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SUBSISTENCE IN THE FLORIDA ARCHAIC: THE STABLE-ISOTOPE AND ARCHAEOBOTANICAL EVIDENCE FROM THE WINDOVER SITE

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A paleodietary analysis of the mid-Holocene mortuary site, Windover (8BR246), based on carbon and nitrogen bone-collagen values and archaeobotanical information is consistent with a subsistence strategy that utilized river-dwelling fauna and a range of terrestrial flora, such as grapes and prickly pear. The isotopic analysis does not support the extensive human dietary use of either marine mammals or classic terrestrial fauna such as deer or rabbit. Seasonal (late summer/early fall) use of the site is indicated by the range of flora found in association with the burials.

El análisis paleodietético de un sitio mortuorio proveniente del Holoceno medio, identificado como sitio Windover (8BR246), basado en contenidos de carbón y nitrógeno de colágeno de hueso y en información arqueobotánica, es consistente con una estrategia de subsistencia que incluye fauna riverina y estuarina, y plantas terrestres tales como uvas y tunas. El análisis de isótopos no apoya el uso extensivo de mamíferos marinos ni tampoco de fauna terrestre tal como el venado o el conejo. La ocupación estacional del sitio (a fines del verano/principios del otoño) se evidencia en el amplio rango de vegetación encontrada en asociación con los enterramientos.

In the southeastern United States the transition from early (12,500–8000 B.P.) to mid-Holocene (8000–5000 B.P.) settlement–subsistence patterns has been analyzed against the backdrop of ecological changes resulting from the retreat of the Laurentide ice field (Clausen et al. 1979; Milanich and Fairbanks 1980; Smith 1986; Widmer 1988). The continuity in early to mid-Holocene tool morphology, as well as the temporal similarities in plant use have been reviewed by Smith (1986). In Florida, as throughout the southeast, there is a richer archaeological record from the middle Holocene than earlier times. Based on the quantity and quality of these archaeological data, major adaptations in the patterns of human mobility and a shift in dietary fauna have been proposed (Chapman and Shea 1981; Lewis and Lewis 1961).

Excellent organic preservation at mid-Holocene mortuary locations in Florida has resulted in the

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excavation of human skeletal populations at Little Salt Spring (Clausen et al. 1979), Bay West (Beriault et al. 1981), Gauthier (Jones and Carr 1981), Warm Mineral Springs (Clausen, Brooks, and Weslowsky 1975), and Republic Groves (Wharton et al. 1981). The contribution of the Florida mortuary sites to our understanding of subsistence patterns has been largely limited to a description of ecological parameters based on pollen and macrofaunal analysis (Clausen et al. 1979; Clausen, Cohen, Emiliani, Homan, and Stipp 1975). Habitation sites of the early to mid-Holocene peoples of Florida have been found, but we continue to rely on skeletal remains as a major source of information about human diets.

We have combined an interpretation of bone-collagen stable carbon- and nitrogen-isotopic values with an archaeobotanical analysis to develop a view of subsistence and settlement of the Archaic peoples who used the Windover (8BR246) burial grounds. This is a unique resource in which to study Archaic subsistence in Florida, and in the southeast in general, due to the combination of human, faunal, and floral remains at this site. The state of preservation at Windover, while variable, has permitted cellular and molecular analysis, including the first sequence of a nuclear gene from ancient human remains (Doran et al. 1986; Lawlor et al. 1991).

In previous paleodietary studies, stable-carbon isotopes of bone collagen have been used as an indicator of maize introduction to the agricultural base or to determine the amount of C_4 (the biosynthetic pathway used by maize) plant input to the diet (Bender et al. 1981; Matson and Chisholm 1991; Schwarcz et al. 1985; Vogel and van der Merwe 1977). The human reliance on marine-derived foodstuffs has been determined via carbon or a combination of carbon- and nitrogen-isotopic values (Chisholm et al. 1982; Schoeninger et al. 1983; Sealy and van der Merwe 1986). These applications rely on a segregation of marine and terrestrial isotopic signatures for their interpretation. In addition, the enrichment of ^{15}N up a food chain has been explored as a paleodietary monitor of trophic placement in both marine and terrestrial ecosystems (Minagawa and Wada 1984; Schoeninger and DeNiro 1984; Wada 1980).

The complexities of stable-isotope analysis in whole ecosystems, marine and terrestrial, have been discussed by many investigators (Ambrose 1986, 1991; Cifuentes et al. 1989; Fry et al. 1978; Heaton et al. 1986; Sealy et al. 1987; Tieszen and Boutton 1986; Yoshioka et al. 1988). The added difficulty of working with an incomplete archaeological record and the vagaries of human food consumption only heighten the challenge of paleodietary interpretations (Sillen et al. 1989).

The question of differential reliance on marine vs. terrestrial foods during the Archaic period is a focus of this study. By combining archaeobotanical information with isotopic analyses we have attempted to overcome the problem inherent in using human carbon-isotopic values (due to their lack of specificity) as the sole source of data for interpreting plant use in preagricultural, nonmaize-ingesting populations. The bone-collagen isotopic data, both carbon and nitrogen, reflect most directly the faunal input to the human diet at Windover, and are an extension of and complement to the botanical information.

