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AN ISOTOPIC STUDY OF DIETARY DIVERSITY IN FORMATIVE PERIOD ANCACHI/QUILLAGUA, ATACAMA DESERT, NORTHERN CHILE

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Abstract

Objectives

To characterize the paleodiet of individuals from Formative Period (1500 B.C. - A.D. 400) Atacama Desert sites of Ancachi and Quillagua as a means of understanding the dietary and cultural impacts of regional systems of exchange.

Materials and Methods

Thirty-one bone samples recovered from the cemetery of Ancachi (02QU175) and in/around the nearby town of Quillagua, were subject of carbon and nitrogen stable isotope analysis and multi-source mixture modeling (FRUITS) of paleodiet. These individuals were compared with nearly 200 contemporary individuals from throughout the region to identify differences in dietary behaviors.

Results

80.6% (25/31) of the samples yielded sufficient well-preserved collagen and were included in the multi-source mixture model. The FRUITS model, which compared individuals with a robust database of available foods from the region, identified a wide diversity of diets in the Ancachi/Quillagua area (including both coastal and interior individuals), and, most notably, twenty-one individuals who consumed an average of 11.9±1.8% terrestrial animals, 21.2±2.4% legumes, and 20.0±4.1% marine fauna, a balanced pattern of protein consumption distinct from both the coastal and inland individuals in our larger regional sample.

Conclusions

The combination of stable isotope analysis and multi-source mixture modeling permitted the characterization of dietary behavior of twenty-five individuals from nodal sites in the Atacama Desert, thus enhancing our understanding of the economic and social relationships that bound together Formative Period sites, populations, and individuals in this hyperarid region.

Introduction

The Atacama Desert is located in northern Chile and southern Peru, between ca. 18° and 30° South. The Atacama is the world's driest desert, with less than 1 mm/yr falling in the study area (Houston 2006), and the region's aridity seems to have been a persistent feature for millennia (Moreno 2009). A recent paleoclimatic study suggests that aridity equal to, if not exceeding, those seen in the present prevailed throughout the Holocene, with the exception of a somewhat wetter period between 1000-2000 years ago (Maldonado, et al. 2016). In order to survive these arid conditions, ancient peoples strategically chose settlement locations on the Pacific coast, at oases, in deep *quebradas* on the western slope of the Andes, and along the Loa River, the region's only persistent river course (Castro, et al. 2016). To supply material needs and wants, Atacameños also developed systems of long-distance exchange, through which both essential and luxury goods moved (Pimentel 2013). Quillagua and Ancachi, the two localities at the heart of this research (Figure 1), are located at a nexus of these trade routes between coastal and inland/highland populations, and a variety of sources support the notion that the Ancachi/Quillagua area has functioned as a frontier zone between groups living to their east, north, and west for much of its inhabited history, from the Formative Period until the 18th century A.D. (Agüero et al. 1999, 2001, 2006; Paz Soldán 1878).

<Figure 1>

While borders or frontiers such as that seen at Ancachi/Quillagua are often conceived of as limiting the interaction of peoples from surrounding areas, a wealth of social science literature sees them instead as zones of cultural transition between the societies that lie on either side (Barth 1998, 2000; Newman, 2006; van Dommelen, 1997, 1998; White, 1991). Viewed as such, these frontier zones are judged to facilitate, rather than restrict, cross-cultural pollination. Indeed, people residing in these zones can become engines of cultural innovation and change. As discussed below, the "contact hypothesis", a sociological precept that describes how perceptions and behavior change when groups of people with diverse backgrounds come into close contact, provides a powerful lens for understanding the conditions under which cultural change might occur. In this regard, the inhabitants of Ancachi and Quillagua serve as ideal indicators from which to develop a better understanding of the movement and exchange of resources within the Atacama Desert during the Formative, and the lived consequences of this exchange for their behaviors and lifeways.

The way in which individuals obtain the necessary nutrients to survive is one of the most fascinating aspects of human behavior (Schwarcz and Shoeninger 1991), and one of the most culturally enmeshed. Indeed, few aspects of human behavior are, simultaneously, as culturally bound and situationally responsive as diet, with the consequence that reconstruction of ancient dietary practices can offer insights into myriad aspects of ancient life (see, for example, the papers in Twiss 2007 [ed.]). The most well-established technique for reconstructing individual-level ancient human diet is stable isotope analysis, which provides high-fidelity data on long-term (decadal) individual consumption patterns (Lee-Thorp 2008). Stable isotope analysis has been part of the archaeologist's toolkit since the last quarter of the 20th century, and it has been proven to provide researchers with an accurate method for estimating the dietary composition of past people, assuming a series of pre-conditions are met.

