called "notched stones" at Oposisi. From his definition
and illustrations (1973: 126, Fig. VII-2) I assume his notched stone
artefacts to be comparable to my potential categories of flake
implements and edge-altered cores which have nearly oblique altered
edges with a very concave profile (see Appendix 7: Table 7.3). In
the Kulupuari assemblages no cores meet these prerequisites. Of the
flake implements only three specimens, one from the recent phase and
two from the earlier one, could be classed as notched stones. All
appear to conform with those from Oposisi. The percentage occurrence
of notched stones at Kulupuari however is half that at Oposisi.

Edge-altered cores

Sixteen edge-altered cores were found at Kulupuari. Seven
of these are clearly associated with the lower stratigraphic unit and
only one with the upper (Table 8.25, 8.26). For analysis I segregate
those items belonging to the early occupation phase from the remaining
cores.

Because there are so few specimens it is difficult to
isolate any differences between the two groups, particularly when
examining qualitative attributes. However, based on the values for
the quantitative attributes it appears that the samples are similar. I characterise edge-altered cores as moderately large and "chunky" implements which are very square in plan. Altered edges are acute, variable in profile and often unifacially retouched (based on the occurrence of macroscopic hinge flake edge alteration).

Allen (1972) does not specifically discuss "core tools", although he notes their presence at Nebira 4. As mentioned above, Vanderwal's "notched stones" lack correspondence with Kulupuari edge altered cores. Furthermore, the "steeply retouched" chipped stone artefacts he describes and illustrates (1973: 126, Fig. VII-3) have a much more oblique altered edge and occur more infrequently than Kulupuari specimens.

Other chipped stone artefacts

Four unique chipped stone artefacts were found during excavations at Kulupuari. The provenance of the first three I describe is unquestionably the earliest phase of occupation; that of the last is ambiguous.

The first is a retouched flake implement (Fig. VI-23 ) which was situated approximately 8 cm above the culturally sterile soil horizon in Pit 3N3W. Its length, width and thickness are 7.4, 4.8, and 2.5 cm respectively; it weighs 103.5 g. The original striking platform has been removed, and most of the dorsal surface along the left margin is extensively altered by the removal of large, hinge terminated retouch flakes. The distal end and right and left margins have altered edges which are generally convex in profile. The maximum edge angle at each of these locations is 73°, 102° and 95° respectively. Almost all of the flake's surface, including the retouch flake scar is heavily patinated. Removal of weathered surface only occurs at isolated localities along both right and left margins. Recent macroscopic edge alteration, as evidenced by the removal patina, also appears along the flake's lateral margins. Microscopic examination of the implement reveals the margin edges to be heavily battered. Small step flakes occur along the dorsal surface of the distal edge.

The second artefact (Fig. VI-23 ) is a thin bifacially modified core implement which was found very near the first but in Pit ONOE and approximately 5 cm higher. Its surface is also heavily
patinated but bears no signs of more recent alteration. Small isolated patches of limestone cortex are still present in the middle of both faces. Its length, width and thickness are 10.65, 5.80 and 1.90 cm respectively; it weighs 108 g. In plan it is ovoid; its cross-section is roughly lenticular. The entire margin is modified with delicately struck hinge and feather flakes. The maximum edge angle present is 45°. Microscopic examination reveals no further edge alteration and on this basis it is questionable if the seemingly fragile edge was ever used.

The remaining early phase artefact is a multiple platform core which was probably used as a hammerstone.

The last chipped stone artefact to be discussed is a core tool (Fig. VI-23) found in the intermediate levels of Pit 5NOE. This area of Kulupuari has not been dated and the artefacts found in association with this specimen cannot be clearly identified as belonging to either occupation horizon. This artefact is roughly trapezoidal in plan and unifacially retouched at one end. In form it resembles an axe. It is 9.7 cm long, 8.9 cm wide along the retouched edge and 3.4 cm wide at the opposite end. The specimen is 1.8 cm thick and weighs 215.5 g. The angle of the altered edge is 52°. The lateral margins exhibit no evidence of modification.
APPENDIX 9

SEDIMENT ANALYSIS

KULUPUARI

X-ray diffraction analysis

A sample of the sediment in each major stratigraphic horizon was taken from the soil column sample collected from the western wall of Pit 3N3W. The material was soaked overnight in a solution of water and Calgon to allow complete dispersal. The clay and silt fraction held in suspension was then decanted. The precipitate was soaked in a solution of hydrochloric acid and vigorously agitated. The remaining sand fraction was soaked in distilled water for a short time and then the water solution was poured off. The material was dried in an oven. A slide containing a 10 mg sample of the sand fraction of each soil horizon was prepared. With the assistance of the Department of Geology, UPNG, the mineral content of each specimen was assayed by X-ray diffraction (for further information cf. Dana and Ford 1949: 28-37).

Figure 9.1 displays the resulting graphs. Table 9.1 lists the findings. After inspecting these results C. Pain (then of the Department of Geography, UPNG) concluded that the mineral composition of the samples were similar and that the sand throughout the deposit had a common volcanic source (1977: pers. comm.).

Grain-size analysis

The material used in this analysis was taken from 2.5-3.5 kg bulk soil samples of each major soil horizon occurring in the western wall of Pit ONOE. The procedures used by P. Hughes in this analysis are as follows (cf. Day 1965: 545-67; Folk 1968: 18-24, 34-90):

1. A 62.5 g sample of air-dried soil was dispersed by soading it overnight in a water and Calgon solution.
2. The sample was transferred to a 1,250 ml settling tube and stirred vigorously to ensure complete dispersal of the soil matrix.

3. The silt and clay fractions were measured using the hydrometer method. The silt was analysed at 1Ø intervals to the silt/clay boundary at 8Ø (see Table 9.2 for a description of the Ø to mm conversion scale). The coarse clay fraction (>10 Ø) was also determined. The clay remaining in suspension was regarded as representing the very fine clay fraction.

4. The entire sample was then washed through a 4 Ø sieve.

5. The sand fraction was first air-dried and weighed and then separated into fractions at 1Ø intervals using a nest of sieves.

6. Finally, the coarse silt fraction was calculated by subtracting the total weight of all other size grades from the sample's total weight (62.5 g).

Tables 9.3-9.6 describe the particle size distribution for each major soil horizon of Kulupuari. The textural name assigned to each horizon follows the method suggested by Hughes (1977: 22-23):

The textural name given to a sediment depends on the relative proportions of the different fractions, starting with the fraction present in the smallest amount and ending with the dominant fraction. Any minor fraction which makes up less than 5% of the weight of the sediment is omitted. For example, a sediment consisting of 6% gravel, 60% sand, 20% silt and 14% clay would be called gravelly clayey silty sand, whereas a sediment consisting of 2% gravel, 80% sand, 15% silt and 3% clay would be classified as silty sand.

The modal subgrade of the dominant fraction is also included in the name where it is known. Thus if the
median diameter of the sand fraction in the above examples was fine sand, their textural names would be gravelly clayey silty fine sand and silty fine sand.

Hughes' interpretation of these results is that Horizons II and III and Horizons IV and V are, respectively, not appreciably different. I therefore surmise that my distinguishing Horizon II from Horizon III during excavations was based primarily upon differences in the organic content of each which were noted as textural differences. I suggest Horizon IV represents a transition between the upper soil horizon (Horizons II and III) and the lower unit and the relatively higher sand content in Horizon IV probably results from the incorporation of material from the upper unit during the initial occupation of the site.

RUPO

Grain-size analysis

The material used in this analysis was taken from three column samples collected in sections of bamboo from the walls of the three primary excavations: Pit A - east wall, Pit B - south wall and Pit C - south wall (see Fig. VIII-2 for a section drawing of the site). The procedures followed parallel those described the analysis of the Kulupuari sediments, with the following exceptions:

1. The weight of each sample differs.
2. The material was initially sieved into three groupings:
   
   >-4Ø (coarse gravel),
   >1 to 4Ø (fine gravel) and
   >-1Ø (sand, silt and clay).

3. The cultural material in the coarse and fine gravel fractions was hand sorted and weighed.
4. Only the -1 to 4Ø (sand) and 4Ø (silt and clay, which I term mud) fractions of the >-1Ø sample were determined and this was done by sieving a 10 g subsample of each sample.
5. Cultural material, which consisted of only shell fragments, in the sand fraction was hand sorted and weighed and its proportional representation in the sand fraction was assumed to apply to the mud fraction.

Table 9.7 presents the findings of this analyses. About half of the samples in the upper 40 cm of the deposit are sandy muds with variable but small amounts of fine gravel. The remainder contains in addition appreciable amounts of coarse gravel. In marked contrast the two samples from the lower levels of the deposit consist of mud with only very small amounts of sand and negligible amounts of fine gravel.

**Calcium carbonate analysis**

The <-10 fraction of each stratigraphic sample, which was sorted during the grain-size analysis, was used in this analysis. Two 2 g subsamples were taken from each sample, crushed and air-dried. The percentage of calcium carbonate in each subsample was determined by the method described by Bauer, Beckett and Bie (1972: 689-90):

1. Dispense approximately 7 ml 5N HCl into a 25 ml beaker having checked that this is sufficient to dissolve all carbonate present in the most calcareous sample.

2. Place an empty 10 ml porcelain crucible bottom down in the top of the beaker.

3. Weigh the combination (W₁) to the nearest 1 mg (on a top loading balance).

4. Extract approximately 1 g (2 g in this study) air-dried, sieved soil (<2 mm) from the sample: place the soil in the crucible.

5. Weigh the combination weight (W₂).

6. Gently pour the soil from the crucible into the beaker, replace crucible on top to catch any splashes or spray, and gently swirl.
7. Swirl twice more at 10 min. intervals: the reaction is complete after 30 min.

8. Reweigh \((W_3)\) without further delay.

The percentage of calcium carbonate was calculated using the following formula:

\[
\% \text{ CaCO}_3 = \frac{(W_2 - W_3) \times 227.4}{(W_2 - W_1)}
\]

(ibid.)

Table 9.8 lists the percentage of calcium carbonate in each subsample. With the exception of the 33-38 cm subsamples from Pit A, all subsamples taken from the upper 40 cm of the site show a comparable amount of calcium carbonate in their sediments. The calcium carbonate in the lower sediments differ markedly. This method of analysis does not differentiate between naturally occurring CaCO\(_3\) and that contributed to the sediments by shell; therefore, the differences between upper and lower stratigraphic units may be exaggerated. Further interpretation of these results are presented in the text (p. 184).

Analysis of roof-fall

This analysis was undertaken to determine the extent to which non-calcareous materials in the limestone in which the rock shelter has formed contribute to the site's sediments. Six specimens of roof-fall included within the three column samples were submitted to J. Caldwell (Department of Biogeography and Geomorphology, ANU) for analysis.

Each sample was crushed into a fine powder and placed into a solution of acetic acid, which was gently heated. The non-calcareous residue was dried and placed into a solution of hydrogen peroxide to remove all organic material. The organic-free residue was dried and weighed to the nearest 0.1 mg.

Table 9.9 lists Caldwell's findings. The interpretation of these results appears in the text (pp. 183-84).
APPENDIX 10

ANU RADIOCARBON LABORATORY REPORT ON C-14 DATES

by H. Polach

Charcoal C-14 ages are with respect to 1950 wood and are based on the 5570 C-14 half-life and hence are reported as AGES BP in conventional radiocarbon years (see Olsson, 1970).

Shells from an inland environment yield only Apparent C-14 ages BP. Thus an Environmental Correction Factor needs to be applied to them before the C-14 results derived from them can be related to charcoal or wood. This factor can range from i.e. 450 ± 35 years to 5700 ± 200 years (limestone dilution effect). In your case we could postulate from the modern values derived from shells in the same and similar environments that the Environmental Correction Factor is most likely to be 2900 ± 150 C-14 years. This value needs to be subtracted from the apparent BP ages reported, and the errors need to be pooled statistically, i.e. ±(a² + b²)½, where a and b are errors of determination and correction factors respectively.

C-14 ages are reported in finalized form to you in Tables 10.1 and 10.2. You may use these in your thesis and subsequent publications.
APPENDIX 11

PETROGRAPHIC EXAMINATION OF POTTERY AND STONE AXE HEADS FROM ARCHAEOLICAL SITES IN THE KIKORI AREA, GULF OF PAPUA

by D.E. Mackenzie

POTTERY

Most of the specimens examined in thin section contain a combination of:

(a) a variety of rock and crystal fragments (including garnet) derived from an amphibolite facies metamorphic terrain,

(b) a variety of intermediate to basic volcanic rocks and

(c) aggregates of highly strained irregular quartz grains (from the Onga Beds?)

that rule out an origin in or near the area in which they were collected. The most likely sources of clays containing such an assemblage of detritus are the coastal plains at the mounts of the Angabunga and Lakekamu Rivers (Yule Island and Moveavi areas, respectively).

Specimens II/1, II/3, II/6, and II/8 contain abundant clasts of chalcedony (cavity-filling, replacement; opaline; variously recrystallized) and silicified fine-grained or glassy volcanic rocks and have a distinctly tuffaceous appearance. Metamorphic detritus and clinopyroxene crystal fragments common in other specimens are very rare or lacking in specimens II/6 and II/8 (which are very alike), but present in II/1 and II/3. Specimens IV/1, IV/7, and IV/10 also contain chalcedony (notably IV/1), but also contain abundant detritus common to the other (chalcedony-free) specimens. The source of the clays that contain metamorphic detritus and chalcedony may well be in the same general area as the other clays. The clays that lack metamorphic detritus (II/6 and II/8) cannot on their own be assigned to a particular source, but the association of similar chalcedony fragments with metamorphic detritus in other clays again suggests that there may be
metamorphic detritus in other clays again suggests that there may be a common source.

<table>
<thead>
<tr>
<th>Specimen No.</th>
<th>Description</th>
<th>Suggested source</th>
</tr>
</thead>
<tbody>
<tr>
<td>II/1</td>
<td>XF: clinopyroxene, plagioclase, hornblende, orthopyroxene. RF: very fine-grained metamorphic rocks, chalcedony, ferruginised porphyritic (?) andesite</td>
<td>volcanic</td>
</tr>
<tr>
<td>II/2</td>
<td>XF: quartz, plagioclase, brown hornblende, clinopyroxene, olivine; garnet (rare) RF: variety of fine-grained volcanic rocks and fine to medium-grained intrusive rocks; possible granitic rocks; quartz ± mica ± hornblende schists; phyllite, phyllitic mudstone.</td>
<td>volcanic metamorphic</td>
</tr>
<tr>
<td>II/3</td>
<td>RF: chalcedony (various forms, including opaline) in various stages of recrystallisation; silicified fine-grained volcanic (including tuffaceous) rocks; quartz – mica schist; spores. XF: hornblends (green, brownish green, or green-brown), quartz, plagioclase</td>
<td>volcanics (incl. pyroclastics) volcanic and/or high-level intrusive.</td>
</tr>
<tr>
<td>II/4</td>
<td>XF: quartz (some is composite); zoned plagioclase, clinopyroxene, hornblende (green-brown, brown) RF: quartzite (or simply metamorphic quartz), granitic rock; fine-grained acid-intermediate and rare basic volcanic rocks; chert; quartz-mica schist.</td>
<td>plutonic or metamorphic; volcanic</td>
</tr>
<tr>
<td>II/5</td>
<td>XF: clinopyroxene (abundant), hornblende; quartz (mainly composite); garnet (rare) RF: fine-grained intermediate to basic volcanic rocks, possible granites; quartz ± mica ± hornblende? schist, quartz – mica – garnet schist; mudstone/shale.</td>
<td>volcanic; plutonic/ metamorphic; metamorphic</td>
</tr>
<tr>
<td>Specimen No.</td>
<td>Description</td>
<td>Suggested source</td>
</tr>
<tr>
<td>-------------</td>
<td>-------------</td>
<td>------------------</td>
</tr>
<tr>
<td>II/6</td>
<td>RF: chalcedony (various forms), silicified very fine-grained volcanic rocks, including tuffs, silicified spores, etc. (now chalcedony)</td>
<td>volcanics (incl. tuffs)</td>
</tr>
<tr>
<td></td>
<td>XF: quartz (small), hornblends (green), twinned plagioclase, ?clinopyroxene</td>
<td>probably volcanic</td>
</tr>
<tr>
<td>II/7</td>
<td>XF: clinopyroxene (very abundant), quartz, plagioclase.</td>
<td>volcanic</td>
</tr>
<tr>
<td></td>
<td>RF: variety of volcanic rocks, including plagioclase and/or pyroxene-phyric intermediate rocks and pyroxene-phyric basic rocks; fine quartz - mica schist or phyllite; vein (?) quartz with Fe-oxides.</td>
<td></td>
</tr>
<tr>
<td>II/8</td>
<td>RF: chalcedony (various forms, including opaline, some ferruginous); silicified fine-grained volcanics including (?) tuff.</td>
<td>volcanics</td>
</tr>
<tr>
<td></td>
<td>XF: quartz, green hornblende, plagioclase</td>
<td>plutonic and/or volcanic</td>
</tr>
<tr>
<td>II/9</td>
<td>XF: quartz, clinopyroxene, rare plagioclase, hornblende, ?biotite.</td>
<td>volcanic and metamorphic</td>
</tr>
<tr>
<td></td>
<td>RF: few very fine-grained volcanic rocks; rare opaline chalcedony and variably recrystallised chalcedony</td>
<td></td>
</tr>
<tr>
<td>II/10</td>
<td>XF: quartz, clinopyroxene, plagioclase, muscovite, green hornblende, epidote, garnet, ?sphene.</td>
<td>volcanic and metamorphic</td>
</tr>
<tr>
<td></td>
<td>RF: quartz-mica schists; fine-grained intermediate to basic volcanic rocks; phyllite; &quot;claystone&quot;.</td>
<td></td>
</tr>
<tr>
<td>II/11</td>
<td>XF: quartz, plagioclase, clinopyroxene, hornblende</td>
<td>volcanic</td>
</tr>
<tr>
<td></td>
<td>RF: very fine-grained pelitic metasediments; very fine-grained volcanic rocks; mudstone; composite (metamorphic?) quartz; quartz-mica schist.</td>
<td></td>
</tr>
<tr>
<td>IV/1</td>
<td>RF: chalcedony (various forms); silicified fine-grained volcanics (including tuff); phyllite, shale.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>XF: quartz, plagioclase; rare clinopyroxene and hornblende</td>
<td></td>
</tr>
<tr>
<td>Specimen No.</td>
<td>Description</td>
<td>Suggested source</td>
</tr>
<tr>
<td>-------------</td>
<td>------------------------------------------------------------------------------</td>
<td>-----------------------</td>
</tr>
<tr>
<td>IV/2</td>
<td>XF: quartz, zoned plagioclase, clinopyroxene</td>
<td>volcanic</td>
</tr>
<tr>
<td></td>
<td>RF: variety of very fine-grained intermediate to basic volcanic rocks; composite (metamorphic?) quartz, quartz-mica schist, shale or mudstone</td>
<td></td>
</tr>
<tr>
<td>IV/3</td>
<td>XF: quartz, plagioclase, clinopyroxene, ?epidote</td>
<td>volcanic, ? metamorphic</td>
</tr>
<tr>
<td></td>
<td>RF: shale and/or phyllite, composite (metamorphic) quartz, quartz-mica schist, fine-grained porphyritic and non-porphyritic volcanic rocks</td>
<td></td>
</tr>
<tr>
<td>IV/4</td>
<td>XF: clinopyroxene (abundant), hornblende, quartz, plagioclase, altered ?olivine</td>
<td>volcanic, some ? metamorphic</td>
</tr>
<tr>
<td></td>
<td>RF: quartz-mica schist, composite (metamorphic) quartz, phyllite, ferruginous phyllite mudstone; very fine-grained andesitic volcanic rock.</td>
<td></td>
</tr>
<tr>
<td>IV/5</td>
<td>XF: quartz, clinopyroxene, plagioclase, hornblende</td>
<td>volcanic</td>
</tr>
<tr>
<td></td>
<td>RF: composite (metamorphic) quartz, phyllitic mudstone very fine-grained quartz-mica schist and phyllite; very fine-grained intermediate to ?basic volcanic rocks</td>
<td></td>
</tr>
<tr>
<td>IV/6</td>
<td>XF: quartz, plagioclase, clinopyroxene, hornblende (brown and green); rare biotite, zircon, garnet and epidote</td>
<td>volcanic and metamorphic</td>
</tr>
<tr>
<td></td>
<td>RF: composite (metamorphic) quartz, very fine-grained quartz-mica schist and phyllite, ferruginous mudstone; very fine-grained porphyritic and non-porphyritic volcanics; ?foram casts. Chalcedony (var. rextall.)</td>
<td></td>
</tr>
<tr>
<td>IV/7</td>
<td>XF: quartz, plagioclase, clinopyroxene, hornblende (brown and green)</td>
<td>mainly volcanic</td>
</tr>
<tr>
<td></td>
<td>RF: fine-grained quartzose metasediments; very fine-grained to glassy (silicified?) volcanic rocks; variously recrystallised (?) chalcedony.</td>
<td></td>
</tr>
<tr>
<td>IV/8</td>
<td>XF: quartz, clinopyroxene, plagioclase, hornblende (brown), garnet, magnetite</td>
<td>volcanic and metamorphic</td>
</tr>
<tr>
<td></td>
<td>RF: fine-grained quartz-mica phyllite or very fine schist (some fragments quite large); very fine-grained andesitic volcanic rocks.</td>
<td></td>
</tr>
<tr>
<td>Specimen No.</td>
<td>Description</td>
<td>Suggested source</td>
</tr>
<tr>
<td>-------------</td>
<td>--------------------------------------------------</td>
<td>-----------------------------------</td>
</tr>
<tr>
<td>IV/0</td>
<td>XF: clinopyroxene (abundant), quartz, plagioclase, hornblende (green-brown), garnet, ?olivine, magnetite</td>
<td>volcanic and metamorphic</td>
</tr>
<tr>
<td></td>
<td>RF: fine to very fine-grained metasediments (quartz + mica ± epidote) and intermediate volcanic rocks</td>
<td></td>
</tr>
<tr>
<td>IV/10</td>
<td>XF: clinopyroxene, plagioclase, hornblende (green to brown), apatite, epidote</td>
<td>volcanic and metamorphic</td>
</tr>
<tr>
<td></td>
<td>RF: fine-grained quartz-mica schist/phyllite; very fine-grained phyllite with quartz &quot;knot&quot;; fine-grained intermediate to basic volcanic rocks, some porphyritic, altered/deritrified glassy volcanic rocks; rare variably recrystallised (?) chalcedony.</td>
<td></td>
</tr>
</tbody>
</table>

STONE AXE HEADS

Of twelve stone axe heads examined in thin section, eleven proved to be basic and intermediate volcanic and, possibly, intrusive rocks, metamorphosed to greenschist grade. These rocks show a high degree of mineralogical and textural similarity with one another and the common presence of bluish amphibole suggests high pressures during metamorphism. On the basis of the lithologies and style of metamorphism of these rocks, I conclude that the axes are not of local origin or from the Highlands or Sepik areas. The most likely source areas are in the drainage basin of the Angabunga River-Alabule River (Tapini-Yule Island area) or the Lakekamu River-Kunimaipu River area to the north. Rocks in these areas include metamorphosed basic volcanic rocks, including pillow lavas, which have undergone high-pressure greenschist grade metamorphism.

