Lapita diet and subsistence strategies on Watom Island, Papua New Guinea: New stable isotope evidence from humans and animals

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ABSTRACT.

Stable isotope ratios ($\delta^{13}C$ and $\delta^{15}N$) were analyzed from the bone collagen of individuals (n = 8) from a Lapita burial ground (ca. 2800–2350 BP) on Watom Island, located off northeast New Britain in the Bismarck Archipelago. The aim of this study was to assess the diet and subsistence strategies of humans that lived during the later Lapita period in Near Oceania. To aid in the interpretation of the human diet we analyzed the stable isotope ratios of faunal material from the site (n = 27). We also aim to assess methods of animal husbandry at the site over time from an analysis of the stable isotope ratios ($\delta^{13}C$ and $\delta^{15}N$) of pig bones (n = 22) from different temporal periods (Lapita, post-Lapita, and late prehistoric). The protein diet of the humans consisted of marine organisms from the inshore environment and some deep-water species, most likely marine turtle, in addition to higher trophic level terrestrial foods, likely pig and native animals (e.g., fruit bat, Cuscus and bandicoot). Although the sample sizes were small, females (n = 4) displayed more variable $\delta^{13}C$ and $\delta^{15}N$ values compared with males (n = 4), which may be associated with the movement of adult females to the island. The stable isotope analysis of the pig bones indicated that there were few differences between the diets of the pigs from the Lapita and post-Lapita layers, suggesting that the method of pig husbandry was similar between these two periods and was likely relatively free-range.

Introduction: the prehistory of Oceania

1. 40,000 years BP: Non-Austronesian speaking people; settled in New Guinea, Solomon and Australia
2. 3,400 years BP: Austronesian speaking people, Bismarck Archipelago (Northen New Guinea) → remote Oceania; Lapita

Lapita

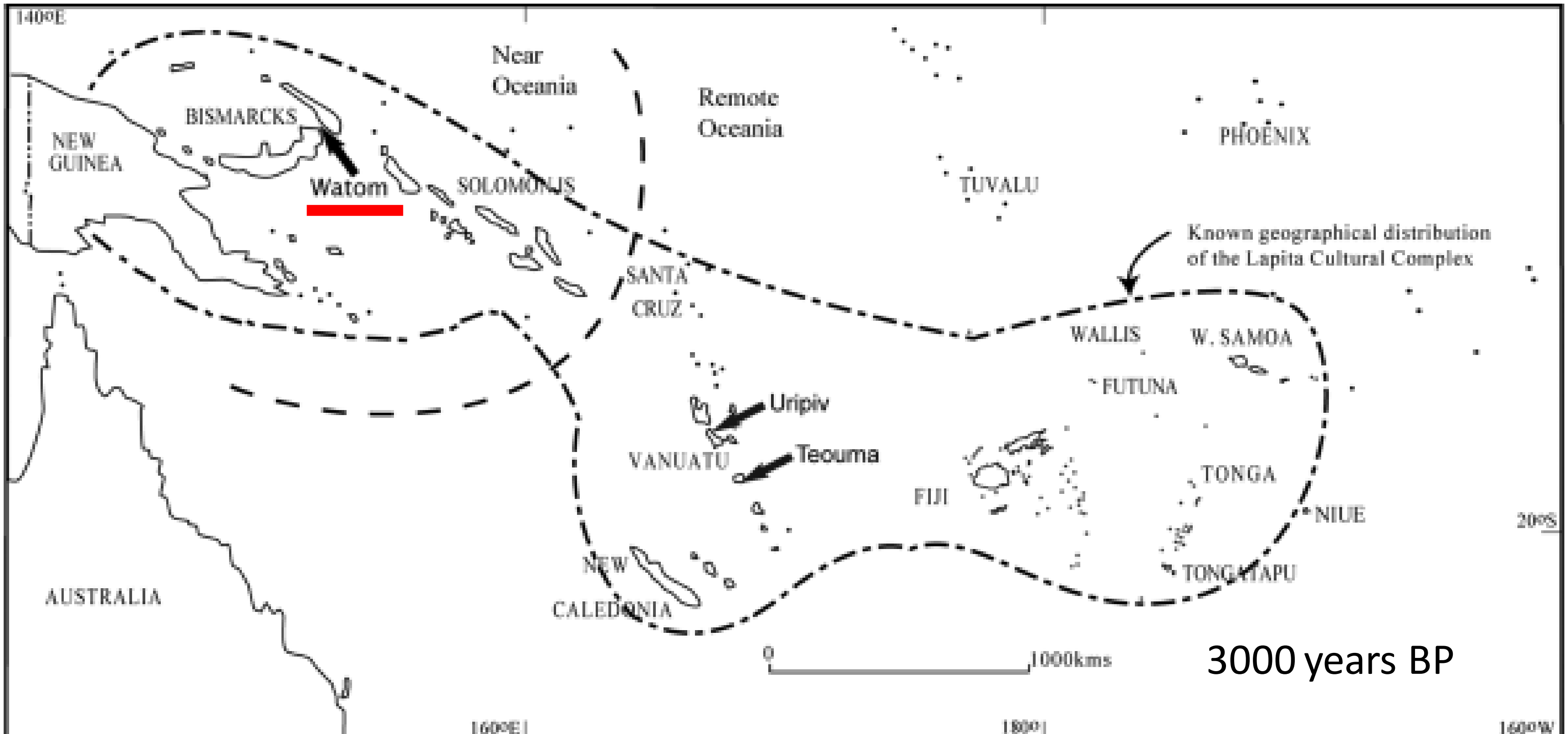
Ancestors of Polynesian who colonized uninhabited Pacific Islands

3600 years BP – 2000 years BP

3600 years BP to present

Figure 1 Map of the Pacific Islands, the known extent of the Lapita Cultural Complex, and the location of Watom Island and the other sites mentioned in the text (Uripiv and Teouma).

