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Liang Nabulei Lisa: A Late Pleistocene and Holocene Sequence from the Aru Islands

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Introduction

The excavation at Liang Nabulei Lisa began on 24 November 1997, approximately one year after the Liang Lemdubu excavation was carried out (see Chapter 4, this volume). The site was selected for excavation as it was located close to a stream-fed *sungai*, had abundant cultural material on the surface and appeared to have some depth of deposit. The Lemdubu excavation had recovered a Pleistocene sequence dating from ca. 27,000 years ago through to the historic period, but the early to mid-Holocene were not represented. It was hoped that Nabulei Lisa would complement the Lemdubu sequence by providing a full Holocene sequence.

Liang Nabulei Lisa is only about 50m inland from the landward end of the southern arm of Sungai Dosi, a tributary of the western end of Sungai Manumbai (Fig. 7.1). It lies near the crest of a low but steep limestone ridge on the eastern side of the tidal *sungai*, and at about 30m altitude. The *sungai* is fringed by mangroves and *Barringtonia* on muds, while the rocky slopes around the cave support a low and not very dense forest in which figs, *Eugenia*, *Litsea* legumes, and *Fagraea* are common, with many palms and large climbers evident. A more varied rainforest occupies the lower areas between ridges although this has been disturbed by cutting and shifting cultivation. Like Lemdubu, Nabulei Lisa is a tunnel cave left stranded near the crest of a ridge, with a collapsed section on the ridge that results in it having two entrances: one northwest and one southeast facing (Figs 7.2–7.4). The cave is capacious and very dry but only a restricted area close to the northwest facing entrance would be useful for habitation. The southeast entrance rises quite steeply to a height of about eight metres above the cave floor, is extremely rocky, and is partially blocked by large boulders of roof-fall and flowstone/stalagmite formations. Extensive stalactite and stalagmite formations occur in the central and southern areas of the cave (Figs 7.2–7.4). A 3–5m wide potential living floor of soft cave earth, interrupted by scattered stalagmite bases, extends along the northeastern wall for about 18m (Fig. 7.2). This surface has dense patches of marine shell scattered about.

Excavation and Stratigraphy

A 1m² excavation, Test Pit A, was positioned at the north entrance of the cave approximately two metres inside the dripline (Figs 7.2, 7.5–7.7). The cave walls in this area were stained black from smoke indicating that repeated fires had been lit, and loose ashy sediment containing shell was exposed on the surface.

Cultural material is abundant along the east wall of the shelter (Fig. 7.2). It is possible that it banked up in this area as a result of people deliberately moving sharp shells and bones away from the more centrally positioned domestic living space.

Excavation was undertaken in approximate two centimetres spits or excavation units, although in reality spit depths varied between 1.5 and four centimetres. Excavation followed visible changes in the stratigraphy where such were evident. Spit depths for the southeast corner of Test Pit A are shown in the section diagram (Fig. 7.8), and all other depth readings are given in Appendix 7.1. Each spit was levelled in using a dumpy and staff. Depth levels were recorded for the corners and a central point in the excavation square. Each bucket removed from an excavation unit was weighed and the weight recorded separately. Rocks discarded were recorded and their volumes estimated. All excavated material was wet sieved at the cave to remove larger fragments of limestone/flowstone and was then re-bagged for further sorting. A <2mm mesh was used for wet sieving, ensuring excellent recovery of small bones, lithics, and macrofloral material. Final sorting was not carried out in the field as even after wet sieving the shell in the upper spits was comminuted and friable. Final sorting was undertaken in Dobo where all material was washed until clean in freshwater, dried and sorted.

Little visible change in the sediment with depth was apparent. Four layers have been distinguished on the basis of slight changes in the colour of the sediments. In some cases these coincide with changes in the distribution and/or abundance of cultural material. The layers are shown on the section in Figure 7.8.

Layer 1 consists of the thin surface topsoil and is equivalent to Spit 1. It was composed of a very fine silt with a minor component of sand (10YR 5/2). In places the top sediments were mottled with pockets of loose ash.

Layer 2 is an ash-rich layer comprising Spits 2–4 (10YR 6/1–5/1) (Fig. 7.8). Aside from the ash lenses there was little to distinguish this layer from Layer 1 above or 3 below. Little bone was recorded in these spits and most shell was extremely burnt and friable and fell apart when trowelled. Much of the bone from this layer was burnt.

Layer 3 (10YR 5/2–4/2 Greyish Brown to Dark Greyish Brown) occurs immediately below the ash layer and includes Spits 5–22. The sediment appears to be texturally similar to the topsoil but with significantly less ash. Bone and shell in this layer are well preserved.



Figure 7.5 Liang Nabulei Lisa: view of Test Pit A, facing northern wall, showing east section

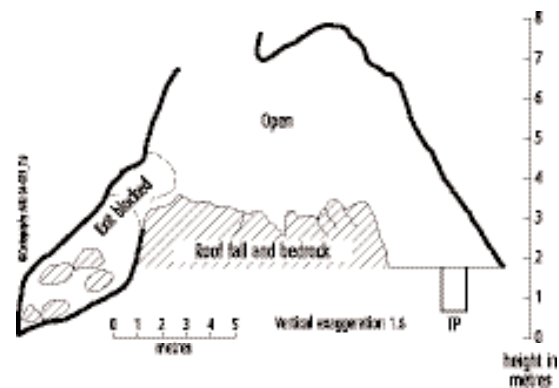


Figure 7.6 Liang Nabulei Lisa: section A-B across northwest entrance of cave through Test Pit A



south



west



north

Figure 7.7 Liang Nabulei Lisa: south, west, and north sections of the excavation

reaches of the cave. Although the surface is about two metres lower than the entrance, the depth of deposit, 135cm, is similar. The upper 40cm consisted of grey-orange silts with occasional pieces of shell but no charcoal. Below this is 57cm of brown cave earth above 25cm of pale grey calcareous silt from which a single *Anadara* shell was recovered. The basal 13cm of brown mottled silt had rotted rock fragments and sat on limestone rubble, probably roof-fall. The probe contains no evidence of direct occupation, and the shells detected were probably discards from the living area at the front of the cave. This indicates that the area of dense occupation deposit is much smaller than the liveable area of the cave.

Layer 4 begins at Spit 23 and continues to the base of the excavation. The sediment in Layer 4 is a richer Dark Greyish Brown (10YR 4/2), and roots and small rocks become more prevalent (Fig. 7.8). There is no obvious change in sediment texture although the sediment was much moister at this depth. Layer 4 coincides with a change in cultural material and this may account for the difference in sediment colour. Shell decreases from over 500g in Spit 20 to less than 20g in Spit 23. Approximately coinciding with the decrease in shell is a massive increase in the quantity of bone recovered.

The excavation was discontinued at a maximum depth of 1.25m (Fig. 7.8). This depth was reached only in the central part of the south face of the pit. Bone was still present but the excavation area was reduced to a crack between rocks and further removals were not possible without enlarging the excavation. Spit 43 was the final spit excavated and both Spit 42 and 43 were very small removals from the restricted area in this part of the square (see Fig. 7.8). Depths of all spits and volumes of removals are provided in Appendix 7.1. The rock underlying the deposit and which forms a floor over most of the square was exposed on the cave surface for some time prior to deposition of sediment, as it has the distinctive pitting which results from water dripping from the roof. Whether it comprised the cave floor or part of a large boulder could not be determined.

Coinciding with the excavation of Test Pit A, an auger probe was carried out at the deepest point in the internal chamber of the cave about 15m in from the excavation (Fig. 7.2). This was done to test the depth of deposit in this area and whether there was any difference in the type or quantity of cultural material in the deeper

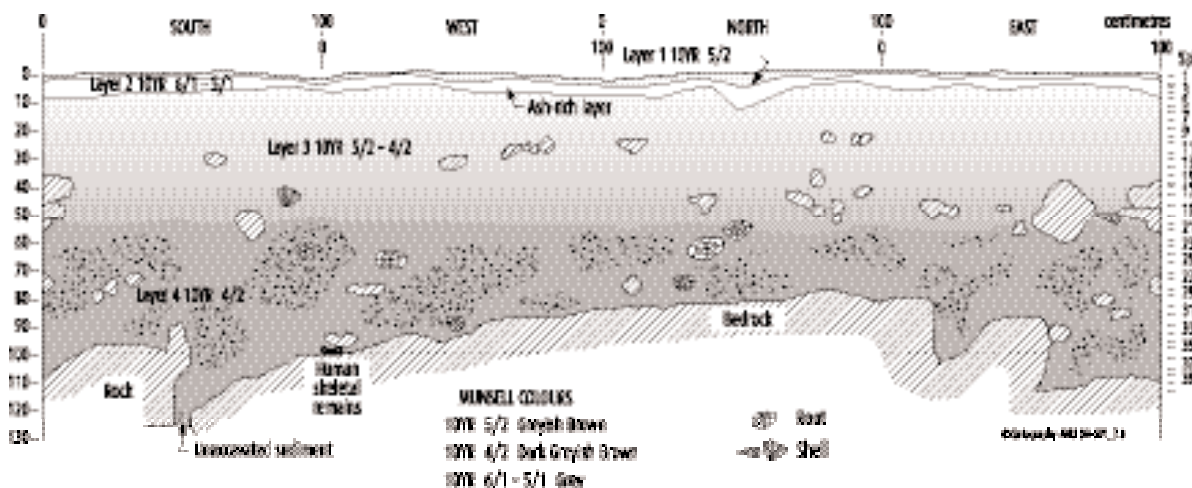


Figure 7.8 Liang Nabulei Lisa: Test Pit A sections with spit depths shown for southeast corner

Dating the Liang Nabulei Lisa Sequence

As at Lemdubu, charcoal was only preserved in the upper part of the deposit (Table 7.1 and 7.2). A variety of materials and experimental techniques have been used to date the Nabulei Lisa sequence.

Sufficient charcoal was available in the upper 10 spits to obtain conventional radiocarbon dates on this material. The charcoal sample from Spit 3 (ANU-10918) was assayed as modern. Spit 5 returned a date of 780±150 BP (ANU-10921), Spit 8 of 260±190 BP (ANU-10920) and Spit 10 of modern (ANU-10919). The dates from Spits 5, 8 and 10 are inverted and possibly indicate some

Table 7.1 Liang Nabulei Lisa: radiocarbon dates.

LAB. CODE	SPIT	DEPTH (CM)	SAMPLE TYPE	δ13C	CONVENTIONAL AGE (YEARS BP, ± 1σ)	CALIBRATED AGE (cal years BP) ¹
ANU-10918	3	10.0	Charcoal	-28.2	Modern	Modern
ANU-10921	5	13.0	Charcoal	-27.3	780±150	512-1045
ANU-10920	8	19.0	Charcoal	-30.1	260±190	0-548
ANU-10919	10	27.5	Charcoal	-28.2	Modern	Modern
OZF249	11	30.5	<i>Casuarium</i> eggshell	-13.6	2530±60	2362-2751
ANU-10906	12	33.0	<i>Terebralia</i> sp.	-5.2	5900±60	6192-6429
ANU-10905	23	61.0	<i>Terebralia</i> sp.	-5.0	6970±160	7167-7754
OZF250	25	68.5	<i>Casuarium</i> eggshell	-16.1	9310±80	10,243-10,689
OZF030	26	71.0	<i>Celtis</i> sp. seed	-25.4	8420±50	9431-9550
OZD696	26	71.0	<i>Celtis</i> sp. seed	-20.4	9320±60	10,279-10,688
AA-32849	26	71.0	<i>Casuarium</i> eggshell	-16.0	10,460±75	11,960-12,833
ANU-10907	26	71.0	<i>Nerita</i> shell	na	4410±60	4411-4773
OZD697	28	76.0	<i>Celtis</i> sp. seed	-18.1	9630±60	10,746-11,172
OZD698	28	76.0	<i>Hyridella misoolensis</i> shell	-10.0	9750±60	10,793-11,255
OZD699	31	84.0	<i>Hyridella misoolensis</i> shell	-26.9	9870±70	11,164-11,553
OZD700	31	84.0	<i>Celtis</i> sp. seed	-27.0	9450±60	10,503-11,068
OZF848	32	86.0	<i>Casuarium</i> eggshell	-15.9	10,340±60	11,767-12,782
OZF518	34	93.0	<i>Casuarium</i> eggshell	-13.6	13,130±80	14,817-16,292
OZD702	36	99.0	<i>Celtis</i> sp. seed	-15.6	9850±60	11,162-11,548
OZF362	41	115.0	<i>Celtis</i> sp. seed	-14.9	7140±50	7839-8107

¹Calibrated ages at maximum - minimum intercepts ± 2σ range, na = not available.

Table 7.2 Liang Nabulei Lisa: weights (g) of cultural material from all spits

CONV. AGE BP	SPLIT	STONE ARTEFACTS	POTTERY	BONE	CHARCOAL	CELTIS SEEDS	CASSOWARY EGGSHELL	MARINE/ ESTUARINE SHELL	TOTAL WT. (KG) SEDIMENT
	1		10.1	26.5	29.0			130.7	24.5
	2		23.3	0.0	1.4			475.6	26.6
Modern	3		16.9	4.2	2.6			693.7	31.3
	4		12.2	28.9				718.3	29.2
	5		17.0	55.9	1.9			1129.4	33.0
	6		9.0	13.8				1160.3	34.3
	7	8.0	12.2	14.4				528.5	29.1
	8	17.4	14.9	25.7	0.7			773.3	30.7
	9	3.3		17.7			1.0	633.8	31.7
Modern	10	29.3		21.9	0.6			938.1	31.8
2530±60	11			23.4			1.5	906.7	34.5
5900±60	12	8.8		19.5			1.9	874.8	25.2
	13			14.2				629.4	28.3
	14	2.5		25.1			1.0	556.6	27.0
	15			23.0				735.9	33.0
	16	2.3		33.1				741.0	30.9
	17			15.5				312.0	33.4
	18			43.5				685.1	27.4
	19			45.3			1.4	646.9	35.6
	20			42.7				519.8	44.9
	21	2.8		37.7		3.5	0.8	90.4	33.9
	22	22.1		35.6		10.7		60.1	37.8
6970±160	23	15.2		63.1				17.4	34.2
	24	5.2		55.6				19.5	34.8
9310±80	25	9.2		77.9			0.4	26.7	36.8
9320±60	26	1.2		68.8		7.7	0.8	39.8	37.1
	27			54.9			0.9	19.6	31.0
9750±60	28	0.1		140.3		5.0	1.2	14.3	33.5
	29	1.1		93.3		3.2	0.5	17.5	33.3
	30	4.9		153.1		7.4		6.4	52.4
9870±70	31	7.8		157.5		1.2		1.4	36.4
10,340±60	32	33.8		170.0			0.4	3.4	35.2
	33	3.0		211.4				-	19.0
13,130±80	34	12.7		254.3			0.4	0.5	18.5
	35	3.5		265.4				0.4	18.5
	36			188.2		0.1			12.5
	37	0.3		180.3					13.5
	38	0.8		250.4					10.9
	39			128.6					4.6
	40			138.8					4.6
	41			93.1					3.5
	42			74.4					3.4
	43			9.0					3.5

degree of disturbance within the upper 25cm of loose ashy deposit. However, for reasons outlined below disturbance is generally thought to be minimal and localized.

Spit 11 was dated on *Casuarium* eggshell to 2530±60 BP (OZF249) and immediately below this a mangrove gastropod *Terebralia* sp. returned an age of 5900±60 BP (ANU-10906). Details about the use of *Casuarium* eggshell as a dating material are provided in Chapter 13. The result on a *Terebralia* sp. from Spit 23 was 6970±160 BP (ANU-10905), suggesting that the deposit between Spits 23 and 12 accumulated rather rapidly.

