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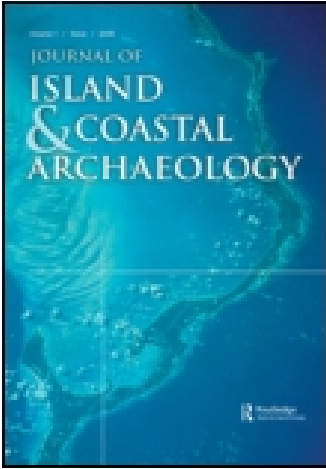
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Evidence for Social and Cultural Change in Central Vanuatu Between 3000 and 2000 BP: Comparing Funerary and Dietary Patterns of the First and Later Generations at Teouma, Efate

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ABSTRACT

In the southern Melanesian islands of Vanuatu, as in New Caledonia, Fiji, and West Polynesia, the archaeological record indicates significant shifts in aspects such as patterns of settlement and mobility, landscape use, and pottery production, some 500 years (2500 BP) after

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initial colonization. The relatively uniform Lapita Cultural Complex, the first manifestation of human activity on these islands, was transformed in each archipelago into various distinctive cultural entities. Using dietary ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values measured in collagen) and mortuary data recorded in 43 Lapita and seven immediately Post-Lapita adult burials from the site of Teouma (Efate, Vanuatu), we demonstrate that these medium-term, transformative processes also affected the economic component of the social system as well as its symbolic and religious structures. Evolutionary change adapting to changing local conditions is envisioned as the likely dominant factor influencing this cultural trajectory, while environmental/climatic change, secondary migration, and internal social changes unrelated to adaptive processes could have interacted to produce the recorded patterns.

Keywords evolutionary change, funerary practices, isotopic dietary simulations, Lapita, Vanuatu

INTRODUCTION

The archaeological records of Vanuatu, as well as of New Caledonia, Fiji, and West Polynesia, indicate a significant shift in the patterns of mobility, environment use, settlement mode, and the production of pottery and other materials, by 2500 BP (Clark and Anderson 2009; Kirch 2000). The relatively uniform Lapita Cultural Complex, marking the first human colonization of Remote Oceania (southeast Solomons to Samoa) around 3000 BP, transformed locally in each archipelago into distinct cultural entities (Bedford 2009; Clark and Anderson 2009; Sand 2010; Sand et al. 2011; Summerhayes 2007). Adaptation to changing local conditions and constraints is a favored primary factor seen as influencing the distinctive intra-archipelago cultural trajectories that occurred across the region after initial arrival (Bedford 2006; Bedford and Clark 2001; Clark and Anderson 2009; Kirch 1984, 2000; Reepmeyer and Clark 2010; Sand 2010; see also Anderson et al. 2006; Spriggs 1997, 2003, 2004). We revisit this proposition using mortuary and dietary data that are generally conservative and stable components of culture. Based on a sample of 50 burials from the site of Teouma on Efate in central Vanuatu, our study demonstrates major changes in food and funerary practices which, added to others in patterns of mobility, resource use, settlement, and artifact production, indicate a significant

intergenerational shift in the social system by some 500 years after first settlement.

DIACHRONIC CHANGES AT TEOUMA

At the site of Teouma, on Efate in central Vanuatu, diachronic changes occur in various sets of human productions and activities (Bedford and Spriggs, 2007; Bedford et al. 2006, 2009, 2010). As indicated by analysis of the ceramic decorative techniques, pottery temper, and obsidian geochemical composition, the initially high level of human mobility declined over time (Bedford et al. 2009; Dickinson et al. 2013; Reepmeyer et al. 2011). Ceramic production changed from Lapita to Arapus (c. 2800 BP) and then to Erueti (c. 2800/2700–2300 BP) styles, with major changes in vessel form and decoration identified by 2500 BP (Bedford 2009). During the Lapita phase some 11% of pottery vessels analyzed at Teouma were imports from New Caledonia (8%), and from northern Vanuatu (3%) or even further afield (Dickinson et al. 2013). In subsequent phases such imports ceased entirely. Imported obsidian disappeared by 2800 BP (although locally procured lithic material was used throughout the sequence) (Reepmeyer et al. 2011). Parallel changes in environment use are observed at Teouma as in other sites in Vanuatu, with an introduction of domesticates and commensal species (pig, chicken, and

rat) from the earliest Lapita phase (Bedford et al. 2009; Storey et al. 2010) and a decline in marine and local terrestrial fauna, including extinction of giant land tortoises (*Meiolania damelipi*), land crocodiles (*Mekosuchus kalpokasi*) and many bird species from Lapita through to the Erueti periods (Bedford 2006; Mead et al. 2002; Steadman 2006; White et al. 2010).

Over time Teouma also displays very distinctive changes in settlement pattern (Bedford et al. 2009, 2010). During the Lapita phase at c. 2900 BP the site initially comprised a cemetery and an adjacent contemporary settlement evidenced by a midden deposit that respects the boundary of the cemetery (in Areas 2 and 3). Within a

few hundred years the settlement expanded across the cemetery area which was buried by the deposition of some 50 cm or more of midden associated with the Arapus and Early Erueti phases, dating to c. 2800–2500 BP. Over time the settlement expanded to cover a much larger area and Erueti period burials, c. 2400 BP, were interred some 70 m away to the south and east (Area 7C and Trench 3) of the Lapita cemetery.

