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## Chapter 2

# Diet and Animal Husbandry of the Preclassic Maya at Cuello, Belize: Isotopic and Zooarchaeological Evidence

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### ABSTRACT

The diet of the Preclassic Maya at Cuello, Belize was studied by means of carbon and nitrogen isotope measurements on human and animal bones from the site, as well as on modern animals from the region. The average  $\delta^{13}\text{C}$  value for Preclassic human bone collagen was  $-12.9 \pm 0.9\%$  (n = 28) and for tooth enamel apatite it was  $-8.7 \pm 2.3\%$  (n = 33); the average  $\delta^{15}\text{N}$  in bone collagen was  $8.9 \pm 1.0\%$  (n = 23). The archaeological faunal remains, in order of frequency, include white-tailed deer, freshwater turtle and dog, plus smaller numbers of armadillo, brocket deer, peccary, and rodent. All of these are C<sub>3</sub> plant eaters (ave.  $\delta^{13}\text{C}$  =  $-20.8\%$ , n = 19), except dog ( $-15.0\%$ , n = 12) and armadillo ( $-16.4\%$ , n = 6). Archaeological plant remains include maize (estimated carbon and nitrogen isotope values  $-10\%$ ,  $+3\%$ ) and a variety of forest species. Marine foods are barely represented in the archaeological deposits. The archaeological and isotopic evidence together indicate that the people at Cuello made substantial use of maize, but were not dependent on it like later Maya populations. C<sub>4</sub> carbon made up ca. 30-35 percent of their bone and tooth

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enamel apatite and 50–55 percent of their bone collagen. This apparent discrepancy is the result of their eating dog and armadillo, both with substantial C<sub>4</sub> components in their diets. The dogs were the size of large terriers, were slaughtered in their prime, and were apparently allowed to scavenge rather than being fed a high-maize diet to fatten them for the pot. The deer neither raided the cornfields nor were they intentionally fed maize. Feeding maize to deer and dogs are phenomena which were observed in historic times, but evidently developed after the Preclassic.

### INTRODUCTION: PRECLASSIC CUELLO

Cuello was excavated by Hammond and co-workers between 1975 and 1993. It is the earliest known Preclassic Maya site, with a Preclassic occupation from ca. 1200 BC to AD 300 as well as later Classic period (AD 300–900) remains; the earliest pottery-using phase (Swasey, 1200–900 BC) has not yet been found at other Preclassic sites, but the Bladen (900–600 BC) and subsequent phases match occupations elsewhere in date and material culture. The Cuello excavations have been extensively described in the report edited by Hammond (1991). Of particular relevance here are the chapters on the ecology and subsistence economy (Ch. 4) by Miksicek and by Wing and Scudder, and on the human burials (Ch. 7), by Frank and Julie Saul. More recent publications have focused on the subsistence economy (Crane and Carr 1994) and on the human skeletal remains (Saul and Saul 1997).

Human burials (166 in all) occur throughout the 1600 year Preclassic occupation at Cuello and so do trash deposits. Analysis of plant remains from the latter show that a range of forest species were exploited for economic purposes, including that of diet. Maize (*Zea mays*) is present from the earliest levels, and analysis of cupule sizes shows that early, very small-cobbed maize was replaced by progressively larger cobs (Miksicek 1991: Fig. 4.1), suggesting (but not guaranteeing) increased productivity over time. Maize was domesticated from wild *teosinte* in Central Mexico as early as 6000 BC, spread to the Belizean tropical lowlands by 3000 BC, and is correlated with extensive forest disturbance by 2500 BC (Pohl et al. 1996). Other staple crops included roots such as tanioc (*Manihot esculenta*), malanga (*Xanthosoma* sp.) and probably sweet potato (*Ipomoea batatas*) (Hather and Hammond 1994). Although initially agriculture in the Cuello area was probably based on swiddening, by the late Middle Preclassic (600–400 BC) there is evidence for drained fields in low-lying wetlands, suggesting either a preference for such locations sufficient to stimulate the necessary investment of labor, or sufficient pressure on the swiddening system to require the adoption of more intensive means of cultivation.