Four dates were obtained for Spit 26. The original date on *Nerita* sp. shell returned an age of 4410±60 (ANU-10907). This date was obviously at odds with the dates returned from samples in Spits 11 (OZF249), 12 (ANU-10906), 23 (ANU-10905), and 25 (OZF250) which were significantly older. A *Celtis philippinensis* seed (OZF030) from the same spit was submitted to the ANSTO laboratory. Unfortunately, this sample was given the wrong pretreatment. *Celtis* is predominantly composed of primary aragonite. The sample OZF030 was treated to remove the inorganic component so was effectively destroyed. A small organic fraction remained and this was dated and returned an age of 8420±50 BP. This explains why the $\delta^{13}\text{C}$ values for this sample are close to -25 permil rather than the usual -14 permil for the inorganic component. Another *Celtis* sample was processed by ANSTO to replace OZF030. This sample (OZD696) was assayed at 9320±60 BP, which is statistically the same date as the *Casuarium* eggshell sample in Spit 25 (OZF250, 9310±80 BP).

A *Casuarium* eggshell fragment was then dated from Spit 26 (AA-32849). This sample returned a slightly older date of 10,460±75. Two samples were dated from Spit 28 — one freshwater bivalve *Hyridella misoolensis* (OZD698) and a *Celtis* seed (OZD697) — returning ages of 9750±60 and 9630±60 BP respectively. Spit 31 was also dated using a *Hyridella* valve (OZD699) and a *Celtis* seed (OZD700) for comparison, and again the results are in good agreement (9870±70 BP and 9450±60 BP respectively). *Hyridella* is a freshwater mussel and potentially subject to contamination from 'old carbon', however, the dates on these samples are in correct stratigraphic order and in accord with the other dated sample materials from the same and adjacent spits. Although the two valves from Spits 28 and 31 produced a statistically overlapping date, there is no chance that they were derived from the same individual as both were left valves. The major difference in the $\delta^{13}\text{C}$ values for the *Hyridella* valves has not been explained by the laboratory.

With the exception of the *Nerita* shell sample (ANU-10907) and the *Celtis* seed (OZF030) that is dated on the organic component, the dates give some confidence that Spits 25–31 were deposited between 10,200 and 12,000 cal BP.

The age estimates on the *Casuarium* eggshells from Spits 32 (10,340±60 BP, OZF848) and 34 (13,130±80, OZF518) indicate these spits were deposited in the terminal Pleistocene. These results are obviously at odds with the much younger results on the *Celtis* seed samples from Spit 36 (OZD702) of 9850±60 BP, or Spit 41 (OZF362) of 7150±50 BP.

Research by Wang et al. (1997:339) suggests that *Celtis* derive atmospheric CO_2 during a single growing season and provided that no diagenesis occurs subsequently, they should make a highly reliable dating material. The results of Wang et al.'s study indicate that diagenesis can be easily detected by XRD analysis. Unfortunately, the Aru *Celtis* seeds were not subjected to XRD analysis prior to dating. Although the small literature on *Celtis* as a dating material suggests that individual samples from selected environments when tested showed no evidence of diagenesis, recent XRD analyses on the species *Celtis philippinensis* from archaeological contexts in the Kimberley region of northern Australia, have demonstrated significant replacement of aragonite with carbonate. For this reason, and for others to do with changes in the faunal composition in the lower part of the sequence (discussed in detail below), the Pleistocene dates below Spit 32 are thought to better estimate the true age of the deposit than the early Holocene ages obtained on the *Celtis* seeds.

In summary, the lower part of Layer 4, from Spits 41–32 is thought to have accumulated in the terminal Pleistocene between 16,200 and 12,000 cal BP. Spits 31–25 built up fairly rapidly

between 12,000 and 10,200 cal BP. The dates would suggest slow deposition or at least minimal accumulation of deposit between Spits 25 and 23, followed again by rapid deposition of sediment and shell in Spits 23–12, probably following the establishment of estuarine conditions between 7700 and 6100 cal BP. There is scant evidence for use of this area of the Nabulei Lisa cave from 6000 cal BP until approximately a thousand years before present, bracketed by the dates between Spits 10 and 3.

The Liang Nabulei Lisa Cultural Sequence

During excavation and on-site sorting it was obvious that the material in the upper four spits was heavily burnt. Marine/estuarine shellfish was concentrated between Spit 20 to the surface. Vertebrate faunal material was present in all levels but was much less abundant than at Lemdubu, especially in the upper part of the sequence. Introduced species such as deer, pig and dog were found only in the upper spits. The vertebrate fauna in Nabulei Lisa show changes in species composition through time that document environmental changes in the vicinity of the site. Stone artefacts occurred below Spit 6 but were fewer in number and even less diverse than at Lemdubu. Pottery was found on the surface and down to Spit 8. Only the surface pottery was painted but this may be due to poor preservation of paints in buried contexts. Aside from the robust seeds of *Celtis philippinensis*, no plant material was preserved, so we have no indication of the nature of plant foods or their contribution to the diet of the Nabulei Lisa occupants. Fragments of human skeletal material representing at least three individuals were found in Layer 4 (Spits 23 to 41) and are discussed in detail in the following chapter.

Weights per spit for each class of cultural materials are presented in Table 7.2. As there was significant variation in the quantity of sediment removed in different spits (e.g. lower excavated spits were very small removals between rocks), the weights of cultural materials have been adjusted to compensate for differences in the amount of sediment removed in Table 7.3.

Organic Remains

Marine/estuarine and freshwater molluscs

All shellfish identifications were carried out at Puslit Arkenas in Jakarta and only weight of shellfish by species was obtained. Examples of different shell types were returned to Australia and identifications were made using the ANH comparative collection; these specimens were then returned to Jakarta. Species represented include the gastropods *Terebralia palustris* and unidentified members of the family Neritidae, and the bivalves *Geloina coaxans* and *Anadara* sp. (see Table 7.4). A few individuals of freshwater species such as the mussel *Hyridella misoolensis* were recovered in Spits 28 and 31. With the exception of the freshwater species all shellfish in the deposit at Nabulei Lisa could probably be obtained from the *sungai* adjacent to the site today. Live specimens of *Geloina coaxans* and *Terebralia palustris* were collected from the *sungai* to the east of the site at the time of the excavation.

Marine/estuarine molluscs occur down to Spit 31, but less than two grams are found below Spit 29. These taxa are most abundant between Spit 20 and the surface. Beneath Spit 20 they decrease dramatically, from 500g in Spit 20 to less than 100g of total shell in Spit 21 (Table 7.4, Fig. 7.9a). This decrease in quantity of shell with depth is unlikely to be due to preservation. The date of 7,060±140 BP was obtained from Spit 23 on a *Terebralia palustris* shell. If a marine reservoir correction of 450 years is applied, it suggests a date for Spit 23 of ca. 6600 BP. This would suggest that the change from freshwater to estuarine/tidal conditions occurred around Spit 20/21 (Fig.

Table 7.3 Liang Nabulei Lisa: distribution and weights (g) of cultural material through the sequence, adjusted for differences in the weight (kg) of sediment per spit

CONV. AGE BP	SPIT	STONE ARTEFACTS	POTTERY	BONE	CHARCOAL	CELTIS SEEDS	CASSOWARY EGGSHELL	MARINE/ ESTUARINE SHELL	TOTAL WT. OF EXCAVATED DEPOSIT
	1		56.6	21.6	62.1			279.5	24.5
	2		0.0	45.9	2.7			936.9	26.6
Modern	3		7.1	28.4	4.4			1161.3	31.3
	4		51.8	21.9				1289.0	29.2
	5		88.8	27.1	3.1			1793.4	33.0
	6		21.0	13.8				1772.7	34.3
	7	14.4	25.9	21.9				951.7	29.1
	8	29.7	4.4	25.5	1.2			1319.8	30.7
	9	5.5		29.2			1.7	1047.7	31.7
Modern	10	48.3		36.0	1.0			1545.8	31.8
2530±60	11			35.5			2.2	1377.1	34.5
5900±60	12	18.3		40.6			4.0	1819.0	25.2
	13			26.4				1165.4	28.3
	14	4.9		48.8			1.9	1080.3	27.0
	15			36.5				1168.5	33.0
	16	3.9		56.2				1256.6	30.9
	17			24.2				489.5	33.4
	18			83.2				1310.2	27.4
	19			66.7			2.1	952.2	35.6
	20			49.9				606.6	44.9
	21	4.3		58.2		5.3	1.2	139.7	33.9
	22	30.6		49.3			14.9	83.3	37.8
6970±160	23	23.3		96.7				26.7	34.2
	24	7.8		83.7				29.4	34.8
9310±80	25	13.1		110.9			0.6	38.0	36.8
9320±60	26	1.7		97.2		10.9	1.1	56.2	37.1
	27			92.7			1.5	33.1	31.0
9750±60	28	0.1		219.5		7.8	1.9	22.4	33.5
	29	1.7		146.7		5.0	0.8	27.5	33.3
	30	4.9		153.1		7.4		6.4	52.4
9870±70	31	11.2		226.8		1.7		2.0	36.4
10,340±60	32	50.3		253.1			0.6	5.1	35.2
	33	8.1		583.1					19.0
13,130±80	34	36.0		720.2			1.2	1.4	18.5
	35	9.9		751.8				1.1	18.5
	36			788.9		0.5			12.5
	37	1.2		699.8					13.5
	38	3.9		1203.6					10.9
	39			1464.6					4.6
	40			1580.2					4.6
	41			1393.4					3.5
	42			1146.2					3.4
	43			134.3					3.5

Table 7.4 Liang Nabulei Lisa: marine and estuarine shellfish weights by spit (g); 1.17g of *Hyridella misoolensis* (= 1 L valve from Spit 28) and 0.86g (= 1 L valve from Spit 31)

DATE	SPIT	ANADARA SP.	GEOLOINA COAXANS	TEREBRALIA PALUSTRIS	NERITA SP.	UNIDENTIFIED	TOTAL SHELL
	1	13.0	10.9	39.3	3.0	64.5	130.7
	2	26.5	51.1	261.9	13.2	122.9	475.6
Modern	3	37.0	181.1	319.2	15.7	140.7	693.7
	4	33.9	216.1	344.4	10.1	113.8	718.3
	5	49.8	603.8	420.7	33.4	21.7	1129.4
	6	49.4	571.2	492.8	31.6	15.3	1160.3
	7	19.6	153.9	197.7	14.9	142.4	528.5
	8	13.1	375.9	353.3	21.9	9.1	773.3
	9	3.3	169.9	321.7	34.4	104.5	633.8
Modern	10	3.6	178.9	383.4	67.2	305.0	938.1
2530±60	11		238.5	445.5	90.0	132.7	906.7
5900±60	12	10.0	182.0	559.0	85.5	38.3	874.8
	13	11.3	123.7	310.0	76.6	107.8	629.4
	14		72.7	314.6	73.1	96.2	556.6
	15	3.0	186.1	404.0	122.6	20.2	735.9
	16	1.4	150.9	427.9	126.1	34.7	741.0
	17		47.8	168.9	57.3	38.0	312.0
	18	14.0	104.6	429.8	97.3	39.4	685.1
	19		86.0	403.1	116.2	41.6	646.9
	20		121.0	283.4	93.6	21.8	519.8
	21		41.7	30.8	11.0	6.9	90.4
	22		28.3	16.5	10.9	4.4	60.1
6970±160	23		7.7	3.4	0.7	5.6	17.4
	24		9.1	5.4	3.3	1.7	19.5
9310±80	25		8.9	10.4	2.4	5.0	26.7
9320±60	26		16.0	18.4		5.4	39.8
	27		9.5	3.4	0.2	6.5	19.6
9750±60	28		8.1	1.0	0.6	4.6	14.3
	29		10.7	4.2		2.6	17.5
	30					6.4	6.4
9870±70	31		1.2				1.2
10,340±60	32					3.3	3.3
	33						
13,130±80	34					0.5	0.5
	35					0.4	0.4

7.9a). The gastropod *Terebralia palustris* dominates the shell assemblage between Spit 20 and the surface (Fig. 7.9b). *Terebralia* are mangrove-dwelling and their dominance between Spits 20 to 9 indicates that mangroves rapidly colonized the *sungai* once tidal conditions established, and then persisted throughout the Holocene. *Geloina coaxans* are filter-feeding bivalves found in sediments on the fringes of mangroves; this taxon is also abundant in the above upper part of the sequence. The small fragment of *Geloina* in Spit 31 may have been brought to the site from some distance away or may result from minor disturbance and vertical movement. The bivalve *Anadara* sp., whose habitat includes sand/mud flats, was recovered chiefly between Spit 8 and the surface (Table 7.4, Fig. 7.9b). This species may have colonized the *sungai* only after estuarine conditions stabilized and some infilling and siltation took place. The Neritidae occupy diverse habitats (including marine, brackish and freshwater); without species identifications, it is not possible to extract environmental information from their distribution. However, the fact that their distribution tracks that of *Terebralia* and *Geloina* so closely suggests that they are probably marine/estuarine species.

No marine/estuarine shellfish were positively identified below Spit 31, and the unidentified shell at this depth is probably from freshwater species. Two fragments of *Hyridella misoolensis* were identified in Spit 28 (1.17g) and three fragments in Spit 31 (0.86g); in each case the fragments were used to date these spits. *Hyridella misoolensis* is a bottom-dwelling, filter-feeding bivalve. It occurs in still or running water and can be found in seasonally still lakes or rivers with a firm silty bottom (Walker, nd).

A single individual *Terebra subulata* — a marine gastropod found on open sandy substrates — was recovered from Spit 28. It has a circular hole drilled opposite the opercular opening and is likely to be an ornamental addition to the assemblage rather than food refuse (Fig. 7.10). It is even possible that it is associated with the secondary burial of the child found between Spits 29 and 35 (see Chapter 8, this volume).

Vertebrate fauna

Nabulei Lisa produced much smaller quantities of faunal remains than Lemdubu and the vertebrate material is more heavily burned and fragmented. Despite these limitations, the assemblage has yielded a remarkably detailed picture of environmental changes in the vicinity of the site and some insights into the nature of human responses to these changes.

Analytical methods

A preliminary examination of the Nabulei Lisa fauna revealed that the samples from the lower levels are dominated by remains of macropodids (wallabies) and snakes, comparable in fact to the greater part of the Lemdubu sequence (O'Connor et al. 2002; and see Chapter 9, this volume). In contrast, the upper levels of Nabulei Lisa were found to contain a more diverse and balanced fauna as well as the remains of introduced animals (e.g. pig and deer), again paralleling a change observed in the uppermost levels of Lemdubu. In the light of these initial impressions, it was decided to focus on the distribution of the various species through the stratigraphic column, and on the quantification of changes in relative abundance among the major species. The critical requirements were therefore:

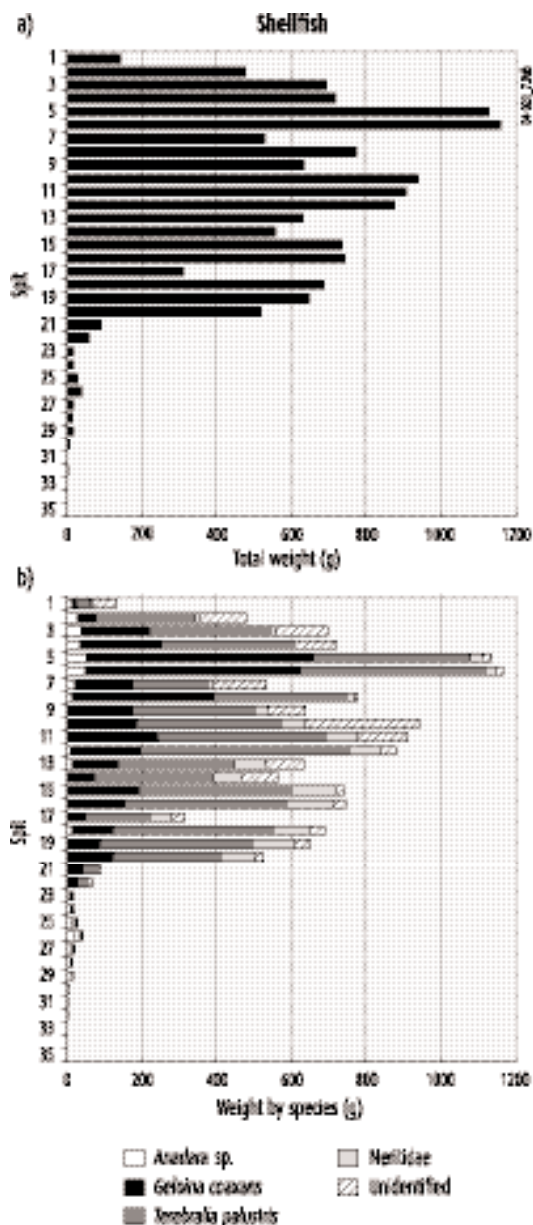


Figure 7.9 Liang Nabulei Lisa: a) total shellfish raw weights (g) b) raw weights of different species of marine/estuarine shellfish

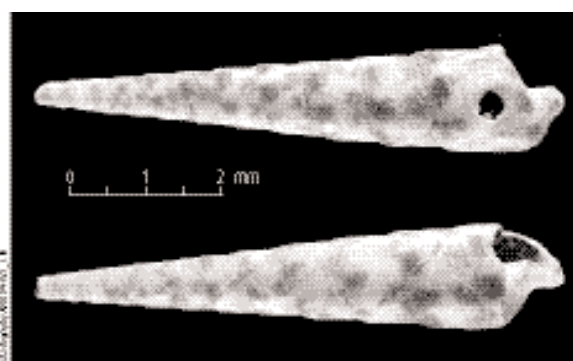


Figure 7.10 Liang Nabulei Lisa: shell of *Terebra subulata* with hole drilled opposite opercular opening, probably used for personal decoration

- 1) to determine the range of species present;
- 2) to establish the pattern of distribution of each species through the sequence; and
- 3) to estimate the relative abundance of the major species, both within each unit (interspecific) and through the sequence (intraspecific).