MATERIALS AND METHODS

Site Description and Chronology

Windover is a cemetery site located in central Florida near the Atlantic Coast at 28.5° latitude (Figure 1). Excavation of the Windover site (8BR246) near Titusville, Florida, was conducted in three field seasons from 1984 to 1986. The site, submerged in a small but persistent pond, was discovered during residential development in 1982. The human burials had been intentionally submerged in the peat muck of the pond bottom at the time of death, and many individuals were held in place by wood stakes. A total of 168 human skeletons was recovered from this Archaic burial site (Doran and Dickel 1988a, 1988b), along with five lithic artifacts, 87 specimens of textiles and other perishables, and tools made of bone, antler, marine shell, and wood (Stone et al. 1990).

Twenty-seven radiocarbon dates on peat, modified wooden stakes, human bone, and a bottle-gourd rind (Doran and Dickel 1988a, 1988b; Doran et al. 1990) were obtained, and the peat deposit ranges from 10,750 B.P. at the base to 4790 B.P. well above the burials. Most of the human skeletal material was located 1.8 m below the standing water level. The radiocarbon dates on human bone

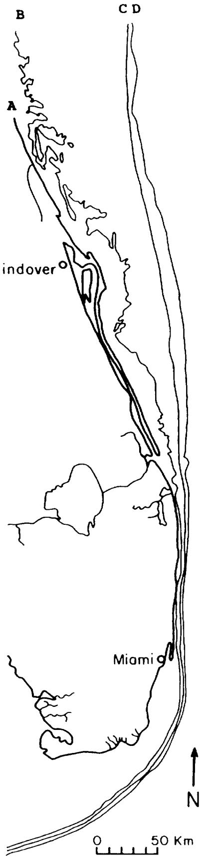

Figure 1. The East Coast of Florida (after Uchupi 1966). The submarine typography is based on hydrographic, coastal, and geodetic surveys and indicates the approximate locations of ancient shore lines. The contours represent (*A*) the present-day coast line of Florida; (*B*) a 20-m depth that was exposed at approximately 6,500 years B.P.; (*C*) a 32-m depth (11,500 years B.P.); and (*D*) a 60-m depth (12,000 years B.P.).

collagen from two different laboratories (n = 6), wooden stakes (n = 5), and the bottle-gourd rind associated with the burials cluster around 7400 B.P. One radiocarbon date on human bone—7500 ± 190 B.P. (TO-1323)—was obtained using collagen purified at the Smithsonian Institution. This protein was characterized on the basis of a complete amino-acid analysis, and shown to be > 99 percent pure. Based on these dates, it has been suggested that burial activities probably began around 8,000 years B.P. and ended approximately 7,000 years B.P. (Doran and Dickel 1988b).

Stable-Isotope Analysis

A total of 32 individual human skeletons was sampled. A small piece (< 5 cm [2″] of rib) was decalcified with constant shaking at 4°C in .5M ethylenediaminetetraactic acid (EDTA), pH 7.2, with daily changes of EDTA for up to three weeks. Although this procedure has removed all mineral and associated humic acids from a variety of fossil-bone samples (Tuross et al. 1988), the bone material from the Windover site was severely complexed with peat. Traditional gelatinization procedures (Longin 1970) did not remove all associated humic acids from this skeletal population, and any halide acid (HCl) decalcification methods resulted in such a large loss of collagen and precipitation of humic acids that it could not be used except on large bone fragments (> 20 g).

In order to address these difficulties an extensive washing with cold (4°C) .1N sodium hydroxide (NaOH) wash was done on all EDTA decalcified collagen replicas. The base was changed up to three times daily with shaking until all the associated dark brown humic material had been removed. The final criterion for collagen purity was a complete amino-acid analysis on every sample. Faunal bone from the site was treated in the same way.

Ironically, although the difficulties in collagen purification imposed by the wet site conditions and resulting peat contamination in the bone were resolved, we were unsuccessful in dealing with the addition of a preservative (Rhoplex-Rohm Hass) that had been applied to this friable skeletal collection (Stone et al. 1990). This acrylic polymer persistently, but erratically, altered the $\delta^{13}C$ values of the collagen, and 15 stable-carbon values from the human collagen and 11 faunal values were discarded due to Rhoplex contamination (Tuross and Fogel 1994a). Fortunately, the $\delta^{15}N$ values are not altered by the application of this preservative, and six human bone specimens were supplied preservative free, thus allowing us to report the $\delta^{13}C$ values from these individuals.

Some of the faunal bone specimens were also usable for $\delta^{13}C$ analysis, because they were larger and the Rhoplex preservative did not penetrate to the interior. Again, the final criterion for collagen purity was a total amino-acid analysis in which not only the ratio of glycine to aspartic acid was measured (Tuross et al. 1988), but also the nanomoles/mg dry weight were determined and referenced to a collagen standard (sigma). Rhoplex contamination is "silent" to the qualitative amino-acid profile of collagen, that is, Rhoplex contains no primary amines that could be identified. However, the addition of this stabilizer resulted in a decreased yield of hydrolyzable amino acids on a weight basis. Only collagen extracts that were quantitatively > 95 percent of the collagen standard are reported here.