3600 years BP

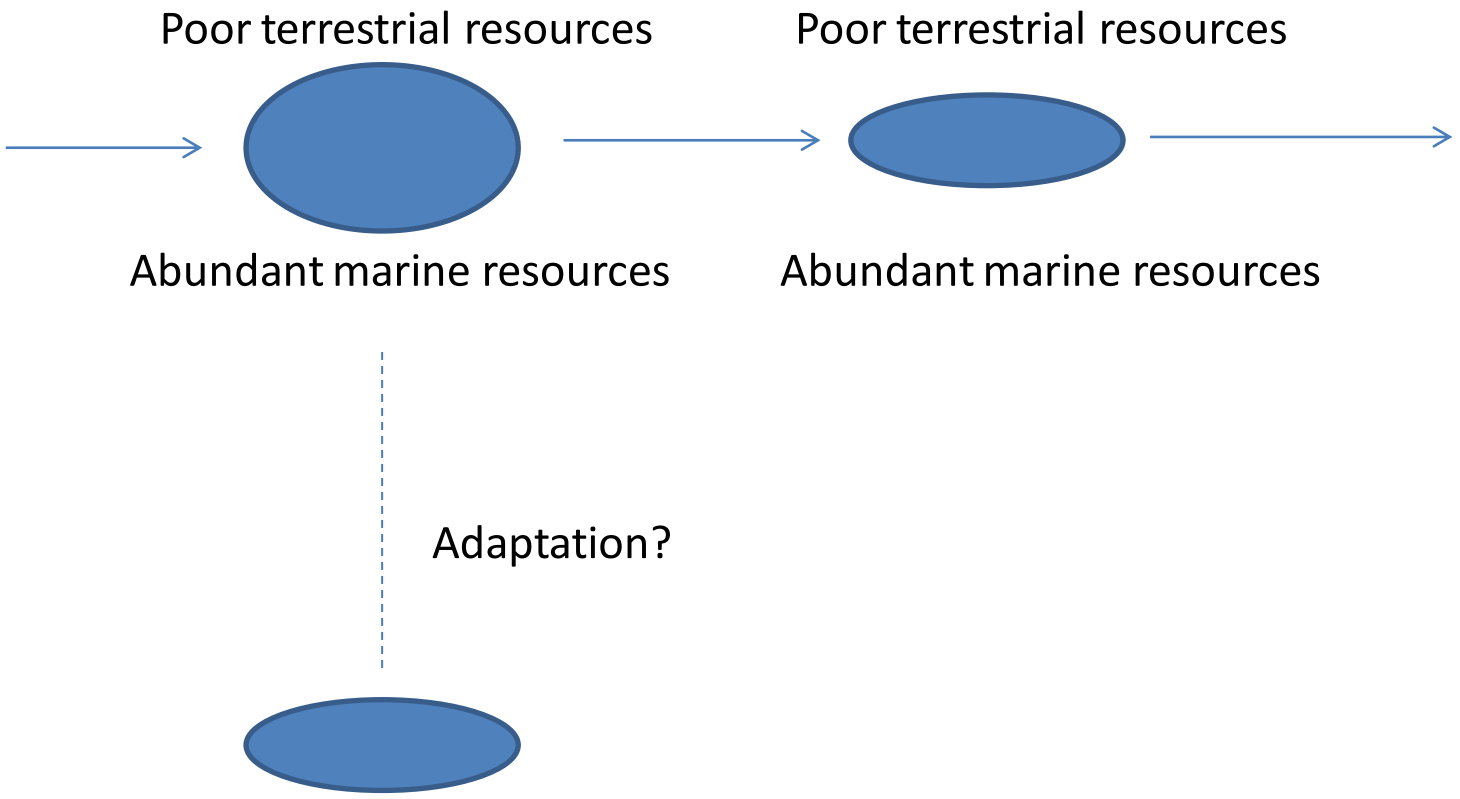


Discovery of Lapita

- 1909: Father Otto Meyer found Lapita pottery on the small island of Watom
- 1950s: Similar pottery in New Caledonia
- Over 250 archaeological sites identified

- Watom: important because of the presence of a cemetery

Question



Poor terrestrial resources
Poor terrestrial resources
Abundant marine resources
Abundant marine resources
Adaptation?

Success of Lapita: their survival strategies?

- Ability to adapt to new island environment?
- Transportation of crops and domesticated animals ?