When combined with multi-source mixture modeling (Fernandes et al. 2014), one can use stable isotope analysis to develop quantitative and probabilistic estimates of the lived behavior (diet) of past societies. In the present case, these techniques allow us to characterize individual-level diet at Ancachi/Quillagua and identify those persons who appear to have been behaving (consuming) in ways not seen elsewhere among their contemporaries or in the broader region. Through this process of estimating ancient diet, we contend that we can, in effect, measure the effects of interaction patterns in these individuals, and thus gauge the presence and effects of ancient frontiers in the archaeological record.

Materials and Methods

Cortical bone samples (~1 g) were obtained from thirty-one individuals from Formative Period burials in the tumulus cemetery of Ancachi and from pit/shaft tombs near the modern town of Quillagua (Agüero et al. 1999, Agüero and Uribe 2015, Gallardo et al. 1993, Latcham 1933). For these purposes, we consider the two sites, which sit approximately 10 km apart, jointly. The present work adds nineteen individuals to a previously published sample of twelve individuals from Ancachi/Quillagua (Pestle et al. 2019). Ultimately, we consider both the internal variability and structure of the paleodiet of these individuals and then position them against a larger regional sample of nearly 200 previously analyzed individuals from the Formative Period (Pestle et al. 2015a, 2015b; Pestle 2017).

The extraction of collagen and hydroxyapatite from human bone samples was performed at the Archaeological Stable Isotope Laboratory at the University of Miami. Each sample was individually ground by hand using a ceramic mortar and pestle. Samples were then separated into size fractions using geological screens. The collagen extraction protocol used was established by Longin (1971) and modified by Pestle (2010). For each bone sample, 0.5 grams of the 0.5-1.0 mm fraction was weighed and placed in 50 ml centrifuge tubes. The samples were demineralized in 30 mL of 0.2 M HCL on a spinning rotator for 24 hours. Samples were then rinsed to neutral through a process of centrifugation, decanting, and the addition of 30 mL of distilled water. Humic removal was accomplished by adding 30 mL of 0.0625 M NaOH to each sample for 20 hours. After time elapsed, the samples were again rinsed to neutral. The remaining collagen was then gelatinized in 10^{-3} M HCL at 90°C and filtered using single-use Millipore Steriflip® vacuum filters, condensed, frozen, and freeze dried. Start and end weights were recorded and used to calculate collagen yield (wt%) for each sample.

Hydroxyapatite extraction followed a protocol established in Lee-Thorp (1989) and Kruger (1991) and modified by Pestle (2010). Approximately 0.1 gram of the 0.125–0.25 mm. fraction was placed in a 50 mL centrifuge tube. After weighing, each sample underwent a 24 h oxidation of organics using 30 mL of 50% bleach. The bleach treatment was then repeated for an additional period for a total of 48 h of treatment. Samples then were rinsed to neutral. The final step in the protocol involved the samples undergoing an acid treatment for the removal of labile carbonates. This was accomplished by the addition of 30 mL of 0.1 M acetic acid to each centrifuge tube for a total of four hours with a 5 min vacuum treatment at the two-hour mark. After the acid treatment, each sample was rinsed again to neutral before being placed in a 50°C oven overnight. Start and end weights were recorded for all hydroxyapatite samples and used to calculate the weight percent hydroxyapatite yield.

Collagen and hydroxyapatite isotopic analysis was performed in the Marine Geology and Geophysics Stable Isotope Laboratory and the Rosenstiel School of Marine and Atmospheric Science at the University of Miami. Collagen samples were packed into tin capsules and analyzed using PDZ Europa ANCA-GSL elemental analyzer interfaced to a PDZ Europa 20-20 isotope ratio mass spectrometer (IRMS). This analytical process yields information on elemental carbon and nitrogen composition as well as the stable isotopes of carbon and nitrogen ($\delta^{13}C_{co}$ and $\delta^{15}N_{co}$). Hydroxyapatite samples were analyzed using Kiel-IV Carbonate Device coupled to a Thermo Finnigan DeltaPlus IRMA, providing the $\delta^{13}C_{ap}$ values. Collagen results were calibrated using acetanilide and glycine. An in-house carbonate standard calibrated to NBS-19 was used for hydroxyapatite. Standards were analyzed in every sample set at the beginning and end of the run, as well as in-between the analyzed samples to ensure accuracy and instrumental stability.

