The applications of stable isotope research in Canada's archaeological past: reconstruction of ancient diets in the northwest Pacific coast, the Canadian Prairies and southern Ontario

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Abstract

Stable isotopic research has provided archaeologists with a unique window to the past. Using stable isotopes, archaeologists are able to determine various social, economic, and political aspects of a past population. Furthermore, with isotopic research one is also able to reconstruct the environmental and ecological context in which a past society lived. The focus of this article will be upon the recent isotopic research undertaken to better understand dietary trends among various groups in Canada's prehistory. Specifically, this article will focus upon understanding the importance of marine resources among the groups living along the Northwest coast of British Columbia, as well as understanding the spread and consumption of maize among groups in the Canadian Prairies and southern Ontario. This paper, then, will largely be a summation of past archeological research to highlight the progress that has been made in the last few decades in understanding Canada's rich and colourful past.

Keywords: stable isotopes, northwest Pacific coast, Canadian Prairies, southern Ontario, diet, consumption, trends, marine resources, maize, *Zea mays.*

Resumen

Las investigaciones de isotópos estables ha proporcionado a los arqueólogos una ventana única acerca del pasado. Con el empleo de isótopos estables, los arqueólogos pueden determinar diversos aspectos sociales, económicos y políticos de una población antigua. Por otra parte, la investigación isotópica es también capaz de reconstruir el contexto ambiental y ecológico en el que una sociedad del pasado ha vivido. El objetivo de este artículo será sobre las recientes investigaciones isotópicas comprometidas para entender mejor las tendencias dietéticas entre diversos grupos de la prehistoria de Canadá. En concreto, este artículo se centrará en la comprensión de la importancia de los recursos marinos entre los grupos que viven a lo largo de la costa noroeste de la Columbia Británica, así como la comprensión de la difusión y el consumo de maíz entre los grupos en las praderas canadienses de Ontario y el sur. Este documento, por tanto, será en gran medida un resumen de la investigación arqueológica pasado para resaltar los avances que se han realizado en las últimas décadas en la comprensión de un pasado rico y colorido de Canadá.

Palabras claves: isotópos estables, costa noroeste del Pacífico, praderas canadienses, sur de Ontario, dieta, consumo, tendencia, recursos marinos, maíz, *Zea mays.*

Introduction

Since its beginnings in the 1970s, stable isotopic research has been applied to various problems of archaeological interest. Isotopic research provides a wealth of information for archaeologists interested in reconstructing various social, political, and economic aspects of past societies. This method of research is based on the analysis of collagen, which provides a record of an individual's diet over their lifespan. Inorganic and organic constituents of bone provide a record of dietary intake. The elements and amino acids liberated from ingested food are incorporated into bone mineral formation of collagen (Pate, 1994).

If preservation is favorable, archaeologists can then extract stable carbon and nitrogen isotopic data from preserved collagen. Isotopic values are then interpreted by archaeologist to better understand whether these people exploited mostly terrestrial or marine resources as well as the trophic level of the foods they were eating. Dramatic changes in isotopic values could indicate events where the population altered their diet drastically, which could be due to a variety of factors such as: introduction of new cultigens or other species, migrations of peoples and animals, extinctions of certain species, climatic changes, etc. Stable isotope analysis, therefore, can aid in reconstructing the ecological and environmental context in which lived the population under study (Dincauze, 1987).

The focus of this article will be in exploring some of the uses of stable isotopic research in a Canadian context. Namely, the use of stable carbon and nitrogen isotopes to better understand trends in consumption patterns in the Canadian prairies of Western Canada, in the northwest coast of British Columbia, and in southern Ontario. The importance of marine resources among certain groups of the northwest coast, as well as the importance of maize in various groups of the Canadian Prairies and southern Ontario will be explored.