The historic Maya diet is protein-deficient, and it was long assumed that prehispanic meat intake was also low (Morley 1946: 25; Béhar 1968), although

the diversity of potential protein sources has been demonstrated by the systematic recovery of even fragmentary animal remains at Cuello (Wing and Scudder 1991: Tables 4.8–4.14). Analysis of these shows the presence of the same economic species throughout the Cuello sequence. Deer (*Odocoileus virginianus*) form about 50 percent of the faunal remains, both in MNI and bone frequency. Two species of freshwater turtle are the next most frequent (mud turtle, *Kinosternon* sp., and *Stomatoplys triporcatus*) followed by dog (*Canis familiaris*). Occurring in smaller numbers are armadillo (*Dasypus novemcinctus*), peccary (*Tayassu* sp.), gibbon (*Agouti paca*), brocket deer (*Mazama americana*), opossum (*Didelphis marsupialis*) and other animals. Fish form less than two percent of the faunal remains and most of them are freshwater species. Mollusc shells are not plentiful, apart from an abundance of the swamp snail *Pomacea flagellata*, which was apparently harvested at optimal size (Miksicek 1991: Fig. 4.2); other shells (river mussel), conch, and thorny oyster) were apparently brought to the site for manufacture into jewelry. Conch (*Strombus gigas*) comes from the Caribbean coast, some 50 km from Cuello. Of the thorny oysters much prized in the Mayan world, *Spondylus americanus* is found along the Caribbean shore but *Spondylus princeps* is a deep-water species from the Pacific, obtained in long-distance trade. Most of the beads and other artifacts are made from *Spondylus* so heavily modified that the species cannot be determined, although *S. americanus* would seem the easier to acquire. Shellfish could, of course, have been transported to Cuello out of the shell from the Caribbean, but their shell-life is extremely short in the tropics.

We wished to establish the nature of the Preclassic Maya diet at Cuello, with special interest in the extent to which maize was a staple, and whether its importance increased over time as it became more productive. Given the importance of maize to Maya civilization, a measure of its consumption in the Preclassic is a high priority.

We also wished to establish whether the Preclassic Maya specifically raised dogs as a food source and fed them maize for this purpose. The consumption of dogs was a common practice in later New World societies where other sources of meat were few (Schwartz 1997). Bishop Landa noted in Historic times (Tozzer 1941: 203) that a small, hairless breed of dog was kept in this manner by the Maya. The dogs of Cuello were not small: all were of large terrier size, but cummacks show that they were butchered and that this was done after the initial growth period, at about 1 year of age (Clutton-Brock and Hammond 1994). It remained for us to determine whether they scavenged or were led. A similar question arises with respect to deer. They were obviously not domesticated like dogs, but Bishop Landa observed that they were tame-able: "They . . . raise other domestic animals, and let the deer suck on their breasts, by which means they raise them and make them so tame that they will not go in the woods, although they take and carry them through the woods and raise them there" (Tozzer 1941: 127). Such a procedure is likely to involve maize fodder for the deer, or at least cornfield browsing.

## PROCEDURE

To resolve these questions, we measured the stable carbon and nitrogen isotope ratios in (1) Preclassic human skeletons from Cuello, using collagen as the sample material, but also measuring the carbon isotopes in the apatite of bone and tooth enamel; (2) animal bones from the archaeological deposits; and (3) bones and/or flesh of modern terrestrial, riverine, and marine animals collected in the area in 1992 (see also Tykot *et al.* 1996). The modern specimens were used to expand the database on the isotopic ecology of Cuello during the Preclassic, insofar as the modern environment can be considered to simulate the ancient one. In particular, the modern collection provided information about the marine system, since marine foods may mimic maize in  $\delta^{13}\text{C}$  values.

Bone from the Cuello archaeological deposits was poorly preserved and of a chalky consistency. Collagen was extracted by breaking the bone into granules of about 2 mm and dissolving them slowly in dilute hydrochloric acid. After neutralization with distilled/deionized water, the samples were treated with NaOH to remove humic acids and defatted with a 2:1:0.8 mixture of methanol:chloroform:water. The collagen pseudomorphs were freeze-dried; combusted in closed quartz tubes with copper oxide, copper, and silver; and the carbon dioxide and nitrogen gases were isolated in a vacuum line. This is a conservative procedure which loses some potential collagen samples, but invariably yields C/N ratios near 3.2. For apatite separation, cleaned bone and tooth enamel were ground in a Spex mill; the organic phase was dissolved in Clorox; possible calcite contaminants were dissolved in dilute acetic acid; and carbon dioxide was liberated in phosphoric acid at 90°C. The weight percent of carbon produced was typically 0.4–0.7%. The carbon and nitrogen isotope ratios were measured in a VG PRISM 2 isotope ratio mass spectrometer in the Department of Earth and Planetary Sciences at Harvard, utilizing the automatic sample manifold, a Carlo Erba analyzer, and a series of NBS and in-house standards. Results are reported in parts per mil (‰) relative to the PDB standard for carbon and to the AIR standard for nitrogen.