With isotopic data in hand, the FRUITS (Food Reconstruction Using Isotopic Transferred Signals) model of Fernandes and colleagues (2014) was used to quantify individual dietary composition. This multi-source mixture modeling technique is one of several developed with the hope of better bounding estimates of food source contribution. Indeed, recent southern Andean attempts (Andrade, et al. 2015; Pestle, et al. 2019; Pestle, et al. 2016; Pestle, et al. 2017) at modeling have tended to use this, or similar, Bayesian approaches, which accommodate underdetermined systems (those with more than n+1 sources), and also allow for the incorporation of priors (Fernandes, et al. 2014; Moore and Semmens 2008; Parnell, et al. 2010). These approaches "offer a powerful means to interpret data because they can incorporate prior information, integrate across sources of uncertainty and explicitly compare the strength of support for competing models or parameter values," (Moore and Semmens 2008:471).

In order to generate consumer (human) data for the model, we first determined the consumer-foodstuff offset (and error) for $\delta^{13}C_{co}$ using the method of Pestle and colleagues (2015). The offset in $\delta^{13}C_{ap}$ was stipulated as 10.1±0.4‰ (Fernandes et al. 2012). Finally, for $\delta^{15}N_{co}$, we employed a trophic fractionation value of 3.6±1.2‰, as recommended by several experimental studies of omnivorous animals (Ambrose 2000; DeNiro et al. 1981; Hare et al. 1991; Howland et al. 2003; Sponheimer et al. 2003; Warinner and Tuross 2009).

Foodweb isotope values comprised the edible portions of eighty-nine archaeological and modern Atacameño plants and animals. The decision to restrict the foodweb sample to only those generated in the course of our work in the region was due to the isotopic dissimilarity between those samples and other previously published values. Any modern data included in this reference sample had $\delta^{13}C$ values corrected by +1.5‰ to account for recent fossil fuel burning (Keeling et al. 1979). Macronutrient composition of each food group was determined by reference to the USDA National Nutrient Database for Standard Reference (Agriculture 2013). Elemental composition (particularly %C) of each foodstuff/macronutrient group was based on formulae provided in Morrison et al. (2000). Digestibility was determined following Hopkins (1981). All nitrogen in bone collagen was stipulated as coming from dietary protein, the carbon in hydroxyapatite was stipulated as reflecting all dietary carbon, and the carbon composition of bone collagen was set as reflecting a 3:1 ratio of dietary protein to energy (Fernandes et al. 2012). Carbon isotope offsets between measured bulk food isotope values and the isotopic values of a foodstuff's fats (bulk-6‰) and carbohydrates (bulk+0.5‰) were based on data from Tieszen (1981). The carbon isotope signature of a measured bulk foodstuff's protein was determined using a mass-balance equation, such that a proportional/weighted average of the $\delta^{13}C$ of protein and energy (fats and carbohydrates) would equal the measured $\delta^{13}C$ bulk value (corrected for the concentration of carbon in each macronutrient and foodstuff-appropriate macronutrient concentration).

Final food group isotope, macronutrient, and elemental concentration values used in the FRUITS simulations are presented in Table 1. We divided the available foodstuffs into five groups (C_3 plants, C_4 plants, legumes, terrestrial animals, and marine animals). Consumption of protein was limited to less than 45% of protein as energy (using the FRUITS a priori data option), reflecting the upper limit of possible human protein intake (World Health Organization 2007). All FRUITS simulations were performed using 10,000 iterations, as recommended by its developers.

Results

Sample preservation quality was determined using both chemical (collagen yield) and elemental (carbon and nitrogen yield, atomic C/N ratio) data. Only well-preserved (collagen yield >0.5 wt%, carbon yield >4.5 wt%, nitrogen yield >0.9 wt%, atomic C/N ratio between 2.9–3.6) samples were included in FRUITS calculations. Based on the arid environmental conditions of the region, samples that met these requirements also were assumed to have acceptable hydroxyapatite preservation (the lack of free water making the prospects of dissolution and recrystallization unlikely).

<Table 1>

As seen in Table 2, 80.6% (25/31) of the samples yielded sufficient well-preserved collagen to be considered as reflecting biogenic isotope signatures. The average collagen yield for those twenty-five samples was 13.7±5.3 wt%, carbon yield averaged 40.8±1.9 wt%, the average nitrogen yield was 14.2±1.0 wt%, making the average atomic C/N ratio 3.4±0.1. Elemental values were not recorded for one sample (I-102), but due to its high collagen yield and unremarkable (non-outlying) isotope values, we nonetheless included it in later analysis. Similarly, sample I-101 had a slightly elevated atomic C:N ratio (3.7), but we retained the sample because its carbon and nitrogen yields were within acceptable ranges and it was not an isotopic outlier.