Materials:

Human skeletons in Watom:

3000 BP-2600 BP

Later stage of Lapita settlements in near Oceania

Lapita skeletons

A cemetery in Watom

Three cemeteries in Vanuatu

Stable isotope analysis of Lapita skeletons:

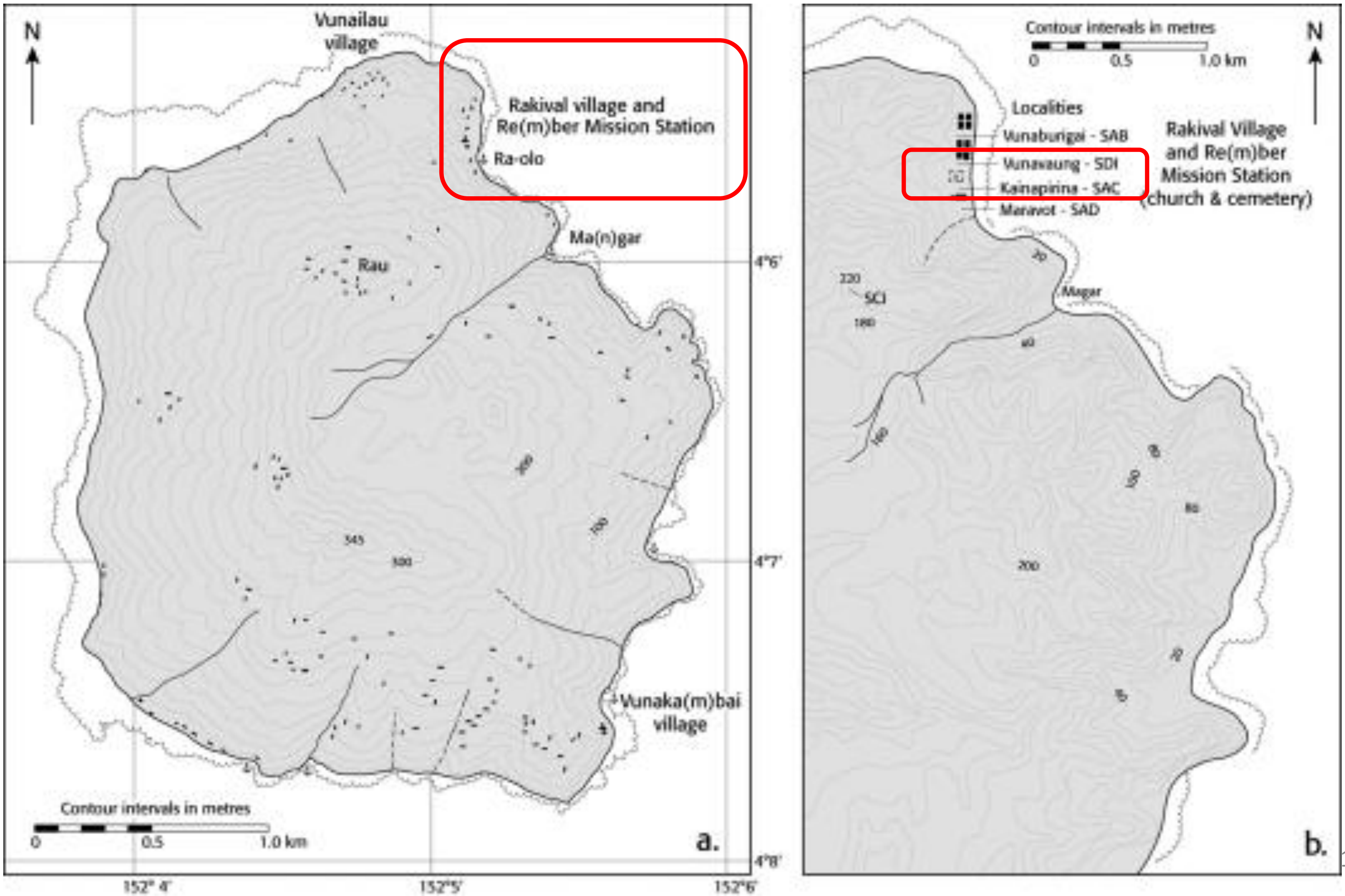
- Reconstruction of diet
- Subsistence practices and animal husbandry methods

Aims

Assessment of diet, subsistence practices and animal husbandry methods of the Lapita in Watom

Stable isotopic analysis (C/N) of bone collagen of humans, pigs, and other animals

Figure 2 Map of Watom Island with reference to Reber-Rakival village and the SAC archeological site, sourced from Anson et al. ([1]).



