ARCHAEOZOOLOGICAL RECORDS FOR THE HIGHLANDS OF NEW GUINEA:

A Review of Current Evidence

Alice Sutton[1], Mary-Jane Mountain[2], Ken Aplin[3], Susan Bulmer[4] and Tim Denham[1]

Abstract

Archaeozoological records for seven occupation sites in the highlands of New Guinea are presented and reviewed. The sites were originally excavated between 1959 and 1981. More recent excavations have not documented comparable archaeozoological records. This paper aims to summarise unpublished research, together with some previously published results, for a broader audience, and elicit general trends within the data. Of significance are methodological insights, observations on Pleistocene and Holocene extinctions and the introduction of exotic fauna, and implications for understanding land-use and socio-economic histories during the late Holocene.

Introduction

The mountainous highlands of New Guinea (land above 1200m above mean sea level) support exceptionally high levels of animal diversity and endemism (Mittermeier *et al.* 2003:10311; Olson *et al.* 2001:936). Several species of mammal, predominantly subalpine and alpine grassland taxa, are known only from a single mountain range (Flannery 1995). New Guinea, like Australia (Roberts *et al.* 2001), experienced a loss of faunal diversity through megafaunal extinction during the late Pleistocene, with further extinction of medium-sized mammals through the Holocene (Flannery *et al.* 1983, 2002; Hope *et al.* 1993; Menzies and Ballard 1994; Mountain 1991).

Human occupation of the highland interior of New Guinea is known to date back to at least 35,000 BP (Fairbairn *et al.* 2006). In a recent review, Fairbairn *et al.* (2006:381) suggested that there was sustained, albeit low intensity, human occupation of the highlands from c.35,000 BP (Hope 1998), with increased intensity of occupation and impact after 20,000 BP. However, there is ongoing debate over the nature and permanency of early occupation (Denham 2007), and a pressing need for more precise evidence on both the timing and causality of mammalian extinctions.

During the Holocene, the highlands underwent significant social and economic transformation largely due to the emergence, development and expansion of agriculture from at least c.7000–6500 cal BP (Denham 2003; Denham *et al.* 2003). Complementary archaeological and palaeoecological research reveal that forest clearance for cultivation had commenced by the early Holocene (Denham *et al.* 2003; Haberle 2003) and may have intensified and become more widespread from approximately 4000 years ago (Powell 1982). In addition to land clearance for agriculture, hunting and the introduction of exotic fauna are likely to have affected faunal distributions and abundances during the Holocene, although the scale and timing of such impacts are not well-documented. Exotic introductions include dogs (*Canis* sp.), pigs (*Sus scrofa*), chickens (*Gallus gallus*) and several rodents (*Rattus* spp.).

This paper is the first systematic review of faunal assemblages at archaeological sites in the highlands of New Guinea (cf. Bulmer 1982). A review of this much neglected data is overdue and imperative to understanding human-animal interactions over the long-term, particularly in comparison to recent vegetation (Hope and Haberle 2005) and agricultural (Denham and Haberle 2008) histories of human-plant relationships in highland valleys, as well as recent zooarchaeological research in lowland New Guinea (Hope and Aplin 2005; Pasveer 2003) and Island Melanesia (Leavesley 2005). Following the zooarchaeological review, several issues of general relevance are discussed, including methodology, Pleistocene and Holocene extinctions, introduction of exotic fauna, and both land-use and socio-economic histories.

Methods

Zooarchaeological assemblages from seven highland sites are presented: Yuku, Kiowa, Aibura, Batari, Kafiayawa (Kafiavana), Kamapuk and Nombe (Figure 1; Table 1). Findings at other sites are not considered in detail because: they were not formally excavated nor faunal analyses quantified, for example, Kelangurr Cave (Flannery 1992a; Hope *et al.* 1993), Mapala Rockshelter (Hope 1981; Hope and Hope 1976) and Bilingeek Rockshelter (Hope *et al.* 1993); they contained no or little faunal material, for example, Omkombogo (White 1967), NFX (Watson and Cole 1977) and Wañelek (Bulmer 1991); they were non-archaeological in nature, for example, West Baliem River (Flannery 1992a) and Pureni Swamp (Flannery and Plane 1986); or, the faunal assemblages remain undescribed or were poorly described, for example, NFB, NFC, NFI, NFJ, NFN, NGM and NGY (Watson and Cole 1977), Manim, Etpiti and Tugeri in the Wurup Valley (Christensen 1975), and Anbannigl, Tsak Pumakos A and B (Kobayashi and Hayakawa n.d.). Of the seven sites considered here, four have only been reported in unpublished theses or reports (Aplin 1981; Bulmer 1966, 1979; Mountain 1991).

The faunal analyses undertaken at each site varied greatly in terms of degree of identification, method of quantification, stratigraphic and chronological control, and analysis of taphonomic factors affecting formation of the archaeofaunal record. Earlier analyses were hindered by a lack of faunal reference material or expertise; identifications were generally limited to cranial elements. More comprehensive identifications, including post-cranial elements, were limited to two sites, Nombe (Mountain

---

[1] School of Geography and Environmental Science, Monash University, Clayton, VIC 3800, Australia Alice.Bedingfield@arts.monash.edu.au; Tim.Denham@arts.monash.edu.au
[2] School of Archaeology and Anthropology, Australian National University, Canberra, ACT 0200, Australia Mary-Jane.Mountain@anu.edu.au
[3] Australian National Wildlife Collection, CSIRO, GPO Box 284, Canberra, ACT 2601, Australia Ken.Aplin@csiro.au
[4] Bulmer and Associates, 10 Tansley Avenue, Epsom, Auckland 1023, New Zealand sueb@titan.co.nz

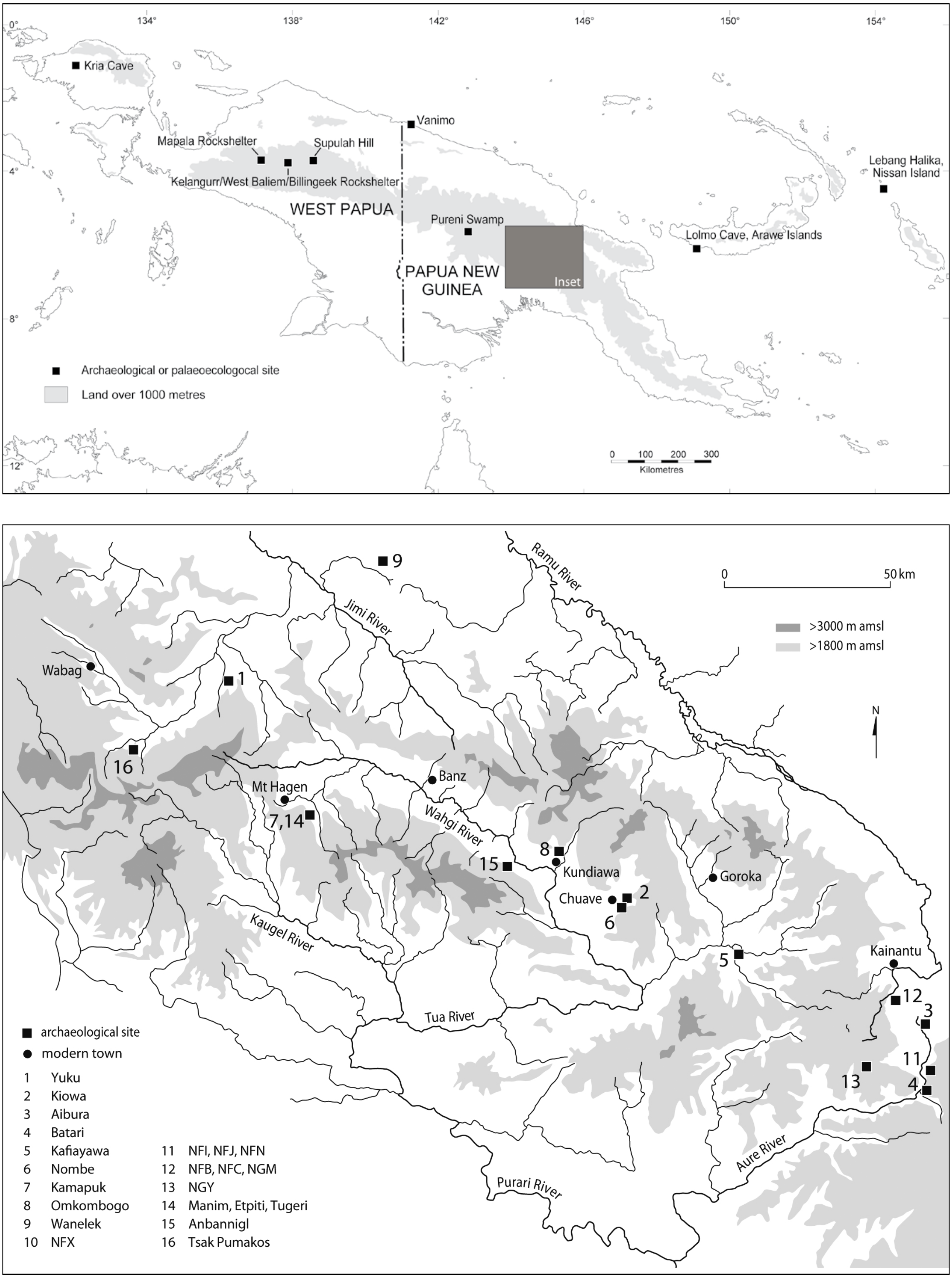

Figure 1 Papua New Guinea, showing sites discussed in the text.

1990, 1991) and Kamapuk (Aplin 1981); taphonomic issues of site formation processes and modes of deposition of faunal remains were also investigated at these sites. All analyses were compromised to varying extents by incomplete taxonomic knowledge of New Guinean mammals which has undergone a progressive and major overhaul since the 1980s (Flannery 1995; Helgen 2007).

To facilitate analysis, all previously published (White 1972) and unpublished data (Aplin 1981; Bulmer 1979; Mountain 1991) were compiled and presented using Tilia 2.0.b.4 and TGView 2.0.2 (Grimm 2004), programmes commonly used by palynologists and palaeobotanists to display chronostratigraphic data. Where the volume of excavated units is known (Mountain 1991; White 1972), or has been estimated (Aplin 1981), density of remains is presented rather than raw counts. At Kiowa and Yuku, the volumes of excavated units are unknown, hence raw counts are used. Depositional zones were defined based on visual comparisons of the faunal data from each site, except Nombe where the original stratigraphic divisions were followed. Cluster analysis of stratigraphic zones was not undertaken due to the sparseness and inconsistency of data for most sites.

Faunal quantification methods follow the original method of the excavator and vary between Minimum Number of Individuals (MNI), Number of Individual Specimens (NISP), or a combination of the two methods (Table 1). The different methods used complicate comparisons between sites, as well as between taxa within a site at Yuku and Kiowa. Quantitative comparisons between sites are precluded due to these methodological constraints, although it is possible to identify general trends and patterns. The original data from Nombe were calculated using both MNI and NISP; here NISP is used to allow comparison with Kamapuk. Nombe and Kamapuk are the most recently analysed and data-rich of the highlands sites, reflecting the combination of good faunal preservation, high density of remains, more precise field sampling, and inclusion of post-cranial elements in the faunal analyses.

The radiocarbon dating at each site is variable in quality, hindering a detailed temporal analysis of faunal assemblages (Table S1, supplementary information). Except where archaeological horizons are well-constrained by radiocarbon dates, occupation periods are discussed in general chronological terms: late Pleistocene (before c.18,000 cal BP), terminal Pleistocene (c.18,000-11,700 cal BP), early Holocene (c.11,700-7800 cal BP), mid-Holocene (c.7800-4000 cal BP) and late Holocene (c.4000 cal BP to present). Although no new study or identification of archaeozoological remains was undertaken for this paper, original data are presented and reinterpreted with reference to recent multidisciplinary research, including advances in mammalian taxonomy.

Zooarchaeology of Highland Sites

Yuku

Yuku is a rockshelter located deep in Lanim Gorge in Western Highlands Province, close to the junction of the

Table 1 Summary of systematic archaeological excavations at highland occupation sites discussed in the text.

Site Name	Altitude (m)	Province	Main Excavator	Main Field Seasons (years)	Period of Occupation (BP)	Period of Occupation (cal BP)	Faunal Quantification Method	Faunal Analyst	Principal Publications
Kamapuk	2050	Western Highlands	Ole Christensen	1972-1974	c.4340-<2540	c.5050-<c.2595	NISP	K. Aplin	Aplin 1981; Christensen 1975
Nombe	1720	Simbu	Mary-Jane Mountain	1971, 1974-1975, 1979-1980	c.30,000-present	Not available	NISP and MNI	M-J. Mountain; L. Dawson (Thyclacine); T. Flannery (Macropods); G.G. George & J. Menzies (Phalangerids & Pseudocheirids); J. Menzies (Chiroptera); J. Van Tets & D. Spencer (Birds); C. Pardoe (Human Remains); K. Aplin; J. Hope	Mountain 1991
Aibura	1640	Eastern Highlands	Peter White	1964-1965	c.3800-<770	c.4170-<c.920	MNI	J.P. White; J.H.Calaby (Mammals); J.A. Mahoney (Muridae); D.F. McMichael (Mollusca)	White 1972
Kiowa	1530	Simbu	Susan Bulmer	1959-1960	>10,350-<4840	>c.12210-<c.5605	Combination of NISP and MNI	J. Menzies	S. Bulmer 1966, 1975, 1979, 1982
Kafiayawa (Kafiavana)	1350	Eastern Highlands	Peter White	1964-1965	>10,730-c.4500	>c.12440-c.5000	MNI	J.P. White; J.H.Calaby (Mammals); D.F. McMichael (Mollusca)	White 1972
Batari	1300	Eastern Highlands	Peter White	1964-1965	>8230–c.850	>c.9095-c.755	MNI	J.P. White; J.H.Calaby (Mammals); D.F. McMichael (Mollusca)	White 1972
Yuku	1280	Western Highlands	Susan Bulmer	1959-1960	>12,100–<4570	>c.14185-<c.5265	Combination of NISP and MNI	J. Menzies	S. Bulmer 1966, 1975, 1979, 1982

Yuem and Lanim rivers, both tributaries of the Lai River. In 1959, the shelter was situated within a gardening area, only 50m from the nearest homestead (Bulmer 1966:115). The rockshelter overhangs approximately 21m², of which 9.5m² was excavated to a maximum depth of 3.6m. Seven stratigraphic layers were identified according to changes in colour, texture and inclusions; the basal layers became progressively calcified. Three zones of occupation, as well as a period of use for human burial, have been identified for Yuku based on the chronological distribution of faunal remains (Figure 2), stone and shell artefact distributions, and archaeobotany (Horrocks *et al.* 2008).

Zone 1, dated to the terminal Pleistocene (Table S1), contains considerably less bone and stone than the more recent zones, suggesting a limited human presence. Zone 2 (early to mid-Holocene) witnesses more intensive site use, with increased deposition of faunal remains, associated with 'a cache of large flake implements, a flat grindstone, and some evidence of grinding on large stone tools' (Bulmer 1979:3). Cuscuses are dominant in the fauna, in particular *Phalanger carmelitae*, and pig is present in small numbers throughout. Zone 3 was associated with human burials and is not considered here (Bulmer 1966). Zone 4 (primarily late Holocene) is characterised by a reduction in bone deposition and an increase in pig remains relative to other taxa. The faunal assemblage indicates hunting in both primary and secondary forest habitats. Apart from the decrease in overall bone quantities in Zone 4, there is no strong signature of forest clearance on the scale observed ethnographically.

