

# A chronology for the earliest human burials at Cuchipuy, central Chile

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## Highlights:

- Fourteen radiocarbon dates on bone collagen are obtained for earliest human burials.
- Results place the start of the oldest funerary context (Stratum 4) at 7240 cal BP.
- A connection between Stratum 4 and Paleoindian deposits within the region is refuted.
- Isotopic values show that early-mid Holocene humans relied on terrestrial and aquatic resources.

## Abstract

Cuchipuy is an archaeological site within the ancient Laguna de Tagua Tagua area (O'Higgins Region, central Chile; known for containing the remains of extinct fauna), with evidence for cultural activity spanning most of the Holocene, including over 50 human burials. The bulk of chronometric work at Cuchipuy was carried out in the 1980s, where a discrepancy within the radiocarbon dating results raised questions on the antiquity of the oldest funerary deposits (Stratum 4). Given the importance of both the site and area in prehistoric studies, this analysis aimed to reassess the chronology of Stratum 4 through the production of new radiocarbon dates on human remains and the application of Bayesian modelling. When combined with previously published ages, results place the commencement of Stratum 4 at 7320-7160 cal BP, within the early-mid Holocene. This is later than previous conclusions based on the discrepant dataset, refuting a temporal connection to Paleoindian deposits within the region. In addition, stable light isotope results suggest that human diet during the period was diverse, relying on both terrestrial and freshwater aquatic resources. This pattern changes with later populations, however, where the isotopic signal reflects the consumption of mainly terrestrial resources.

**Keywords:** radiocarbon dating, Bayesian modeling, stable isotope analysis, human remains; Archaic

## 1. Introduction

Cuchipuy is a multicomponent site located within the ancient Laguna de Tagua Tagua area (an extinct lake), O'Higgins Region, central Chile (Fig. 1), containing over 50 human burials (Kaltwasser et al., 1980). The site sits 8 km east of the Taguatagua 1 and 2 archaeological sites, which date to the Pleistocene/Holocene transition and present evidence for butchering activities on megafauna (Casamiquela et al., 1967; Méndez, 2015; Montane, 1968; Montané, 1968; Nuñez et al., 1994). Cuchipuy is found at the base of a hill and was cut, to the east, by the construction of a road that first exposed the human remains. Initial excavations occurred in 1978-79 under J. Kaltwasser, and were part of a salvage operation (Kaltwasser et al., 1986, 1984, 1982, 1980, 1979). Then, archaeologists identified four distinct geocultural strata within different excavation units across a

30x40 m area. Stratum 1 corresponds to a top layer containing multiple isolated human burials with associated ceramic artefacts. Stratum 2 is gravelly, lacking in ceramics, and with stone structures containing multiple human burials. Stratum 3 is a layer of earth, fine sand, and calcium carbonate, devoid of burials and with very few human bones and cultural materials. Stratum 4, at a starting depth of 1.80-2 m and a thickness of 1 m, represents the deepest funerary context with human burials and associated lithic points (Kaltwasser et al., 1986). In 2009, archaeological excavations adjacent to previous work began and six new stratigraphic levels were identified (Méndez et al., 2021). There is no formal correlation between these and the four strata defined by Kaltwasser. Although no human remains were found, lithics were found at the base of the sequence (Arenas, 2013).

Efforts at establishing a chronology for Cuchipuy began between 1980-1982, when eleven charcoal, bone, and sediment dates were obtained for Strata 2-4 (Kaltwasser et al., 1983; Table 1). The dataset is incongruent, however, with paired skeleton and charcoal samples in Stratum 4 (Unit 2) dating to  $6,105 \pm 145$  BP (Beta-1454) and  $8,070 \pm 100$  BP (Beta-1453), respectively. More recently, thermoluminescence (TL) dates on ceramics (Arenas et al., 2016; Westfall et al., 2001) and radiocarbon ages on charcoal/sediments have been obtained (Méndez et al., 2021) (the bulk of these resulting from the 2009 excavation). Starting in the 1980s, researchers have maintained that the oldest funerary context at Cuchipuy is at least 8,000 BP (~8900 cal BP) given the paired charcoal measurement (Beta-1453) and an apparent correspondence between Stratum 4 and lithostratigraphic unit 5 at Taguatagua 1/2 (Kaltwasser et al., 1986, 1983), a Paleoindian level containing the remains of extinct fauna (Casamiquela et al., 1967; Montané, 1968; Nuñez et al., 1994). To test this, we secured samples from 16 human remain samples from this layer to produce new radiocarbon dates on bone collagen (Table 2). Combined with Bayesian modelling and stable light isotope analyses, this provides an opportunity to build a reliable chronology for the oldest funerary context and overall sequence at Cuchipuy, as well as assessing diet for the earliest humans interred.