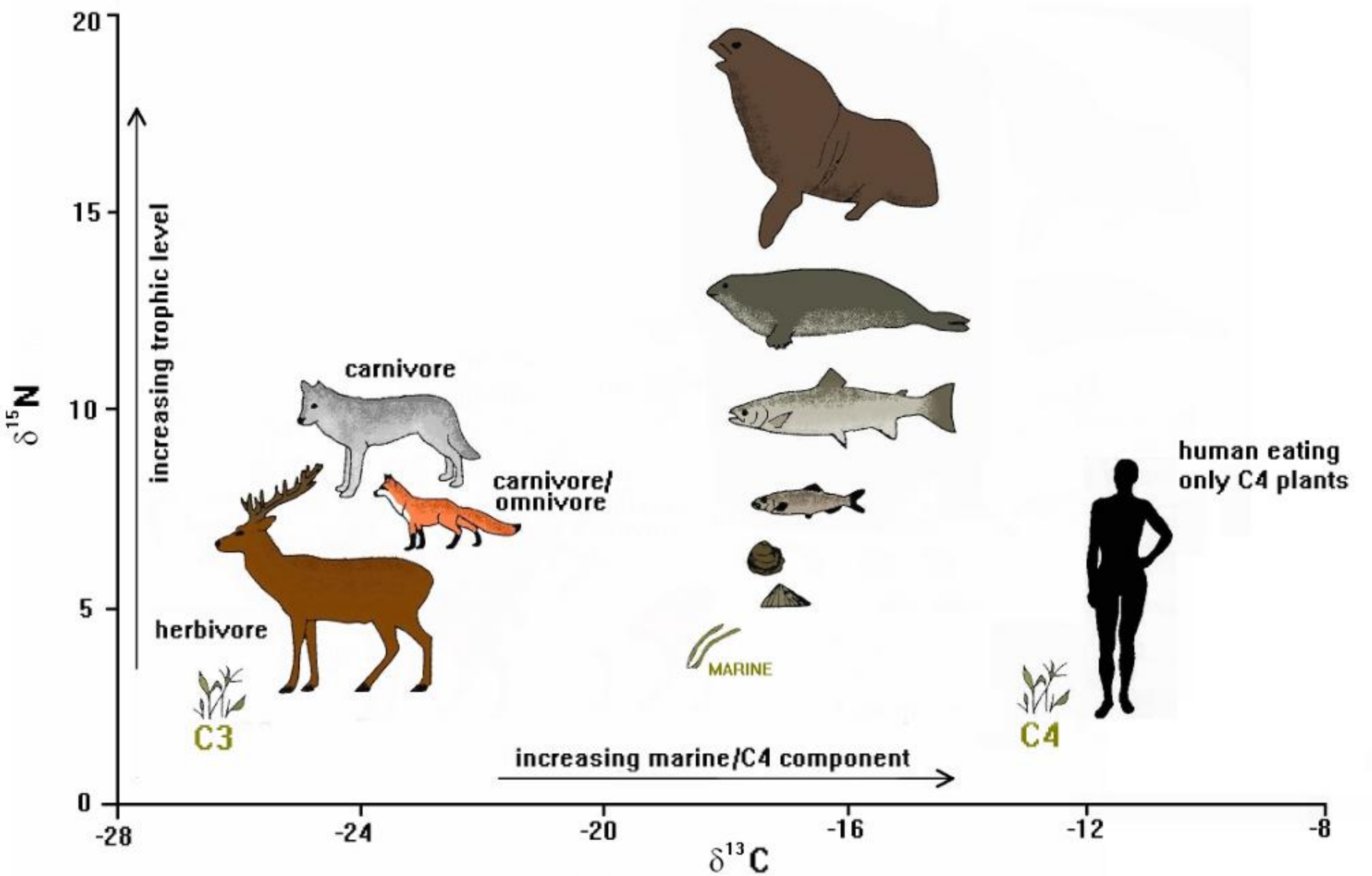
Sites

- Excavations: 1965/1966, 1985, 2008/2009
- Radiocarbon dates of human bones: ca. 2800-2350 BP
- Lapita pottery

- Surrounded by reef with areas of seagrass meadow
- Warm and humid
- Primary vegetation: Rainforest and swamp
- Edible native plants: sago palm, pandanus, tropical almond, canarium nut, fig, and coconut
- Crops: taro (*Colocasia/Alocasia*), yam, banana and sugarcane.
- Marine fauna bones: a high percentage of reef fish + shark, skate, shellfish, turtle and crab. No freshwater fish.
- Terrestrial fauna: dominated by pigs + bandicoot, reptile, rat. No dogs.

$\delta^{15}N$ and $\delta^{13}C$

Increasing trophic level



Increasing marine/C4 component

Materials

- Cortical bone from *six Lapita humans* + three individuals from the 1985/86 excavations
- Lapita pigs (n=25) and fish (n=3)
- Prehistoric/current plants/animals from published studies

1.5g of cortical bone, extraction of collagen, cleaning, demineralization.
EA-IRMS
Analytical error was routinely 0.1‰ for d13C and 0.2‰ for d15N.

Results-1

Pig husbandry practices

TABLE 1. Species, temporal period, bone collagen $\delta^{13}C$ and $\delta^{15}N$ values, and collagen quality indicators of the prehistoric fauna from Watom