This review will be a summation of a variety of research projects that have been undertaken in the past with overall goal of emphasizing the usefulness of stable isotopic research for the purpose of understanding dietary trends and patterns. Stable isotope research can provide supporting data to past archaeological interpretations that are based solely on macro or micro evidence. Four previous archaeological research projects will be highlighted for the purpose of: i) showing the validity in using stable isotopic data to either support or disprove past interpretations in the literature; ii) using stable isotopic analysis of faunal remains to reconstruct ancient ecological settings; and iii) using stable isotopic data to show dietary trends and variability.

Stable carbon and nitrogen analyses

Bone is composed of organic matter (mostly type I collagen) and inorganic matter (carbonated hydroxyapatite). The stable carbon and oxygen isotope compositions (^{13}C and ^{18}O) of carbonate in skeletal materials have been used to better understand and reconstruct ancient climates, migrations patterns, physiology, and ancient diets. Carbon occurs in three isotopic forms: stable ^{12}C, stable ^{13}C, and radioactive ^{14}C. All these three carbon isotopes enter the base of the food chain as environmental carbon is incorporated into terrestrial and aquatic plant tissue via photosynthesis (Pate, 1994). The type of carbon used in photosynthesis will then affect the isotopic value in plant tissues.

Nitrogen on the other hand, possesses two stable isotopic forms: ^{14}N and ^{15}N. Plants obtain nitrogen from the soil (eg., after bacterial mineralization of organic matter), via symbiotic relationships with atmospheric nitrogen-fixing bacteria (eg., rhizobia) or capturing animals (carnivorous plants). When these plants are consumed by animals of a higher trophic level, their carbon and nitrogen atoms are then incorporated into the tissues of these animals which, after dying, preservation allowing, can be analyzed by archaeologists.

British Columbian northwest coast

The prehistoric cultural sequence in the northern British Columbian coast can be summarized into two broad periods: the Archaic and the Pacific period. The Archaic period began at 10,000 BP and ended around 5,000 BP. Sites from this time period are thus far only known in the Queen Charlotte Islands. Archaeological assemblages are dominated by microblades, unifaces and some bifaces (Ames, 1998). Archaeological sites are generally small and were not occupied for a long length of time (Ames, 1998).

As for the Pacific period, it is divided in three sub-periods: the Early Pacific (5,000 to 3,500 BP), the Middle Pacific (3,500 to 1,500 BP), and the Late Pacific (1.500 BP to 200 BP). Over the time span of the Pacific period, we see the appearance of large and extensive shell midden deposits, midden burials, the appearance of barbless harpoon tips, increased evidence of warfare, and some of the earliest structures. By the Late Pacific period, we see a cessation in midden burials, a practice that extended along the entire British Columbia northwest coast (Ames, 73).

Haida Gwaii

Haida Gwaii (Queen Charlotte Islands) is located not far from the north coast of British Columbia. This region is part of indigenous territories and is composed of two large islands and a series of smaller ones. It is located about 55 kilometers from the nearest adjacent land on the British Columbian coast (Szpak et al, 2009). Past archaeological research in the area shows a population whose major subsistence focus was on marine resources rather than terrestrial animals (Cannon et al, 1999; Szpak et al, 2009).

Cultures in this region developed into socially-stratified societies, with economies primarily based on fishing, hunting, and gathering. Marine species such as salmon and shellfish were particularly important in the development of these societies (Szpak et al, 2009). The intensive exploitation of marine resources in this region began as early as 3,500 BP. However, in other regions of the northwest coast such as at the Namu site, this intensive exploitation of marine resources began at 7,000 BP (Cannon et al, 1999).

The faunal samples collected by Szpak et al (2009) in their study of at the Haida Gwaii region span from 2,000 BP to 200 BP. During this time period, there are increased evidences of conflicts and regional interactions, as well as an increased focus on marine resources and food procurement technologies around (Fladmark et al, 1990; Fedje and Mackie, 2005; Mackie and Acheson, 2005). Changes in settlement patterns are also inferred, with many groups now opting for a more sedentary lifestyle (Szpak et al, 2009).