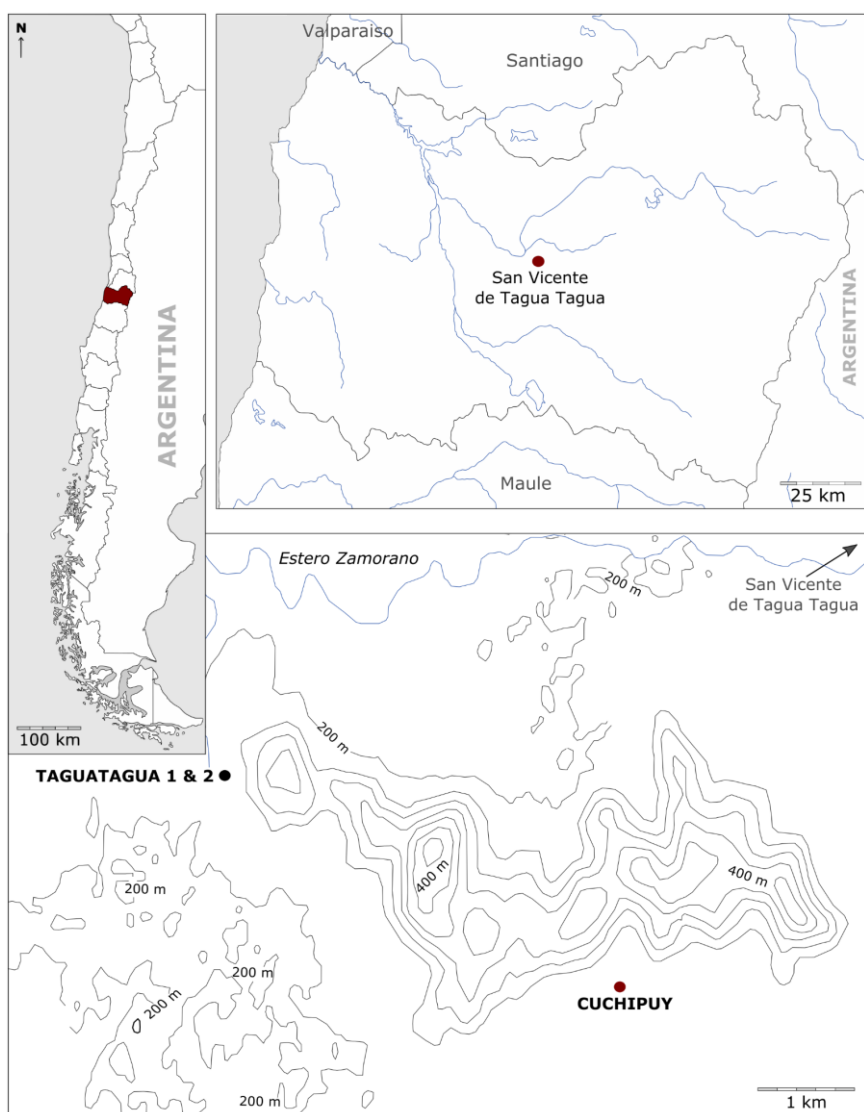


Fig. 1. Map showing the location of Cuchipuy (in red) and the Taguatagua 1 and 2 archaeological sites (bottom panel), near San Vicente de Tagua Tagua (in red; top-right panel), O'Higgins Region, central Chile (in red; top-left panel).

Table. 1. Previously published radiocarbon ( $^{14}\text{C}$ ) and thermoluminescence (TL) dates (Arenas et al., 2016; Kaltwasser et al., 1986, 1983; Westfall et al., 2001) included in the Bayesian modelling. In radiocarbon dating, BP or 'before present' date is (uncalibrated) before 1950, whilst for luminescence dating, BP is before date of measurement.  $\pm$  denotes error at 1 sigma. For radiocarbon ages the term 'cal BP' refers to radiocarbon measurements that have undergone calibration and can be compared in calendar years. For luminescence dates (for this purpose), the term 'cal BP' refers to calendar years before present and takes into account the year of measurement (2010 for UCTL-2027 and -2028, and an assumed year of 2000 for UCTL-1318 given the publication date). BCE = Before Common Era. CE = Common Era. All cal BP dates are noted to a 95.4% confidence interval.

\*reflects paired charcoal and bone samples.

Method	Material	Context	Laboratory code	Date (BP)	$\pm$	cal BP	Reference
$^{14}\text{C}$	unidentified charcoal	Stratum 4	Beta-1453*	8070	100	9265-8595	Kaltwasser et al., 1983
$^{14}\text{C}$	bone collagen	Stratum 4	Beta-1454*	6105	145	7280-6560	Kaltwasser et al., 1983