## INTERPRETATION

Where  $\text{CO}_2$  in the free atmosphere has a  $\delta^{13}\text{C}$  value of  $-7\text{‰}$ ,  $\text{C}_3$  and  $\text{C}_4$  plants are anticipated to have  $\delta^{13}\text{C}$  values of about  $-26.5\text{‰}$  and  $-12.5\text{‰}$  respectively (van der Merwe 1989); archaeological maize, however, typically averages  $-9.5\text{‰}$  (Schwarcz *et al.* 1985). The isotopic values of modern maize and  $\text{C}_3$  plant foods in Mesoamerica (Wright 1994: 203–206), after correction for the Industrial Effect, average  $-9.6\text{‰}$  and  $-26.4\text{‰}$  respectively. Since herbivore collagen is typically enriched by  $+5\text{‰}$  relative to the diet (van der Merwe 1989), animals from this region with a pure  $\text{C}_3$  plant diet should

have  $\delta^{13}\text{C}$  values around  $-21.5\text{‰}$ ; the archaeological deer and peccary from Cuello average  $-21.0\text{‰}$ . Similarly, a pure  $\text{C}_4$  plant diet should be represented by collagen values around  $-4.5\text{‰}$ . Bone apatite is typically enriched by  $+12\text{‰}$  relative to the diet (Krueger and Sullivan 1984; Lee-Thorp *et al.* 1989; see also Ambrose and Norr 1993), suggesting endpoints of  $-14.5\text{‰}$  and  $+2.5\text{‰}$ . The approximate contribution of  $\text{C}_4$  foods to collagen and apatite is estimated by interpolation, with the understanding that these percentages may be modified by future research on diet-tissue fractionation and local endpoint values.

## CUELLO ISOTOPIC ECOLOGY

The modern environment at Cuello has been extensively altered by human action: the area today has extensive stands of sugar cane, open grasslands for cattle grazing, and two types of savanna. The latter include some  $\text{C}_4$  grasses, which may be immigrants. The river banks are densely covered in mangrove and tropical forest, and remnant tropical forest patches occur nearby. The Preclassic landscape is generally interpreted as having been tropical forest, based on the animal and plant species from the archaeological deposits. This is largely borne out by the isotope ratios of deer and peccary ( $\delta^{13}\text{C} = -20.7 \pm 0.7\text{‰}$ ;  $\delta^{15}\text{N} = 5.7 \pm 0.7\text{‰}$ ), which are consistent with a forest environment (Table 1; Fig. 1.1). The same is true for mud turtles ( $-20.4 \pm 2.5\text{‰}$ ;  $6.7 \pm 2.0\text{‰}$ ), which evidently also had a  $\text{C}_3$  plant diet. There is substantial evidence, however, that a  $\text{C}_4$  plant component was present at Cuello in Preclassic times. Insect-eating armadillos average  $-16.4 \pm 2.8\text{‰}$  in  $\delta^{13}\text{C}$  and one mud turtle has a  $\delta^{13}\text{C}$  value of  $-16.4\text{‰}$ . This may be explained as due to the habit armadillos have of making their burrows in cornfields, where they are easily caught, and the possibility that an occasional mud turtle migrated from the river to a drainage canal next to a raised cornfield in swampy wetland. Since indigenous  $\text{C}_4$  grasses and sedges are known from open grasslands in the lowland tropics (see e.g., Tieszen and Boutton 1989: 176), their presence in Belize cannot be discounted and deserves further investigation.

The marine isotopic environment was assessed by analyzing specimens from Caye Caulker, some 20 km offshore. The results are not detailed here, as they largely confirm those of a study of coral reef fauna from the Bahamas by Keegan and DeNiro (1988). Fish bone collagen from Caye Caulker averages  $-7.3 \pm 2.0\text{‰}$  in  $\delta^{13}\text{C}$  and  $6.8 \pm 1.4\text{‰}$  in  $\delta^{15}\text{N}$  ( $n = 9$ ), while shellfish like conch, whelk, winkle, and flat tree oyster average  $-13.3 \pm 1.8\text{‰}$  and  $3.5 \pm 1.3\text{‰}$  ( $n = 11$ ). These isotopic values are very different from those encountered in studies of marine foodwebs outside the Caribbean (Fig. 2.2). They are primarily due to extensive stands of flowering marine grasses like *Thalassia testudinum* (turtle grass), which grow in the shallows between the mainland and the offshore reefs; they have exceptional isotope ratios, on the order of  $-6\text{‰}$

for  $\delta^{13}\text{C}$  and 1‰ for  $\delta^{15}\text{N}$  (Keegan and DeNiro, 1988). Fortunately, as the isotopic values for the collagen and apatite of Cuello human bone show, marine foods were not a significant component of their diet, as would be anticipated for a site located some 50 km inland.