The major focus of this research was on collecting and analyzing various vertebrate faunal samples for isotopic analyses. The faunal remains sampled for this study derived from various village sites, all located in the southern region of Haida Gwaii (Szpak et al, 2009). The main goals of this study were: i) provide a more complete baseline of faunal data in Haida Gwaii through a study of faunal isotopic values; and ii) address ecological conditions in this region during this time period.

Faunal samples were collected primarily from three village sites, along with a small number of fauna collected from four additional villages (Szpak et al, 2009. Overall, 104 samples were included in this study which covered 32 different vertebrate taxa. Szpak et al (2009) chose the species that were most likely to have been considered of great economic importance to the people of Haida Gwaii, according to previous archaeological research (Blackman, 1990; Orchard, 2007).

The identification of trophic positions of each species was carried using bone collagen $\delta^{15}N$ values. Past nitrogen isotopic research in this region has focused on three species: harbor seals, northern sea lions and harbor porpoises (Pauly et al, 1998b; Beattie et al, 1999; Das et al, 2003). A study of the nitrogen values of these three species in the archaeological samples will determine their diet, which, in turn, could be used to make inferences of what food was available for humans living in the area.

These species tend to be primarily associated to near-shore areas and would normally have less negative $\delta^{13}C$ values than the ones found off-shore, such as salmon and other oceanic fish (Szpak et al, 2009). In sea otter populations with density near equilibrium, they will usually be eating near-shore species of fish (Riedman and Estes, 1988??). The sea otters in this study, however, were consuming more benthic invertebrates, such as sea urchins, clams, and other bivalve mollusks that live near or at the substrate of oceans or lakes. This information, combined with vast amounts of sea otter bones present in the faunal assemblages, suggests that populations of sea otters in Haida Gwaii were below equilibrium density, most likely due to human hunting (Szpak et al, 2009).

In the case of northern fur seals, the isotopic data suggests that their population at this time period had a markedly different biogeography than modern ones. Isotope values can be associated to the latitudes occupied by a population. It was expected that the isotopic signatures of the fur seal remains collected from Haida Gwaii would reflect a latitude intermediate between Alaska and California, given the relatively high-latitude of southern Haida Gwaii (Szpak et al, 2009). Yet, the isotopic signatures of these fur seals suggest that they were year-round occupants and that they were primarily eating off-shore species (Szpak et al, 2009). This would certainly question the assumption of fur seals as being species that lived primarily near shores, and certainly brings to the forefront that such species may have drastically changed their feeding habitats in the past few hundred years.

No human samples were analyzed in this study, but they have been previously analyzed by archaeologists working in the Haida Gwaii region. The known carbon and nitrogen isotopic values of human skeletal remains in the region show that, though overall there is a big focus on marine foods, there is also evidence of temporal and regional variability. It is often assumed that the diets of people living along the coast were uniform across space and time, yet it must also be consider that the coastal environment is rich in various species of fish, marine mammals, and shellfish. It is therefore problematic to assume that people were eating the same species in similar amounts (Butler and Campbell, 2004).

Along with environmental factors, food choices are also influenced by other more social and ideological factors. Some of the environmental factors that may affect food choices can be elucidated through isotopic analyses, such as the ones conducted in this research. As the data has shown in this study, fur seals were not generally feeding near-shore, and this suggests that the fur seals consumed by these individuals may have been hunted by individuals using floating devices away from the shore.

This work emphasizes the importance of providing a baseline of faunal data from which to study various aspects of ancient societies. By understanding the various species present at the time and where these were foraging, we can better understand human hunting and foraging behavior. Additionally, understanding a species feeding by identifying the trophic levels of the food they were eating, may shed light on whether these species were at, below, or above population equilibrium, which will then help us to determine whether these were being over-exploited by humans or other predators.

Thus, the research by Szpak et al (2009) highlights the use of stable isotopic data in reconstructing the ecological and environmental setting in which a past population lived. The next archaeological research that will be summarized below highlights the importance of using faunal dog remains as proxies to understand human diets in cases where human remains are not readily available.