The twelfth specimen (56/3) is a fine-grained silicified sediment containing possible Early Cretaceous radiolarians. Broadly similar rocks occur in the abovenamed areas, but they are of Late Cretaceous to Eocene age. Specimen 56/3 may be from float derived from the headwaters of the Lakekamu River system or, possibly, the Angabunga River system.
<table>
<thead>
<tr>
<th>Specimen No.</th>
<th>Rock Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>36/2</td>
<td>metamorphosed basaltic andesite or basalt</td>
<td>Fine-grained felted aggregate of actinolite, quartz, blue-green amphibole, and opaque oxide minerals.</td>
</tr>
<tr>
<td>51/3</td>
<td>metamorphosed acid andesite, or dacite</td>
<td>Fine-medium-grained, largely recrystallised aggregate of actinolite, chlorite, quartz, epidote, and large altered sphene crystals.</td>
</tr>
<tr>
<td>56/2</td>
<td>metamorphosed basaltic andesite or basalt</td>
<td>Fine-grained felted aggregate of actinolite, albite, quartz, and abundant opaque oxides; &quot;wispy&quot; texture. Similar to 36/2.</td>
</tr>
<tr>
<td>56/3</td>
<td>silicified sericitic meta-mudstone</td>
<td>Very fine-grained aggregate of quartz, sericite, and abundant opaque oxides, with radiolarian casts of Cretaceous (possibly Lower) age.</td>
</tr>
<tr>
<td>57/1</td>
<td>metamorphosed basaltic andesite or basalt</td>
<td>Fine-grained interlocking (felted) aggregate of actinolite albite, quartz (?), and abundant opaque oxides; quartz veinlet. Same as 56/2.</td>
</tr>
<tr>
<td>59/1</td>
<td>metamorphosed andesite. (meta-andesite)</td>
<td>Fine-grained felted, subtrachytic aggregate of actinolite, albite, chlorite, opaque oxides, and probable quartz; phenocrysts of plagioclase (now albite) up to 4 mm long.</td>
</tr>
<tr>
<td>59/2</td>
<td>metamorphosed basaltic andesite</td>
<td>Fine-grained felted aggregate of actinolite, quartz, albite, chlorite, and abundant opaque oxides. Phenocrysts of plagioclase (now albite).</td>
</tr>
<tr>
<td>61/1</td>
<td>meta-andesite</td>
<td>Medium-grained aggregate of actinolite, blue-green amphibole, albite, quartz, opaque oxides, and chlorite; rare phenocrysts of plagioclase (now albite).</td>
</tr>
<tr>
<td>65/1</td>
<td>metamorphosed ?gabbro</td>
<td>Medium to coarse-grained aggregate actinolite (pleochroic from yellow-green to blue), albite, quartz, and opaque oxides.</td>
</tr>
<tr>
<td>70/1</td>
<td>meta-andesite</td>
<td>Fine-grained felted aggregate of actinolite (pleochroic from green to blue), albite, quartz, and opaque oxides.</td>
</tr>
<tr>
<td>Specimen No.</td>
<td>Rock Type</td>
<td>Description</td>
</tr>
<tr>
<td>-------------</td>
<td>--------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>121/1</td>
<td>meta-andesite</td>
<td>Fine-grained aggregate of chlorite, actinolite, quartz, albite, and opaque oxides.</td>
</tr>
<tr>
<td>130/1</td>
<td>metabasalt</td>
<td>Fine-grained felted aggregate of actinolite, albite, quartz, and opaque oxides.</td>
</tr>
</tbody>
</table>
APPENDIX 12

MURANO GLASS BEAD

A total of 74 glass beads were recovered during my excavations at Kulupuari, Mampaiu, Ibira, Rupo and Herekuna. Of these only the single multi-coloured specimen was considered for sourcing analysis. This artefact (Plate VI-3a) was recovered at a depth of 10 cm in Pit 5NOE, Kulupuari, and was found in association with a small white bead. To conduct the analysis I enlisted the assistance of Dr A. Lamb (Head of Department of History, Hatfield Polytechnic, Hatfield, England), who has made the study of trade beads a specific concern. A full transcript of his report follows:

19 July 1979

Dear Mr Rhoads,

Thank you for your letter of 19 June 1979. I have examined as well as I can your admirable colour slides and, indeed, have made black and white enlargements from them of which I enclose two. They are done with a special reversal printing paper of very high contrast; but they serve to indicate some details of possible diagnostic import.

Without examining the actual bead one must, you will appreciate, have to be to some degree cautious in one's observations. However, I will rush into the following extent.

a. Despite the apparent swirling structure of the core of the bead, the presence of air holes would indicate pretty firmly that the bead is drawn and, in fact, is a variety of multiple layer cane bead.

b. I have looked very carefully at the structure of the four sets of longitudinal stripes and can say this about them
   i. they are very deeply impressed into the body of the bead,
   ii. they look to me as if they at some time included another colour than the reddish-brown, a colour which has weathered away,
iii. I would suspect that these stripes were in fact not simple trails but the inlaying of further canes into the original glass gather from which the bead was drawn,

iv. If so, then the inlay canes show no sign of twisting,

v. Nor do they seem to have been hollow, though I cannot rule this last possibility out on the basis of the evidence of your slides.

What can one conclude from all this?

i. Beads were indeed made in Holland and elsewhere in the Netherlands (the Spanish part), from the late 16th century onwards to the end of the 17th century when their manufacture, to the best of our knowledge, stopped. I refer to

F.W. Hudig, *Das Glas mit besonderer Berücksichtigung der Sammlung in Nederlansch Museum voor Geschiednis en Kunst in Amsterdam*, Vienna 1923

and


But, so far as one can tell from the actual Netherlands material which has recently come to light during the excavation for the Metro in Amsterdam, these were of a rather limited repertoire in which I have not seen anything quite like the bead which you illustrate in your slide. The evidence rather suggests that these Netherlands beads were made, at least initially, by Italian craftsman; and it may even be that some glass canes were imported from Murano for the manufacture of at least some of the decoration of beads. So, when the chips are down, one cannot really be sure of Netherlands as opposed to Italian manufacture. My own impression, for what it is worth, is that your example is *not* Dutch, but rather Venetian. This impression, I must repeat, is based on the assumption that the Netherlands repertoire was smaller than that of Murano and that within that repertoire, of which I have now seen many hundreds of examples, there comes to my mind no exact match.
ii. The features of the trailing, plus other more subjective elements detected in your slides, makes me feel that within the Murano context this particular bead is quite early. Deep trailing is certainly an early feature; and had the particular bead type been common in the later repertoire, I would almost certainly have seen its match after having handled many thousands of beads from the European manufacturues dating from the late 18th century onwards. Hence I would not be at all unhappy to put your bead in a mid-17th century to mid-18th century horizon.

iv. The general design of your bead is of a type which rather incorrectly (in the terminology of Murano) has been called by West African archaeologists a *Rosetta* bead (incorrectly because the Murano people used the term Rosetta to cover a multitude of many-layered cane beads). The general pattern seems to have hit the trade routes, at least in West Africa, some time in the 17th century, and probably in the early part. Of course, from then on they continued to circulate and good early examples can still be obtained in African markets.


A careful examination of both these works, which have illustrations (but drawings and painting only, alas) will not yield a precise match for your bead.

Having said all this, I would not rule out the possibility that your bead is much later. What I mean is this: if the context requires a 17th century date, there is nothing in your bead, as revealed in your slides, to rule that date out. However, if you wanted a later date, then your bead, on its own, would not be particularly significant. Here, of course, lies the irritating fascination of bead studies: they all too often lead one into cul-de-sacs. On the whole, however, I would be inclined to stick by my impression that your bead falls into the general period c. 1650 to c. 1750; and I would be happier with Murano rather than the Netherlands as the place of manufacture. But I could be wrong.
I hope all this is of some use to you. If you get some more beads, please do not hesitate to send me pictures (black and white will do in the majority of cases provided colours are indicated in the accompanying comment). An assemblage of beads nearly always tells one much more than any single specimen.

Yours sincerely,

Alastair Lamb

Following on from Dr. Lamb's findings, there would appear to be two possible means by which the bead was introduced into areas along the south coast of New Guinea:

1. Dutch exploratory voyages, or
2. Moluccan trading voyages.

Table 12.1 lists the Dutch voyages to the New Guinea and Torres Strait region, which span the period from initial contact in 1605 AD to the reconsolidation of Dutch East Indies Company enterprises in the late eighteenth century when Dampier and Cook established British interests in Australia. This information clearly illustrates that the Dutch failed to locate an easterly passage through the Torres Strait area; therefore, if the Dutch are responsible for introducing the bead into the region it must have been transported through traditional exchange systems (cf. Haddon 1904: 296-7; Landtman 1927: 213-14) to the Kikori area.

Based upon Lamb's suggested date range for the bead's manufacture there is only one Dutch voyage during which the bead could have been deposited in the area: Gonzal in 1756. My analysis of the report by de Haan of the voyage (Heeres 1899: 92-100) leads me to suggest that anchorages between 17-26 April and 28 April-13 May were made at Torres Strait Islands lying near Muralug (Prince of Wales Island). No mention of direct contact with the people living on the islands is made; however, considerable time was spent at both localities. Such a lengthy stay in the area may have resulted in beads being used as gratuities or in barter as was the case with Carstenz's early voyage to this region (Heeres 1899: 32, 40). Of course, without the actual voyage logs I am only able to speculate.
The most recent calendrical date for the proto-historic occupation of Kulupuari is prior to Gonzal's voyage. Therefore, if the Dutch directly introduced the bead into the region by Dutch, then the bead's deposition at Kulupuari must date from the historic period.

The transport of the Murano bead into the region by Moluccan traders is another possibility. Support for this conclusion comes from the recovery of white glass beads, similar to the specimen found with the Murano bead, at the Ibira open site (p.165ff.) whose most recent calendrical date (at two standard deviations) is near the beginning of the seventeenth century. The reader is directed to my description of the Ibira site for a further discussion.

**Glass dog's tooth**

This artefact (Plate VI-3c) was found in the top 5 cm of the deposits at Rupo. As it occurred well within the limits of recent root disturbance and early contact trade items (e.g. a glass bottle and steel bush knife) were noted on the surface of the site, I conclude it relates to very recent site use.

My cursory investigation of historical evidence reveals that both the Germans and British may have introduced similar items into New Guinea. The Germans introduced imitation dog teeth into the Manus Island area (Pfeil 1899, cited by Epstein 1968: 35). According to Beaver (1920: 229) London-based firms shipped 'dog teeth' to the South Seas. Neither of these references provide a satisfactory resolution to the problem. I must, therefore, defer it to future research by students with a greater period of access to the relevant archival documents.
APPENDIX 13

FAUNAL IDENTIFICATION PROCEDURES

by

Ken Aplin

INTRODUCTION

In this appendix I discuss some aspects of an integrated study of the faunal remains recovered by Rhoads from archaeological sites in the Waira region. The laboratory analyses described here were undertaken with the assistance of Rhoads in May 1979 and continued until November of that year.

The following discussion includes (1) a brief description of the collection; (2) a statement of method; (3) an outline of laboratory procedures; and (4) a short account of each animal group, with details of laboratory procedures and discussion of select specimens.

THE COLLECTION

The faunal collection consists of material from the archaeological sites described by Rhoads in Chapters 6 - 8. A summary of the collection is found in Tables VI-15; VII-4,7,15; VIII-10,20,27. The assemblages span in time from earlier than 2000 BP through to the historic past and document the use of a wide range of aquatic and terrestrial faunal resources. Although a similar suite of animal remains was found at all sites, the physical character of the assemblages varies markedly between deposit types.

Open Sites

The open site assemblages provide an age-graded series in which the physical character closely reflects the extent to which post-depositional decay has progressed.
Small but well preserved assemblages were recovered from the historic or recent prehistoric sites of Bagaima and Waira and from a post-contact shell midden at Kulupuari (see Chapters 6 and 7). These collections consist almost entirely of fresh, unburnt bone, and calcined bone (i.e. "totally cremated bone", Herrmann 1977) which typically comprises less than 3% of the total. In contrast to the finely fragmented burnt bone, the unburnt material consists of much larger splinters and chunks. Several types of faunal remains do not occur at open sites and are believed to have been removed very rapidly in solution. These include arid otoliths and crustacean exoskeleton. An exception to the rule is the occurrence of some very decomposed crab chelae in the post-contact midden at Kulupuari, providing some support for this contention.

Several sites yielded faunal remains in a similar but rather more decomposed state. Mampaiu in particular contains an extremely decomposed but primarily unburnt collection reminiscent of the basal horizon at Kulupuari (see Chapter 6).

A large but very poorly preserved assemblage was recovered from Kulupuari. It consists almost entirely of thoroughly fragmented calcined bone that ranges in condition from relatively fresh to rounded and corroded. Unburnt bone only forms a significant component of the assemblage in the lower horizons of the site. This material resembles the assemblage from Mampaiu but is even further decomposed, often being present as little more than a trace in the matrix (J.W. Rhoads 1979: pers. comm.). Therefore, although the bone from Kulupuari is broadly consistent in character with that from the other open sites, it appears to have undergone dramatic alterations associated with a massive post-depositional decay of bone. Judging from the burning pattern established in the more recent assemblages, a postulated reduction in bulk by a factor of thirty may not overestimate the magnitude of the alterations.

The rapid decay of unburnt bone under open site conditions results from the effective combination of (1) the biochemical breakdown of the organic fraction and (2) the aggressive solution of the inorganic fraction by percolating rain and flood-waters. Calcined bone is, however, unaffected by biochemical action due to its totally inorganic composition (Baer et al. 1973; Herrmann 1977) and is
subject to slower solution rates because of its amorphous micro-
structure. Its survival chances under most conditions are far
greater than for either unburnt or incompletely burnt bone. The
survival of unburnt but very decomposed bone in the lowest levels
of Kulupuari and at Mampaiu may reflect a special circumstance in
which, while solution remains effective in removing the inorganic
fraction of the bone, the organic fraction is protected from
biochemical decay by anaerobic conditions.

Rockshelter Sites

Large collections were recovered from three rockshelters
(see Chapter 8). Ouloubomoto and Rupo exhibit essentially similar
long histories of accumulation dating back to Pre-ceramic Period
deposits. They both preserve faunal remains throughout sequences
that span the last 2000 or more years. In contrast the deposit at
Herekuna accumulated rapidly during more recent times and consists
largely of abundant well-preserved shellfish remains.

These assemblages present essentially similar characters that
differ somewhat from the typical open-site material described above.
While burnt bone comprises a large portion of the rockshelter remains
calcined bone is relatively uncommon. This pattern is not replicated
in the unburnt and highly calcined open site assemblages. Decay
processes alone do not account for these differences and, therefore,
an explanation in terms of human burning practices may be appropriate.
The fragmentation of bone has, however, been more thorough at the
rockshelters and appears to be unrelated to burning state. Although
burning is clearly the major cause of fragmentation at Kulupuari,
treadage may be the most effective process in the rockshelter confines.

The rockshelter assemblages are very much better preserved than
open site remains of equivalent age. Evidence for bone decay is
lacking at Herekuna, although in this case the protective, midden
environment is almost certainly responsible. In the two older
deposits unburnt bone exhibits a noticeable deterioration with depth
that results in its virtual absence from the earliest horizons.
Burnt bone, however, appears to be unaffected throughout the sequences,
except for some carbonate encrustation on Ouloubomoto material. The
good preservation of bone in the rockshelter deposits is primarily a
result of the non-aggressive nature of the limestone seepage into the deposit, although the fine-textured, compact deposits may also constitute a partially anaerobic environment conducive to survival.

Although the rockshelter assemblages have not been affected by the degree of post-depositional alteration noted for Kulupuari, they nonetheless represent only a very small proportion of the total food remains discarded during periods of human use of the site vicinity.

Support for this contention is (1) although many individual animals can be confidently recognized in the assemblage, there is rarely more than a single (non-fish) bone thought to have come from any particular individual and (2) the unidentified bone is totally insufficient in either quantity or character to account for the remainder of the identified individuals. Suitable hypotheses to account for the loss of bone from these sites may revolve around (1) human disposal patterns, (2) processes of bone destruction at the surface of a deposit (e.g. weathering, repeated firing) and (3) processes of selective post-depositional decay that totally destroy certain elements while leaving others seemingly unmarked.

METHOD

The faunal study was primarily concerned to interpret the spatial orientation and scheduling of subsistence activities carried out from the various sites. Among the animal species found in the collection most are caught throughout the Waira region, but exhibit quite strong locational preferences on a permanent or seasonally changing basis (see Appendix 16). As a qualitative measure of the faunal composition would be inadequate to detect variations of this kind, an appropriate quantitative measure of the proportional representation of different taxa in the assemblages was sought.

The most widely used technique involves the calculation of the minimum number of individuals (MNI) representing the various taxa in a collection. This is best applied to situations where (1) each individual is represented by a fairly complete set of skeletal remains (e.g. owl pellet accumulations) or, (2) certain diagnostic
elements survive deterioration in preference to all others. Dentition is generally believed to satisfy the second condition and is commonly used to calculate MNI to the exclusion of other skeletal elements.

The MNI technique is inadequate for the study of small, highly 'altered' assemblages. Under these conditions all taxa assume an indiscriminantly low MNI value, irrespective of their proportional representation among the remains. As a preliminary measure, MNI was calculated by cultural horizon in the sites using (1) all identified bone, and (2) dentition alone. Even when using all of the identified remains the MNI value was found to be unity for most taxa. Based on dentition alone many of the taxa present in each horizon went unrecorded. Although teeth occur infrequently in the sites this is believed to attest to their effective destruction in these environments, rather than to suggest an initially small sample. It is quite clear that while enamel is certainly less soluble than bone, teeth can be readily destroyed by (1) shattering of the enamel crown during firing, or (2) disintegration of the dentin core by solution and fragmentation of the thin enamel cap.

The approach adopted for this study emphasises both the physical condition and taxonomic composition of the total faunal collection. The assemblages are considered to be essentially non-static in nature and are described in terms of initial and altered character states.

The method consists of the determination of the weight of remains for the various taxa recovered and the abstraction from this of the proportional representation of each in the total assemblage. The most reliable results are obtained with a 'total identification'. This involves (1) the allocation to low level taxa (species - family) of a large proportion of the remains, followed by (2) an assessment of the higher level taxonomic composition (class) of any unallocated material. The second step removes much of the uncertainty associated with a truly 'unidentified' category.

One advantage of this approach is that small collections can theoretically be described with the same resolution as larger ones. In faunal analysis small size is typically equated with limited
interpretive value. Although this is true in some situations it is equally as untrue in the present case for the following reason. In an 'unaltered' assemblage a small quantity of remains probably reflects a limited number of events and may not provide an exemplary pattern of the overall subsistence strategy. However, in a 'highly altered' assemblage the small quantity potentially represents a broad spectrum of subsistence activities and, conditional on the processes of decay, may accurately portray the returns of an overall subsistence strategy.