<sup>14</sup> C	unidentified charcoal	Stratum 2	Beta-2168	5760	90	6735-6310	Kaltwasser et al., 1983
<sup>14</sup> C	bone collagen	Stratum 4	Beta-2169	5060	170	6200-5330	Kaltwasser et al., 1983
<sup>14</sup> C	unidentified charcoal	Stratum 4	Beta-2170	5690	80	6640-6295	Kaltwasser et al., 1983
<sup>14</sup> C	unidentified charcoal	Stratum 3	Beta-3471	7610	80	8540-8190	Kaltwasser et al., 1983
<sup>14</sup> C	unidentified charcoal	Stratum 3	Beta-3472	6160	100	7260-6745	Kaltwasser et al., 1983
<sup>14</sup> C	unidentified charcoal	Stratum 3	Beta-3473	7060	140	8170-7585	Kaltwasser et al., 1983
<sup>14</sup> C	peat	Stratum 4	Beta-3903	6840	90	7845-7480	Kaltwasser et al., 1983
<sup>14</sup> C	unidentified charcoal	Stratum 3	Beta-3904	7160	80	8170-7750	Kaltwasser et al., 1983
<sup>14</sup> C	unidentified charcoal	Stratum 3	Beta-3905	7370	100	8360-7965	Kaltwasser et al., 1983
<sup>14</sup> C	-	Stratum 1 (Ceramic phase)	-	1320	80	1315-980	Kaltwasser et al., 1986
TL	ceramic	Ceramic phase; level I	UCTL-1318	700	80	CE 1135-1460	Westfall et al., 2001
TL	ceramic	Ceramic phase; Unit 6; level II	UCTL-2027	1760	170	BCE 95 - CE 590	Arenas et al., 2016
TL	ceramic	Ceramic phase; Unit 6; level III	UCTL-2028	1930	190	BCE 305 - CE 460	Arenas et al., 2016

## 2. Materials and Methods

### 2.1. Radiocarbon dating

Samples were processed for radiocarbon dating at the Oxford Radiocarbon Accelerator Unit (ORAU). The 16 bone samples obtained (Table 2) were first manually cleaned by air abrasion and cut using a small diamond disc. Fragments were chemically pretreated and targeted for “collagen” (following the use in DeNiro and Weiner, 1988; Hedges and Van Klinken, 1992; van Klinken, 1999) by means of an acid-base-acid protocol, gelatinisation, Ezeefiltration, and ultrafiltration (ORAU pretreatment code, ‘AF’) (Brock et al., 2010). Where consolidants were present, chemical pretreatment was preceded by a series of solvent washes (acetone/methanol/chloroform) and the pretreatment code given an asterisk, e.g., AF\*. Samples were then rinsed with 0.5M hydrochloric acid [three or four washes over an ~18 hour period; at room temperature (RT)], 0.1M sodium hydroxide (30 minutes at RT), and 0.5M hydrochloric acid (~1 hour; at RT). Each acid or base wash was followed by three rinses with ultrapure MilliQ™ deionized water. The extracted collagen was then gelatinised in a pH 3 solution at 75°C for 20 hours and filtered using pre-cleaned Ezeefilters™. The gelatin was transferred into previously cleaned ultrafilters (Vivaspin™ 15–30 kD molecular weight cut-off) and centrifuged until 0.5–1.0 mL of the >30 kD gelatin fraction was left.

115 The ultrafiltered gelatin was collected using glass pipettes and placed into previously pre-baked  
 116 glass tubes. Samples were then thoroughly frozen at -18°C and lyophilised using a VaCo 5 freeze-  
 117 dryer (Zirbus) for a minimum of 12 hours. Freeze-dried samples were placed into tin capsules and  
 118 combusted in an elemental analyzer (EA; Carlo-Erba NA-2000) coupled to a continuous flow  
 119 isotope ratio mass spectrometer (CF-IRMS) (Sercon 20/20). This allowed for measurement of  
 120 elemental ratios (CN) and stable isotope values ( $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$ ), which are used for quality  
 121 assessment in radiocarbon dating (Brock et al., 2010). The  $\text{CO}_2$  collected was transferred to pre-  
 122 outgassed rigs containing a 2.0-2.5mg iron catalyst and  $\text{H}_2$  added at a ratio of 2.2 $\text{H}_2$ :1 $\text{CO}_2$  and  
 123 heated at 560°C for 6 hours. Graphite targets were made with approximately 0.5-1.8 mg of carbon,  
 124 depending on the yield of each sample (Dee and Bronk Ramsey, 2000). Radiocarbon measurement  
 125 was done with a High Voltage Engineering Europa accelerator mass spectrometer (AMS) system,  
 126 following (Bronk Ramsey et al., 2004).

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 128 Table. 2. List of samples obtained for radiocarbon dating and stable light isotope analysis from  
 129 Stratum 4 at Cuchipuy.