Namu

The archaeological site of Namu is also located on the northwest coast of British Columbia. Past archaeological research in this region shows well preserved vertebrate and invertebrate faunal remains, primarily composed of marine resources, dating as far back as 6,000 years ago (Cannon et al, 1999). Human skeletal remains have also been recovered from the archaeological site and have undergone stable isotopic analysis (Chisholm et al, 1982, 1983??). It has been confirmed that people living at the site between 4,500 and 2,800 BP were eating primarily marine food. However, the limited amount of human remains recovered from the archaeological site encouraged Cannon et al (1999) to use archaeological dog remains, readily available at the site throughout the various time periods, to make inferences about the human diet.

There were various advantages to using dog remains instead of human ones, as the former were more prevalent overall the latter, and also represented a longer span of time than the human remains (Cannon et al, 1999). With dog remains being present for a longer length of time, it is possible to study changes in diet over a longer length of time. Thus, Cannon et al (1999) collected fifteen dog bones, being distributed across a range of excavation units and levels, covering the time period of 6,060 to 1,405 BP.

Dogs will often eat the table scraps and leftovers of humans (Tankersley and Koster, 2009). Just as with humans, stable carbon and nitrogen isotopic compositions of dog tissue reflect the food ingested during their lifetime. Therefore, if dogs often eat the leftovers of human meals, we can assume that both remains would have similar isotopic values. Thus, if the carbon and nitrogen isotopic values of dog remains change drastically, it can be assumed that the human economy may have also changed at such time.

Because of the lack of availability of human skeletal material at the Namu Site, dog remains were used as a proxy for isotopic research. If dogs are indeed a suitable proxy for monitoring human consumption patterns, their ^{13}C levels should be relatively similar to the ones obtained from human bone samples previously obtained. Overall, the human bones showed that a great proportion of their diet (over 90%) was obtained from marine-based resources (Cannon et al, 1999). This study had two main goals: i) test the validity of using dog remains as a proxy for human consumption patterns; and ii) studying changes in human consumption in this region.

The results of the study showed that, overall, the carbon values of dog remains were similar to the human isotopic values, suggesting that dog remains can be a suitable proxy for human ones. The dog's isotopic values confirm that humans were mainly exploiting marine food resources. Their isotopic values show trends where salmon appears to have been consumed less frequently, with a revealing simultaneous increased consumption of terrestrial resources (Cannon et al, 1999). The dog data also shows trends in shellfish over such time period, with such food resource increasing in abundance after 3,500 BP.

These results are relatively similar to the human isotopic values collected in previous research projects (Chisholm et al, 1982, 1983??). Cannon et al (1999) concluded that using dog remains holds many advantages for archaeologists hoping to see trends in food consumption. Depending on the archaeological context, dog remains can be more readily available than human remains as previously indicated. Besides, they should not be subjected to the limiting ethnical issues and considerations that may be encountered when using human remains for isotopic analyses. Additionally, dog bones may in fact be *more* sensitive than human remains. Indeed, human collagen is replaced over their lifetime, and the final available material is therefore an average of their diet over the span of the lifetime since collagen is being replaced. On the contrary, dogs have much shorter lives (about 10 times) than human, and therefore their collagen may be more sensitive to short-term effects, such as poor salmon runs. Therefore, dog remains may be better for archaeologists hoping to gain a clearer understanding of short-term dietary variability.

Maize in the Canadian Prairies and southern Ontario

The upward shift in $^{13}C/^{12}C$ ratios of human remains in the archaeological record in North America and Mesoamerica is often associated to the consumption of corn (Gannes et al, 1997). Different plants use different photosynthetic pathways, which will determine their isotopic composition. In terrestrial plants, carbon isotope fractionation occurs in three different photosynthetic pathways: C_3, C_4 and Crassulacean Acid Metabolism (CAM). Most native plants in temperate regions belong to the C_3 group, and therefore have different isotopic values than C_4 ones.