Kiowa

Kiowa is a rockshelter situated near the entrance of a large cave and less than 10m from a small stream, approximately 2km southeast of Chuave Station, Chimbu Province (Bulmer 1966:90). Deposits seemingly containing multiple lenses of fire ash, interleaved with adjacent soils at the edges of the rockshelter, were excavated to a maximum depth of 3.65m. Twelve stratigraphic layers were identified; the lowest two excavation levels were constrained due to large limestone boulders, which 'undoubtedly qualify any conclusions that might be made about the character of the early habitation of the site, as the area sampled is so small' (Bulmer 1966:91). Due to logistical difficulties, only a selection of faunal material could be brought back for analysis (Bulmer 1979:5), including all crania, all large animal bones, all worked bone, all eggshell and two 30cm x 30cm bags of bulk bone from each layer.

Human occupation at Kiowa is divided into four main periods primarily based on patterns in the distribution of faunal remains (Figure 3). Zone 1A (Pleistocene/Holocene transition) represents a period of initial use of the site, perhaps as a temporary shelter. Zone 1B (early Holocene) saw the deposition of large quantities of fruit-bat bones, primarily of *Aproteles bulmerae* and *Dobsonia magna* (previously classified as *D. moluccensis* ssp. *magna*) (Menzies 1977). A high rate of deposition of faunal remains is inferred given the comparatively small excavated area and potentially short period of

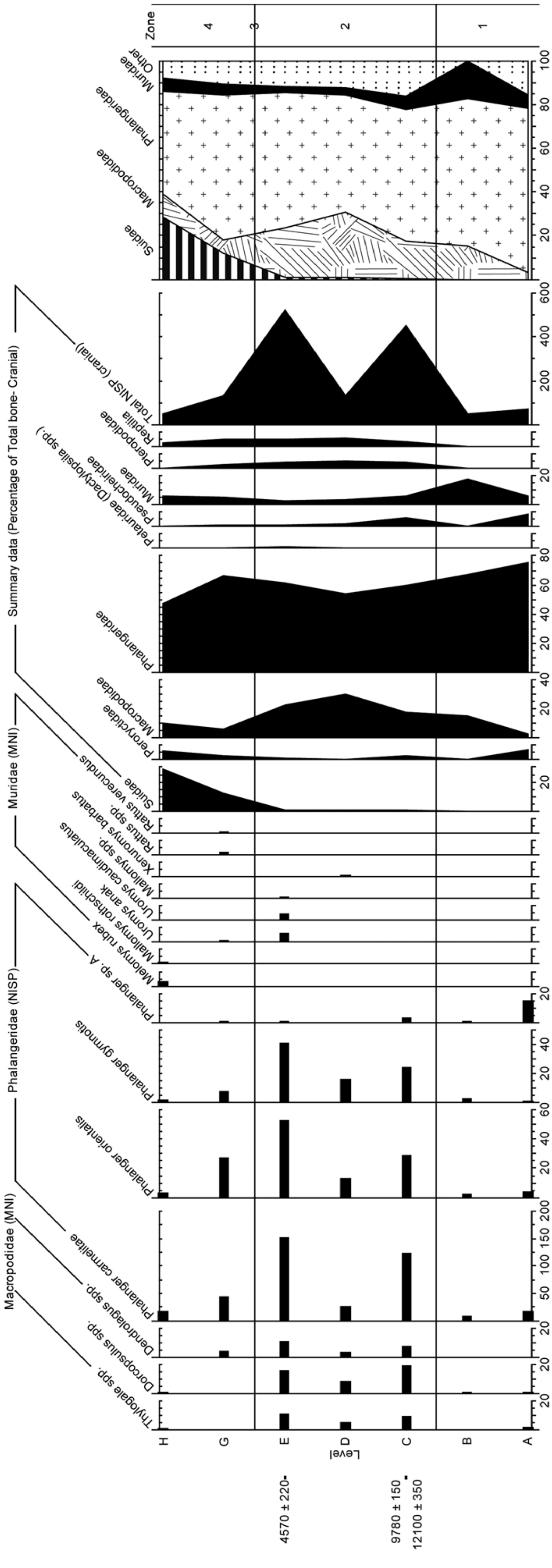

Figure 2 Archaeofaunal summary for Yuku (Bulmer 1979).

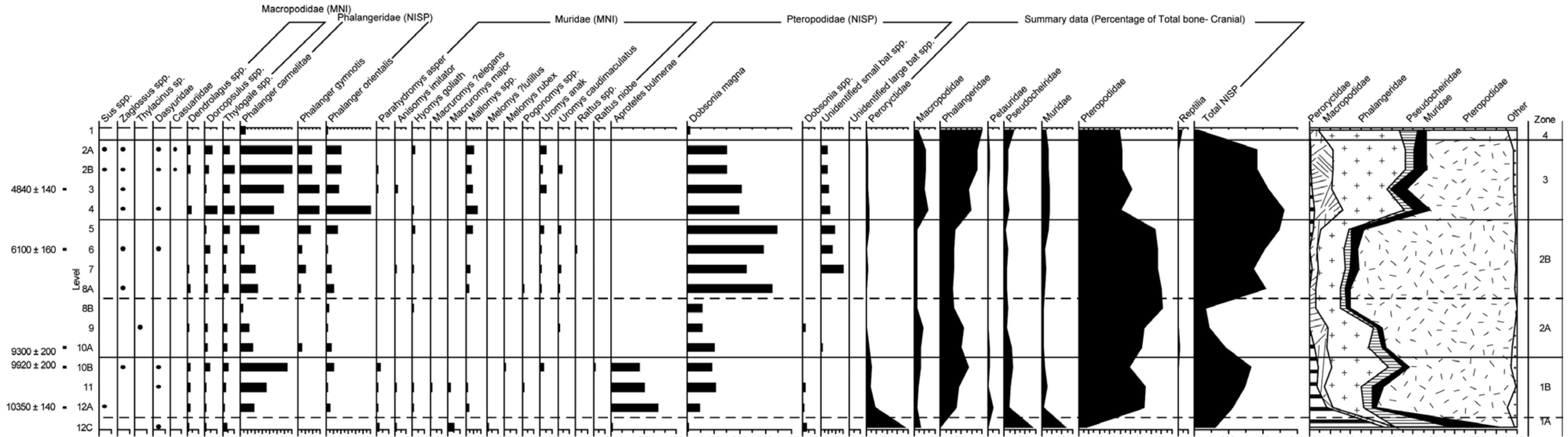

Figure 3 Archaeofaunal summary for Kiowa (Bulmer 1979). Dots represent taxon present in small quantities.

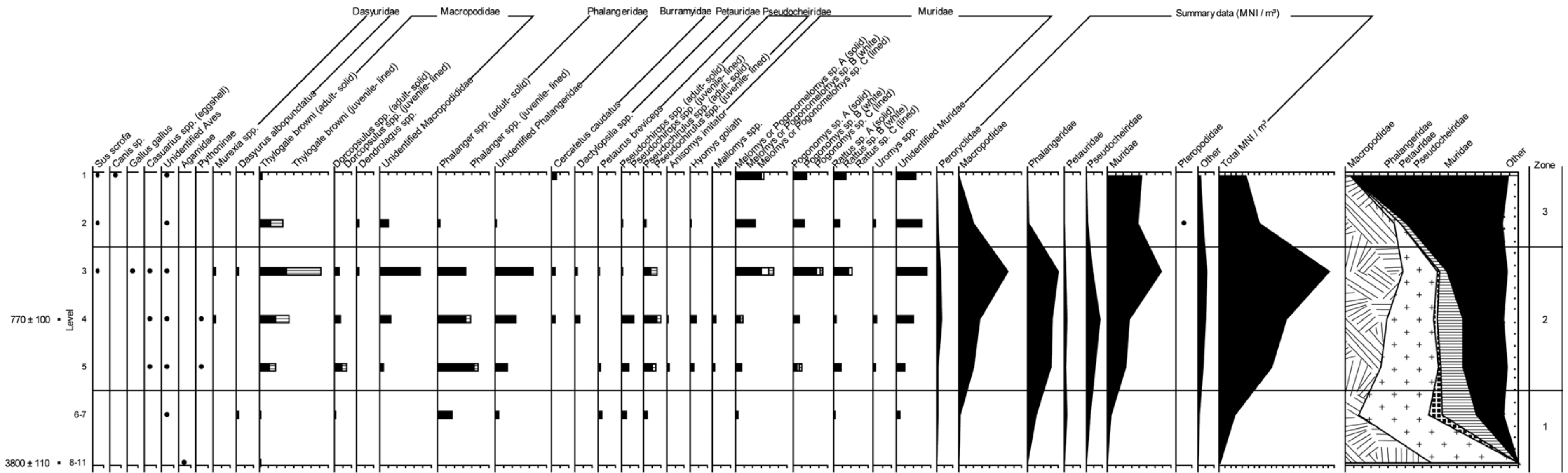

Figure 4 Archaeofaunal summary for Aibura (White 1972). Dots represent taxon present in small quantities.

time over which the remains were deposited. *A. bulmerae* appears to have become locally extinct shortly after Zone 1 ended. Controversially, remains of *Sus scrofa* were found in this zone; direct dating of selected pig teeth failed to confirm their antiquity (see below). Zone 2A (early Holocene) probably represents a period of lower intensity site use; a gradual increase in the relative frequency of *D. magna* is observed. Remains of now extinct *Thylacinus* sp. are present in Zone 2A (Van Deusen 1963). Zone 2B (early to mid-Holocene) represents a period of intense and systematic hunting of *D. magna*, which accounts for more than 70% of faunal remains. An increase in small bat remains in Zone 2B may be due to natural deaths below a colony or indicate an increase in dietary stress, with a shift onto smaller prey. Taphonomic analysis is needed to clarify this point. The most recent level of Zone 2B marks the initial appearance of ground axe-adzes and waisted blades.

Zone 3 (mid-to-late Holocene) marks a change in the relative contribution of different taxa to the faunal record. In particular, the number of large bats decreases relative to macropodids and cuscus. Pig bone is present above Level 2B, as are grindstones. The change in faunal composition may correspond to a change in site use, possibly due to a reduction in local populations of *D. magna* through overhunting. The occurrence of a long-beaked echidna (*Zaglossus* sp.) throughout this zone suggests that human impacts on the local environment were fairly modest up to the late Holocene. Echidnas are particularly susceptible to overhunting and they are now absent from any part of the highlands where human population density is high (Flannery 1995:71-73). The consistent presence of *Phalanger carmelitae*, *Mallomys* spp. and other primary forest dwellers during Zone 3 supports this inference. Zone 4 represents a period of disuse of the site during the late Holocene (Bulmer 1979:4).

Aibura

Aibura is located approximately 19km southeast of Kainantu. It is a four-chambered cave within a limestone block that rises out of a swampy valley draining into Kondanauta Creek, a tributary of the Lamari (White 1972:51). In 1964–1965, the valley floor contained numerous old gardens and was covered in tall grasses, with stands of trees close to water courses and on surrounding peaks (White 1972). White (1972) identified three occupation 'horizons' based on the distribution of artefacts; an alternative tripartite division of human activity is proposed here based on the density and diversity of faunal remains (Figure 4).

Zone 1 (from c.4450-3890 cal BP, Levels 11-6; Table S1) exhibits low but an increasing density and diversity of remains, with possums and cuscuses the dominant taxa. In Zone 2 (Levels 5-3) the quantity and diversity of fauna increases, with macropodids and murids increasing proportionally to possums and cuscus. The site was probably used fairly regularly as a base for hunting; some primary forest was still within walking distance. An increase in *Thylogale browni* towards the end of Zone 2 may be indicative of grassland patches established within a forest mosaic. Remains of *Sus scrofa* and *Gallus gallus* are present from Level 3 and represent a strong indictor of a nearby agricultural settlement. In Zone 3 (Levels 2-1), representing the last c.500 years, the site was used as a shelter by people gardening nearby, as observed by White in 1964-1965. Taxa often indicative of primary forest, such as cuscus, *Mallomys* spp. and cassowary (eggs) are virtually absent, and overall density of faunal remains is low. The considerable number of small murids in Zones 1 and 2 are most likely the prey remains of owls and detailed analysis of this material could yield information on local environments.

A major change in cultural remains occurs between Levels 4 and 5, dated to 910–620 cal BP (Table S1). Level 4 marks the first occurrence of marine shell and shell artefacts, pottery and small ground artefacts. The changes evidenced in Level 4 suggest pervasive social changes that are only subtly indicated in the faunal record. It is possible that the period dating from c.910–620 cal BP at Aibura saw increased trade and exchange, as well as an increased focus on pigs as part of a more sedentary lifestyle.

Batari

Batari is a small cave situated within steep relief of incised volcanics, tuffaceous sandstones and calcarenites. In the late 1960s the area was sparsely populated and gardens were scattered across the landscape (White 1972:11). Nearby hills were covered with grass, though *Casuarina* and pine grew next to streams and isolated peaks supported remnant forests (White 1972:11). White (1972) divided excavated material into four arbitrary horizons owing to an overall lack of observable stratigraphy. The only observable stratigraphic feature was a complex of hearths near the top of the deposit which appeared undisturbed, as did the material encased below.

The small number and low taxonomic resolution of identifications of faunal remains at Batari limit a detailed interpretation of human-faunal interaction and preclude division of material into zones based on faunal remains (Figure 5). The average rate of deposition of faunal remains through the sequence is estimated at only one animal per 40 years. The faunal assemblage consists mainly of small-to-medium sized possums and cuscuses, macropodids and murids, and there is little overall change in the relative proportions of these taxa through time. Density of faunal remains is highest in Horizon IV, dated to at least c.8650 cal BP (Table S1). Pig remains in the most recent horizon, dated to 830–680 cal BP (Table S1), are approximately contemporaneous to the earliest pig bone at Aibura. A humerus fragment in Horizon II was tentatively identified as *Gallus gallus*. Similarly to Aibura, the initial occurrence of pig coincides with the first appearance of marine shells, and certain stone artefact types including 'small ground-stone artefacts' (White 1972:20).

Kafiayawa (Kafiavana)

Kafiayawa (Kafiavana) is a small rockshelter located on the banks of the Fayantina River, 19km southeast of Goroka. The spelling of the site name has recently been revised to Kafiayawa (Vincent Pou, pers. comm., 2007). The shelter is situated half-way up an 80m high calcareous siltstone outcrop (White 1972:83); the surrounding valley floors are poorly drained and contain *Phragmites* swamp. Anthropogenic grassland covers most of the surrounding ridges, with isolated pockets of garden and garden regrowth (White 1972:83). According to the people of Legaiya village, the site was used occasionally as a refuge during conflict prior to European arrival (White 1972:83).

Like Batari, the small quantity of faunal remains and low taxonomic resolution of identifications at Kafiayawa preclude a division into zones based on faunal remains (Figure 6). An average deposition rate of less than one animal per 60 years is estimated for the sequence as a whole. *Sus scrofa* was present in contexts dated from c.10,820–10,200 cal BP to c.5740–4950 cal BP (Table S1), but recent direct dating suggests that pig remains are very recent (Hedges *et al.* 1995:428). There is generally a weak correlation between densities of faunal remains and stone implements, except in the upper horizons (I-IV), where they seem to be negatively correlated. In particular, very little bone is present in Horizon VII, which comprises the upper part of a stone artefact concentration (White 1972:92). Taphonomic factors relating to deposition or preservation of bone may explain this unusual pattern of bone relative to artefact densities (White 1972).

Nombe

Nombe is located on the eastern slopes of the Erimbari limestone escarpment, approximately 2.5km southeast of Kiowa rockshelter. In Pleistocene times Nombe was a large cave at the base of a cliff with an active stream flowing through the middle. Today, the site comprises a long shelter (roughly 18m x 4m) with only a very small cave at the rear. At the time of excavation, the adjacent slope was periodically gardened and left fallow to regenerate with secondary vegetation (Mountain 1991). Nombe was first excavated in 1964 by Peter White, however due to 'considerable natural disturbance' no clear stratigraphy was observed and the excavated portion of the site was divided into two arbitrary horizons (White 1972:127). The site was re-excavated by Mary-Jane Mountain during four field seasons between 1971 and 1981. Stratigraphy at Nombe is complicated by human activity during the late Pleistocene that locally admixed units. Natural processes added flowstones, tephra blocks and fallen limestone boulders to the accumulating sediments. Mountain divided the site into four broad stratigraphic and chronological units for analysis, Strata A-D, which provide a conservative chronological framework to interpret the complex site and are therefore retained here (Figure 7). Stratum D was divided into five subunits (D1 to D5) based on characteristics of the clay sediment present.