Prior to detailed analysis of the vertebrate fauna, all samples were washed in a fine-mesh sieve and air dried. Artefacts produced on bone as a raw material were separated from the remaining bone material at this stage; these are reported in Chapter 11.

An initial sort of each sample produced the following categories:

- reptile bone (lizards, snakes, turtles, crocodylians)
- bird bone
- fish bone
- cranial and all recognisable post-cranial remains of various mammalian families other than Macropodidae
- cranio-dental and pedal (foot) bones of macropodids
- avian eggshell
- crustacean exoskeleton
- 'unidentified' bone.

For most samples, the 'unidentified' category includes a large proportion of macropodid bone fragments representing all body parts other than cranio-dental and pedal remains, along with a small proportion of genuinely non-diagnostic bone fragments. The decision to not isolate all of the macropodid remains was based on time considerations, especially in regard to the parallel analysis of the much larger Lemdubu vertebrate faunal assemblage.

Remains of each major taxon were then examined in turn to identify the individual taxa. As a rule, mammalian remains were identified to generic or species level, while remains of other groups were identified to family or higher level and then assigned to a size category (e.g. small fish, large bird). For macropodids, species level identifications were made on cranial and dental remains, and from two of the most diagnostic foot bones, the calcaneum and astragalus. No special effort was made to identify the genera or species of reptile or bird remains, except where the conclusion was obvious (e.g. cassowary, crocodile). Lack of suitable reference material seriously hinders precise taxonomic allocation of the majority of Papuan birds and reptiles.

The 'unidentified' bone was further sorted into the following four burning categories, drawing on previous classifications by Ubelaker (1978), Shipman et al. (1984) and Pearce & Luff (1994):

- 1) Unburnt (bone is pale, yellow to light brown and porous);
- 2) Lightly burnt (bone is light brown to dark brown and more dense in texture; this is usually the result of cooking of the bone inside a fleshed carcass rather than direct contact with flames);
- 3) Burnt (bone is very dark brown or dark grey to black and very dense, usually resulting from direct contact with flame); and
- 4) Calcined (bone is grey to white, very dense and sometimes crazed or warped; all organic material has been lost, resulting in shrinkage and increased brittleness).

Each burning category was weighed separately.

For each identified taxon, the allocated bone fragments were first sorted according to the four burning categories. Each category was then counted (NISP) and weighed separately. This procedure allows us to calculate the total weight of each burning category for each spit (by summing identified taxa + unidentified). It also allows us to compare the intensity of burning of bone from each of the major taxa. For the various macropodid species, separate counts and weights were made on teeth or tooth-bearing elements, other cranial pieces, and calcanea and astragali. The remains of pythons

(Boidae) and other large reptiles were counted in two classes: vertebrae and cranial — the latter including tooth bearing elements. Raw bone weights and NISP data for all identified specimens is shown in Appendix 7.2.

Crustacean exoskeleton and avian eggshell were weighed as single samples without reference to burning condition.

Because the abundance of each of the major animal groups has been calculated in slightly different ways, it is not possible to directly equate the relative abundance of each taxon with any measure of economic importance. However, the fact that the same methods were applied consistently through the sequence (and also for the analysis of the Lemdubu fauna) means that proportional increases or decreases in any particular taxon can be treated as indicators of economic and/or environmental change, although perhaps not necessarily equally scaled from group to group.

Vertical distribution and preservational state of bone

The vertical distribution of bone based on raw weights is shown in Figure 7.11a, and 7.11b shows bone weights adjusted for weight of excavated sediment by spit (Table 7.3). Bone is sparse in Spits 1–17. There is a minor increase in bone quantities between Spits 18 and 23 and another slight increase between Spits 28 and 32. Below Spit 32 bone quantities increase dramatically, with a further increase to maximum levels between Spits 38 to 42. The lowermost spit produced a small quantity of bone.

The proportion of bone in each burning class varies markedly through the sequence (Fig. 7.12). Three main zones can be distinguished. Bone from the uppermost Spits 1–3 shows a high proportion of burning, with calcined bone alone accounting for more than 50% of the total bone in these levels. Between Spits 4–32 there is a marked decline in the proportion of burning; unburnt bone makes up around 50–60% of the total remains, with occasional excursions above and below these values. Calcined bone usually makes up less than 20% of the remains in these levels. Below Spit 32 even less of the bone shows any evidence of burning, with unburnt bone making up 70–85% of the total remains. This corresponds with the zone of highest bone concentrations in the sequence.

Faunal assemblages characterized by a high proportion of calcined bone are often a product of intense post-depositional destruction or degradation in environments where all but the most resistant remains have disappeared. To explore this possibility in the case of the upper levels of Nabulei Lisa, we examined the unburnt bone from each level for obvious signs of post-depositional destruction or degradation, such as tooth marks, root marks, surface pitting or

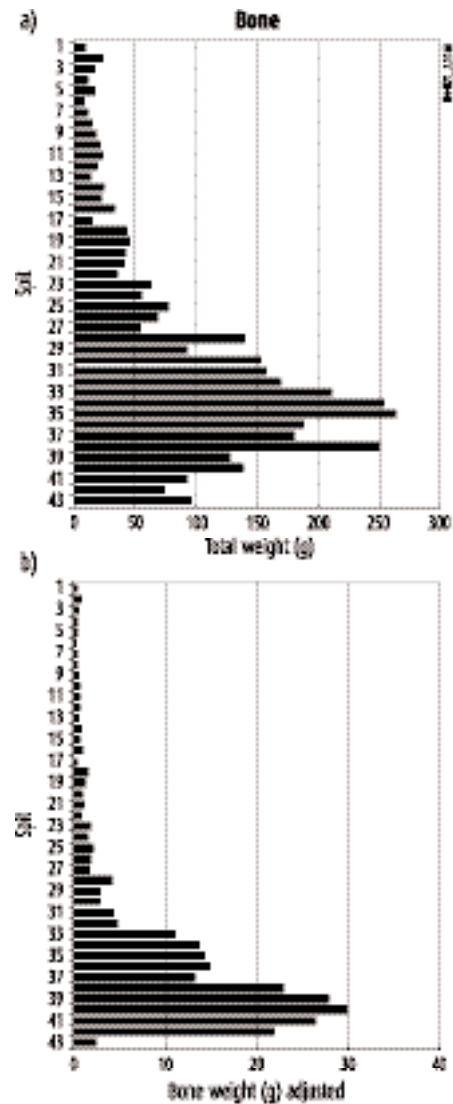


Figure 7.11 Liang Nabulei Lisa: a) total bone weight (g) and b) adjusted bone weight through the sequence (bone weight/excavated deposit weight)

rounding of fracture edges. Although a small proportion of bone fragments showed surface damage consistent with root and tooth marks, these are not concentrated in any particular part of the sequence. Overall, the bone appears well-preserved throughout the sequence and there is little indication that much material has been lost following burial of the assemblage. However, there are good grounds to suggest that the more intense burning of the faunal remains in Spits 1–3 may have caused a higher rate of destruction of bone than occurred during earlier times.

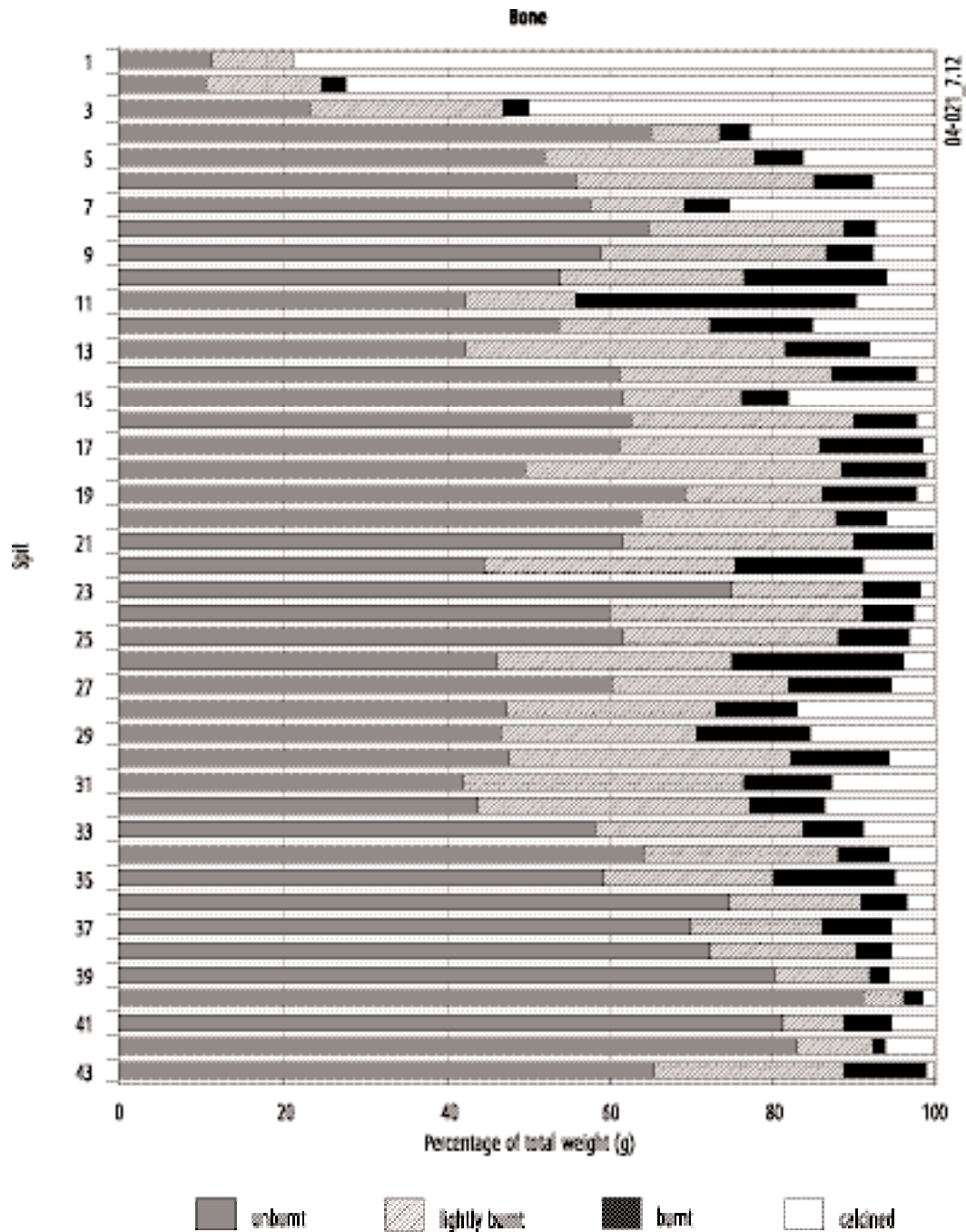


Figure 7.12 Liang Nabulei Lisa: changes in the burning composition of the bone assemblage through time, based on weight of remains in each burning category

Origin of the remains

The relative paucity of small mammal remains through the sequence (see Fig. 7.13), and the preponderance of medium- to large-bodied animals such as macropodids, boid snakes and phalangers (Fig. 7.13; Appendix 7.2), suggests that the Nabulei Lisa fauna is predominantly derived from human activity. This conclusion is supported by the scarcity of tooth marks on the remains and by the lack of rounding of fracture edges on all but a few specimens. Some of the smaller mammal remains, including the occasional bones of smaller rodents and bats, might be derived from other

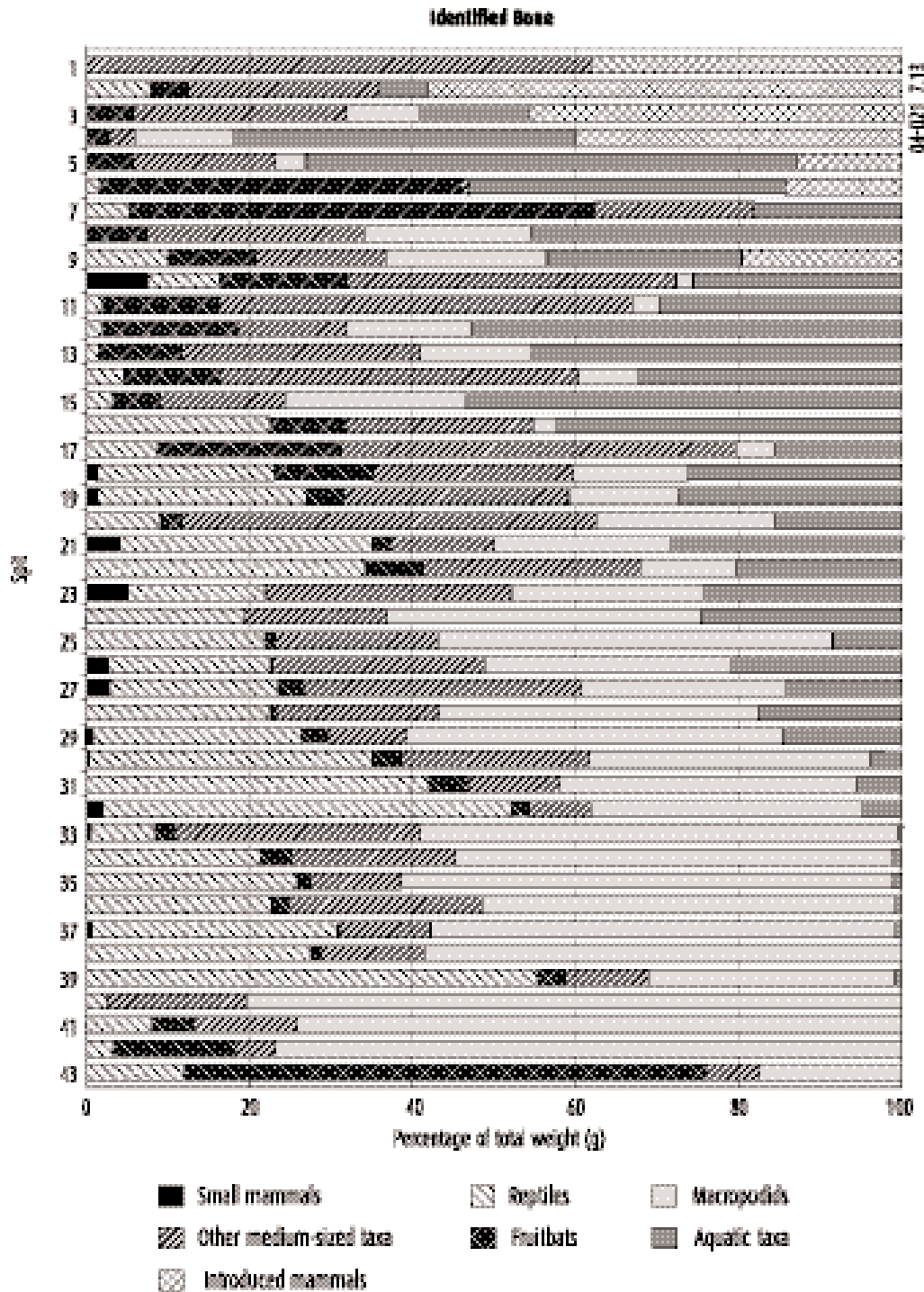


Figure 7.13 Liang Nabulei Lisa: changing proportional representation of major vertebrate groups through time, based on the weight of identified remains of each group

sources including the regurgitated pellets of predatory birds roosting in the cave. However, as these are scattered through the sequence, they do not influence the overall composition of the fauna. Bones of very small microchiropteran bats might be from natural deaths in the cave.