On the other hand, terrestrial plants such as seasonal grasses, trees, tubers and most bushy plants use instead the C_3 photosynthetic pathway (DeNiro, 1987; Coltrain et al, 2007). The C_4 plants include teosinte, maize, amaranth, sugar cane, sorghum and some millets (DeNiro, 1987). The CAM plants, on the other hand, are plants such as cactus, yucca, pineapple, prickly pear and agave (DeNiro, 1987; Coltrain et al, 2007). Maize uses a photosynthetic pathway that results in higher $^{13}C/^{12}C$ ratios in comparison to temperate plants. Nitrogen can also be used to determine the plant types. Legumes are depleted in ^{15}N compared to non-leguminous plant, and therefore the individuals that consume a considerable amount of beans will have a lower ^{15}N value that those that consume the other type of plants. Nitrogen levels, therefore, can tell apart leguminous plants from non-leguminous ones. Thus, peanuts, beans, peas and other legumes (C_3) have lower $\delta^{15}N$ values than those of non-leguminous plants. Maize has a higher nitrogen level than the leguminous plants (DeNiro, 1987).

The origin and subsequent spread of *Zea mays* from Mexico to the North represents a fundamental moment in the history of ancient people. With the appearance of maize in the archaeological record, contemporaneous changes in settlement patterns and social organization are also found. Therefore, much archeological efforts have been channeled towards understanding when maize first made its way into various regions of America.

There is much debate among archaeologists about whether the spread of maize reflects a physical movement of people who brought maize with them into regions where such plant did not grow previously. Or, rather, that maize was brought into these regions through extensive trade networks. Much of the archaeological record of eastern North America suggests that the transition from a hunter-gatherer lifestyle to intensive horticulture was gradual, beginning first with the domestication of indigenous plants such as *Chenopodium* and, later, the adoption and domestication of secondary cultigens such as maize (Katzenberg et al, 1995). A widespread adoption of maize through eastern

North America is observed by 600 AD. Past archaeological research suggests that maize became widespread in the Lower Great Lakes by 900 AD (Boyd et al, 2008). These secondary crops did not arrive into a hunting-gathering environment but were adopted into it, and in some cases eventually displaced existing indigenous crops (Rose, 2008). Most of such primary crops in North America are C_3, in contrast of the tropical maize, a secondary crop which made its way from Mexico and spread extensively to the North (Rose, 2008). Stable isotope research can further our understanding of when maize became an essential component of prehistoric diets.

Much research has focused on understanding the spread and subsequent intensification of maize horticulture in large-scale villages, but few have focused on the role it played in small-scale societies, such as those that occupied regions of the Canadian prairies (Boyd et al, 2008). Next are highlighted two studies about the spread of maize among small-scale societies that were part of a wider and more complex economic transition that was sweeping across North America.

However, as was the case with marine resource in the northwest coast of British-Columbia, the consumption of maize in North American was subject to variability over space and time. It was not always incorporated in indigenous diets and it was not necessarily eaten in large quantities. Additionally, it is often assumed that maize consumption is associated to a more sedentary lifestyle, yet this is not necessarily the case in all instances. Thus, two studies will be presented below to highlight the variability in the consumption of maize in different regions of Canada.

Late Woodland maize in the northern Great Plains

Little is known of the impact that maize had among the small-scale societies living along the borders of the Great Plains in the eastern Canadian Prairies and the adjacent boreal forest. This area holds an extensive archaeological record, though the habitation sites in this region are generally small and were occupied for only brief periods (Boyd et al, 2008). Indeed, there is no evidence of permanent settlements, nor features that could indicate that they were storing food (Boyd et al, 2008).

This region marks the northernmost limit where maize grows today, and despite the lack of evidence of food-storage and tools associated to gardening, a study by Boyd et al (2006) has resulted in the discovery of microscopic maize remains, suggesting that maize was present in this region prior to European contact. To acquire a better understanding of exactly how important maize was in the diets of peoples living in this region, Boyd et al (2008) carried out stable carbon and stable nitrogen analyses of food residue samples from a large collection of archaeological sites spread across the border between the Canadian Prairies and the boreal forests.