One to three milligrams of purified collagen were sealed in a quartz tube under vacuum with granular copper metal and cupric-oxide wire. The samples were combusted at 900°C for one hour, and then cooled at a controlled rate. Gases (CO_2 and N_2) were separated by cryogenic distillation. Resultant isotope ratios of CO_2 and N_2 were measured on isotope-ratio mass spectrometers (Nuclide 6-60-RMS for CO_2; modified Dupont 491, double-focusing instrument for N_2).

Isotope ratios are defined as

$$\delta^{N}E = \left[\frac{(R_{sample} - R_{standard}) \times 10^{3}}{R_{standard}}\right]$$

in units of parts per millions (‰), where N is the heavy isotope, ^{13}C or ^{15}N, and E is the element C or N. R_{sample} refers to the ratio of the heavy to light isotope ($^{15}N/^{14}N$, $^{13}C/^{12}C$), and $R_{standard}$ refers to an analogous ratio in standard compound. The standard for $\delta^{15}N$ analysis is air ($\delta^{15}N = .0$); the standard for $\delta^{13}C$ analysis is a fossil marine belemnite (PDB) ($\delta^{13}C = .0$). Replicate analysis of purified collagen yielded results with a standard deviation of ± .2 ‰ for $\delta^{15}N$ and ± .1 ‰ for $\delta^{13}C$.

Botanical Recovery and Sampling

Sampling for botanical remains at Windover included environmental samples of column and individual soil samples that together provided horizontal and vertical testing of individual strata. Column samples consisted of 15-x-15-x-5-cm segments of peat that were removed in vertical columns from the walls of various units and packaged for subsequent laboratory processing. Soil samples of 3–5 liters were collected during the course of the excavation for further characterization of specific strata and possible depositional episodes within the pond. The second type of soil samples were recovered in direct association with human remains, including potential lower bowel or abdominal contents. In total, plant remains were identified in connection with 27 burials or concentrations of human bone. Control samples of surrounding peat were taken to determine the background seeds that were found naturally in the peat stratum.

Established archaeobotanical methods and procedures for peat soils and waterlogged remains were followed in the work on the Windover samples (Coles et al. 1989; Greig 1989; Newsom 1987, 1988a, 1988b). The soil and column samples were processed by gentle washing and partitioning of the contents in nested geological sieves. All material between 2 and 4 mm was sorted and identified; remains caught in the 1-mm sieve were sorted only for identifiable seeds, the finest (125 μm) component was subsampled 10 percent by volume, and all seeds were identified. The special samples from the burials and related control samples were not passed through the geologic sieves, but were

Table 1. $\delta^{15}N$ in Human Bone Collagen from the Windover Site.

Sample Number	$\delta^{15}N$ (‰)	Gly/Asp[a]
400-2	11.7	6.9
SS67	11.5	6.6
63.748	12.9	7.1
5759	11.8	6.5
59118	12.1	6.6
57169	13.3	6.6
SS625	12.4	6.7
SS642	11.5	7.0
SS624	11.1	6.6
SS654	12.6	6.7
SS655	11.9	6.8
SS648	11.4	6.6
SS633	12.0	6.9
SS641	11.9	6.9
SS302	12.2	6.5
SS687	12.9	6.6
SS644	10.2	6.8
SS652	11.7	7.0
SS650	12.2	7.0
SS657	12.7	6.6
SS686	10.1	6.7
SS698	12.2	7.1
SS697	11.2	6.9
SS634	12.2	6.9
SS643	11.6	7.0
SS630	11.3	6.9
SS70	12.9	6.5
SS564	12.7	6.9
SS628	11.2	6.5
SS184	10.2	7.0
SS189	8.9	6.5
SS627	12.3	6.6
Mean ± 1 S.D.	11.8 ± .9	6.7 ± .2

[a] Gly/Asp is the ratio of the amino acids, glycine, and aspartate in collagen residues. In well-preserved collagen the values range from 6 to 7 (Tuross et al. 1988).

entirely sorted directly under a dissecting microscope. Seed identifications were made using pictorial guides (e.g., Landers and Johnson 1976; Martin and Barkley 1961) and by reference to comparative specimens in the Florida Museum of Natural History. The macrobotanical remains from the Windover excavations have been deposited and are curated at the Environmental Archaeology Laboratory, Florida Museum of Natural History, Gainesville.

ECOLOGICAL SETTING OF THE WINDOVER SITE, PAST AND PRESENT

The early to middle Holocene was a time of rapid and profound worldwide changes in temperature, sea level, and coastal configuration. In North America, beginning at about 18,000 years B.P., the Laurentide ice sheet retreated, resulting in a rise in sea level from tens to over 100 meters (Emery and Merrill 1979; Emery and Milliman 1970; MacIntyre et al. 1978; Milliman and Emery 1968). *When* the present-day location of coastline in Florida stabilized is debated (DePratter and Howard 1981), but during the interval that the Windover burial ground was in use (7000–8000 B.P.), sea level was rising rapidly, transgressing perhaps as much as 10 m (Lighty et al. 1983). This change in sea level was accompanied by a rising water table that resulted in the development of the permanent standing-water features in South Florida such as Lake Okeechobee, the Everglades, and the St. Johns marsh system along the east-central peninsula.

The development of standing surface water and the attendant hydric plant assemblages produced an important addition to the physiography of Florida: estuary formation. The transformation of coastal and adjacent inland environments from the early Holocene high energy beach and hypersaline lagoons hypothesized by Widmer (1988) to brackish estuaries and fresh-water ecosystems occurred in east-central Florida before and, perhaps, during the Windover occupation (Ruppe 1980; Uchupi 1966).