Material

Since 2004 a total of 79 mortuary contexts have been identified in three localities of the Teouma site (Figure 1). Detailed mortuary analyses have already been

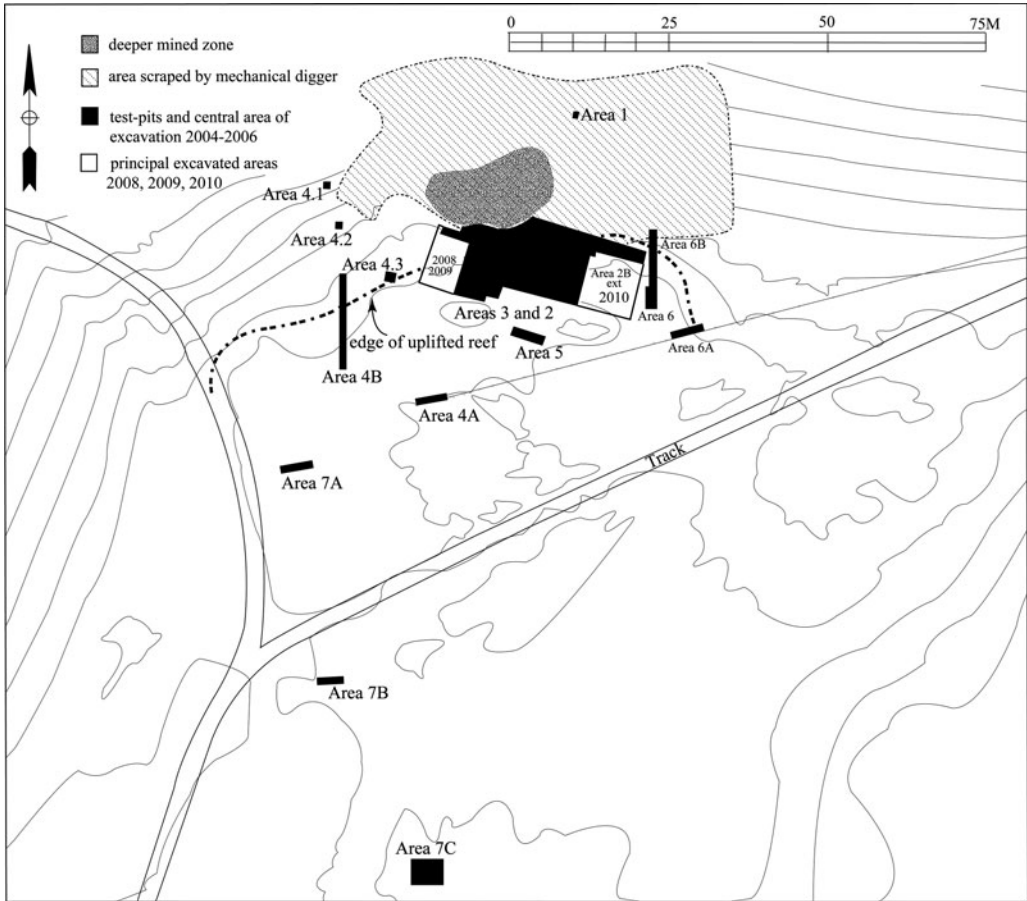


Figure 1. Map of the site of Teouma (central Vanuatu).

Table 1. Radiocarbon dates from Teouma (central Vanuatu) Area 7C and backhoe Trench 3.

Burial N°	Lab N°, ¹⁴ C age	Calibrated date (68.2% probability range)
Area 7C B1	*Wk-24480, 2423 ± 30 BP	2460–2352 BP
Area 7C B2A	*Wk-24481, 2455 ± 30 BP	2653–2365 BP
Area 7C B2B	*Wk-24482, 2465 ± 30 BP	2682–2364 BP
Area 7C B3	*Wk-24483, 2423 ± 30 BP	2463–2355 BP
Area 7C B4	*Wk-24484, 2452 ± 30 BP	2655–2645 BP
Trench 3 B1	Wk-30871, 2501 ± 27 BP	2696–2460 BP
Trench 3 B2	Wk-30872, 2422 ± 27 BP	2456–2348 BP

*In Valentin et al. (2011).

Calibrated radiocarbon dates are at two standard deviations using OxCal 4.1 (Bronk Ramsey 2009), with a delta-R of 40 ± 44 for Vanuatu marine shell samples as calculated by Fiona Petchey (University of Waikato, Radiocarbon Dating Laboratory). The bone dates from Teouma Area 7C were calibrated by Fiona Petchey using mixed marine and terrestrial curves based on measured isotope data. We have opted to use INTCAL 09 for all terrestrial calibrations, and have not incorporated a Southern Hemisphere offset given the position of the thermal equator at the Inter Tropical Convergence Zone (ITC Z) as the boundary between the atmospheres of the Southern and Northern Hemispheres (see Petchey et al. 2011:34).

published for 29 of the 71 inhumations (Valentin et al. 2010a) and one cremation (Scott et al. 2010) from Areas 2 and 3 of the Lapita cemetery. Valentin et al. (2009) briefly summarized mortuary data recorded on 44 Lapita burials there while the five Erueti burials from Area 7C were briefly presented in Valentin et al. (2011). Published isotopic dietary data (at the time of article acceptance) only concern Lapita individuals from Areas 2 and 3, including 33 adults recovered in primary contexts and seven infants (Kinaston et al 2009; Valentin et al. 2010b).

Building on these previous analyses, this study for the first time compares a sample of 50 adult burials from the Teouma Lapita and immediately Post-Lapita periods using both mortuary and isotopic dietary data. Forty-three were Lapita inhumations excavated during the first three field seasons (2004–2006) in Area 2 and 3 and seven were Erueti period inhumations recovered during the 2008 and 2010 excavations in Area 7C and Trench 3. Confirming their attribution to the Lapita period, burials in Areas 2 and 3 were placed at the base of the stratigraphy, associated with Lapita pots and artifacts radiocarbon dated to c. 2900 BP (Bedford et al. 2006, 2009). In the absence of distinc-

tive material culture associations, burials in Area 7C and Trench 3 were attributed to the Erueti period based on radiocarbon dating (Table 1).