Samples of carbonized food residues were collected from sites dispersed across the southern region of Manitoba, though two locales were particularly emphasized: Tiger Hills and Oak Lake Sandhills, where evidence of maize consumption had been previously discovered (Boyd et al, 2006). The samples from southern Manitoba were then compared to samples collected from contemporaneous sites in the southern boreal forests and the Lockport region of the northern Red River Valley. The various locales from which were collected these samples were dated using ceramic evidence.

Archaeologists have concluded that the sites occupying the northern edge of the Great Plains and the boreal forest included in this study were occupied after about 700 AD (Boyd et al, 2008). Maize was present in this region as early as 700 AD, though it is still unknown whether the maize was grown locally or was obtained through trade. Maize macrofossils seem to decline generally in frequency in the boreal forest archaeological sites. Boyd et al (2006) suggest three different reasons to explain this low frequency: i) due to the region being furthest away from the source of maize, trading for maize was costly to people living in the boreal forest; ii) if they grew their own maize, then the shorter growing region in this area would have resulted in the production of less maize; and iii) they simply did not consider it all that important, and therefore did not incorporate it in their diet quite as frequently or abundantly as people in the prairies (Boyd et al, 2008).

The majority of native plants in this study area are C_3. The few species of C_4 plants present generally decrease in abundance with latitude over the prairies. Also present in the prairies were bison that would have consumed many of the C4 plants. It is therefore problematic to apply stable carbon and stable nitrogen isotope studies in this region, as it is difficult to determine whether the isotopic values in human remains are the result of these individuals eating maize or eating animals that would have grazed on C_4 plants (Boyd et al, 2006, 2008). There is a similar issue in interpreting the isotopic value of food-carbonized remains in ceramics collected at these sites. It is impossible to determine whether it was bison meat or maize being processed in these ceramics.

Overall, the results suggest that individuals from the locales of Tiger Hill and the Oak Lake Sandhills were ingesting food with less depleted ^{13}C. This indicates that they could have been eating either C_4 plants or tissues of animals that had fed on C_4 plants. When comparing the values obtained between the two locales, we see that these are generally similar, suggesting that the diets of people from these locales was relatively similar. On the contrary, the values obtained from locales in the boreal forest, the Lockport and the Winnipeg river are more variable, suggesting that individuals were exploiting a variety of different resources, with some occasional consumption of C_4 plants such as maize (Boyd et al, 2006, 2008).

Overall, the botanical and chemical evidence analyzed in this study show that carbonized-maize remains are present on these sites after 700 AD. Despite variability in the importance of maize in the economies of the locales considered, maize consumption appears to have become a commonality that linked these small villages throughout this region. The results are surprising, as many assumed that maize horticulture and consumption went hand in hand with increased social organization and the construction of permanent villages. Yet, in this study, maize consumption and horticulture are found in small and moving groups.

Maize in southern Ontario

Compared to the locales explored in the Boyd et al (2008) study, southern Ontario is home of fertile floodplains, which was a favorable environment to grow crops. It is therefore no surprise that the first agricultural communities of Ontario were present in the south (Crawford et al, 1998). Examples of crops that were grown are: beans, cucurbit, tobacco and maize. Prior to the arrival of the latter, however, evidence suggests that numerous aboriginal groups were eating locally available resources, such as several fruits, seeds, berries, game and freshwater fish (Katzenberg et al, 1995). Indigenous groups also grew their own native crops, such as *Chenopodium*. It is believed by archaeologists that maize became a significant crop throughout the Lower Great Lakes region of North America between 900-1100 AD (Crawford et al, 1997??).