The middle Holocene in Florida, particularly toward its close, was characterized by fluctuation and adjustment of terrestrial environmental conditions, as well as by sea-level changes (Watts 1980; Watts and Hansen 1988). The Windover people were burying their dead at some distance from the sea during the warm dry episode known as the Hypsithermal (Pielou 1991; Smith 1986). Pollen studies of the early to middle Holocene in Florida (ca. 10,000–5000 B.P.) project a dry oak woodland over much of the peninsula (Cooperative Holocene Mapping Project [COHMAP] 1989; Watts 1980; Watts and Hansen 1988).

Much like today, however, the seasonal shift in rainfall cycled between a system dominated by continental patterns (and cyclonic activity) in the winter, to a tropical/convectional system in the summer (Critchfield 1974; Pierson 1956). The tropical influence may have been weaker during the Hypsithermal, so that summer rains were less intense, or perhaps the climatic system was sufficiently altered such that the latitudinal gradient was shifted south, resulting in a continental domination of weather patterns throughout the year. Either situation, by itself or in tandem with other factors, could account for the dryer conditions inferred by the oak woodland of the pollen diagrams (COHMAP 1989; Watts and Hansen 1988).

The Windover site is situated just north of the tropical/subtropical climatic boundary of the peninsula based on the 18° isotherm (Nieuwolt 1977; Pierson 1956). The climate is classed as subtropical based on the plant hardiness scale (Little 1978). The vegetation at this zone of intergradation, much like a broad ecotone, combines temperate and tropical elements. Coastal vegetation is dominated by xeric associations characteristic of the dune and coastal strand ecosystems, including expanses of salt marsh. Inland, extensive areas are dominated by pine woodlands, including a xeric sand-pine association on the excessively drained sandy soils of relic Plio-Pleistocene dune ridges, and pine flatwood on wetter, flat terrain. Interspersed throughout the pinelands are wetlands, including freshwater marshes, hardwood and cypress swamps, and bayheads. There are also associations of broadleaved evergreen trees and palms that form dense, mesic forests in relatively small areas (Davis 1943; Long 1974).

The primary intent of this discussion has been to characterize the environmental changes that occurred during the Windover occupation of the east-central Florida and to outline the high level of habitat diversity and natural resources available within the environs of the Windover burial site that provide the potential for a broad-spectrum subsistence economy.

RESULTS AND DISCUSSION

The Stable-Isotopic Data

The human-collagen stable nitrogen-isotope values ($\delta^{15}N$) tightly cluster at 11.8 ‰ with a standard deviation of .9 ‰ (n = 30) (Table 1). The human bone collagen $\delta^{15}N$ values are inconsistent with a heavy reliance on deep-sea products in the Windover diet. Previous studies have ascribed substantial marine input into the human diet when the $\delta^{15}N$ from human bone collagen measured 14–20 ‰ (Schoeninger et al. 1983; Sealy and van der Merwe 1986; Sealy et al. 1987; Walker and DeNiro 1986). A comparison of the nitrogen-isotopic values from human bone collagen at the Windover site with other archaeologically recovered human populations indicates that these Archaic peoples have the lowest $\delta^{15}N$ yet observed in near-coastal populations. As previously described, Windover is now on the east coast to Florida (Figure 1), however, during the mid-Holocene the cemetery was some distance from the sea. The relatively low $\delta^{15}N$ of bone collagen in this human population is consistent with a subsistence base that made little or no dietary use of deep-sea marine sources, especially marine mammals at the top of the food chain. These human nitrogen values might be explained by the use of shellfish in the diet (Sealy et al. 1987), however, there were no accumulations of marine shells found during the excavation.

Table 2. δ^{13}C in Bone Collagen of Humans and Associated Fauna.

Bone Collagen	δ^{13}C Value
Human[a]	
400-2	−15.9
SS67	−16.0
63748	−15.0
5759	−17.2
57118	−14.1
57169	−15.3
Mean ± 1 S.D.	−15.5 ± 1.0
Fauna	
Deer	−26.2
Deer	−22.2
Duck	−16.9
Duck	−16.7
Catfish	−16.2
Dog	−17.5
Rabbit	−15.0
Flora	
Peat	−25.9
Prickly pear seed	−16.0
Prickly pear seed	−16.0

[a] Sample numbers listed.

Collagen stable-carbon isotopes (Table 2; Figure 2) might be expected to add to the analysis of a marine vs. terrestrial input in the human diet, as well as contribute to an identification of the types of terrestrial food sources. Human-collagen values of δ^{13}C intermediate to pure C_3 and C_4 isotopic extremes have been interpreted as evidence of substantial marine diets (Chisholm et al. 1982; Walker and DeNiro 1986) or, in other contexts, as proof of a reliance on the C_4 plant, maize (Vogel and van der Merwe 1977). Neither of these interpretations is tenable as an explanation for the δ^{13}C values of the human bone collagen at Windover (Table 2). The average δ^{13}C of the bone collagen of the adult humans is −15.6 ‰ (Figure 2). The stable carbon-isotopic evidence from the associated flora and fauna indicates that the combination of CAM plants such as prickly pear ingested directly and the C_4 grasses consumed by fauna (Table 2) are the likely source of the human δ^{13}C values.