METHODS

Mortuary Data Collection and “Anthropologie de Terrain”

Mortuary data collection, aiming to define the type of body treatment that was undertaken has focused on two aspects. The first deals with the anatomical composition of each burial to identify the skeletal elements present in situ, thereby identifying and interpreting any loss in elements. The second concerns the spatial distribution of the skeletal elements within the grave, analyzed following the methodology of “Anthropologie de Terrain” (Duday 1990, 2009; Duday et al. 1990; and see Ortiz et al. 2013 for a review). In short, “Anthropologie de terrain” attempts to reconstruct the initial conditions of burial (initial body position, body manipulation, presence of body container), taking account of subsequent taphonomic distortions. It focuses on data collected in

the field including: visible aspect of the bone in plan view; state of articulation of each joint (fully articulated, partially articulated, disarticulated); relocation of bone or body segment within the grave; and delimiting and restraining effects on the skeleton.

Stable Isotope Analysis and Modeling Diet

Stable isotope ratios are routinely used in the Pacific area to reconstruct past dietary behaviors and subsistence strategies (i.e., Ambrose et al. 1997; Valentin et al. 2010b; and see Kinaston and Buckley 2013 for a review). This is because carbon isotope ratios can discriminate between the consumption of marine and terrestrial products, and nitrogen isotope ratios allow assessment of the amount of animal, including marine, protein in the diet (Katzenberg and Saunders 2008; Schoeninger 2010). In addition, models of dietary reconstruction (Phillips and Koch 2002) allow a simplified representation of the diet for an individual or a population by integrating the isotope values of several foods potentially consumed. Based on such an approach, two modeling sets were applied for the first time both to Teouma Lapita and Erueti individuals to characterize human dietary patterns and quantify the relative contributions of different dietary sources. The first set of modeling was run with the Iso-Conc mixing model (Phillips and Koch 2002) using exclusively isotopic data from currently published prehistoric Teouma food resources, so as to be closest to the environmental conditions likely to have been experienced by the humans recovered from the site (individual data from the literature [Table 2] while another set of data has just been published [Kinaston et al. 2014]). These resources divide into three dietary poles corresponding to flesh from herbivores (land-turtles and fruit bats), omnivores (pigs, rat, and chicken), and marine (reef-fish) species. The second set of modeling was run with the IsoSource mixing model (Phillips and Gregg 2003) which allows calculations of proportions of more than three dietary sources and therefore addition of a second marine pole representing offshore fish, absent in the Teouma isotopic record. Carbon ($n = 23$) and nitrogen ($n = 14$) iso-

topic data measured on offshore fish of the Pacific area and published by Ambrose et al. (1997) and Leach et al. (1996) were used to this end. Carbon and nitrogen isotope ratios ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$) were measured in bone collagen of 26 of the 43 Lapita burials (individual data in Valentin et al. 2010b) and 6 of the 7 Erueti burials. Erueti burial bone collagen was extracted using a protocol described elsewhere (Herrscher and Le Bras-Goude 2010). Carbon and nitrogen isotope analyses were carried out by Elemental Analysis and Isotope Ratio Mass Spectrometry (Europa Scientific EA and Europa Scientific 20-20 IRMS). Isotopic measurement reproducibility is inferior to 0.1‰ for both carbon and nitrogen. Six collagen extractions were considered well enough preserved to interpret their isotope data in a dietary perspective despite low percentages of carbon and nitrogen contents (Ambrose and Norr 1993; DeNiro 1985). The seventh (from Trench 3-B1) exhibited a yield of collagen extraction under 10 mg.g⁻¹ and was discarded (Table 3) (van Klinken 1999).

RESULTS AND INTERPRETATION

Mortuary Evidence

The mortuary evidence presents a clear contrast between Lapita and Erueti burials in relation to five components defining treatment of the deceased: body position, bone manipulation, bone collection, ornaments and grave goods. Comparisons between the Lapita and Erueti period burials primarily highlight differences in body position. Original body position was reconstructed at least partially for 28 Lapita and 5 Erueti burials. The Lapita bodies were laid on the back (22 burials) and face down (6 burials) with a high level of variation in lower limb positions (Table 4 and Figure 2). Hips and knees were generally flexed (17 burials), with various degrees of flexion and in various planes (Table 4). Hips and knees were fully extended with lower limbs parallel in only 9 burials of this sample. In contrast, the Erueti sample displays a limited range of variation of body positions, including on the back with the lower limbs extended (1 burial) and on the side with the lower limbs semi-flexed (4

Table 2. Isotopic data from archaeological faunal remains from the Teouma site (Efate, central Vanuatu).

