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New insights into the marine contribution to ancient Easter Islanders' diet

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ABSTRACT

Easter Island (or Rapa Nui), internationally renowned for its megalithic statues, is the most isolated inhabited island of the Pacific. Archaeological surveys undertaken from the end of the 19th century led to the discovery of the remains of several hundred human individuals. The majority were buried in monuments (funerary stone platform called *ahu*) or in caves. This paper presents a study of the ancient Easter Islanders' diet through carbon and nitrogen stable isotope analysis of human tooth and bone collagen and, more particularly, evaluates the impact of gender, age, social status and location of burials. The 125 studied individuals are from 16 sites, which date mainly from the 17th to the 19th centuries. This anthropological material is housed at the Royal Belgian Institute of Natural sciences and the Father Sebastián Englert Anthropological Museum of Easter Island. One hundred and seven individuals showed well-preserved collagen. The stable isotope data provide new information on ancient Easter Islander dietary habits. They demonstrate gender disparity in access to food resources and show that children were breastfed until 3 years of age. Furthermore, the isotopic signatures cluster according to the place of burial (*ahu*) indicating family dietary specificities. Finally, our study reveals influences of social status on food intake: individuals from *Ahu Nau Nau*, which is said to be the royal *ahu*, display the highest nitrogen and carbon isotope values. A greater consumption of marine products may explain this distinction.

1. Introduction

The aim of this paper is to bring new insights into the ancient[1] Easter Islanders' diet. Dietary reconstructions have already been performed at the population scale but dietary differences between groups in the Easter Island population have not yet been investigated. We therefore applied stable isotope analysis to more than 100 human samples to test if parameters such as gender, age at death and social status influenced food intake.

1.1. Easter Island and the origin of its inhabitants

Easter Island (or Rapa Nui), internationally renowned for its megalithic statues (*moai*), is the most isolated inhabited island of the Pacific (Fig. 1). It is located 3600 km from the Chilean coasts and 4200 km of Tahiti. Today, its closest populated neighbour is Pitcairn Island, 2075 km to the west. Easter Island has a volcanic origin and a land area of 160.5 km^2 (Fischer and Love, 1993).

According to some authors, the initial human settlement of Easter Island took place between the 8th and the 10th century A.D. (Bahn, 1993). For others, it occurred more recently, dating to the 12th century AD (Hunt and Lipo, 2006). Anthropological (Turner and Scott, 1977; Gill and Owsley, 1993), palaeogenetic (Hagelberg et al., 1994), ethnographic (Métraux, 1971) and linguistic (Du Feu and Fischer, 1993) research showed that Easter Islanders had a Polynesian origin.

1.2. History, chronology, social organisation and burial practices of the ancient Easter Islanders

The history of Easter Islanders was far from peaceful. They had to face deforestation (the island had, until the beginning of the 17th century, a forest cover where palm trees dominated; Flenley and King, 1984; Orliac and Orliac, 1998), slave raids in the 19th century (Lavachery, 1935; Maude, 1981; Fischer, 2005) and then, epidemics and colonialism (Fischer, 2005; Métraux, 1971).

Several chronologies have been proposed for the Rapa Nui cultural sequence (Mulrooney et al., 2010). Biological anthropologists generally use a chronology combining the systems presented by McCall (1979) and Mulloy (1961), divided in five phases (Shaw, 2000)[2]:

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[1] We mean by "ancient", the human populations who have lived on Easter Island, regardless of whether they were Prehistoric (precontact) or more recent.

[2] The date AD 1680 is based on oral tradition: it relates to a shift in the socio-political structure of the society (cessation of statue carving, shift in burial practices, etc.). AD 1722 is the first recorded European contact and AD 1864, the arrival of the first missionary.

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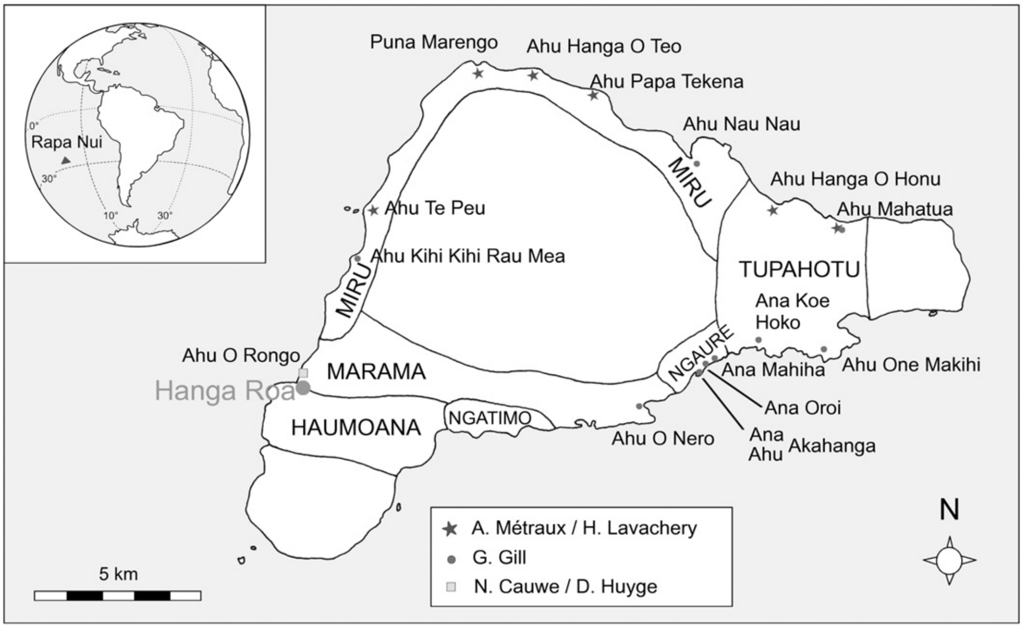

Fig. 1. Location of Easter Island (Rapa Nui). Map of the island with its capital (Hanga Roa), the reported clan divisions in capital letters (after Routledge, 1919) and the different studied sites.

- Early Prehistoric Period = AD 400–1100 (absent in Hunt and Lipo (2006)'s late colonisation model)
- Middle Prehistoric Period = AD 1100–1680
- Late Prehistoric Period = AD 1680–1722
- Protohistoric Period = AD 1722–1864
- Historic Period = 1864–present.

The Rapa Nui people were organised in 'kinship groups' called *mata* (tribes) (McCall, 1979) made up of descendants of a common ancestor (Métraux, 1971, p. 123). During her stay on the island in 1913–1915, the British archaeologist K. Routledge recorded ten tribes, which were associated with different parts of the island (Routledge, 1919, p. 221–224; Fig. 1). One tribe, named *Miru*, ranked above the other tribes (Routledge, 1919, p. 240–243). The *ariki-mau* or king of Easter Island was a member of the *Miru* tribe. He had *mana* (supernatural power) and his power was manifested through a system of restrictions (*tapu*), which governs the right to use various resources (Métraux, 1971, p. 130–132).

Rapa Nui society was essentially patriarchal and the place of women was secondary to men. Women were subject to the authority of their father and their husband (Métraux, 1971, p. 98, 111–113). They appear to have been bound to domestic chores, crop harvesting, motherhood and the care of children (Arredondo, 2000a, 2000b). Children were under paternal authority. They were always welcome but sons were preferred (Métraux, 1971, p. 101; Arredondo, 2000a).

Various burial practices have been recorded on Easter Island. The majority of the deceased were buried in monuments (*ahu*). In Prehistoric period (mainly 13–15th centuries), the dead were generally incinerated and their ashes gathered in stone-lined cists located at the rear of the *ahu* (Ayres and Saleeby, 2000; Huyge et al., 2002; Polet, 2003). After deforestation, the progressive abandonment of *moai* cult and their overthrow, Easter Islanders continued to bury their dead in the *ahu* but, this time, mostly in niches dug in the platform or under lying moai (Seelenfreund, 2000; Cauwe, 2011). In addition, there were also burials in caves that seem to have taken place after the discovery of the island by the Europeans (Shaw, 2000), some of which may have contained individuals who died during the great epidemics of the 19th century.