The existence of a patchy C_3 biome is suggested by the bone collagen δ^{13}C of the deer at −22.2 ‰ and −26.2 ‰, the δ^{13}C of the peat, −25.2 ‰ (Table 2), and the archaeobotanical data from the region. The fauna that were excavated from the Windover pond are not necessarily contemporaneous with the human occupation at the site, but faunal-isotopic data included here (Tables 2 and 3) provide the best evidence for the available food base of the Windover population. No midden or habitation site has been discovered associated with the mortuary activities (Doran and Dickel 1988a).

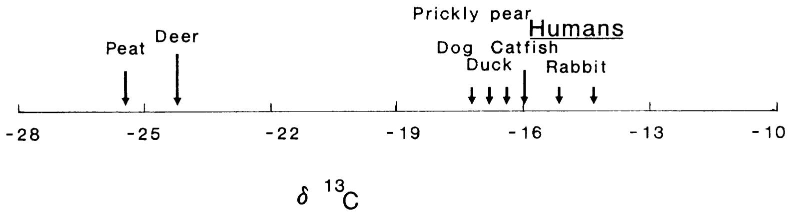

Figure 2. Stable-carbon-isotope ratios from selected flora, fauna, and humans of the Windover site, and the range in C_3 (left portion of graph) and C_4 values (right portion of graph). The average bone collagen δ^{13}C of adult humans ($n = 6$) and representative animals (bone collagen) and plants (whole tissue or seeds). Only a limited number of Windover fauna are reported due to contamination by the consolidant Rhoplex (see Materials and Methods section).

Table 3. $\delta^{15}N$ in Faunal Bone and Peat from the Windover Site.

Common Name	$\delta^{15}N$ (‰)	Gly/Asp[a]
Catfish	7.1	6.5
Duck	10.8	6.6
Duck	10.5	7.0
Turtle	10.4	6.9
Racoon	10.9	6.9
Racoon	10.6	7.0
Deer	7.8	6.8
Duck	10.5	7.0
Catfish	6.8	7.2
Catfish	6.8	7.1
Alligator	7.7	7.0
Turtle	9.2	6.9
Opossum	8.4	6.9
Dog	7.4	7.0
Deer	6.0	7.0
Blue Heron	9.1	6.5
Osprey	9.7	6.9
Rabbit	5.0	6.9
Peat	3.4	—

[a] See explanation of Gly/Asp in Table 1.

The fractionation that occurs between the $\delta^{13}C$ of the diet and consumer bone collagen is on the order of 1.5–5 ‰ (DeNiro and Epstein 1978; Hare et al. 1991; Tieszen et al. 1983; van der Merwe and Vogel 1978). A human diet that relied heavily on C_3-feeding fauna would produce an adult human bone collagen $\delta^{13}C$ in the range of −20 ‰, instead of the observed human Windover value of −15.6 ‰. As detailed below, many plants that utilize a C_3 biosynthetic pathway were part of the Windover human diet, so other sources of food that are isotopically "heavy" in ^{13}C must have been ingested in order to account for the human $\delta^{13}C$ values. Likely candidates include the riverine-based fauna, such as duck and catfish, that have intermediate C_3/C_4 bone collagen $\delta^{13}C$ (Table 2).

A human diet that relied heavily on classic terrestrial sources, such as deer and rabbit, is also inconsistent with the nitrogen-isotopic data of the Windover humans and fauna. The average $\delta^{15}N$ from deer and rabbit bone collagen (terrestrial herbivores) is 6.3 ± 1.4 ‰ (Table 3; Figure 3). If deer and rabbit meat were the major dietary sources, it is expected that human bone collagen $\delta^{15}N$ would be in the range of 8–9 ‰ (Hare et al. 1991; Schoeninger and DeNiro 1984) instead of the observed mean at Windover of 11.8 ‰. The late Archaic sites of Eva, Cherry, and Ledbetter in Tennessee have average human bone collagen $\delta^{15}N$ in the range of 8 ‰, consistent with a reliance on terrestrial herbivores such as deer or rabbits (Tuross and Fogel 1994b).

Both the human and faunal bone collagen carbon- and nitrogen-isotopic data, independently and in tandem, support an interpretation of riverine-dominated subsistence by the peoples who used Windover. The relationship of humans and associated fauna from Windover in terms of ^{15}N fractionation is shown in Figure 3. The pure herbivores are placed in Trophic Level 1, and all other animals (omnivores and carnivores) at Trophic Level 2. The addition of human values, arbitrarily placed at Trophic Level 3, produces a linear relation with a slope of 2.8. The slope of the linear regression line (Figure 3) is a measure of increase in ^{15}N up the Windover food chain and agrees with an original trophic-ladder enrichment of $\delta^{15}N$ described by Wada (1980) and colleagues (Minagawa and Wada 1984), and later Schoeninger and DeNiro (1984). An increase in ^{15}N of approximately 3 ‰ with each step up a food chain was observed in both previous studies and in the Windover samples (for review see Owens [1987]). Applying the 3 ‰ stepwise-enrichment paradigm in $\delta^{15}N$ to the Windover human bone collagen values leads to the conclusion that the human diet was dominated by animal protein at the "second" trophic level such as duck, turtle, and catfish and *not* by a heavy reliance on terrestrial foods such as deer and rabbit.