Label	Name	Latin name	Skeletal element	C (%)	N (%)	C/N	$\delta^{15}\text{N}$		Period	Date cal BP	Reference
							(‰)	(‰)			
TF01	Fruit bat	<i>Notopterus macdonaldi</i>	Humerus shaft	39.4	14.5	3.2	-19.5	5.0	E	2500-2300 BP	Valentin et al. 2010b
TF02	Fruit bat	<i>Notopterus macdonaldi</i>	Metapodial	34.7	12.6	3.2	-19.0	4.5	E	2500-2300 BP	Valentin et al. 2010b
TF03	Pig	<i>Sus scrofa</i>	Femur shaft	29.8	10.7	3.3	-20.1	9.8	E	2500-2300 BP	Valentin et al. 2010b
TF04	Pig	<i>Sus scrofa</i>	Humerus shaft	35.6	12.8	3.3	-18.9	8.3	E	2500-2300 BP	Valentin et al. 2010b
TF05	Rat	<i>Rattus exulans</i>	Long bone shaft	37.8	13.2	3.4	-18.9	8.7	E	2500-2300 BP	Valentin et al. 2010b
TF06	Rat	<i>Rattus exulans</i>	Cortical bone	33.4	12.2	3.2	-19.4	10.4	E	2500-2300 BP	Valentin et al. 2010b
TF07	Reef fish	Scaridae	Dentary element	28.6	10.2	3.3	-10.9	8.1	E	2500-2300 BP	Valentin et al. 2010b
WK25601	Tortoise	<i>?Meiolania damelipi</i>	bone	43.4	15.0	3.4	-23.2	3.0	L	2890-2760 BP	White et al. 2010
WK25602	Tortoise	<i>?Meiolania damelipi</i>	bone	42.2	15.0	3.3	-22.8	3.3	L	2890-2760 BP	White et al. 2010
NZA29452	Chicken	<i>Gallus gallus</i>	Tarsometatarsus	39.7	13.5	3.4	-20.5	12.4	L	2950-2750 BP	Storey et al. 2010
WK25198	Chicken	<i>Gallus gallus</i>	Humerus distal end	33.0	11.4	3.4	-18.2	9.8	L	3250-2950 BP	Storey et al. 2010

E = Eructi; L = Lapita.

Table 3. Isotopic data of Erueti (c. 2400 BP) period human remains from the Teouma site (Efate, central Vanuatu).

Burial N°	Location	Skeletal element	Yield			$\delta^{13}\text{C}$ (‰)	$\delta^{15}\text{N}$ (‰)	
			(mg/g)	C (%)	N (%)			C/N
Burial 1	Area 7C	Long bone shaft	30.3	23.2	8.1	3.3	-19.7	9.2
Burial 2A	Area 7C	Parietal	21.2	28.6	10.0	3.3	-19.7	9.1
Burial 2B	Area 7C	Long bone shaft	14.1	26.6	9.4	3.3	-19.7	8.2
Burial 3	Area 7C	Maxilla	39.3	34.4	12.1	3.3	-19.7	8.3
Burial 4	Area 7C	Vertebra	21.1	27.1	9.5	3.3	-19.2	9.3
Trench 3-B1	Trench3	Long bone shaft	6.0	—	—	—	—	—
Trench 3-B2	Trench3	Long bone shaft	16.2	29.6	10.5	3.3	-19.0	8.2

burials) (Figure 3). Although in articulation, the Lapita skeletons in primary contexts (34 burials minus 2 altered by further activities at the site) are incomplete to varying degrees, with a similar pattern of missing elements (Figure 2 A, B, C). Skulls in the correct anatomical position were systematically absent, forearm bones were frequently lacking, along with clavicles, scapulae, sterna,

humeri, and ribs, while isolated teeth, hyoid bones and hand bones were uncovered in situ in most cases. This repetitive pattern is interpreted as reflecting a practice of post-decomposition bone removal and thus of secondary burial as defined by Hertz in 1907 (Valentin et al. 2009, 2010a), while taphonomic processes were responsible for localized bone loss and fragmentation (Figure 2).

Table 4. Lower limb positions in the studied Teouma Lapita burials.

Lower limb position	Burials	Number of burials
Hips and knees extended, lower limb parallel	B 5, 12, 15, 16, 34, 36, 38, 40, 47	9
Hips extended and knees reversed-flexed, lower legs parallel or crossed	B 1, 4, 18, 32, 33 (see Figure 2C)	5
Hips extended with the knees flexed, lower legs against thighs	B 9, 25, 37	3
Hips flexed and knees semi-flexed in the sagittal plane	B 8, 10, 14, 31, 44 (see Figure 2A)	5
Hips flexed with lower limbs folded over the torso, extended and crossed	B 48 (see Figure 2B)	1
Hips flexed with lower limbs extended, folded on the side	B 49	1
Hips flexed with knees highly flexed against the chest (B19)	B 19	1
Hips in abduction, knees flexed, and lower legs crossed	B 7	1
Hips extended and knees unknown	B 2	1
Hips and knee unknown	B 6	1



Figure 2. Examples of burial contexts recovered at Teouma Lapita cemetery (Efate, central Vanuatu). A: Burials B44 and B30, B30 is a bone collection including up to five individuals that has been placed on the knees of B44; B: Burials B48 and B46, B48 is an incomplete inhumation, B46 is an infant inhumation placed later above B48's right elbow; C: Burials B33 and B39, B39 comprises a bundle of forearm bones and B33 is an incomplete inhumation; Originally, B44 was laid on the back, hips extended and knees flexed in the sagittal plane, B48 was on the back with the hips flexed and the lower limbs extended and crossed, folded over the torso, B33 was on the back, hips extended and knees reversed-flexed, lower legs over thighs. B44, 48, and 33 are incomplete inhumations of which several bones including skull and forearm bones (B44 and 33) were removed after body decomposition. Note the *in situ* bone fragmentation in all burials.

At the opposite end of the spectrum, and despite poorer relative preservation due to the shallow depth of interment, the Erueti burials all comprised a virtually complete individual, with each part of the skeleton represented. This reflects the practice of inhumation as a simpler and more definitive form of disposal.