Species distributions

The archaeological fauna includes many of the mammal species that are present on the Aru Islands today, but also contains several species that have never been recorded as living animals. The major additions are three macropodids (*Macropus agilis*, *Thylogale stigmatica* and *Dorcopsis* sp.), two bandicoots (*Isoodon macrourus* and *Echymipera kalubu*), and the Short-beaked Echidna (*Tachyglossus aculeatus*). Other additions are a Native Cat (*Dasyurus albopunctatus*), several small rodents (*Rattus sordidus*, *Pogonomys* sp., *Pseudomys* sp., and *Melomys* sp. cf *M. burtoni*), and several bats (*Chaerephon* sp. cf *C. jobensis* and a small *Dobsonia* sp.). The basis of these taxonomic determinations is discussed in Chapter 3 (this volume).

Four species of macropodids are recorded in the archaeological fauna, compared with a single species (*Thylogale brunii*) recorded for the islands today. The additions are a mixed bunch and include *Macropus agilis*, a true grassland/ savannah wallaby, *Dorcopsis* sp. an inhabitant of dense rainforest, and *Thylogale stigmatica*, an inhabitant of rainforest margins and wet gallery forests. The *Macropus* and *Thylogale* species were reported earlier from Liang Lemdubu (O'Connor et al. 2002), but *Dorcopsis* sp. is an entirely new record for the islands.

As reported previously in O'Connor et al. (2002) for the Liang Lemdubu fauna (see also Chapter 9, this volume), the archaeological *Thylogale* remains are divisible into two or three taxa. One of these is clearly referable to the extant Aru species *Thylogale brunii*. The remaining specimens as a group compare most closely to modern reference specimens of *T. stigmatica*. However, the sample shows a greater size variation than would normally be observed within a single population and may include two closely related taxa. Because it was not possible to allocate many of the less complete specimens to either the larger or smaller form of *T. stigmatica*, the two groups are not distinguished in the analysis.

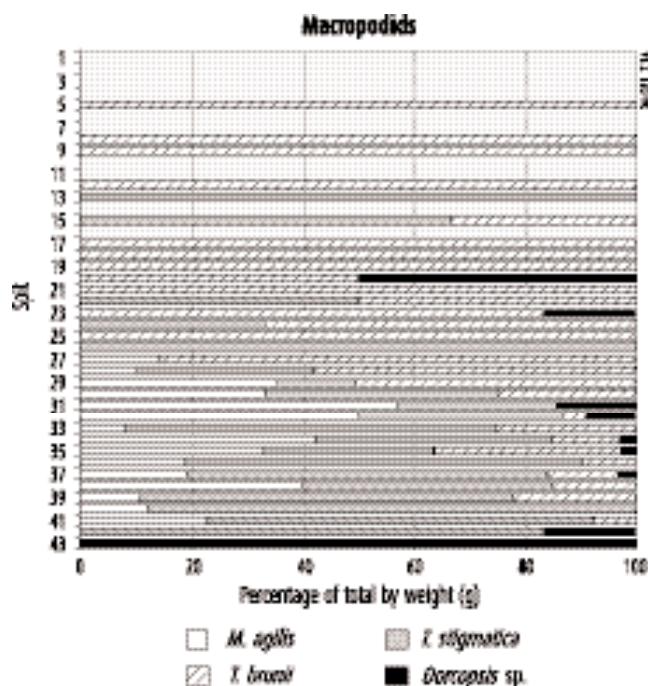


Figure 7.14 Liang Nabulei Lisa: distribution of different wallaby species through the sequence

Each of the four macropodids shows a contrasting distribution within the sequence (Fig. 7.14). The two *Thylogale* species together make up the greater part of the macropodid remains throughout the sequence. *Thylogale brunii* is dominant above Spit 30, but poorly represented below that level (Fig. 7.15a). It is the only macropodid found above Spit 12, an observation that is consistent with the persistence of this species on Pulau Kobroor until the present day. *Thylogale stigmatica* is consistently well represented below Spit 30 but occurs sporadically up to a final occurrence in Spit 12 (Fig. 7.15b). *Macropus agilis* makes up a significant proportion of all macropodid remains in Spits 27–41 but is absent above Spit 27 (Fig. 7.15c). *Dorcopsis* sp. occurs in low but consistent quantities in the lower part of the deposit, up to Spit 31 (Fig. 7.15d). A single example was recovered above this level, coming from Spit 23.

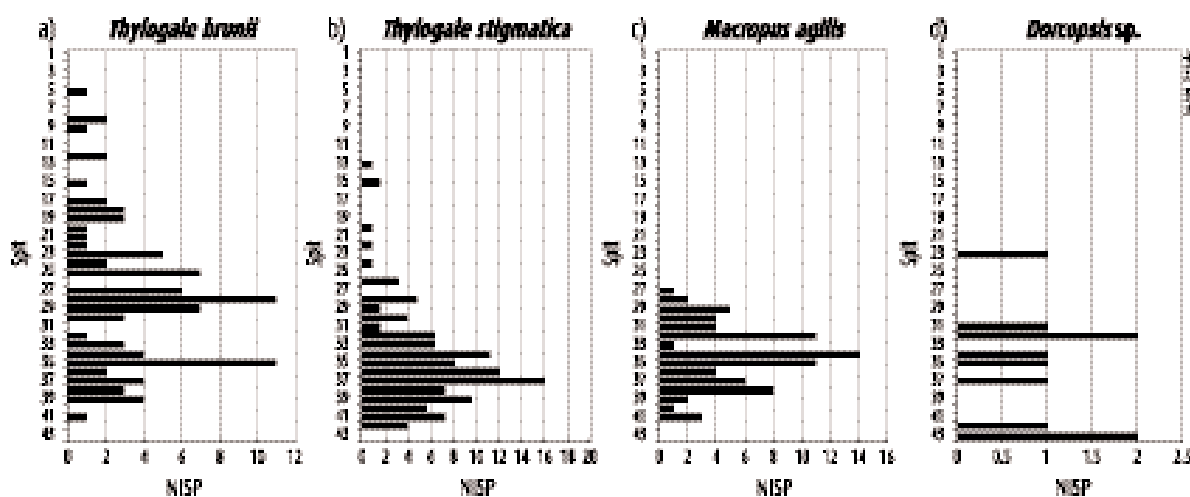


Figure 7.15 Liang Nabulei Lisa: distribution of a) *Thylogale brunii* b) *Thylogale stigmatica* c) *Macropus agilis* and d) *Dorcopsis* sp. through the sequence

To be more certain on the stratigraphic ranges of the various macropodids, the 'unidentified' material from the higher levels was subjected to special scrutiny. No post-cranial remains of *Macropus agilis* were identified in any sample above Spit 27. From Spits 26–11, the unidentified category is dominated by the remains of small macropodids, consistent in size with one or other of the two *Thylogale* species. In contrast, the bulk of the 'unidentified' category from Spits 1–10 appeared to be made up of highly fragmented remains of larger mammals (presumably pig and deer), together with remains of smaller mammals (e.g. possums, bats). Small macropodids clearly make up a smaller proportion of this category than is true for any of the lower levels.

The *Dorcopsis* remains from Nabulei Lisa are too fragmentary to identify the species involved (see Chapter 3, this volume). There are two principal candidates: *D. muelleri* that occurs on the adjacent southern coastal lowlands of Indonesian Papua; and *D. luctuosa* that occurs in southeastern New Guinea but with modern records in the Trans-Fly region (Groves and Flannery 1989; Flannery 1995b). All species of *Dorcopsis* inhabit deep closed forest habitats (Flannery 1995a), yet little detailed information is available on their ecology. In general, they are shy and secretive animals, intolerant of human presence. Today, they most often fall prey to hunting dogs but they can also be captured by hand or in nets (Flannery 1995b). Although a species of *Dorcopsis* has not been recorded in the contemporary Aru fauna, the possibility cannot be ruled out that they persist somewhere within the island group, perhaps in areas of dense forest far from areas of human habitation.

The ecology of the various New Guinean *Thylogale* species is unfortunately not well known. The endemic New Guinean *T. brunii* is reported to occur in dense monsoonal rainforest in the Morehead area (Waithman 1979). In the recent past, it was apparently present in grassland/savannah habitats around Post Moresby (Flannery 1995a). In Australia, *T. stigmatica* prefers rainforest habitat but it also occurs in wet sclerophyll and vine forest. Tate and Archbold (1935) described this species from 'mixed grasslands and gallery woods' on the Oriomo Plateau of Papua New Guinea, while Waithman (1979) reports it to be uncommon in low mixed savannah and woodland near swamps in the Morehead area. Where the two species occur together in the Trans-Fly region, it would thus seem that *T. brunii* tends to dominate in the core rainforest habitats, perhaps causing *T. stigmatica* to occupy the rainforest margins.

At least three species of bandicoots are represented in the Nabulei Lisa assemblage, compared with a single species in the modern fauna (Fig. 7.16a). The sole surviving taxon, *Echymipera rufescens*, is well-represented in the lower part of the deposit but has its most recent

definite occurrence in Spit 21 (Fig. 7.16b). Small numbers of unallocated bandicoot remains occur above this level. *Echymipera kalubu* is tentatively identified from Spits 10, 16, 20 and 35. This species is more confidently identified in the Lemdubu fauna (Chapter 9, this volume). Both species of *Echymipera* occur today in lowland rainforest habitats on the New Guinea mainland. However, *E. kalubu* appears to have broader ecological tolerance than *E. rufescens*, as it extends to higher elevations and also occurs in anthropogenic grassland. The third species of bandicoot is *Isoodon macrourus*, a species that is broadly associated with savannah grassland habitat in New Guinea and northern Australia (Flannery 1995a). This species is confined to Spits 26–38 within the sequence; it reaches peak abundance in Spit 34 (Fig. 7.16c). An enigmatic, fourth bandicoot taxon, recognized in the Lemdubu fauna, is represented in the lower levels of Nabulei Lisa, with dentary fragments and pedal elements in Spits 40 to 33.

Four species of possums are represented in the assemblage. All are part of the contemporary fauna of the Aru Islands. The Spotted Cuscus, *Spiloguscus maculatus*, is present in approximately half of all excavated spits, with no obvious change in absolute abundance from bottom to top (Fig. 7.17a). Two smaller cuscuses, *Phalanger gymnotis* and *P. intercastellanus*, also occur sporadically through the sequence and in almost equal numbers throughout (Fig. 7.17b). Relative to the total quantity of faunal remains, all three cuscus species are proportionally better represented in the upper half of the sequence. The Striped Possum, *Dactylopsila trivirgata*, is poorly represented by comparison, with single fragments in each of Spits 20, 28, 30 and 31. All four species are indicative of forest habitats. *Phalanger gymnotis* has not been recorded outside of rainforest habitats. The remaining species are more adaptable and occur today in a variety of forest types including riparian forests and relatively open woodlands. The scarcity of *Dactylopsila trivirgata* in Nabulei Lisa and Lemdubu (Chapter 9) appears to contrast with its current status as one of the more commonly collected native mammals on both Wokam and Kobroor Islands (see Chapter 3).

The only dasyurid species that is positively identified in the Nabulei Lisa fauna (Spit 37) is *Dasyurus albopunctatus*, an inhabitant of rainforest. A second, smaller species is represented by very incomplete remains in Spit 32.

The Nabulei Lisa fauna produced very little in the way of rodent remains and the majority of these are derived from large murids (Fig. 7.18). The few diagnostic specimens are all referable to *Uromys caudimaculatus*, a highly adaptable species that occurs across a variety of habitat types.

Bat remains are present in virtually all samples and it was generally possible to separate these into megachiropterans and microchiropterans based on size and morphology (Fig. 7.19a and b). Megachiropteran bat remains were found throughout the deposit but never in especially large

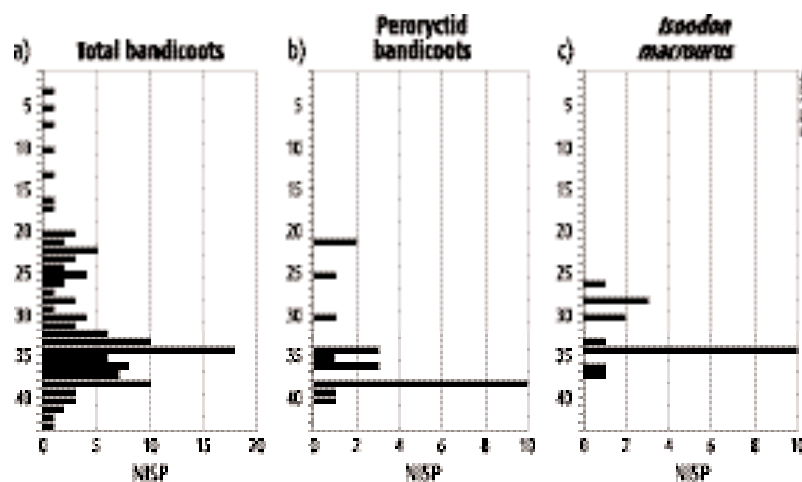


Figure 7.16 Liang Nabulei Lisa: distribution of a) all bandicoot species b) peroryctid bandicoots (*Echymipera* spp. and *Peroryctes* spp.) and c) *Isoodon macrourus* through the sequence

numbers (Fig. 7.19a). Most of the identifiable elements consist of isolated teeth and partial lower jaws. Fortunately, species of *Dobsonia* share a distinctive dental morphology that allows members of this genus to be distinguished from other comparable-sized pteropodids including species of *Pteropus*. All dentary fragments and isolated molars in the Nabulei Lisa assemblage appear to belong to a large species of *Dobsonia*, tentatively identified as *D. moluccensis*. These come from various levels in the excavation, from the very base (Spit 43) up to Spit 7 near the surface. No specimens were found of the second, much smaller *Dobsonia* species that occurs in Lemdubu. Microchiropteran remains are concentrated in two parts of the sequence, in Spits 28–43 and in Spits 2–18 (Fig. 7.19b). A total of eight lower jaws are present and all clearly represent a single taxon which is tentatively identified as *Chaerephon* sp. cf. *C. jobensis*, a molossid bat that is known to sometimes roost in caves. These small animals are more likely to represent the result of natural deaths in the cave rather than human food refuse. The gap in their occurrence may represent a period when the cave was abandoned by the bat colony, perhaps in response to human activity.