Extrapolating the linear regression line in Figure 3 to the y-axis results in an intercept of 3.3 ‰. This value should represent the $\delta^{15}N$ of the average plant base of the ecosystem, and agrees well with the peat value of 3.4 ‰ at the Windover site.

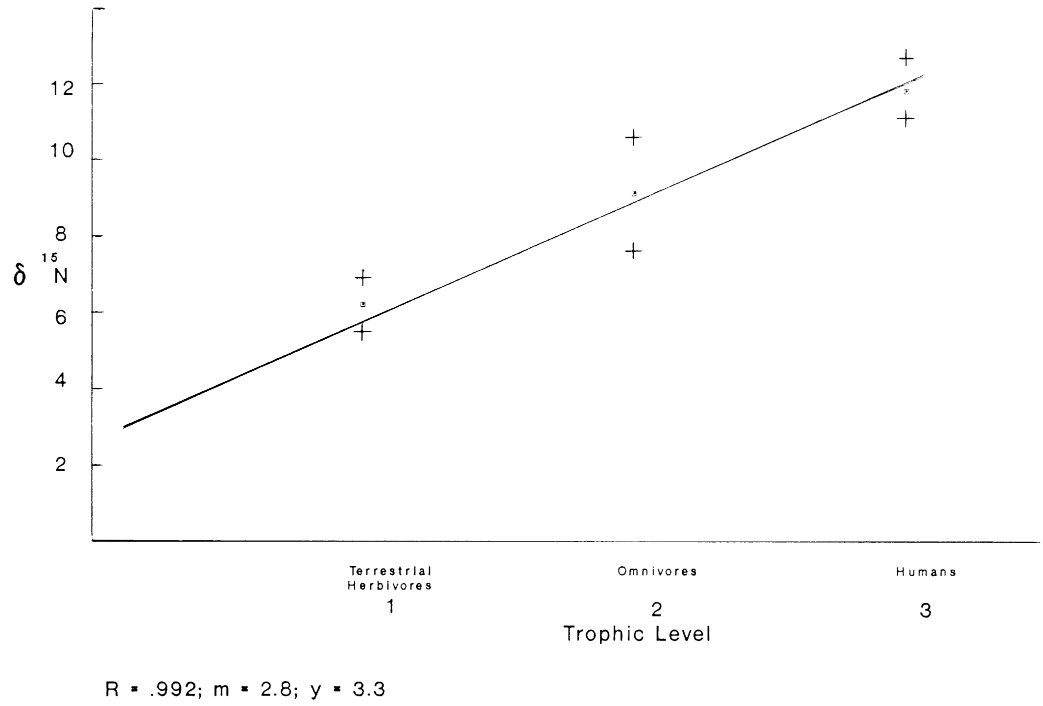

Figure 3. Isotopic enrichment of ^{15}N in the Windover food web. Humans are arbitrarily placed at a "third" trophic level.

The carbon-isotopic values from human bone collagen are also best explained as a fractionation derived from a diet made up of meat other than deer (Figure 2), and are consistent with the use of duck, catfish, turtle, and other river-dwelling animals of the east Florida ecosystem.

The Botanical Data

Stable carbon-isotopic analyses can only distinguish the major groups of photosynthetic plants, and are unable to provide a detailed knowledge of dietary plant use at Windover. Archaeobotanical analysis of preserved plant matter provides another window to this subsistence strategy. Thirty-one potential food or medicinal plants were identified in the Windover deposit (Table 4). At least 13 edible species were found directly associated with the human remains and three of these plants were found exclusively in this context (hackberry, black gum, and cabbage palm). As a whole, the plant species assemblage for the burial contexts is dominated by the seeds of edible, fleshy fruits. Virtually, all of the plants identified, with the exception of prickly pear, utilize a C_3 photosynthetic pathway.

Analysis of six abdominal samples with two control samples averaged two seeds per ml with the exception of Burial 125, in which a concentration of 32 seeds per ml was found. Based on the seed density, number, and type, and the distribution of bones and especially, charcoal densities, Burial 125 is thought to offer the firmest evidence for food remnants that were ingested just prior to death (Figure 4).

Burial 125 is an adult female of approximately 70 years of age. In the 102-ml sample, taken from the area of the sacrum, there was a dense concentration of seeds, totaling 3,324. The majority (83 percent) of the seed total is elderberry. Given the small size of the elderberry fruit (4 mm in diameter), the seed count is not inordinate and could have been ingested at a single meal. Putative food stuffs such as grape and the CAM plant, prickly pear cactus, were also identified from Burial 125. Seeds of sawgrass, waterlily, and spikerush are considered intrusive, as they are moderately to very abundant in the control and column samples.

Table 4. Edible Plants Identified in the Windover Deposits.