1.3. Stable isotopes and dietary reconstruction

Stable isotope analyses have proved to be efficient methods for reconstructing palaeodiets (Brown and Brown, 2011; Schwarcz and Schoeninger, 2011). They are based on the fact that the differences in isotopic composition between different categories of food are reflected in the bones or teeth of the consumer. There is an isotopic enrichment in the animal relative to its diet: this is called the trophic level effect. The magnitude of this increase depends on the isotope in question (Post, 2002).

The contribution of these isotopic analyses to the knowledge of past populations' lifestyles is invaluable because they give a direct measure of diets at individual level and consequently enable associations to be highlighted between subsistence and other attributes such as social status, age at death or sex (Katzenberg, 2000).

Stable isotopes have been used to assess the marine contribution to ancient diet (Mays, 1997; Richards and Hedges, 1999; Richards et al., 2005), which is peculiarly relevant for the insular Rapa Nui sample. They have also been applied to study changes in eating behaviour according to age, such as weaning (Fogel et al., 1997; Fuller et al., 2006, Tsutaya and Yoneda, 2015).

2. Easter Island subsistence in its Pacific context

Documenting ancient Easter Islanders' diet is interesting for several reasons. Firstly, it presents a good opportunity to reconstruct aspects of the past lifeways of this poorly documented population. It also provides an example of a culture in isolation where plant and animal dietary components were limited. At a wider scale, it contributes to the knowledge of Pacific past food culture.

Some general assumptions about Rapa Nui subsistence can be made. As Easter Islanders were living in an oceanic insular context, a mixed diet including terrestrial and marine food is to be expected. Given their Polynesian origin, their diet is supposed to display similarities with other Pacific Islanders. Nevertheless, due to their marginal location in Polynesia, their isolation and the environmental changes (deforestation) they underwent, some dietary peculiarities linked to a reduced biodiversity can be predicted.

2.1. Diet of Pacific Islanders

The Pacific Islands were colonised during a major human migration beginning ca. 50,000 years ago and spreading from Near Oceania to Remote Eastern Polynesia (Irwin, 1992). Aside from food and drink provisions required for the voyages, the sea travellers carried with them the animals and plants they could raise once ashore in their new island environment. Gradually, throughout the migrations, a Pacific food culture developed (Haden, 2009, p. 3–4). This is characterised by the species eaten but also by the technologies of cultivation, preservation and cooking (Aalbersberg and Parkinson, 1994; Lewis, 2008). The onboard food plants were mainly taro, coconut, yam, sago, banana, arrow-root, breadfruit, pandanus, sugarcane and sweet potato. The travelling animals were pigs, chickens, dogs and Polynesians rats. Not all these domesticates reached or survived in all part of Oceania (Clarke, 1994, p. 12). These 'transported landscapes' were supplemented with local resources such as fruits, and marine invertebrates and vertebrates (Kirch, 1984). The available indigenous foods varied from one island to another (Ayres, 1985) because Pacific Islands are diverse in their geology, topography, ecology and climate. The diversity of plant and animal species however drops markedly from west to east (Briggs, 1995, p. 365).

Throughout the Pacific Islands, food resources were not evenly distributed between the members of the society. Certain types of food were considered 'high-status' and were reserved for privileged individuals or eaten in larger quantities by these people (Oliver, 1989). In Oceania, food taboos were introduced to protect the resources and, when imposed on certain categories of people (based mainly on sex, age, marital status and social rank), to maintain dietary inequalities (Williamson, 1937, p. 139–147; Lewis, 2008).

Stable isotope analysis has been applied in reconstructing the diet of Pacific populations (Kinaston and Buckley, 2013). It has been used to assess the proportion of terrestrial versus marine food (Ambrose et al., 1997, Valentin et al., 2010), to demonstrate temporal changes in diet (Pate et al., 2001; Field et al., 2009), to study the link between diet and gender (Kinaston et al., 2014; Stantis et al., 2015), age (Kinaston et al., 2013a) and social status (McGovern-Wilson and Quinn, 1996; Valentin et al., 2006; Stantis et al., 2015).

2.2. Dietary evidence for ancient Easter Islanders

Retrieving information on Easter Islanders' dietary habits is not an easy task given the absence of written archives and the disappearance of the majority of keepers of ancient knowledge during the slave raids and epidemics of the 19th century (Lavachery, 1935; Maude, 1981; Fischer, 2005). The main source of direct information on the diet of ancient Easter Islanders is in fact food waste (middens), human remains and ethnographical studies (for the post European contact period).

Ethnohistoric researches (Pollock, 1993; Routledge, 1919; Métraux, 1971), archaeobotanical data (Flenley, 1993; Cummings, 1998), dental microwear studies (Polet et al., 2008) and starch grains analysis from dental calculus (Tromp and Dudgeon, 2015) demonstrate the dominance of tubers (sweet potato, taro, yam and arrow-root) in their daily diet. The high percentages of dental caries recorded by Owsley et al. (1983, 1985) confirm this hypothesis: the tubers eaten by Rapanui are rich in starches and highly cariogenic (Lingström et al., 2000). Bananas and sugarcane consumption (Pollock, 1993) may also have worsened the situation. Phytoliths of sugarcane have been found in human dental calculus, though at a low frequency (5.85%) (Dudgeon and Tromp, 2012).

Ethnographers emphasise the low level of marine food consumption during the historic periods (Routledge, 1919; Métraux, 1971). Archaeozoologists and archaeologists have demonstrated that this has not always been the case: there must have been a decrease of fishing (especially of deep-sea fishing) with time (Ayres, 1985; Vargas Casanova et al., 1993; Steadman et al., 1994; Rorrer, 1998; Ayres et al., 2000; Martinsson-Wallin and Crockford, 2002). On the other hand, chicken and rats also constituted an important source of dietary protein (Klemmer and Zizka, 1993; Steadman et al., 1994).

Moreover, frequency of stress indicators (enamel hypoplasia and *cribra orbitalia*) in Easter Islanders is similar to other ancient populations of the Pacific and lower than that of European medieval populations (Polet, 2006). This suggests that malnutrition was not severe during childhood on the island.

Stable isotope analysis has also already been undertaken on ancient Easter Islanders. In 1997, Fogel et al. analysed nitrogen isotope values of a small sample (the precise number of individuals and their provenance/location on the island is not mentioned) composed of chickens, rats and humans from Rapa Nui. They concluded that there must have been some marine foods in the humans' diet and that further analyses needed to be done. In 2013, Commendador et al. compared the carbon and nitrogen isotopic ratios of 41 Rapa Nui adult human teeth with 132 animal remains, and produced radiocarbon dates for 26 of these human teeth (Commendador et al., 2014). Human samples were from seven archaeological sites, and animal samples were from a single site (Anakena Beach). These authors concluded that the Easter Islanders' diet was predominantly terrestrial, a relatively surprising conclusion in an insular context with abundant zooarchaeological remains of marine animals (Table 1 in Commendador et al., 2013) and with a well-developed and diversified fishing technology (Métraux, 1971, p. 174–192; Arana, 2014). They demonstrated a decline in nitrogen isotope ratios through time, interpreted as a chronological decrease in consumption of terrestrial animal protein. Their data also suggested differential access to marine resources in relation to the interment locations but the sample sizes were too small to demonstrate a consistent pattern. Commendador et al. (2013) also compared the isotopic signatures of their Rapa Nui samples with data published for 12 other Pacific Islands. They showed that the Rapa Nui material was higher in nitrogen isotopes ratios but within a similar range of carbon isotopes ratios than the other Pacific Islands. This suggests that Rapa Nui diet was more focused on terrestrial resources than most other Pacific Islands.