The remains of introduced mammal species are confined to the upper part of the sequence (Fig. 7.13). Pig bone occurs in Spits 2–6 and appears again in Spit 9; all of these occurrences presumably date to within the last 1000 years. In contrast, deer and dog remains are restricted to Spit 1. The Rusa Deer, *Cervus timorensis*, may be a recent introduction to the Aru Islands. Healey (1995:56) suggested that Rusa Deer may have been introduced by the Portuguese. However, Wallace does not mention this species at all, and it is unlikely that he would have failed to notice it if it was abundant and as important a hunted animal then, as it is today. Van Strien (1996) also favours a more recent date of introduction, during the early years of Dutch administration. No other introduced mammals are recorded in the archaeological fauna. One notable absence from the record is the Palm Civet *Paradoxurus hermaphroditus*, which is present in Aru today.

Snakes are consistently well-represented throughout the greater part of the sequence; in

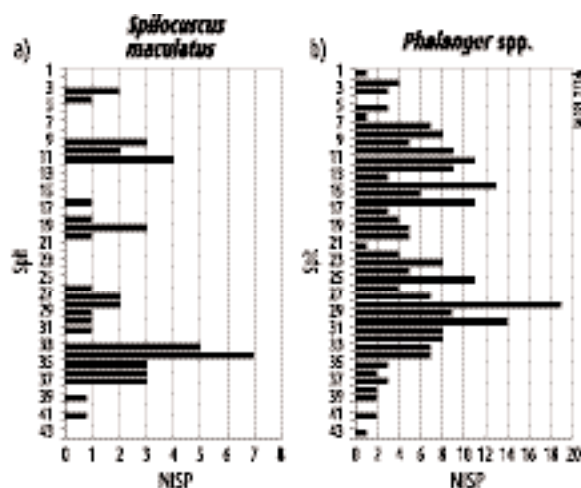


Figure 7.17 Liang Nabulei Lisa: distribution of possum species a) *Spilococcus maculatus* and b) *Phalanger* spp. through the sequence

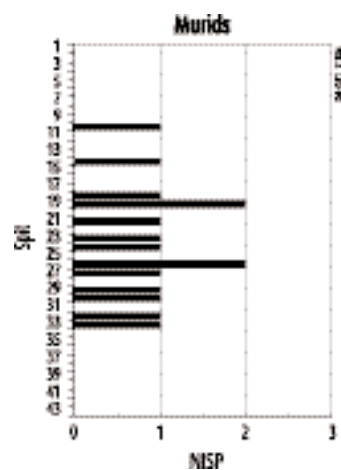


Figure 7.18 Liang Nabulei Lisa: distribution of murids through the sequence

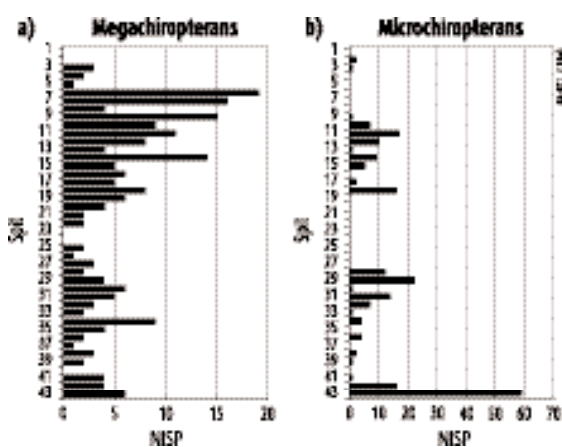


Figure 7.19 Liang Nabulei Lisa: distribution of a) megachiropterans and b) microchiropterans bats through the sequence

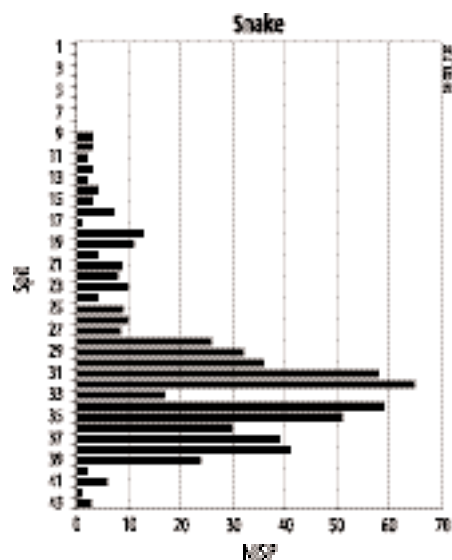


Figure 7.20 Liang Nabulei Lisa: distribution of boid snakes through the sequence

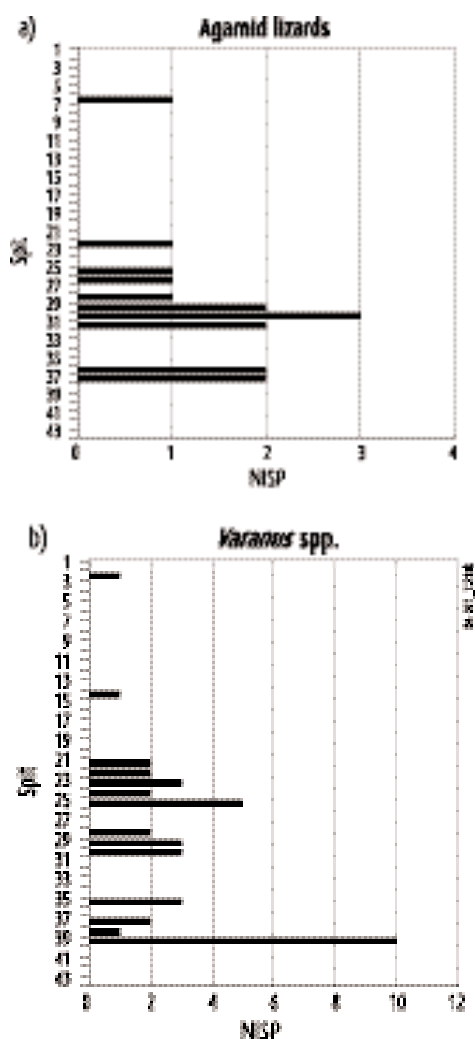


Figure 7.21 Liang Nabulei Lisa: distribution of a) Agamid and b) *Varanus* spp. lizards through the sequence

most spits they account for around 5–10% of all bone (Fig. 7.13). However, snakes are absent above Spit 9 (Fig. 7.20). Almost all of the snake remains come from moderately large snakes belonging to the Family Boidae (pythons), with rare examples referable to the Family Colubridae. In view of the high meat weight to bone ratio of these large pythons, they must have made a regular and important contribution to the diet.

Other reptile groups are less well-represented in the site. These include two families of lizards, the Agamidae (dragons) and Varanidae (monitors); remains of both groups occur sporadically through the deposit (Fig. 7.21a and b). The remains of freshwater turtles (family Cheluidae) are confined to a narrow band of the deposit, between Spits 19–26 (Fig. 7.22). Freshwater turtles are presumably indicative of at least seasonal wetland or riverine habitat in the vicinity of the site, prior to the establishment of estuarine conditions.

No definite cassowary bone was recovered from Nabulei Lisa, however, eggshell fragments occur between Spits 9–34. Cassowaries are not known to lay eggs in caves, hence it is reasonable to assume that any eggshell in the deposit results from eggs brought into the site by people as food. Three species of cassowary are found in New Guinea (*C. unappendiculatus*, *C. bennetti*, and *C. casuarius*), but only *C. casuarius* is found in northern Australia and in the Aru Islands today (see Chapter 13, this volume). *Casuarius casuarius* is actively hunted in the Aru Islands today and the eggs collected for food. No information is available on the breeding times of *C. casuarius* in Aru. In north Queensland breeding ‘occurs mostly in the dry season from about June to October’ coinciding ‘with the average maximum availability of fruit in the forest’ (Crome 1975:9, 13). If the archaeological eggshell is from *C. casuarius* then the eggshell fragments presumably demonstrate use of the site in the dry season.

The absence of eggshell fragments above Spit 9 and below Spit 35 is difficult to explain solely in terms of sample sizes. Intense burning and destruction of the remains in Spits 1–3 might help explain this absence for the uppermost levels, but this argument would not hold for Spits 4–8 or for the lower levels. The absence of eggshell below

Spit 35 is especially difficult to explain when it is remembered that the highest concentrations of bone were recovered from these levels.

The fish remains are derived mostly from small- to medium-sized fish and make a regular and sizable contribution throughout (Fig. 7.23). However, the collection also includes some larger, obviously marine taxa, especially in the upper half of the sequence. Identification of this material has not yet been attempted.

Crustacean exoskeleton

Crustacean exoskeleton was found in small quantities down to Spit 32 but the largest quantities occur in Spits 3–20 (Fig. 7.24a). Most of the sample consists of fragments of chelae. Three different morphological types were noted, differing in the overall form of the chelae (short, robust versus elongate, gracile), the style of ornamentation and the presence of distinct pores. Examples of each type were shown to Dr Diana Jones of the Western Australian Museum. She identified them as belonging to two families, Xanthidae (the more robust elements) and Portunidae (the more gracile groups). Xanthid crabs are typically associated with marine, higher energy environments such as rocky shorelines. Among the portunids, she further distinguished the specimens with distinct pores from those lacking such structures and advised that these represent ecotypes: those taxa with pores are indicative of faster flowing freshwater stream conditions, and those without pores are associated with muddier water conditions and exposed muddy substrate. The samples were subsequently divided into these three groups — xanthid, portunid A (with pores), and portunid B (without pores) — and a count made of the number of fragments in each group.

Changes in the representation of each group of crustaceans through the deposit is shown in Figure 7.24b. The pattern is remarkably strong, with evidence for progressive replacement of a freshwater crab community, first by an estuarine, and then finally by a fully marine community. The major phases in the transition are represented by: Spits 32–22, during which period the freshwater portunids are dominant and xanthids make an occasional appearance; Spits 20–11, characterized by a mixed assemblage of estuarine portunids and xanthids; and Spits 10–2 when xanthids dominate. The major transition at Spit 20 corresponds exactly to the time when marine and estuarine shell increase dramatically in abundance. The absence of any crab remains below Spit 32 is of some interest, especially given the increased abundance of vertebrate bone below this level. One obvious possibility is that the occupants of the site simply could not be bothered with hunting for crabs during the early period of occupation of the site. However, it is also possible that the *sungai* channel did not contain sufficient water throughout the year during this period (16,200–12,000 cal BP) to support viable long-term populations of the particular portunid crab

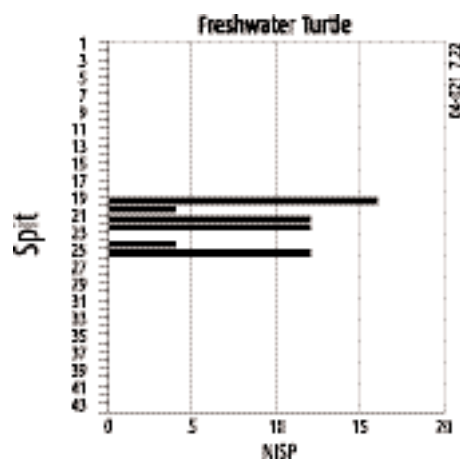


Figure 7.22 Liang Nabulei Lisa: distribution of freshwater turtles (family Cheluidae) through the sequence

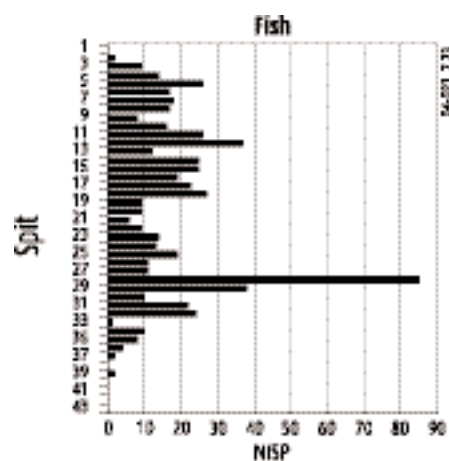


Figure 7.23 Liang Nabulei Lisa: distribution of fish through the sequence

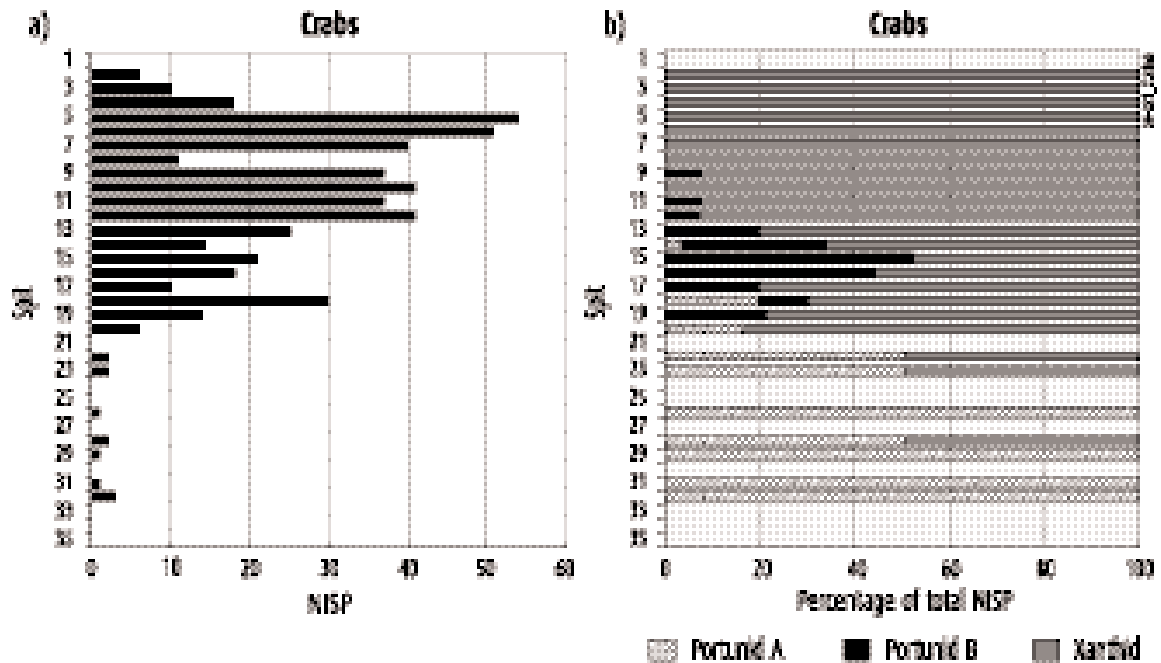


Figure 7.24 Liang Nabulei Lisa: Distribution of a) total crustacean remains and b) three major crustacean groups through the sequence

species. The scarcity of freshwater mollusc remains in the lower part of the deposit may also point to conditions that were at least seasonally unsuitable for establishment of a full freshwater stream community.

Plant material

Seeds of *Celtis philippinensis* were the only plant material preserved. They are confined to the lower part of the excavation, with most examples coming from Spits 21–31 and one specimen only below this level (from Spit 36; Table 7.2). Being composed primarily of inorganic material, *Celtis* seeds are very robust so it is unlikely that poor preservation conditions are responsible for their absence in the upper and lowermost spits. It may be significant that their major appearance in Spit 31 corresponds with the first appearance of crab remains and that their disappearance coincides with the major increase in marine and estuarine shell and crab species in Spit 20. A possible scenario is that *Celtis* trees grew along the freshwater stream below the site for a few thousand years in the early Holocene but ceased to grow in this area when tidal conditions established. Their absence from the same area during the earlier period might be a further indication of seasonally dry conditions in the *sungai* channel at this time.

Palaeoenvironmental Interpretation

The combined mollusc, crustacean, and vertebrate faunal analysis provides a remarkably detailed picture of environmental changes in the vicinity of Liang Nabulei Lisa over the past 16,000 years. The sequence of changes is most conveniently described as a succession of four time periods. However, the exact delineation of these periods should be regarded as somewhat arbitrary.