<Table 2>

Turning to isotopic results (Table 2), $\delta^{13}C_{co}$ for the twenty-five well preserved samples averaged -15.5±0.9‰ (range -17.1–-13.4‰) and $\delta^{13}C_{ap}$ averaged -11.4±0.8‰ (range -13.0–-9.8‰), which, when combined, yielded an average $\Delta^{13}C_{ap\text{-}co}$ of 4.2±0.6‰ (range 3.2–5.2‰). $\delta^{15}N_{co}$ averaged 17.3±3.0‰, and possessed an immense range of 10.9–25.8‰. To begin with, then, there is notable isotopic variation within the sample, particularly in $\delta^{15}N_{co}$, suggesting similar diversity in patterns/sources of protein consumption.

Based on the results of FRUITS modeling (Table 3), C_3 plants were the largest average dietary contributor, providing an average of 37.2±4.4% of calories, with a range of 28.5–46.2%. In comparison, C_4/CAM plants made up an average of only 8.7±1.4% of diet, ranging between 6.2–13.0%. Turning to dietary protein, terrestrial animals contributed between 5.2–19.8% (average 12.0±2.7%), marine animals 19.5±7.0% (range 7.7-41.3%), and legumes 22.5±6.0%

(range 10.8–39.2%). It is the variability of these protein sources, each of which show at least threefold variability, and in particular that of marine faunal sources (which shows a greater-than fivefold difference between minimum and maximum modeled contribution), that is most noteworthy.

<Table 3>

Discussion

Comparing these results to Formative Period individuals from coastal and interior sites in the Atacama (Figure 2), (at least) two distinct dietary regimes are evident among the individuals from Ancachi/Quillagua. On the one hand, certain individuals (e.g. J-86 from Quillagua [41.3±11.7% marine protein] and L-139 from Ancachi [10.7±7.7% marine]) possess modeled diets consistent with either a coastal (high marine protein intake) or interior (heavy terrestrial protein reliance) origin. This provides direct testament to the presence in Ancachi/Quillagua of people of presumably non-local origin, or at least people who ate in ways consistent with other far-removed locales. It is our contention that these individuals came to be buried in Ancachi/Quillagua as a consequence of their direct personal movement/involvement in systems of regional exchange. Like other Formative Period individuals who we have recovered from alongside trade routes through the Atacama (Knudson et al. 2012, Pimenetel et al. 2017, Torres-Rouff et al. 2012), these individuals were agents (travelers, traders) embedded in these region-wide systems of exchange.

<Figure 2>

A larger number of the Ancachi individuals (84%, 21/25), however, would appear to have consumed a mixed diet (particularly in terms of protein composition/balance) unlike that seen in almost any other site in the region (Villa Chuqicamata in the modern city of Calama being the only other exception). These individuals consumed an average of 11.9±1.8% terrestrial animals, 21.2±2.4% legumes, and 20.0±4.1% marine fauna, a balanced pattern of protein consumption that is notably distinct from both the coastal and inland individuals in our larger regional sample. Since Ancachi/Quillagua were located at a centralized location between coastal and interior populations, in a border/frontier space, we contend that the unique dietary pattern seen in this population evince the types of interactions and cultural innovation that only (or most often) occur in such border spaces. Individuals of diverse origin and food culture were coming together at Ancachi/Quillagua, interacting via meaningful economic and social exchanges, and (one of) the products of this interaction was new dietary practices, new cultural forms.

In Sociology, the Contact Hypothesis has been employed for over sixty years as means of explaining how attitudes and behaviors can change as a consequence of long-term meaningful (equal-status, non-transactional) interaction between groups of distinct interest/origin. While this notion was originally developed in the context of racial prejudice reduction in the United States of the mid-20th century (Allport 1954), decades of further study has validated its prediction that under circumstances of prolonged equal-status co-existence and interaction, common experience will shape and sway the opinions and worldview of even the most entrenched actors (Kende et al. 2018; Mirwaldt 2010, Pettigrew and Troop 2006, Pettigrew et al. 2011). When these interactions extend beyond the transactional, to the kinds of more profound egalitarian relationships that emerge when diverse individuals interact and coexist for long periods of times while engaged in mutually-beneficial activities, individuals begin to exhibit real social and cultural exchange, and new and hybrid behaviors emerge.