2.3. Research questions of this study

In the present study, we further examine the contribution of marine food in the diet of Easter Islanders, with a special focus on the impact on diet of biological parameters such as gender and age at death, and the influence of cultural factors such as social status and burial location on diet, something new in this context.

Based on carbon and nitrogen stable isotope analysis of 125 human samples coming from sites from across the island and dated mainly from the Late Prehistoric and Protohistoric Periods, our study will try more specifically to answer to the following questions:

- Did the people buried in caves belong to a particular social group characterised by different dietary habits than people buried in *ahu*?
- Is there a recognisable regional variation in the diet that can be associated with historic tribe group divisions?
- Was diet related to social status? Did the royal *Miru* tribe benefited from a privileged diet?
- Given the gender inequality in everyday-life authority and family responsibilities, did women and children have access to the same foods as men?
- How did children's diet change during growth? When did weaning occur?

3. Material

Archaeological surveys undertaken from the end of the 19th century on Easter Island allowed the discovery of the remains of several

Table 1
Details of the samples selected for stable isotope analyses. G = Gill, LM = Lavachery and Métraux, CH = Cauwe and Huyge, RBINS = Royal Belgian Institute of Natural Sciences, MAPSE = Museo Antropológico Padre Sebastián Englert, RMAH = Royal Museums of Art and History, CHB = ^{14}C on human bone, CC = ^{14}C on charcoal, OH = Obsidian hydration. Dates come from Lavachery (1935), Seelenfreund (2000), Shaw (2000), Huyge and Cauwe (2002) and Commendador et al. (2013).

	Site	Collectors	Repository	Chronology	Dating methods	N total	N selected
Ahu	Nau Nau	G	MAPSE	15th–19th c.	CHB	480	27
	Kihi Kihi Rau Mea	G	MAPSE	17–20th c.	OH/CHB	48	14
	O'Nero	G	MAPSE	End 17th–19th c.	OH	29	11
	Akahanga	G	MAPSE	17–19th c.	CHB	42	9
	One Makihi	G	MAPSE	18–19th c.	CHB	19	2
	Mahatua	G/LM	MAPSE	19–20th c.	CHB	23	13
	Hanga O Onu = La Pérouse Bay	LM	RBINS	19th c. ?		8	8
	Papa Tekena	LM	RBINS	19th c. ?		3	3
	Tepeu	LM	RBINS	19th c. ?		2	2
	Hanga o Teo	LM	RBINS	19th c. ?		1	1
	O Rongo	CH	MAPSE	End 13th c.–beginning 14th c.	OH/CC	6	4
Cave	Akahanga	G	MAPSE	18th–19th c.	OH	14	2
(*Ana*)	Koe Hoko	G	MAPSE	18th–19th c.	OH	22	9
	Mahiha	G	MAPSE	17th–19th c.	OH	12	6
	Oroi	G	MAPSE	18th–19th c.	OH/CHB	43	11
Other	Puna Marengo	LM	RBINS	19th c. ?		1	1
	? (engraved skulls)	LM	RMAH	19th c. ?		2	2

hundred individuals where often, unfortunately, only the skulls were collected.

The chronological attribution of the skeletons, however, is problematic as most of the monuments were used over a long period of time. Moreover, dating was mainly carried out on obsidian artefacts (Seelenfreund, 2000; Shaw, 2000) or wood charcoal (Mulrooney, 2013) but rarely on human remains directly (26 radiocarbon dates can nevertheless be found in Commendador et al., 2014).

The 125 samples studied come from 16 sites (mainly *ahu* and caves), which date principally from the 17th to the 19th centuries (Fig. 1 and Table 1). They are composed of:

- skulls and long bones brought back to Europe in 1935 by A. Métraux and H. Lavachery (Lavachery, 1935). These specimens come from the north of the island and belong to the collections of the Royal Belgian Institute of the Natural sciences (RBINS). Two engraved skulls from unknown location belong to the collections of the Royal Museums of Art and History (RMAH);
- skeletons exhumed at the end of the 1970s by G. Gill (Gill and Owsley, 1993). These specimens belong to the collections of the Museo Antropológico Padre Sebastián Englert (MAPSE) of Easter Island, which holds the majority of the anthropological material recently excavated;
- skeletons recently discovered by N. Cauwe and D. Huyge (Huyge et al., 2002; Polet, 2003; Cauwe, 2011). These specimens are housed at the MAPSE.

4. Methods

We used the results of the morphological sex determination and age-at-death estimation of G. Gill (published in Gill, 2000; Seelenfreund, 2000 and Shaw, 2000) and the genetic sex determination performed by Dudgeon (2008, p. 141–147). We applied the same anthropological methods to the human remains Gill did not study (as described in Gill, 2000). When there was a contradiction between the "morphological" and the "genetic" sex diagnoses, we used the latter.

For the isotopic analyses, we sampled 200–300 mg of compact bone with a manual drill fitted with Bullet® bits. These bits do not compress the material and form shavings instead of powder. Small pieces of dentine were cut using a metal cutting handsaw (a new blade was used for each sample). Dentin samples were powdered using an agate mortar and pestle. About five milligrammes of each powder was then analysed with a CNS Elemental Analyser to screen out samples that retained less than 10% of their original collagen following the approach of Bocherens et al. (2005).

Collagen was purified according to the modified Longin protocol (Longin, 1971) as described in Bocherens et al. (1997). Only extracts with chemical composition within the range of modern bone collagen extracted using the same protocol were retained for interpretation of their isotopic results, i.e., an atomic C/N ratio ranging from 2.9 to 3.6 (DeNiro, 1985) and a nitrogen amount higher than 5% in the extract (Ambrose, 1998). Measurements of carbon and nitrogen isotopic composition were performed using a NC 2500 Elemental Analyzer connected to a Thermo Quest Delta + XL isotopic ratio mass spectrometer at the Geochemistry department of the University of Tübingen. Isotopic relative abundances are expressed as 'delta' values relative to international standards as follows: $\delta^{E}X = (R_{sample} / R_{standard} - 1) \times 1000$, where X is C or N, E is the atomic number 13 or 15, and R is the isotopic ratios $^{13}C/^{12}C$ and $^{15}N/^{14}N$, respectively. Delta values are reported relative to international reference standards: a Vienna Pee Dee Belemnite (V-PDB) for carbon and atmospheric nitrogen (AIR) for nitrogen. Isotopic values of the samples are calibrated to the $\delta^{13}C$ values of USGS 24 ($\delta^{13}C = -16.00‰$, relative to VPDB) and to the $\delta^{15}N$ values of IAEA 305 A ($\delta^{15}N = 39.80‰$, relative to AIR). The standard errors based on repeated measurements of internal standards are ±0.1‰ and ±0.2‰ for $\delta^{13}C$ and $\delta^{15}N$ values, respectively.

5. Results

The results of the 125 collagen extractions are presented in Table 2. Eighteen samples were rejected because their nitrogen content was too low and/or because their C/N ratio was out of the acceptable range.

For 107 Rapanui individuals, their bone collagen $\delta^{15}N$ values ranged from 10.6‰ to 16.9‰ with a mean of 13.4 ± 1.2‰. Their $\delta^{13}C$ values ranged from −21.0‰ to −15.5‰ with a mean of −18.4 ± 0.9‰. The carbon and nitrogen isotopic values of all individuals are strongly correlated ($r(107) = 0.42$, $p < 0.001$).

The 107 human stable isotope data obtained in the present study can be compared to the fauna data from Commendador et al. (2013) (Fig. 2). Most of the humans display $\delta^{13}C$ that are within the range of terrestrial plants and animals but some individuals display intermediate values between marine and terrestrial organisms. Their $\delta^{15}N$ are in the range of terrestrial and marine animals (but higher than inshore fish).

The individuals buried in *ahu* were compared with the individuals buried in cave with a Student's t-test. These two groups do not display significant differences in their carbon and nitrogen isotopic signals ($p > 0.1$) (Table 3).