Spits 43–33 (16,200–12,000 cal BP)

The earliest phase of occupation of the site is characterized by higher absolute quantities of vertebrate faunal remains and by the predominance of macropodid and snake remains. Other groups of mammals including bandicoots, possums, and bats are all represented, but in small numbers. This period is further characterized by the presence of all four macropodid species including *Macropus agilis* and *Dorcopsis* sp., and by the dominance of *Thylogale stigmatica* over the other species. The bandicoot *Isoodon macrourus* is also well-represented. Fish remains are rare through this period and there is no evidence for exploitation of crabs or freshwater molluscs, perhaps because these groups were unavailable locally.

The occurrence of *Macropus agilis* and *I. macrourus* in these levels points to the presence of substantial areas of open habitat in the vicinity of the site. This was most likely some form of savannah woodland with grassy understorey. The lowland evergreen rainforest environment around the site today certainly does not provide a suitable habitat for either of these species. In this context, the simultaneous presence in these levels of a suite of typical lowland ‘rainforest’ species — including *Dorcopsis* sp., *Echymipera rufescens* and *Phalanger gymnotis* — is intriguing, and surely points to a mosaic of wet and dry habitats around the site. This conclusion is further supported by the presence of two species of *Thylogale* wallabies in these levels, both of which show a preference for forest edge habitats, typically the interface between rainforest and more open habitats. In the immediate context of Nabulei Lisa, the most likely scenario is that patches of dense evergreen or semi-evergreen rainforest were present in sheltered contexts along watercourses, including the major *sungai* channels. Drier, more open habitats presumably dominated on more elevated and exposed sites away from the channels.

The very limited evidence for exploitation of freshwater resources during this period raises the possibility that the major *sungai* channels were seasonally dry to the extent that crabs and economically useful molluscs were unable to establish viable, long-term populations. The apparent absence of cassowaries in the local area during the earlier part of this period (below Spit 35) might also be taken as an indicator of relatively dry conditions compared with subsequent periods. Despite these indications, the site appears to have been used more intensively during this period than at any time subsequently, at least if the quantity of vertebrate faunal remains is taken as a measure of activity.

Spits 32–26 (12,000–10,200 cal BP)

This period is characterized by greater diversity and more evenness of representation in the vertebrate assemblage. Macropodids and snakes remain important but there is a proportional increase in the quantities of fish, phalangerid possums and bandicoots. At the species level, this period is characterized by the decline or disappearance of *Dorcopsis* sp. (one record only at Spit 23), and by an increase in the proportional representation of *T. brunii*. *Macropus agilis* and *I. macrourus* are present through this period but make their last appearance together in Spit 26. Small quantities of freshwater crab and mollusc remains are present through this period. Marine and estuarine shell both make their first appearance, albeit in small quantities, in Spit 29. The total quantity of faunal remains is lower through this part of the deposit. However, cassowary eggshell is present in most levels.

The presence of both *M. agilis* and *I. macrourus* through this period documents a continuation of open savannah habitats in the area around the site. The apparent decline of *Dorcopsis* sp. could be taken as evidence for a reduction in area or suitability of wetter forest types from the preceding period, perhaps as a result of increasing aridity. However, other changes in the fauna suggest the opposite scenario of wetter conditions with a possible expansion of rainforest habitats. Most compelling in this regard are the increased importance of *Thylogale brunii*, a species that appears to thrive today in rainforest habitats in the Aru Islands, and the evidence for exploitation of freshwater crabs and molluscs during this period. The evidence for cassowaries in the local area

might also point to larger areas of dense forest habitat. Given these contrary indications, we feel that a more likely interpretation for the decline of *Dorcopsis* sp. at this time is that it fell victim to some combination of over-hunting and interspecific competition, perhaps due to the greater tolerance of the *Thylogale* species to human disturbance.

The molluscan and crab remains give a clear and consistent picture of local freshwater conditions in the *sungai* channel through this period, but with coastal conditions sufficiently nearby that small quantities of typical estuarine and marine organisms were making their way to the site.

Spits 25–10 (ca. 7700–6100 cal BP)

This period is characterized mainly by the absence of *Macropus agilis* and *Isoodon macrourus*. Otherwise, it continues the same trend of progressive decline in the relative importance of macropodids and corresponding increases in the representation of phalangerids, bats and fish. *Thylogale stigmatica* occurs sporadically up to Spit 12.

The loss of the savannah and grassland dwelling mammals by the start of this period is a clear signal that these open habitats have either disappeared entirely, or else become reduced to small remnants of insufficient size to support viable populations even of the bandicoot. In general terms, the local environment may have resembled that found around the site today but with a slightly more diverse mammal fauna that included *T. stigmatica*. The eventual loss of this species rather than *T. brunii* may have been largely a result of chance factors; both species are probably capable of occupying continuous rainforest habitat in addition to the preferred forest edges. However, it is also possible that *T. brunii* had a slight competitive edge that allowed it to become increasingly dominant as closed forest gradually became more continuous.

The brief appearance of freshwater turtle in the lower part of this period (Spits 19–26) is further evidence that the major *sungai* channel supported at least a seasonally productive stream or wetland habitat. However, such conditions were evidently short-lived and the dramatic increase in marine and estuarine shell above Spit 20, and simultaneous change in the crab fauna, clearly reflect the local establishment of estuarine conditions with associated mangrove communities in the *sungai* at that time. The mollusc fauna does not seem to record the eventual change from estuarine to marine conditions in the *sungai*. In contrast, the crab fauna shows a very suggestive decline in estuarine species and corresponding rise of true marine species from Spit 15 onwards.

Spits 1–9 (ca. 1000 cal BP–modern)

This period is characterized by the appearance of several introduced mammals (pig, dog and deer) and by a decline in the relative abundance of macropodids, phalangerids, snakes and fish. Bats show a slight increase in relative abundance during this period. *Thylogale brunii* is the only macropodid identified from these levels.

Unfortunately, the archaeological remains from this period are too sparse to build a detailed picture of faunal exploitation during this interesting, final phase of occupation. Accordingly, it is unclear whether the site was being used as a remote hunting camp subject to occasional visits, or alternatively, whether the area around the site was subject to cultivation as it is today.

Human Skeletal Material

A small quantity of human skeletal material was recovered from Liang Nabulei Lisa. Some was recognized during excavation and removed and bagged separately, and other fragments were recognized during sorting of the faunal material. A full description of this material is presented in the following chapter.

Bone Artefacts

Bone artefacts were recovered from Liang Nabulei Lisa, distributed more or less evenly between Spits 12–37 (Fig. 7.25). The artefacts are described in detail and illustrated by Pasveer in Chapter 11 (this volume). There are a total of fifteen specimens, with peak occurrences in Spit 28 and Spit 31 (see Fig. 11.1). This distribution indicates that most of the bone artefacts ($n=11$) date between 9000 and 13,000 BP. The Nabulei Lisa bone artefacts are difficult to categorise as they are highly variable in shape, including unipoints, spatulae forms and a single bipoint. A total of 80% are produced on shaft fragments and a large number are made on lightly burnt bone which may indicate that the raw material was deliberately prepared by lightly ‘cooking’ it prior to manufacture. Interestingly, while some complete points were recovered most of the bone artefacts at Nabulei Lisa are represented by fragments. This suggests that they result from repair or maintenance activities taking place on site rather than from the primary manufacture, as no broken or incomplete specimens from the early stages of production were found.

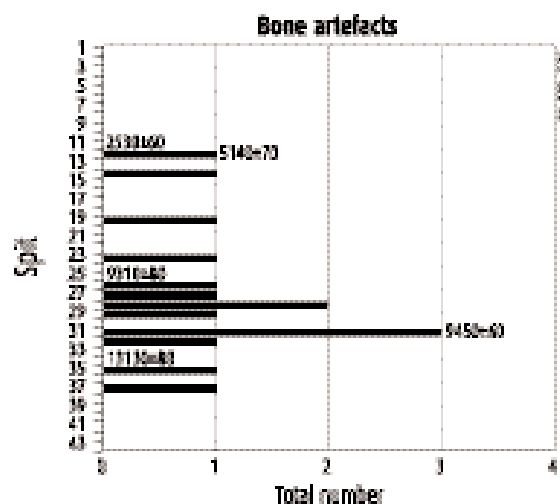


Figure 7.25 Liang Nabulei Lisa: distribution of bone artefacts through the sequence

Stone Artefacts

Stone artefacts were sparse throughout, with only 42 recovered in total. No stone artefacts at all occur in Spits 1–6. As these spits fall within the last thousand years, and in view of how poorly represented stone artefacts are throughout, their absence is hardly surprising as we may presume that metal would have been used for many activities by this time. No stone artefacts occur below Spit 35, however, the volume of deposit drops off sharply at this point so the absence is probably a sample size effect. The assemblage is composed almost exclusively of small unretouched flakes of chert and limestone. There is a change in raw material proportions at Spit 30. Above Spit 30, stone artefacts are predominantly made of limestone. Below Spit 30, 80% of artefacts are made on chert and 20% on limestone. Although with such small artefact numbers this change may not appear very significant, it does parallel a similar change at Lemdubu (Chapter 9, this volume). In Lemdubu chert accounts for between 30–56% of raw material in the upper spits, 2–5, in Spit 6 it accounts for 60% of all raw material, and below Spit 9 it accounts for 80–90%. As at Lemdubu, the changeover from chert to limestone appears to occur at the Pleistocene/Holocene interface. Attributes of the artefact assemblages from both caves such as technology of manufacture and weathering are discussed in detail in Chapter 10 (this volume).

Pottery

Several broken pottery vessels with intact rims were recovered from the surface of Liang Nabulei Lisa as well as a number of more fragmented sherds (Figs 7.26–7.30) Some of the surface pottery was painted with red designs, reminiscent of the contemporary pottery produced at Batu Lei in the

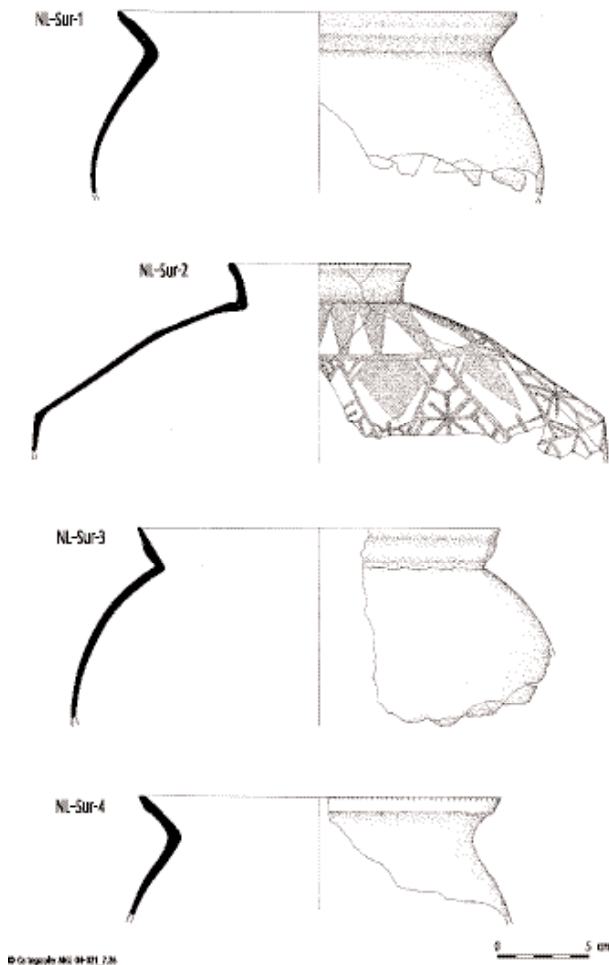


Figure 7.26 Liang Nabulei Lisa: vessel forms among the surface collected pottery, including everted globular pots with raised ridges on the rim exterior (NL-Sur-1, NL-Sur-3); a strongly restricted, everted and carinated jar — possibly a water jar — with a red painted rectilinear design (NL-Sur-2); and an out-curving globular pot with lip notching on a collared rim (NL-Sur-4)

south east (NL-Sur-2, Fig. 7.26). The method of manufacture of the Batu Lei pottery is discussed and illustrated in Chapter 6 (this volume). Aside from the broken vessels collected from the surface, the Nabulei Lisa pottery consisted of a small number of undecorated and largely undiagnostic sherds confined to the top eight spits of the excavation: a depth of approximately 18cm below the surface (Table 7.5). Based on the date from Spit 11 of 2530 ± 60 (OZF249), at a depth of approximately 25cm, it is assumed that the pottery in Nabulei Lisa all dates to the last 1000 years. As might be expected in a cave site, pottery is not abundant in the excavation. The maximum number of sherds in any single spit was eight — in Spit 1. Weights are presented in Table 7.2. With the exception of painted decoration, the sherds recovered from the excavation look similar in all respects to the surface pottery (i.e. in terms of vessel form and temper), and to the ethnographic examples, so it seems likely that painted decoration simply does not survive burial. Two conjoinable fragments of Chinese blue and white porcelain, comprising a small section of the rim and body, were recovered from Spit 3 (NL-A-3, shown conjoined in Fig. 7.30), and a rim and body section of a small porcelain bowl with a pale green glaze was recovered from the surface (NL-Sur-16, Fig. 7.29).

There is considerably less variety in the Nabulei Lisa earthenware pottery assemblage than in that recovered from the Wangil test excavation (see Chapter 4, this volume) in terms of vessel form, types of decoration, and fabric. Vessel forms at Nabulei Lisa included a series of restricted orifice cooking pots, usually with plain lips, and apart from one rim/ neck sherd (NL-A-6) lacking incised decoration on the body. The collar form (Figs 7.27–7.28) was distinctive and different from the Wangil examples. Some strongly restricted orifice vessels were most probably water jars, one of which was decorated with a complex rectilinear painted design in red (NL-Sur-2, Fig. 7.26). This resembles ethnographically recorded decoration (see Batu Lei pottery Fig. 6.7, Chapter 6, this volume). One slightly restricted bowl form with a strongly everted notched lip (NL-A-6) may be paralleled at Wangil where some broken examples of similar rims occur. Clearly, however, the curvilinear incised decoration favoured at Wangil in the last thousand years is absent at Nabulei Lisa. In addition, no examples of the fine, burnished, red-slipped pottery found at Wangil were recovered at Nabulei Lisa. Five temper ‘types’ were identified in the macroscopic fabric examination of the Nabulei Lisa assemblage whereas nine types were recognized at Wangil. Based on this initial separation, 25 sherds from Nabulei Lisa were sent to William R. Dickinson for thin-