The key to interpretation of these highly 'altered' assemblages clearly lies in an understanding of the three components of 'alteration': (1) the patterns of human discard of debris, (2) the processes of loss and destruction operating in surficial contexts in rockshelters, and (3) the processes of decay operating after burial. The importance of the first and second components cannot be estimated other than to suggest that, on the rockshelter evidence, the combination appears to produce a very 'altered' pre-burial assemblage. The detail recorded for the assemblages will, however, permit a thorough assessment of the third component to be made. Although this analysis has not yet been performed, my laboratory impressions, backed up by some preliminary bivariate plots of burning patterns and decay rates, suggest that the following propositions may hold for a given site:

(1) that burning patterns are roughly comparable for all taxa although the aquatic elements, fish and turtle, may be slightly more burnt on average; and

(2) that decay rates are comparable within an animal class (e.g. Mammalia, Teleostomi), but differ somewhat between them. In particular, unburnt fish bone decays more rapidly than unburnt mammal or reptile bone.

The broad implications of these propositions are:

(1) that higher taxonomic level proportional representation (e.g. mammals vs fish) will not be altered drastically by decay. Although fish bone decays more rapidly than other types, this may be balanced by an initially higher burning frequency; and
(2) that proportional representation will alter less between members of a single animal class (e.g. Peramelidae vs Macropodidae), than between members of two classes (e.g. Peramelidae vs Ariidae).

I conclude, therefore, with the proposition that the level of interpretation invoked in the testing of the alternate land-use models is entirely in keeping with the integrity of the analysis.

LABORATORY PROCEDURES

This section describes the procedures followed during the initial sort and those commonly applied to all groups. Specific procedures or techniques are detailed in the discussion of the relevant class.

Examination of select items was conducted under binocular magnification no greater than 40X and all weights were taken on an electronic balance.

Cleaning

When received the collection was in an uncleaned state. It was subsequently cleaned using dental probes and brushes. Washing was avoided because the material was in a corroded and friable condition.

Sorting

The material was sorted into the following categories:

- fish bone, fish otoliths, turtle carapace, bird eggshell, crustacean gastroliths and exoskeleton and other bone.

This stage was conducted while cleaning and both tasks were largely performed by Rhoads.

Recording

The carapace was then divided into burning classes (unburnt, burnt or calcined) and each was recorded by weight and number.
Crustacean gastroliths and exoskeleton and bird eggshell were also divided into burning classes (unburnt or burnt), each of which was recorded by number and weight. Fish bone received special attention which is described below.

Each piece of bone falling in the category "other bone" was individually examined and divided into three groupings:

- Identified (stored with allocation), "potentially identifiable" but requiring a more detailed examination (stored separately) and unidentified (stored by excavation unit).

Following this stage the "potentially identifiable" material was re-examined and either (1) identified and incorporated into this grouping or (2) rejected and incorporated into the unidentified grouping.

Unidentified bone was next sorted into two groupings:

1. bone unidentified on morphology but probably pig bone as indicated by its size and textural characteristics; and

2. bone unlike pig bone and probably small mammal, bird or reptile.

The material belonging to each grouping was then divided into burning classes (unburnt, burnt or calcined) and recorded (number and weight).

Identified bone other than fish was recorded by considering each animal grouping successively. All remains belonging to a single group were laid out together and decisions made concerning the taxonomic status of each bone. Each piece was then recorded by taxon, body part, bone portion, bone symmetry, burning class, weight and age/size. Special specimens such as pig teeth and marsupial dentition were set aside for further description and comparison.

Storage

All faunal remains were stored in vials or boxes labelled with their identification and archaeological provenance. Friable bones were consolidated with an acetone solution.
NOTES ON TAXA

Teleostomi

Introduction

Fish remains from a wide range of taxa dominate the faunal assemblages of most sites. The fish communities and aquatic ecology of Purari/Kikori system are now well documented by the survey work of Haines (1976, 1979). Appendix 16 discusses the aquatic habitats and fish communities projected for the region around Waira. Archaeological fish assemblages were assessed against this backdrop to determine (1) foraging location within the landscape and (2) the scheduling of site use.

Laboratory method

The laboratory method outlined below had been completely implemented well before Haines' definitive work (1979) became available. Formerly and in the absence of any ecological background, the fish remains were accorded a low priority. The fish remains hold the most potential for future work in the collection towards refinement of the land-use models.

The following procedure was carried out on all fish remains:

1. separating out all dentitions, ariid otoliths, dorso-cranial plates, and siluroid spines;
2. sorting of the remaining 'unidentified' bone into syncranial plates, vertebrae, and ribs and spines;
3. sorting of each of the anatomical categories of step 2 into burning classes (unburnt, burnt, calcined), recording (number, weight), and assessment of size composition of the total sample;
4. comparing dentitions to reference specimens and allocation to taxa. Taxon, body part, burning state, fish-size class recorded for each item;
5. recording number, weight and assessing fish size composition by burning class for ariid dorso-cranial plates and siluroid spines;

6. measurement of ariid otoliths and recording number and weight by burning class.

Identification method

A list of the taxa possibly occurring in the Waira region was drawn up from the catch records in Liem and Haines (1977). This served to limit the scope of comparisons. Two comparative collections and one documentary source were consulted.

1. a series from the Kikori River collected by Rhoads and identified by R. McKay (Curator of Fishes, Queensland Museum). Although comprising a small number of species it includes specimens of all the forms commonly found in the sites;

2. a collection of New Guinea and Pacific fish held in the Department of Prehistory, RSPacS, which filled some of the many gaps present in the Kikori River series.

3. the brief descriptions of fish dentition given by Munro (1967) which were consulted for taxa not present in 1. and 2.

The classification employed is that of Munro (1967) for all groups except the Ariidae, for which the systematics of Roberts (1978) are adopted.

Results

A summary of the results of the fish analysis is presented in the thesis text. The following discussion provides explanatory comments on several aspects of the analysis.
Taxonomic representation

Nine taxa representing eight families were identified in the collections. Their systematics are as follows:

Ariidae
   Arius spp.
Plotosidae
   Plotosus papuensis/canius
Eleotridae
   Oxyeleotris sp.
   'Havio' (K) possibly Ophiocara sp.
Ambassidae (?)
   Indet gen. et sp. A. possibly Parambassis gulliveri
Sparidae
   Acanthopagrus berda
Lutjanidae
   Lutjanus sp. and argentimaculatus
Latidae
   Lates calcarifer
?Theraponidae
   ?Therapon sp.

Eleven fish groups known from the Kikori River were not represented in the sites. A number of these are small fish (Ambassia spp., Nematocentris, Gobiidae) or fish with degenerate dentition (Mugilidae, Aserragodes, Zenarchopterus), which are unlikely to be recovered. However, some of the unrepresented groups (Toxotes, Sautengraulis, Nibea, Megalops, Polynemidae, Elasmobranchii) do possess large, well formed dentitions and their absence from the sites is probably an accurate indication of their local scarcity or inaccessibility under traditional fishing techniques. Only one of them, the river-bank patrolling surface feeder Toxotes chatareus is thought to be locally abundant. It is possibly only caught regularly on a line (see Haines 1979: 56).

Proportional representation

In this section I discuss two aspects of the bone density figures presented in Tables VI-15, VII-7, VIII-10,20,27.

The first concerns the range of material subsumed by each category and offers some simple guidelines for correct manipulation
of the data. The subsequent discussion is concerned with the influence of recovery rates on proportional representation in the assemblages.

Although most of the fish identifications were performed on dentitions, two fish groups were also recognized from among the non-dentigerous remains.

Ariidae

Ariidae comprise well over 50% by weight of all fish remains in the collection. The range of skeletal elements recognized: the distinctively granulated dorso-cranial plates, large lenticular otoliths, 'ropey-textured' syncranial plates and dentition. These elements make up a large portion of the skeletal weight of catfish. The exclusion of ariid vertebrae, ribs, spines and some syncranial plates from the total results in a slight underestimate of the proportional representation of ariids in the collection.

The ariid remains from most sites are of sufficiently large fish that the question of recovery rates does not assume importance. Small ariids were, however, recovered from Kulupuari. This occurrence will be discussed later.

Ariidae/Plotosidae

Distinctively serrated dorsal and pectoral spines of siluroid catfish also occur in large numbers in the collection. On the basis of dentition it appears that the Plotosidae are considerably less common than the Ariidae and, therefore, are not expected to have contributed significantly to the number of catfish spines present. This category may effectively be added to the ariid remains for analysis.

Other taxa

A single procedure was followed for the eight or more remaining taxa. Specific identifications were attempted only for dentitions and the remainder of the non-ariid fish bone was placed into the 'unidentified fish bone' category. Contained in the latter category
are (1) a small proportion of the ariid remains and (2) virtually all of the non-ariid remains. A reasonable estimate of the proportional representation of the non-ariid fish taxa is obtained by adding the identified fish of this group to the unidentified remains. However, the inclusion of some ariid remains in the latter category makes it a consistently slight overestimate. Within this group estimation of the relative importance of one taxon over another is not recommended because of the small numbers of dentitions involved.

The non-ariid fish recovered from the rockshelters were represented by sizeable individuals to the virtual exclusion of small fish. In contrast, the remains of small fish were abundant at Kulupuari. Very few of the tiny dentitions of these species (Eleotridae, Nematocentris*) were recovered, however, and consequently they are seriously under-represented among the identified non-ariid remains. To help get around this problem a simple descriptive method of size estimation was introduced into the laboratory procedure. Casual mentions of fish size in Chapters 6 – 8 refer to this documentation. The three size classes established are listed below with their approximate correlates in fish length.

- small - 15 cm
- medium 25 - 45 cm
- large 60 cm

The fish remains were allocated to a size class by comparison to reference specimens of known size. Samples comprising many fragments were assigned rough proportional size-estimates; eg. mostly small, few medium-large. Within certain fish groups the size classes may correspond loosely to age grades. For example, the small ariid remains from Kulupuari are interpreted as young individuals of the two locally common Arius spp., both of which attain similar adult dimensions (approx. 60 cm). However, for most fish groups the size classes are not intended to represent an age series.

* A rare form identified subsequent to the analysis
Size estimation

The arid otoliths found in the sites provided a second, quantitative estimate of size for this group.* These large, lenticular otoliths were abundant at the rockshelter sites but were unfortunately, not preserved at any open site. The technique calculates arid catfish length from the dimensions of their otolith using a regression established by R. McKay for northern Australian Arius leptaspis:

\[
\text{Fish length} = 6 \times (\text{otolith depth}) - 30
\]

Although \textit{A. latirostris} may also be represented in the archaeological sample, a similar length-otolith dimension relationship probably exists for this species (R. McKay 1979: pers. comm.).

Tables VII-11; VIII-21; VIII-28 present the summary statistics of fish length calculated from otolith size. The results indicate that the aruids represented in the rockshelters are of a uniformly moderate size, a conclusion reached earlier on the basis of skeletal remains.

Microscopic examination of the otoliths revealed a series of distinct growth and check periods. Many of the fish vertebrae also exhibit a similar phenomenon. Lowe-McConnell (1975: 201-203) reviews the causes of growth cessation in tropical aquatic habitats and concludes that two factors are of primary importance.

1. Local food abundance. In the Waira region this may vary between different waterway types and between different trophic levels along the food chain.

2. The reproductive cycle of the fish. A wide range of reproductive cycles operate in the Kikori River and may variably relate to flooding events, food abundance or periodic migrations into or out of the area.

The multitude of fish responses in the Kikori aquatic habitats precludes a simple interpretation of growth checking in the archaeological fish remains.

*I thank Dr David Horton AIAS for putting me onto this work.
Notes on Selected Taxa

Arididae

Four or more species of ariid catfish probably occur in the Waira region. One very large catfish collected by Rhoads appears to represent *Arius stirlingi* (R. McKay 1979: pers. comm.) previously reported from the Lorentz, Purari and Fly Rivers (Roberts 1978: 37-38). The two species most frequently caught in the Kikori River are *Arius leptaspis* and *A. latirostris*. Both are of comparable size, occupy similar niches, and possess at least superficially similar oral tooth band patterns (Munro 1967: Fig. 9). *Nedystoma dayi*, a small, shallow water inhabitant, has not been recorded from the Kikori but is common in the lower Purari. It can be readily distinguished from small specimens of *Arius* by the narrow bands of small teeth in its jaws (Munro 1967: 85); it does not appear to be represented in the sites. The archaeological ariid dentaries fall readily into two size-independent morphological groups and it seems likely that both of the common species of *Arius* are represented.

Plotosidae

This family is represented in the Kikori/Purari rivers by a single genus, *Plotosus*, of which one or possibly two (ecotypical?) named species occur (*P. papuensis*; *P. canius*). It was recognised on the basis of its large grinding molars and distinctively porous-boned dentition.

Lutjanidae

Two species of *Lutjanus* were identified in the comparative series collected by Rhoads (*L. argentimaculatus*, *L. sp.*). Their dentitions are morphologically identical and can only be distinguished by size in fully grown fish. This was not attempted for the fragmented archaeological material. The two species are likely to possess similar habitat requirements, although *Lutjanus* sp. may extend into smaller fast-flowing waterways.
Eleotridae

At least two forms of eleotrid are present in the archaeological material. A large form is indistinguishable from the local Itamanamo (K) and *Oxyeleotris lineolatus* from the Northern Territory. However, a small form identical to the 'swamp-fish' Havio (K) does not possess the enlarged inner/outer rows of canines that characterise the dentary of *Oxyeleotris* (Munro 1967: 522) and it probably represents a species of *Ophiocara*.

Ambassidae?

Occasional specimens of a highly distinctive form designated Indet. gen. et sp. A. were found at several sites. The premaxilla possesses a long, upright anterior process and a small, tapering posterior process. The teeth are villiform and arranged in discrete rows running diagonally across the tooth band in both dentary and premaxilla. It may represent *Parambassis gulliveri* for which a comparative specimen is not available, but which tallies with the unknown form in so far as Munro's (1967: 257) description goes.

Theraponidae?

This tentative allocation is based on a complete articular that shows many similarities to a specimen of *Therapon jarbua*. A single species, *T. fuliginosus*, is reported for riverine habitats in the Purari/Kikori system and attains a length of 35 cm.

REPTILIA

Reptiles are represented in the collection by very abundant fragments of chelid turtle shell and variable quantities of a range of snakes, lizards, turtles and a crocodile. Terminology and mensuration follow Hoffstetter and Gasc (1969) and Smith (1975) respectively.
Chelidae

Four species of chelid turtle representing three genera: *Chelodina*, *Emydura* and *Elseya* may inhabit the rivers of the Papuan Gulf (see Appendix 16 for further discussion). Available reference material was limited to two shells and associated, partial skeletons of *Chelodina* sp. *novaeguineae* and a skull of *Elseya novaeguineae*.

Two distinct types of chelid shell are represented in the collection. The first displays a pattern of shallow, longitudinal grooving that also occurs on the *Chelodina* specimen, while the other possesses low, broad tubercles and is on average somewhat thicker. The second type of shell is uncommon but occurs at most sites. Further morphological evidence suggests that *Chelodina* is the commonly occurring chelid. Although the arrangement of the bony carapacial and plastral plates does not vary significantly in New Guinea chelids, the pattern of plastral scute impressions possesses considerable taxonomic value (Burbidge *et al.* 1974: 395–96). The archaeological shell fragments conform exclusively to the *Chelodina* pattern where they can be allocated.

Considerable variation exists in the size of turtle remains found at the various sites. The turtle shell from Kulupuari is consistently and markedly smaller in size than that from the other site. At least some of the small remains represent *Chelodina* and it seems plausible to suggest that they are young individuals of one or other of the local species. The remainder of the open sites and the rockshelters contain turtle shell of uniformly larger size.

Testudine: Unknown Family

A somewhat larger testudine is represented by a single specimen, a badly corroded upper limb bone collected from the surface at Kulupuari. An estimated body length of about half a metre places it within the range of *Carettochelys insculpta*, the pitted-shell Turtle, and *Pelochelys bibroni*, the soft-shelled Turtle, but the physical condition of the bone precludes its precise allocation.
Crocodilidae

Crocodile remains were recognized from two contexts in the collection. A single, large tooth from Rupo (Pit B, Spit 2) possesses some weak vertical grooving near the base but is otherwise unfluted. In this regard it compares well to the teeth of Crocodylus porosus, but may be unlike the possibly vertically fluted teeth of C. novaeguineae. The additional crocodilian remains came from Kulupuari (Pit 6NOE Spit 2) and comprise calcined fragments of larger femur and humerus. Judging by size they probably represent a single individual of C. porosus.

Varanidae

Varanid remains were found at Rupo, Ouloubomoto and Kulupuari but are only common at the latter site. Among the allocated remains are eight fragmentary dentaries, thirty four vertebral fragments including twenty-four from the dorsal series and a range of elements from the appendicular skeleton. Varanid vertebrae are described by Hecht (1975) and Smith (1976) and some limited comparative measurements are available (Smith 1976: Table 4). Very few dimensions (in mm) could be taken on the archaeological specimens. Kulupuari: Pit ONOE/Spit 2: 7: 13.2 and 9: 19.1; Pit 6NOE/Spit 3: 3: 7.3.

The majority of specimens are too large to be of the Tree Monitor, Varanus prasinus, that rarely attains a metre in total length. The measurements presented above as well as the majority of the fragmentary remains are within the size range of V. varius, the Lace Monitor. Two New Guinea species, V. indicus and V. salvadori of comparable body size although the latter possess an exceptionally long whip-like tail that contributes to a total length of over 4 m in some individuals.

Agamidae

Two dentaries and one dorsal vertebra represent this group of lizards. The dentaries were identified on the basis of the acrodont tooth implantation and the vertebra on its triangular ventral outline and strong subcentral ridges. Two different agamid species appear to be represented. One of the dentaries resembles some species of Amphibolurus. While the other dentary is of similar size it is
unlike either the first or the water dragon, *Physignathus*. It may represent an anglehead, *Goniocephalus* sp.

**Scincidae**

A single vertebral centrum may represent this family. The centrum is unconstricted behind the condyle and exhibits strong sub-central ridges, a haemal keel and a strong dorso-ventral fattening of the condyle. The vertebra's size suggests a relatively large individual (condyle-cotyle length = 8.0 mm). The New Guinea Scincidae do not appear to include a suitable taxon for this specimen and the family allocation may be in error.

**Serpentes**

Three families of snake were recognized in the collection. Boid pythons are a recurrent element in several sites, while elapid and colubrid snake occur infrequently.

**Boidae**

Pythons are represented by a total of thirty-nine vertebrae and two cranial elements. The generalised boid vertebra is adequately described in the literature (see Hoffstetter and Gasc 1968: 284-90; Underwood 1976).

Twelve species of boid are known to occur in New Guinea. Boids resident in the middle Kikori River region may include *Python* spp., *Chondropython viridis* and *Liasis* spp., including *L. amethystinus*, Smith (1976: 46) suggests that *Python* including *L. amethystinus*, may be distinguished from *Chondropython* and *Liasis childreni* by the paired foramina at the base of the neural spine. Fifteen of the archaeological specimens exhibit this characteristic, three do not. Vertebral lengths (pr-po) indicate that at least some of the snakes are of a comparable size to *Python (Liasis) amethystinus* (1.5 - 3.0 m) calculated from Smith (1976: 43).

*Chondropython* may be recognised by an unusually elaborate zygosphenic joint, a thickening of the tip of the neural spine (Hoffstetter and Gasc 1969: 290) and an anteriorly bifurcating neural spine (Smith 1976: 46). The non-*Python* vertebrae are not clearly of this species. They are also too large to be *Liasis*
childreni or a species of Aspidites. They may represent Python vertebrae in which paired foramina on the neural arch are absent.

**Elapidae**

Five elapid dorsal vertebrae were recovered from the sites of Rupo and Ouloubomoto. These were allocated on the basis of the following characteristics: pronounced hypapophyses present, paracotylar foramina present on the fossae on either side of the cotyle, parapophysial processes present and antero-ventrally directed on either side of the cotyle, prezygapophysial spine (accessory process) long (c.f. Hoffstetter and Gasc 1969: 285-86; Smith 1975/Smith 1976: 44).

The five vertebrae derive from relatively large snakes in which vertebral length (pr-po) varies between 7.0 - 10.5 mm. They indicate snakes less than 2 m in length (Smith 1976: 44).

**Colubridae**

A single dorsal vertebra from Kulupuari is confidently assigned to the Colubridae and to the subfamily Colubrinae, rather than Acrochordinae. The specimen is thoroughly calcined but in remarkably good condition. It represents a relatively small and probably terrestrial snake. The diagnostic characters are: vertebra long and relatively low, ventral surface of the centrum exhibiting a distinct haemal keel and subcentral ridges but not a pronounced hypapophysis, paracotylar foramina present only on one side, parapophysial processes absent; a vaulted neural arch; prezygapophysial spine (accessory process) long and lacking parazygosphenial foramina.

Measurements are as follows (in mm): vertebral length (pr-po) 8.8, vertebral height 4.9, condyle width 2.1, width across the prezygapophyses 7.59 and width across the postzygapophyses 5.0.
AVES

Bird remains contribute only a small proportion of the bone belonging to any site. Only two avian families were recognised in the collection and both are terrestrial in habit. Casuariidae were identified from Herekuna, Ouloubomoto, Rupo and Kulupuari. Only at Kulupuari do cassowaries constitute a significant component of the faunal remains. Two species of Megapodidae are recorded, one from Herekuna and the other from Ouloubomoto. Very few pieces of structurally "bird-like" bone were noted in addition to those just listed. The paucity of bird remains in the collection is an unexpected but apparently accurate portrayal of their limited importance.