The carbon isotope ecology of the marine system is controlled by ocean bicarbonates and has presumably not changed since the Preclassic. The terrestrial system is controlled by atmospheric carbon dioxide, which has changed as a result of the Industrial Effect (van der Merwe 1989). This is noticeable in the collagen  $\delta^{13}\text{C}$  values of modern animals hunted in the forest, which are about 1.6‰ more negative than those from the Preclassic (Table 2.2). The number of specimens are too small to serve as a proxy measurement for atmospheric change, but they provide a reminder that modern values cannot be used unchanged in a study of archaeological diets. The canopy effect (van der Merwe and Medina 1991) will also result in depleted carbon isotope ratios for animals living in heavily forested environments.

## DEER AND DOGS

The collagen  $\delta^{13}\text{C}$  values of deer bone from the Preclassic at Cuello are consistent with those of  $\text{C}_3$  plant eaters (Table 2.1; Fig. 2.1). They did not eat maize and were evidently not tamed or loose-herded. The dogs (Table 2.1; Fig. 2.1), however, often had a substantial  $\text{C}_4$  component in their diet. Their  $\delta^{13}\text{C}$  values average  $-15.6 \pm 3.9\text{‰}$  ( $n = 12$ ) and their  $\delta^{15}\text{N}$  values average  $7.5 \pm 2.0\text{‰}$  ( $n = 12$ ). The large variation in these values, compared to those of their human owners, suggest that they were not fed a stable household diet, but that they also scavenged, foraged and hunted for food on their own. Using the endpoints described above, we estimate their collagen includes about 35–40 percent  $\text{C}_4$  carbon. Elsewhere in Belize, similar values for both deer and dogs have been reported for Preclassic Colha, but some dogs and deer from several Classic and Postclassic sites have considerably more enriched carbon isotope ratios (White et al. 1993; 1997). Dogs from Classic Maya sites in Honduras and Guatemala typically have very enriched  $\delta^{13}\text{C}$  values ( $-8.9 \pm 0.9\text{‰}$ ) indicating heavy dependence on  $\text{C}_4$  plant foods (Gerry 1993; 1997; Gerry and Krueger 1997).

## HUMANS

The  $\delta^{13}\text{C}$  values of the Preclassic humans at Cuello (Table 2.1) average  $-12.9 \pm 0.9\text{‰}$  ( $n = 28$ ) in collagen,  $-9.8 \pm 1.0$  in bone apatite ( $n = 16$ ), and  $-8.7 \pm 2.3\text{‰}$  in tooth enamel apatite ( $n = 33$ ); the  $\delta^{15}\text{N}$  values in collagen average  $8.9 \pm 1.0\text{‰}$  ( $n = 23$ ). The discrepancy in the number of specimens is due to the fact that more teeth were available than post-cranial material, while some of the specimens contained insufficient collagen to measure the nitrogen isotope ratios. Additional bone apatite analyses are in progress.

Table 2.1. Carbon and nitrogen isotope values of animal and human skeletal remains from the Preclassic archaeological deposits at Cuello, Belize.

		$\delta^{13}\text{C}_{\text{coll}}$	$\delta^{15}\text{N}_{\text{coll}}$	$\delta^{13}\text{C}_{\text{apatite}}$	$\delta^{13}\text{C}_{\text{enamel}}$	ap-coll	enamel-coll
<i>Mazama americana</i>	ave.	-22.0	5.0	-12.9		9.1	
	s.d.	0.8	1.1	1.1			
	n	5	4	4			
<i>Odocoileus virginianus</i>	ave.	-20.5	5.8	-12.4	-13.7	8.1	6.8
	s.d.	0.9	1.3	1.5			
	n	5	6	4	1		
<i>Tayassuidae sp.</i>	ave.	-20.8	5.7	-13.0	-13.8	7.8	7.0
	s.d.	0.7	0.7	1.5			
	n	6	6	5	1		
<i>Kinosternon sp.</i>	ave.	-20.4	6.7	-12.0		8.4	
	s.d.	2.5	2.0	1.0			
	n	4	3	6			
<i>Dasyptus novemcinctus</i>	ave.	-16.4	8.2	-12.8		3.6	
	s.d.	2.8	0.3	0.2			
	n	6	4	2			
<i>Canis familiaris</i>	ave.	-15.6	7.5				
	s.d.	3.9	2.0				
	n	12	12				
<i>Homo sapiens</i> (females)	ave.	-13.2	8.9	-9.8	-9.7	3.4	3.5
	s.d.	0.9	0.9	0.9	2.6		
	n	11	8	5	9		
<i>Homo sapiens</i> (males)	ave.	-12.8	8.8	-9.8	-8.5	3.0	4.3
	s.d.	0.9	0.9	1.3	2.5		
	n	15	13	8	11		
<i>Homo sapiens</i> (juveniles)	ave.	-12.5	10.9	-9.7	-8.4	2.8	4.1
	s.d.	1.5					
	n	1	1	1	11		
<i>Homo sapiens</i> (all)	ave.	-12.9	8.9	-9.8	-8.7	3.1	4.2
	s.d.	0.9	1.0	1.0	2.3		
	n	28	23	16	33		