Table 2
List of specimens and results of isotopic analyses. Bold type indicates contradictions between the morphological sex diagnosis and the genetic sex diagnosis, and for those samples where the atomic C/N ratio was outside the range of 2.9–3.6.

Analysis no.	Museum inventory no.	Element sampled	Site	Age	Sex morph	Sex DNA	%Cc	%Nc	C/N	$\delta^{13}C$ ‰	$\delta^{15}N$ ‰
IP-1	1	Skull	Puna Marengo	Adult	?	–	23.4	9.9	**2.8**		
IP-2	5	Skull	Ahu Mahatua	Adult	?	–	26.1	10.1	3.0	−18.5	11.9
IP-3	2	Skull	Hanga o Onu	Adult	?	–	39.1	13.7	3.3	−18.6	13.0
IP-4	3	Skull	Hanga o Onu	Adult	?	–	34.3	12.3	3.2	−17.7	11.5
IP-5	7	Skull	Hanga o Onu	Adult	?	–	14.0				
IP-6	9	Skull	Hanga o Onu	Adult	?	–	36.2	12.5	3.4	−17.5	12.9
IP-7	10	Skull	Hanga o Onu	Adult	?	–	39.3	14.0	3.3	−17.7	13.6
IP-8	11	Skull	Hanga o Onu	Adult	?	–	37.7	13.0	3.4	−18.6	12.7
IP-9	12	Skull	Hanga o Onu	Adult	?	–	35.7	12.3	3.4	−18.4	13.2
IP-10	15	Skull	Hanga o Onu	Adult	?	–	34.9	12.9	3.2	−17.9	14.6
IP-11	6	Skull	Ahu Papate Kena	Adult	?	–	37.2	13.6	3.2	−18.2	12.2
IP-12	13	Skull	Ahu Papate Kena	Adult	?	–	38.9	13.3	3.4	−18.8	12.5
IP-13	14	Skull	Ahu Papate Kena	Adult	?	–	36.6	12.7	3.4	−18.6	13.1
IP-14	16	Skull	Hanga o Teo	Adult	?	–	12.0	3.4	**4.1**		
IP-15	Juv. 1	*Pars lateralis*	Ahu o rongo	Newborn	?	–	1.0				
IP-16	Juv. 2	Canine	Ahu o rongo	3 years	?	–	41.0	14.3	3.4	−20.4	14.3
IP-17	Juv. 3	Metacarpal IV	Ahu o rongo	6 years	?	–	36.7	13.0	3.3	−18.7	13.8
IP-18	Juv. 4	1st molar	Ahu o rongo	10 years	?	–	39.6	13.7	3.4	−19.6	14.3
IP-21	17-06-0609	Femur	Ana Koe Hoko	>40 years	F	–	42.6	14.4	3.4	−19.6	11.8
IP-23	17-06-0018	Humerus	Ahu Nau Nau	30–40 years	H	–	1.8				
IP-24	17-06-0521	Fibula	Ahu o Nero	30–40 years	H	–	31.8	11.3	3.3	−18.6	14.3
IP-25	17-06-0056	Femur	Ahu Nau Nau	3 years	?	–	34.9	11.5	3.5	−18.4	15.6
IP-27	17-06-0480	Calcaneus	Ana Mahiha	1.5–2 years	?	–	38.2	13.4	3.3	−15.7	15.6
IP-28	17-06-0328	Femur	Ahu Akahanga	11 years	?	–	33.5	12.3	3.2	−18.1	12.5
IP-29	17-06-0087	Femur	Ahu Nau Nau	Newborn	?	–	38.9	13.2	3.4	−17.2	15.2
IP-30	17-06-0603	Femur	Ahu o Nero	19–21 years	**F**	**H**	39.8	15.4	3.0	−17.7	11.6
IP-31	17-06-0086	Femur	Ahu Nau Nau	1.5–2.5 years	?	–	16.3	5.1	**3.7**		
IP-32	17-06-0119	Radius	Ahu Nau Nau	>40 years	H	–	37.9	12.2	3.6	−21.0	10.9
IP-33	17-06-0001	Femur	Ahu Nau Nau	4 years	?	–	30.1	9.9	3.5	−18.5	13.3
IP-34	17-06-0112	Femur	Ahu Nau Nau	13–18 years	H ?	–	39.2	14.0	3.3	−19.6	14.0
IP-35	17-06-0473	Femur	Ana Mahiha	20 years	H	H	36.7	14.2	3.0	−17.6	12.7
IP-36	17-06-0102	Ulna	Ahu Nau Nau	30–40 years	H	–	35.7	12.1	3.4	−15.5	14.8
IP-38	17-06-0009	Femur	Ahu Nau Nau	>40 years	H	–	34.8	11.7	3.5	−16.0	15.6
IP-39	17-06-0608	Tibia	Ana Koe Hoko	30–40 years	F	–	34.7	12.4	3.3	−18.6	13.4
IP-40	17-06-0443	Femur	Ana oroi	25–27 years	F	F	40.1	13.9	3.4	−19.1	12.2
IP-41	17-06-0611	Femur	Ahu o Nero	0–6 month	?	–	34.7	12.4	3.3	−18.6	13.4
IP-42	17-06-0573	Tibia	Ana Koe Hoko	>40 years	H	–	13.4	3.4	**4.6**		
IP-43	17-06-0445	Tibia	Ana oroi	30–40 years	H	–	34.0	11.4	3.5	−18.2	13.6
IP-44	17-06-0101	Femur	Ahu Nau Nau	6 years	?	–	40.2	13.9	3.4	−17.2	15.0
IP-45	17-06-0007	Tibia	Ahu Nau Nau	6 m. – 1.5 y.	?	–	6.7	2.1	**3.7**		
IP-46	17-06-0103	Femur	Ahu Nau Nau	4.5 years	?	–	16.4	5.2	**3.7**		
IP-47	17-06-0589	Femur	Ahu o Nero	25–30 years	H	–	36.2	13.3	3.2	−20.0	11.8
IP-48	17-06-0613	Femur	Ana Akahanga	20–34 years	F	–	28.2	10.3	3.2	−16.8	13.0
IP-49	17-06-0245	Femur	Ahu Nau Nau	6 m.–1.5 y.	?	–	34.4	11.6	3.5	−18.1	16.7
IP-50	17-06-0122	Femur	Ahu Nau Nau	9 years	?	–	39.9	13.9	3.4	−18.5	12.8
IP-51	17-06-0441	Tibia	Ana oroi	30–40 years	F	–	36.3	12.5	3.4	−18.7	12.7
IP-52	17-06-0142	Humerus	Ahu Nau Nau	2 years	?	–	34.7	11.8	3.4	−17.3	15.4
IP-53	17-06-0610	Femur	Ana Koe Hoko	>40 years	H	H	35.4	12.2	3.4	−18.0	13.3
IP-54	17-06-0471	Femur	Ana oroi	22 years	F	–	36.5	12.6	3.4	−18.8	12.7
IP-55	17-06-0168	Femur	Ahu Akahanga	30–40 years	F	–	38.8	13.5	3.4	−18.9	12.5
IP-56	17-06-0489	Occipital	Ahu o Nero	2 years	?	–	33.1	11.3	3.4	−19.4	12.1
IP-57	17-06-0450	Tibia	Ahu Akahanga	1 year	?	–	35.2	12.5	3.3	−16.7	14.3
IP-58	17-06-0250	Femur	Ahu Akahanga	15–17 years	**H**	**F**	41.1	14.4	3.3	−16.6	13.4
IP-60	17-06-0036	Humerus	Ahu Nau Nau	1.5–2 years	?	–	31.3	10.3	3.5	−17.9	15.2
IP-61	17-06-0612	Femur	Ahu o Nero	>40 years	F	–	39.7	13.8	3.3	−18.3	12.8
IP-62	17-06-0022	Femur	Ahu Nau Nau	11 years	?	F	32.4	10.7	3.5	−19.1	14.4
IP-63	17-06-0325	Skull	Ahu Akahanga	30–40 ans	F	–	22.0	5.0	**5.1**		
IP-64	17-06-0584	Femur	Ahu o Nero	>40 years	F	–	40.5	13.9	3.4	−18.7	12.2
IP-65	17-06-0446	Femur	Ana oroi	>40 years	H	–	39.2	13.8	3.3	−18.0	13.0
IP-66	17-06-0474	Humerus	Ana Mahiha	3.5 years	?	–	35.8	12.3	3.4	−16.9	14.3
IP-67	17-06-0104	Tibia	Ahu Nau Nau	7.5 years	?	–	11.6	**3.7**	**3.6**		
IP-68	17-06-0468	Tibia	Ana Mahiha	16–17 years	H	–	32.2	11.0	3.4	−17.9	13.1
IP-69	17-06-0513	Skull	Ahu o Nero	13–18 years	?	–	1.8				
IP-70	17-06-0047	Femur	Ahu Nau Nau	3–4 years	?	–	35.4	11.7	3.5	−17.9	16.9
IP-71	17-06-0572	Tibia	Ana Koe Hoko	30–40 years	F	–	36.7	11.9	3.6	−20.4	12.4
IP-72	17-06-0528	Femur	Ahu o Nero	12 years	?	–	40.9	13.6	3.5	−18.9	12.8
IP-73	17-06-0006	Femur	Ahu Nau Nau	>40 years	F	–	36.9	12.4	3.5	−18.0	13.0
IP-74	17-06-0082	Tibia	Ahu Nau Nau	0–6 months	?	–	33.5	11.1	3.5	−18.8	14.4
IP-75	17-06-0017	Femur	Ahu Nau Nau	1.5–2 years	?	–	32.3	10.3	**3.7**		
IP-76	17-06-0462	Femur	Ana Mahiha	19 years	F	F	35.6	12.4	3.4	−18.6	13.6
IP-77	17-06-0444	Femur	Ana oroi	>40 years	H	–	36.3	12.8	3.3	−17.3	13.9
IP-78	17-06-0174	Femur	Ahu Akahanga	30–40 years	H	–	29.8	10.5	3.3	−18.6	13.0
IP-79	17-06-0592	Femur	Ana Koe Hoko	21–34 years	H	–	40.4	14.1	3.3	−18.6	13.8