Moreover, Lapita bodies were manipulated *in situ* during decomposition and segments of corpse and bones were re-arranged in the grave (4 burials). In addition, nine structured human-bone collections of various forms (Figure 2, A and C), sometimes enclosed in dentate-stamped decorated pottery vessels, were deposited beside or with some of the incomplete skeletons. Similarly

a range of burial goods such as dentate-stamped pottery vessels, sometimes of exotic provenience and of various shapes and sizes, unworked bivalve shells, *Conus* sp. shell rings, and other ornaments comprising shell beads and bracelets were associated with some of the incomplete Lapita inhumations (Bedford et al. 2009, 2010). Contrasting with this material wealth, the Erueti burial areas are characterized by a lack of any associated bone positions. They also showed no sign of body and bone manipulation, nor bone collections, ornaments, or other non-perishable grave goods (Figure 3).

Finally, the Teouma population associated with the Lapita phase demonstrates a high level of interaction with their dead

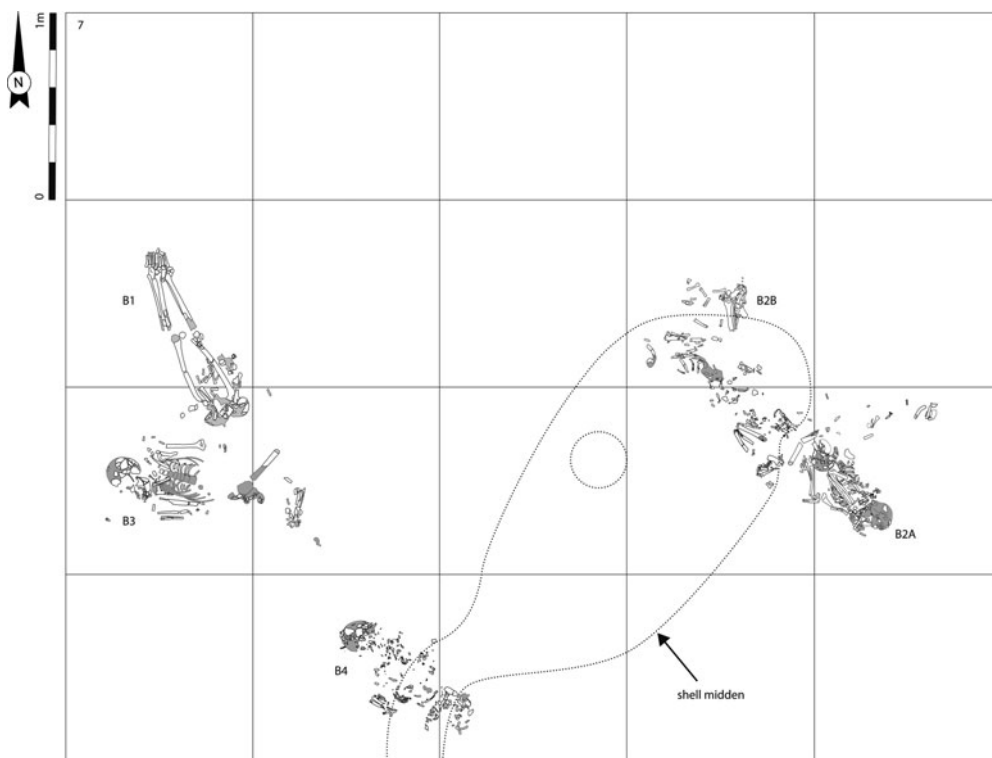


Figure 3. Erueti burial cluster recovered at Teouma site (area 7C) (Efate, central Vanuatu).

and their bones and had at the same time a wide sphere of interaction, indicated by long-distance exchanges (Dickinson et al. 2013; Reepmeyer et al. 2011). In contrast, the Teouma population associated with the Erueti phase maintained an apparently lower level of interaction with the dead and presented a reduced sphere of interaction, significant long-distance relations having ceased by the end of the Lapita period (Reepmeyer et al. 2011). While the general ethnographic record suggests that mobile groups are less likely to practice secondary burial (Schroeder 2001:88), this may not apply to early colonizing groups in the Pacific arriving in pristine environments. The multi-stage burial practice at Teouma may pertain to a general strategy, which aimed at facilitating the survival of Lapita groups scattered across a vast and thinly populated region of the southwest Pacific (Bedford et al. 2011; Clark 2007). Further indications of such a

shared funerary system can be seen in the association of exotic vessels with the Teouma burials and at the site of Lapita (Koné) in New Caledonia where human bone and body manipulation is in evidence (Valentin et al. 2005). The burial method used during the Erueti phase, expressed by a single archaeologically visible event, reflects a radically different attitude of the living towards the dead and death, and possibly towards social relationships (Valentin et al. 2011).

Dietary Evidence

Considered together, animal carbon and nitrogen available data range from -23.2 to -10.9‰ and 3.0 to 10.4‰ respectively, with an expected relative position of the different species (Table 2; Figure 4). The Arapus/Erueti period rats and pigs present the most comparable isotopic results for both carbon and nitrogen, between -18.2 and