Individual number	Individual name	Skeletal element	Context
1	Esqueleto 2	Rib fragment	Unit 6; union C-1; grid/meter 8
2	Esqueleto 5	Rib fragment	Unit 2; grids/meters 7 and 8
3	Esqueleto 6	Rib fragment	Level 2/10-20 south; grids/meters 7 y 8
4	Esqueleto 1	Mandible fragment	Level 2; grid/meter 7
5	Esqueleto 2	Ulnar fragment	Level 2; grid/meter 7
6	Esqueleto 4	Cranial fragment	Level 2; grids/meters 7 and 8; -0.2 depth
7	Individuo 7	Cranial fragment	Grid: slope; grids/meters 7 and 8
8	Esqueleto 1	Rib fragment	Level 2 (white layer); grid/meter 5 (south)
9	Esqueleto 2	Rib fragment	Slope; grid/meter 7
10	Individuo 3/7	Coxal fragment	Mound 1N
11	Esqueleto 3	Rib fragment	Level 2; grid/meter 7
12	Individuo 2	Rib fragment	Grid: 1 North; level 20-14
13	Esqueleto 1	Long bone fragment	Unit 2; grids/meters 1 and 2 north
14	Esqueleto 6/7	Tibial fragment	Grids/Meters 7 and 8
15	Esqueleto 8	Cranial fragment	Level 3; grids/meters 7 and 8
16	Esqueleto 9	Rib fragment	Level 3; grids/meters 7 and 8

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### 132 2.3. Calibration and Bayesian modeling

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134 Radiocarbon calibration was undertaken using SHCal20 (Hogg et al., 2020) in OxCal 4.4 (Bronk  
 135 Ramsey, 2009a). Bayesian modeling was done through the same platform (Bronk Ramsey, 2009a),  
 136 using chronometric data (new and previously published) and known stratigraphic information  
 137 (Tables 1 and 3). In brief, Bayesian modelling is a statistical tool that allows the incorporation of  
 138 relative prior information with absolute dates. Prior beliefs can involve absolute, e.g., historical  
 139 accounts, or relative information, e.g., stratigraphy (Harris, 2014). Posterior beliefs are expressed as  
 140 probability density functions through the use of Markov Chain Monte Carlo methods which, by  
 141 repeated sampling, calculate the highest probability distribution of dates as weighted towards the  
 142 prior beliefs. In this study, uniform phases were used for each strata. These assume that all events  
 143 included are equally likely to occur anywhere within two boundaries. The ‘General’ outlier model

was also applied to all dates, with each given a 5% prior probability of being an outlier (Bronk Ramsey, 2009b). This analysis addresses the assumption that all dates are correct, downweighting offset measurements. All modelled/calibrated estimates are noted at 95.4% credible/confidence intervals and rounded to five years.

## 2.4. Stable light isotope analysis

For thirteen individuals, leftover collagen material from the radiocarbon dating process was measured in duplicate for stable light isotopes ( $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$ ), using an EA (Carlo-Erba NA, 2000) coupled CF-IRMS (SERCON 20/22) system. Isotopic compositions were calibrated relative to the Vienna Pee Dee Belemnite (VPDB) and atmospheric  $\text{N}_2$  (AIR) scales using international standards USGS40 and USGS41. Measurement uncertainty was monitored using an internal standard (L-Alanine, Sigma-Aldrich) with well-characterized isotopic compositions ( $\delta^{13}\text{C} = -27.11 \pm 0.10\text{‰}$ ,  $\delta^{15}\text{N} = -1.56 \pm 0.10\text{‰}$ ). Precision of replicate standard and sample measurements was  $\pm 0.08\text{‰}$  for  $\delta^{13}\text{C}$  and  $\pm 0.12\text{‰}$  for  $\delta^{15}\text{N}$ . Accuracy, determined from observed and known  $\delta$  values of standards, was  $\pm 0.10$  for  $\delta^{13}\text{C}$  and  $\pm 0.11$  for  $\delta^{15}\text{N}$ . Total analytical uncertainty was calculated following (Szpak et al., 2017) and estimated to be  $\pm 0.13\text{‰}$  for  $\delta^{13}\text{C}$  and  $\pm 0.16\text{‰}$  for  $\delta^{15}\text{N}$ .

## 3. Results and Discussion

### 3.1. Chronology

Of the 16 samples, fourteen were successfully measured (Table 3). Two samples failed during chemical pretreatment due to poor collagen preservation with no sample yield. Generally, elemental values, ratios and collagen yields are within acceptable values, indicating good preservation and little to no contamination (Ambrose, 1990; Brock et al., 2010; DeNiro, 1985; van Klinken, 1999). The only exception is individual 4, with a  $<1\%$  collagen yield. Given that C%, N% and C:N values are within range, however, the diminished yield is likely the result of sample loss during processing.