That a form of eating unlike anything else seen in the Formative Period Atacama would emerge in a space like Ancachi and Quillagua would suggest that beyond simply functioning as economic nodes, these sites acted as locations of social exchange and interculturation. People were not only passing through these spaces in pursuit of material needs, but the positioning of these sites as a nexus or node in the Formative Period's regional exchange network would appear to have facilitated the transculturation of individuals involved, and the emergence of new ways of eating, if not new ways of living. These processes would likely have been similar/the same that produced, for instance, new regional stylistic conventions and symbolic vocabularies during the Formative (Castro et al. 2016).

Conclusions

Dietary patterns are fundamental to an individual's identity, and their reconstruction can serve as a powerful tool for understanding past cultural and ethnic differences and identity formation. In this present work, stable isotope analysis and multi-source mixture modeling permitted the characterization of dietary behavior of twenty-five individuals buried in a region thought to be central to a vast regional exchange system. Our results suggest that the diets of these Ancachi/Quillagua individuals were strongly influenced by the kind of exchange systems that surrounded them in life. One possible explanation for the novel dietary patterns we observed is that these systems of economic exchange had fostered meaningful social relationships among different cultural groups. Through these interactions, some of the individuals studied here adopted new cultural lifestyles and behaviors, consuming resources from both coastal and interior cultural patterns, in an entirely new way of living otherwise not seen in the surrounding region. Further analysis of additional human remains recovered from Ancachi/Quillagua cemetery should be performed to validate and develop this notion, but based on the data presented here, it is clear that something novel, and indeed phenomenal, was taking place in this portion of Atacama Desert region more than 2,000 years ago.

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Figure and Table Captions

Figure 1: Map of study region, with sites mentioned in text noted.

Figure 2: FRUITS modeled consumption of marine animals and C3 plants for Ancachi/Quillagua individuals and comparative interior and coastal populations.

Table 1: Macronutrient, isotopic, and elemental data for food groups used in FRUITS multi-source mixture model.

Table 2: Chemical, elemental, and isotopic data for all Ancachi/Quillagua individuals.

Table 3: Results of FRUITS multi-source mixture modeling for Ancachi/Quillagua individuals.