Sample	Species	Element	Period	%C[ab]	$\delta^{13}C$ (‰)	%N	$\delta^{15}N$ (‰)	C:N
BF 101	*Sus scrofa*	Phalanx	Late prehistoric	42.0	−20.2	13.9	4.7	3.5
~~BF 103~~	~~*Sus scrofa*~~	~~Humerus~~	~~Post-Lapita~~	~~***33.1***~~	~~***−20.1***~~	~~***10.9***~~	~~***5.7***~~	~~***3.6***~~
BF 105	*Sus scrofa*	Phalanx	Post-Lapita	37.3	−20.2	12.5	7.7	3.5
BF 109	*Sus scrofa*	Phalanx	Post-Lapita	41.9	−18.6	14.7	7.7	3.3
BF 111	*Sus scrofa*	Humerus	Post-Lapita	41.1	−19.2	13.6	10.1	3.5
BF 112	*Sus scrofa*	Humerus	Post-Lapita	40.6	−18.3	14.1	10.9	3.4
BF 115	*Sus scrofa*	Phalanx	Post-Lapita	45.4	−19.6	15.5	7.0	3.4
BF 116	*Sus scrofa*	Femur	Post-Lapita	43.5	−19.6	14.2	7.3	3.6
BF 117	*Sus scrofa*	Tibia	Post-Lapita	43.9	−19.2	15.2	7.9	3.4
BF 119	*Sus scrofa*	Rib	Lapita	44.2	−19.0	15.0	7.4	3.4
BF 120	*Sus scrofa*	Phalanx	Lapita	43.8	−20.0	15.2	9.0	3.4
BF 122	*Sus scrofa*	Scapula	Lapita	40.4	−20.3	13.8	6.5	3.4
BF 123	*Sus scrofa*	Skull	Lapita	38.7	−18.7	12.9	8.1	3.5
~~BF 124~~	~~*Sus scrofa*~~	~~Phalanx~~	~~Lapita~~	~~***39.3***~~	~~***−20.6***~~	~~***11.9***~~	~~***6.8***~~	~~***3.8***~~
BF 125	*Sus scrofa*	Rib	Lapita	39.2	−20.0	13.1	7.7	3.5
BF 126	*Sus scrofa*	Tibia	Lapita	43.7	−19.1	15.0	7.3	3.4
BF 128	*Sus scrofa*	Humerus	Lapita	38.5	−20.5	13.1	7.0	3.4
BF 130	*Sus scrofa*	Phalanx	Lapita	42.3	−19.2	14.6	10.1	3.4
BF 131	*Sus scrofa*	Long bone	Lapita	43.7	−17.3	15.4	12.3	3.3
BF 132	*Sus scrofa*	Rib	Lapita	43.6	−19.9	14.8	8.2	3.4
BF 133	*Sus scrofa*	Femur	Lapita	42.4	−19.2	14.4	9.1	3.4
BF 135	*Sus scrofa*	Rib	Lapita	43.0	−19.6	14.8	8.3	3.4
BF 138	*Sus scrofa*	Radius	Lapita	42.3	−19.3	14.9	8.3	3.3
~~BF 139~~	~~*Sus scrofa*~~	~~Rib~~	~~Lapita~~	~~***30.2***~~	~~***−17.0***~~	~~***4.2***~~	~~***8.0***~~	~~***8.5***~~
BF 155	Scaridae	Pharyngeal plate	Post-Lapita	34.6	−5.0	11.4	7.2	3.6
BF 157	*Monotaxis grandoculis*	Dentary	Post-Lapita	41.8	−5.1	14.3	10.5	3.4
BF 162	*Monotaxis grandoculis*	Premaxilla	Post-Lapita	40.8	−3.7	14.2	9.3	3.4
BF 167	Lutjanidae	Hyomandibular	Lapita	42.4	−7.3	14.4	13.3	3.4
BF 168	Scaridae	Pharyngeal plate-upper	Lapita	35.4	−6.1	12.5	7.6	3.3
~~BF 169~~	~~Scaridae~~	~~Pharyngeal plate-lower~~	~~Lapita~~	~~***37.4***~~	~~***−8.7***~~	~~***10.9***~~	~~***8.3***~~	~~***4.0***~~
BF 172	*Sus scrofa*	Humerus	Lapita	43.9	−19.8	15.3	6.5	3.3

The range in d13C and d15N values was much greater in the Lapita pigs (-20.5‰ to -17.3‰ and 6.5‰ to 12.3‰, respectively) as compared to the post-Lapita pigs (-20.2‰ to -18.3‰ and 7.0‰ to 10.9‰, respectively).

TABLE 2. *Descripitive statistics for Watom faunal samples*

Species	Period	n =	$\delta^{13}C$ (‰)	±1 SD	$\delta^{15}N$ (‰)	±1 SD
Sus scrofa	All layers	22	−19.4	0.7	8.1	1.6
Sus scrofa	Late prehistoric	1	−20.2		4.7	
Sus scrofa	Post-Lapita	7	−19.2	0.6	8.4	1.5
Sus scrofa	Lapita	14	−19.4	0.8	8.3	1.5
Scaridae	Post-Lapita	1	−5.0		7.2	
Scaridae	Lapita	1	−6.1		7.6	
Monotaxis grandoculis	Post-Lapita	2	−4.4	1.0	9.9	0.8
Lutjanidae	Lapita	1	−7.3		13.3	