The Preclassic human diet at Cuello can be interpreted in the light of isotope ratios for human bone and potential foods (Table 2.1; Fig. 2.1). Using the endpoints discussed above, we estimate the  $\text{C}_4$  contribution to human collagen carbon was ca. 50–55 percent and that the  $\text{C}_4$  contribution to human bone and tooth enamel apatite was ca. 30–35 percent. Controlled diet experiments suggest that the apatite value can be taken as the average  $\text{C}_4$  content of the diet, while the  $\text{C}_4$  carbon in collagen overemphasizes the  $\text{C}_4$ -based protein component (Ambrose and Norr 1993). This leads to the conclusion that maize provided something less than 30 percent of the Preclassic human diet at Cuello, while frequent portions of dog meat served to enlarge the

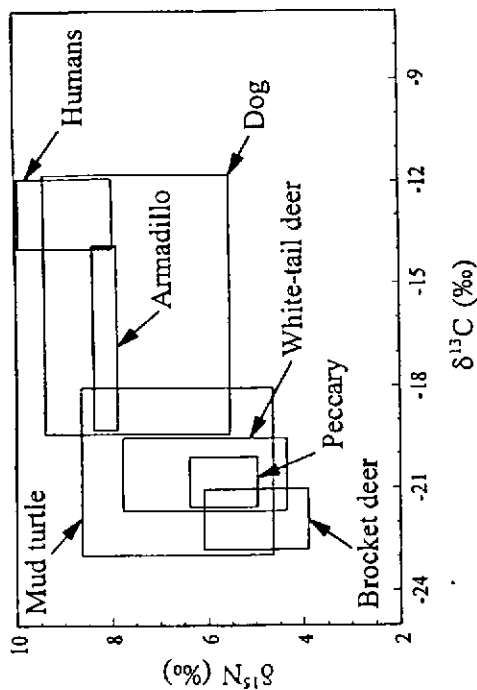


Figure 2.1. Carbon and nitrogen isotope values of human and animal bone collagen from the Preclassic at Cuello.

collagen  $C_4$  carbon content to 50–55 percent. Armadillo meat played a smaller role towards the same end. Had marine foods been consumed in any quantity, this would have been evident from enriched nitrogen as well as carbon isotope values. We may conclude then that the historically observed practice of

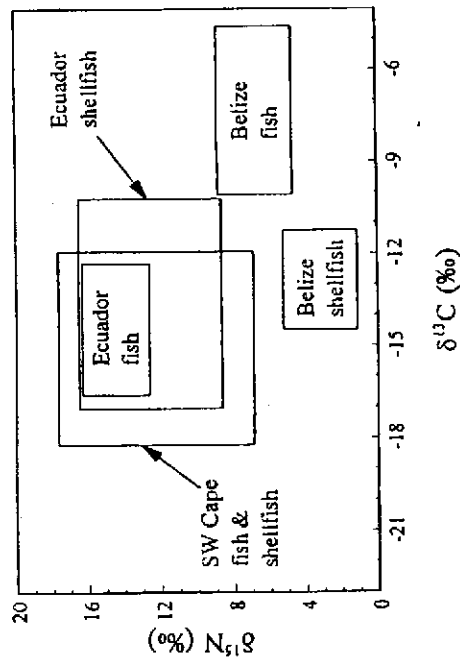


Figure 2.2. Carbon and nitrogen isotope values of marine fauna from Belize, Ecuador (van der Merwe et al. 1993), and the southwestern Cape coast of South Africa (Scały and van der Merwe 1986).