Using new and previously-published chronometric data (Tables 1 and 3), Bayesian modelling estimates the commencement of Stratum 4 to 7320-7160 cal BP, and the strata 4/3 transition to 7240-6960 cal BP (Figure 2; see Supplementary Information for model output in Table S1). This places the oldest funerary context within the early-mid Holocene (or early-mid Archaic period, as defined by (Cornejo et al., 2016)). Although transitions between strata 4/3 and 3/2 appear to be largely contiguous (with the latter estimated at 7155-6495 cal BP), a gap between strata 1 and 2 is apparent and likely lasted 290 to 4,755 years. This is either a real taphonomic event or a result of sampling/dating bias. The sequence ends with Stratum 1 (Ceramic phase), between 1285 cal BP and the present. Of the 29 dates included, eleven were identified as major ( $>60\%$ ) outliers (OxA-37324, OxA-37331, OxA-37335, Beta-2169, -2170, -3903, -1453, -3471, -3473, -3904 and -3905). These include four bone collagen and three charcoal ages within Stratum 4, and four charcoal dates in Stratum 3. For the latter, these comprise the majority of that component, at 75%. Generally, bone collagen outliers likely represent age underestimates, with the opposite true for charcoal dates. This indicates vertical mixing (both upward and downward) within the deposits and/or inbuilt age for the charcoal. The former is expected given the context, whilst the latter cannot be further investigated due to the current evidence, e.g., unidentified species.

Table 3. Radiocarbon dating results for Stratum 4 at Cuchipuy. 'P', pretreatment. %collagen is the yield of extracted collagen as a function of the starting weight of bone samples. C:N is the atomic weight ratio of carbon to nitrogen. %C and %N are the percentage of carbon and nitrogen, respectively, in the combusted sample. Stable isotope values are expressed in per mille (‰) relative to VPDB and AIR. AF\* denotes solvent washing. All cal BP dates are noted to a 95.4% confidence interval. Samples for individuals 15 and 16 failed during pretreatment due to no collagen yield.

196 Radiocarbon calibration was undertaken using SHCal20 (Hogg et al., 2020) in OxCal 4.4 (Bronk  
197 Ramsey, 2009a).

Individual number	P code	%collagen	C:N	%C	%N	$\delta^{13}\text{C}$	$\delta^{15}\text{N}$	Lab number	Date (BP)	$\pm$	cal BP
1	AF	5.8	3.2	46.7	17.1	-18.9	10.2	OxA-37324	5540	32	6395-6205
2	AF	5.2	3.2	47.1	17.2	-19.0	11.5	OxA-37325	6180	45	7170-6885
3	AF	1.4	3.2	40.5	14.6	-17.2	11.7	OxA-37326	6286	34	7265-7010
4	AF	0.7	3.3	43.9	15.6	-18.0	13.0	OxA-37327	6259	34	7255-6995
5	AF	2.4	3.2	43.4	15.6	-20.5	9.7	OxA-37328	6194	32	7165-6935
6	AF	4.5	3.2	42.2	15.3	-18.0	11.4	OxA-37329	6314	33	7310-7020
7	AF	4.6	3.2	43	15.5	-20.1	9.9	OxA-37330	6342	35	7410-7080
8	AF	1.9	3.3	42.9	15.3	-19.5	8.7	OxA-37331	5474	33	6310-6115
9	AF	5.9	3.3	42.5	16.7	-17.7	13.5	OxA-37766	6302	38	7280-7010
10	AF	5.3	3.2	47.4	17.2	-16.4	15.4	OxA-37332	6221	34	7240-6950
11	AF	4.1	3.2	43.5	15.8	-19.4	9.4	OxA-37333	6271	34	7260-7000
12	AF	4.8	3.2	49	17.9	-19.5	11.2	OxA-37334	6281	34	7260-7000
13	AF	4.9	3.2	47.3	17.2	-19.4	11.6	OxA-37335	5901	36	6790-6555
14	AF	5.8	3.2	44.8	16.3	-19.4	9.7	OxA-37336	6342	33	7325-7155
15	AF*	0	-	-	-	-	-	-	-	-	-
16	AF	0	-	-	-	-	-	-	-	-	-