Three basal clays (Stratum D2/3/4) were amalgamated, representing the period from >32,000 BP to c.25,000 BP. These clays contained extremely sparse cultural materials, indicative of very occasional human visitation, and only small quantities of faunal remains, none of which can definitely be attributed to human predation (Mountain 1991). Two clay units (Stratum D1/5), dating from c.25,000 BP to <14,500 BP, contain small but significant quantities of artefactual material, including an edge-ground axe, a waisted artefact, ochre and a small proportion of burnt bone (Mountain 1991:4.17). Significantly, remains of three extinct megafaunal taxa (*Dendrolagus noibano*, *Protemnodon tumbuna* and an unidentified diprotodontid) occur in Stratum D1/5 (Flannery *et al.* 1983), but there is no direct evidence (e.g. burning or cut marks) of human predation. *Thylacinus cynocephalus* is present in Stratum D, and some faunal remains in this lowest stratum may be attributable to predation by thylacines (Mountain 1991). Animal taxa represented in Stratum D1/5 suggest human exploitation of both forest and alpine grassland environments, with the cave itself probably situated close to the treeline through the Last Glacial Maximum (Mountain 1991:8.39).

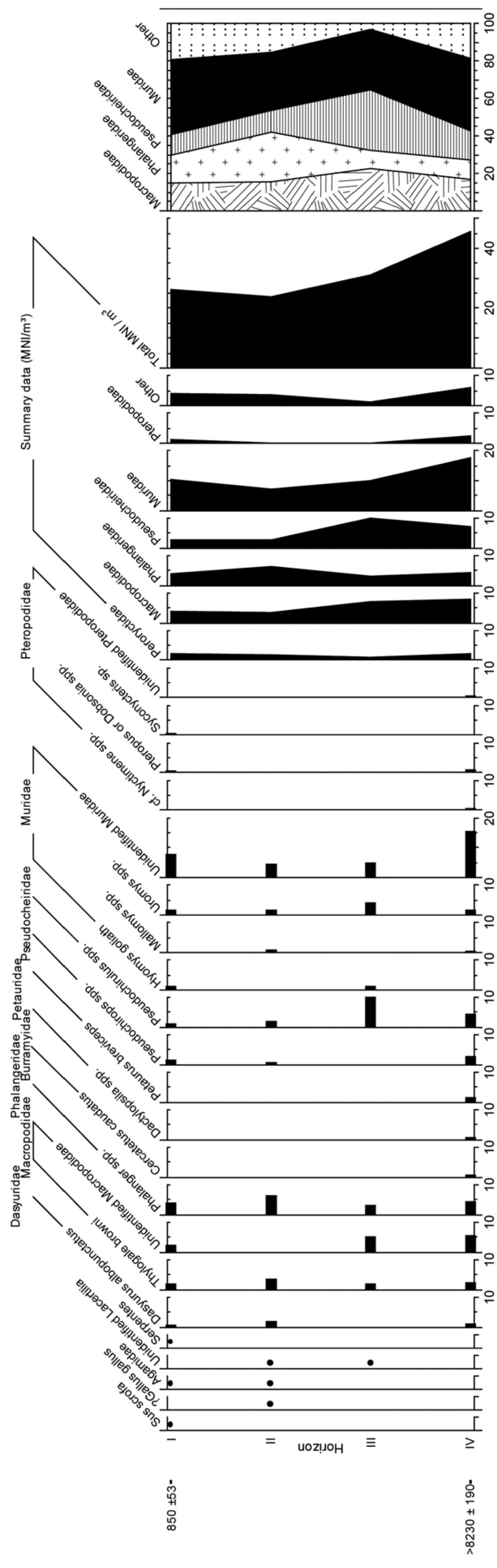

Figure 5 Archaeofaunal summary for Batari (White 1972). Dots represent taxon present in small quantities.

During Stratum C (terminal Pleistocene), human activity remained sporadic, as indicated by the very low quantities of both bone and artefacts (Evans and Mountain 2005). Much of Stratum C consists of culturally sterile flowstone and tephra-like blocks, but includes disturbed upcast from a small trench excavated at that time into Stratum D. These areas of 'mixed' deposit in Stratum C were excluded from faunal analysis (Mountain 1991:4.13). Within Stratum C frogs are still relatively abundant and bats and forest taxa dominate the assemblage; no extinct megafaunal remains were found in unmixed contexts.

Within Stratum B (early Holocene to c.6300-5440 cal BP; Table S1) there are greatly increased rates of deposition of burnt and broken bone, stone artefacts, egg shell and ochre. Marine shells and obsidian are suggestive of inclusion within extensive exchange networks (Hughes 1977). A decrease in the number of very small animals, in particular frogs, and an increase in medium-sized mammals (e.g. cuscus, *Dobsonia magna*) probably signal a reduced non-cultural (e.g. owl prey) component to the faunal assemblage and probably reflect an increasing frequency and/or intensity of site use. A decrease in the proportion of larger taxa (e.g. *Zaglossus* sp., *Dendrolagus dorianus*) may reflect the cumulative effects of direct (predation) and indirect (disturbance and habitat destruction) human impacts on local populations. However, the continued dominance of cuscuses (particularly *Phalanger carmelitae*; Mountain 1991:8.34) in the faunal record throughout the Holocene suggests continued exploitation of forest environments. A relative increase in medium-sized murids and small/medium macropodids (mostly *Thylogale browni*) in Stratum B may indicate forest disturbance locally and possibly even the establishment of grassland habitats, but could represent a shift in preferred hunting methods (Mountain 1991). Pig appears in Stratum B contexts, but direct dating suggests that these remains are intrusive (Hedges *et al.* 1995; see below).

Stratum A (c.6300-5440 cal BP to present; Table S1) exhibits lower rates of faunal deposition than Stratum B. Pig remains are more abundant in Stratum A. Remains of *Canis* sp. and *Thylacinus* sp. occur in Stratum A, possibly indicating their respective introduction and extinction some time within the last c.5500 years.

Kamapuk

During 1972–1973 Ole Christensen excavated a series of four rockshelters along an altitudinal gradient in the Wurup Valley (Christensen 1975); Kamapuk is the only site that has been subjected to detailed faunal analysis (Aplin 1981). Kamapuk is a small and narrow shelter located at the top of a small ridge between Kamapuk and Kanarui Creeks (Aplin 1981:22). In 1975, the site was situated within a zone of gardens and regrowth forest and was used occasionally by people collecting *Pandanus* and hunting birds and bats (Donoghue 1988:22).

The Kamapuk faunal sequence is divided into four zones (Figure 8). During Zone 1 (from 5300-4800 cal BP, Levels 15-13; Table S1) the site appears to have been used as an occasional camp for hunters accessing mid-montane and moss forest habitats. Zone 2A saw a marked increase in the rate of deposition of faunal remains (Levels 9-12) and a broader range of prey species. The balance of species present during Zone 2A suggests that forest disturbance, presumably for gardening, was already occurring in the vicinity of Kamapuk. The disappearance of cassowary from the record following Zone 1 could be a result of overhunting, changing patterns in the consumption of these highly valued taxa, increased value as exchange commodities, or consumption in more communal settings. However, the presence of *Zaglossus* sp. during Zone 2 suggests that hunting pressure was not yet severe. In Zone 2B (late Holocene, Levels 8-6), the density of faunal remains decreases while the range of species accessed increases slightly to include more mid-montane species. Donoghue (1988:82) has suggested that encroachment of the agricultural zone upon the area directly below Kamapuk forced people to hunt at progressively higher altitudes.

During Zone 3 (Levels 4-1; Aplin 1981) density of faunal remains is very low. Aplin (1981:56) suggests increasing disturbance of local forest environments based on the disappearance of a number of forest dwellers (e.g. *Dorcopsulus vanheurni*, *Petaurus breviceps*, *Dactylopsila* spp.). Interestingly, very few bird and bat remains are present, despite ethnographic reports suggesting these taxa were a major focus of hunting in recent times. Donoghue (1988:22) suggests that the site was an occasional camp or stopover for groups harvesting *Pandanus* and engaged in incidental hunting. Unlike other sites where the appearance of stone grinding is nearly contemporaneous with the initial appearance of pigs, ground stone axe-adzes first appear at Manim, which is around 300 vertical metres below Kamapuk, approximately 6000 years ago (Christensen 1975); pigs appear in the Kamapuk record after c.1000 BP.

Findings

Methodological Implications

The relative 'species richness' of the two most recently analysed sites, Nombe and Kamapuk (Table S2, supplementary information), is partly a consequence of access to more extensive reference material and the emphasis given to detailed taxonomic identifications. Additionally, the identification strategy for these sites included post-cranial as well as cranial elements, even though identification of many post-cranial elements can only be taken to genus or family level. At Nombe, *Zaglossus* sp. and *Casuarius* sp. are rarely represented by cranial elements, yet both are readily identified by post-cranial elements. The apparent paucity of these taxa in archaeological deposits at other sites (except Kamapuk) may therefore be a product of limiting faunal analyses to cranial elements.

Several other factors relating to site function and human selectivity in the consumption and disposal of different taxa, body parts and bones probably result in the under-representation of some taxa in highland assemblages (Bulmer 1976). For example, ethnographic sources document considerable economic and cultural importance for both echidnas and cassowaries. These taxa were more often consumed at communal events or used in ceremonial transactions than eaten at hunting or stopover locations (Dwyer 1990; Majnep and R. Bulmer 1977), thereby accounting, at least in part, for their limited occurrence in cave and rockshelter deposits. Ethnographic practices of selective curation of animal skulls and mandibles also influence which skeletal elements are preserved at different site types (Bulmer 1976); cranial elements in particular were sometimes retained and kept in men's houses and hunting shelters rather than discarded at the site of capture, butchering or partial consumption. Consequently, various elements may be under- or over-represented at different types of sites.

Another important methodological difference between sites is the resolution of field recovery. Most sites were sieved using ¼ inch (6.25mm) sieves, with the exception of Kamapuk (owing to Christensen's interest in the history of plant use) and some excavation units at Nombe, which were finely wet-sieved through 1mm sieves. The implications of field recovery methods relative to assemblage composition are particularly clear for Nombe where a comparison of faunal size classes derived from different field sampling methods illustrates the under-representation of small and very small taxa in more coarsely sieved units (Figure S1, supplementary information)).

Where large quantities of small and very small mammals are present at an archaeological site, careful consideration must be given to distinguishing cultural from non-cultural remains. Small mammals make an important contribution to the diet of many highlanders and fringe highlanders today (Dwyer 1990; Morren 1986), but the bones of such animals are generally consumed along with the meat (Ken Aplin, personal observation). While smaller vertebrate remains may be non-cultural in origin, largely due to the activity of owls, they nonetheless warrant careful analysis on account of their (generally) narrower niche and habitat ranges, and because they are unlikely to be carried any great distance prior to consumption.

In addition to highlighting the effect of mesh size on taxa frequencies, Figure S1 shows the differences between MNI and NISP as means of quantifying the same assemblage. In theory, the larger the sample size of faunal remains, the more the two methods converge to give similar taxonomic abundances (Amorosi *et al.* 1996). Figures S1c and S1d compare abundances of different size classes quantified using NISP and MNI for a large sample (NISP=15,671; MNI=1646; Mountain 1991:7.27) of faunal remains from the main cultural layer (Stratum B) at Nombe. The results suggest that NISP is more likely to under-represent small and very small taxa when coarser sieving techniques are employed. Interestingly, NISP also seems to under-represent the proportion of larger taxa in wet-sieved areas of the site, which may be attributable to the overall smaller sample sizes recovered using this technique.

Finally, the recent advance in knowledge of New Guinean mammal taxonomy means that the existing collections of highlands archaeological fauna are in need of fresh analysis (unfortunately, the Kamapuk fauna were destroyed in 2003 during the Canberra bushfires). This is particularly pertinent for several groups including the cuscuses, wallabies, bandicoots, and all rodents including both giant and smaller forms. Particular benefit in the form of more detailed environmental histories might be obtained through examination of the abundant small mammal remains recovered from several of the sites (e.g. Aibura, Batari, Nombe).

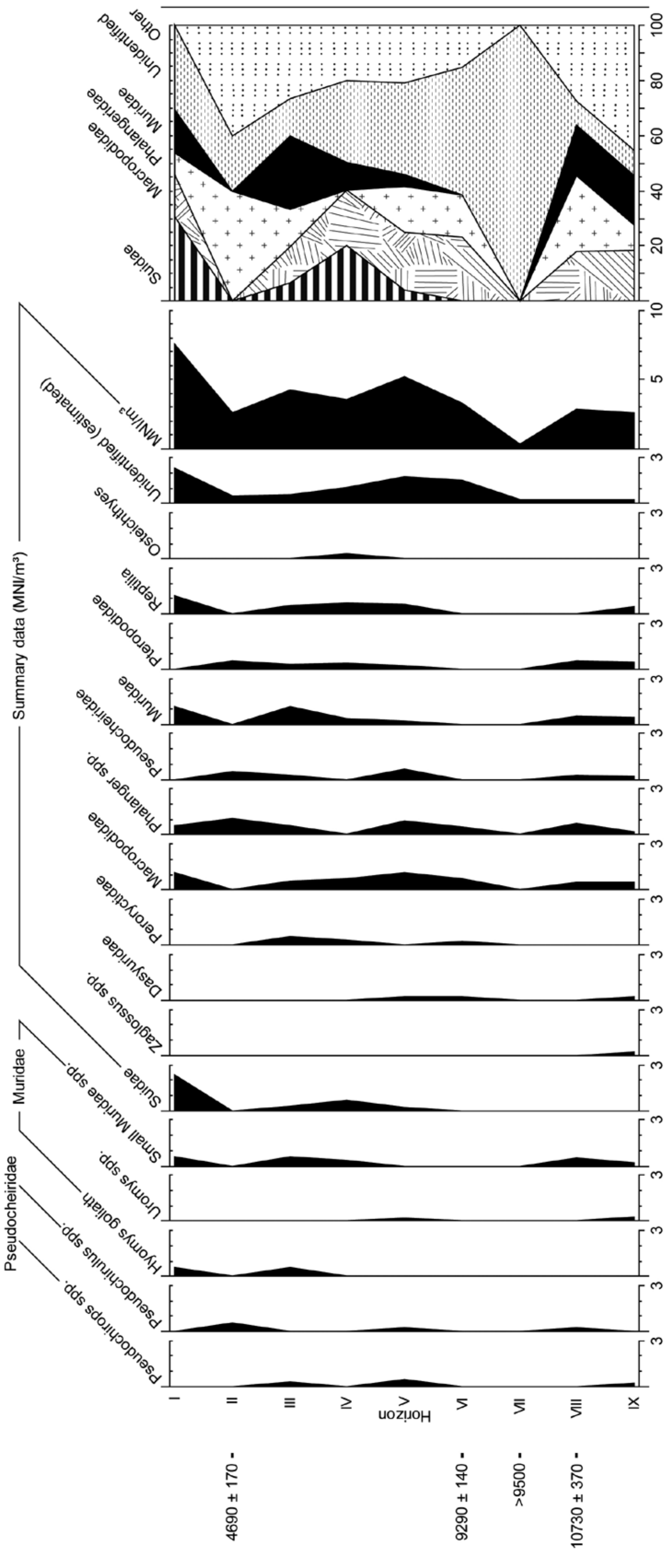

Figure 6 Archaeofaunal summary for Kafiayawa (Kafiavana) (White 1972).

Extinctions

At least nine species of mammal have become extinct in the highlands during the last 40,000 years, with another two species reported to have become locally extinct (Table 2). These extinctions arguably post-date initial human arrival to New Guinea's highland interior. At present, chronologies are too imprecise and archaeological associations too meagre to ascertain a causal link between mammalian extinctions and human activity for the Pleistocene. In contrast, there is more compelling evidence for a human role in the disappearance of several species during the Holocene.