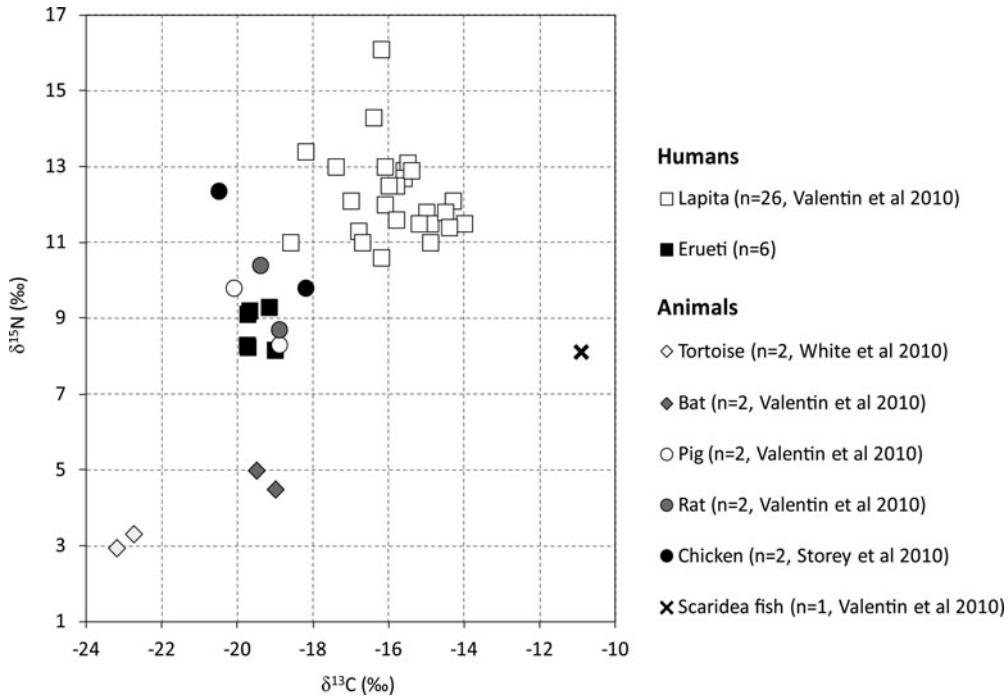


Figure 4. Carbon and nitrogen stable isotope values of bone collagen from Teouma (Efate, central Vanuatu) human and animal bone data.

−20.1‰ and 8.3 and 12.4‰ respectively, indicating consumption of isotopically similar food items. Land-turtles exhibit the lowest carbon and nitrogen values (−23.2 and −22.8‰; 3.0 and 3.3‰). These values are close to values measured on C_3 plants from Pacific Islands (Ambrose et al. 1997; Keegan and DeNiro 1988), confirming the vegetarian diet of these specimens. Comparison between isotopic data for land-turtles and bats reveals higher carbon and nitrogen values among the bats (−19.5 and −19.0‰; 4.5 and 5.0‰), suggesting that bats may have consumed a wider range of food items. Despite the small sample size, it is interesting to note that the chicken specimens from the Lapita period present a higher mean value for nitrogen than the Arapus/Erueti omnivore specimens (11.1‰; $n = 2$) versus 9.3‰ ($n = 4$). As proposed by Storey et al. (2010), such a result could indicate higher consumption of animal protein. However, particular environmental conditions during the earliest period

could also be suggested. Specific environments such as dry and hot zones are known to induce an enrichment in nitrogen values across the food web, through plants up to the end-members (Ambrose 1991; Dupras et al. 2001, Schwarcz et al. 1999; Sealy et al. 1987). Aridity could have been one of the factors that elevated the nitrogen values of the local Lapita food web, based on a palaeoenvironmental study arguing that drier environmental conditions were experienced in the Teouma region c. 3500–3250 cal BP, slowly ameliorating by 2500 cal BP (Wirmann et al. 2011).

The Erueti individuals exhibit carbon and nitrogen isotope values ranging respectively from −19.7 to −19‰ and 8.2 to 9.3‰ whereas the Lapita individuals show higher values respectively from −18.6 to −14‰ and 10.6 to 16.1‰ (Valentin et al. 2010b; Figure 4; Tables 3 and 5). A U-Mann-Whitney test indicates significant differences for both carbon and nitrogen values. The significant

Table 5. Statistical parameters of Lapita and Erueiti period human isotopic data from the Teouma site (Efate, central Vanuatu).

	<i>n</i>	$\delta^{13}\text{C}$ (‰)					$\delta^{15}\text{N}$ (‰)					Variability coefficient
		Mean	Min	Max	SD	Var.	Mean	Min	Max	SD	Var.	
Lapita	26	-15.9	-18.6	-14.0	1.1	1.3	12.3	10.6	16.1	1.2	1.4	11.38
Erueiti	6	-19.5	-19.7	-19.0	0.3	0.1	8.7	8.2	9.3	0.5	0.3	3.45
ANOVA		$F(1,30) = 59.149; p = .000$					$F(1,30) = 50.249; p = .000$					

isotopic impoverishment in ^{13}C -carbon and ^{15}N -nitrogen indicates a modification in dietary practices through time, marked by change in both the nature of the protein and the quantity of animal protein consumed. In addition, as highlighted by calculation of the coefficient of variability, the variability within each group is different (Table 5). Dispersion around the mean value of both carbon and nitrogen isotopes are clearly higher in the Lapita group than in the Erueti group which forms a narrow cluster (Figure 4). These results indicate heterogeneity in the individual Lapita dietary intake and a higher level of homogeneity among Erueti individuals.

In terms of quantification, IsoConc simulations based on three dietary poles indicate that the Lapita diet was richer and more diversified than the Erueti diet. The former balanced Scaridae fish-flesh (32.4%), herbivore flesh and/or C_3 vegetal items (17.0%), and omnivore flesh (50.6%), while the latter consisted mainly of herbivore flesh and/or C_3 plants (85.4%) (Figure 5). With the addition of offshore fish-flesh as a fourth dietary pole, IsoSource simulations confirm the dietary shift between the Lapita and Erueti groups (Figure 6). Again, whereas the Lapita diet combines almost equally the four poles (from 16.2% of reef fish-flesh to 33.5% of herbivore flesh), the Erueti diet is unevenly distributed, involving primarily herbivore flesh and/or vegetal items (87.6%).