d13C and d15N values were similar between the Lapita and post-Lapita periods

Late prehistoric pig showed the lower values

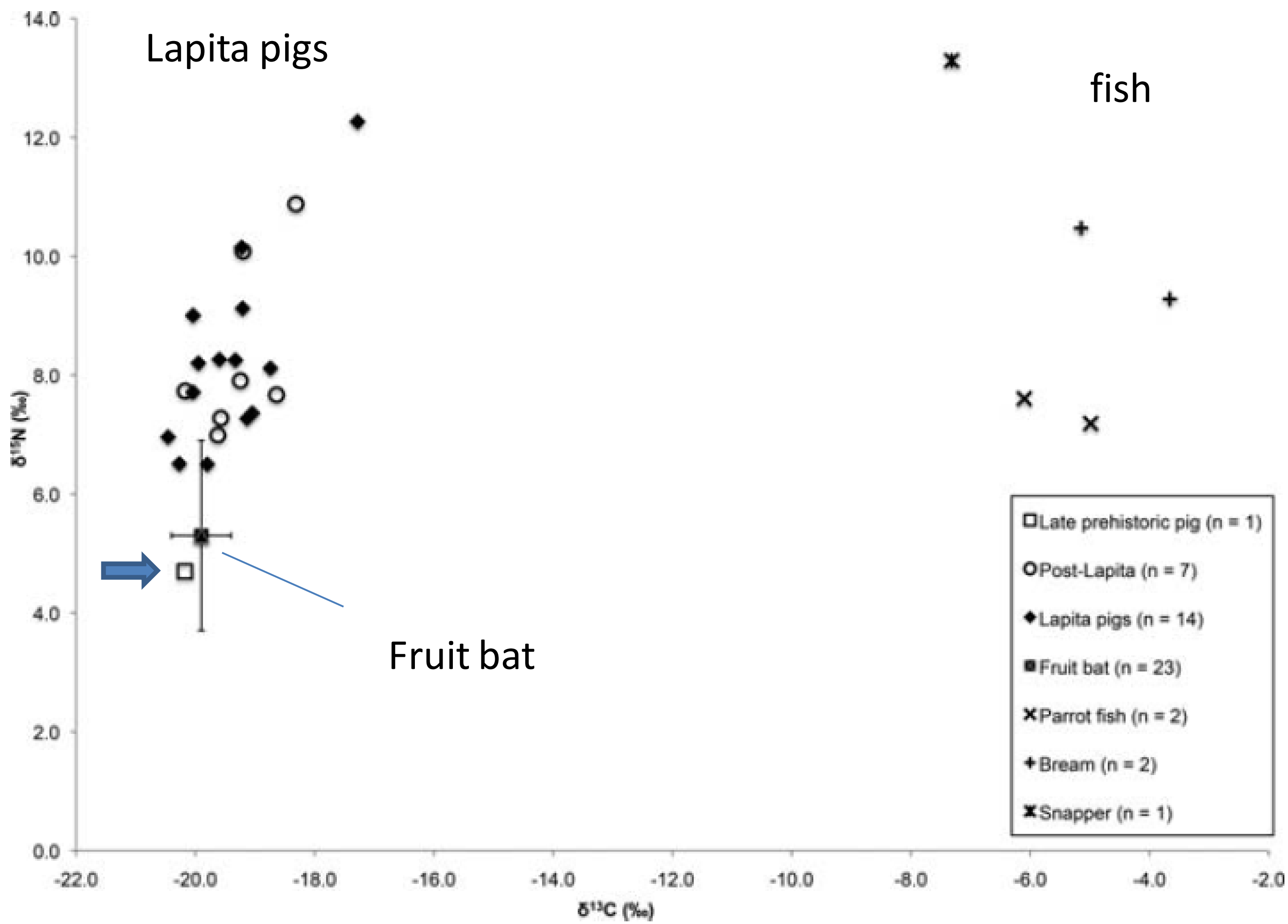


Fig. 3. δ^{13}C and δ^{15}N values of the Watom fauna with reference to the average (±1 SD) stable isotope values of Pacific island fruit bats (representing a purely C_3 terrestrial-based diet).

Evidence for animal husbandry practices

The diet of pigs was terrestrial and their protein resources were from lower tropic levels than the humans.

$\delta 15N/\delta 13C$ values were similar between the Lapita (n=14) and post-Lapita (n=7) pigs → do changes of husbandry practice over time

Late prehistoric pig showed lower $\delta 15N$ value than those of Lapita or post-Lapita→ the change from free-range pig husbandry system to human-feeding system ?

$\delta^{18}O$ and $^{87}Sr/^{86}Sr$ study showed many pigs are nonlocal to Watom → Pig exchange system as observed in current Melanesia.

Results-2

Lapita diet, 3000 BP-2600 BP, Watom

TABLE 3. Demographic data, bone collagen $\delta^{13}C$ and $\delta^{15}N$ values, and collagen quality indicators for the humans from Watom

Burial	Age[a]	Sex[b]	Element[c]	%C[de]	$\delta^{13}C$ (‰)	%N	$\delta^{15}N$ (‰)	C:N
W1[f]	YA	F	?	40.6	−18.1	14.2	10.9	3.3
W2[f]	YA	F	?	39.1	−18.5	13.9	10.7	3.3
W3[f]	MA	M	?	42.2	−17.8	15.1	11.1	3.3
W5	YA	M	Tibia shaft	44.2	−18.2	14.5	10.2	3.6
W10	YA	F	LB shaft	40.5	−18.7	13.8	11.7	3.4
W8	UK	M	Fibula shaft	42.7	−18.4	14.3	10.5	3.5
W9	OA	F	Fibula shaft	42.1	−16.8	14.4	13.5	3.4
W13	UK	M	Radius shaft	41.2	−18.1	14.7	11.2	3.3
W15	YA	M	Humerus shaft	***39.1***	***−19.8***	***9.6***	***10.5***	***4.8***

[a] YA = Young adult (17–34.9 years), MA = Mid adult (35–49.9 years), OA = Old adult (50+), and UK = Adult with unknown age; estimated from standards found in Buikstra and Ubelaker (1994).