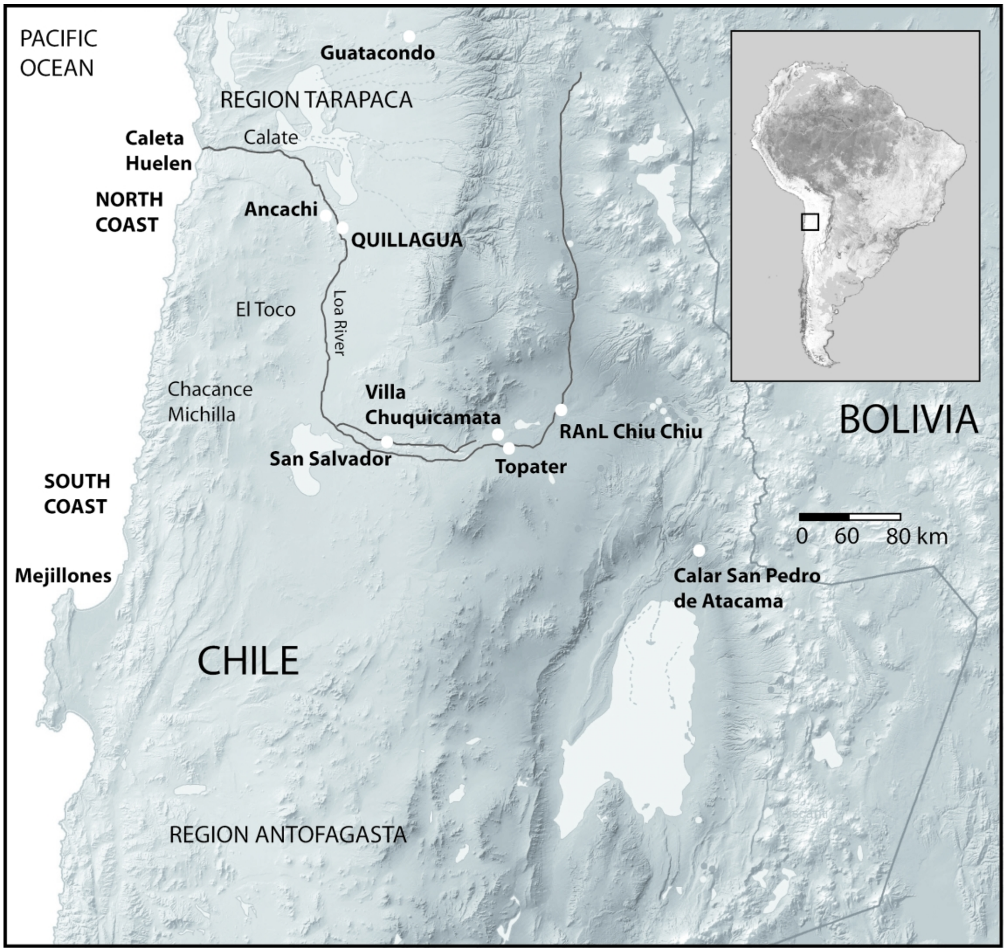

Figure 1: Map of study region, with sites mentioned in text noted.

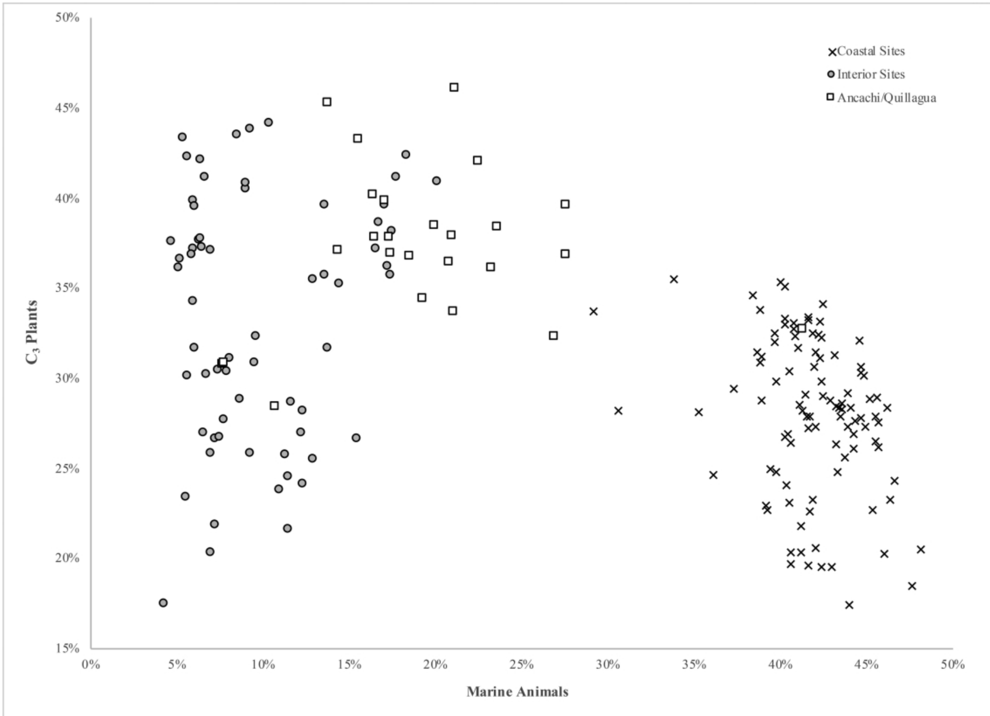

Figure 2: FRUITS modeled consumption of marine animals and C3 plants for Ancachi/Quillagua individuals and comparative interior and coastal populations.

241x174mm (300 x 300 DPI)

		Macronutrient concentration (%)				%C				Tissue $\delta^{13}C$ (‰)					Tissue $\delta^{15}N$ (‰)	
Food grouping	Group *n*	Protein	Fat	Carbohydrates	Energy	Protein	Fat	Carbohydrates	Energy	Bulk	Protein	Fat	Carbohydrates	Energy	Bulk	Protein
Terrestrial animals	24	83±12	16±12	1±3	17±12	43±12.7	12±12.1	0±4.2	13±12.7	-16.5±3.8	-14.8±3.8	-22.5±3.8	-16±3.8	-22.3±3.8	9.8±2.4	9.8±2.4
Marine animals	31	74±15	19±16	7±9	26±15	39±15.3	15±16.6	3±9.6	18±15.3	-14.6±2.9	-12.4±2.9	-20.6±2.9	-14.1±2.9	-19.5±2.9	20.9±3.4	20.9±3.4
C_3 plants	17	10±5	5±4	84±7	89±5	5±6.9*	4±6.7	37±8.5	41±6.9	-23.7±2.0	-22.3±2.0	-29.7±2.0	-23.2±2.0	-23.8±2.0	8.6±5.4	8.6±5.4
C_4/CAM plants	13	10±5	5±4	84±7	89±5	5±6.9*	4±6.7	37±8.5	41±6.9	-11.2±1.6	-9.8±1.6	-17.2±1.6	-10.7±1.6	-11.3±1.6	12±5.6	12±5.6
Legumes	4	24±2	2±1	71±3	72±2	13±5.6*	1±5.3	31±5.8	33±5.6	-23.5±1.7	-24.2±1.7	-29.5±1.7	-23.0±1.7	-23.2±1.7	0.7±3.0	0.7±3.0