(continued on next page)

Table 2 (*continued*)

Analysis no.	Museum inventory no.	Element sampled	Site	Age	Sex morph	Sex DNA	%Cc	%Nc	C/N	δ^{13}C ‰	δ^{15}N ‰
IP-80	17-06-0159	Fibula	Ahu Nau Nau	30–40 years	H	–	38.2	13.2	3.4	−18.7	14.8
IP-81	17-06-0479	Femur	Ana Mahiha	2 years	?	–	36.5	12.9	3.3	−15.7	15.5
IP-82	17-06-0011	Tibia	Ahu Nau Nau	30–40 years	H	–	33.5	11.1	3.5	−17.7	14.7
IP-83	17-06-0520	Tibia	Ahu o Nero	>40 years	H	–	36.5	12.8	3.3	−18.7	13.9
IP-84	17-06-0469	Tibia	Ana oroi	7 years	?	–	40.1	14.1	3.3	−19.9	10.6
IP-85	17-06-0449	Femur	Ahu Akahanga	>40 years	H	–	36.7	12.8	3.3	−18.2	13.5
IP-86	17-06-0431	Femur	Ana oroi	30–40 years	H	–	39.5	13.6	3.4	−18.1	13.9
IP-87	17-06-0014	Femur	Ahu Nau Nau	30–40 years	H	H	38.3	13.5	3.3	−17.6	14.3
IP-88	17-06-0048	Tibia	Ahu Nau Nau	3 years	?	–	13.8	3.9	**4.2**		
IP-90	17-06-0512	Humerus	Ahu o Nero	15 years	?	–	20.4	4.5	**5.2**		
IP-91	17-06-0175	Tibia	Ahu Akahanga	4 years	?	–	32.7	10.6	3.6	−17.8	15.4
IP-92	17-06-0162	Femur	Ahu Nau Nau	30–40 years	F	–	16.6	5.1	**3.8**		
IP-93	4	Skull	engraved skull	Adult	?	–	39.5	13.2	3.5	−18.8	11.5
IP-94	8	Skull	engraved skull	Adult	?	–	38.7	13.1	3.4	−18.5	13.0
IP-95	Reg 164	Tibia	Ahu Te Peu	Adult	?	–	36.9	12.7	3.4	−18.1	12.7
IP-96	Reg 165	Tibia	Ahu Te Peu	Adult	?	–	39.1	13.6	3.3	−18.2	12.2
IP-100	17-06-0615	Femur	Ahu Mahatua	30–40 years	F	–	36.5	12.4	3.4	−18.5	12.9
IP-101	17-06-0616	Femur	Ahu Mahatua	19–24 years	F	F	38.4	13.2	3.4	−18.9	12.8
IP-102	17-06-0617	Femur	Ahu Mahatua	>40 years	F	–	31.7	10.9	3.4	−19.1	13.3
IP-103	17-06-0626	Femur	Ahu Mahatua	>40 years	H	H	26.9	9.1	3.5	−18.6	13.1
IP-104	17-06-0618	Femur	Ahu Mahatua	>40 years	H	–	32.5	11.0	3.4	−18.0	14.0
IP-105	17-06-0623	Tibia	Ana Koe Hoko	25–29 years	F	F	37.6	13.0	3.4	−18.1	13.6
IP-107	17-06-0627	Femur	Ahu Mahatua	30–40 years	H	–	41.0	14.4	3.3	−17.9	13.4
IP-108	17-06-0630	Femur	Ana Koe Hoko	5 years	?	–	30.0	9.8	3.6	−19.0	13.7
IP-109	17-06-0632	Humerus	Ahu Mahatua	3 years	?	–	32.0	11.0	3.4	−18.4	15.9
IP-110	17-06-0633	Femur	Ahu Mahatua	20–34 years	F	–	38.6	13.4	3.4	−18.8	12.3
IP-111	17-06-0637	Humerus	Ahu Mahatua	21–34 years	H	–	45.0	13.7	**3.8**		
IP-112	17-06-0640	Femur	Ahu Mahatua	21–34 years	H	–	38.3	13.5	3.3	−18.1	13.6
IP-113	17-06-0645	Femur	Ahu Kihi Kihi Rau Mea	>40 years	F	–	38.0	13.3	3.3	−19.4	12.3
IP-114	17-06-0659	Femur	Ahu Kihi Kihi Rau Mea	>40 years	F	–	37.0	12.8	3.4	−18.7	12.5
IP-115	17-06-0641	Femur	Ahu Mahatua	18 years	F	–	35.7	12.2	3.4	−18.6	12.7
IP-116	17-06-0642	Femur	Ahu Mahatua	>40 years	F	–	36.5	12.6	3.4	−18.7	12.9
IP-117	17-06-0666	Femur	Ahu Kihi Kihi Rau Mea	17–18 years	H	–	36.9	12.9	3.3	−18.7	12.7
IP-118	17-06-0669	Femur	Ahu Kihi Kihi Rau Mea	>40 years	F	–	38.5	13.5	3.3	−19.3	12.2
IP-119	17-06-0677	Tibia	Ahu Kihi Kihi Rau Mea	>40 years	F	–	37.6	13.1	3.3	−18.0	13.2
IP-120	17-06-0670	Femur	Ahu Kihi Kihi Rau Mea	30–40 years	**H**	**F**	26.0	8.5	3.6	−18.0	13.5
IP-121	17-06-0671	Femur	Ahu Kihi Kihi Rau Mea	30–40 years	H	–	33.2	11.1	3.5	−18.9	13.7
IP-122	17-06-0676	Femur	Ahu Kihi Kihi Rau Mea	12 years	?	F	25.2	8.1	3.6	−18.3	12.6
IP-123	17-06-0682	Femur	Ahu Kihi Kihi Rau Mea	>40 years	H	–	31.0	10.0	3.6	−18.0	13.3
IP-124	17-06-0683	Femur	Ana Akahanga	30–40 years	H	–	27.0	8.6	3.6	−17.7	13.9
IP-125	17-06-0678	Skull	Ahu Kihi Kihi Rau Mea	1.5–2.5 years	?	–	17.3	4.6	**4.4**		
IP-126	17-06-0686	Tibia	Ahu Kihi Kihi Rau Mea	4 years	?	–	29.1	9.6	3.5	−20.1	11.8
IP-127	17-06-0687	Femur	Ahu Kihi Kihi Rau Mea	>40 years	H	–	32.4	10.9	3.4	−18.8	13.5
IP-128	17-06-0691	Femur	Ahu Kihi Kihi Rau Mea	30–40 years	F	–	44.7	16.0	3.3	−18.4	12.6
IP-129	17-06-0692	Femur	Ahu Kihi Kihi Rau Mea	>40 years	H	–	37.6	12.9	3.4	−18.9	12.9
IP-130	17-06-0708	Femur	Ahu One Makihi	20–34 years	F	–	34.7	11.9	3.4	−18.6	12.7
IP-131	17-06-0712	Tibia	Ana oroi	7 years	?	–	34.5	11.6	3.5	−19.0	12.9
IP-132	17-06-0217	Femur	Ana Koe Hoko	30–40 years	H	–	37.9	12.9	3.4	−18.4	14.4
IP-133	17-06-0714	Femur	Ana oroi	>40 years	F	–	32.4	11.3	3.4	−19.3	12.5
IP-134	17-06-0713	Femur	Ana oroi	21–24 years	F	–	28.4	9.8	3.4	−18.8	12.9
IP-135	17-06-0709	Humerus	Ahu One Makihi	13–16 years	?	–	27.5	9.6	3.4	−17.5	13.0
IP-136	17-06-0715	Tibia	Ana Akahanga	>40 years	F	–	25.3	8.8	3.4	−18.4	13.0