Nombe rockshelter is the only systematically excavated highlands archaeological site to have produced remains of extinct megafauna (Table 2). Remains of *Protemnodon nombe*, *P. tumbuna*, an unidentified diprotodontid, and *Dendrolagus noibano* were recovered from the basal Stratum D2/3/4, dated to older than c.25,000 BP. Remains of *P. tumbuna*, *D. noibano* and the diprotodontid were also recovered from Stratum D1/5 dated to c.25,000–14,500 BP. Significantly, the occurrence of these taxa in Stratum D1/5 suggests an extended period of overlap (c.10,000-15,000 years) between human activity and extinct fauna in highland New Guinea (Mountain 1991:8.11-13, 9.4-5). Mountain (1991:9.4) suggests that thylacines plausibly hunted protemnodons and may have contributed to the Nombe faunal assemblage during the Pleistocene. Accordingly, the Nombe evidence does not provide incontrovertible evidence of humans hunting megafauna. Consideration should be given to direct dating of the Nombe megafaunal specimens using electron spin resonance (ESR) or Uranium series methods, in order to more precisely determine the time of extinction of these animals.

Evidence from two sites in central Papua Barat (Indonesian New Guinea) suggest extinct fauna survived at high altitudes after c.46,000 years ago (Fairbairn *et al.* 2006:380). Kelangurr Cave comprises a rich bone deposit inside an old stream channel, which contains the remains of two large extinct species, the diprotodontid *Maokopia ronaldi* and *Protemnodon hopei* (Flannery 1992a; Hope *et al.* 1993). Dating of the stratigraphy using ESR measurements and chemical analysis tentatively suggest a 'last-glacial age' for the darker, more mineralised bone that includes the extinct fauna (Hope *et al.* 1993:120, 123). *M. ronaldi* and *P. hopei* were also identified in nearby fossiliferous deposits eroding from clays deposited between 40,000–15,000 BP along the West Baliem River (Hope *et al.* 1993). While no evidence of human activity was observed at either of these sites, Hope *et al.* (1993:125) suggest that evidence of anthropogenic burning and disturbance at c.32,000 BP at nearby Supulah Hill is 'tantalisingly close' to the minimum age for large fauna at the Baliem River site. Further work is needed in order to refine the chronologies and associations of people and megafauna in this productive region.

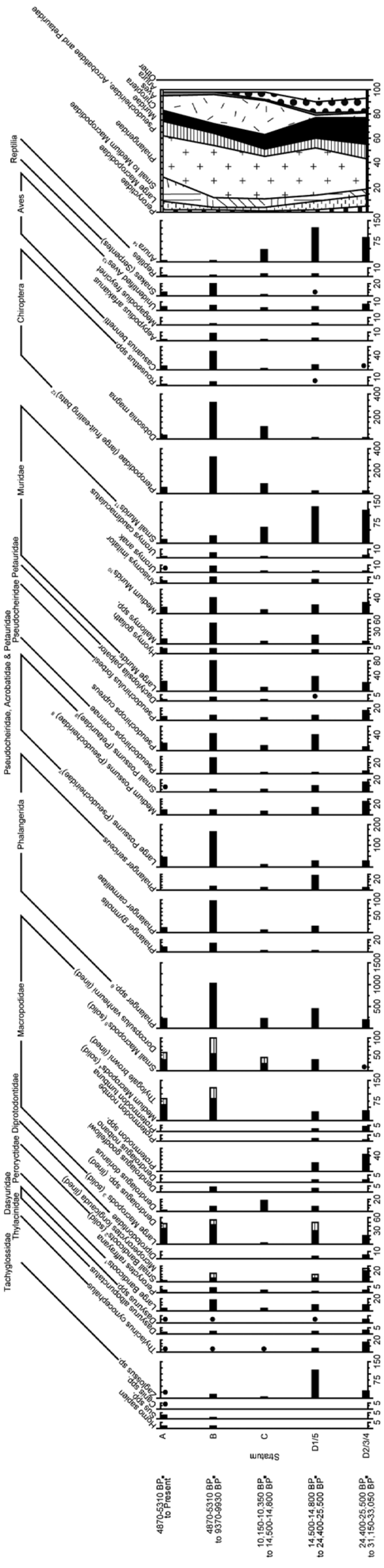

Figure 7 Archaeofaunal summary for Nombe (Mountain 1991). Dots represent taxon present in small quantities. 1=Large bandicoots are mostly unidentified to species, but contain small numbers of identified *Echymipera kalubu* and *E. rufescens*. 2=Mostly post-cranial fragments; non-diagnostic to species but based on size are likely to be *Microperoryctes longicauda*. 3=Mostly post-cranial fragments; non-diagnostic to species but based on size are likely to be *Dendrolagus* spp. 4=Mostly post-cranial fragments; non-diagnostic to species but based on size are likely to be *Thylogale browni*. 5=Mostly post-cranial fragments; non-diagnostic to species but based on size are likely to be *Dorcopsulus vanheurni*. 6=*P. vestitus* is likely to exist in this category but was not identified at the time. 7=Mostly post-cranial fragments; non-diagnostic to species but based on size are likely to be either *Pseudochirops cupreus* or *P. corinnae*. 8=Mostly post-cranial fragments; non-diagnostic to species but based on size are likely to be either *Pseudochirulus forbesi* or *Dactylopsila palpator*. 9=Mostly non-diagnostic to species but includes *Pseudochirulus mayeri*, *Petaurus breviceps* and *Disteochurus pennatus*. 10=Mostly non-diagnostic to species but includes *Uromys anak*, *Uromys caudimaculatus*, *Anisomys imitator*, *Parahydromys asper*, *Hydromys* spp. and *Xenuromys* spp. 11=Mostly non-diagnostic to species but includes *Melomys rubex* and *Pogonomys* spp. 12=*Aproteles bulmerae* has been identified as present in this category, but no attempt has yet been made to quantify the remains. 13=Mostly non-diagnostic to species but includes *Harpyopsis novaeguinae*, *Megapodius* spp., *Aepypodius arfakianus*, *Megapodius freycinet*, *Gallinula* spp., *Gallinula tenebros*, *Ninox* spp., *Tyto alba*, *Tyto tenebricosa*, and members of Columbidae, Passeridae and Psittacidae. 14=Mostly non-diagnostic to species but includes lizards (Lacertilia) including skinks (Scincidae), and freshwater turtles (Chelidae).

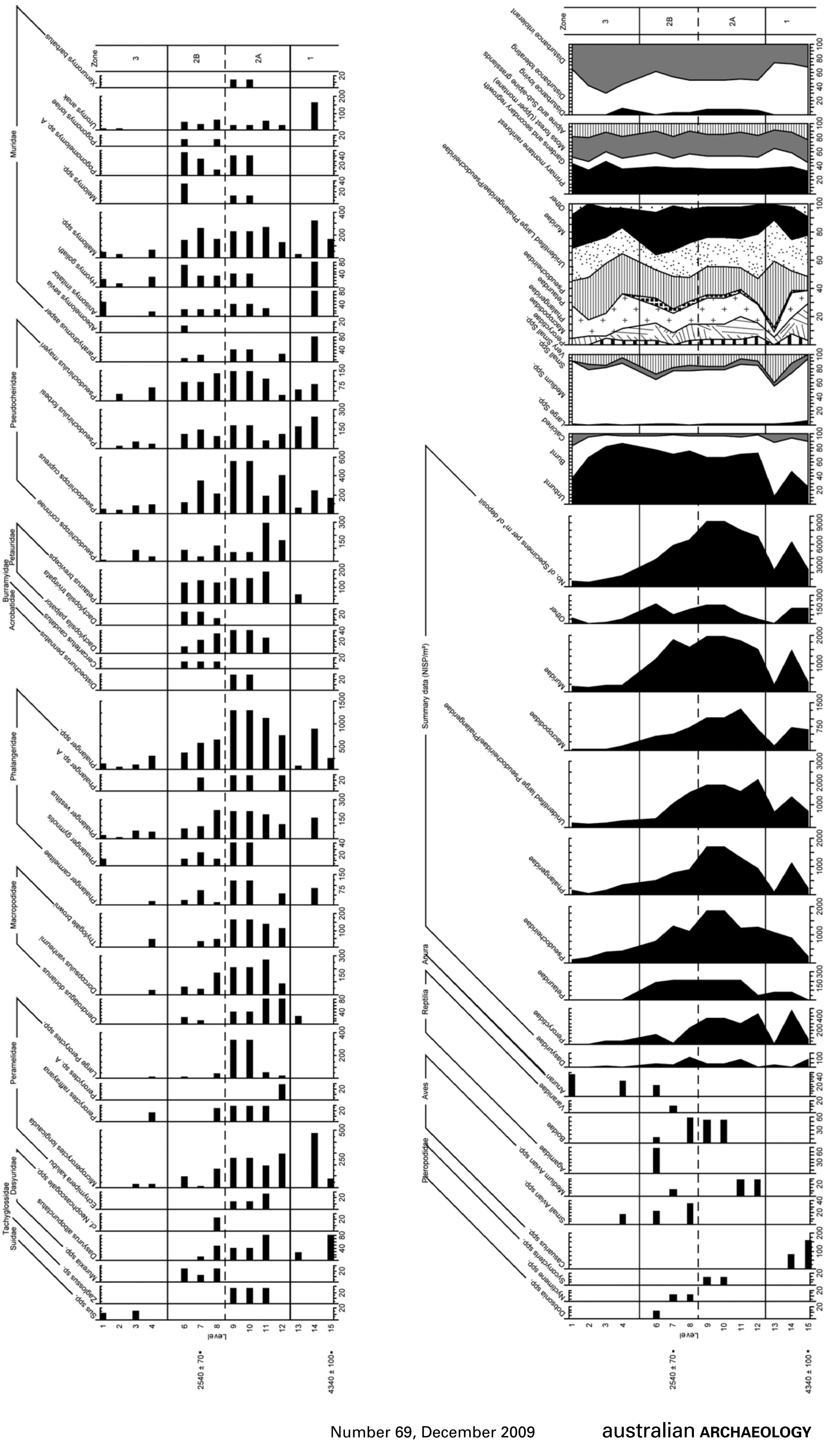

Figure 8 Archaeofaunal summary for Kamapuk (Aplin 1981).

Roberts *et al.* (2001) concluded that megafaunal extinction was a continent-wide (Sahul) event between 51,000–40,000 years ago, with a mean date of c.46,000 years ago. Their analysis excluded nearly all archaeological sites, including Nombe, because they did not contain articulated remains of megafauna (Wroe and Field 2006:2698). The exclusion of Nombe is unjustifiable for two main reasons. First, all mixed units had already been excluded from the original analysis (Mountain 1991:4.13). Second, although the stratigraphy at Nombe is complex, radiocarbon dates are in correct chronostratigraphic order, except for the trench upcast that post-dates the megafauna. Although requiring further testing using direct dating methods, the Nombe evidence suggests that megafauna survived long after humans first arrived in New Guinea, and at least 15,000 years after Roberts *et al.* (2001) argue for continent-wide extinction. Evidence from Pureni, Kelangurr Cave and West Baliem River also indicates the persistence of three megafaunal species after 46,000 BP. In sum, the evidence from the highlands is suggestive of megafaunal populations persisting long after initial human colonisation of New Guinea.

Remains of the globally extinct thylacine (*Thylacinus cynocephalus*) occur in archaeological contexts dating to the early Holocene at Kiowa (Bulmer 1979) and from the late Pleistocene to the mid-late Holocene at Nombe (Mountain 1991). Six individuals were recorded at Nombe, with remains identified from each stratum, including a partial mandible of a thylacine near the base of Stratum A. Some of the Nombe thylacine bones from Holocene strata are burnt, possibly representing captures by human hunters (Mountain 1991). The introduction of the dog (*Canis* sp.) is often cited as contributing to the extinction of the thylacine in New Guinea (Flannery 1995; Mountain 1991; Smith 1982), as in Australia (Archer 1974; White and O'Connell 1982). However, the absence of robust archaeological data and chronologies for these two events in the highlands, and for New Guinea generally, presently precludes any causal link.

At Kiowa, the disappearance of a large fruit bat, *Aproteles bulmerae* during the early Holocene (Table S1) reflects its local extirpation, probably as a result of overhunting by humans. The tendency of this species to form very large, isolated colonies make this species particularly susceptible to overhunting (Flannery 1995), particularly in the context of ethnographically observed hunting techniques in New Guinea that can result in large numbers of bats caught in a single hunting episode (Mary-Jane Mountain, personal observation).

The disappearance of two wallaby species, *Thylogale* sp. (probably *T. calabyi*, originally cited as cf. *brunii*) and *T. christenseni* after c.3460 cal BP (3250 BP), the former presumed extirpated and the latter extinct, is evidenced from two alpine sites in central Papua Barat: Billingeek Rockshelter and Mapala Rockshelter. At Billingeek, extinct taxa were associated with hearths containing faunal remains of two locally rare species, *Zaglossus* sp. and *Dendrolagus dorianus* (Hope *et al.* 1993). Hope (1981:378) speculated that a reduction in alpine grassland following the Last Glacial Maximum (LGM) placed these species under stress, although hunting and the introduction of dogs probably account for their ultimate demise or rarity. At Mapala, dog remains were found in the same charcoal lens as bones of both locally extinct thylogales.

Exotic Faunal Introductions

Direct archaeological evidence for the introduction of exotic animals is sparse, controversial and inadequate at highland occupation sites prior to the late Holocene (Table 3), despite evidence for the translocation of animals across water barriers in this region from c.19,000 BP (Heinsohn 2001; Leavesley 2005; White 2004). The introduction and adoption of two exotic species, dog and pig, transformed the nature of hunting and the orientation of social life, respectively. Dogs can dramatically increase the productivity of hunting in the interior of New Guinea (Dwyer 1990). Pigs, and the advent of pig husbandry, enabled highlanders to become less dependent on hunting and gathering for sources of animal protein and provided a means to intensify and augment social networks through exchange, thereby establishing the preconditions for the societies first recorded in the main highland valleys during the twentieth century (e.g. Strathern 1971; Modjeska 1982).

There are taxonomic uncertainties regarding both the earliest populations of dogs and pigs in New Guinea, namely before absorption or replacement by recently introduced domesticated forms of *Canis lupus familiaris* and *Sus scrofa*, respectively. The New Guinea 'singing dog' is probably related to the Australian dingo, but is 'adapted behaviorally and morphologically to the New Guinea mountain habitat' (Koler-Matznick *et al.* 2007:47). Although some classify the singing dog ('*Canis hallstromi*'; Koler-Matznick *et al.* 2007) and dingo ('*Canis dingo*'; Corbett 2001) separately from the domestic dog (*C. lupus familiaris*), and consider their origins to be somewhat distinctive, others consider them all to be variations of the same species (*C. lupus familiaris*) introduced to Sahul during the late Holocene (e.g. Flannery 1995). Significantly, a comprehensive genetic study of Australian dingoes concluded that 'dingoes originated from domesticated dogs' (Savolainen *et al.* 2004:12389) and a similar origin is implied for New Guinea singing dogs.

Similarly, there has been much genetic research regarding the origins of pigs on New Guinea (Groves 1981). More recently a 'Pacific Clade' of domesticated pigs was posited to be suggestive of a domestication centre in the Halmahera and New Guinea region (Larson *et al.* 2005). Subsequent expanded analysis indicated that this latter domestication centre is actually derived from domesticated pigs of ultimate mainland Asian origin (Larson *et al.* 2007; Dobney *et al.* 2008).

In sum, recent genetic studies indicate dogs and pigs in New Guinea originated from domesticated forms in East Asia and mainland Asia, respectively (Savolainen *et al.* 2002 and Dobney *et al.* 2008, respectively). The timings of introduction to New Guinea are, consequently, constrained by the domestication of the dog during the terminal Pleistocene in either Southwest Asia (Leonard *et al.* 2002) or East Asia (Savolainen *et al.* 2002) and of the pig at c.9000 years ago in Eurasia (Giuffra *et al.* 2000; Larson *et al.* 2007), as well as by the archaeological evidence from New Guinea and adjoining islands. Varying views suggest the introduction of both species to New Guinea during either the late Holocene (e.g. Spriggs 1997) or the terminal Pleistocene/early Holocene (e.g. Allen *et al.* 2001; Bulmer 1982).