Table 2.2. Carbon isotope values in collagen of modern and ancient fauna with  $C_3$  plant diets. The isotope values for ancient armadillo were not included in the average since they clearly consumed some  $C_4$  plants.

	modern $\delta^{13}C\%$	ancient $\delta^{13}C\%$
<i>Mazama americana</i> brocket deer	-22.0 ± 0.8 n = 5	-22.0 ± 0.8 n = 5
<i>Odocoileus virginianus</i> white-tailed deer	-23.3	-20.3 ± 0.8 n = 5
<i>Tayassuidae</i> sp. peccary	-23.3	-20.8 ± 0.8 n = 5
<i>Kinosternon</i> sp. mud turtle		-20.4 ± 2.5 n = 4
<i>Lepirus baizhii</i> tapir	-24.2	
<i>Potos flavus</i> kinkajou	-22.4	
<i>Agouti paca</i> paca	-21.5 n = 2	
<i>Dasyppus novemcinctus</i> armadillo	-21.3 n = 2	-16.4 ± 2.8 n = 6
average	-22.4 ± 1.1 n = 8	-20.8 ± 1.4 n = 19

dog-eating on a regular basis may be extended back in time to the Preclassic, even in Belize where alternative meat sources were relatively more abundant than in other regions.

It is not possible to solve the dietary equation for Preclassic Cuello more accurately at present. In this preliminary report, we have treated all of the human teeth as one group, although various molars, premolars, and some canines and incisors were analyzed. Since these teeth form at different juvenile ages, isotopic variation resulting from the introduction of solid foods and ultimately from weaning is expected (e.g., Wright and Schwarcz 1998). The average carbon isotope enrichment of the tooth enamel by about 1‰ relative to the bone apatite data set is likely a trophic effect resulting from the pre-weaning diet represented in early forming teeth; the larger standard deviation for the tooth enamel data set is a result of our including teeth representing both pre- and post-weaning diets.

It is perhaps more instructive to compare the Preclassic  $\delta^{13}C$  collagen values with those of modern residents. The hair of the camp cook at the Cuello excavations had a  $\delta^{13}C$  value of -16.4‰ and a  $\delta^{15}N$  value of 9.8‰ (Table 2.3).

Table 2.3. Carbon and nitrogen isotope values in hair of modern human and canid residents of the Cuello area: Orange Walk, Belize, 1992.

	$\delta^{13}\text{C}_{\text{‰}}$	$\delta^{15}\text{N}_{\text{‰}}$
Mrs. Arjelia Martinez	-16.4	9.8
Blackie, her dog	-16.8	8.2

To normalize these values for comparison with Preclassic collagen it is necessary to add to the  $\delta^{13}\text{C}$  value 1.5‰ for the Industrial Effect and 1‰ for the spacing between hair and collagen, yielding -13.9‰; the  $\delta^{15}\text{N}$  value of 9.8‰ remains constant. These values are quite close to the average for Preclassic Cuello, and suggest that  $\text{C}_4$  sources constitute about 40–50% of her diet. Béhar (1968) estimated that maize constituted about 70% of the modern Maya diet, an average value subject to regional variation and which may be further modified by late 20<sup>th</sup> century economic circumstances. Our modern resident eats about three maize tortillas with every meal and a fair amount of beef, which has been raised on a mixture of  $\text{C}_3$  and  $\text{C}_4$  grasses. Her dog, Blackie, has  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values of -14.3‰ and 8.2‰, as normalized for the Preclassic. These values are likewise nearly identical to those of Preclassic dogs. Blackie eats the leftovers of his owner's meals and gets somewhat smaller portions of tortilla and meat in the process. If the modern resident and her dog are representative of the general population, then these observations help to put the Preclassic diet in perspective.

Finally, a detailed comparison of burials from several Preclassic phases at Cuello shows no significant chronological trends in their isotope ratios (Iytkot *et al.* 1996). Adult males and females, however, do differ by up to 1.0‰ in  $\delta^{13}\text{C}$  values, a gender-based difference observed elsewhere for the Preclassic (White 1997; Wright 1997). Males had a  $\text{C}_4$  dietary component as much as 10 percent higher than females, perhaps acquired in the form of maize beer. For juveniles, the specimen numbers are too small for firm conclusions. Several adult individuals from a mass burial at Cuello have distinctly enriched isotopic values relative to the single burials presented here, suggesting that they were not native to Cuello (Iytkot *et al.* 1996).

## MAYA DIETS

Five other isotope studies of Maya skeletal populations in Belize are available for comparison with Cuello (Table 2.4; Fig. 2.3). These include a time series from Preclassic to Historic at Lamanai (White and Schwarcz 1989), an Early through Terminal Classic sequence at Pacbitun (White *et al.* 1993),

Table 2.4. Carbon and nitrogen isotope values of human bone collagen at various Maya sites.