Table 7.5 Liang Nabulei Lisa: surface and excavated pottery sherd descriptions

NUMBER	SHERD TYPE	VESSEL FORM	RIM DATA				DECORATION DATA			FABRIC ANALYSIS
			DIRECTION	RIM PROFILE	LIP PROFILE	EXTRA RIM FEATURES	RIM DIAMETER	LOCATION	TECHNIQUE	
NL-Sur-1	rim/ neck/ shoulder	everted globular pot	everted	gradual convergent	rounded		rim exterior	raised ridge	1B	
NL-Sur-2	rim/ neck/ carination	strongly restricted, everted, carinated jar (shouldered- ware)	everted	parallel	rounded		1) lip 2) body below collar (above & below carination)	1) notching 2) red paint	1	
NL-Sur-3	rim/ neck/ shoulder	everted globular pot	everted	gradual convergent	rounded	asymmetrically thickened exterior	rim exterior	raised ridge	1	
NL-Sur-4	rim/ neck	out-curving globular pot	out-curving	abrupt convergent	rounded	asymmetrically thickened exterior (collared rim)	lip	notching	1	
NL-Sur-5	rim/ neck/ shoulder	everted globular pot	everted	gradual convergent	pointed		interior & exterior	red slip	1	
NL-Sur-6	rim/ neck	everted globular pot (shouldered-ware)	everted	abrupt convergent		asymmetrically thickened exterior; channelled neck/ body convergence			1B	
NL-Sur-7	rim/ neck	everted restricted neck vessel	everted convergent	gradual rounded			28cm		1	
NL-Sur-8	rim/ neck/ shoulder	everted globular pot (shouldered- ware)	everted	parallel	rounded	asymmetrically thickened exterior (collared rim); channelled neck/ body convergence	16cm		1	
NL-Sur-9	rim/ neck	everted globular pot (shouldered- ware)	everted	gradual convergent	flat	asymmetrically thickened exterior; channelled neck/ body convergence	20cm	1) wiped lines 2) red slip	1	
NL-Sur-10	rim/ neck/ carination	everted carinated jar	everted	gradual convergent	pointed		lip	notching	1	
NL-Sur-11	rim/ neck	everted restricted neck vessel	everted	abrupt convergent	pointed	asymmetrically thickened exterior (collared rim)	exterior	black paint?	1B	
NL-Sur-12	rim/ neck	out-curving restricted neck vessel	restricted neck vessel	out-curving	parallel		28cm		1	
NL-Sur-13	rim/ neck body	everted globular pot (shouldered -ware)	everted	gradual divergent	rounded	asymmetrically thickened exterior (collared rim); channelled neck/ body convergence	exterior	red slip	1	
NL-Sur-14	rim/ neck								1	
NL-Sur-16	rim	open bowl	direct	abrupt convergent	rounded		interior & exterior	pale green glaze	porcelain	
NL-Sur-18	rim/ neck	everted restricted neck vessel	everted	gradual convergent	pointed	asymmetrically thickened exterior	rim exterior	raised ridge w/ a channel on either side	1	

continued over

Table 7.5 Liang Nabulei Lisa: surface and excavated pottery sherd descriptions

NUMBER	VESSEL FORM			RIM DATA			DECORATION DATA			FABRIC ANALYSIS
	SHERD TYPE	DIRECTION	RIM PROFILE	LIP PROFILE	EXTRA RIM FEATURES	RIM DIAMETER	LOCATION	TECHNIQUE		
NL-A-1a	body								1	
NL-A-1b	body								1	
NL-A-1c	body								1	
NL-A-1d	body								1	
NL-A-1e	body								1	
NL-A-1f	body								1	
NL-A-1g	body								1	
NL-A-1h	body								1	
NL-A-3	rim/ body	slight out-curving	gradual convergent	rounded			interior & exterior	blue and white paint/ glaze	porcelain	
NL-A-3a	body								1	
NL-A-3b	body								1	
NL-A-4a	body								1	
NL-A-4b	body								1	
NL-A-4c	body								1	
NL-A-4d	body								1	
NL-A-4e	body								1C	
NL-A-5a	body								1	
NL-A-5b	body								1C	
NL-A-5c	body								1B	
NL-A-5d	body								1	
NL-A-5e	body								1	
NL-A-5f	body								1C	
NL-A-6	rim/ neck	everted restricted neck vessel	parallel	flat		14cm	1) lip 2) exterior lip 3) exterior neck corner point	1) linear incised notching 2) groove 3) linear incision	1	
NL-A-6a	body								1	
NL-A-7a	body								1	
NL-A-7b	body								1	
NL-A-7c	body								1	
NL-A-7d	rim								1	
NL-A-8	neck/ shoulder	everted globular pot	everted			10cm (at neck)	exterior	red slip	1	
NL-A-8a	rim		parallel	flat					1	
NL-A-8b	rim								1	

sectioning and petrographic analysis. He examined them all and then selected seven representing the above macroscopic groups for detailed analysis. He concluded that the Nabulei Lisa tempers were all 'quartz-calcite which were generically very similar to the Batu Lei sand and presumably indigenous to Aru.' The sand samples referred to had been collected in 1998 from the contemporary pottery making village. These were identified as Temper Type 1. The quartz-calcite Nabulei Lisa sherds could be further subdivided into two classes:

- 1) Temper Type 1B. Calcareous grains dominant, but with terrigenous grains present in significant amounts. NL-Sur-1 (Nabulei Lisa-Surface), NL-Sur-6, NL-Sur-11, and NL-A-5C fall into this class; and
- 2) Temper Type 1C. Calcareous and terrigenous grains present in subequal proportions (post-burial leaching has corroded many calcareous grains in NL-A-5F). NL-A-4, NL-A-5B, and NL-A-5F fall into this class.

Pottery sherds from Nabulei Lisa that were not petrographically analysed have been identified in Table 7.5 simply as temper 'Type 1', while the thin-sectioned sherds are identified as Types 1B and 1C.

The restricted range of pots at Nabulei Lisa and the similarities with the contemporary Batu Lei pottery may be due to:

- 1) The difference in sample size. Far fewer sherds were recovered from Nabulei Lisa;
- 2) Stylistic change through time. There is a general tendency in Island Southeast Asia for pottery to become more highly decorated over time. However, this is unlikely to account for the differences between the two assemblages. The Nabulei Lisa and Wangil assemblages are more or less contemporaneous;
- 3) Difference in site type/function. While it is located close to the *sungai*, being a cave site Nabulei Lisa was probably used predominantly as a hunting camp or casual stop-over whilst visiting gardens. Simply for this reason it is not likely to have the range of pottery found at a permanent village settlement on the coast;
- 4) Stylistic differences between pottery production centres in the Aru group. Nabulei Lisa is geographically closer to Batu Lei, than to the pottery producing centres of Samang and Maekoor (see Chapter 6, this volume), and so its indigenous pottery probably comes from a different source than that at Wangil.

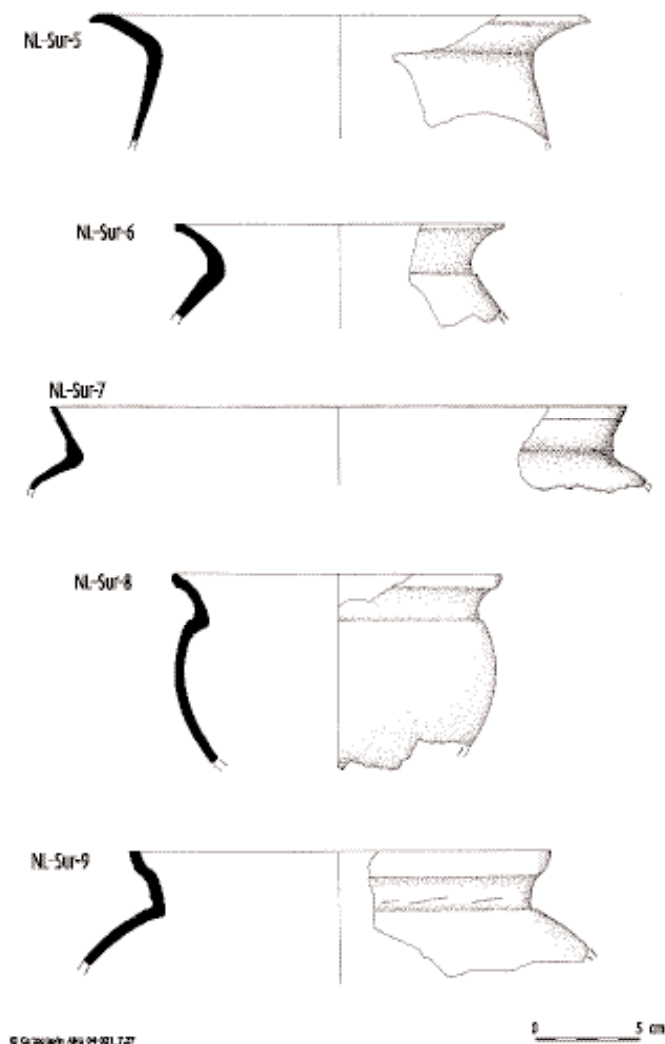


Figure 7.27 Liang Nabulei Lisa: vessel forms among the surface collected pottery, including plain everted globular pots (NL-Sur-5, NL-Sur-7 — the former with red slip); and everted globular pots with shoulders (NL-Sur-6, NL-Sur-8, NL-Sur-9 — the latter with red slip)

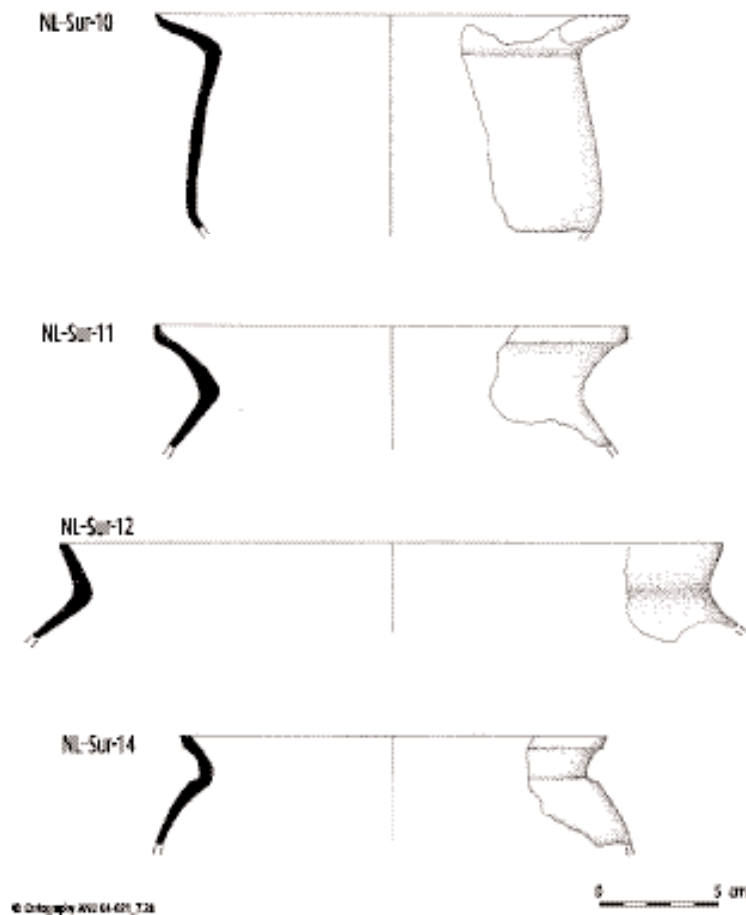


Figure 7.28 Liang Nabulei Lisa: vessel forms among the surface collected pottery, including an everted carinated jar with lip notching (NL-Sur-10); everted and out-curving, restricted neck vessels (probably globular pots) (NL-Sur-11, NL-Sur-12); and a shouldered, everted globular pot with red slip (NL-Sur-14)

species during this time, but it disappears in Spit 28 around the beginning of the Holocene, providing further support that more open conditions prevailed widely in the Aru Islands prior to about 10,000 BP. A freshwater stream probably flowed along the same channel where the tidal *sungai* is today, although there are indications in the crab remains that it may have been dry or at least seasonal in the early period of site occupation represented by the cultural material below Spit 31. Patches of rainforest thicket are likely to have been present along this channel from which the hunters of Liang Nabulei Lisa could exploit a range of closed forest dwelling animals. Freshwater shellfish and crabs were exploited from the stream. The beginning of the Holocene brought wetter conditions to the newly formed coastal regions of southern New Guinea, including the Aru Islands. The almost immediate loss of savannah-dependent species at the beginning of the Holocene tracks the expected changes in vegetation well. With the Holocene rise in sea level, tidal conditions were established, and the succession from freshwater to brackish to marine/estuarine conditions is reflected clearly in changes in the species composition of the crabs and shellfish.

The upper 6000 years attest to use of the cave when it was proximal to the tidal *sungai* and estuarine marine conditions prevailed. During this time the economic emphasis seems to have switched to the immediate resources of the *sungai*, supplemented by hunting of small to medium game species from the surrounding forest. Prior to this time, freshwater fish and shellfish were exploited but in small numbers, and the emphasis was on hunting of medium to large game

Conclusions

Liang Nabulei Lisa provides a detailed cultural sequence that bridges the terminal Pleistocene to mid-Holocene. The site perfectly complements the record from Liang Lemdubu, where most of the deposit accumulated in the period from ca. 28,000 BP to the beginning of the Holocene. The placement of Liang Nabulei Lisa close to the major *sungai* channel also provides a wealth of detailed information of the changes that occurred within the aquatic to marine realm during the marine transgression, thereby providing a part of the overall archaeological picture that is missing from the Liang Lemdubu record.

The faunal sequence indicates that between 16,000 and 11,000 cal BP savannah/ grassland environments were accessible to hunters using Liang Nabulei Lisa. As in the Lemdubu cave, Agile Wallaby (*Macropus agilis*) was an important game

species. Evidence for the introduction of domestic animals such as pig and dog, and by proxy the introduction of an agricultural economy into the Aru Islands, appears only in the last thousand years of the Liang Nabulei Lisa sequence. Pottery is also confined to the uppermost levels of the site dating within the last thousand years, and a restricted range of vessels are represented. This may reflect the limited range of activities that are carried out at cave sites rather than provide an accurate reflection of the date of the introduction of horticulture and pottery production in Aru (see Chapter 6, this volume).

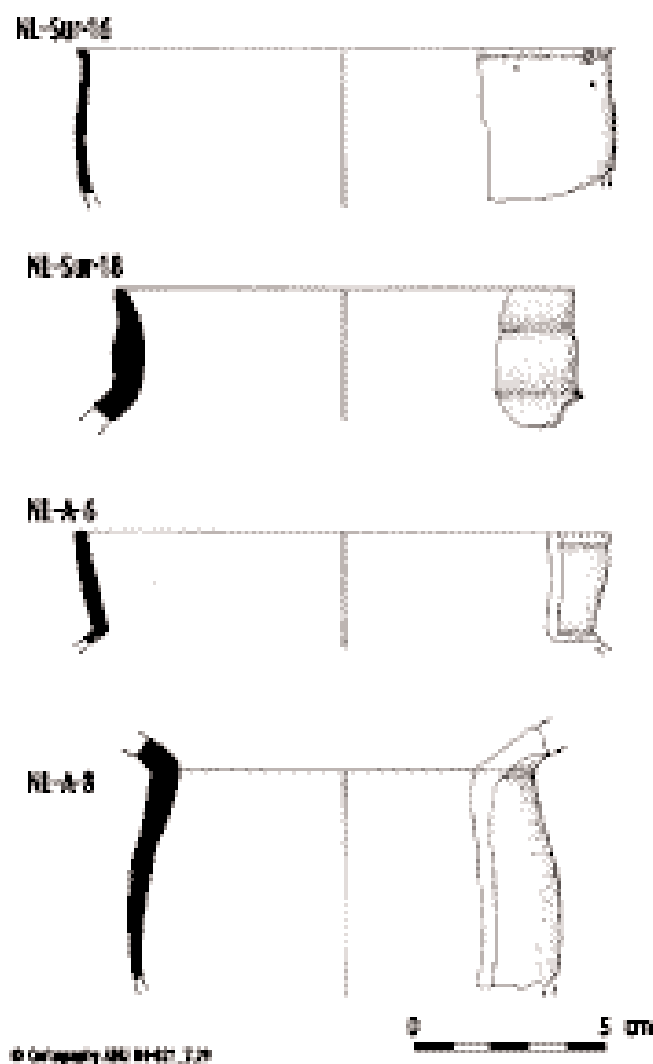


Figure 7.29 Liang Nabulei Lisa: diagnostic and decorated pottery sherds from the surface collection and excavation, including the rim of an open porcelain bowl with pale green glaze (NL-Sur-16); a rim sherd with an exterior raised ridge (NL-Sur-18); an everted rim sherd with incised linear notching on the lip and linear incision on the exterior neck corner point (NL-A-6); and a neck/shoulder sherd from a red-slipped, everted globular pot (NL-A-8)



Figure 7.30 Liang Nabulei Lisa: rim and body section of a Chinese blue and white tradeware bowl from Spit 3 (NL-A-3)

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Appendix 7.1

Liang Nabulei Lisa: Depths (cm) of Excavation Units (Spits) and Weight (kg) of Sediment and Rocks by Spit