Casuariidae

The cassowary remains consist of a number of highly burnt pedal phalanges and three fragmentary tibiotarsii. One of the latter from Ouloubomoto is of a cassowary fledgling. The other tibiotarsii are from a post-contact midden at Kulupuari. Both are clearly referrable to one of the large lowlands cassowaries, as opposed to the dwarfed highlands form, Casuarius bennetti (see Miller 1962 for tibiotarsal dimensions). The Double-Wattled Cassowary, C. casuarius, is listed for the Purari/Kikori delta (Liem and Haines 1979) and is well known to Kairi hunters.

One of the tibiotarsii from Kulupuari bears a pair of abraded 'V' sectioned grooves that are symmetrical about the lateral border of the shaft and converge above the outer distal condyle. A transverse break of the shaft is located above the initiation of the tendinal groove and occurred subsequent to the alteration of the surface. This specimen probably represents an unsuccessful attempt to produce a dagger, the tibiotarsus being a favoured bone for this purpose.

All of the eggshell found in the sites is of cassowary type (Tyler and Simkiss 1959). Small quantities occur in the rockshelter deposits but the open sites typically lack eggshell due to their poorer preservational environment.
Megapodidae

Two fragmentary ulnae were allocated to this family by Dr J. Van Tets (Division of Wildlife Research, CSIRO). Both of the two locally known species, *Talegalla fuscirostris* and *Megapodius freycinet* are represented. A femoral shaft found with the *Talegalla* specimen is consistent with this species but is in itself insufficient for allocation.

MAMMALIA

Although the faunal collection contains representatives of four placental and four marsupial families, it only partially documents the diverse mammalian fauna of the New Guinean lowlands rainforest. Several families of terrestrial and arboreal small mammals are unrepresented (Dasyuridae, Petauridae, Burramyidae) as are the microchiropteran bats. In addition the highly diverse rodent fauna is severely underrepresented.

The allocation of mamalian remains was conducted with reference to the osteological collections in the following institutions (registration prefix): Dept. of Prehistory, R.S.Pac.S., A.N.U. (M,W,Z.S.); Australian Museum (AM); Queensland Museum (J); C.S.I.R.O. (CM).

The names of extant mammals are used in the sense of Kirsch and Calaby (1977) or Laurie and Hill (1954). The most recent revision of the taxonomy of fossil forms is followed. Tooth crown morphology is described according to the terminology of Ride (1964) or Archer (1976a, b) where it differs. The terminology of individual teeth proposed by Archer (1978) is adopted in preference to that of all previous authors.

PLACENTALIA

Suidae

*Sus scrofa papuensis*

Pig remains are common at all sites but are most abundant at the open sites during the Early/Recent Ceramic and Proto-Historic phases. They are recorded in the Pre-Ceramic deposits at Rupo and Ouloubomoto.
(see Tables VIII-10; VIII-20), however at both sites the pig remains occur within a zone of mixing between Pre- and Early Ceramic deposits and are accepted as intrusive elements into the earlier fauna. In view of the small size of the assemblage their absence from an undisputed Pre-Ceramic context does remain inconclusive. In a wider context pigs are reported from the South Coast prior to 2500 BP (Vanderwal 1972) and reliably from the Highlands at 5-6000 BP (White 1972). Claims of 10-11000 BP remains from Kiowa are as yet insufficiently documented for assessment (Bulmer 1975: 18).

To date archaeological pig remains from New Guinea have been interpreted with untested reference to present analogues of man-pig relations. Rhoads briefly discussed the inadequacies of this approach in Chapter 9.

The present study avoids reference to present Kairi pig husbanding techniques. As an alternative it draws upon several aspects of the archaeological pig remains to isolate patterns indicative of (1) the returns of wild pig hunting, or (2) the produce of a pig management programme. A model for the distribution and ecology of wild pigs in the Waira region serves as the forum for discussion. Chapter 9 presents the results and interpretation of the analysis; the techniques used will be discussed here.

Proportional Representation

A precise measure of the proportional representation of pig remains at the sites was achieved by using two separate allocation techniques.

1. The Sue class consists of remains that were confidently allocated to pig on morphological grounds. A reference series of 8 pigs of various ages was used for comparison. Included were several complete deciduous and permanent dentitions and skeletal material ranging in age from a suckling pig to a 3 or more year old sow. This class typically makes up between 25 and 75% of the total 'pig' remains.
2. The probable pig class (UIP) consists of bone that was insufficient for morphological allocation, but, on the basis of size and/or texture, is probably pig bone. The animals likely to be confused with pig among fragmented remains are humans and cassowaries, neither of which are expected to have contributed significantly to this collection.

**Population Structure**

Two components of the population structure of the pig remains were assessed to varying success.

**Sex**

Pigs are readily sexed from the size of their canines which are considerably enlarged in males (Sissan and Grossman 1961). The majority of the canines in the collection are reduced to tiny enamel fragments and are of little use in sexing. Only two sexable canines were found in the collection and both are from moderate sized males: (Kul 9NOE/1 : C5 ; Bag 9SOE : RCL ). Sisson and Grossman (1961) describe sexual dimorphism in the pig pelvic girdle. The morphological detail of this dimorphism will almost certainly need restating for the New Guinean pig. However, the fragmentary pelvic material from the sites is insufficient for this task and no attempt was made to sex these remains.

**Age**

More success was had with aging of the remains. Two independent techniques were used. The primary technique calculates age from the eruptive and attritional condition of the teeth. A number of features of the pig dentition make it particularly valuable as an age indicator:

1. both the deciduous and permanent dentitions consist of large and morphologically well differentiated teeth;

2. the teeth erupt sequentially over a long period of time, beginning in utero and with M3 still erupting at 30 months (Barrett 1978:289); and

3. the sequence and timing of eruption do not vary greatly (i) between the different races of pigs, (ii) between the
sexes, or (iii) with nutritional status (McCance et al 1961 cited in Barrett 1978:288).

A variety of similar techniques for aging of dentition are available in the literature (see Barrett 1978). The method adopted for this study is that developed for Malaysian feral pigs by Diong (1973), which has the advantages of (1) combining aspects of eruption timing and attritional states and, (2) being applicable to a comparable lowlands rainforest habitat and pig diet.

The archaeological material consists almost entirely of disassociated and often fragmentary teeth. The dental dimensions given in Table IX-12 are at the small end of the range given by Diong (1973: Table 2). Teeth were allocated to a particular age grade following a microscopic examination of occlusal wear, interstitial facetting and root development. Many of the archaeological specimens were partially or freshly erupted teeth exhibiting little wear for which an aging resolution of ±1 month is possible. Unerupted teeth provide a direct estimate of maximum age that can be refined by considering the state of crown and/or root development. Fully erupted teeth provide a direct estimate of minimum age but which can be refined by assessing attritional state. Worn teeth were correlated to a series of more complete dentitions from archaeological sites on Yule and Motupore Islands. Age estimates based on this method are less reliable and are typically assigned a resolution of ± 2 months. The results of this aging procedure are presented in Tables IX:3 and IX:6.

The second aging method was carried out on the post-cranial remains. Sisson and Grossman (1961) supply epiphyseal fusion times for the pig skeleton. The epiphyses of virtually all skeletal elements fuse after 12 months and the majority after 24 months. The archaeological post-cranial remains are in a generally unfused condition consistent with the results of the dental aging.

Dental Trauma

The extreme fragmentation of the remains has undoubtedly hindered the recognition of skeletal pathology and abnormality in the collection. A single specimen from Ouloubomoto (Test 2 Spit 2) shows evidence of
dental trauma; it is a calcined premaxillary fragment comparable in size to a 10-12 month old pig but with loss of $1^2+3$ and an advanced stage of alveolar resorption.

**Canidae**

Dogs are represented in three rockshelter assemblages but are surprisingly absent from any open site. The stratigraphically earliest evidence of dog is a perforated canine from Rupo (Pit A, Spit 3). It appears in an Early Ceramic Period context and probably dates older than 900 BP. Amongst the assemblages dog has constituted two or possibly three classes of remains.

**Decorative Items**

Perforated dog canines were found at Rupo and Herekuna (see Chapter 8). Similar artefacts are reported for the Yule Island area from 2000 BP (Vanderwal 1978).

**Food Remains**

Several specimens of dog from Rupo may represent food remains. These are an unburnt cervical centrum of an adult and an unburnt molar ($M_4$), which is fully erupted and unusual in that the crown shows little evidence of wear (K. Gollan 1979: pers. comm.).

**Burial or Natural Death**

The partial remains of two dogs were recovered during test excavations at the Urapo rockshelter.* The unburnt and relatively unfragmented bones cannot be readily interpreted as food remains and are perhaps best explained as natural deaths occurring in a lair.

Urapo *Canis*: large adult: $R.M_1$; cervical vertebra; distal radius; astragalus; rib shaft juvenile: posterior maxillary fragment.

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*This site is not discussed elsewhere in the thesis. A single arid spine comprises the remainder of faunal material from this site.
Muridae

Three or more murid taxa are represented in the collection. The remains include a number of incisors and a range of post-cranial elements, but no cheektooth material.

Murinae

All of the murid material is allocated to this group rather than the Hydromyinae because (1) the $I_1$ are strongly recurved rather than proodont, (2) the buccal surface of $I_1$ is laterally compressed rather than convex, and (3) the elements of the appendicular skeleton are elongated. The squat condition found in the Hydromyinae reaches an extreme in the most specialised form Crossomys, but is still marked in the less extreme forms such as Hydromys and Leptomys.

_Uromys caudimaculatus_

The remains of the mottled tailed tree rat were recovered from Rupo and Kulupuari. Several $I_1$ are identical to a Queensland specimen of _Uromys_ (J 17612). In addition some large post-cranial elements may belong to this species.

Gen. indet.

At least two taxa are represented in the remainder of the murid material. An isolated $I_1$ is intermediate in size between _Uromys_ and _Rattus_ spp., and compares well to a specimen of _Xeruromys barbatus_ (w 263), a rarely caught species known from lowland habitats. Also present are incisors and post-cranial material consistent in size and morphology to the larger species of the _Rattus_ group.

Pteropididae

Flying foxes are represented at Herekuna, Ouloubomoto and Mampaiu by a quantity of post-cranial remains and several fragmentary dentaries. This material is readily divided into two groups comprising a small and a large form. The range of pteropidids found along the south coast is discussed in Appendix 16.
Pteropus neohibernicus

Rhoads collected a nearly complete skeleton (ZS 124) of this large flying fox in the Waira region. The specimen compares well in morphology and dimensions to a series of *P. neohibernicus* described in Andersen (1912), but falls at the small end of the range (Table 13:13). Among the archaeological material a fragment of dentary (Table 13:14) and a range of post-cranial elements are as large or larger than ZS 124. A second large species (*P. conspicillatus*) is common along the south coast and, although it possesses a weak dentition, its post-cranial remains are probably included in the collection.

Pteropus? (= *P. macrotis*)

The identity of the smaller flying fox is uncertain. Ramal dimensions and the obviously smaller and posteriosly weakened molar series are comparable to *P. alecto* and *P. poliocephalus*. Most of the post-cranials remains are, however, of smaller individuals than are indicated by the dentaries and are likely to be of *P. macrotis* (= *epularius*). The remains of the small flying fox are allocated to *P. macrotis* for convenience but a wider range of species may be represented.

MARSUPIALIA

Peramelidae

Bandicoots are represented by a range of edentulous ramal fragments and post-cranial elements. The material is somewhat enigmatic as to the taxa represented.

*E. rufescens*

A relatively complete skeleton of the rufescent bandicoot was collected by Rhoads (ZS 112). The cranium is fragmentary but shows a number of the diagnostic characters noted by Tate (1948: 329-334) and Lidicker and Ziegler (1968:4). This species grows to an
exceptionally large size. Although a number of post-cranial elements and dentary fragment (Her. Pit A, Spit 3A) are indistinguishable from this specimen, the majority of the peramelid remains are very small by comparison. The dimorphism is far too extreme to represent sexual variation in one population.

Eohymipera sp. cf. kaluba

Table 13:1 presents a series of ramal dimensions of a small and intermediate bandicoot forms. Although the alveolar dimensions are not significantly smaller than for E. rufescens, the ramal dimensions suggest a considerably more slender dentary. Further support for the existence of two forms derives from the post-cranial remains. Several specimens of the small form possess fully fused epiphyses suggesting adult status. In contrast some of the very large remains have unfused epiphyses. On both morphological and distributional grounds (see Appendix 16) the small form most likely represents E. kaluba. This species is considerably smaller than E. alara, Peroryotes broadbentii and P. raffrayanus, and is morphologically distinct in both cranial and post-cranial remains from Isoodon obesulus (see Tate and Archbold 1937: 433-36; Lidicker and Ziegler 1968: Table 1; Tate 1948). Specimens of E. kaluba from the highlands possess a more slender ramal body relative to tooth size than E. rufescens (szl12).

E. k. oriomo, known from the Oriomo river of the Western Division of Papua, is considerably smaller than other named races. (Tate and Archbold 1936; Tate and Archbold 1937: 358). Table 13.2 details the occurrence of the small, large intermediate bandicoot remains in the sites. A karst oriented distribution for the small form is not inconsistent with its being E. kaluba, a species that appears to favor more open, dryer habitats and to be excluded from deep forest habitats by competition with stricter forest forms e.g. E. rufescens (see Appendix 16).

Petauridae

Two petaurid genera may be represented in the collection.
cf *Dactylopsila* sp.

The striped possum is known from the delta region (Liem and Haines 1977) and is known by the Kairi. Two small humeral shafts have been tentatively referred to this group after comprehensive elimination of peramelids, dasyurids and murids. Comparison with specimens of the congeneric but more specialized *D. (Dactylonax) palpator* does not reveal any unique characters beyond those shared by all petaurids.

*Pseudocheirus (Pseudocheirus)* sp. cf *canescens*

The ring-tailed possum group attains its greatest diversity at higher altitudes in New Guinea and its representation is the collection, although not altogether anomalous, is nonetheless noteworthy. A single specimen from Ouloubomoto represents this group. It is a ramal fragment without teeth but possessing alveolae for a complete permanent dentition. The relatively short cheektooth series (alv. length $P_5 - M_5 = 15.1$ mm) indicates a species of *Pseudocheirus (Pseudocheirus)*. Of the two low altitude species the specimen compares more favourably in size to *P. (P.) canescens*, the widespread Lowlands Ring-tail, than the Weyland Mountains Ring-tail, *P. (P.) caroli*.

Phalangeridae

Considerable confusion surrounds the taxonomy of the predominantly New Guinean marsupial genus *Phalanger*. Seven species are commonly thought to constitute three species groups, (*orientalis, ursinus* and *maculatus*; Tate 1945:2; Kirsch and Calaby 1977:20). Among these, three are expected on distributional groups to be present in the Waira region (see Appendix 16).

*Phalanger maculatus*

The most recent revision of this species group recognizes six races (Feiler, 1978), one of which subsumes the commonly accepted form *atrimaculatus* (= *P.m. rufoniger*). Feiler (1978) and Tate (1945) are in essential agreement concerning the southcoast races of *P. maculatus*. 
They propose the form *P. m. chryssorhos* for the Fly basin and westwards and *P. m. goldiei*, a considerably larger-tooth form, for the eastern end of the coastal strip. The Kikori area may be a contact zone between the two forms (Tate 1945:23).

Archaeological material of *P. maculatus* comprises some dental remains including a well preserved dentary with P3 - M4 (Bageima 19N22W) and a range of post-cranial elements. Several specimens retain the distinctive P3 of this animal. The P3 of *P. maculatus* is a broad, unicuspid tooth with its main shearing crest inflected outwards; crest relatively short and blending with variably formed vertical ridgelets (Turnbull and Lundelius 1970:13-14). Two crests run from the main cuspid to a discontinuous basal cingulum. The antero-medial crest is well developed while the buccal crest is weak.

Table 13.3 gives the dimensions of post-canine dentition in both the archaeological and some comparative material. The majority of published accounts give upper cheektooth dimensions only and are, therefore, of very little use for this study. The degree of dental variation in the archaeological remains is, however, compatible with that found in single locality samples of other races of *P. maculatus* (Tate 1945; Feiler 1978 a,b) and no definite comment can be made on the particular race occuring in the Kikori area.

*Phalanger gymnotis/leucippus*

Tate (1945) synonymised *P. leucippus* with *P. gymnotis* and considered the single species to be widespread in New Guinea through an altitudinal range of 0-7000 feet. Feiler (1978) reinstated *P. leucippus* as a full species but stressed the close relationship with *P. gymnotis*, the latter species restricted to the islands off southern Irian Jaya.

The archaeological material includes a ramus with P3 and M5, a maxilla with M2-M5 and various cranial and post-cranial remains. The P3 is confidently referred to the *P. leucippus* form as described by Feiler. This large tooth is very strongly inflected outwards from the toothrow and exhibits a high, well developed main shearing crest across which the vertical ridgelets maintain their form, an accentuated buccal crest and reduced antero-medial one and a virtual lack of a
basal cingulum (Turnbull and Lundelius 1970: 13-14). A length/breadth of 6.5/5.0 (mm) puts the tooth well outside the *P. gymnotis* range and within that of *P. leucippus* (Feiler 1978: 391). The molar of these forms has not undergone the expansion of the premolar. In dimensions they fall well below those of *P. maculatus* but within the range of some *P. orientalis* races (see Table 13:14).

**Phalanger orientalis**

Among the geographical races of the Grey Phalanger, the south coast form *P. orientalis mimicus* is one of the smallest (Tate and Archbold 1935; Tate 1945:12; Feiler 1978:388-89). The dental dimensions of an individual of this race are given in Table 13:14 and are clearly very much smaller than the archaeological molar series of *P. gymnotis/leucippus*. A single specimen may represent this small form. It consists of a ramal fragment with the buccal halves of alveolae of M₃ – 3. These alveolae are at least 25% smaller in length than for the *P. gymnotis/leucippus* material.

**Macropodidae**

Three macropodids are represented in the collection. Of these, *Thylogale brunii* and *Dorcopsis veterum* were predictable on distributional and habitat grounds. The third macropodid is a species of *Dendrolagus* or Tree Kangaroo that is generally associated with highlands habitats (see Appendix 16). The three species are distinguished on dental morphology and size. Post-cranial remains were allocated to either (1) the short-footed, long-forelimbed tree climbing *Dendrolagus* or (2) the more generalized, terrestrial wallabies *Thylogale/Dorcopsis*. Although the pedal elements of *Dorcopsis* show a number of non-macropodine characteristics that will distinguish them from *Thylogale* (Woodburne 1967), they could not be confidently differentiated in the absence of a comparative specimen of *Dorcopsis*.

**Thylogale brunii**

*Thylogale* is readily distinguished from the other genera on premolar and molar morphology. The characteristics employed here follow Turnbull and Lundelius (1970) and Hope (in press) and will not be
repeated. A combination of absolute size and relative premolar length distinguish the endemic *T. brunii* from the sub-fossil montane *T. christenseni* Hope, in press, and the shared *T. stigmaticata* of Eastern Australia and the Fly Basin. Three races of *T. brunii* are currently recognized. The archaeological material is clearly larger than the highland form *T. b. keyserri* and possesses the enlarged permanent premolar that distinguishes the south coast race *T. b. brunii* from the otherwise similar sized, *T. b. browni* of the northern coastal strip (Tate 1948) (see Table 13.6).

*Dorcopsis verterum*

Three species are commonly assigned to *Dorcopsis* but the generic limits may eventually be broadened to include the smaller montane forms *Dorcopsulus* spp. The *Dorcopsis* dentition is adequately described by Garrod (1875) and has since been mentioned in conjunction with fossil macropodids by Stirton (1963), Plane (1967), Woodburne (1967), Turnbull and Lundelius (1970) and Archer (1979).

A single species of *Dorcopsis* is projected to occur in the lowlands rainforest of the south coast. The name *D. vetenan* Lesson is adopted after Hussan (1955) although the specific name may in fact refer to a Tree Kangaroo, *D. inustus*, rather than a forest wallaby (George and Schüner 1978).

Although *Dorcopsis* and *Dendrolagus* shared many plesiomorphic dental characters the two genera may be confidently differentiated on the morphology of P2, P3, M1 and M2. The remainder of the molar series are more readily confused, particularly in worn specimens. The tooth dimensions of definite *Dorcopsis* are presented in Table 13.11. Although the individual dimensions fall within the range established by a large archaeological series of *Dorcopsis cf veterum* from Yule Island, bivariate plots show the Kikori material to be relatively narrow for their lengths and to fall outside the point scatters of this series.

*Dendrolagus cf goodfellowi*

An unburnt dentary with I5 and relatively unworn P3 – M3 is confidently allocated to *Dendrolagus* and shows most similarity to
the Ornate Tree Kangaroo *Dendrolagus goodfellowi*. Additional material that may represent this taxon consists of a dentary fragment retaining M₃₋₅, and three terminal pedal phalanges. The remains were recovered from Kulupuari, Bageima and Rupo in Recent Ceramic through to post-contact deposits.