	n	$\delta^{13}\text{C}_{\text{‰}}$	$\delta^{15}\text{N}_{\text{‰}}$
<b>Belize</b>			
Preclassic: Lamanai (White & Schwarcz 1989)	2	-12.4 ± 0.3	10.2 ± 0.6
Preclassic: Cuello (Iytkot <i>et al.</i> 1996)	28, 23	-12.9 ± 0.9	8.9 ± 1.0
Classic: Baking Pot/Barton Ramie (Gerry 1993)	47	-11.2 ± 1.4	8.9 ± 0.7
Classic: Lamanai (White & Schwarcz 1989)	14	-14.1 ± 0.9	10.2 ± 0.6
Classic: Mojo Cay (Norr 1991)	8	-8.5 ± 0.4	10.1 ± 0.9
Classic: Pacbitun (White <i>et al.</i> 1993)	20	-10.2 ± 1.6	9.2 ± 0.7
Post-classic: Lamanai (White & Schwarcz 1989)	25, 24	-9.3 ± 0.8	9.5 ± 0.9
Historic: Lamanai (White & Schwarcz 1989)	11, 9	-9.9 ± 0.9	9.7 ± 0.6
Modern (normalized): Cuello (Iytkot <i>et al.</i> 1996)	1	-13.9	9.8
<b>Peten</b>			
Preclassic: Altar de Sacrificios, Seibal (Wright 1994)	16	-10.2 ± 1.2	8.8 ± 1.1
Classic: Altar de Sacrificios, Seibal, Dos Pilas, Aguatza, Itzan (Wright 1994)	88, 87	-9.2 ± 1.1	9.1 ± 1.1
Classic: Uaxactun, Holmul, Seibal, Altar de Sacrificios (Gerry 1993)	65	-9.5 ± 1.0	9.3 ± 0.8
<b>Copan, Honduras</b>			
Classic (Gerry 1993)	41, 38	-10.2 ± 0.9	7.6 ± 0.8
Classic (Reed 1994)	46	-9.3 ± 0.7	7.6 ± 0.5
<b>Iximché, Guatemala</b>			
Postclassic (Whittington and Reed 1996)	13	-7.8 ± 0.4	7.9 ± 0.4

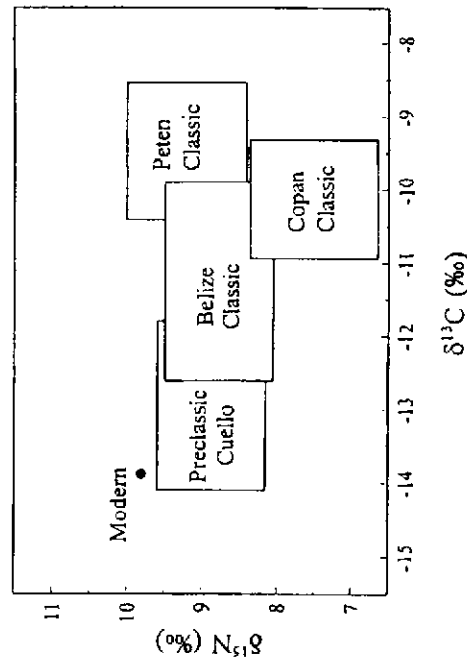


Figure 2.3. Carbon and nitrogen isotope values of human bone collagen at Maya sites in Belize. The value for the modern sample has been corrected for collagen-hair spacing and the Industrial Effect. Boxes represent isotopic means ± one standard deviation.

a mostly Preclassic sample from Calal Pech (White *et al.* 1996), and analyses of the Classic populations at Mojo Cay (Norr 1991), Baking Pot and Barton Ramie (Gerry 1993; 1997; Gerry and Krueger 1997). Some differences are apparent between these sites (the carbon isotope values for the Late/Terminal Classic at Lamanai are very negative), but the general trend is that of an intensification of maize consumption from the Preclassic through the Classic to Postclassic and Historic times. Our data for Mrs. Martinez suggests that maize has become less important in the modern diet, returning to a similar level as that observed for the Preclassic. This trajectory has been observed elsewhere, Ecuador being an example (van der Merwe *et al.* 1993).

The substantial differences which existed between Preclassic diets in Belize (White and Schwarcz 1989; Tykot *et al.* 1996) and in the Peten region of Guatemala (Wright 1994) can most likely be attributed to differences in local ecology, as well as in population density and in status-based access to certain food resources (Table 2.4; Fig. 2.4). Local ecological differences also may explain most of the dietary differences observed in the Classic period, for which we have data from Belize (White and Schwarcz 1989; Norr 1991; White *et al.* 1993; Gerry 1993), Honduras (Gerry 1993; Reed 1994), and Guatemala (Gerry 1993; Wright 1994) (Fig. 2.5). People in Guatemala and Honduras remained considerably more dependent on maize than those in Belize, with Copan residents in particular having a "corn and beans" diet. This is understandable, as Copan lies at the head of a closed mountain valley where a concentration of people would rapidly eradicate wildlife and forest in the cause of agriculture. Unlike Belize, the Copan valley of today is nearly devoid of