* assumes 87.4% digestiblity of plant protein as compared to animal protein

Sample	Site	Burial	Collagen yield	%C	%N	Atomic C:N	$d^{13}C_{co}$ (‰)	$d^{15}N_{co}$ (‰)	$d^{13}C_{ap}$ (‰)	$\Delta^{13}C_{ap-co}$ (‰)
I-99*	Ancachi	UR-3	18.4%	39.6	13.6	3.4	-14.8	20.4	-11.6	3.2
I-100*	Ancachi	UR-3	23.9%	43.5	14.9	3.4	-15.1	17.9	-11.4	3.7
I-101*	Ancachi	UR-1	14.6%	38.6	12.0	3.7	-15.4	18.5	-10.5	4.9
I-102*	Ancachi	UR-6	24.5%	-	-	-	-15.3	16.9	-11.5	3.8
I-103*	Ancachi	UR-2	14.6%	39.6	13.4	3.4	-15.4	16.7	-11.8	3.6
I-105*	Ancachi	UR-4	20.2%	39.8	14.0	3.3	-14.6	16.9	-11.2	3.4
J-84*	Quillagua	Museo, caja 3-3	16.0%	44.4	15.6	3.3	-15.1	17.7	-11.6	3.5
J-86*	Quillagua	Torre 203, Qui.1, museo, exhibido	7.0%	41.9	13.6	3.6	-13.4	25.8	-10	3.4
J-92*	Quillagua	Torre 203, Qui 02	16.6%	44.9	16.3	3.2	-16.5	10.9	-11.5	5.0
J-93*	Quillagua	Qui. Res. 2013-1	3.2%	38.9	13.4	3.4	-17.1	11.2	-12.1	5.0
L-133	Ancachi	12140, 343, 399	7.8%	37.9	13.2	3.3	-16.4	16.8	-11.9	4.5
L-134	Ancachi	12146, 344, 400	5.7%	38.1	13.6	3.3	-15.1	17.5	-10.6	4.5
L-135	Ancachi	12065, 340, 401	13.4%	41.0	14.6	3.3	-14.7	17.7	-10.7	4.0
L-136	Ancachi	12141, 342, 403	11.1%	39.9	14.6	3.2	-17.1	16.0	-13.0	4.1
L-137	Ancachi	12137, 345, 402	16.8%	41.1	15.0	3.2	-14.8	20.2	-10.9	3.9
L-138	Ancachi	12139, 347, 398	15.1%	41.6	14.7	3.3	-16.0	15.3	-11.4	4.6
L-139	Ancachi	12148, 1899, 403	12.6%	40.7	14.8	3.2	-14.6	12.3	-10.1	4.5
L-140	Ancachi	12152, 348, 397	12.9%	41.0	14.7	3.2	-15.8	16.7	-12.1	3.8
L-141	Ancachi	ANC16	16.7%	40.8	13.6	3.5	-16.0	19.0	-11.7	4.3
L-144	Ancachi	ANC-30-I1	15.1%	42.2	15.0	3.3	-15.5	16.4	-11.7	3.9
L-148	Ancachi	ANC12	7.4%	39.9	14.1	3.3	-16.0	16.5	-11.2	4.8
L-149	Ancachi	ANC7	8.1%	42.2	14.1	3.5	-16.9	16.7	-12.5	4.4
L-150	Ancachi	ANC6-I1	12.9%	41.4	14.3	3.4	-16.4	19.4	-12.9	3.5
L-151	Ancachi	ANC13	10.8%	37.3	12.7	3.4	-15.4	19.1	-11.2	4.1
L-152	Ancachi	ANC-2-I1	16.4%	42.2	15.1	3.3	-15.0	19.6	-9.8	5.2