The known distribution of various *Dendrolagus* species is outlined in Appendix 16. Although *D. goodfellowi* is known from two locations in the upper reaches of the southern drainage, the extension of the species into the lowlands rainforest of the Waira region may represent a unique occurrence for New Guinea. The suggestion has been made on several occasions that this material represents trade items derived from the North. While this possibility is not completely ruled out, it does not tally with (1) present evidence for trade practices in the area or, (2) the distribution and character of the remains in the sites. The matter should be resolved with the continuation of faunal survey work in the Purari/Kikori catchments (Liem and Haines 1977).

A complete description and comparison of this material are in preparation. The following account details the characters sufficient for the diagnosis as *Dendrolagus* and makes some preliminary comments on the specific affinities of the specimens.

**Kulupuari Test 8 Horizon 1**

A dentary with I₁ and P₃ - M₅.

**P₃**: a long plagiaulacoid tooth, longer than *Thylogale* spp., shorter than *Dorcopsis veterum*; longitudinal shearing crest occlusally straight but anterior section offset buccally; shearing crest with two intermediate ridgelets, maintain identity as they fold over crest, merge with buccal and lingual enamel surfaces; series of basal cuspules in line with ridgelets; shearing crest occlusally lowest between anterior moiety and first ridgelet, equal height elsewhere; anterior moiety composed of two discrete cuspules, antero-buccal cuspule dominant, offset buccally from midline of tooth.

**M₂₋₅**: low crowned, lophodont teeth; procingular shelf narrow; pronounced procingular shelf buccal to preprotocristid, increasing M₃₋₅; premetacristid of M₃ doesn't connect to lingual end of procingulum; premetacristids and preentocristids of M₂₋₅ short, strong buccal inflection; cristid obliqua joins contribution from protolophid at a more buccal point than in *Dorcopsis*; lophids tilted forward on roots; talonid with a strong buccal cingular tongue-like extension.
Ramal body: masseteric canal more enlarged than in Dorcopsis, ramal body swollen below posterior molars; ventral margin of dentary more strongly inflected.

The dendrolagine lower dentition exhibits little specific differentiation other than allometric variation. Tables 13.9 and 13.10 document a clear size separation between D. goodfellowi and all other Dendrolagus spp. including D. matschiei, form sometimes considered conspecific with D. goodfellowi (e.g. Lidicker and Zeigler 1969). Furthermore the closest comparison is to the form described as D. spadix by Troughton and Le Souef and coming from the slopes of Mt. Bosavi to the northwest of the Waira region. Both D. spadix and the Waira form are small toothed but trend in dimensions with the series of D. goodfellowi measured. In contrast, while the specimen from Bageima exhibits many of the Dendrolagus characteristics outlined above, it falls well outside both the Dendrolagus and Dorcopsis ranges in proportions. Although this study confirms the recent scepticism concerning the validity of Dendrolagus spadix as a full species (Kirsch and Calaby 1977), it is suggestive of the existence of a small and possibly narrow-toothed form of the Ornate Tree Kangaroo along the southern foothills and lowland forests of the western district of Papua.
APPENDIX 14

ANALYSIS OF ARTEFACTS FROM MAMPAIU AND BAGEIMA OPEN SITES

MAMPAIU

Pottery

Table 14.1 describes the distribution of pot sherds recovered from excavations at Mampaiu. The stratigraphic occurrence of comparatively large sherds and the density of pottery, also indicated in this table, generally support the level from 10-20 cm below ground surface to be the major depositional zone for pottery. As well, pottery is primarily restricted to the southern edge of the terrace (see pp. 157, Plate VII-1).

Nine sherds comprise the total excavated rim sherd sample. All bowl rim sherds are either weathered or lacking a shoulder. On 4 of the 5 bowl rims several qualitative and quantitative attributes of form are present. Three of these are simple composite bowl rims with a straight rim course, a parallel profile and a round lip. Another bowl rim sherd has a concave rim course, a thickening/thinning profile and a round lip. The measurements taken on each sherd fall well within the range recorded for similar rims in the Kulupuari assemblage (Appendix 8: Table 8.4). The one rim sherd without a weathered surface has interior and exterior surface colouring. Its lip is decorated with a single incised line and repeated circular punctations. A number of incised parallel lines appear on the upper exterior rim; the decoration occurring below is unclear because of the small sherd size. Tool decoration is also present on the exterior rim of one of the weathered specimens. Parallel incised lines are located near the lip and shoulder. The decoration in between consists of short, angled parallel incised lines with a row of circular punctations along the margins of each line grouping.

Of the four jar rims only one has an unweathered surface and this specimen is broken at approximately the middle of the rim. Its lip is a complex flat form and it is decorated with two parallel bands of
paint, one occurring near the outer edge of the lip and the other covering the interior lip edge and upper interior rim. All the remaining jar rims have a round lip. The one everted jar rim sherd has a convex rim course and a thinning profile. The other two specimens are straight jar rims with a parallel profile. The rim course of one is convex and that of the other parallel. The measurements taken on the straight jar rims are consistent with those noted for the Kulupuari assemblages (Appendix 8: Tables 8.2, 8.3). The quantitative attributes for the everted jar rim sherd consistently correspond with the lowest values for similar vessel forms at Kulupuari.

The three decorated body sherds exhibit only surface colouring. Two sherds are painted on the exterior surface. The other specimen has colouring applied to both surfaces.

Only one other pottery specimen, which was found on the surface, is worthy of further note. This is a bowl rim sherd with interior surface colouring and straight line and triangular figures still on its weathered exterior surface. The lower portion of the rim and the shoulder are no longer present; therefore, form attributes are not considered. On decoration alone I suggest this rim sherd is comparable to bowl rim sherds from Kulupuari.

**Chipped Stone Artefacts**

The distribution of descriptive attributes for debitage at Mampaiu appears in Table 14.2. "Volcanic" and "limestone" cherts occur in roughly the same frequency by weight. Volcanic chert flakes weigh approximately 50 percent less than those removed from limestone chert cores and, therefore, are numerically more frequent. Most flakes retain little or no cortex.

The majority of non-utilized cores were found on the site surface. Each of the 4 specimens are large and discoidal and multiple platform core types occur equally. Three of the specimens are "volcanic" chert, the other "limestone" chert. The 2 excavated cores are very small and appear to be core fragments.

There are 6 altered flakes in the collection. The largest specimen, which weighs 38 g, is difficult to distinguish from a non-utilised core because it has been extensively retouched. The distal end of the original flake is removed, and the new surface has been
used as a platform from which to modify the flake's ventral surface. This specimen is omitted from further discussion.

Tables 14.3 and 14.4 present a summary of the quantitative and qualitative attributes for Mampaiu edge-altered flakes. Four of the specimens may be characterised as small, thin side-altered implements whose plans are roughly square. Their altered edges are acute and extensively modified by macroscopic step and feather flakes. One flake has multiple-altered edges. The edge of another specimen exhibits only microscopic alteration. The one end-altered flake has a form comparable to the side-altered flakes. Its altered edge is, however, more oblique and has microscopic edge rounding, as well as light macroscopic step flake modification.

**Ground Stone Artefacts**

Excluding those implements discussed in the text, there is an additional ground stone artefact made from meta-volcanic stone in the Mampaiu collection. This specimen resembles an axe-adze whose cutting edge has broken off. Its maximum width is 4.25 cm and it is 2.25 cm wide at the butt. Its maximum thickness is 2.35 cm. Its cross-section is elliptical and the sides are straight. These observations are consistent with those of Kulupuari axe-adzes of similar material (Tables VI-10, VI-11).

The remaining ground stone artefacts are fashioned from other types of metamorphic stone, which is probably of Highlands origin. One specimen is the cutting end of an axe-adze whose surfaces are badly chipped. It appears to have been heavily abused or possibly represents a portion of an unfinished implement.

The other artefact is a complete axe-adze. Its cross-section is elliptical and its sides are asymmetrical. Its measurements are as follows:

- maximum length : 5.40 cm
- length from cutting edge to girth : 4.70 cm
- width at cutting edge : 2.25 cm
- width at girth : 2.80 cm
- width at butt : 1.50 cm
- maximum thickness : 1.80 cm
- weight : 44.0 g
The specimen's cutting edge is asymmetrically bevelled with a chin angle of $72^\circ$ and a dorsal surface bevel of $66^\circ$.

**Pottery**

Over 90 percent of all pot sherds recovered from the Bageima open site are small fragments (Table 14.5). Almost all sherds are heavily weathered.

Eight pot sherds are representative of bowls. The only rim sherd present is a small portion of a simple composite bowl with a straight rim course, parallel profile and round lip. The quantitative attributes present include orientation angle: $-5^\circ$, inclination angle: $260^\circ$, rim length: 2.75 cm and rim thickness A: 0.65 cm. The sherd is too small to enable the measurement of the orifice diameter and rim thickness B. The remaining bowl sherds are small near-rims whose body thickness measurements average 0.81 cm with a standard deviation of 0.12 cm.

Six jar sherds are present. Three are rim sherds, one of which has an everted jar form, another a straight jar form and the last one of an indeterminable form. The first has a convex rim course, thinning profile and a round lip. Its measurements are orifice diameter: 18 cm, orientation angle: $30^\circ$, inclination angle: $100^\circ$, rim length: 1.15 cm, rim thickness A: 0.78 cm and rim thickness B: 0.80. The straight jar rim sherd has a straight rim course, parallel profile and round lip. Its measurements are: orientation angle: $0^\circ$, inclination angle: $150^\circ$, rim length: 1.76 cm and rim thickness A: 0.98 cm. The remaining jar rim has rim length of 1.55 cm and a rim thickness of 0.58 cm. None of the jar near-rim sherds are large enough to enable the determination of their original orientation.

The plain and weathered body sherds average 0.67 cm in maximum thickness.
APPENDIX 15

ANALYSIS OF OULOUBOMOTO CERAMICS

Five jar rim sherds were recovered during excavations at Ouloubomoto. The three everted jar rims were encountered at 8-10 cm in Pit A and Test Pit 3. One specimen has a very convex rim course, a thinning profile and a round lip. Both of the other rim sherds have a convex rim course, parallel profile and round lip. The following list presents the measurements for the quantitative attributes present on each rim.

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Specimen</th>
<th>Specimen</th>
</tr>
</thead>
<tbody>
<tr>
<td>230/3 (Pit A)</td>
<td>47/1 (Test Pit 3)</td>
<td>47/2 (Test Pit 3)</td>
</tr>
<tr>
<td>Orifice diameter</td>
<td>18 cm</td>
<td>-</td>
</tr>
<tr>
<td>Orientation angle</td>
<td>+60°</td>
<td>+60°</td>
</tr>
<tr>
<td>Inclination angle</td>
<td>-</td>
<td>60°</td>
</tr>
<tr>
<td>Rim length</td>
<td>1.48 cm</td>
<td>3.46 cm</td>
</tr>
<tr>
<td>Rim thickness A</td>
<td>0.55 cm</td>
<td>0.74 cm</td>
</tr>
<tr>
<td>Rim thickness B</td>
<td>-</td>
<td>0.85 cm</td>
</tr>
</tbody>
</table>

A comparison of these values with those observed for Kulupuari everted jar rim sherds (Appendix 8: Table 8.2) demonstrates notable differences with regard to the angle measurements and rim length. The orientation angle of two Ouloubomoto rims exceeds the mean values for Kulupuari rims by more than twice the standard deviation; the other rim's measurement is equivalent to the mean figures. The two inclination angle values approach the lowest figures recorded for Kulupuari everted jar rims. The length of two jar rims from Ouloubomoto compares only with Kulupuari rims falling beyond two standard deviations. One Ouloubomoto jar rim (47/1) is decorated with parallel bands of paint which are applied angularly across the interior rim (Fig. VII-2c). One rim exhibits no decoration and the other specimen is badly weathered.
The only straight jar rim, which was found at a depth of 8-10 cm in Pit A, is undecorated. This sherd has a straight rim course, thinning profile and round lip. The quantitative attributes present on this specimen are: orifice diameter 19 cm, orientation angle 0°, rim length 2.73 cm and rim thickness A 1.42 cm. The rim length and thickness values correspond most closely with Kulupuari straight jar rims with measurements which occur at or exceed two standard deviations from the mean (Appendix 8: Table 8.3).

The remaining jar rim, which appeared in Pit C at a depth of 30-40 cm, is broken at the neck and its vessel type is unidentifiable. It has a straight rim course, parallel profile and round lip. The length of its rim is 2.20 cm. This value generally exceeds one standard deviation from the mean values of everted and straight jar rims at Kulupuari. The maximum thickness of this rim sherd is 0.57 cm, which is compatible with the values for everted jar rims from Kulupuari. This specimen is decorated with a single band of paint which follows the course of the vessel aperture and extends from the lower interior rim to the beginning of the exterior rim.

Four jar near-rim sherds appear in the Ouloubomoto collection. The three decorated specimens, which were found in Spit 2 of Test Pit 2, are painted. The interior rim of two specimens is coloured with a solid band running with the course of the rim. The other near rim sherd has colouring extending to just below the exterior neck. The inclination angle of the only large near-rim sherd is 85 degrees, a figure which is only marginally comparable to Kulupuari everted jar rims (Appendix 8: Table 8.2). The thickness of the body just below the rim for the two sherds upon which a definite measurement could be made is 0.65 and 0.95 cm. The lower value, which was taken on the sherd for which an inclination angle was computed, corresponds well with that for everted jars from the Kulupuari collection. The other figure falls within one standard deviation of the mean values for everted and straight jars at Kulupuari.

The remaining jar near-rim is not decorated, but its interior neck exhibits tool smoothing marks similar to that noted on Kulupuari jar rims. The thickness measurement (B) for this sherd is 0.65 cm.
Of the 18 decorated body sherds recovered from Ouloubomoto only three belong to a stratigraphic level above 20 cm. These sherds, all of which were found in Test Pit 2, are painted. The maximum thickness of the sherd found in Spit 1 is 0.65 cm; the other two have a thickness of 0.66 and 0.80 cm.

Eleven of the decorated body sherds recovered from Pit B at a depth greater than 20 cm have smoked exteriors and colouring on the interior surface. They range in thickness from 0.44-0.78 cm with a mean value of 0.45 cm. The other decorated body sherd from this pit exhibits exterior colouring and is 0.35 cm thick.

Two of the decorated body sherds found in Spit 4, Pit C, have tooled designs on their exterior surface. Parallel incised lines appear on one, while a single incised line with a fringe of parallel, gash-incised lines decorates the other. The remaining decorated body sherd has exterior colouring. Thus, in general, the decorated body sherds at Ouloubomoto resemble those recovered from Kulupuari in decoration and thickness (Appendix 8:A.55§f).

With the exception of two plain body sherds found in Spit 2, Pit B, all specimens assigned to this category belong to stratigraphic layers below 40 cm. The two specimens noted have a maximum thickness of 0.34 and 0.45 cm. All of the remaining plain body sherds vary from 0.30-0.45 cm in thickness with a mean value of 0.39 cm. These values individually compare favourably with those obtained from Kulupuari sherds; however, the mean value is somewhat low (Appendix 8:A.55§f).
APPENDIX 16

ANIMAL ECOLOGY OF THE WAIRA REGION

by K.Aplin and J. Rhoads

This discussion considers the behavioural characteristics of animal communities which inhabit the middle Kikori River area. Since it is intended to provide a basis from which to understand the relationship between human predation strategies and the distribution and abundance of animal foods, certain aspects of animal ecology (e.g. habitat preference and population structure) receive most of our attention. The descriptions presented here are compiled from a survey of the literature concerned with (1) the geographical occurrence and abundance of certain animals in various habitat associations and (2) the variability of behaviour patterns within different environments. The distribution and behaviour patterns occurring in the Waira region are postulated by associating trends in the ecology of animals which are observed throughout New Guinea with the particular characteristics of the local environment. These conclusions are in all cases tested against the reported observations of Kairi informants. An important factor contributing to these predictions is the seasonal inundation of the Waira plain which affects both the distribution of many animal species and the suitability of certain hunting and fishing techniques.

Rather than considering the full range of animals present in the region we concentrate only on those groups appearing in significant numbers or contexts within the archaeological record and for which some body of knowledge exists. The taxa discussed are fish, reptiles, pig, rats, bandicoots, petaurid possums, phalangers, wallabies and tree kangaroos.
New Guinea freshwater fish communities exhibit several characteristics which set them apart from fish faunas occurring in other tropical regions. The number of species found in freshwater environments is low and of that total only a few are restricted to this habitat. The remainder belongs to families which primarily inhabit the lower reaches of tidal rivers or move between fresh and salt water environments to forage or breed (Lowe-McConnell 1975:12). The second unusual characteristic is the relatively large size attained by the majority of freshwater fish (Roberts 1978:11-12; Haines 1979:44).

These traits are best understood by reference to the region's biogeographical history. The freshwater ichthyofauna of New Guinea evolved almost entirely from recent marine ancestors. Thus, the freshwater fish groups which form the dominant groups elsewhere in the world are omitted from the evolutionary sequence. Perhaps as a consequence of their marine origin most New Guinea fish groups evidence no major adaptive radiation within riverine environments.

The rivers of the Papuan Gulf drain extensive highlands and lowlands areas and carry massive amounts of suspended sediments into the Gulf of Papua. This condition is most extreme in the region falling between the Fly and Purari Rivers, where turbid water conditions inhibit reef development and unstable deltaic islands comprise the most common coastal landform. Within this environment one finds the greatest diversity of fish species occurring along the Papuan coast.

Away from the coast the rivers flow through highly dissected plateaux or low-forested hills. The rivers are fast flowing and turbid and bodies of stillwater, such as lagoons or lakes, rarely occur. Fish communities inhabiting both deltaic and riverine environments rely heavily upon detrital mud and detritophagous invertebrates (prawns, crabs, etc.) for food.
Two of the area's river systems are exceptional. The Vailala River situated to the east of the Purari River lacks a deltaic segment at its outflow into the Gulf of Papua and this contributes to its particularly depauperate ichthyofauna. The Fly River has a lengthy lowland segment over which the flow of waters is extremely sluggish as a result of the sinuous channel course and the deep inland penetration of tidal influences. Further inland in the middle Fly River region one finds numerous lagoons, swampy backwaters and shallow dendritic lakes, whose margins are densely vegetated with rooted aquatic plants. These special qualities of the Fly River support a diversity of fish not commonly found in other Papuan rivers.

Kikori River Ecology

The following model of the Kikori River ichthyofauna is intended to (1) provide an outline of ecological zonation and associated fish communities found along the river course and (2) postulate the fish faunas to be found in aquatic habitats throughout the Waira region (see Table 16.1). The model relies heavily upon the work of Haines (1979), which focuses on the description of fish communities living in the Kikori/Purari delta and the Purari River system using a method of experimental catches in a number of habitats throughout this region.

Ecological zonation

This discussion outlines the structure and composition of the fish fauna to be found in the major ecological zones of the Kikori River between the coast and the Highlands foothills. For each zone particular attention is given to:

1. structure of the food chain;
2. species diversity and gross taxonomic composition;
3. nature of fluctuations in total fish abundance;
4. organisation of the fish community, particularly with regard to the migration pattern of certain groups.
Littoral

This zone includes the coastal strand and its associated beaches, inlets, lagoons and tidal pools. Water salinity is usually high, but during periods of high inland rainfall the flush of river waters may decrease soluble salts to as low as five percent. The aquatic ecology is comparable to that of the lower estuarine zone and will, therefore, be discussed in the following section. Haines (1979:Table 2) lists catches of more than 80 species of which the dominant families are Engraulidae, Clupeidae, Mugilidae, Ambassidae and Gobiidae. He also suggests that many more species may occasionally visit this zone. There is some information (see Table 16.2) which seems to indicate that the fish are less abundant in this and each of the successive estuarine habitats than in lower riverine environments. Barramundi and sharks comprise the greatest quantity (by weight) of fish caught by Haines.

Lower estuarine

This zone consists of a complex network of varying size channels separated by tidally inundated mudflats, which are usually covered by mangrove forest. Water salinity differs throughout this area depending upon the reach of invasive seawater. Turbid conditions prevail.

There are two alternate nutrient chains for tropical aquatic environments (Lowe-McConnell 1975:207-11). The first depends on a high level of primary aquatic production and runs from phytoplankton through zooplankton, zooplankton eaters to piscivores. Except under special conditions in the riverine zones where filamentous algae occur, the production of aquatic flora and phytoplankton appears to be minimal throughout the Purari-Kikori river system (Haines 1979:22). The other nutrient chain depends upon the incorporation of forest products into a nutrient-rich channel bottom detritus and runs from detrital micro-organisms through detritus-eating invertebrates and fish to piscivores. The production of detrital material predominantly occurs in the densely forested catchment of freshwater riverine environments and these nutrients are transported into the deltaic region in suspension or as bedload. Prawns play an important role in
the lower estuarine environment as they are the dominant consumers of detrital mud and are in turn predated upon by the majority of fish species.

Haines (1979:Table 3) lists 51 fish species caught in the lower estuarine zone of the Purari River and these include catfish, salmon, barrumundi, nursery fish, small forms of mullet and several families of gobioïds. Although most fish inhabiting the Kikori-Purari river systems appear in this habitat (Table 16.1), few groups permanently live here. Large numbers of fish come to the lower estuarine and near coastal environments to spawn, primarily in October-November but as late as January-February. Several species (e.g. barramundi, thread-fin salmon, ox-eye herring) pass through the mangrove estuary to breed at sea and juveniles of these groups often return to this environment, probably in October-November, to seek refuge. Populations of mullet, mud-skippers, bream and bass frequent this zone but at times travel to adjacent habitats in search of food.