In lowland New Guinea, pig is reported throughout a c.6000 year record near Vanimo on the north coast (Gorecki *et al.* 1991), although these claims have been questioned (Harris 1995). Pig dating to c.3500 years ago is reported for two sites in the Bismarck Archipelago: Lolmo cave in the Arawe islands, west of New Britain (Gosden *et al.* 1994) and Lebang Halika in the Nissan islands, east of New Ireland (Spriggs 1997). At Kria cave on the Bird's Head Peninsula of Papua Barat, direct dating of a pig bone produced an age of >1840 cal BP (Pasveer 2003). In the highlands of New Guinea, pig remains that might pre-date the late Holocene have been reported from four sites: Nombe, Yuku, Kiowa and Kafiayawa (Table 3). However, direct dating of pig teeth from late Pleistocene and early Holocene contexts at Nombe (Strata B and D) and from early to mid-Holocene contexts at Kafiayawa, resulted in dates falling within the last 400 years (Hedges *et al.* 1995:428). At both sites, occasional pig remains presumably percolated downwards from late Holocene provenances, in which they are more prevalent. While direct dating programmes have not been undertaken for Kiowa or Yuku, the relative frequency of pig remains shows a similar sharp decline with depth; in both sites pig is rare before, and becomes more common during, the late Holocene. At Aibura and Batari pig is confined to provenances dated to within the last 1000 years (White 1972) and post-dates c.1200 years ago at Kamapuk (Aplin 1981).

Archaeological evidence for the introduction of dogs is similarly uncertain. There is no clearly dated evidence for dogs in the highlands before c.1000 years ago, although Bulmer (2001) has argued for a much greater antiquity. The earliest dated occurrence of *Canis* sp. in a highlands archaeological site occurs in mid-to-late Holocene contexts at Nombe rockshelter (Mountain 1991). At Mapala, remains of *Canis* sp. were recovered from a thick charcoal rich lens that is dated to 'younger than c. 5440 BP [c.6230 cal BP]' (Hope 1981). At both Kamapuk and Aibura, *Canis* sp. is present only in recent or late Holocene contexts (Aplin 1981; White 1972). Ethnographic evidence from highland New Guinea suggests that evidence for dogs in archaeological sites may not be forthcoming, as general prohibitions against eating dogs were widespread (e.g. Majnep and Bulmer 2007:283; Sillitoe 2003:174).

In our view, archaeozoological evidence is inadequate to address questions of when pigs and dogs were introduced to New Guinea, although both were clearly present by 1500 years ago. However, dogs were introduced to Australia, and presumably also to New Guinea, approximately 4000–3500 years ago (Corbett 2001), and the regional evidence for contemporaneous movement of domestic pigs is compelling (e.g. Gosden *et al.* 1994; Spriggs 1997). Until reanalysis of all previously excavated material from the highlands and lowlands is completed, it would be unwise to summarily dismiss the possibility of an earlier introduction of dogs and pigs to New Guinea (cf. Bulmer, cited in Allen *et al.* 2001).

Significance for Land-Use Histories and Social Change

The archaeozoological records contain highly variable signatures of past environmental transformations. At Yuku and Kiowa there are no clear signals of forest disturbance or associated clearance, whereas at Batari and Kafiayawa the data are too limited for interpretation. In contrast, habitat change and forest disturbance during the Holocene can be inferred using faunal evidence at Aibura, Kamapuk and Nombe.

At Aibura, primary forest taxa such as cuscus, the giant rat *Mallomys* sp. (originally cited as *M. rothschildi*) and cassowary (eggshell) are rare or absent from the record after 910–620 cal BP (Table S1), and increasing numbers of *Thylogale* sp. (most likely *T. browni*, a forest-edge taxon that utilises grassland) in the levels preceding this change suggest intensifying disturbance. The faunal assemblage at Kamapuk suggests decreasing forest cover locally, particularly from about 1200 years ago (Aplin 1981:56). At Nombe, disturbance of forest habitats during the Holocene is suggested by increasing numbers of *T. browni*; however, the continued presence of primary forest dwellers (e.g. *Mallomys* sp., *Dorcopsulus vanheurni* and Phalanger *carmelitae*) indicates that forest was accessed locally until the late Holocene (Mountain 1991).

Evidence for decreasing site use or abandonment towards the end of the Holocene partly accounts for the lack of evidence for forest clearance during this period. Excluding Batari and Kafiayawa due to chronological uncertainties, there are two distinct periods of decreasing site use and abandonment. The first period begins around 5000 years ago, when both Nombe and Yuku show reduced deposition of faunal remains. The second period occurs from around 1500–500 years ago and is evidenced by dramatic decreases in faunal deposition at Kamapuk, Aibura and Kiowa. Furthermore, Batari was more or less abandoned after 830–680 cal BP (Table S1). Trends of decreasing site use during the mid- and late Holocene could represent highly localised processes, including changes in the location of human settlements and hunting activities; however, they could also represent much broader social transformations among highland communities.

To an extent, decreased site use during the mid- and late Holocene is counter-intuitive. Archaeological and palaeoecological records suggest that populations in the highlands, as well as the intensity and extent of agriculture, increased after 4000 years ago (see Golson 1977; Haberle 2003; Haberle and Chepstow-Lusty 2000; Powell 1982). Similarly, an increase in *Casuarina* pollen in several highland valleys after c.1200 cal BP suggests increasing population pressure, drivers of agricultural innovation and importance of silvicultural practices (Haberle 2007). Thus, the apparent decreased use of caves and rockshelters may reflect transformations in the social significance and spatial structuring of hunting and other social and subsistence activities, rather than simple correlations to human or animal populations.

The decreased use of some sites during the mid-Holocene (i.e. from 5000 years ago) relative to earlier periods could be accounted for by an increased reliance on food production. In at least some highland valleys people became more reliant on growing food in increasingly anthropogenic landscapes dominated by regrowth and grassland habitats. As people invested more heavily in gardens to grow food, particularly in more intensive forms of dryland and wetland agriculture (Golson 1977; Golson and Gardner 1990; Powell *et al.* 1975), their activities became more fixed in space (Denham and Haberle 2008). Significantly, in the Eastern Highlands, where a regional scale study has been undertaken, the majority of open sites were first occupied around 4000 years ago (Watson and Cole 1977). Although the

Table 2 Most recent ages of species extinctions and extirpations in the highlands. 1=Probably cf. *Thylogale browni*, still extant in other parts of New Guinea (Flannery 1995). 2=Local extinction; species is now known to be extant in other locations in New Guinea (Flannery 1995).

Taxon	Site	Most Recent Context	Most Recent Age (BP)	Reference
Diprotodontidae				
Maokopia ronaldi	West Baliem River	Eroding fossil-bearing river clays	40,000-15,000	Hope *et al.* 1993
Hulitherium thomassetti	Pureni	Non-archaeological swamp deposit	c.38,000	Flannery and Plane 1986
Diprotodontid	Nombe	Stratum D1/5	25,000-14,500	Mountain 1991
Maokopia ronaldi	Kelangurr	Bone deposit inside old stream channel	Inferred last glacial age, c.20,000	Hope *et al.* 1993
Macropodidae				
Protemnodon hopei	West Baliem River	Eroding fossil-bearing river clays	40,000-15,000	Hope *et al.* 1993
Protemnodon nombe	Nombe	Stratum D2/3/4	>25,000	Mountain 1991
Dendrolagus noibano	Nombe	Stratum D1/5	25,000-14,500	Mountain 1991
Protemnodon tumbuna	Nombe	Stratum D1/5	25,000-14,500	Mountain 1991
Protemnodon hopei	Kelangurr	Bone deposit inside old stream channel	Inferred last glacial age, c.20,000	Hope *et al.* 1993
Unidentified 'large macropod': *Protemnodon* or *Sthenurus* spp.	Kafiayawa	Basal, non-cultural deposit	Unknown, pre-10,730 (pre-c.12,800 cal BP)	Plane 1972
Thylogale cf. *brunii* [1]	Mapala	>20cm thick charcoal-rich lens within subsurface deposit	<5440 (<c.6230 cal BP)	Hope 1981
Thylogale christenseni	Mapala	>20cm thick charcoal-rich lens within subsurface deposit	<5440 (<c.6230 cal BP)	Hope 1981
Thylogale cf. *brunii* [1]	Billingeek	Series of ash lenses within subsurface deposit	c.3250 (c.3460 cal BP)	Hope *et al.* 1993
Thylogale christenseni	Billingeek	Series of ash lenses within subsurface deposit	c.3250 (c.3460 cal BP)	Hope *et al.* 1993
Thylacinidae				
Thylacinus cynocephalus	Nombe	Stratum A	<4500 (<c.5000 cal BP)	Mountain 1991
Thylacinus cynocephalus	Kiowa	Layer 9	9000-6000 (c.10,200 cal BP-c.6840 cal BP)	Bulmer 1979
Pteropodidae				
Aproteles bulmerae [2]	Kiowa	Layer 10A	c.9300 (c.10660 cal BP)	Bulmer 1979

Table 3 Earliest occurrence of exotic fauna at highlands sites. 1=Early pig remains at Kafiayawa and Nombe have been redated to within the last 400 years (Hedges *et al.* 1995).

Taxon	Common Name	Site	Earliest Age (years BP)	Earliest Age (cal BP)	Reference
Canis sp.	Dog	Aibura	<c.1000	<c.930	White 1972
Canis sp.	Dog	Kamapuk	<c.1200	<c.1120	Aplin 1981
Canis sp.	Dog	Mapala	<c.5400	<c.6230	Hope 1981
Canis sp.	Dog	Nombe	<4500	<c.5000	Mountain 1991
Gallus gallus	Chicken	Aibura	<770	<c.920	White 1972
?Gallus gallus	Chicken	Batari	>850	>c.760	White 1972
Sus scrofa	Pig	Kafiayawa	c.9300-4700[1]	c.10,660-c.5350	White 1972
Sus scrofa	Pig	Kiowa	c.10,350	c.12,210	Bulmer 1979
Sus scrofa	Pig	Nombe	25,000-14,500[1]	>c.17,420	Mountain 1991
Sus scrofa	Pig	Yuku	12,000-10,000	c.13,860-c.11,470	Bulmer 1979

link between horticulture and sedentism is complex in New Guinea, as elsewhere, an increased dependence on spatially fixed resources can be envisaged to have resulted in reduced mobility, as well as a more spatially restricted and stronger sense of territoriality (Denham and Haberle 2008). Even though hunting was still widely practiced, its relative contribution to diet and its social significance decreased through time in some of the main highland valleys. At Kamapuk and Aibura, faunal evidence suggests a continuity of behaviour through the late Holocene to the present; namely occasional use of rockshelters and caves in degraded habitats proximate to gardening zones, with opportunistic rather than targeted exploitation of local faunal resources.

Faunal and cultural trends suggest social and economic life was radically altered from around 1500 years ago due to the adoption of pigs and incorporation into localised, but spatially extensive, exchange networks. Pig husbandry facilitated the reliable production of protein in the highlands, where pigs became a valuable exchange commodity, thereby transforming the orientation and intensity of horticulture and social life by mediating the interaction between individuals and between social groups (Golson 1982; Golson and Gardner 1990; Kelly 1988; Modjeska 1982). Archaeological and palaeoecological studies witness an expansion of agricultural activities during the late Holocene in order to grow food for people and pigs. Additionally, artefact assemblages at Aibura and Batari indicate increased frequencies of exotic trade items during the last c.800 years and before c.850 years, respectively. At Aibura, the appearance of objects such as marine shells, shell artefacts, pottery and small ground artefacts slightly precedes the initial appearance of pigs. At Batari the initial appearance of pigs coincides with the first occurrence of marine shells, shell artefacts, obsidian and small ground artefacts. Similar, but less clear, trends can be elicited at Yuku, Kiowa and Nombe. Although exchange networks have a long antiquity in the interior of New Guinea, potentially extending into the Pleistocene, they became more intensive and extensive during the late Holocene (Hughes 1977).

Conclusion

Current knowledge of human-animal interactions over the long-term in the highlands is fragmentary and limited, in part due to methodological limitations in past approaches to field recovery and laboratory analyses and in part due to difficulties in working with the diverse and still incompletely known New Guinean fauna. The small number of well-dated and thoroughly analysed assemblages limits our ability to assess the extent to which native animal populations have been impacted by past hunting pressure, introduction of exotic species, and the progressive creation of anthropogenic landscapes. Yet despite several major limitations, highland archaeozoological records provide significant insights into the region's past.

Reanalysis of several important faunal assemblages (i.e. Kiowa, Aibura and Nombe) is warranted on account of improvements over the last few decades in both mammal taxonomy and knowledge of individual species distribution and ecology. In particular, greater emphasis on the smaller mammal taxa would almost certainly be rewarded by new insights into environmental changes local to each of the sites. In addition, an expanding anthropological literature on hunting practices in highland and highland fringe areas (Healey 1990; Hyndman 1990; Mack and West 2005; Majnep and Bulmer 2007; Sillitoe 2002) would facilitate more comprehensive interpretations of changes in human activities in the past, including the response to progressive environmental degradation. Where possible, such studies should include comprehensive analyses of both cranial and post-cranial material and could benefit from consideration of age and sex of prey items (cf. Leavesley 2005), greater attention to site specific taphonomic factors and bone modifications, and possibly the incorporation of ancient DNA studies. Some of these analyses may be possible using existing collections; however, some limitations, especially those related to field recovery techniques, can only be overcome through new excavations of suitable occupation sites.

Multiple highland sites (e.g. Nombe, Pureni, Kelangurr Cave and West Baliem River) provide evidence that several large mammals survived in New Guinea beyond the c.46,000 year old mean date proposed by Roberts *et al.* (2001) for continent-wide extinction of megafauna. Greater chronological certainty is available for Holocene extinctions and extirpations, although a causal link to human practices has not been established. Questions concerning the Pleistocene and Holocene extinction of fauna in New Guinea, like Sahul as a whole, will only be resolved through additional field investigations and the generation of detailed regional and species-specific chronologies. Similarly, the timing and impact of exotic introductions to the highlands of New Guinea are currently uncertain. These issues are significant. Dogs would have greatly increased the efficiency of hunting and their introduction may have considerably hastened the decline of many native animals. The introduction of pigs revolutionised the economic and social fabric of highland societies, with widespread environmental impacts.

A paradox facing researchers is the decreasing use of rockshelter and cave sites during the mid- and late Holocene, at times of presumably increasing human populations and increasingly intensive and extensive forms of agriculture. The archaeozoological records suggest that simple correlations between variables are inadequate to understand economic and social transformations through time and their variable manifestation across space. Archaeozoological investigations at multiple sites are essential to reconstruct the temporal and spatial variability of past human-environment interactions in the highlands of New Guinea, as elsewhere.

Supplementary Information

Supplementary information for this article is available online at www.australianarchaeologicalassociation.com.au.

Acknowledgements

Many thanks to J. Peter White and three anonymous reviewers for valuable comments on earlier drafts of this paper. Thanks also to Kara Rasmanis in the School of Geography and Environmental Science at Monash University for redrafting several figures. Tim Denham was supported by Monash and ARC Discovery postdoctoral fellowships.

References

Allen, M.S., E. Matisoo-Smith and A. Hornsburgh 2001 Pacific 'Babes': Issues in the origins and dispersal of Pacific pigs and the potential of mitochondrial DNA analysis. *International Journal of Osteoarchaeology* 11:4-13.

Amorosi, T., J. Woollett, S. Perdikaris and T. McGovern 1996 Regional zooarchaeology and global change: Problems and potentials. *World Archaeology* 28:126-157.