Taxon	Common Name	Parts Used
Amaranthus sp.	water hemp/amaranth	greens, seeds
Arundinaria gigantea	switch cane	seeds, shoots
Brasenia schreberi	water shield	rootstock, leaves
Carya sp.	hickory	nut, nut oil
Castanea sp.	chinquapin/chestnut	nuts
Celtis sp.*	hackberry	fruit
Cyperus spp.	sedge/nutsedge	tubers
*Diospyros virginiana**	persimmon	fruit
Ilex sp.*	holly	leaves
*Lagenaria siceraria**	bottle gourd	seeds, flowers
Melothria pendulata	creeping cucumber	fresh fruit
Morus rubra	red mulberry	fruit
*Myrica cerifera**	wax myrtle	all parts (medicinal)
*Nuphar lutea**	spatterdock	rootstock, seeds
Nymphaea spp.	waterlily	rootstock, seeds
*Nyssa sylvatica**	black gum	fresh fruit
Opuntia sp.*	prickly pear	fruit, pad
*Passiflora incarnata**	maypop	fruit
Pinus sp.	pine	shoots, strobili
Polygonum spp.	smartweed/knotweed	seeds, whole plant
Polyporus sp.*	sulphur-shelf fungi	edges of basidiocarp
Prunus sp.	wild plum	fruit
Quercus sp.*	oak/acorn	nut, nut oil
Persea sp.	red bay	leaves (condiment)
Sabal palmetto	cabbage palm	fruit, meristem
*Sambucus canadensis**	elderberry	fruit, flowers
Scirpus sp.	bulrush	seeds, shoots, tubers
Serenoa repens	saw palmetto	fruit, meristem
Solanum sp.	nightshade	fruit (medicinal)
Typa sp. (?)	cattail	rhizomes, shoots
Vitis sp.*	wild grape	fruit, leaves

Note: Sources include Angier 1980; Coon 1974; Elliot 1976; Hudson 1976; Moerman 1986; Morton 1982; and Peterson 1977.
* = Plants recovered in assocation with human skeletal remains.

Seeds are not the only constituents of the abdominal samples. Bone was recovered from Burial 125; the fauna consists primarily of small, whole fish parts. Identifiable specimens include remains from small killifish and golden shiner, and a single catfish bone. The faunal material could be intrusive into the burial, although the possibility that these fish were a food source certainly exists—particularly in light of the fact that the same fish have been identified in late Archaic middens from the nearby St. Johns River basin (Russo 1986). A lower abdominal sample from another burial (# 142) also contained a quantity of whole fish and pulverized bone.

Seasonal Use of the Windover Mortuary Site

Another question that can be examined with the botanical identifications from Windover is season(s) of burial site utilization. Virtually all of the plants associated with the burials bear fruit during the latter half of the year—from approximately July to October (Figure 5). Bottle gourd ripens from September to October, but cannot be used to determine season of occupation or visitation because its container function means it could be discarded (interred) at any time. Hickory nut was not found in direct association with human remains, but was frequent in the general levels dating to the aboriginal use of the site; it is another late summer/fall resource. Prickly pear bears fruit irregularly; it was observed with ripe fruit near the site in October as well as March. No fruits expressly indicative of the early part of the year (e.g., blueberry [late spring] or blackberry [late spring/early summer] have been identified.

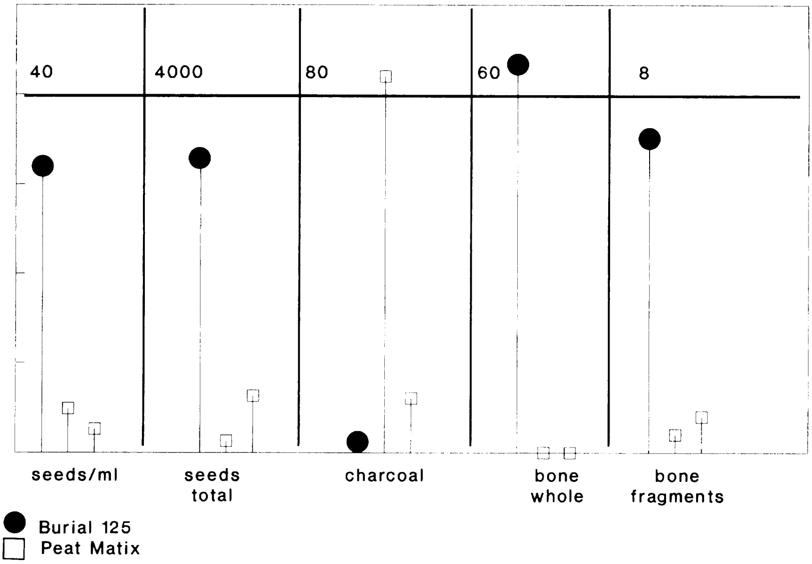

Figure 4. Stomach contents of Burial 125 and two peat-matrix control samples analyzed for number of seeds/ml, total seed count, amount of charcoal, the number of whole bones, and bone fragments. Each column is scaled to the maximum value indicated.

Further corroborating a midsummer/fall period for site activities and burial placement are the pine poles or stakes associated with the burials. The stakes from at least six burials had their outermost growth rings preserved so that growth cessation, i.e., time of cutting, could be determined. Poles from five burials had fully developed latewood within the last growth increment, indicating that the wood was harvested from August to September (or later). A stake from the sixth burial showed that the piece was cut somewhat earlier than the others, perhaps during late June or the month of July.