If we examine the isotope distribution according to sex (adult individuals), we observe that males display higher carbon and nitrogen isotopic values than females (Fig. 3). The result of student's t-test is statistically significant for δ^{13}C values ($p < 0.05$) and very highly significant for δ^{15}N values ($p < 0.001$) (Table 3). Females and males individuals were also compared within each location (cave and *ahu*). The same trend was observed as in the overall sample excepted for the difference of δ^{13}C between males and females buried in *ahu* that was not significant (Table 3).

The isotope distribution according to age at death was also studied (Fig. 4). The individuals that display the highest nitrogen isotope values belong to the category 0–3 years. Two young children, however, display low δ^{15}N: a 2 years old individual (IP-56) and a baby (IP-41), both from *Ahu O Nero*. The isotopic signatures of the children older than 4 years are more or less similar to those of the adults.

The spatial distribution of the isotopic signatures also gave interesting results. Some clustering of carbon and nitrogen isotopic signatures occurs according to the individuals' place of burial (Fig. 5). Particularly, the individuals from *Ahu Nau Nau* (located in Anakena Bay), which is said to be the royal *ahu*, display the highest value of nitrogen and carbon isotope values (except IP-32, a male individual over 40 years old).

In Fig. 6, the present Rapa Nui dataset was compared with other Pacific populations: 12 samples compiled by Commendador et al. (2013) and data from Taumako Island, Southeastern Solomons (Kinaston et al., 2013b). We observed the same trends as Commendador et al. (2013): with the exception of Hanamiai in French Polynesia, the comparative samples have lower δ^{15}N values than our Rapa Nui samples and the δ^{13}C values of the Easter Islanders are in the lower half of the Pacific distribution. For reasons of clarity, we did not plot more data in Fig. 6 but the recently published samples from Watom, Papua New Guinea (Kinaston et al., 2015), from Tonga (Stantis et al., 2015), Teouma (Efate Island), Vanuatu (Kinaston et al., 2014) and from Nebira, south coast of Papua New Guinea (Kinaston et al., 2013a) display isotopic signatures located within the range of variability of the 13 other Pacific samples.

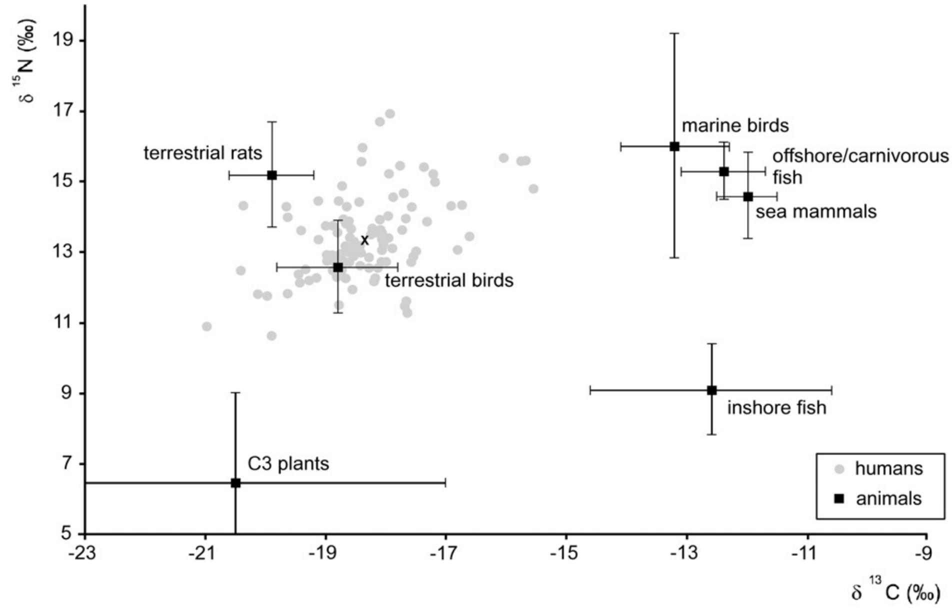

Fig. 2. Bivariate plot of $\delta^{15}N$ and $\delta^{13}C$ values from Easter Islanders (x = average) and fauna (data from Table 3 of Commendador et al., 2013).

6. Discussion

Easter Island was among one of the most remote islands of Polynesia. It displayed only a fraction of the biotic diversity found to the west of the Pacific Islands. Despite this restricted environment (that was also subject to deforestation), the Rapa Nui people survived and prospered. They had a balanced diet (indicated by low frequencies of deficiency indicators) which varied depending on biological and sociocultural factors.

The positive correlation between carbon and nitrogen isotopic ratios indicates that the differences in isotopic values between individuals are a result of differing proportions of marine and terrestrial foods consumed (Richards and Hedges, 1999). This correlation has been observed in other Pacific samples, where starchy vegetables such as taro, yams and banana formed the base of subsistence (Kinaston et al., 2013; Stantis et al., 2015). From comparing faunal and human bone collagen presented in Fig. 2 and taking into account trophic level effect, we suggest that humans with $\delta^{13}C$ ranging from −21.0 to −16.8‰ could have a mainly terrestrial diet, such as starchy plants and domesticated (and wild) terrestrial animals (the upper limit of 16.8‰ is based on the average value of terrestrial birds +2‰, which is the maximum value for carbon isotopic trophic enrichment in Bocherens and Drucker, 2003). C3 plants were at the base of their food web (sugarcane, a C4 plant, seems to have been a very small proportion of Easter Islanders' diet). Individuals with higher $\delta^{13}C$ values (mainly coming from *Ahu Nau Nau*) included marine products (fish, shellfish and, in a smaller proportion, sea birds and their eggs) in their diet. The higher $\delta^{15}N$ and low $\delta^{13}C$ values of the Rapa Nui individuals in comparison with other Pacific samples can be explained by a predominance of terrestrial dietary resources including food with high nitrogen isotopic ratios. This food could have contained a high proportion of terrestrial animals (mainly chicken and rats), or, as suggested by Commendador et al. (2013), displayed a higher ^{15}N baseline, possibly due to local geological and/or climatic and environmental factors.