Aplin, K. 1981 Kamapuk Fauna: A Late Holocene Vertebrate Faunal Sequence from the Western Highlands District, Papua New Guinea with Implications for Palaeoecology and Archaeology. Unpublished BA (Hons) thesis, Australian National University, Canberra.

Archer, M. 1974 New information about the Quaternary distribution of the Thylacine (Marsupialia, Thylacinidae) in Australia. *Journal of the Proceedings of the Royal Society of Western Australia* 57:43-50.

Bergmans, W. and S. Sarbini 1985 Fruit bats of the genus Dobsonia Palmer, 1898, from the islands Biak, Owii, Numfoor and Yapen, Irian Jaya (Mammalia: Megachiroptera). *Beaufortia* 34(6):181-189.

Bonaccorso, F.J. 1998 *Bats of Papua New Guinea*. Conservational International Tropical Field Guide Series. Washington DC: Conservation International.

Bulmer, R. 1976 Selectivity in hunting and in the disposal of animal bone by the Kalam of the New Guinea Highlands. In G.d.G. Sieveking, I.H. Longworth and K.E. Wilson (eds), *Problems in Economic and Social Archaeology*, pp.169-186. London: Duckworth.

Bulmer, S. 1966 The Prehistory of the New Guinea Highlands: A Discussion of Archaeological Field Survey and Excavations, 1959-60. Unpublished MA thesis, University of Auckland, Auckland.

Bulmer, S. 1975 Settlement and economy in prehistoric Papua New Guinea: A review of the archaeological evidence. *Journal de la Société des Océanistes* 31:7-75.

Bulmer, S. 1979 Archaeological Evidence of Prehistoric Faunal Change in Highland Papua New Guinea. Unpublished paper to Australian and New Zealand Association for the Advancement of Science Congress, Section 25A. Auckland.

Bulmer, S. 1982 Human ecology and cultural variation in prehistoric New Guinea. In J.L. Gressitt (ed.), *Biogeography and Ecology of New Guinea*, pp.169-206. The Hague: Junk Publishers.

Bulmer, S. 1991 Variation and change in stone tools in the highlands of Papua New Guinea: The witness of Wanelek. In A. Pawley (ed.), *Man and a Half: Essays in Pacific Anthropology and Ethnobiology in Honour of Ralph Bulmer*, pp.470-478. Auckland: The Polynesian Society.

Bulmer, S. 2001 Lapita dogs and singing dogs and the history of dog in New Guinea. In G.R. Clark, A.J. Anderson and T. Vunidilo (eds), *The Archaeology of Lapita Dispersal in Oceania: Papers from the Fourth Lapita Conference, June 2000, Canberra, Australia*, pp.183-201. Terra Australis 17. Canberra: Pandanus Books.

Calaby, J.H. and J.M. Taylor 1980 Re-evaluation of the holotype of *Mus ruber* Jentink, 1880 (Rodentia: Muridae) from Western New Guinea (Irian Jaya). *Zoologische Mededelingen* 55:215-219.

Christensen, O.A. 1975 Hunters and horticulturalists: A preliminary report of the 1972-4 excavations in the Manim Valley, Papua New Guinea. *Mankind* 10:24-36.

Corbett, L. 2001 *The Dingo in Australia and Asia*. Marleston, SA: J.B. Books.

Denham, T. 2003 Archaeological evidence for mid-Holocene agriculture in the interior of Papua New Guinea: A critical review. *Archaeology in Oceania* 38(3):159-176.

Denham, T. 2007 Exploiting diversity: Plant exploitation and occupation in the interior of New Guinea during the Pleistocene. *Archaeology in Oceania* 42(2):41-48.

Denham, T. and S. Haberle 2008 Agricultural emergence and transformation in the Upper Wahgi valley during the Holocene: Theory, method and practice. *The Holocene* 18:499-514.

Denham, T., S. Haberle, C. Lentfer, R. Fullagar, J. Field, M. Therin, N. Porch and B. Winsborough 2003 Origins of agriculture at Kuk Swamp in the highlands of New Guinea. *Science* 301:189-193.

Dobney, K., T. Cucchi and G. Larson 2008 The pigs of Island Southeast Asia and the Pacific: New evidence for taxonomic status and human-mediated dispersal. *Asian Perspectives* 47:59-74.

Donoghue, D. 1988 Pandanus and Changing Site Use: A Study from Manim Valley, Papua New Guinea. Unpublished BA (Hons) thesis, University of Queensland, Brisbane.

Dwyer, P.D. 1990 *The Pigs that Ate the Garden*. Michigan: Ann Arbor.

Evans, B. and M-J. Mountain 2005 *Pasin bilong tumbuna*: Archaeological evidence for early human activity in the highlands of Papua New Guinea. In A. Pawley, R. Attenborough, J. Golson and R. Hide (eds), *Papuan Pasts: Cultural, Linguistic and Biological Histories of Papuan-Speaking Peoples*, pp.363-386. Pacific Linguistics 572. Canberra: Research School of Asian and Pacific Studies, Australian National University.

Fairbairn, A., G.S. Hope and G.R. Summerhayes 2006 Pleistocene occupation of New Guinea's highland and subalpine environments. *World Archaeology* 38:371-386.

Flannery, T.F. 1992a New Pleistocene marsupials (Macropodidae, Diprotodontidae) from subalpine habitats in Irian Jaya, Indonesia. *Alcheringa* 16:321-331.

Flannery, T.F. 1992b Taxonomic revision of the *Thylogale brunii* complex (Macropodidae: Marsupialia) in Melanesia, with description of a new species. *Australian Mammalogy* 15:7-23.

Flannery, T.F. 1995 *Mammals of New Guinea*. Sydney: Australian Museum/Reed Books.

Flannery, T.F., J. Long, M. Archer and S. Hand 2002 *Prehistoric Mammals of Australia and New Guinea: One Hundred Million Years of Evolution*. Sydney: University of New South Wales Press.

Flannery, T.F., M-J. Mountain and K. Aplin 1983 Quaternary kangaroos (Macropodidae: Marsupialia) from Nombe rock shelter, Papua New Guinea, with comments on the nature of megafaunal extinction in the New Guinea highlands. *Proceedings of the Linnean Society of New South Wales* 107:75-97.

Flannery, T.F. and M. Plane 1986 A new late Pleistocene diprotodontid (Marsupialia) fom Pureni, Southern Highlands Province, Papua New Guinea. *Journal of Australian Geology and Geophysics* 10:65-76.

Giuffra, E., J.M.H. Kijas, V. Amarger, Ö. Carlborg, J-T. Jeon and L. Andersson 2000 The origin of the domestic pig: Independent domestication and subsequent introgression. *Genetics* 154:1785-1791.

Golson, J. 1977 No room at the top: Agricultural intensification in the New Guinea highlands. In J. Allen, J. Golson and R. Jones (eds), *Sunda and Sahul: Prehistoric Studies in Southeast Asia, Melanesia and Australia*, pp.601-638. London: Academic Press.

Golson, J. 1982 The Ipomoean revolution revisited: Society and the sweet potato in the Upper Waghi Valley. In A. Strathern (ed.), *Inequality in New Guinea Highlands Societies*, pp.109-136. Cambridge: Cambridge University Press.

Golson, J. and D.S. Gardner 1990 Agriculture and sociopolitical organization in New Guinea highlands prehistory. *Annual Review of Anthropology* 19:395-417.

Gorecki, P.P., M. Mabin and J.B. Campbell 1991 Archaeology and geomorphology of the Vanimo coast, Papua New Guinea: Preliminary results. *Archaeology in Oceania* 26(3):119-122.

Gosden, C., J. Webb, B. Marshall and G.R. Summerhayes 1994 Lolmo Cave: A mid- to late Holocene site, the Arawe Islands, West New Britain Province, Papua New Guinea. *Asian Perspectives* 33:101-118.

Grimm, E.C. 2004 *TILIA 2.02*. Springfield: Illinois State Museum.

Groves, C.P. 1981 *Ancestors for the Pigs: Taxonomy and Phylogeny of the Genus* Sus. Technical Bulletin Number 3. Canberra: Department of Prehistory, Research School of Pacific Studies, Australian National University.

Haberle, S.G. 2003 The emergence of an agricultural landscape in the highlands of New Guinea. *Archaeology in Oceania* 38(3):149-158.

Haberle, S.G. 2007 Prehistoric human impact on rainforest biodiversity in highland New Guinea. *Philosophical Transactions of the Royal Society B* 362:219-228.

Haberle, S. and A. Chepstow-Lusty 2000 Can climate influence cultural development? A view through time. *Environment and History* 6:249-269.

Harris, D. 1995 Early agriculture in New Guinea and the Torres Strait divide. *Antiquity* 69:848-854.

Healey, C.J. 1990 *Maring Hunters and Traders: Production and Exchange in the Papua New Guinea Highlands*. Berkeley: University of California Press.

Hedges, R.E.M., R.A. Housley, C. Bronk Ramsey and G.J. van Klinken 1995 Radiocarbon dates from the Oxford AMS system: Archaeometry datelist 20. *Archaeometry* 37:417-430.

Heinsohn, G.E. 2001 Human influences on vertebrate zoogeography: Animal translocation and biological invasions across and to the east of Wallace's Line. In I. Metcalfe, J.M.B. Smith, M. Morwood and I. Davidson (eds), *Faunal and Floral Migrations and Evolution in Southeast Asia-Australasia*, pp.150-167. Lisse: A.A. Balkema.

Helgen, K.M. 2007 A taxonomic and geographic overview of the mammals of Papua. In A.J. Marshall and B.M. Beehler (eds), *The Ecology of Papua: Part One*, pp.689-749. The Ecology of Indonesia Series V1. Singapore: Periplus Editions.

Hope, G.S. 1998 Early fire and forest change in the Baliem Valley, Irian Jaya, Indonesia. *Journal of Biogeography* 25:453-461.

Hope, G.S and K.P. Aplin 2005 Environmental change in the Aru Islands. In S. O'Connor, M. Spriggs and P. Veth (eds), *The Archaeology of the Aru Islands, Eastern Indonesia*, pp.25-40. Terra Australis 22. Canberra: Pandanus Press.

Hope, G.S., T.F. Flannery and Boeadi 1993 A preliminary report of changing Quaternary mammal faunas in subalpine New Guinea. *Quaternary Research* 40:117-126.

Hope, G.S. and S.G. Haberle 2005 The history of the human landscapes of New Guinea. In A. Pawley, R. Attenborough, J. Golson and R. Hide (eds), *Papuan Pasts: Cultural, Linguistic and Biological Histories of Papuan-Speaking Peoples*, pp.541-554. Pacific Linguistics 572. Canberra: Research School of Asian and Pacific Studies, Australian National University.

Hope, G.S. and J.H. Hope 1976 Man on Mount Jaya. In G.S. Hope, J.A. Peterson, U. Radok and I. Allison (eds), *The Equatorial Glaciers of New Guinea*, pp.225-240. Rotterdam: A.A. Balkema.

Hope, J.H. 1981 A new species of Thylogale (Marsupialia: Macropodidae) from Mapala rock shelter, Jaya (Carstensz) Mountains, Irian Jaya (Western New Guinea), Indonesia. *Records of the Australian Museum* 33:369-387.

Horrocks, M., S. Bulmer and R.O. Gardner 2008 Plant microfossils in prehistoric archaeological deposits from Yuku rock shelter, Western Highlands, Papua New Guinea. *Journal of Archaeological Science* 35:290-301.

Hughes, I. 1977 *New Guinea Stone Age Trade*. Terra Australis 3. Canberra: Department of Prehistory, Research School of Pacific Studies, Australian National University.

Hyndman, D.C. 1990 Back to the future: Trophy arrays as mental maps in the Wopkaimin's culture of place. In R. Willis (ed.), *Signifying Animals: Human Meaning in the Natural World*, pp.63-75. London: Routledge.

Kelly, R.C. 1988 Etoro suidology: A reassessment of the pig's role in the prehistory and comparative ethnology of New Guinea. In J.F. Weiner (ed.), *Mountain Papuans: Historical and Comparative Perspectives from New Guinea Fringe Highlands Societies*, pp.111-186. Michigan: University of Michigan Press.

Kirsch, J.A.W., M.S. Springer, C. Krajewski, M. Archer, K. Aplin and A.W. Dickerman 1990 DNA/DNA hybridization studies of carnivorous marsupials. I: The intergeneric relationships of bandicoots (Marsupialia: Perameloidea). *Journal of Molecular Evolution* 30:434-448.

Kobayashi, T. and S. Hayakawa n.d. An Archaeological Investigation of Cave Remains in the Highlands of East New Guinea. Translation from the Japanese provided by M-J. Mountain.

Koler-Matznick, J., B.C. Yates, S. Bulmer and I.L. Brisbin 2007 The New Guinea singing dog: Its status and scientific importance. *Australian Mammalogy* 29:47-56.

Larson, G., T. Cucchi, M. Fujita, E. Matisoo-Smith, J. Robins, A. Anderson, B. Rolett, M. Spriggs, G. Dolman, T-H. Kim, N. Thi Dieu Thuy, E. Randi, M. Doherty, R. Awe Due, R. Bollt, T. Djubiantono, B. Griffin, M. Intoh, E. Keane, P.V. Kirch, K-T. Li, M. Morwood, L.M., Pedriña, P.J. Piper, R.J., Rabett, P. Shooter, G. Van den Bergh, E. West, S. Wickler, J. Yuan, A. Cooper and K. Dobney 2007 Phylogeny and ancient DNA of Sus provides insights into Neolithic expansion in Island Southeast Asia and Oceania. *Proceedings of the National Academy of Sciences* 104:4834-4839.

Larson, G., K. Dobney, U. Albarella, M. Fang, E. Matisoo-Smith, J. Robins, S. Lowden, H. Finlayson, T. Brand, E. Willerslev, P. Rowley-Conwy, L. Andersson and A. Cooper 2005 Worldwide phylogeography of wild boar reveals multiple centres of pig domestication. *Science* 307:1618-1621.

Leavesley, M.G. 2005 Prehistoric hunting strategies in New Ireland, Papua New Guinea: The evidence of the cuscus (*Phalanger orientalis*) remains from Buang Merabak cave. *Asian Perspectives* 44:207-218.

Leonard, J.A., R.K. Wayne, J. Wheeler, R. Valadez, S. Guillén and C. Vilà 2002 Ancient DNA evidence for Old World origin of New World dogs. *Science* 298:1613-1616.

Mack, A.L. and P. West 2005 *Ten Thousand Tonnes of Small Animals: Wildlife Consumption in Papua New Guinea: A Vital Resource in Need of Management*. Resource Management in Asia-Pacific Working Paper 61. Canberra: Resource Management in Asia-Pacific Program, Research School of Pacific and Asian Studies, Australian National University.

Majnep, I.S. and R. Bulmer 1977 *Birds of My Kalam Country*. Auckland: Auckland University Press.

Majnep, I.S. and R. Bulmer 2007 *Animals the Ancestors Hunted: An Account of the Wild Mammals of the Kalam Area, Papua New Guinea*. Adelaide: Crawford House.

Menzies, J.I. 1977 Fossil and subfossil fruit-bats from the mountains of New Guinea. *Australian Journal of Zoology* 25:329-336.

Menzies, J.I. 1990 A systematic revision of *Pogonomelomys* (Rodentia:Muridae) of New Guinea. *Science in New Guinea* 16:118-137.

Menzies, J.I. and C. Ballard 1994 Some new records of Pleistocene megafauna from New Guinea. *Science in New Guinea* 20: 113-139.

Mittermeier, R.A., C.G. Mittermeier, T.M. Brooks, J.D. Pilgrim, W.R. Konstant, G.A.B. da Fonseca and C. Kormos 2003 Wilderness and biodiversity conservation. *Proceedings of the National Academy of Sciences* 100:10309-10313.

Modjeska, N. 1982 Production and inequality: Perspectives from central New Guinea. In A. Strathern (ed.), *Inequality in New Guinea Highlands Societies*, pp.50-108. Cambridge: Cambridge University Press.