* individuals were previously published in Pestle et.al 2019

Sample	Site	Burial	Terrestrial animals	sd	C_3 plants	sd	C_4/CAM plants	sd	Legumes	sd	Marine animals	sd
I-99*	Ancachi	UR-3	8.4%	7.6%	39.6%	18.2%	7.7%	6.4%	16.7%	13.7%	27.6%	11.3%
I-100*	Ancachi	UR-3	12.3%	10.3%	38.0%	18.5%	8.7%	7.1%	20.1%	15.2%	20.9%	10.4%
I-101*	Ancachi	UR-1	11.0%	9.5%	36.2%	18.4%	9.6%	7.6%	20.0%	15.0%	23.2%	11.1%
I-102*	Ancachi	UR-6	13.0%	10.9%	36.8%	19.0%	8.8%	7.2%	22.9%	16.1%	18.5%	9.5%
I-103*	Ancachi	UR-2	13.3%	11.0%	37.9%	19.2%	8.3%	6.8%	23.1%	16.7%	17.3%	9.3%
I-105*	Ancachi	UR-4	14.0%	11.5%	34.4%	18.3%	9.8%	7.7%	22.5%	15.3%	19.3%	10.0%
J-84*	Quillagua	Museo, caja 3-3	12.7%	10.4%	38.5%	18.6%	8.4%	6.9%	20.4%	15.9%	20.0%	10.0%
J-86*	Quillagua	Torre 203, Qui.1, museo, exhibido	5.2%	4.6%	32.8%	14.7%	10.0%	8.0%	10.8%	9.4%	41.3%	11.7%
J-92*	Quillagua	Torre 203, Qui 02	13.4%	10.5%	30.8%	19.1%	9.6%	7.4%	38.5%	18.1%	7.7%	6.3%
J-93*	Quillagua	Qui. Res. 2013-1	13.9%	11.1%	30.9%	19.8%	8.3%	6.6%	39.2%	19.1%	7.7%	5.9%
L-133	Ancachi	12140, 343, 399	12.6%	10.7%	40.3%	19.1%	7.5%	6.3%	23.3%	17.2%	16.4%	9.1%
L-134	Ancachi	12146, 344, 400	13.4%	11.1%	33.7%	18.4%	9.8%	8.0%	22.0%	15.6%	21.0%	10.6%
L-135	Ancachi	12065, 340, 401	12.3%	9.9%	36.5%	18.4%	10.3%	8.1%	20.2%	15.1%	20.8%	10.1%
L-136	Ancachi	12141, 342, 403	11.7%	10.5%	45.3%	21.3%	6.2%	5.2%	23.1%	17.5%	13.7%	8.5%
L-137	Ancachi	12137, 345, 402	9.1%	8.6%	36.9%	17.5%	8.7%	7.1%	17.8%	13.8%	27.5%	11.0%
L-138	Ancachi	12139, 347, 398	14.5%	11.4%	37.1%	20.0%	8.8%	6.9%	25.3%	17.4%	14.4%	8.8%
L-139	Ancachi	12148, 1899, 403	19.8%	12.8%	28.5%	17.5%	13.0%	8.9%	28.1%	15.7%	10.7%	7.7%
L-140	Ancachi	12152, 348, 397	12.8%	10.8%	39.9%	20.3%	7.5%	6.3%	22.7%	16.7%	17.0%	9.3%
L-141	Ancachi	ANC16	9.4%	8.5%	42.1%	18.6%	7.5%	6.4%	18.5%	14.6%	22.5%	10.7%
L-144	Ancachi	ANC-30-I1	13.4%	11.1%	37.9%	19.7%	8.2%	6.5%	24.0%	16.9%	16.5%	9.0%
L-148	Ancachi	ANC12	13.3%	10.8%	37.0%	19.1%	9.0%	7.3%	23.4%	16.4%	17.4%	9.5%
L-149	Ancachi	ANC7	12.1%	11.1%	43.3%	20.1%	7.0%	5.8%	22.1%	16.3%	15.6%	8.9%
L-150	Ancachi	ANC6-I1	8.8%	8.6%	46.2%	18.8%	6.4%	5.6%	17.5%	14.9%	21.1%	10.1%
L-151	Ancachi	ANC13	10.0%	9.0%	38.4%	18.6%	8.5%	7.0%	19.6%	14.6%	23.6%	10.5%
L-152	Ancachi	ANC-2-I1	10.6%	9.5%	32.3%	17.4%	10.3%	8.1%	19.9%	14.7%	26.9%	11.1%

* individuals were previously published in Pestle et.al 2019