On the basis of stable isotope analysis, we can state that there was no noteworthy difference in diet between individuals buried in *ahu* and those buried in caves. Shaw (2000) mentioned that burial patterns are very similar in both cave and *ahu* tombs, which might indicate that it was in fact the same groups of people, each with its own dietary habits, which buried their dead in both structures.

Table 3
Statistical parameters of the comparisons of isotopic signatures ($\delta^{13}C$ and $\delta^{15}N$ in ‰) between individuals buried in *ahu* and individuals buried in caves, between males and females, between males and females buried in *ahu*, between males and females buries in caves. NS = not significant, * = significant, ** = highly significant, *** = very highly significant.

	N	Mean	Standard deviation	N	Mean	Standard deviation	p	Significance level
	Ahu			Cave			Student's t-test	
$\delta^{13}C$	79	−18.3	0.87	28	−18.2	1.09	0.36	NS
$\delta^{15}N$	79	13.4	1.23	28	13.3	1.02	0.32	NS
	Males			Females			Student's t-test	
$\delta^{13}C$	32	−18.2	0.98	30	−18.6	0.73	0.0407	*
$\delta^{15}N$	32	13.5	0.95	30	12.8	0.46	0.00016	***
	Males in ahu			Females in ahu			Student's t-test	
$\delta^{13}C$	23	−18.3	1.18	17	−18.6	0.45	0.27	NS
$\delta^{15}N$	23	13.6	1.00	17	12.6	0.42	0.0006	***
	Males in cave			Females in cave			Student's t-test	
$\delta^{13}C$	10	−18.0	0.38	12	−18.8	0.87	0.015	*
$\delta^{15}N$	10	13.6	0.52	12	12.8	0.55	0.0043	**

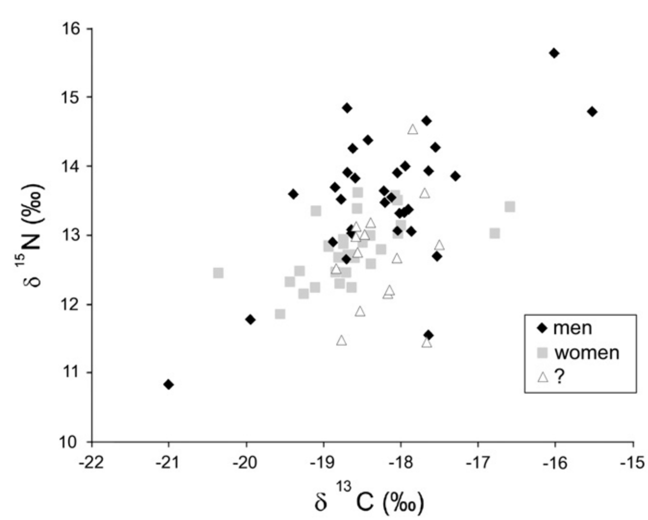

Fig. 3. Bivariate plot of $\delta^{15}N$ and $\delta^{13}C$ values from males, females and adults of unknown sex from Easter Islands.

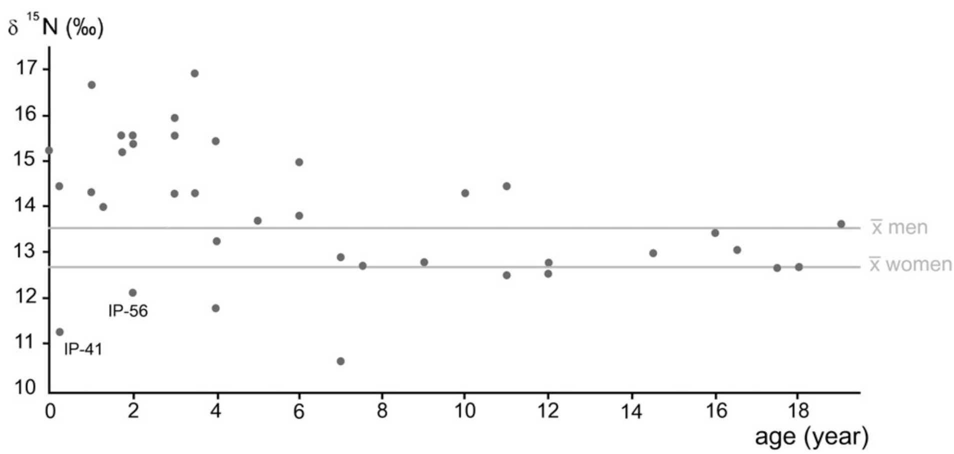

Fig. 4. Evolution of nitrogen isotopic signatures in relation of the age at death. The individuals that display the highest nitrogen isotope signatures are younger than 4 years old. Two children are exceptions: a 2 year old individual (IP-56) and a baby who died between 0 and 6 months (IP-41).

The sex difference in carbon and nitrogen isotopes indicates that men had a higher intake of animal proteins than women. There is little mention of gender difference in diet in the ancient Rapa Nui population. Métraux (1971, p. 164) quotes the description of a banquet by Father Zumbohm in 1879. The text gives the order in which the guests received their food. The best pieces were given to the missionaries. After this, the chief and his friends were served. Then the common people helped themselves. The women and children were served last. "*From a delicacy like chicken or fish all they got was the bones to chew and* "*these bones were already chewed once or twice*"". No other anthropobiological data (dental microwear, caries, microfossils in dental calculus) indicates sex-based difference in diet except stress indicators study (Polet, 2006). Rapanui women show significantly higher enamel hypoplasia frequencies than men. This leads to the assumption of gender disparities in the access to basic resources from childhood onwards as the tooth crown records stress events that occurred during its formation. This sex difference results from a preferential investment in boys (Guatelli-Steinberg and Lukacs, 1999). Sex-based differences in diet have also been observed in other Pacific samples such as Teouma in Vanuatu (3100–2900 BP; Kinaston et al., 2014), Taumako in the Solomon Islands (c. 750–300 BP; Kinaston et al., 2013b) and 'Atele in Tonga (c. 500–150 BP; Stantis et al., 2015). In all these sites, males display higher δ^{15}N values indicating that they were eating food from a higher trophic level such as domestic mammals, fish, endemic terrestrial animals and/or marine turtles.

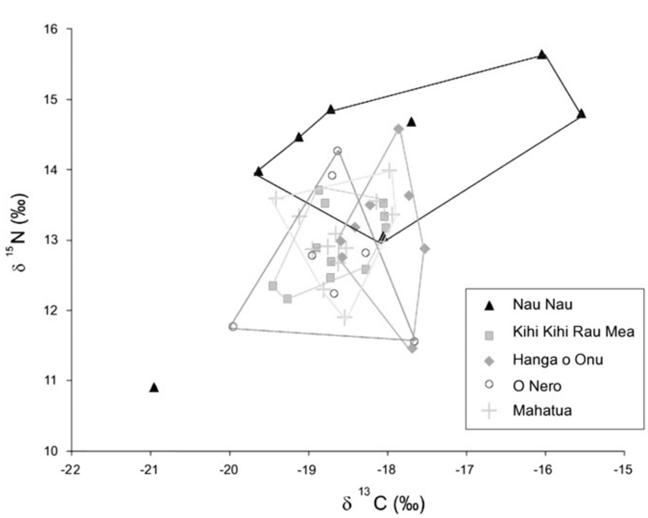

Fig. 5. Bivariate plot of δ^{15}N and δ^{13}C values from Easter Islanders aged over 12 years and buried in different *ahu*.

The higher nitrogen isotopes for the 0–3 year class can be explained by the fact that they were breastfed. In consuming mother's milk, a human product, babies are one trophic level higher than their mother (e.g., Fogel et al., 1997; Fuller et al., 2006). Two young children are exceptions: a 2 years old individual who was probably already weaned and a baby who probably died at birth without consuming any mother's milk. The diet of the children of 4 years or more is more or less similar to that of adults.