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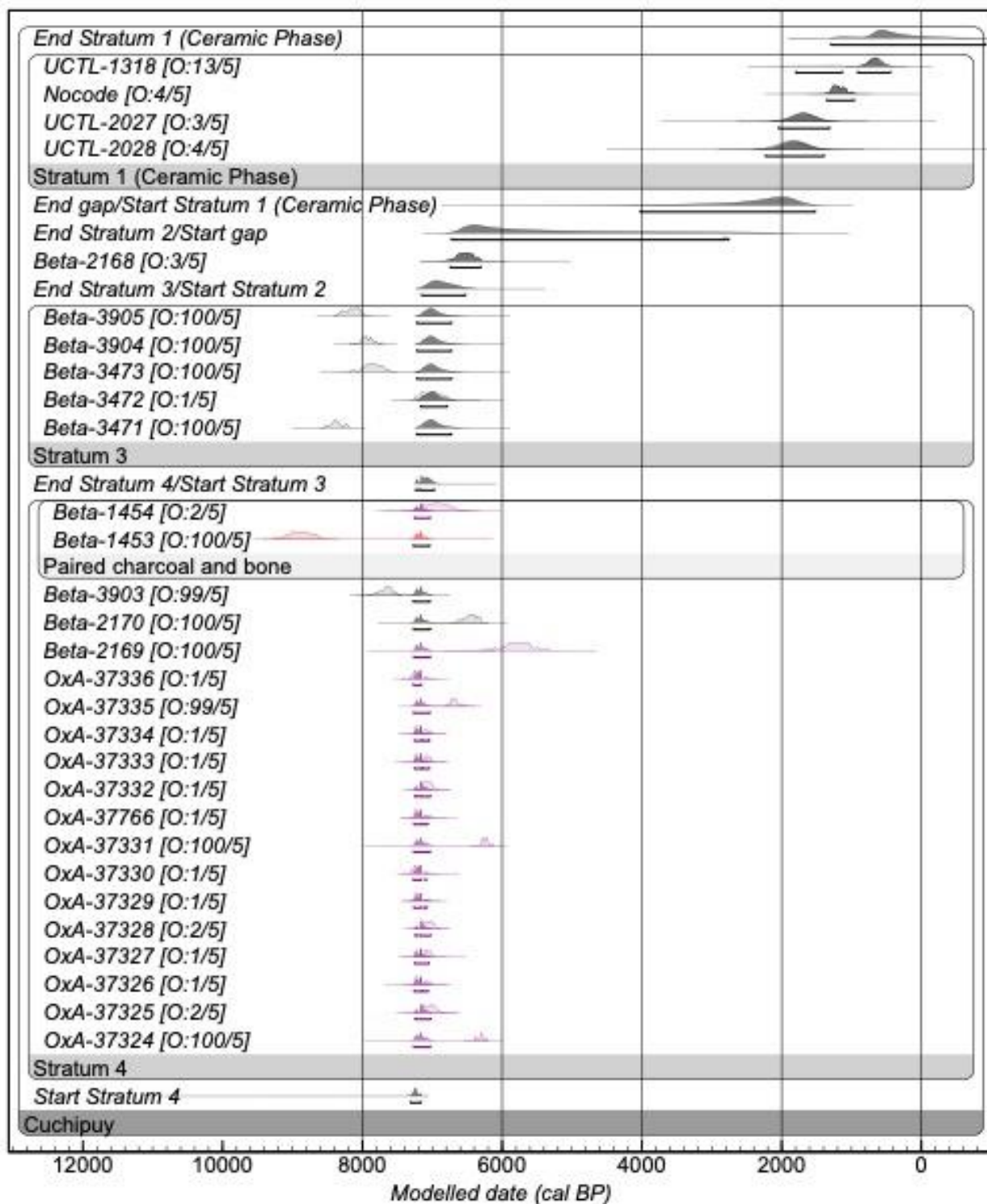


Fig. 2. Bayesian model for Cuchipuy. Outlier analysis output is noted as ‘O:posterior probability/prior probability’. Distributions representing bone collagen dates are coloured in purple. Beta-1453, an outlier at 100% probability and the terrestrial pair to a human-derived measurement (Beta-1454) is coloured in red. The start of Stratum 4 is estimated at 7320-7160 cal BP, with the end at 7240-6960 cal BP (within the early-mid Holocene).

Bayesian modelling results show that contrary to previous conclusions (Kaltwasser et al., 1983, 1980), Beta-1453 (a charcoal age and likely outlier at 100% probability) is not the most reliable measurement with which to base the antiquity of Stratum 4. Although reported to have been paired and physically attached to a human individual with a younger, discrepant age (Beta-1454; here not



identified as an outlier), depositional turbation and old-wood effects were not seriously considered. Instead, (Kaltwasser et al., 1983) deemed the bone age to be an underestimate following (Tamers and Pearson, 1965), who questioned the validity of radiocarbon dates on bone. These bone ages were obtained ~15 years following that publication, however, with a reliable method for collagen extraction within radiocarbon dating already well established (Longin, 1971) (although the reliability of Beta measurements cannot be currently assessed given the lack of elemental and stable light isotope data). Along with the fact that the majority of outlying dates (~64%) are non-bone measurements, this example serves to highlight the importance of species/sample identification for wood charcoal to account for inbuilt age (McFadgen, 1982), and the potential vertical mixing of mobile plant macrofossils within burial deposits. Following this, where available and ethical, direct bone dating of articulated skeletal remains is crucial in the establishment of a robust chronology for archaeological sites where these factors apply. Moreover, regardless of the integrity of the archaeological context, human remains have a higher degree of association with cultural activity than geological material (Waterbolk, 1971).