Morren, G.E.B. 1986 *The Miyanmin: Human Ecology of a Papua New Guinea Society*. Michigan: Ann Arbor.

Mountain, M-J. 1990 Taphonomic aspects of faunal analysis from Nombe rockshelter, Simbu Province, Papua New Guinea. In S. Solomon, I. Davidson and D. Watson (eds), *Problem Solving in Taphonomy: Archaeological and Palaeontological Studies from Europe, Africa and Oceania*, pp.207-218. Tempus 2. St Lucia, QLD: Anthropology Museum, University of Queensland.

Mountain, M-J. 1991 Highland New Guinea Hunter-Gatherers: The Evidence of Nombe Rockshelter, Simbu, with Emphasis on the Pleistocene. 2 vols. Unpublished PhD thesis, Australian National University, Canberra.

Olson, D.M., E. Dinerstein, E.D. Wikramanayake, N.D. Burgess, G.V.N. Powell, E.C. Underwood, J.A. D'Amico, I. Itoua, H.E. Strand, J.C. Morrison, C.J. Loucks, T.F. Allnutt, T.H. Ricketts, Y. Kura, J.F. Lamoreux, W.W. Wettengel, P. Hedao and K.R. Kassem 2001 Terrestrial ecoregions of the world: A new map of life on earth. *BioScience* 51:933-938.

Pasveer, J.M. 2003 *The Djief Hunters: 26,000 Years of Rainforest Exploitation on the Bird's Head of Papua, Indonesia*. Modern Quaternary Research in Southeast Asia 17. Leiden: A.A. Balkema.

Plane, M.D. 1972 Fauna from the basal clay at Kafiavana. In J.P. White, *Ol Tumbuna: Archaeological Excavations in the Eastern Central Highlands, Papua New Guinea*, p.168. Terra Australis 2. Canberra: Department of Prehistory, Research School of Pacific Studies, Australian National University.

Powell, J.M. 1982 The history of plant use and man's impact on the vegetation. In J.L. Gressitt (ed.), *Biogeography and Ecology of New Guinea*, pp.107-227. Vol. 1. The Hague: Junk Publishers.

Powell, J.M., A. Kulunga, R. Moge, C. Pono, F. Zimike and J. Golson 1975 *Agricultural Traditions in the Mount Hagen Area*. Occasional Paper 12. Port Moresby: Department of Geography, University of Papua New Guinea.

Reimer, P.J., M.G.L. Baillie, E. Bard, A. Bayliss, J.W. Beck, C.J.H. Bertrand, P.J. Blackwell, C.E. Buck, G.S. Burr, K.B. Cutler, P.E. Damon, R.L. Edwards, R.G. Fairbanks, M. Friedrich, T.P. Guilderson, A.G. Hogg, K.A. Hughen, B. Kromer, F.G. McCormac, S.W. Manning, C.B. Ramsey, R.W. Reimer, S. Remmele, J. Southon, M. Stuiver, S. Talamo, F.W. Taylor, J. van der Plicht and C.E. Weyhenmeyer 2004 IntCal04 Terrestrial radiocarbon age calibration, 26 - 0 ka BP. *Radiocarbon* 46:1029-1058.

Roberts, R.G., T.F. Flannery, L.K. Ayliffe, H. Yoshida, J.M. Olley, G.J. Prideaux, G.M. Laslett, A. Baynes, M.A. Smith, R. Jones and B.L. Smith 2001 New ages for the last Australian megafauna: Continent-wide extinction about 46,000 years ago. *Science* 292:1888-1892.

Robins, J.H., M. Hingston, E. Matisoo-Smith and H.A. Ross 2007 Identifying *Rattus* species using mitochondrial DNA. *Molecular Ecology Notes* 7:717-729.

Savolainen, P., T. Leitner, A.N. Wilton, E. Matisoo-Smith and J. Lundeberg 2004 A detailed picture of the origin of the Australian dingo, obtained from the study of mitochondrial DNA. *Proceedings of the National Academy of Sciences* 101: 12387-12390.

Savolainen, P., Y. Zhang, J. Luo, J. Lundeberg and T. Leitner 2002 Genetic evidence for an East Asian origin of domestic dogs. *Science* 298:1610-1613.

Sillitoe, P. 2002 Always been farmer-foragers? Hunting and gathering in the Papua New Guinea Highlands. *Anthropological Forum* 12:45-76.

Sillitoe, P. 2003 *Managing Animals in New Guinea: Preying the Game in the Highlands*. New York: Routledge.

Smith, M. 1982 Review of the Thylacine (Marsupialia, Thylacinidae). In M. Archer (ed.), *Carnivorous Marsupials*, pp.237-253. Sydney: Royal Zoological Society of New South Wales.

Spriggs, M. 1997 *The Island Melanesians*. Oxford: Blackwell.

Strathern, A. 1971 *The Rope of Moka: Big-Men and Ceremonial Exchange in Mount Hagen, New Guinea*. Cambridge: Cambridge University Press.

Stuiver, M. and P.J. Reimer 1993 Extended ^{14}C data base and revised CALIB 3.0 ^{14}C calibration program. *Radiocarbon* 35:215-230.

Van Deusen, H.M. 1963 First New Guinea record of Thylacinus. *Journal of Mammology* 44:279-280.

Wakefield, N.A. 1963 The Australian pigmy-possums. *The Victorian Naturalist* 80:99-116.

Watson, V.D. and J.D. Cole 1977 *Prehistory of the Eastern Highlands of New Guinea*. Seattle: University of Washington Press.

White, J.P. 1967 Taim Bilong Bipo: Investigations Towards a Prehistory of the Papua New Guinea Highlands. Unpublished PhD thesis, Research School of Pacific Studies, Department of Prehistory, Australian National University, Canberra.

White, J.P. 1972 *Ol Tumbuna: Archaeological Excavations in the Eastern Central Highlands, Papua New Guinea*. Terra Australis 2. Canberra: Department of Prehistory, Research School of Pacific Studies, Australian National University.

White, J.P. 2004 Where the wild things are: Prehistoric animal translocations in the circum New Guinea Archipelago. In S. Fitzpatrick (ed.), *Voyages of Discovery: The Archaeology of Islands*, pp.147-164. Westport, CT: Praeger/Greenwood.

White, J.P. and J.F. O'Connell 1982 *A Prehistory of Australia, New Guinea, and Sahul*. Sydney: Academic Press.

Wroe, S. and J. Field 2006 A review of the evidence for a human role in the extinction of Australian megafauna and an alternative interpretation. *Quaternary Science Review* 25:2692-2703.

SUPPLEMENTARY INFORMATION

Archaeozoological Records for the Highlands of New Guinea: A Review of Current Evidence

Alice Sutton, Mary-Jane Mountain, Ken Aplin, Susan Bulmer and Tim Denham

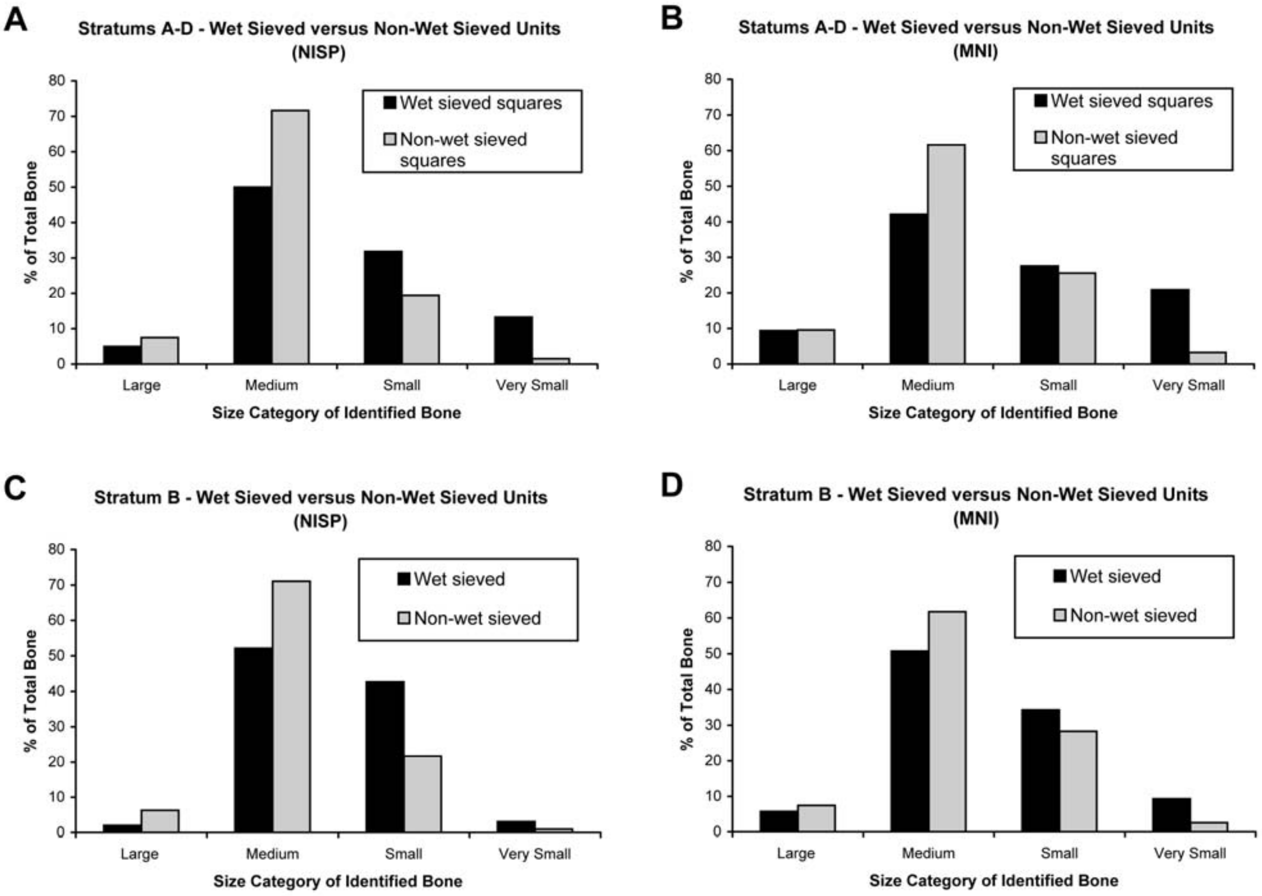

Figure S1 Comparisons of size class frequencies for wet-sieved and non-wet sieved units at Nombe. (A) Stratums A-D – comparison of wet-sieved versus non-wet-sieved units (NISP). (B) Stratums A-D – comparison of wet-sieved versus non-wet-sieved units (MNI). (C) Stratum B – comparison of wet-sieved versus non-wet-sieved units (NISP). (D) Stratum B – comparison of wet-sieved versus non-wet-sieved units (MNI).

Table S1 Radiocarbon dating summary (Aplin 1981; Bulmer 1979; Mountain 1991; White 1972).

Site	Lab. No.	Context	Sample	Subsample	^{14}C Age (years BP)	Calibrated Age BP 2σ	Probability
Yuku	GX-3111A	Sq. 1A, Layer 3A	Bone (apatite)		6710 ± 265	8050-7000	0.997
						8100-8100	0.001
						8130-8130	0.000
						8150-8140	0.001
	GX-3111B	Sq. 1A, Layer 3A	Bone (collagen I)		4570 ± 220	4770-4620	0.037
						5740-4790	0.963
	GX-3113A	Sq. 1A, Layer 4D	Bone (apatite)		6740 ± 230	8020-7170	1.000
	GX-3113B	Sq. 1A, Layer 4D	Bone (collagen I)		9700 ± 300	12070-10240	1.000
	ANU-358	Main Trench, Layer 4C	Charcoal		9780 ± 150	11720-10700	0.998
						11750-11740	0.002
	GX-3112A	Sq. 1A, Layer 5B	Bone (apatite)		9430 ± 340	11750-9700	1.000
	GX-3112B	Sq. 1A, Layer 5B	Bone (collagen I)		12100 ± 350	15080-13290	1.000
Kiowa	Y-1371	Layer 3	Wood carbon (charcoal)		4840 ± 140	5150-5150	0.002
						5920-5290	0.998
	Y-1370	Layer 6	Wood carbon (charcoal)		6100 ± 160	6590-6567	0.006
						6610-6600	0.003
						7330-6620	0.987
						7410-7400	0.004
	Y-1367	Layer 10	Wood carbon (charcoal)		9300 ± 200	9990-9940	0.011
						10020-10010	0.002
						10060-10040	0.005
						11180-10130	0.982
	Y-1368	Layer 10	Wood carbon (charcoal)		9920 ± 200	12110-10740	1.000
	Y-1366	Layer 12	Wood carbon (charcoal)		10350 ± 140	11670-11620	0.013
						12720-11700	0.987
Aibura	GaK-622	Lower part of the ash lenses in HI (Base HI, Square VII, Level 4)	Wood carbon		770 ± 100	610-560	0.106
						910-620	0.894
	GaK-623	Lowest level of the black silt in HIII (Lower HIII, Square IX, Level II)	'Lumps of carbon'		3800 ± 110	4450-3890	0.982
						4480-4470	0.001
						4510-4480	0.017

Site	Lab. No.	Context	Sample	Subsample	^{14}C Age (years BP)	Calibrated Age BP 2σ	Probability
Batari	ANU-39	Hearth complex at top of Horizon I	Wood charcoal (20g)		850±53	830-680	0.804
						910-840	0.196
	ANU-38a	Upper part of Horizon IV (layer of fine silt?)	Unidentifiable food bone (500g)	Carbonate	3470±60	3890-3580	1.000
	ANU-38b			Acid-insoluble fraction	≥8230±190	≥9540-8650	1.000
	ANU-40	Lower part of Horizon IV (within matrix containing cultural material, but very close to undisturbed natural sediments containing carbon)	Wood charcoal (6.3g)		16850±700	21830-18790	1.000
Kafiayawa (Kafiavana)	ANU-42	Base of HII in the upper part of a layer of grey-brown sandy silt	Wood carbon		4690±170	4940-4880	0.025
						5740-4950	0.975
	NZ1025	Sample collected from 'ash bands and the material below them' (Lower HVI and most of HVII)	Food bone remains (277g)	Carbonate	6180±125	7330-6750	0.993
						7370-7360	0.001
						7410-7400	0.007
	NZ1026			Collagen	9290±140	10820-10200	0.952
						10870-10850	0.006
						11070-10950	0.042
	ANU-20	Banked silty sands, 250-270cm below the surface in the lower half of HVII	Wood carbon (3 small samples)		>9500	>10780-10700	0.993
						>10990-10990	0.007
	ANU-41a	Banked silty sands, 260-310cm below the surface in the lower part of HVII and upper HVIII	Unidentifiable food bone (500g)	Carbonate	≥6750±100	≥7790-7440	1.000
	ANU-41b			Acid-insoluble fraction	≥10730±370	≥11580-11400	0.029
						≥13290-11590	0.971
Nombe	ANU-3073	Stratum A1, Sq. J71	Charcoal		100.4±0.9%	50-30	0.131
						80-60	0.220
						90-90	0.005
						140-100	0.318
						260-220	0.326
	ANU-3685	Stratum A3, Sq. T79	Charcoal		900±80	940-680	0.994
						950-950	0.006
	ANU-2570	Stratum A3, Sq. D79	Charcoal		3420±310	2910-2890	0.004
						4450-2920	0.987
						4520-4460	0.010
	ANU-3689	Stratum B6, Sq. PQR71, Spit 5	Bone[1]		5090±220	5410-5320	0.029
						6300-5440	0.971