In most populations in the pre-industrial period, the babies were routinely nursed for three to four years (Dettwyler, 1995). It seems to have been the case in Easter Island. This long duration of breast-feeding (up to 3 years) could have been beneficial for this population as it reduced infant and child mortality. In populations without access to modern forms of contraception, breast-feeding duration is indeed one of the major determinants of fertility due to its effect on duration of lactational amenorrhea and its relationship to inter-birth interval (Bongaarts and Potter, 1983, p. 24–28). Birth-spacing affects infant and child mortality: delaying a child's birth by a minimum of two years could almost halve the risk of dying before the age of five (Hobcraft et al., 1983).

In the same way as Commendador et al. (2013) suggested from their limited data, we observed clusters of individuals related to their place of burial. This result could indicate family dietary specificities. The hypothesis that individuals placed within the same tomb represent members of the lineage residing in the local area is supported by morphological and genetic data. Gill and Owsley (1993) found that heritable congenital skeletal anomalies were distributed unevenly throughout the island: high frequencies of bipartite patella were recorded at *Ahu Nau Nau*, of ankylosed sacroiliac joint at *Ana Oroi* and of supracondylar foramen of the humerus at *Ahu Kihi Kihi Rau Mea*. Discrete cranial morphological traits (Chapman and Gill, 1998) and genetic analyses (Dudgeon, 2008) demonstrate a spatial heterogeneity, supporting the idea of lineage-based burial units. The isotopic variations however do not match the tribal land divisions recorded by K. Routledge (Routledge, 1919, p. 221–224). For example, the individuals from *Ahu Nau Nau* and those from *Ahu Kihi Kihi Rau Mea*, both located on the Miru tribe land (Fig. 1), display very different nitrogen and carbon isotopic values (Fig. 5). However, these land divisions should be used with caution since they were recorded as late as the 20th century and may have changed over time.

A greater consumption of marine products may explain the highest value of nitrogen and carbon isotope values in *Ahu Nau Nau*. This 'privileged' diet is probably related to the taboos (*tapu*) they imposed on the other islanders (Métraux, 1971, p. 130–132). Fishing *Tapu* was

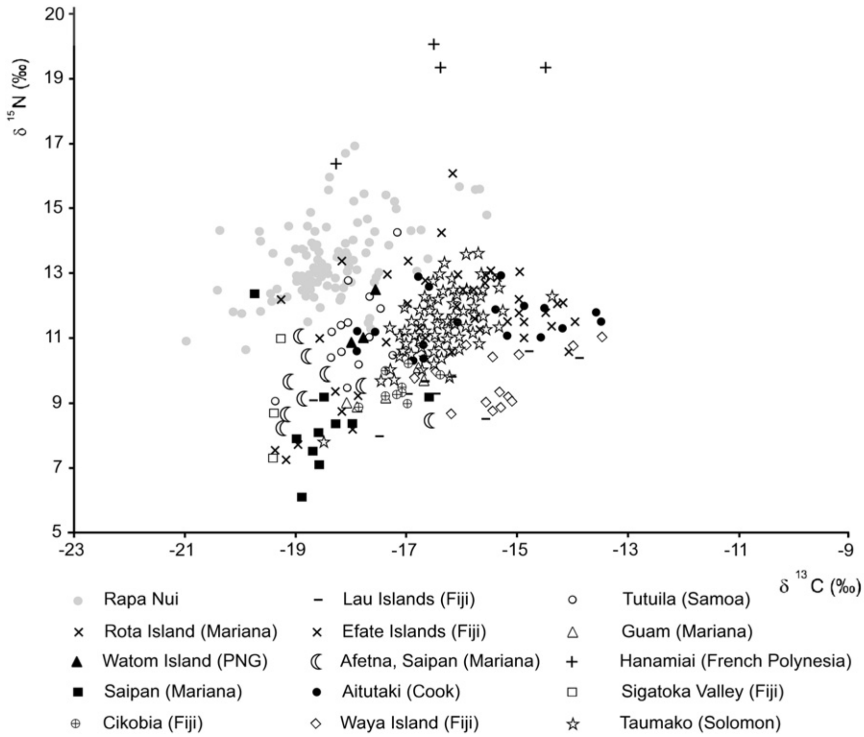

Fig. 6. Bivariate plot of $\delta^{15}N$ and $\delta^{13}C$ values from the 107 Easter Islanders and published human values from 13 other Pacific islands (references can be found in Commendador et al., 2013; data from Taumako Island comes from Kinaston et al., 2013b).

applied from May to October but did not concern the aristocracy. During these months, only the royal canoe could be used for fishing, with a crew composed of important men (Métraux, 1971, p. 173). All the fish caught from the royal canoe were presented to the king, who kept them for his own use or, more often, distributed among the important old men (this might also play a role in gender differences in diet). The hands of the king were also *tapu*: the only activities he was permitted to undertake were the making fishing lines and nets and fishing in canoes. High social status associated with higher proportion of marine food in the diet compared to the rest of the population has been observed in other Pacific populations such as Afetna, Mariana Islands (McGovern-Wilson and Quinn, 1996) and Taumako, Solomon Islands (Kinaston et al., 2013b).

The isotopic difference between *Ahu Nau Nau* and other Rapa Nui sites could be of chronological origin. This site is one of the oldest of our sample and Commendador et al. (2013) demonstrated a decline in nitrogen isotopes ratios through time. However, the site of *Ahu O Rongo* which is even older than *Ahu Nau Nau* does not display high values of $\delta^{15}N$.

Other arguments support a dietary difference between the individuals buried in *Ahu Nau Nau* and the others. Remains of offshore fishing hooks are more prevalent in the West and North of the island and that is where the royal *ahu* is (Ayres, 1979). The only harpoon head has been found in Anakena bay (Wallin, 1996). The majority of petroglyphs depicting marine organisms, canoes or implements related to deep-water fishing activities are located in the North of the island (Lee, 1992, p. 74–96, 104–112, 113–115). Furthermore, *Ahu Nau Nau* individuals are characterised by a lower rate of *cribra orbitalia* than the other Easter Islanders (Polet, 2006). They were less anaemic or had less vitamin B12 deficiency (Walker et al., 2009), most probably as a result of a higher intake of iron- and/or cobalamin rich foods such as meat and seafood. Individuals *Ahu Nau Nau* also differed in their dental micro-wear, displaying significantly less features and a lower proportion of short scratches (Polet et al., 2008). These results indicate that they consumed more animal products such as fish than the other Easter Islanders.

As most of the burial sites were used over long periods of time, we can assume that the dietary differences between genders and between lineages continued during the post-contact period (at least until the disappearance of most of the population following the Peruvian slave trade and epidemics).

7. Conclusion

This study aimed to document the diet of ancient Easter Islanders, dating mainly from the 17th to the 19th centuries.

Despite their remote and restricted environment, they had a balanced diet which varied depending on biological and socio-cultural factors. Consistently with Commendador et al. (2013), we conclude that the Easter Islanders relied more heavily on terrestrial food resources than other Pacific Islanders. We observed sex differences in stable isotope values, revealing that Rapa Nui women ate significantly less terrestrial and/or marine animal products. This sex-based difference in diet is corroborated by the study of enamel hypoplasia and by ethnographic data. The clustering of isotopic signatures according to the place of burial (*ahu*) may indicate family dietary specificities. With regard to the social status, our study shows that the "royal *ahu*" can be distinguished from other *ahu* on the basis of its stable isotopes. A greater marine product consumption was at the origin of this distinction. We showed that children were breastfed until 3 years old. This long duration of breast-feeding might have had a favourable impact on infant and child mortality.

Inequality in food distribution linked to gender and social status has been observed in other Pacific Islands. It could be a common characteristic of the Pacific food culture in the past.

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