In their study of maize consumption in southern Ontario, Katzenberg et al (1995) aimed to present new data on stable carbon and stable nitrogen isotopes in human bone collagen from six different sites in southern Ontario, all dated between 400-1500 AD. In order to better understand the spread of maize, they compared their isotopic data to data collected from other sites in northeastern North America. Samples were collected from a variety of sites. They included the Monarch Knoll site, which pre-dates the introduction of maize (about 450 AD), the Varden site (900 AD), the Surma site (700 AD), the Miller site (dated to 1152 ±118 AD, with a calibrated date of 1115 ±70 AD), the Force site (radiocarbon dates range from 1235 ±75 to 1325 ±75 AD), the Bennett site (radiocarbon date of 1260 ±60 AD, and a calibrated date of 1260 ±130 AD) and the Woodbridge-McKenzie site (1500 AD).

The results of the Katzenberg et al (1995) study show, overall, a steady increase in maize consumption following its introduction around 700 AD. The Monarch Knoll site shows little to no consumption of C_4 plants, as is expected from a site that pre-dates the introduction of maize in the region. At the Surma site, there is some consumption of C_4. Compared to the Surma site, however, the Varden site shows much less consumption of C_4 plants, thereby suggesting that maize may not have figured highly in their diet as in the peoples of Surma. This is also consistent with the floral and faunal remains discovered at the site, which show that such people had a broad diet composed of large species of fish, berries, plumps and grapes. No maize remains were found at the site.

Katzenberg et al (1995) propose that the large amounts of carnivorous fish in their diet may have affected their isotopic values to make it seem as if they were eating C_4 plants. The later sites, as one would expect, show increased consumption of maize. Lastly, the samples collected from the Bennett site and the Woodbridge-McKenzie site suggest that people were consuming a considerable amount of C_4 plants, which is consistent with the archaeological data excavated from these sites, pointing that these were large horticultural villages (Katzenberg et al, 1995). In considering their data with other data sets published from this region, the highest ^{13}C values are present between 1300-1400 AD, dropping slightly around the proto-historic and historic periods, as is expected with indigenous populations being dramatically affected by disease and warfare.

Before growing maize, indigenous people in this region cultivated indigenous plants, such as *Chenopodium*, which has a C_3 photosynthetic pathway. Apart from species of carnivorous freshwater fish and waterfowl (who have lower C_3 values than terrestrial herbivores and herbivorous fish), most locally available foods also have C_3 photosynthetic signatures (Katzenberg et al, 1995) In such research, they conclude that the general trend towards increasing $\delta^{13}C$ values between 500-1300 AD in eastern North America is due largely to an increased consumption of maize. Certain areas, such as the northern regions of Illinois show higher ^{13}C values than southern regions such as Tennessee, Arkansas and Missouri, which seems to suggest that in these southern area there was a delay in the consumption of maize, maybe due to a reliance of people on their aboriginal crops (Katzenberg et al, 1995). Many have assumed that the adoption of maize was uniform across North America. However, studies such as this one say otherwise. It appears that though in certain areas an increased dependence on maize is found, people did not necessarily drop their indigenous crops for the new crop. There is, therefore, a dietary variability across North America.

Conclusions

The examples provided in this article were chosen specifically to highlight the progress of stable isotopic research in the recent decades. Stable isotopic analyses of carbonized food, fauna, and human remains can help archaeologists reconstruct various aspects of the past. Isotope research on the northwest coast of British Columbia supports the faunal macroscopic data, which suggests that these people were primarily eating marine resources, though the diets are subjected to regional and temporal variability. Furthermore, one of the highlighted studies showed the usefulness in using dog remains as proxies, in contexts where archaeologists have limited access to human remains, either due to ethical considerations or issues with preservation. The second half of the article covered isotopic research in the Prairies and southern Ontario, to consider the spread and intensification of maize consumption. As seen with the data from the northwest coast, there existed much temporal and regional variability in the importance of maize in the diets of humans. Thus, the adoption of maize was a relatively slow process, with some groups still eating their own indigenous crops abundantly in the process over time. There are, of course, some obvious issues with stable isotopes research; essentially, that this type of research is quite expensive and that samples can be easily contaminated. If finances are not a concern, then stable isotopic research can be successfully exploited to reveal some interesting information about ecological contexts and dietary variability in the archaeological record.

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