TABLE 4. Descriptive statistics for Watom humans

	n =	δ^{13}C (‰)	±1 SD	δ^{15}N (‰)	±1 SD
Adults	8	−18.1	0.6	11.2	1.0
Males	4	−18.1	0.3	10.8	0.5
Females	4	−18.0	0.9	11.7	1.3

Mean δ15N: Females > Males

Range in δ15N/δ13C: Females > Males

- Females consumed more marine foods than males
- Female diets were more variable than that of the males

TABLE 3. Demographic data, bone collagen $\delta^{13}C$ and $\delta^{15}N$ values, and collagen quality indicators for the humans from Watom

Burial	Age[a]	Sex[b]	Element[c]	%C[de]	$\delta^{13}C$ (‰)	%N	$\delta^{15}N$ (‰)	C:N
W1[f]	YA	F	?	40.6	−18.1	14.2	10.9	3.3
W2[f]	YA	F	?	39.1	−18.5	13.9	10.7	3.3
W3[f]	MA	M	?	42.2	−17.8	15.1	11.1	3.3
W5	YA	M	Tibia shaft	44.2	−18.2	14.5	10.2	3.6
W10	YA	F	LB shaft	40.5	−18.7	13.8	11.7	3.4
W8	UK	M	Fibula shaft	42.7	−18.4	14.3	10.5	3.5
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[a] YA = Young adult (17–34.9 years), MA = Mid adult (35–49.9 years), OA = Old adult (50+), and UK = Adult with unknown age; estimated from standards found in Buikstra and Ubelaker (1994).

Sex difference in diet

Mean δ15N: Females > Males

Range in δ15N/δ13C : Females > Males

- Females consumed more marine foods than males
- Female diets were more variable than that of the males

* Pacific island palaeodietary study: Males consumed more marine foods than females

$\delta^{18}O$ and $^{87}Sr/^{86}Sr$ study for W9 and W10 showed that they spent her childhood in areas outside Watom and moved into Watom later in life. They consumed more marine foods than males, while other females consumed equaivalent amount of marine foods.

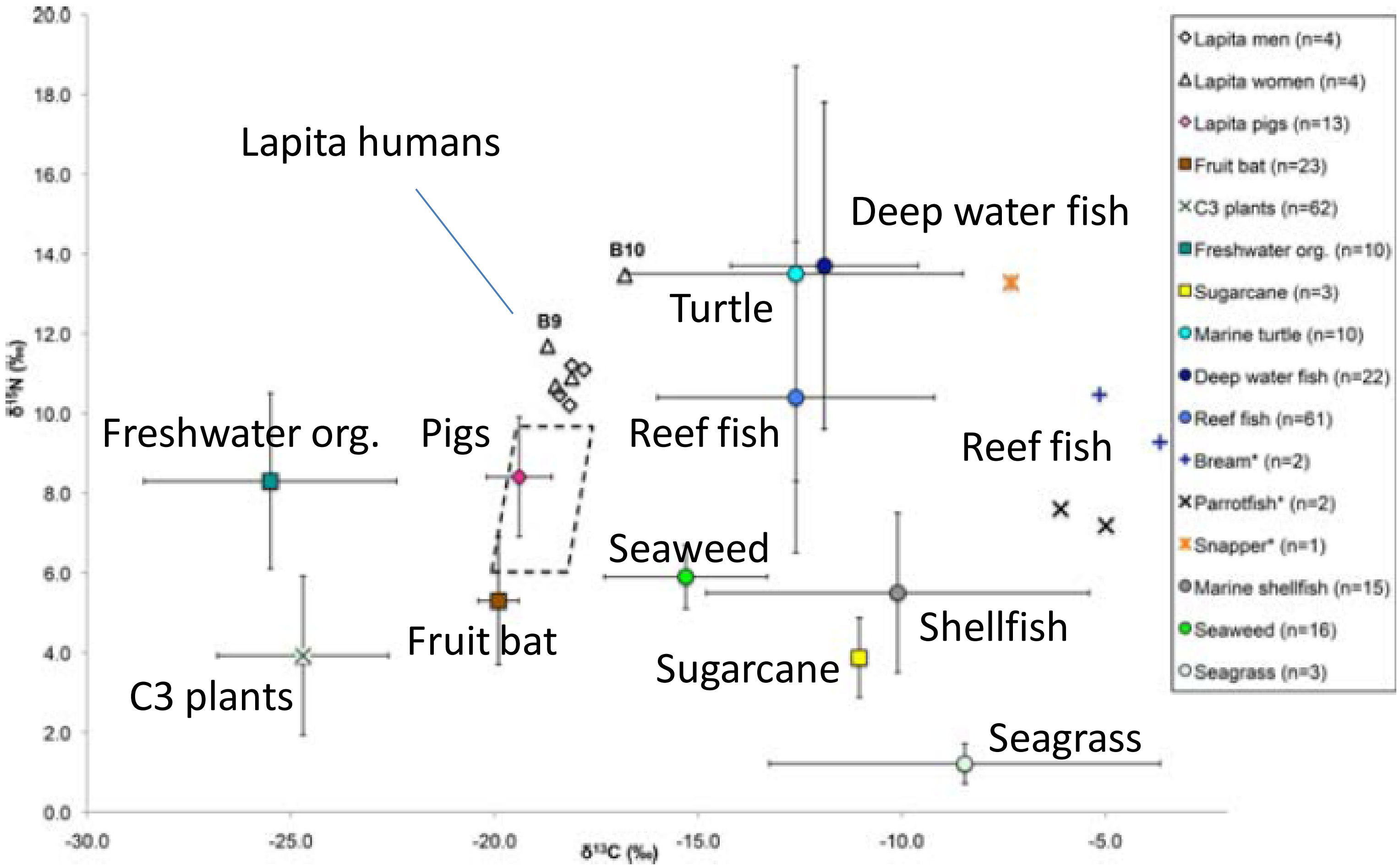

Fig. 4. Watom humans plotted on a tropical Pacific island dietary baseline. The dashed rectangle delineates a trophic effect of 4‰ for $\delta^{15}N$ and 1‰ for $\delta^{13}C$ values. Note that burials 9 and 10 (B9 and B10) are identified as outliers from their $\delta^{13}C$ and $\delta^{15}N$ values. Fish species marked with and asterisk (*) are from the Watom site.