Stable light isotope results show that Archaic-aged individuals likely had a mixed terrestrial and aquatic (freshwater) diet (see section 3.2). Therefore, the potential impact of a freshwater reservoir effect (Philippsen, 2013) in the radiocarbon ages must be considered. Currently, however, there is no quantified offset for Cuchipuy or the Laguna de Tagua Tagua area. This is further complicated by previously obtained data for this site, which shows a terrestrial date (Beta-1453) found in close association with a human individual to be *older* than the bone collagen date obtained (Beta-1454). This is opposite to the expected pattern for freshwater reservoir effects, where human-derived  $^{14}\text{C}$  measurements are generally anomalously older than paired terrestrial samples due to uptake of 'old' radiocarbon through diet. To address potential freshwater reservoir effects, we ran an alternate Bayesian model to that in Fig. 2, where all bone collagen dates are assumed to be anomalously old by employing the 'Charcoal' outlier model (Bronk Ramsey, 2009b) (see Fig. S1 in Supplementary Information). Through comparison of the start boundary for Stratum 4, both models are found to be statistically comparable (see Fig. S2 in Supplementary Information). This suggests that potential freshwater reservoir effects have no significant impact in the modelled output and in our conclusions.

### 3.2. Diet

Of the fourteen samples that survived radiocarbon pretreatment, only one (individual 4 in Table 3) did not yield enough material for stable light isotope measurement (Table 4). Results are noted in Table 3 and Fig. 3. These values and those obtained through the radiocarbon dating process were comparable, however, with a combined average difference of 0.1‰ (within the former's analytical uncertainty). For this reason, isotopic values for individual 4 are included in the analyses and discussion.

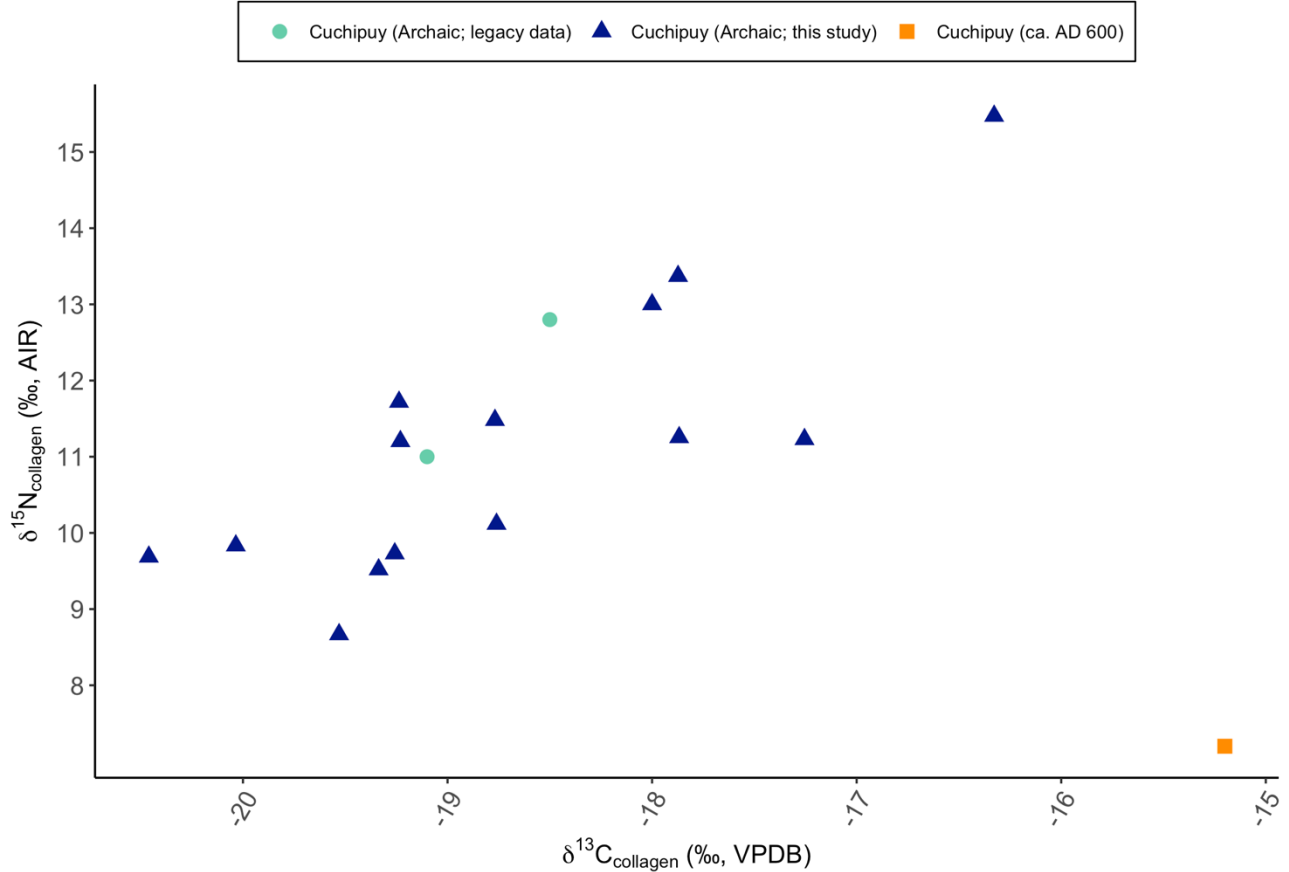
The Cuchipuy individuals average  $-18.7 \pm 1.1\text{‰}$  (median  $-19.0\text{‰}$ ) for  $\delta^{13}\text{C}_{\text{collagen}}$  and  $11.2 \pm 1.8\text{‰}$  for  $\delta^{15}\text{N}_{\text{collagen}}$  (median  $11.2\text{‰}$ ) ( $n = 14$ ), indicating low isotopic variability and a relatively symmetrical distribution. Together with previously published results from two Archaic individuals at the site (Sanhueza and Falabella, 2010) (Fig. 3), the isotopic evidence suggests a diverse diet, likely focused on terrestrial and freshwater aquatic resources, in agreement with zooarchaeological evidence (Kaltwasser et al., 1986). Individual 10, in particular, shows an enrichment in  $^{15}\text{N}$  (15.5‰) reflecting a diet dependent on the latter. When compared with isotopic values obtained from a geologically younger individual (ca. AD 600) from the site (Sanhueza and Falabella, 2010), carbon and nitrogen isotope compositions become more enriched/depleted with time, respectively. This is consistent with previous studies showing an increased reliance on terrestrial resources—including  $\text{C}_3$  and  $\text{C}_4$  plants, e.g., quinoa and maize, respectively—during later occupational phases in the region (Falabella et al., 2007).