The decrease in high trophic level food items such as animal resources in the diet could echo the decline in wild native prey availability through extinction observed in the Vanuatu faunal assemblages (Bedford 2006). Alternatively, this dietary pattern might reflect the Erueti social structure, with a group of people sustained by a uniform diet focused on a limited number of terrestrial items and generally excluding meat of domesticated animals. Remains of domesticated animals are regularly found throughout the central Vanuatu first millennium BC sequence (Bedford 2006) suggesting that, despite their presence, the Teouma population associated with the Erueti culture were not usually dependent on this potential dietary resource. Through time, one may observe a

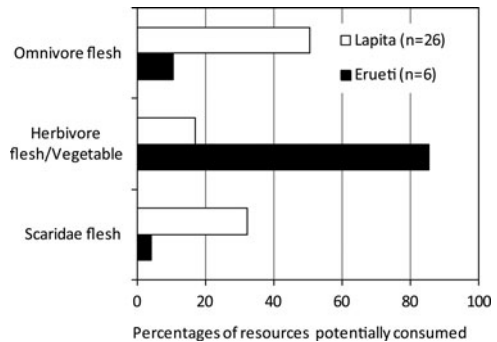


Figure 5. Dietary isotopic simulations for the two Teouma human groups with IsoConc software (© Microsoft Excel software, <http://www.epa.gov/wed/pages/models.htm>, 3 sources/2 isotopes; Phillips and Koch 2002).

trend in dietary choices operated by people focusing on vegetal items without excluding the input of herbivore flesh as flesh of vegetarian bats. This increasing interest in vegetal foods could be seen as following on from favorable environmental conditions or improved horticultural techniques.

DISCUSSION

Despite the small size of the Erueti sample and if we consider that both samples are representative of their respective cultures, the analysis presented in this paper highlights major diachronic changes in two significant aspects of human behavior, illustrating an alteration of investment in funerary rituals at the same time as the agricultural economy becomes fully established. The first concerns funerary practices, with the abandonment of a lengthy and complicated protocol (involving bone exhumation and reburial) displaying diversity among adults for a simpler and definitive process of primary inhumation showing uniformity among adults. The second change is in dietary practices, with the abandonment of a broad-based diet comprising marine resources (summed IsoSource percentages: 36.9% Lapita versus 4.8% Erueti) showing heterogeneity among

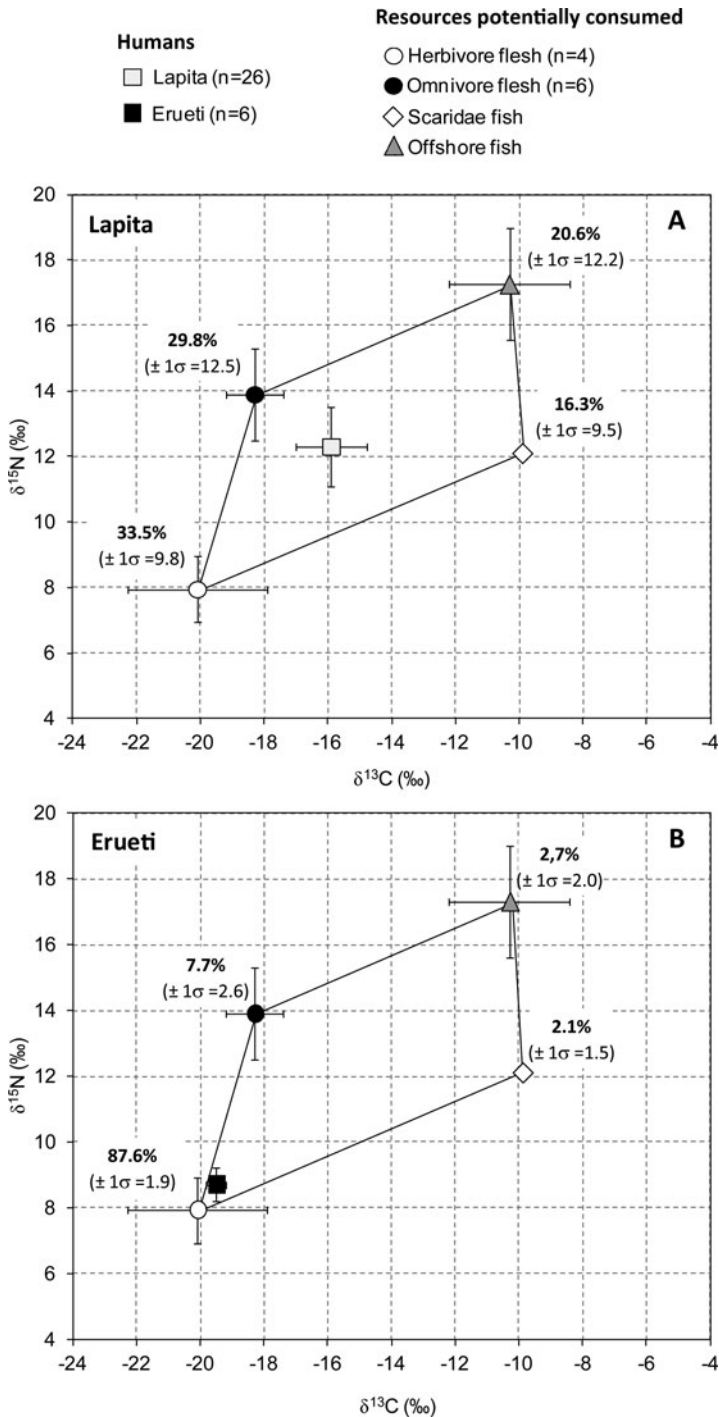


Figure 6. Dietary isotopic simulations with IsoSource software for the Lapita (A) and Erueti (B) groups (© I.3.1 Visual Basic, <http://epa.gov/wed/pages/models.htm>, Phillips and Gregg 2003). Offshore fish resource isotopic data from Ambrose et al. 1997 and Leach et al. 1996.

individuals for the quasi-exclusive use of terrestrial resources mainly composed of low trophic level foods by all the individuals (63.3% Lapita versus 95.3% Erueti). The two behavioral modifications identified here constitute additions to changes over time from the Lapita period to the Erueti period, already recorded at Teouma (Bedford 2009; Bedford et al. 2010; Reepmeyer et al. 2011). They include changes in mobility patterns, land use, artifact manufacture and provenience. Changes in ceramic production are interpreted as the result of a gradual internal process, a demonstrated continuity in vessel form and decoration supporting the view that there was a local development of the ceramic technology (Bedford 2009).