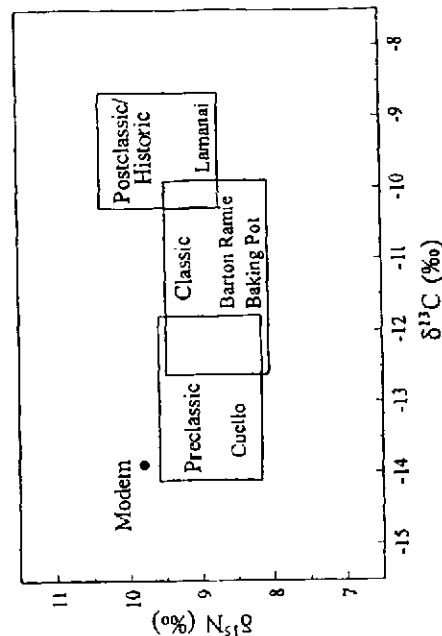


Figure 2.4. Carbon and nitrogen isotope values in human bone collagen from Preclassic Belize (Cuello and Lamanai) and from the Preclassic Peten (Altar de Sacrificios and Seibal).

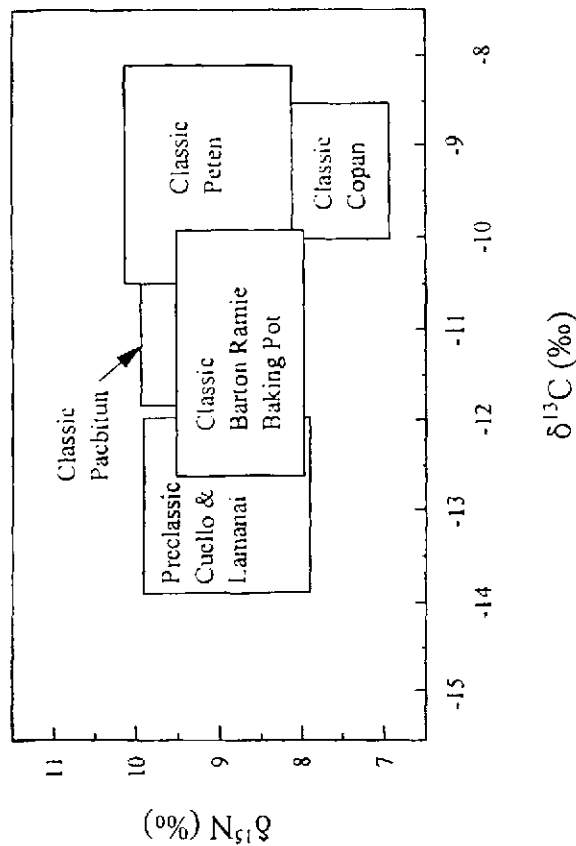


Figure 2.5. Carbon and nitrogen isotope values in human bone collagen from Preclassic Belize; Classic Belize (Pachitun, Baking Pot, and Barton Ramie only); the Classic Peten (Uaxactun, Itzamal, Seibal, Altar de Sacrificios, Seibal, Dos Pilas, Aguateca, Itz'at), and Classic Honduras (Copan).

indigenous animals and plants. The Classic Maya of the Peten evidently ate more meat than those of Copan, but they were also highly dependent on maize. The Preclassic and Classic Maya of Belize had a much more diversified diet than those of Guatemala and Honduras. They had access to a wider range of ecozones and presumably had a lower population density.

The fact that geography and local ecology played the primary role in determining diet in the Maya world argues forcefully against theories about the demise of Maya civilization that are based on the collapse of maize agriculture (e.g., Sanley *et al.* 1986; Culbert 1988; see also Wright and White 1996; White 1997; Wright 1997).

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## Chapter 3

# An Overview of Causes for Stable Isotopic Variations in Past European Human Populations: Environmental, Ecophysiological, and Cultural Effects

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### ABSTRACT

The reconstruction of ancient human diet based on carbon and nitrogen analysis has proved to be relatively simple in the New World: utilization of  $C_4$  and marine resources causes relatively large shifts in these stable isotopes. In Europe those food sources seem to play a relatively limited role, resulting in a relatively small range of values observed in past human populations, making dietary analysis much less straightforward. However, an apparent non-random pattern is often observed when isotopic values of regional or temporal groups are compared. In this paper we will describe the factors that contribute to those small-scale isotopic variations, and assess the importance of environmental factors as opposed to anthropogenic, cultural factors. This assessment is