The complexity of fish movements within and through the lower estuary zone creates difficulties in interpreting fish abundance. On an average it is comparable to the coastal zone. While barramundi, salmon and elasmobranch typically appear in Haines' net hauls, it may be anticipated that other fish (e.g. arfids) which inhabit nearby habitats will occur in catches at specific times of the year. For purposes of interpreting human activity patterns this zone holds considerable potential.

**Upper estuary**

Further inland one finds a broad brackish to freshwater zone of inter-connected, tidally influenced waterways lined with nipa palms and some pandanus. While the channels now become relatively stable the regular influx of flood waters continues to inhibit the growth of aquatic vegetation. Water conditions in this zone remain turbid and the sediments lying in the channel beds are always roughly divided detrital muds.

Prawn communities flourish in this habitat and form a large proportion of fish food. However, detrital mud constitutes an important primary dietary component of fish communities here. Freshwater swamp forests begin to appear in isolated areas and their contribution of allochthonous vegetable products and terrestrial
insects provide a small but significant proportion of fish food.

The number of fish species caught in this zone drops by 15-30 percent from that noted in the lower estuary habitat (Haines 1979:Table 3). Haines' records for the Kikori confirm an increase in the occurrence of catfish, but barramundi, salmon and nursery fish continue to appear. The most notable characteristic of this zone is the increasing dominance of freshwater fish (e.g. archer fish, detritophagous Eleotridae and freshwater anchovy) over brackish water groups (e.g. Gobiidae). The general comments made for the breeding and foraging patterns of the lower estuary zone continue to apply for this habitat. However, a number of fish (e.g. goldspot and sharp-nosed catfish) are known to breed and develop specifically within this environment.

Lower riverine

Above the delta the major rivers deeply cut limestone plateaux with broad swathes. Depositional landforms covered with climax rainforest border and waterways to different extents and localised catchments intersect the major rivers with outflows of varying sizes. The major rivers are generally fast flowing and muddy, but the secondary and tertiary streams respond closely to localised rainfall conditions and therefore experience differential periods of water flow. The major rivers and their primary tributaries are usually influenced by a tidal rise and fall of a metre or slightly more. During the rainy season overbank flow contributes to a major alteration of the environment and the restocking of fish communities living in alluvial plain waterways, which include small streams and doline ponds, is accomplished through such means.

Trends in the modification of the basic nutrient chain which have already been noted continue in the lower riverine zone. Prawns occur at a greatly diminished density and thereby play only a minor role in the processing of detrital mud. This is balanced by an increase in detritophagous fish species, the most notable of which are catfish and gudgeons. Forest products also constitute an important source of fish food.

The diversity of fish species reported for this area (Haines 1979:Table 3) is equivalent to that reported for the lower estuarine zone. Despite this, very few of the species which dominate the waterway near the coast appear in large numbers in riverine environments.
Catfish seem to be the only group to have undergone extensive radiation in freshwater habitats and they form the major portion of fish communities in the lower riverine zone.

Haines' experimental catch rates (see Table 16.2) suggest that this habitat maintains a consistently higher fish abundance than that of the deltaic system. Catfish provide approximately one-half of catches by weight. Muddy waters appear to be an ecological requirement for aruids and under these conditions they assist in maintaining the fish biomass at very high levels.

**Upper riverine**

In the upland reaches of the Kikori-Purari river systems water turbidity lessens. The increased water-flow prohibits the accumulation of detrital mud and thus restricts the occurrence of detritophagous prawns and fish. Water velocity also deters the growth of rooted aquatic plants, but submerged tree litter and rocky river bottoms occurring here support anchored algae.

A reduction in the numbers or total absence of catfish contributes to a drastic lowering of the total fish biomass. This in turn creates a situation where large numbers of piscivorous fish cannot be maintained. The omission of important portions of the aquatic food chain serves to diminish the diversity of species and fish size. Forest products constitute a major proportion of fish food. As water velocity increases all fish but those which feed primarily on river bottoms drop-out.

**Aquatic Habitats of the Waira Region**

We now present a model of the aquatic habitats and attendant fish communities of the Waira region. This construct serves as the basis for interpreting the fishing strategies employed by prehistoric and historic peoples of the area (see Chapter 9).

The species listing (Table 16.1) for the riverine environment was compiled from Haines (1979:Table 3) and skeletal specimens collected by Rhoads. The distribution and abundance of fish groups present in the various aquatic habitats was postulated by first considering the habitat requirements and foraging and breeding behaviours of the fish taxa as they are documented in the Purari (Haines 1979) and Fly (Roberts 1978). This information was then tailored so as to comply with the individual character of each aquatic habitat in the Waira region.
Main Channel

This habitat consists of the Kikori River and the Sirebi River below the gorge. The Kikori channel is wide and deep and passes through the Waira region in a long meander. Water flow is rapid and turbulent, but a few eddies and areas of quiet water occur at isolated localities along the river course. The river transports sediments originating in an extensive catchment, thus water conditions are always turbid. Approximately 10 km upstream from Waira, the Sirebi River passes through a gorge cut into a broad karst plateau. Below the gorge the Sirebi is similar to the Kikori in character. However, water flow is generally sluggish and at its mouth the Sirebi banks up against the greater volume of the Kikori and generates eddy conditions in this area.

Fluctuations in water-level in both rivers follow the daily rise and fall of tides. During the rainy season there is considerable overbank flow from these rivers and the annual flood depth is predicted to reach 0.6m (see Appendix 1).

The main channel unlikely constitutes a fish habitat in itself, but a number of large species, consisting predominantly of prawn eaters or piscivores, probably range widely in the river and forage along the channel margins. It is doubtful that large catches could be made in this habitat because the rapid flow, high water turbidity and restricted niches serve as a deterrent to most fish groups.

Fish communities occurring in the main channel habitat are probably concentrated in the sluggish waters of the Sirebi. Large carnivorous fish are most prominent and these include *Lates calcarifer*, *Lutjanus* spp., *Plotosus papuensis/oanius*, *Megalops cyprinoides* and *Elasmobranchii*.

Headwaters

This habitat occurs in the generally fast-flowing waterways feeding the upper reaches of the Sirebi River. Water turbidity is variable but occasionally high. The short interval between rainfall and run-off in this area results in a continual flushing of detritus and debris from the waters. Small clear pools are often found along waterways well inland from the main channel of the Sirebi.
The low-level of detrital muds in this area contributes to a major alteration to the food chain which dominates other riverine zones. Therefore, the total biomass of this habitat is low and few fish species permanently inhabit this area. Based upon Haines' catch records (1979: Table 3) the most common fish are small forms which feed upon allochthonous resources (e.g. *Nenatocentris rubostriatus* and *Ambassis* spp.). The larger, bank patrolling archer fish, *Toxotes chatareus*, also appears. Carnivorous fish (e.g. *Lutjanus* spp., *Parambassis gulliveri* and *Elasmobrartchii*) are present but sustained at low densities only.

Fish biomass may increase seasonally with the movement of mullet, possibly *Crenimugil labiogus*, into the area to spawn in clearwater side-streams during the early months of the rainy season. Catch productivity for juvenile mullet congregations in the Upper Purari are the highest on record for the entire system (Haines 1979: Table 14, Wai Creek).

**Channel Margins**

This habitat includes isolated inlets and mouths of small side-creeks. Water velocity in these areas is variable and, at localities where water flow is reduced, detrital muds accumulate. Dense terrestrial vegetation lines the banks, except at sites of human disturbance (e.g. gardens), and the overhanging foliage and protruding roots provide a suitable environment for prawns and gastropods. Daily and seasonal fluctuations in the water-level allow fish communities to gain access to a wide range of foods, which include prawns, molluscs and terrestrial plants and insects. Detrital resources are available at all times.

Channel margin conditions along the Kikori are fairly uniform and areas of reduced flow are limited to creek mouths. Those of the Sirebi are most diverse as the channel is sinuous and water flow is variable along the river course. At the mouth of the Sirebi water conditions are comparable to those found in backwaters.

This habitat contains the highest diversity of species and the largest fish biomass found in the local riverine environment. Fish populations are probably concentrated in areas where water flow is low and near the mouths of small waterways which afford ready access to the margin of the alluvial plain. Ariid catfish, including the omnivore *A. leptaspis* and *A. latinostris*, are the dominant group in this habitat. Other species consistently present include other detritophages/prawn-
eaters (Oxyeleotris sp.), forest produce feeders (Toxotes chatareus, Nematocentris rubostriatus) and numerous other fish which subsist primarily upon prawns and molluscs (e.g. Plotosus popuensis/canius, Acanthopagrus berda, Scutengraulis scratchleyi, Lutjanus spp., Lates calcarifer).

Small Subsidiary Waterways

This habitat is comprised of the narrow streams which drain the alluvial plain. These waterways narrow quickly away from their mouths and terrestrial vegetation and tree litter choke most of their inland course.

Water-level and flow are closely controlled by localised rainfall seasonal flooding and, to a lesser extent, tidal fluctuations. During the height of the dry season the drop in the water-table results in stagnation and in some cases ponding. Except during wet season floods the current is usually moderate to sluggish with some backflow near stream mouths.

Detrital mud is the primary fish food in this habitat. Of less importance to fish in this habitat are the prawns, gastropods and terrestrial resources which are more intensively exploited elsewhere.

Ariidae and Eleotridae are the major fish families occurring here. The ariid catfish present are mostly reduced in size, possibly including juvenile forms of Arius spp. and a small form, Nedystoma dayi. Fish communities which primarily inhabit the channel margin habit (e.g. Acanthopagrus berda and Parambassis gulliveri) frequent the deeper waters near stream mouths and probably expand upstream during periods of river inundation.

Utiti Creek (lower reach)

This and the following two habitats discussed are not unique within the region. They are given as specific examples because of their close proximity to archaeological sites described in the text of the thesis.
Near the mouth and for approximately 4 km upstream the channel of the Utiti Creek is moderately deep and about 200 m wide. Water conditions are turbid and flow is sluggish. Tidal fluctuations and the great volume of Kikori River waters flowing by the mouth create backflow. The catchment for the Utiti is small and run-off from rainfall quickly evacuates the area, thereby restricting overbank flow and high water conditions to only brief periods.

Detrital mud, prawns and molluscs serve as the major source of fish food. Moving upstream these items decrease in importance and terrestrial resources play a greater role. The rich resources in this habitat support a large fish population which is primarily comprised of ariid catfish. Fish groups frequenting the channel margin environment occasionally appear. These include molluscivores (Plotosus popuensis/canius, Acaanthopagrus berda), carnivores (Lutjanus spp., Parambassis gulliveri, Lates calcarifer and Nibea soldado) and a few insectivores (Toxotes chatareus), which become more abundant upstream. During high water conditions many channel margin fish invade the upper reaches of the Utiti.

Utiti Creek (headwaters)

In this area the channel is narrow and shallow. The current flows at a moderate to quick rate over a rocky bottom. Fluctuations in the water level usually occur in response to tidal changes and localised rainfall.

Terrestrial vegetation lines the banks and occasionally blocks the channel. In conjunction with terrestrial insects such plant matter forms a major source of fish food. Algae growing on tree litter and rocks may support populations of the clearwater tolerant species Ambassis spp. and Zenarchopterus novaequineae.

The only common fish appearing in this habitat are insectivores (Toxotes chatareus and Nematoctenctis rubostriatus). Other fish groups may forage into this area for brief periods. The waters are generally too clear for ariid catfish.
Hevere Creek

This habitat occurs as varying size waterways which drain the karst plateau and are primarily fed by groundwater. Many of these creeks and streams emanate from doline ponds which may serve as terminal points for the underground drainage pattern prevalent through the karst region.

The Hevere Creek consists of a series of pools joined by a narrow channel. Its course is blocked with terrestrial vegetation and tree litter and this contributes to the sluggish flow of its waters. Fluctuations in the water-level result from local rainfall and seasonal inundation from the main rivers. During the height of the dry season water flow sometimes ceases altogether.

The postulation of the fish communities occupying this habitat is difficult. It seems probable that population size and species diversity are low and this may result in the absence of carnivorous forms. Arid catfish (*Nedystoma dayi*, *Arius leptaspis/latirostis*) likely comprise the most common fish. Eleotrids and archer fish (*Toxotes chatareus*) probably also occur, with the latter confined to areas of clear water.

Inundated Flood plain

Most of the alluvial plain surrounding Waira Village is covered by flood waters throughout the wet season (see Appendix 1). At the beginning of the rains the flood level fluctuates greatly, but it is soon followed by a rapid rise which is predicted to reach 0.6m annually. These waters recede gradually after the initiation of the dry season and isolated ponds appear in low-lying areas of the plain.

The following discussion of fish behavioural patterns over the inundation period is derived from the model for seasonally flooding tropical rivers suggested by Lowe-McConnell (1975).

As flooding begins waters become enriched with nutrients released from the breakdown of organic matter on the forest floor. This stimulates an explosion of microbiological activity and a rapid increase in the production and availability of several types of fish food (*e.g.* crustacea, molluscs, terrestrial foods). The abundance of food resources and their accessibility via flood waters promotes a redistribution of fish communities. These conditions also sponsor
a major growth period for a large number of fish species. When the
flood waters recede fish groups not adapted to stillwater habitats
retreat to the main channel along drainage routes.

The Lowe-McConnell model also describes a cycle of fish
reproduction brought on by the seasonal rise in water levels. At
peak overbank flow fish migrate out onto the plains to spawn and/or
to use this habitat as a nursery zone. This pattern is probably not
as definite in the Waira region because the majority of fish occurring
here are continual breeders or reproduce in saline environments after
migration. However, the flooding of the Waira plain does coincide
with peak breeding periods for some locally reproducing fish (e.g.
*Arius leptaspis*) and it is envisioned that the plain might serve as
a sanctuary for juvenile fish.

The extent to which channel margin and flood plain drainage
fish communities move onto the plain is difficult to estimate. It
seems likely that those groups moving farthest inland and remaining
there for the longest period of time are the species best suited to
survival in still, muddy water conditions. The ariid catfish,
particularly small individuals, and the detritophagous eleotrids are
probably the most abundant fish living within the inundation zone
and these are the species most likely to have been isolated after
the contraction of flood waters.

REPTILES

The available information describing the behaviour of
reptile species which occur or on the basis of distributional
characteristics may appear in the Waira region is scarce and
incomplete. Therefore, the discussion of each taxa is brief.

Varanidae

Monitor lizards are efficient predators which are frequently
found along the margins of aquatic habitats. They are known to eat
carrion. Three or more species possibly inhabit the Waira area
(Liem and Haines 1977:Appendix II).
Varanus salvadori

Salvadoris Monitor Lizard is for the most part restricted to lowlands forests and swamps. It grows to a length of just over 4 m, two-thirds of which consists of a thin tail (Cogger 1972:656).

V. indicus

Usually found near watercourses or in mangrove and palm swamps, the Common Water Monitor attains a size of just over 1 m. It occurs throughout New Guinea and its skin is commonly used for drums.

V. prasinus

This species, Emerald Monitor, inhabits most lower altitudinal zones in New Guinea. It spends most of its time in trees and is the smallest species of this genus, rarely growing to more than 1 m (De Rooj 1970:151-52).

Agamidae

There are 15 species of dragon lizards in New Guinea (Cooger 1972:651). Although Liem and Haines (1977: Appendix II) do not report the occurrence of agamids in the Kikori/Purari delta the distributional characteristics of two taxa suggest that they probably are present in the Waira region. These are one species of Gonocephalus, angleheads, and another belongs to Physignathus, water dragons.

Testudines

Up to eight species of turtles representing four family groups occur in the Kairi area.

Carettochelys insculpta

Pitted-shell Turtle, which belongs to the family Carettochelyidae,
is only recorded for the Daly River area of the Northern Territories, Australia and for rivers and lakes just inland from the south coast of New Guinea. It feeds on forest foods, including green pandanus fruits (Schodde et al 1972) and freshwater snails. It grows to almost 1 m in size.

This species lays its eggs, 15 on average in each nest, in sand or mud banks from August to November (Cogger 1972:1149).

Pelochelys bibroni

Soft-shelled Turtle, a member of the family Trionychidae, most commonly occurs in freshwater habitats, but it has also been noted near coastal environments. Liem and Haines (1977:Appendix II) note its presence in the Kikori/Purari delta.

Cheloniidae

Members of this family predominately inhabit marine environments and only come ashore to lay eggs. Two species, Chelonia mydas (Green Turtle) and Caretta caretta (Hawksbill Turtle) are reported in the area (Liem and Haines 1977).

Chelidae

Chelodina siebeniooki

Siebemock's Snake-neck Turtle, the first of four species of Chelidae discussed, only occurs in freshwater and feeds on aquatic snails, insects and fish. It lays upwards to 20 eggs each season in the banks of waterways situated away from large rivers and creeks.

C. novaeguineae

A specimen of the New Guinea Snake-neck Tortoise collected by Rhoads in the Waira area has been identified by G. Czechura (Queensland Museum) on a complete shell and some associated post-cranial material. This species occupies the same habitat and has comparable feeding and breeding patterns as those of other Chelidae.
Elysea novaeguineae

G. Czechura also identified this species from a specimen collected by Rhoads. The New Guinea Snapper is sympatric with Chelodina spp. in southern New Guinea and Northern Australia.

Emydura subglobosa

Liem and Haines (1977:Appendix II) record the presence of this species in the Kikori/Pruari delta. Red Short-neck Tortoise is similar to other Chelidae with respect to most behavioural patterns.

Crocodylia

Both species of crocodile are present in the Waira region. Crocodylus porosus probably breeds in the lower estuarine zone. Because of its slow migration away from breeding areas this species probably occurs as moderate to large-size individuals near Waira. C. novaeguineae is present and probably breeds locally in the Kairi area (see Webb and Messel 1978).

Boidae

At least two genera of python, Chondropython viridis (Green Python) and Python spp., have been found in the delta region by Liem and Haines (1977: Appendix II). Pythons feed on birds and small mammals.

Colubridae

This is the most common of all lowlands snake families. The majority of species occur near waterways and subsist largely on frogs. This family is non-venomous and includes some tree snakes.

Achrochordidae

File snakes are flabby aquatic species which reach up to 2 m in length. They feed on fish and are especially common in the waterways and swamps of south New Guinea.
Hydrophiidae

This family is comprised of the highly poisonous sea snakes. At least one form of *Aipysurus* spp is listed by Liem and Haines (1977).

PIG (*Sus scrofa*)

**General Behaviour**

Pigs are generally sedentary and prefer well covered areas with a year-round water supply (Diong 1973:120; Barrett 1978:305). If, however, local conditions become less favourable they will rapidly adjust to the changing situation and shift their daily range. When living in high rainfall areas, they abandon favoured haunts in low-lying areas and migrate to upland regions during the wettest months (Diong 1973:132; Rhoads, this study). In cases where lucrative foods such as wild fruit or nuts (Barrett 1978:309; Morren 1979) or garden crops (Diong 1973:133; Dornstreich 1973:135-36) become available they quickly shift their foraging patterns. If heavily predated by man pigs limit the expansion of their home range (Barrett 1978:303).

Daily movement in rainforest environments is generally restricted to the early morning and evening. Pigs living in areas with extreme seasonal changes in the daily temperature orient their movements and feeding times to avoid very cold or hot conditions (pp 303-04).

**Food Habits**

Pigs are highly selective omnivores. They repeatedly change their foraging habits radically with the seasonal availability of preferred foods, which are usually masts or energy-rich root crops (p. 309). In lowland Malaysia Diong (1973:128) notes that they also feed on molluscs, arthropods and fish and to a lesser degree on soil, worms, roots and various types of wild vegetable foods.
Group Composition and Movement

Pig groups or sounders are usually comprised of an adult sow and one to three generations of offspring. Group size in the American Southwest ranges from 6 - 10 hogs with a monthly average of 8 (Barrett 1978:302). Authorities appear to agree that the largest sounders rarely number more than 25 - 30 individuals (ibid; Diong 1973:133). Adult sows maintain a home range of 10 km. Their daily range is much reduced and in some instances is no more than 0.5 km. With the exception of breeding males, most offspring set up a home range near that of their dam.

Adult boars normally travel alone and often establish a home range of at least 50 km as a result of their incessant search for select foods and breeding opportunities. They have been noted to move as much as 11 km in a day or two (Barrett 1978:304). Adult barrows rarely shift their home range, which is often less than that of sows.

Life History

Boars and sows usually begin breeding at 12-17 and 6-7 months respectively. Estrus occurs every 21 days, although ovulation ceases for about two months post-partum. The average gestation period is 114 days (p.323). In New Guinea Dornstreich (1973:235) has noted that all mating occurs in the rain forest.

Just prior to farrowing sows build nests in heavily vegetated localities some distance away from the family group. The litter size for wild pig is usually 4-6 and sows average two litters a year. After farrowing sows remain near the nest for only one to two weeks and progressively extend their daily range as their young become more mobile. Weaning occurs at 3-4 months.