The changes in funerary and dietary perception and practice can be seen as further indications of adaptation to changing local conditions and constraints. As for Hawai'i (Kirch 1985, 2007, 2010), an archipelago characterized by major diachronic changes in settlement pattern, land use, agricultural technology, and sociopolitical organization (some centuries *after* initial colonization and Tahitian contact about AD 1300), a demographic transition concomitant with political change and cultural innovation is a plausible explanation for the alteration in the economic, symbolic, and religious components of the social system observed at Teouma.

Environmental and climatic conditions could also have influenced the development of horticulture in central Vanuatu. Haberle and Chepstow-Lusty (2000:357) noted that "increased drought stress associated with ENSO [El Niño-Southern Oscillation] events are considered to have had a significant influence on vegetation dynamics in the Pacific region over the last five to three millennia," although effects can vary greatly over relatively short geographical distances (Allen 2006; Morrison and Addison 2008). The possibility of a negative impact of drier conditions on the Teouma food web during the Lapita period suggested by the isotopic data at hand, while needing to be further assessed using a larger isotopic faunal dataset, is supported by local palaeoenvironmental data (Wirrmann et al. 2011). The difficult local growing conditions, which appear to have

improved by 2500 BP (Wirrmann et al. 2011), might have delayed an early horticultural expansion and consequently an early regular integration of vegetable foods in the diet.

Early secondary contacts and migration could also have complicated the Teouma picture (see Green 1963; Spriggs 1997). Indeed, it should not be entirely ruled out that cultigens and the vegetarian trend of Erueti dietary habits reflected in our isotopic data were introduced later in time in Vanuatu, as has been proposed for other parts of Remote Oceania (Clark and Anderson 2009). There is direct evidence for several cultivated crops in Vanuatu at least for Late Lapita and Erueti periods. Non-*Colocasia* aroid starch residues, *Dioscorea* sp. starch grains and banana (*Musa* sp.) phytoliths have been identified in Late Lapita sediments from northern Vanuatu while banana (*Musa* sp.) phytoliths are present in Early Erueti period sediments from Epi Island in central Vanuatu (Horrocks and Bedford 2005, 2010; Horrocks et al. 2009). There is also evidence that the change in funerary practices began to occur at the end of the Lapita period (Bedford et al. 2011; Valentin et al. 2011). Simple primary inhumation of adults has been identified in Late Lapita burials from Vao Island in north Vanuatu (Bedford et al. 2011) as well as in Late Lapita and immediately Post-Lapita burials from Fiji (Nunn 2007; Pietruszewsky et al. 1997) and New Caledonia (Pietruszewsky et al. 1998; Valentin 2003). Furthermore, the possibility of long-distance contacts with northern Melanesia at the very end of the Lapita period is now supported by the discovery of a piece of Mopir obsidian at Teouma (Reepmeyer et al. 2011). The Mopir obsidian sources were covered by volcanic deposits from the Witori eruption of c. 3350 cal BP, and seem only to have become available again in small quantities in Late Lapita times (Summerhayes 2009). It is thus a possibility that new mortuary and subsistence practices were brought in or influenced by newcomers, most likely during the Late Lapita phase as regional interaction largely ended at the end of Lapita. Levels of contact and/or influence were likely to have varied greatly from one region to another during Late Lapita times. Such contact-induced

changes could have contributed to the high levels of cultural diversity suggested to have emerged at the end of the Lapita period in Island Melanesia (Bedford and Clark 2001; Spriggs 2004).

CONCLUSION

Analysis of the burials from the site of Teouma (central Vanuatu) demonstrates a clear shift in both usually conservative funerary and dietary habits over time and a major change affecting the economic component of the social system and its associated symbolic and religious structures. The Lapita adults received a complicated, multi-stage, mortuary treatment with a high level of inter-individual diversity. These same Lapita individuals appear also to have benefited from a diet including a wide range of food items, almost evenly consumed, but with a high range of variation within the population. In contrast, Erueti individuals received a simplified and less diversified funerary treatment. They also appear to have been sustained by a diet of more restricted breadth comprising a limited range of food items of low trophic level such as vegetal resources and herbivore flesh, coupled with dietary homogeneity among individuals.

Adaptive responses to local conditions and/or constraints appear at this stage to be a convincing hypothesis to explain a lack of culturally stable transmission in mortuary and dietary practices, as well as in some other cultural practices, from the Lapita to Erueti periods; but the intertwined actions of other factors remain to be further explored. There may have been climatic conditions that affected the environmental potential for horticultural development in the islands and/or a later introduction to the region of particular mortuary and subsistence practices brought or influenced by newcomers. There could also have been broader initial behavioral diversity than usually considered among Lapita settlers and a rearrangement of cultural practices over time. The significant challenge is in teasing apart these various possibilities and this will require more focused analysis of a range of human biological features

and an increased sample of archaeological materials of all types across space and time in the Vanuatu archipelago and the wider region.

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