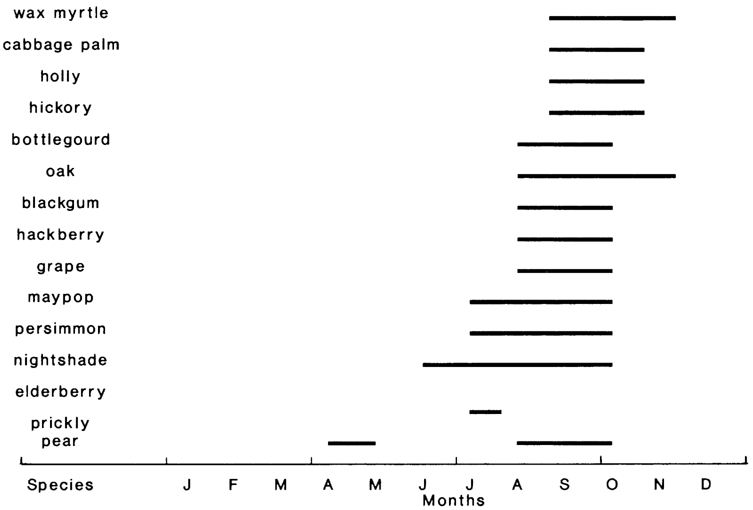

Figure 5. The temporal range in fruit production of the flora associated with the Windover burials.

Table 5. Organic Content of Human Whole Bone from the Windover Site.

Sample Number	C/N	%N[a]
SS642	8	32
SS654	8	62
SS633	47	5
SS641	13	23
SS302	6	42
SS644	32	8
SS652	17	13
SS650	37	10
SS657	78	2
SS686	5	61
SS697	4	59
SS630	10	24
SS70	14	39

[a] %N relative to a modern bovine compact-bone standard (100%).

CONCLUSIONS

The bone-chemistry and archaeobotanical evidence from the Windover burial site support a view of human existence 7,000–8,000 years ago that was seasonally opportunistic and included use of aquatic resources, probably both freshwater and estuarine, in the diet. The long-term use of the cemetery site, for perhaps as long as 1,000 years, indicates the persistence of this way of life. It is conceivable that seasonal mobility with a change in habitation location was practiced by the Windover peoples. This scenario would predict that winter and spring camp sites were based at a distance from the Windover burial ground, and that the deceased were interred at another location because of the difficulty in reaching the Windover pond.

Another possibility is that the seasonal fluctuation in the water table made the Windover pond usable as a burial site only during the wet summer and early fall months. Movement between habitation sites need not be invoked to explain the seasonally selective use of the burial site. The habitat diversity in the vicinity of the Windover pond would also allow for seasonally driven changes in food-gathering locations without requiring a change in habitational site.

Changes in standing surface water may well have been a critical factor to a population who were making use of the developing freshwater and salt marsh environments for food and for submersion burial of their dead. The quality of the bone and the macromolecular preservation in the Windover skeletons was extremely variable, although a detailed analysis correlating excavation location and bone quality has not been done. The elemental ratios of carbon to nitrogen (C/N), and the nitrogen content of whole bone (%N), a good proxy for overall organic preservation (Table 5) (Tuross and Stathoplos 1993), exhibit a wide range in the Windover bone. One explanation that could account for this variability in bone preservation is the alternate flooding and partial drying of the Windover Pond over the past 8,000 years. Changes in plant species observed through the column samples from the Windover pond (Newsom 1988b) lend support to the hypothesis of a fluctuating pond margin with episodes of drier periods (Davis 1943:196; Lowe 1986).

Some archaeobotanical analyses have been carried out at three other Archaic components in Florida (Newsom 1985, 1987, 1988a). The combined data from these sites indicate that prickly pear, grape, and palm fruits were important food resources, as were other seasonally available pulpy fruits. Other plant sources such as acorns and the seeds of wild grasses, while present, were apparently not important dietary staples.

Archaic-period plant use in peninsular Florida primarily appears to have involved opportunistic collection of fresh fruits from forested and disturbed habitats. Interestingly, hickory and other nut foods, found at later Archaic sites throughout the southeast, do not appear to have a major role in the diet of the Archaic people of peninsular, Florida. This difference may be explained by a decline in nut-producing trees with decreasing latitude. We should note that largely missing from the archaeobotanical assemblages for Florida sites is the contribution of green vegetables, root stocks, and tubers due to the inherently low preservation capacity of these plant parts.

Schoeninger and DeNiro (1984) suggested that enrichment of ^{15}N up a terrestrial food chain could be a useful monitor of trophic level, and ultimately, human food use in paleopopulations. More recently, several investigators have detailed difficulties in applying this paradigm (Ambrose and DeNiro 1986; Heaton et al. 1986; Sealy et al. 1987). The demonstration of trophic-level enrichment of nitrogen isotopes in the skeletal and plant remains excavated at Windover has proven robust, and is a general confirmation of the original hypothesis concerning the utility of nitrogen isotopes in assessing paleodiets. The addition of carbon-isotopic analysis provides additional information on human subsistence, and the combination of both isotopes is clearly of greater value than either measure in isolation. The further coupling of archaeobotanical analyses from a mortuary site provides a fuller explication of subsistence patterns than is normally obtained from isotopic analyses alone. The overall human dietary pattern at Windover suggests a complicated and widespread use of seasonally available plants and riverine animals that could be nutritionally adequate in providing calories, protein, fats, carbohydrates, minerals, and variety.

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