The critical survival period for pigs occurs during the first six months. Crushing of piglets in the nest and trampling by adult hogs are common causes of infant mortality. Piglets often die if they are born when the natural supply of protein-rich foods is low and their dam may have insufficient or nutrient-poor milk. Starvation may also occur two to three months after weaning as a result of the inability of
young pigs to alter their diet or the poor quality of available foods.

The probability for survival increases notably after individuals reach 6 months, after which time a pig has a life expectancy of 4 years (Barrett 1978:331) unless predators or disease cause death. Tooth deterioration increases after an individual reaches this age and septicemia brings on most old age deaths.

Pig in the Waira Region

Two aspects of pig behaviour discussed above are of particular importance in considering the characteristics of populations in the Waira region. Informant reports describing the movement of pigs to the karst during wet season floods and to perennial streams in the height of the dry are in total agreement with observations recorded in the literature for other areas of the world. Also, it seems reasonable to assume that the survival of piglets and weaned hogs is greatest in the dry season. At this time a diverse and extensive range of rich food resources are available and starvation would unlikely preclude normal maturation. However, the restriction of wet season movements to the karst, which has poor forest resources, suggests a higher probability of death for individuals of this age group. Cursory observations of pig populations in northern Australia support this conclusion (Barrett 1979: pers. comm).

RATS

Possibly three species of murids occur in the Waira region. The presence of the first two discussed is supported by informant reports and either archaeological evidence or studies conducted in the delta (Liem and Haines 1977: Appendix II).

*Uromys caudimaculatus*

The range of the Mottled-tail Tree Rat includes all of New Guinea south of the central mountain range and parts of the north coast (Laurie and Hill 1954:129). It is most commonly found below
1900m. This murid lives mostly in trees, although it is noted as spending considerable time foraging on the forest floor (Ziegler 1972:1019).

*Hydromys ohrseagaster*

The Common Water Rat usually frequents the banks of streams and large waterways. Observations record it as occurring below 1500m.

*Xenuromys barbatus*

This species, the Mimic Tree Rat, is poorly known as only five specimens have been caught. Catch localities occur at elevations below 600m in areas of West Irian and eastern Papua New Guinea. The presence of this species in the Waira area is suggested by an extremely tentative archaeological occurrence.

**BATS**

Flying foxes (Pteropididae) nest in trees or caves. Feeding takes place in the late afternoon and tree fruit and the nectar from tree flowers serve as the major foods. *Pteropus* is reported travelling long distances to favoured feeding grounds (Van Deusen 1972:61).

Usually no more than three species of flying fox - a large, medium and small form - coexist in the same region (McKean 1970:245). The occurrence of *Pteropus neohibernicus* and *P. macrotis* in the Waira region is confirmed in archaeological finds. The medium size form, if present, may be either *P. pohlei* or *P. conspicillatus*.

**BANDICOOT**

Peramelidae are small solitary animals which fiercely maintain individual territories. During the day they shelter in burrows or nests; at night they forage among leaf litter for insects, larvae and worms. Tree fruit, such as pandanus and figs, are heavily exploited only seasonally. In Australian environments males maintain a home range two to ten times, depending upon habitat, to that of females (Stodart 1977:
Females have short periods of oestrus. Gestation lasts approximately 12 days. The young are weaned after a few days and only a few survive to maturity (p.188. Life expectancy is 2½-3 years.

Liem and Haines (1977:Appendix II) report the occurrence of more than one species of *Eohymipera* in the Kikori/Purari delta. Aplin (see Appendix 13) suggests that two forms of this genus are represented in the archaeological faunal collection. A specimen collected by Rhoads confirms the presence of *E. rufescens* in the Waira area.

**Eohymipera rufescens**

The Rufescent Bandicoot is distributed along the south coast of New Guinea from the Astrolabe Range near Port Moresby to the islands off Cape Vogel (Tate 1948:31). In this region it appears to prefer forested areas. However, elsewhere in New Guinea this species has been observed in grasslands and open woods below 1000m (Ziegler 1972:7). The Rufescent Bandicoot inhabits rain and gallery forests and their margins in Cape York. Although it ranges into adjacent grasslands or scrub, it seems to prefer areas near water with a sparse understory and dense leaf litter (Hulbert et al. 1971:330; Gordon and Laurie 1977).

In the Waira area the most permanent breeding population is probably established near perennial waterways in the karst margin. They may also inhabit zones of moderate flood risk, but their long-term occupancy of this area is subject to the rate of recolonisation and population increase after extensive floods. The home range of most individuals probably includes much of the alluvial plain, except during the wet season when overbank flow prohibits access to many areas.

**Eohymipera kalubu**

The Spiny Bandicoot is known from several areas of Papua New Guinea, with the Oriomo River being the closest occurrence to the Waira region. In the lowlands environments below 1000m asl it occurs in a wide range of habitats which include grasslands, primary rain forest, gallery forest and areas of human disturbance.
Aplin (see Appendix 13) postulates this species to be the small form of bandicoot recovered from archaeological deposits in the Waira area. He eliminates *Peroryctes ratfrayanus* on the basis of distributional records and average size of individuals. From what little is known of the habitat requirements of *E. kalubu* it seems most likely that the karst escarpment/plateau serves as the primary focus of this bandicoot population in the Waira region.

**Petaurid Possums**

*Petaurus breviceps*

The Sugar Glider is widespread in New Guinea with several forms inhabiting environments from sea level to 2600m. Kairi informants report its occurrence in the Waira area; Liem and Haines (1977:Appendix II) note its presence to the south. This species is a small nocturnal animal which hides in tree cavities during the day (Ziegler 1972:10). It feeds on insects and tree fruit and flowers. No specimens of this species are present in Rhoads' archaeological collection. The Kairi refuse to eat gliders because they are thought to be the medium by which sorcerers travel.

*Daotylopsila trivirgata*

This species, Common Striped Possum, occurs throughout the New Guinea lowlands and hill forests to an elevation of 1000 m, as well as in Cape York (Laurie and Hill 1954: 17-18; George 1973:422). Liem and Haines (1973:Appendix II) record it for the Kikori/Purari delta and it is known to the Kairi.

Ziegler (1972:10) reports that this species prefers an open woodland habitat; in Cape York it is found in vine forest and adjacent woodland (Van Dyck 1979:84). The Common Striped Possum hides during the day in tree hollows, feeding only at night. Grubs and termites which it gathers from rotten wood are its primary foods (Rand 1937).
Little can be said concerning its distribution in the research area.

*Pseudocheirus* sp.

Most ringtail species inhabit high altitude environments. *Pseudocheirus canescens* and *P. caroli* are the only lowlands forms. *P. canescens*, Lowland Ringtail, is recorded in areas below 1500m in south-east and far west Papua, Tritan Bay (north-west Irian Jaya), Sorong (Cape Vogel), Salawati Island (west of Cape Vogel), areas of the north and south Papuan ranges from 300-1700m, Gira River district (Papua) at 200m, Port Moresby region, Astrolabe Range (400m) and Idenberg River. *P. caroli* is known only from the Weyland Mountains and is a larger form of ringtail (Tate 1945:25). Since the distributional patterns of these species omits areas in the vicinity of the Kikori River it is difficult to speculate as to the exact species recovered from the Ouloubomoto rock shelter near Waira and as to the habits of ringtails occurring in this region.

CUSCUS

Archaeological evidence and distributional records support the occurrence of three species of *Phalanger* in the Waira region.

*Phalanger maculatus*

The Spotted Phalanger is almost completely arboreal. During the day it shelters in dense foliage and at night it feeds on leaves and fruits (Menzies 1972; Ziegler 1972; George 1973). In the Kikori/Purari delta this species attains extremely high densities in the mangrove forest. Therefore, it seems most likely that in the Waira area it is most common in the rich and dense forests of the alluvial plain.
Phalanger gymnotis

The Gray Phalanger, which occurs sympatrically in lowlands environments with *P. maculatus* and *P. orientalis* (George 1973:421), has less specialised feeding patterns than *P. maculatus*. At night it forages in trees, as well as on the ground, and consumes leaves and fruit, insects and possibly small mammals. Holes under tangled tree roots, rock clefts and caves are sought for shelter during daylight hours and this habitat requirement restricts this phalanger to more rugged terrains (see Tate 1945:16; George 1973:421). In the Waira region *P. gymnotis* probably moves onto the alluvial plain margins at times but is most frequently found along the karst escarpment and in the karst plateau.

Phalanger orientalis

The Common Phalanger is not well known. George (1973:421) suggests that it shelters in tree hollows. Its habits and distribution in the Waira area cannot be speculated upon.

WALLABIES AND TREE KANGAROO

Thylogale brunii

This species, Dusky Wallaby, is widespread throughout the lowlands, foothills and part of the central range of the eastern half of New Guinea (Tate 1948:318; Laurie and Hill 1954:28). Along the south coast it is known from the Fly River area, where it is sympatric with *Dorcopsis*, to near Port Moresby at elevations of 0-3800m (Ziegler 1972:11). Like *Dorcopsis*, *Thylogale* is a solitary animal which feeds on leaves, fruit and possibly insects. It feeds mainly at night and shelters in deep vegetation during the day.

The Dusky Wallaby is not well adapted to open country and appears to prefer areas of secondary regrowth. On occasions it ventures into deep forest (Ziegler 1977:134). In areas of alpine or man-made grassland *Thylogale* never travels far from isolated forest patches (Hope, in press).
In view of the above it seems reasonable that *Thylogale* usually inhabits the karst escarpment and plateau in the Waira region. It may also forage on the alluvial plain and during the wet season move further inland to avoid competition with populations of *Dorcopsis* seeking refuge from flood waters.

*Dorcopsis venterum*

The Common Forest Wallaby occurs in lowland and foothill environments from Cape Vogel to Port Moresby (Tate 1948:288-89). This species inhabits dense forest, although it sometimes appears in secondary regrowth forests or man-made grasslands (Ziegler 1977:135). *Dorcopsis* probably inhabits the deep forest of the Waira plain and during floods moves to the area along the karst escarpment.

*Dendrolagus* sp. (*goodfellowi*)

The Ornate Tree Kangaroo is best known from the upper rain and moss forests of the eastern two-thirds of the Highland mountain range (Ziegler 1972:12; Ziegler 1977:135-36; Lidicker and Ziegler 1968:Fig.3). However, a tree kangaroo almost certainly conspecific with *D. goodfellowi* is known from the Karimui Plateau (Wagner 1967:10) and the slopes of Mt. Bosavi where it is known under the synonym of *D. spadix* Troughton and Le Souef 1936. The occurrence of tree kangaroo in the Waira region is indicated by archaeological finds from Rupo, Kulupuari and possibly Bageina (see Appendix 13 for further discussion).

All tree kangaroos are nocturnal, sleeping aloft during the day in groups consisting of an adult male and several females (Olds and Collins 1973:123-25). They subsist primarily upon foliage and fruit but often forage extensively on the ground. Their occurrence in the lowland rain forest of the Waira region is unprecedented and distributions within this environment cannot be speculated upon.
APPENDIX 17

THE HUMAN REMAINS

by Alan Thorne, Department of Prehistory
Research School of Pacific Studies
Australian National University

This report describes the skeletal and dental remains from the excavations at two sites, Kulupuari and Rupo. The material is extensive but in most cases only small sections of particular individuals are represented. Erosion of bone in a noticeable feature of the material from both sites. Without good comparative reference material it is difficult to assign these remains to any present or past population and I have limited my remarks to basic facts about the morphology and pathology. All dimensions listed are in millimetres.

I am grateful to Jim Rhoads for inviting me to undertake the examination of the material, which includes some of the oldest skeletal evidence for man on the island of New Guinea.

KULUPUARI

Pit 5NOE/Horizon 1

When the package containing these remains was opened it was clear that severe damage had occurred in transit and as a result the skeletal material consisted of a number of permanent teeth, mostly lacking roots, plus a pile of tiny eroded bone fragments. All the remains appear to be those of a single individual. Given the conditions under which the remains were excavated and conservational problems in the field, it is remarkable that anything has survived.
The teeth, and their dimensions, are as follows:

<table>
<thead>
<tr>
<th>Maxillary</th>
<th>Mesiodistal</th>
<th>Buccolingual</th>
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</thead>
<tbody>
<tr>
<td>right 1</td>
<td>9.4</td>
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<tr>
<td>left 3</td>
<td>8.85</td>
<td>8.5</td>
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<tr>
<td>&quot; 4</td>
<td>7.7</td>
<td>10.45</td>
</tr>
<tr>
<td>&quot; 5</td>
<td>6.85</td>
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<td>7.75</td>
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<td>12.5</td>
</tr>
<tr>
<td>right 6</td>
<td>10.6</td>
<td>10.8</td>
</tr>
<tr>
<td>&quot; 7</td>
<td>10.0</td>
<td>12.1</td>
</tr>
<tr>
<td>&quot; 8</td>
<td>9.8</td>
<td>11.7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mandibular</th>
<th>Mesiodistal</th>
<th>Buccolingual</th>
</tr>
</thead>
<tbody>
<tr>
<td>right 3</td>
<td>7.6</td>
<td>7.8</td>
</tr>
<tr>
<td>&quot; 4</td>
<td>7.55</td>
<td>8.3</td>
</tr>
<tr>
<td>left 4</td>
<td>7.5</td>
<td>8.25</td>
</tr>
<tr>
<td>&quot; 6</td>
<td>11.3</td>
<td>10.9</td>
</tr>
<tr>
<td>right 6</td>
<td>12.4</td>
<td>10.7</td>
</tr>
<tr>
<td>&quot; 6</td>
<td>11.0</td>
<td>10.3</td>
</tr>
<tr>
<td>&quot; 7</td>
<td>10.8</td>
<td>10.05</td>
</tr>
</tbody>
</table>

The remains are those of a late adolescent or adult as the third molars display blunting of the cusps. Wear on the other teeth is moderate, with minor dentine exposure on most teeth. There is no evidence of any pathology or abnormality.

Pit ONOE/Spit 1

1. Permanent mandibular right 5 - only a crown remains and it shows mild interproximal facets and blunting of the occlusal surface, particularly of the buccal half. Dimensions: MD 7.6, BL 8.13.
2. Permanent mandibular left 7 - the apical halves of the roots are missing but the tooth is otherwise complete. The occlusal surface is blunted but there is no dentine exposure or fissure obliteration. A minor mesial interproximal facet is developed. Dimensions: MD 10.07 (9.0 C.E.J.), BL 10.03 (8.85 C.E.J.).

3. Permanent mandibular right 6 - only the crown is preserved. Wear on the occlusal surface is general and all five cusp tips are through to the dentine. Both interproximal facets are well developed. Dimensions: MD 11.9, BL 11.1.


Pit ONOE/Spit 2

1. A permanent mandibular left 7 - the buccal side of the crown and root is damaged. Little of the roots is preserved but they were relatively short and firmly fused. Tiny facets are present on the tips of both lingual cusps but the buccodistal cusp is blunt and displays a triple facet. The mesiobuccal cusp has an extensive buccal facet. The tooth has been in occlusion long enough to develop pronounced interproximal facets but no dentine is exposed. Dimensions: MD 11.7.

2. Portion of a permanent maxillary molar - the tooth is either a 7 or 8 but too much is missing for precision.

Pit 3N3W/Horizon 2

Portions of a fragmentary human cranium. Small eroded sections of the right parietal and the petrous and mastoid parts of the right temporal bone are preserved. The bones are those of an adult. The bones suggest small size and gracility but there is no positive indication of sex. Portions of three teeth are present.

1. Permanent mandibular left canine - only an enamel cap is preserved. Most of its lingual half is missing. Wear of the crown had proceeded to a point where a very small area of dentine was exposed. Most of this was due to the creation of a shallow, crescentic facet spanning the distal half of the occlusal ridge. The facet is smooth,
almost polished, and slopes downward onto the labial surface. Dimensions: Crown Height 11.0, MD 7.8.

2. Permanent maxillary right second molar - only the crown is preserved. The tooth displays small interproximal facets. Wear is mild and had produced general blunting of the cusps, but without dentine exposure. Both buccal cusps were chipped antemortem. The crown has been burnt, producing discolouration of the surface. Dimensions: MD 11.0, BL 13.1.

3. Permanent maxillary premolar - this specimen is a badly chipped enamel cap. It is probably a 5 as the cusps appear subequal in height. There is virtually no sign of occlusal wear and the tooth had been burnt severely as the surface is crazed.

RUPO

Pit A/Spit 1

The bones in this zone are a heterogeneous collection of postcranial remains and four teeth. There is a single adult thoracic vertebra, rib fragments, portions of two hands (2 lunates and to pisiforms plus a metacarpal and 2 carpal phalanges), 3 metatarsals, and eroded cuneiform and a coccyx. In addition are a few fragments of juvenile material. The teeth are all permanent:

<table>
<thead>
<tr>
<th>Maxillary</th>
<th>Mesiodistal (CEJ)</th>
<th>Buccolingual (CEJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>right 1</td>
<td>8.9 (6.1)</td>
<td>7.2 (6.3)</td>
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<td>&quot; 1</td>
<td>8.8 (6.6)</td>
<td>7.65 (7.1)</td>
</tr>
<tr>
<td>left 4</td>
<td>6.9 (4.9)</td>
<td>9.5 (8.1)</td>
</tr>
<tr>
<td>right 4</td>
<td>6.7 (5.0)</td>
<td>9.0 (8.7)</td>
</tr>
</tbody>
</table>

Pit A/Spit 5

A few fragments of at least one deciduous molar tooth.
Pit A/Spit 6

Portions of 3 permanent teeth, with enamel sections missing - one of the teeth is a mandibular canine and the other a maxillary right 6.

Pit A/Spit 7

Two permanent maxillary tooth crowns, a right canine (MD 7.8, BL 8.6) and a left 2 (MD 7.55, BL 6.4).

Pit A/Spit 8

Three permanent teeth are represented, two of them chipped and eroded. One of these is a mandibular premolar, the other is an incisor. The third tooth is a maxillary left 2 (MD 6.35, BL 5.7).

Pit A/Spit 9

The solitary human skeletal evidence is a permanent mandibular right first molar tooth. The tooth has not erupted and its dimensions are: MD 12.65, BL 11.5.

Pit A/Spit 10

Apart from a permanent maxillary left canine crown (MD 8.65, BL 8.85) the material consists of a number of very eroded cranial fragments. The bones are adult but as the external and intracranial surfaces are damaged nothing of consequence can be said about the specimens.

Pit A/Spit 11

The bone from this spit probably relates to that from the one above. Most of the fragments are postcranial. Once again they are badly eroded but it is clear they were adult (or adults). The cortical thickness suggest gracility and small size. Five permanent molar teeth are present and appear to belong to a single individual. The third molars were not erupted and wear on the remainder is slight.
A large number of human bones and teeth were found in this spit. There are several eroded infant and adolescent fragments, mostly cranial. The bulk of the remains are adult however and include cervical and thoracic vertebrae, portions of several ribs, and both hand and foot bones. At least two left feet are represented. The isolated teeth present, and their dimensions, are as follows:

<table>
<thead>
<tr>
<th>Maxillary</th>
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<th>Buccolinguial (CEJ)</th>
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</thead>
<tbody>
<tr>
<td>left 6</td>
<td>11.0 (7.5)</td>
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<tr>
<td>right 6</td>
<td>12.3 (9.8)</td>
<td>11.7 (9.0)</td>
</tr>
<tr>
<td>&quot; 7</td>
<td>12.5 (10.7)</td>
<td>11.5 (9.7)</td>
</tr>
<tr>
<td>&quot; 8</td>
<td>12.7 (10.2)</td>
<td>11.75 (9.8)</td>
</tr>
<tr>
<td>left 8</td>
<td>12.75 (10.15)</td>
<td>11.75 (10.0)</td>
</tr>
</tbody>
</table>

| Pit B/Spit 1 |

<table>
<thead>
<tr>
<th>Maxillary</th>
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<th>Buccolinguial (CEJ)</th>
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<tbody>
<tr>
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## Mesiodistal (CEJ) and Buccolingual (CEJ)

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<th>Buccolingual (CEJ)</th>
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<td>12.5 (11.0)</td>
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<td>10.6 (8.4)</td>
<td>12.4 (11.1)</td>
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<td>&quot; 7</td>
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<td>left 8</td>
<td>8.8 (7.2)</td>
<td>10.8 (9.85)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mandibular</th>
<th>Mesiodistal (CEJ)</th>
<th>Buccolingual (CEJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>left 1</td>
<td>5.15 (3.8)</td>
<td>5.35 (5.0)</td>
</tr>
<tr>
<td>&quot; 1</td>
<td>6.05 (4.0)</td>
<td>6.2 (5.9)</td>
</tr>
<tr>
<td>right 2</td>
<td>5.2 (3.4)</td>
<td>5.5 (5.3)</td>
</tr>
<tr>
<td>left 2</td>
<td>5.2 (3.5)</td>
<td>5.3 (4.9)</td>
</tr>
<tr>
<td>&quot; 2</td>
<td>5.4 (4.2)</td>
<td>6.1 (5.8)</td>
</tr>
<tr>
<td>&quot; 3</td>
<td>7.6 (5.3)</td>
<td>8.8 (8.5)</td>
</tr>
<tr>
<td>right 3</td>
<td>7.6 (5.4)</td>
<td>8.5 (-)</td>
</tr>
<tr>
<td>&quot; 3</td>
<td>6.6 (4.6)</td>
<td>7.0 (-)</td>
</tr>
<tr>
<td>&quot; 3</td>
<td>6.8 (5.1)</td>
<td>7.25 (7.1)</td>
</tr>
<tr>
<td>left 4</td>
<td>6.5 (4.6)</td>
<td>8.1 (6.8)</td>
</tr>
<tr>
<td>right 4</td>
<td>6.5 (4.7)</td>
<td>8.1 (7.0)</td>
</tr>
<tr>
<td>&quot; 5</td>
<td>7.1 (5.25)</td>
<td>8.4 (7.2)</td>
</tr>
<tr>
<td>&quot; 5</td>
<td>6.8 (5.1)</td>
<td>8.3 (7.25)</td>
</tr>
<tr>
<td>left 5</td>
<td>8.0 (5.9)</td>
<td>8.4 (7.2)</td>
</tr>
<tr>
<td>&quot; 6</td>
<td>11.3 (9.5)</td>
<td>11.6 (9.1)</td>
</tr>
<tr>
<td>&quot; 7</td>
<td>11.8 (10.25)</td>
<td>10.9 (8.1)</td>
</tr>
<tr>
<td>right 7</td>
<td>10.5 (8.9)</td>
<td>9.95 (7.8)</td>
</tr>
<tr>
<td>&quot; 8</td>
<td>9.4 (7.4)</td>
<td>9.4 (7.8)</td>
</tr>
</tbody>
</table>

### Deciduous max.

<table>
<thead>
<tr>
<th></th>
<th>Mesiodistal (CEJ)</th>
<th>Buccolingual (CEJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>right B</td>
<td>5.7 (4.2)</td>
<td>5.3 (4.7)</td>
</tr>
<tr>
<td>left D</td>
<td>6.8 (-)</td>
<td>9.35 (-)</td>
</tr>
</tbody>
</table>

### Pit B/Spit 2

The human bones from this zone that can be identified positively are an adult left intermediate cuneiform, a cervical vertebra (5 or 6), a thoracic vertebral body that appears adolescent or young adult, and a
tarsal proximal phalange from digits two or three. There are two teeth, a permanent maxillary left 5: MD 6.65 (4.9 CEJ), BL 9.3 (8.4 CEJ) and a deciduous maxillary right E: MD 8.9 (6.5 CEJ), BL 9.9 (8.75 CEJ).