Site	Lab. No.	Context	Sample	Subsample	^{14}C Age (years BP)	Calibrated Age BP 2σ	Probability
Nombe (cont.)	ANU-3684	Stratum B4, Sq. J71, Spit 5	Bone		5340 ± 110	6320-5900	0.993
						6390-6370	0.007
	ANU-3074	Stratum B2, Sq. A1, Spit 2	Bone		5810 ± 180	7030-6280	0.978
						7070-7040	0.006
						7090-7080	0.002
						7160-7110	0.014
	ANU-3075	Stratum B4, Sq. A1, Spit 3	Bone		6380 ± 90	7040-7030	0.007
						7050-7050	0.001
						7080-7070	0.004
						7110-7090	0.011
						7470-7160	0.976
	ANU-3076	Stratum B4, Sq. A1, Spit 4	Bone		5875 ± 115	6970-6410	1.000
	ANU-3688	Stratum B4, Sq. X3, Spit 3	Bone		6740 ± 120	7840-7430	1.000
	ANU-3687	Stratum B8, Sq. C3, Spit 4	Bone		8320 ± 840	11500-7480	0.995
						11610-11520	0.005
	ANU-3686	Stratum B4, Sq. H71, Spit 7	Bone		9650 ± 280	11830-10240	0.982
						11970-11870	0.018
	ANU-2579	Stratum C8, Sq. A4	Flowstone		10250 ± 100	11430-11410	0.005
						11530-11500	0.010
						11550-11540	0.002
						12400-11600	0.970
						12570-12500	0.014
	ANU-2576	Stratum C8, Sq. X3	Flowstone		10250 ± 100	11430-11410	0.005
						11530-11500	0.010
						11550-11540	0.002
						12400-11600	0.970
						12570-12500	0.014
	ANU-2569	Stratum C8, Sq. D79	Charcoal		11400 ± 190	13650-12930	1.000
	ANU-2581	Stratum C8, Sq. A4	Flowstone		11850 ± 150	14010-13380	1.000
	ANU-2580	Stratum C8, Sq. A4	Flowstone		14650 ± 150	18210-17010	0.963
						18480-18310	0.037
	ANU-2578	Stratum D1, Sq. D71, Spit 9	Calcite		24950 ± 550	n/a	n/a
	ANU-2565	Stratum D2, Sq. X3, Spit 6	Snail shell		29600 ± 500	n/a	n/a
	ANU-2566	Stratum D2, Sq, A4, Spit 3	Snail shell		32100 ± 950	n/a	n/a

Site	Lab. No.	Context	Sample	Subsample	^{14}C Age (years BP)	Calibrated Age BP 2σ	Probability
Kamapuk	ANU-1325	Unit IV (Level 7)	Wood carbon (charcoal)		2540 ± 70	2420-2360	0.059
						2760-2430	0.941
	ANU-1326	Unit VII (Level 15)	Wood carbon (charcoal)		4340 ± 100	4640-4630	0.005
						4680-4640	0.024
						4760-4690	0.061
						4790-4790	0.000
						5300-4800	0.910

Notes:

[1] Dates on bone from Nombe are considered minimum ages. See Mountain (1991:3.13) for discussion.

- Grey shading indicates a date that is considered problematic by the original excavator (see text for appropriate reference).
- All calibrations undertaken using CALIB version 5.1 (Method B, two sigma; Stuiver and Reimer 1993) and the northern hemisphere calibration dataset (IntCal04; Reimer *et al*. 2004). The northern hemisphere calibration dataset (IntCal04; Reimer *et al*. 2004) extends to 21,381 BP; consequently it is not possible to calibrate radiocarbon ages older than this limit using this dataset.

Table S2 Earliest record of faunal taxa from seven highlands archaeological sites.

Family	Genus/Species	Common Name	Kamapuk	Nombe	Batari	Aibura	Kafiayawa	Yuku	Kiowa
Mammalia									
Tachyglossidae		Echidnas					TP		EH
	Zaglossus spp.	Long-Beaked Echidnas	MH/LH	LP					
Dasyuridae		Dasyurids/Native Cats					TP		LP/TP
	Murexia spp.	Marsupial Mice	MH/LH			LH			
	Neophascogale sp.[1]	Neophascogales	MH/LH						
	Dasyurus albopunctatus[2]	New Guinea Quoll	MH	LP	TP/EH	MH/LH			
	'Small' dasyurids			LP					
Peroryctidae		Bandicoots			TP/EH	MH/LH	EH		LP/TP
	Microperoryctes longicauda	Striped Bandicoot	MH	LP					
	Peroryctes raffrayana	Raffray's Bandicoot	MH/LH	LP					
	Echymipera kalubu	Common Echymipera	MH/LH	LP					
	Echymipera rufescens	Long-Nosed Echymipera		EH/MH					
Burramyidae		Pygmy Possums							
	Cercartetus caudatus[3]	Long-Tailed Pygmy-Possum	MH/LH		TP/EH	LH			
Acrobatidae		Feather-Tailed Possums							
	Distoechurus pennatus	Feather-Tailed Possum	MH/LH	LP					
Petauridae		Petaurids (Possums)							
	Petaurus breviceps	Sugar Glider	MH	LP	TP/EH	MH/LH			
	Dactylopsila trivirgata	Striped Possum	MH/LH						
	Dactylopsila palpator	Long-Fingered Triok	MH/LH	LP					
	Dactylopsila spp.				TP/EH	LH			
Pseudocheiridae		Ringtail Possums			TP/EH	MH/LH	TP		
	Pseudochirops corinnae	Plush-Coated Ringtail	MH/LH	LP					
	Pseudochirops cupreus	Coppery Ringtail	MH	LP					
	Pseudochirulus forbesi	Painted Ringtail	MH	LP					
	Pseudochirulus mayeri	Pygmy Ringtail	MH	LP					
Phalangeridae		Cuscuses			TP/EH	MH/LH	TP		
	Phalanger vestitus	Stein's Cuscus	MH						
	Phalanger carmelitae	Mountain Cuscus	MH	LP					
	Phalanger sericeus	Silky Cuscus		LP					
	Phalanger gymnotis	Ground Cuscus	MH/LH	LP					

Family	Genus/Species	Common Name	Kamapuk	Nombe	Batari	Aibura	Kafiayawa	Yuku	Kiowa
Macropodidae		Macropods			TP/EH	MH/LH	TP		
	Dorcopsulus vanheurni	Small Dorcopsis	MH/LH	LP					
	Thylogale browni[4]	New Guinea Pademelon	MH/LH	LP	TP/EH	MH/LH			
	Dendrolagus dorianus	Doria's Tree-kangaroo	MH	LP					
	Protemnodon tumbuna	(extinct)		LP					
	Protemnodon nombe	(extinct)		LP					
	Dendrolagus noibano	(extinct)		LP					
	Dendrolagus goodfellowi	Goodfellow's Tree-Kangaroo		LP					
	Dorcopsulus spp.					MH/LH		LP/TP	LP/TP
	Dendrolagus spp.					LH		TP/EH	LP/TP
	Thylogale spp.							LP/TP	LP/TP
Thylacinidae		Thylacines							
	Thylacinus cynocephalus	Thylacine (extinct)		LP					EH
Diprotodontidae		Diprotodontids							
	Unidentified small diprotodontid			LP					
Muridae		Mice & Rats							
	Mallomys spp.	Woolly-Rats	MH	LP	TP/EH	MH/LH		LH	TP
	Hyomys goliath	Eastern White-Eared Giant-Rat	MH	LP	EH-LH	MH/LH	EH/MH		TP
	Uromys anak	Black-Tailed Giant-Rat	MH	LP				MH	EH
	Uromys caudimaculatus	Mottled-Tailed Giant-Rat		LP				MH	EH
	Anisomys imitator	Uneven-Toothed Rat	MH	LP		MH/LH			LP/TP
	Parahydromys asper	Waterside Rat	MH	EH/MH					LP/TP
	Xenuromys barbatus	Rock-Dwelling Giant-Rat	MH/LH						
	Abeomelomys sevia[5]	Menzies' Mouse	MH/LH	LP					
	Pogonomys loriae	Large Tree-Mouse	MH/LH						
	Pogonomys sylvestris	Grey-Bellied Tree-Mouse	x						
	Melomys rubex	Mountain Melomys		EH/MH				LH	?LP/EH
	*Melomys lutillus**	Grassland Melomys							LP/TP
	Rattus praetor/Rattus steini[6]	Large Spiny Rat / Small Spiny Rat						MH/LH	MH
	Rattus niobe[7]	Moss-Forest Rat							?LP/EH
	Rattus verecundus[7]	Van Deusen's Rat						MH/LH	
	Macruromys major	Greater Small-Toothed Rat							LP/TP
	*Macruromys elegans**	Lesser Small-Toothed Rat							TP/EH
	Mallomys spp.							MH	

Family	Genus/Species	Common Name	Kamapuk	Nombe	Batari	Aibura	Kafiayawa	Yuku	Kiowa
	Melomys spp.		MH/LH			MH/LH			
	Uromys spp.				TP/EH	MH/LH	TP		
	Pogonomys spp.					MH/LH			TP/EH
	Rattus spp.					MH/LH			
	Abeomelomys spp.					MH/LH			
	Xenuromys sp.			EH/MH				EH-MH	
	Hydromys spp.			EH/MH					
	Large murids								
	Small murids			LP			TP		
Pteropodidae		Fruit and Blossom Bats			TP/EH	R/LH			
	Aproteles bulmerae	Bulmer's Fruit Bat		x					LP/TP
	Dobsonia magna[8]	Great Bare-Backed Fruit-Bat		LP					LP/TP
	Dobsonia spp.		MH/LH		TP/EH	R/LH			LP/TP
	Nyctimene spp.	Tube Nosed Bats	MH/LH		TP/EH				
	Syconycteris spp.	Blossom Bats	MH/LH		LH				
	Rousettus spp.[9]			LP					
	Pteropodids			LP	TP/EH	R/LH	TP		MH/LH
Microchiroptera (suborder)		Microbats							
	Unidentified Microchiroptera		x						EH
Suidae		Pigs							
	Sus scrofa	Wild Boar	LH	LP	LH	LH	EH/MH		TP
Canidae		Dogs							
	Canis lupus familiaris		?LH	LH		R/LH			
Aves									
Unidentified Aves		Unidentified Birds							
	Small birds		MH/LH	LP					
	Medium-sized birds		MH/LH	LP					
Casuariidae		Cassowaries							MH/LH
	Casuarius bennetti	Dwarf Cassowary		LP					
	Casuarius spp.		MH		TP/EH	?LH			
Accipitridae		Hawks, Eagles, Vultures, Kites							
	Harpyopsis novaeguinae	New Guinea Harpy Eagle		EH/MH					
Megapodiidae		Megapodes							
	Aepypodius arfakianus	Wattled Brush Turkey		LP					

Family	Genus/Species	Common Name	Kamapuk	Nombe	Batari	Aibura	Kafiayawa	Yuku	Kiowa
	Megapodius freycinet	Dusky Scrub Fowl		LP					
Tytonidae		Barn Owls							
	Tyto alba	Barn Owl		LP					
	Tyto tenebricosa	Greater Sooty-Owl		EH/MH					
Strigidae		True Owls							
	Ninox spp.			LH					
Columbidae spp.		Doves, Pigeons		MH/LH					
Passeriforme (order)		Passerines		LP					
Rallidae		Rails							
	Gallinula tenebrosa	Dusky Moorhen		EH/MH					
	Gallinula spp.	Moorhen spp.		LP					
Phasianidae		Pheasants, Fowls, Quails							
	Gallus gallus	Red Junglefowl (Domestic Chicken)			?LH	LH			
Psittacidae		True Parrots		EH/MH					
Sauropsida									
Lacertilia (suborder)		Lizards		EH/MH	EH/LH		TP		
Agamidae		Agamids	MH/LH		LH	LH			
Varanidae		Monitor Lizards	MH/LH						
Scincidae		Skinks		LP					
Serpentes (suborder)		Snakes		LP	LH				
Boidae		Boas	MH/LH	LP		LH			
Testudines (suborder)		Freshwater Turtle		EH/MH					
Amphibia									
Anura (order)			MH/L	LP					
Osteichthyes									
Osteichthyes		Bony Fish					EH/MH		

Key:

R	Recent (last few hundred years)
LH	Late Holocene (c.3,500 BP to present; c.4,000 cal BP to present)
MH	Mid-Holocene (c.7,000 BP–c.3,500 BP; c.7,800 cal BP–c.4,000 cal BP)
EH	Early Holocene (c.10,000 BP–c.7,000 BP; c.11,500 cal BP–c.7,800 cal BP)
TP	Terminal Pleistocene (15,000 BP–c.10,000 BP; c.18,000 cal BP–c.11,500 cal BP)

LP	Late Pleistocene (c.40,000 BP–c.15,000 BP; c.46,000 cal BP–c.18,000 cal BP)
x	Present in assemblage (initial occurrence uncertain)

Notes:

[1] Probably *N. lorentzii*, Speckled Dasyure, the only member of the genus *Neophascogale*.

[2] Revised by Kirsch *et al.* (1990); previously known as *Satanellus albopunctatus* (cf. Aplin 1981; White 1972).

[3] Previously known as *Eudromicia caudata* (cf. White 1972); Wakefield (1963) combined *Eudromicia* with the genus *Cercartetus*, which has been retained in subsequent studies.

[4] Previously considered a subspecies of *T. brunii* (cf. Aplin 1981; Mountain 1991; White 1972); revised by Flannery (1992b) and identified as a distinct species. Specimens identified as *T. brunii* are reclassified here as *T. browni* based on known altitudinal limits of both species.

[5] Previously *Pogonomelomys sevia* (cf. Aplin 1981; Mountain 1991); revised by Menzies (1990) and placed within its own genus.

[6] Originally identified as *Rattus ruber* by Bulmer (1979); populations formerly identified as *R. ruber* are now variously identified as *R. praetor*, *R. steini*, *R. novaguineae, R. mordax* and *R. giluwensis* (Calaby and Taylor 1980).

[7] Both species have been placed in the genus *Stenomys* in the past (e.g. Flannery 1995); here we follow Robins *et al.* (2007) in placing these species within the genus *Rattus*.

[8] Bergmans and Sarbini (1985; see also Flannery 1995) have given the New Guinean subspecies (*D. moluccensis* ssp. *magna*) specific status as *D. magna*. More recent studies (e.g. Bonaccorso 1998) have retained subspecific status however on the basis of too few data to inform differences between the populations; *D. magna* is used here.

[9] Probably *R. amplexicaudatus*, Rousette Bat, the only member of the genus *Rousettus* in New Guinea.

* Identification requires reassessment.

australian ARCHAEOLOGY

The official journal of the Australian Archaeological Association Inc.

number 69 December 2009

australian
ARCHAEOLOGY

Australian Archaeology, the official publication of the Australian Archaeological Association Inc., is a refereed journal published since 1974. It accepts original articles in all fields of archaeology and other subjects relevant to archaeological research and practice in Australia and nearby areas. Contributions are accepted in six sections: Articles (5000-8000 words), Short Reports (1000-3000), Obituaries (500-2000), Thesis Abstracts (200-500), Book Reviews (500-2000) and Backfill (which includes letters, conference details, announcements and other material of interest to members). *Australian Archaeology* is published twice a year, in June and December.

Australian Archaeology is indexed in the Arts and Humanities Citation Index of the ISI Web of Knowledge, SCOPUS, Australian Public Affairs Information Service (APAIS), Anthropological Literature and Anthropological Index Online.

Australian Archaology is ranked as a tier A journal by the Australian Research Council, European Reference Index for the Humanities and French Agence d'Evaluation de la Recherche et de l'Enseignement Supérieur.

Subscriptions are available to individuals through membership of the Australian Archaeological Association Inc. or to organisations through institutional subscription. Subscription application/renewal forms are available at http://www.australianarchaeologicalassociation.com.au.

Graphic Design: Lovehate Design
Printing: Screen Offset Printing

Cover: Computer-enhanced photograph of northwest rock art panel at Kabadul Kula showing excavation pit with alignment of three granite boulders (Photograph: Ian J. McNiven)

All correspondence and submissions should be addressed to:

Australian Archaeology
PO Box 6088
St Lucia QLD 4067
AUSTRALIA
Email: journal@australianarchaeology.com
URL: http://www.australianarchaeologicalassociation.com.au

ISSN 0312-2417

TABLE OF CONTENTS

ARTICLES

SHORT REPORTS

BOOK REVIEWS

BACKFILL