Abundant marine resourced
To domesticated animals and crops

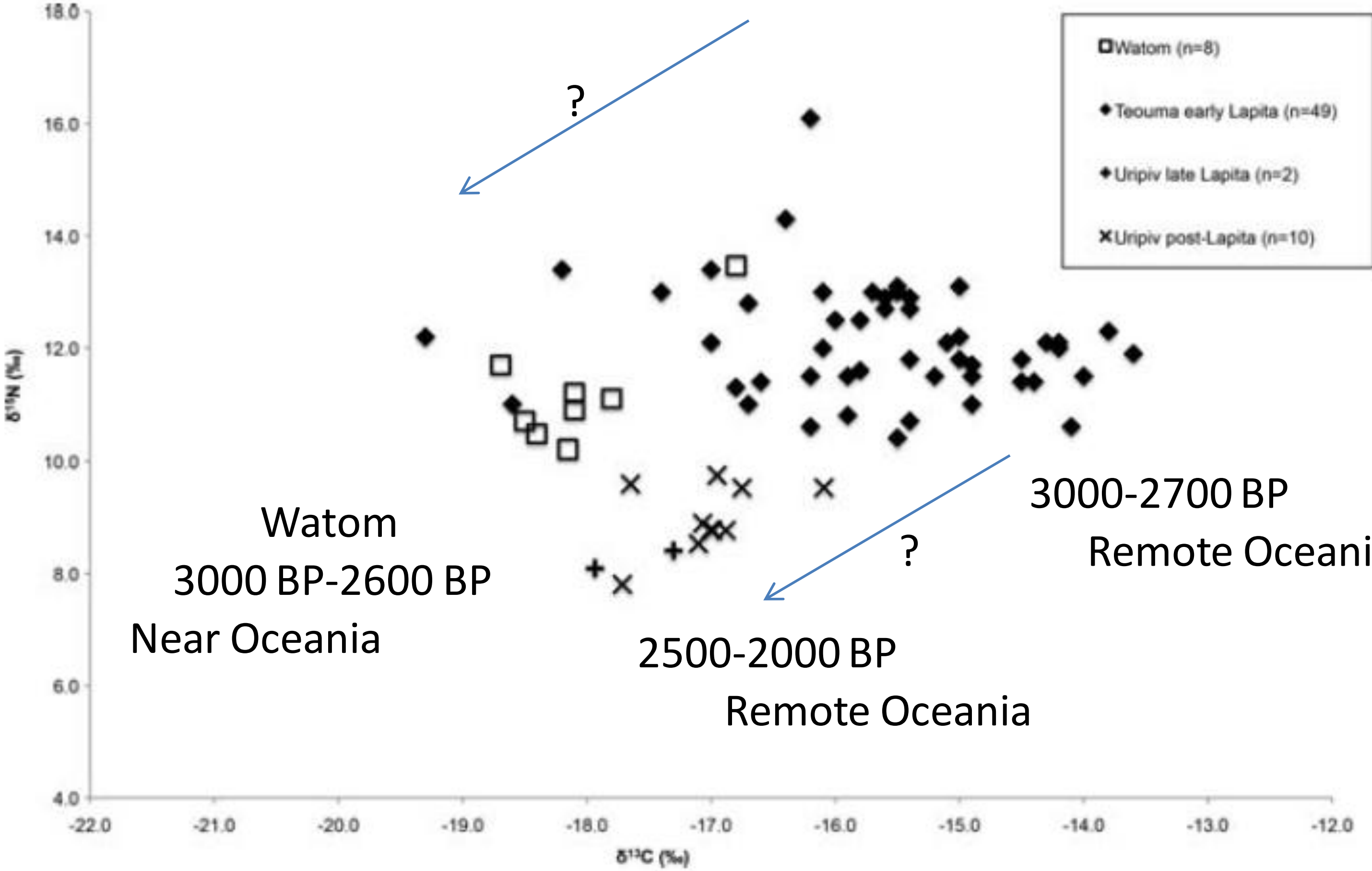

Fig. 5. $\delta^{13}C$ and $\delta^{15}N$ values of humans from the prehistoric Pacific island cemetery sites of Watom, Teouma, and Uripiv.

CONCLUSION: Lapita diet and subsistence

The results support a number of current theories of Lapita subsistence strategies that posit that Lapita populations would have utilized broad-spectrum foraging (especially of the marine environment), in addition to lower levels of horticulture and animal.

Differences between the stable isotope ratios of individuals from other Lapita cemetery samples suggest that dietary variation occurred during the Lapita period and was likely influenced by the location of the settlement in the Pacific (i.e., Near vs. Remote Oceania), the type of island (e.g., large vs. small), and the specific temporal period (i.e., early vs. late Lapita periods).

Sex differences in diet may have been a result of the movement of nonlocal women to Watom, possibly as a result of marriage.

The stable isotope analysis of the pigs from different periods indicates that there were few differences between the diet of pigs from the Lapita and post-Lapita periods, suggesting that animal husbandry methods were similar between these times. These animal husbandry methods probably included free-range methods, supplemented by feeding with horticultural plant products and human food scraps.