SPIT	NW DEPTH	NE DEPTH	SW DEPTH	SE DEPTH	CENTRAL DEPTH	SEDIMENT WT.	ROCKS WT.
1	1.5	2.0	1.0	3.0	2.5	24.3	0.2
2	1.5	2.5	2.5	1.0	2.5	26.6	0.0
3	2.0	2.5	2.0	3.5	5.0	31.3	0.0
4	3.5	2.0	2.0	2.0	0.5	29.3	0.0
5	2.0	3.0	3.0	3.0	2.5	33.0	0.0
6	3.5	3.0	3.0	2.5	3.0	34.1	0.2
7	1.5	2.5	3.0	2.0	2.5	29.1	0.0
8	2.0	2.0	2.0	3.0	3.0	30.7	0.0
9	3.0	3.0	3.5	2.5	3.0	31.8	0.0
10	3.0	3.0	2.0	2.5	3.0	28.7	3.1
11	2.0	2.5	3.5	3.5	3.0	32.0	2.5
12	2.0	2.5	2.0	2.0	2.5	24.4	0.8
13	3.0	2.5	2.0	3.0	1.5	25.3	3.0
14	2.5	1.5	2.0	2.5	2.5	23.6	3.4
15	4.0	2.5	3.5	2.5	1.5	30.4	2.6
16	2.0	3.0	3.0	1.5	3.0	28.3	2.6
17	3.0	1.5	2.5	2.0	1.5	28.7	4.7
18	2.0	rock nr	2.5	4.0	3.5	25.9	1.5
19	3.3	rock nr	2.2	3.5	3.7	32.9	2.7
20	2.7	10.0	3.8	3.5	2.3	34.4	10.5
21	2.4	2.7	1.5	1.8	2.8	27.1	6.8
22	1.6	2.8	3.5	3.7	3.2	32.0	5.8
23	3.5	4.5	3.0	2.0	2.5	30.0	4.2
24	2.5	2.0	3.0	2.5	3.0	31.3	3.5
25	3.5	4.5	3.5	3.0	4.5	31.9	4.9
26	1.5	0.5	2.5	3.5	2.5	28.8	8.3
27	4.0	3.0	3.0	2.0	1.5	27.3	3.7
28	3.0	1.5	3.0	3.5	3.5	29.0	4.5
29	2.0	4.0	1.0	1.0	3.0	27.3	6.0
30	4.0	2.5	4.5	4.5	4.0	39.4	13.0
31	0.0	2.0	3.0	2.8	1.0	27.8	8.6
32	4.2	3.3	2.8	3.4	2.2	31.7	3.5
33	3.3	4.2	2.2	2.8	3.8	17.7	1.3
34	3.5	3.0	3.0	3.0	3.0	18.5	0.0
35	3.0	3.5	1.5	2.0	2.5	16.0	2.5
36	3.8	5.2	3.5	3.8	3.5	12.5	0.0
37	3.7	0	3.5	3.7	3.5	13.5	0.0
38	rock nr	5.1	2.3	1.5	3.3	10.9	0.0
39	rock nr	rock nr	rock nr	3.0	3.2	4.6	0.0
40	rock nr	rock nr	rock nr	2.5	3.0	4.6	0.0
41	rock nr	rock nr	rock nr	rock nr	3.0	3.5	0.0
42	rock nr	rock nr	rock nr	rock nr	4.0	3.4	0.0
43	rock nr	rock nr	rock nr	rock nr	6.0	3.5	0.0

NB: nr = no reading recorded

Appendix 7.2

Liang Nabulei Lisa: Faunal Data

NISP Data for all Identified Faunal Specimens by Spit

SPIT	<i>DASYRUS ALBOPUNCTATUS</i>	CF <i>SMINTHOPSIS</i> SP.	<i>ISOODON MACRORUS</i>	PERORYCTIDAE	UNIDENTIFIED BANDICOOT	<i>DORCOPSIS</i> SP.	<i>THYLGALE STIGMATICA</i>	<i>THYLGALE BRUNNI</i>	<i>MACRUPUS AGILIS</i>	<i>SPILOSCUS MACULATUS</i>	<i>PHALANGER GYMNOTTIS</i>	<i>PHALANGER MIMICUS</i>	<i>PHALANGER</i> SP.	<i>DACTYLOPSILA TRIVIRGATA</i>	<i>UROMYS CAUDIMACULATUS</i>	SMALL MURID	PTEROPODIDAE	MICROCHIROPTERA	SUIDAE	CERVIDAE	CANIDAE	FROG	BIRD	CROCODILE	CHELUID TURTLE	BOIDAE	COLUBROIDEA	UNIDENTIFIED SNAKE	VARANIDAE	AGAMIDAE	ARIIDAE	PTOTOSIDAE	LUTJANIDAE	LABRIDAE	UNIDENTIFIED FISH	PORTUNIDAE TYPE A	PORTUNIDAE TYPE B	XANTHIDAE			
1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
2	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2		
3	0	0	0	0	1	0	0	0	0	2	0	0	3	0	0	0	3	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	
4	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	
5	0	0	0	0	1	0	0	1	0	0	0	0	3	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	54	
6	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	19	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	51	
7	0	0	0	0	1	0	0	0	0	0	0	0	7	0	0	0	16	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40	
8	0	0	0	0	0	0	0	2	0	0	0	0	8	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	
9	0	0	0	0	0	0	0	1	0	3	0	0	5	0	0	15	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	7	0	0	34		
10	0	0	0	0	0	0	0	0	0	2	0	0	9	0	1	9	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	41	
11	0	0	0	0	0	0	0	0	0	4	0	1	10	0	0	11	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	34	
12	0	0	0	0	0	0	0	2	0	0	0	0	9	0	0	8	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	38	
13	0	0	0	0	1	0	1	0	0	0	0	0	3	0	0	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	
14	0	0	0	0	0	0	0	0	0	0	2	0	11	0	0	14	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	
15	0	0	0	0	0	0	0	2	1	0	0	0	6	0	0	5	5	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	
16	0	0	0	0	1	0	0	0	0	1	0	1	10	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
17	0	0	0	0	1	0	0	2	0	0	0	0	3	0	0	5	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	
18	0	0	0	0	0	0	0	3	0	1	1	0	3	0	1	8	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21	
19	0	0	0	0	0	0	0	3	0	3	0	0	5	0	2	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	
20	0	0	0	0	2	0	1	1	0	1	1	1	3	1	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	
21	0	0	0	0	2	0	0	1	0	0	0	0	1	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
22	0	0	0	0	5	0	1	1	0	0	0	0	4	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

continued over

Weight (g) of Bone for each Identified Taxonomic Group and Weight of Bone in Each Burning Category by Spit

SPIT	TOTAL UNBURNT BONE	TOTAL LIGHTLY BURNT BONE	TOTAL BURNT BONE	TOTAL CALCINED BONE	TOTAL ALL BONE	TACHYGLOSSIDAE	DASYURIDAE	PERAMELOIDEA	MACROPODIDAE	PHALANGERIDAE	PETARIDAE	MURIDAE	CHIROPTERA	SUIDAE	CERVIDAE	CANIDAE	FROG	BIRD	CROCODILE	CHELUID TURTLE	SNAKE	VARANIDAE	AGAMIDAE	FISH	UNIDENTIFIED BONE
1	1.2	1.0	0	8.0	10.1	0	0	0	0	0.6	0	0	0	0	0.1	0.3	0	0	0	0	0	0	0	0	9.2
2	2.5	3.3	0.7	16.8	23.3	0	0	0	0	0.7	0	0	0.1	1.8	0	0	0	0	0	0	0	0.3	0	0.2	20.2
3	3.9	4.0	0.5	8.5	16.9	0	0	0.3	0.6	1.3	0	0	0.4	2.8	0	0	0	0	0	0	0	0	0	0.8	10.9
4	8.0	1.0	0.5	2.8	12.2	0	0	0	0.7	0.2	0	0	0.2	2.2	0	0	0	0	0	0	0	0	0	2.3	6.7
5	8.9	4.4	1.0	2.8	17.0	0	0	0.2	0.1	0.3	0	0	0.2	0.4	0	0	0	0	0	0	0	0	0	1.7	14.2
6	5.1	2.6	0.7	0.7	9.0	0	0	0	0	0.1	0	0	2.4	0.8	0	0	0	0	0	0	0	0	0.1	2.1	3.7
7	7.0	1.4	0.6	3.1	12.2	0	0	0.3	0	1.0	0	0	3.7	0	0	0	0	0	0	0	0	0.3	0	1.2	5.8
8	9.7	3.6	0.6	1.1	14.9	0	0	0	1.5	1.9	0	0	0.5	0	0	0	0	0	0	0	0	0	0	3.3	7.8
9	10.5	4.9	1.0	1.4	17.7	0	0	0	2.8	2.3	0	0	1.5	2.8	0	0	0	0	0	0	1.5	0	0	3.4	3.5
10	11.8	5.0	3.8	1.3	21.9	0	0	0.1	0.2	2.6	0	0	1.5	0	0	0	0	1.2	0	0	0.8	0	0	2.5	12.3
11	10.0	3.1	8.1	2.2	23.4	0	0	0	0.5	6.7	0	0	1.9	0	0	0	0.1	0	0	0	0.3	0	0	3.8	10.1
12	10.6	3.5	2.5	2.9	19.5	0	0	0	1.7	1.5	0	0	1.9	0	0	0	0	0	0	0	0.2	0	0	5.9	8.4
13	6.1	5.6	1.5	1.1	14.2	0	0	0.1	0.5	0.9	0	0	0.4	0	0	0	0	0	0	0	0.1	0	0	1.6	10.7
14	15.4	6.6	2.6	0.6	25.1	0	0	0	1.2	7.2	0	0	1.9	0	0	0	0	0	0	0	0.3	0.4	0	5.3	8.8
15	14.2	3.3	1.3	4.2	23.0	0	0	0	3.1	2.2	0	0	0.8	0	0	0	0	0	3.2	0	0.5	0	0	4.3	8.9
16	20.8	9.0	2.5	0.8	33.1	0	0.1	0.1	0.5	3.7	0	0	1.6	0	0	0	0	0	0	0	3.7	0	0	7.1	16.3
17	9.5	3.8	1.9	0.3	15.5	0	0	1.1	0.3	2.4	0	0	1.6	0	0	0	0	0	0	0	0.6	0	0	1.1	8.4
18	21.7	16.8	4.6	0.4	43.5	0	0	0	2.9	5.2	0	0	2.5	0	0	0	0	0	0	0	4.6	0	0	5.6	22.3
19	31.5	7.6	5.2	1.1	45.3	0	0	0	3.4	7.0	0	0	1.1	0	0	0	0	0	0	5.8	6.6	0	0	1.2	19.9
20	27.3	10.3	2.5	2.7	42.7	0	0	1.3	4.3	8.4	0.3	0	0.6	0	0	0	0	0	0	0.7	1.8	0	0	2.3	23.1
21	23.3	10.6	3.7	0.1	37.7	0	0	1.3	3.6	0.8	0	0	0.4	0	0	0	0	0	0	3.3	4.6	0.6	0	1.4	21.1
22	15.9	10.9	5.7	3.1	35.6	0	0	1.1	1.7	2.8	0	0	1.0	0	0	0	0	0	0	0	4.5	0.3	0.2	3.0	20.9
23	47.4	10.3	4.1	1.3	63.1	0	0	1.9	6.0	5.6	0	1.3	0	0	0	0	0	0	0	2.2	3.5	0.7	0	3.9	38.1
24	33.3	17.4	3.5	1.4	55.6	0	0	0.7	7.7	2.7	0	0	0	0	0	0	0	0	0	0	3.6	0.4	0	4.9	35.7
25	48.1	20.6	6.8	2.4	77.9	0	0	2.6	15.8	3.9	0	0	0.5	0	0	0	0	0	0	0.6	5.5	1.5	0.2	2.3	45.1
26	32.0	19.6	14.5	2.7	68.8	0	0	0.6	8.4	6.7	0	0.8	0.1	0	0	0	0	0	0	1.3	5.3	0	0.2	4.4	41.1

continued over

Weight (g) of Bone continued

SPLIT	TOTAL UNBURNT BONE	TOTAL LIGHTLY BURNT BONE	TOTAL BURNT BONE	TOTAL CALCINED BONE	TOTAL ALL BONE	TACHYGLOSSIDAE	DASYURIDAE	PERAMELOIDEA	MACROPODIDAE	PHALANGERIDAE	PETAURIDAE	MURIDAE	CHIROPTERA	SUIDAE	CERVIDAE	CANIDAE	FROG	BIRD	CROCODILE	CHELUID TURTLE	SNAKE	VARANIDAE	AGAMIDAE	FISH	UNIDENTIFIED BONE
27	33.1	11.8	6.9	3.0	54.9	0	0	0.3	6.0	7.7	0.2	0.7	0.7	0	0	0	0	0	0	0	2.2	2.8	0	3.4	31.0
28	66.9	35.8	14.3	23.4	140.3	0	0	0.3	20.1	8.9	1.0	0	0.4	0	0	0	0	0	0	0	11.0	0.5	0.1	9.1	88.9
29	43.6	22.6	12.8	14.3	93.3	0	0	0	13.6	2.8	0	0.2	1.0	0	0	0	0	0	0	0	6.5	0.9	0.2	4.3	63.8
30	73.3	52.6	18.3	9.0	153.1	0	0	1.4	16.7	9.9	0	0.3	1.7	0	0	0	0	0	0	0	14.5	2.0	0.4	1.9	104.5
31	66.5	54.0	17.1	20.1	157.5	0	0	0.6	14.8	3.8	0.2	0	2.0	0	0	0	0	0	0	0	16.4	0	0.6	2.3	117.0
32	75.1	56.3	16.0	22.7	170.0	0	0.1	1.1	13.3	1.9	0	0.8	0.9	0	0	0	0	0	0	0	19.6	0.1	0	1.8	130.6
33	123.5	54.3	15.1	18.6	211.4	0	0	4.2	21.4	6.8	0	0.2	0.8	0	0	0	0	0	0	0	2.9	0	0	0.2	174.9
34	163.5	60.3	16.2	14.3	254.3	0	0	8.0	48.1	9.9	0	0	3.6	0	0	0	0	0	0	0	19.1	0	0	0.8	164.7
35	157.3	55.7	39.6	12.9	265.4	0.5	0	2.4	41.0	5.1	0	0	1.0	0	0	0	0	0	0	0	15.9	1.9	0	0.8	197.4
36	140.7	30.2	11.0	6.3	188.2	0	0	2.1	18.2	6.3	0	0	0.8	0	0	0	0	0	0	0	7.3	0	0.9	0.3	152.5
37	126.7	28.9	15.0	9.6	180.3	0	0.3	2.5	27.1	2.7	0	0	0.2	0	0	0	0	0	0	0	13.5	0.6	0.2	0.3	132.9
38	181.1	45.6	10.0	13.7	250.4	0	0	7.2	38.9	1.2	0	0	0.8	0	0	0	0	0	0	0	18.0	0.4	0	0	183.7
39	103.3	14.8	3.2	7.2	128.6	0	0	0.8	10.6	2.8	0	0	1.1	0	0	0	0	0	0	0	9.7	9.8	0	0.3	93.4
40	126.4	7.1	3.1	2.2	138.7	0	0	1.6	9.5	0	0	0	0	0	0	0	0	0.4	0	0	0.3	0	0	0	126.9
41	75.5	7.1	5.4	5.1	93.1	0	0	1.8	14.2	0.6	0	0	0.9	0	0	0	0	0	0	1.6	0	0	0	0	73.9
42	61.9	6.9	1.1	4.5	74.4	0	0	0.5	8.7	0	0	0	1.7	0	0	0	0	0	0	0.4	0	0	0	0	63.1
43	5.9	2.1	0.9	0.1	9.0	0	0	0.1	0.6	0.1	0	0	2.1	0	0	0	0	0	0	0	0.4	0	0	0	5.7