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Table 4. Bone collagen stable light isotope values for thirteen Cuchipuy individuals from Stratum 4. Isotopic values are expressed in per mille (‰) relative to VPDB and AIR. These are comparable to those produced through the radiocarbon dating process, with a combined average difference of 0.1‰. This is within the analytical uncertainty for these measurements.

Individual number	Individual name	$\delta^{13}\text{C}$	$\delta^{15}\text{N}$
1	Esqueleto 2	-18.8	10.1
2	Esqueleto 5	-18.8	11.5
3	Esqueleto 6	-17.3	11.2
5	Esqueleto 2	-20.5	9.7
6	Esqueleto 4	-17.9	11.3
7	Individuo 7	-20.0	9.8
8	Esqueleto 1	-19.5	8.7
9	Esqueleto 2	-17.9	13.4
10	Individuo 3/7	-16.3	15.5
11	Esqueleto 3	-19.3	9.5
12	Individuo 2	-19.2	11.2
13	Esqueleto 1	-19.2	11.7
14	Esqueleto 6/7	-19.3	9.7

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Figure 3. Bivariate plot of  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  bone collagen values obtained for fourteen Cuchipuy individuals (blue triangles), as well as previously published results for two Archaic humans (green circles) and a third, geologically younger individual (ca. AD 600) at the site (orange square) (Sanhueza and Falabella, 2010).

#### 4. Conclusion

New radiocarbon measurements on bone collagen were obtained from fourteen human individuals located within the oldest funerary context (Stratum 4) at Cuchipuy. Combined with previously published ages, using a Bayesian modelling approach, these contribute to the development of a high-resolution chronology for the site. Results place the start of Stratum 4 at 7320-7160 cal BP, and the end at 7240-6960 cal BP (within the early-mid Holocene). A temporal hiatus of between 290 and 4,755 years preceding Stratum 1 (Ceramic phase) is identified, likely the result of sampling/dating bias or a real taphonomic event. Outlier analysis indicates vertical mixing within the deposits and/or inbuilt age for the charcoal. Given the archaeological context, turbation is not unusual. Old-wood effects, however, cannot be further investigated given the data reported. These results suggest that, contrary to previous conclusions, an early charcoal date of  $8,070 \pm 100$  BP or 9265-8595 cal BP (Beta-1453), does not reliably date the earliest human burials at Cuchipuy. Instead, it is likely an overestimation. This refutes the temporal connection between Stratum 4 and a Paleoindian level at the Taguatagua 1 and 2 sites. The chronology for Taguatagua 1 and 2 requires improvement, however; direct dating of faunal bone (including human-modified fragments) has been unsuccessful due to poor collagen preservation (Montane, 1968); in line with collagen extraction attempts made by the first author of this study in 2018). Stable light isotope analyses indicate low isotopic variability within Stratum 4 individuals. Combined with previously published results, the values obtained suggest that human diet during the early-mid Holocene was likely diverse, relying on terrestrial and aquatic resources. This is opposed to later populations, showing a largely terrestrial isotopic signal that reflects the intensification and consumption of crops like maize and quinoa. The varied diet and abundance of bioarchaeological evidence at early-mid Holocene Cuchipuy support the interpretation by (Barberena et al., 2017), who suggest that the Laguna de Tagua Tagua area likely acted as a refugium for hunter-gatherer groups attracted to abundant and predictable resources. Regionally, Cuchipuy provides the earliest, reliably-dated concentration of human remains and the onset of burial practices.

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