**Pit B/Spit 3**

The only human material from this spit is an unerupted deciduous maxillary left E. Root development had just begun and is consistent with a personal age of 1-2 years. The dimensions are: MD 9.0 (6.9 CEJ), BL 10.4 (9.35 CEJ).

**Pit B/Spit 5**

In this spit were a small right scaphoid (maximum length 18.35), a left lunate, the distal end of a metatarsal and three permanent teeth. Their dimensions are:

<table>
<thead>
<tr>
<th>Tooth</th>
<th>Mesiodistal (CEJ)</th>
<th>Buccolingual (CEJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>right 2</td>
<td>6.95 (5.35)</td>
<td>6.6 (6.35)</td>
</tr>
<tr>
<td>&quot; 4</td>
<td>6.3 (4.6)</td>
<td>9.1 ( - )</td>
</tr>
<tr>
<td>&quot; 6</td>
<td>11.7 ( - )</td>
<td>12.35 ( - )</td>
</tr>
</tbody>
</table>

**Pit B/Spit 7**

A small group of eroded fragments of human bone indicates portion of the posterior half of a frontal bone and part of a right petrous bone.

**RUPO**

**Pit B - lowest level**

The skeletal material from this area appears, at least osteologically, to consist of the remains of a single individual. Except for the teeth, a vault section including parts of the frontal, occipital and the parietals, and portions of the mandible, preservation is very poor. There are numerous cranial and postcranial fragments but in most cases the external surfaces are powdery and lacking basic surface detail. Given the excavation problems at this site, the lack of
Plate 17.1  Rupo: Human cranium and mandible
\textit{in situ} (scale in cm)
laboratory or other conservation facilities in the field, and the
difficulties in transporting the materials from Papua-New Guinea to
Canberra it is surprising that what is present has survived for
assessment. Jim Rhoads is to be complimented in making the best of a
very difficult salvage problem.

There are 20 teeth preserved, all permanent and with complete
roots. Wear is most marked on the anterior teeth, which display
evidence of mild overbite and chipping of the maxillary lateral
incisor and canines. This chipping occurred some time before death as
the chipped edges are smooth and rounded. Despite the considerable
extent of dentine exposure there does not appear to be a case where
the pulp chamber or root canal is exposed, so that either this was
about to occur or more likely, wear was relatively slow and secondary
dentine deposition was effectively compensating for occlusal wear.
Wear of the maxillary and mandibular premolars was flat and more
advanced than on any molar. On several teeth, molars especially,
there is clear evidence of cervical pathology, almost certainly due to
caries. The dimensions of the teeth are as follows:

<table>
<thead>
<tr>
<th>Maxillary</th>
<th>Mesiodistal (CEJ)</th>
<th>Buccolinguale (CEJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>right 1</td>
<td>9.75 (8.0)</td>
<td>7.8 (7.05)</td>
</tr>
<tr>
<td>left 2</td>
<td>7.65 (6.1)</td>
<td>6.95 (6.3)</td>
</tr>
<tr>
<td>&quot; 3</td>
<td>8.0 (6.4)</td>
<td>8.6 (7.7)</td>
</tr>
<tr>
<td>right 3</td>
<td>8.3 (6.4)</td>
<td>8.35 (7.7)</td>
</tr>
<tr>
<td>&quot; 4</td>
<td>7.7 (5.3)</td>
<td>10.5 (9.9)</td>
</tr>
<tr>
<td>left 4</td>
<td>7.7 (5.25)</td>
<td>10.7 (9.7)</td>
</tr>
<tr>
<td>&quot; 5</td>
<td>8.1 (5.7)</td>
<td>10.5 (8.9)</td>
</tr>
<tr>
<td>right 5</td>
<td>7.9 (5.65)</td>
<td>10.35 (8.95)</td>
</tr>
<tr>
<td>left 6</td>
<td>10.9 (8.5)</td>
<td>12.2 (10.95)</td>
</tr>
<tr>
<td>&quot; 7</td>
<td>10.2 (7.7)</td>
<td>12.35 (10.4)</td>
</tr>
<tr>
<td>right 7</td>
<td>10.0 (7.6)</td>
<td>12.4 (10.65)</td>
</tr>
<tr>
<td>left 8</td>
<td>9.5 (7.7)</td>
<td>11.8 (10.3)</td>
</tr>
</tbody>
</table>
Given the conditions of the pieces, little can be said about the postcranial remains. Parts of both upper limbs and one lower are represented. The bones seem to have been lightly constructed and delicate but one could not hazard a guess as to sex.

What is left of the mandible consists of parts of both bodies, lacking the superior symphyseal region, plus a small fragment of the lower border of the symphyseal area. Unfortunately these three pieces cannot be linked. The lateral surfaces of the bodies, posterior to the mental foramina, are almost featureless and the similar lingual surfaces display very shallow submandibular and digastric fossae. The posterior edges of both mental foramina are present, aiding an accurate identification of the edentulous sockets on both sides. On the left side the socket for the second premolar is clear and deep. Behind it fragmentation and resorption suggests that the first molar had been lost premortem. The socket area of the second and third molars indicates massive bone loss, consistent with advanced apical abscess formation. It would be surprising if these last two molars were present at death. On the right side the story is similar and even more pronounced. Here there is evidence that the first molar was present but the area of the second and third molars suggests that both these teeth had been lost premortem and resorption was proceeding to obliterate the sockets. Given the teeth present one might reasonably question whether some or even all of them relate directly to the individual represented skeletally. Not enough is preserved to accurately test this, in terms of attempting to replace teeth in their presumptive sockets.
The reconstructed vault fragment indicates a relatively young adult. There is no evidence of suture closure, to judge from the entire sagittal suture, most of the right coronal and parts of both lambdoid sutures. The cranium was clearly dolicocephalic, with the most lateral point on the right parietal low down on the bone. Below this point the root of the mastoid indicates that the process was well developed. The external surface of the cranium, despite its present condition, was clearly smooth and gracile. There is the barest trace of a temporal line posteriorly on the right side and the occipital bone is rounded in all directions and lacking a well marked nuchal area. There is no evidence of lambdoid or other sutural bones. The only notable anatomical features is the presence of an oval parasagittal depression on the right side. It is clearly defined on the coronal suture anteriorly and must have encompassed a small part of the frontal bone. On the parietal bone it has a length of 55 mm and a maximum breadth of 25 mm. There is no sign of a similar feature on the left side.

With such limited cranial material it is difficult to comment on possible population relationships. However, there is nothing that would suggest Australian about the individual and its features, dentally and skeletally, would probably disappear in the Motupore population (also very fragmentary) presently under reconstruction and study. To suggest an affinity of, say, an Austronesian or non-Austronesian kind is not possible on this individual and such an assessment must await considerable new material, together with research in this direction on existing collections.

The final comment on this cranium concerns two artificial grooves cut into the external surface of the bones. The first of these is visible for about 30 mm on the anterior part of the right parietal bone. The groove begins 46 mm lateral to the sagittal suture and 20 mm posterior to the coronal. It passes down and forward, deepening as it goes, so that it would have reached the coronal suture close to prerion. For most of its course cancellous bone is exposed but there is no sign of pathology or bone remodelling. The second groove starts on the upper part of the occipital bone on the right side, just to the right of the midline and 33 mm posterior to lambda. It passes forward and laterally, crossing the right lambdoid suture 33 mm lateral to lambda and on to the right parietal bone for another 31 mm.
At this point another groove is visible and appears to be an effective continuation of the other occipito-parietal groove. The fact that the ends of the grooves are about 6-7 mm apart makes it clear that two grooving acts were involved but it is not clear whether the anterior groove was begun posteriorly or not, and its anterior end is lost at a gap in the right parietal. The second groove is preserved for 20 mm. Unlike the groove on the anterior part of the right parietal, neither of the second pair of grooves penetrates the outer tabular bone. The absence of pathology or redeposition of bone strongly suggests that these artificial external features were created postmortem.

**Pit C/Spit 1**

Part of the neural arch of a thoracic vertebra, a first coccygeal vertebra with long, thin cornua and transverse processes and a juvenile carpal middle phalange.

**Pit C/Spit 2**

There is extensive adult and juvenile material in this spit. The juvenile bones include eroded fragments of ribs, pelvis, thoracic and cervical neural arches and bodies, carpals, metacarpals and phalanges, plus several epiphyses from carpal bones and a humerus. There is no evidence of pathology on these bones.

The adult bones include broken pieces from the vertebral column, including the atlas, thoracic and lumbar bodies. There is mild development of arthritic lipping on the anterior margins of the thoracic and lumbar bodies. A few rib fragments are present and the tip of a mandibular left coronoid process. There are numerous hand bones, mostly complete. They include a left and right hamate (the left bone is larger than the right), four metacarpals (right 1 and 4, left 3 and 4), four proximal and five middle phalanges. Feet are represented by a left metatarsal 3, a right cuboid, left and right cuneiform, a left intermediate cuneiform, a left proximal phalange from either digits 2 or 3 and a left distal first digit phalange. No pathology is evident on any of these bones or fragments.
The following isolated teeth are also present:

<table>
<thead>
<tr>
<th>Permanenr teeth</th>
<th>Mesiodistal (CEJ)</th>
<th>Bussolingual (CEJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Maxillary</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>right 1</td>
<td>9.25 (6.4)</td>
<td>7.9 (6.5)</td>
</tr>
<tr>
<td>&quot; 2</td>
<td>6.7 (3.7)</td>
<td>6.5 (6.2)</td>
</tr>
<tr>
<td>&quot; 2</td>
<td>7.0 (5.2)</td>
<td>6.6 (5.95)</td>
</tr>
<tr>
<td>&quot; 2</td>
<td>7.2 (5.0)</td>
<td>8.05 (7.7)</td>
</tr>
<tr>
<td>&quot; 4</td>
<td>7.8 (5.0)</td>
<td>5.6 (4.1)</td>
</tr>
<tr>
<td>left 5</td>
<td>7.8 (5.0)</td>
<td>5.5 (4.6)</td>
</tr>
<tr>
<td>right 5</td>
<td>7.35 (4.65)</td>
<td>5.1 (4.8)</td>
</tr>
<tr>
<td>&quot; 6</td>
<td>11.5 (8.35)</td>
<td>12.9 (11.7)</td>
</tr>
<tr>
<td>left 7</td>
<td>9.9 (7.8)</td>
<td>11.9 (10.4)</td>
</tr>
<tr>
<td>&quot; 8</td>
<td>7.8 (6.1)</td>
<td>10.0 (9.4)</td>
</tr>
<tr>
<td><strong>Mandibular</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>left 2</td>
<td>5.0 (4.7)</td>
<td>5.5 (5.4)</td>
</tr>
<tr>
<td>right 2</td>
<td>5.95 (4.8)</td>
<td>6.2 (6.1)</td>
</tr>
<tr>
<td>left 2</td>
<td>6.2 (4.0)</td>
<td>6.0 (5.8)</td>
</tr>
<tr>
<td>right 2</td>
<td>6.2 (4.3)</td>
<td>6.4 (5.9)</td>
</tr>
<tr>
<td>&quot; 2</td>
<td>5.4 (3.65)</td>
<td>5.7 (5.55)</td>
</tr>
<tr>
<td>left 4</td>
<td>6.8 (5.2)</td>
<td>7.8 (7.0)</td>
</tr>
<tr>
<td>right 4</td>
<td>7.55 (5.55)</td>
<td>8.4 (7.4)</td>
</tr>
<tr>
<td>left 5</td>
<td>8.1 (5.2)</td>
<td>7.9 (7.0)</td>
</tr>
<tr>
<td>right 5</td>
<td>7.9 (5.3)</td>
<td>7.85 (7.5)</td>
</tr>
<tr>
<td>&quot; 5</td>
<td>7.9 (5.3)</td>
<td>7.9 (6.95)</td>
</tr>
<tr>
<td>&quot; 5</td>
<td>7.8 (5.25)</td>
<td>8.1 (7.6)</td>
</tr>
<tr>
<td>&quot; 5</td>
<td>8.15 (5.7)</td>
<td>9.7 (8.5)</td>
</tr>
<tr>
<td>left 6</td>
<td>12.15 (8.45)</td>
<td>11.05 (8.7)</td>
</tr>
<tr>
<td><strong>Deciduous</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>maxillary</td>
<td></td>
<td></td>
</tr>
<tr>
<td>left B</td>
<td>4.75 (3.5)</td>
<td>4.6 (4.4)</td>
</tr>
<tr>
<td>left C</td>
<td>6.8 (4.6)</td>
<td>6.5 (5.5)</td>
</tr>
<tr>
<td>mandibular</td>
<td></td>
<td></td>
</tr>
<tr>
<td>right C</td>
<td>6.0 (5.0)</td>
<td>6.0 (5.4)</td>
</tr>
<tr>
<td>left C</td>
<td>6.0 (5.2)</td>
<td>5.6 (5.35)</td>
</tr>
<tr>
<td>&quot; A</td>
<td>4.2 (3.7)</td>
<td>3.7 (3.2)</td>
</tr>
<tr>
<td>right A</td>
<td>4.3 (3.2)</td>
<td>3.8 (3.4)</td>
</tr>
<tr>
<td>&quot; D</td>
<td>7.7 (6.6)</td>
<td>7.9 (6.85)</td>
</tr>
</tbody>
</table>
**Pit C/Spit 3**

Bones in this spit consist of a lumbar and two fragmentary thoracic vertebrae, a left ulna lacking both ends, a right navicular and a right middle cuneiform. There are 10 isolated permanent teeth. Their dimensions are given below (those marked with an asterisk have incomplete roots).

<table>
<thead>
<tr>
<th></th>
<th>Mesiodistal (CEJ)</th>
<th>Buccolinguial (CEJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Maxillary</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>left 2</td>
<td>8.25 (6.0)</td>
<td>7.2 (7.1)</td>
</tr>
<tr>
<td>&quot; 3</td>
<td>8.6 (5.6)</td>
<td>8.4 (8.1)</td>
</tr>
<tr>
<td>&quot; 4</td>
<td>7.5 (5.2)</td>
<td>10.0 (9.5)</td>
</tr>
<tr>
<td>right 5*</td>
<td>7.0 (5.5)</td>
<td>10.9 (10.0)</td>
</tr>
<tr>
<td><strong>Mandibular</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>right 2</td>
<td>6.6 (4.8)</td>
<td>6.3 (6.2)</td>
</tr>
<tr>
<td>left 3</td>
<td>7.6 (5.7)</td>
<td>8.3 (8.1)</td>
</tr>
<tr>
<td>&quot; 3</td>
<td>8.0 (6.0)</td>
<td>7.8 (7.7)</td>
</tr>
<tr>
<td>&quot; 5*</td>
<td>8.2 (5.7)</td>
<td>9.6 (8.3)</td>
</tr>
<tr>
<td>right 5*</td>
<td>8.4 (5.6)</td>
<td>9.7 (8.4)</td>
</tr>
<tr>
<td>left 6*</td>
<td>13.4 (10.8)</td>
<td>12.0 (9.7)</td>
</tr>
</tbody>
</table>

**Pit C/Spit 4**

Material from this spit consists of a right first metatarsal and 8 isolated teeth. Two teeth are incomplete.

<table>
<thead>
<tr>
<th></th>
<th>Mesiodistal (CEJ)</th>
<th>Buccolinguial (CEJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Maxillary</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>left 1</td>
<td>10.6 (8.3)</td>
<td>8.0 (7.1)</td>
</tr>
<tr>
<td>&quot; 1</td>
<td>9.6 (6.7)</td>
<td>7.8 (7.0)</td>
</tr>
<tr>
<td>right 2</td>
<td>8.2 (6.1)</td>
<td>7.5 (7.0)</td>
</tr>
<tr>
<td>&quot; 7</td>
<td>10.3 (7.6)</td>
<td>7.65 (5.9)</td>
</tr>
<tr>
<td>&quot; 8</td>
<td>8.4 (6.1)</td>
<td>10.8 (9.7)</td>
</tr>
<tr>
<td>&quot; D</td>
<td>6.9 (5.2)</td>
<td>9.15 (8.5)</td>
</tr>
<tr>
<td><strong>Mandibular</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>left 1</td>
<td>5.4 (3.9)</td>
<td>-</td>
</tr>
<tr>
<td>right 3</td>
<td>7.3 (5.6)</td>
<td>7.75 (7.45)</td>
</tr>
</tbody>
</table>
Pit C/Spit 9

A collection of bone fragments from this level includes at least two pieces that are human. One is a transverse process from a thoracic vertebra and the other a 2 cm long portion of the midshaft of an ulna. It is likely that other fragments are also human, based on surface texture, cortical thickness and size parameters. However, the fragments are too small and eroded for precise identification.

Test Pit 3/Pit 1

There are adult and subadult cranial and postcranial bones, plus isolated teeth, in this spit. The teeth and their dimensions are as follows:

<table>
<thead>
<tr>
<th></th>
<th>Mesiodistal (CEJ)</th>
<th>Buccolingual (CEJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maxillary</td>
<td></td>
<td></td>
</tr>
<tr>
<td>right 2</td>
<td>6.8 (5.0)</td>
<td>6.8 (6.5)</td>
</tr>
<tr>
<td>&quot; 4</td>
<td>7.9 (5.2)</td>
<td>10.5 (9.2)</td>
</tr>
<tr>
<td>left 8</td>
<td>8.75 (6.4)</td>
<td>11.5 (10.5)</td>
</tr>
<tr>
<td>&quot; 6</td>
<td>unerupted</td>
<td>unerupted</td>
</tr>
<tr>
<td>left B</td>
<td>5.5 (3.65)</td>
<td>5.1 (4.5)</td>
</tr>
<tr>
<td>Mandibular</td>
<td></td>
<td></td>
</tr>
<tr>
<td>left 2</td>
<td>6.1 (4.3)</td>
<td>6.6 (6.1)</td>
</tr>
<tr>
<td>&quot; 2</td>
<td>6.5 (5.0)</td>
<td>6.3 (6.2)</td>
</tr>
<tr>
<td>&quot; 1</td>
<td>5.3 (4.1)</td>
<td>6.4 (6.3)</td>
</tr>
<tr>
<td>&quot; 6</td>
<td>unerupted</td>
<td>unerupted</td>
</tr>
</tbody>
</table>

The subadult bones consist of numerous eroded fragments. Ribs, vertebral bodies and neural arches, and small cranial vault pieces are present.

The adult bones are all postcranial. Several eroded rib, vertebral and ulna portions are present, plus the following bones: from the hands the left and right hamates, left lunate, right second and fourth metacarpals, right middle third phalange; from the feet a right lateral cuneiform plus six proximal phalanges from digits 2-5.
Test Pit 3/Spit 2

A fragment of an infant ulna.

Test Pit 3/Spit 3

A permanent maxillary left lateral incisor tooth. Its dimensions are: MD 6.95 (5.1 CEJ), BL 6.6 (6.4 CEJ).