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Stable isotope evidence of juvenile foraging in prehistoric Central California

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ABSTRACT

Ethnographic evidence demonstrates that hunter–gatherer children may forage effectively enough to supplement an adult provisioned diet, where ecology, subsistence strategies, and social organization are conducive to juvenile participation. We use stable isotope measures (δ^{15}N and δ^{13}C) from bone collagen and serial-samples of dentinal collagen extracted from first molars to examine childhood dietary patterns among 24 individuals from the Late Holocene Central California site CA-ALA-554. We identify weaning age and early childhood dietary patterns, and find evidence for independent child foraging among 25% of the sample population ($n = 6$), the majority of whom lived during the high-stress Medieval Climatic Anomaly (1100–700 BP).

1. Introduction

Modern *Homo sapiens* exhibit unique life history traits as compared to other mammals and primates, including a particularly helpless infancy period, relatively short lactation periods and interbirth intervals, and long childhoods (Dettwyler, 2004; Hawkes et al., 1998; Hrdy, 1999; Sellen, 2006). A long period of somatic investment prior to sexual maturity reduces lifetime fertility, and it has been suggested that natural selection could favor delayed maturation and prolonged investment in growth if the costs of reduced fertility are outweighed by reduced mortality associated with a longer period of learning required for difficult or complex foraging tasks (Blurton Jones et al., 1994; Blurton Jones and Marlow, 2002; Gurven and Kaplan, 2006; Hawkes et al., 1998; Hrdy, 1999; Kaplan et al., 2000).

Focus on child foraging behavior among ethnographic populations of hunter–gatherer groups has stemmed from attempts to test the embodied capital hypothesis to determine whether differences between food items taken by children and adults are a function of the correlation of learning and age, or of size and strength (Blurton Jones, 2005; Bock, 2005; Dettwyler, 2004; Hawkes et al., 1998; Hrdy, 1999; Sellen, 2006).

Ethnographic evidence demonstrates that hunter–gatherer children often supplement food provisioned by adults through foraging, at least when social organization, ecology, and subsistence strategies are conducive to juvenile participation (Bird and Bliege Bird, 2000, 2002, 2005; Blurton Jones et al., 1994). For example, in their comparison of !Kung and Hadza child foraging, Blurton Jones et al. (1994) note that local ecology has a significant impact on whether children forage. In easily navigated environments with food items accessible to children in proximity to a central place, children forage for resources that require little or no processing (Blurton Jones, 2005; Blurton Jones et al., 1994). Hadza children forage independently for berries and small game away from camp in small, mixed-cohort groups, and experience high enough return rates to supplement half of their daily caloric requirements (Blurton Jones et al., 1994; Crittenden et al., 2013; Marlowe, 2005). In contrast, !Kung children do not engage in any foraging activity, and are mostly or entirely dependent on adults for their subsistence needs. This has been attributed to the wide and patchy distribution of water and resources, paucity of shade, and the difficulty associated with navigating the Kalahari (Blurton Jones et al., 1994, 1989; Howell, 2010; Marlowe, 2005).

Tucker and Young (2005) similarly note the importance of environmental conditions in child foraging efficiency among the Mikea of Madagascar, where children's foraging contributes significantly to the household economy. The Mikea Forest offers an ideal environment for child foragers, with no predators and very few toxic plants. At age four or five, children begin harvesting wild tubers using strategies optimal for their strength and skill levels, as predicted by the marginal value theorem (Charnov, 1976). Likewise, Bird and Bliege Bird have found that among the Martu and Meriam of Australia, size, as measured by height, is strongly correlated to foraging success, and that children make prey choice decisions that maximize their encounter rates and overall efficiency (Bird and Bliege Bird, 2000, 2002, 2005; Bliege Bird and Bird, 2002; Bliege Bird et al., 1995). Among the Meriam prey choices include shellfish, sessile resources that require minimal skill in procurement and processing, and among Martu small reptiles (Bird and Bliege Bird, 2000, 2002, 2005; Bliege Bird and Bird, 2002; Bliege Bird et al., 1995).

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Although the Tsimane are not exclusively a foraging population, a systematic study conducted by Schniter et al. (2015) on the pre-reproductive skill acquisition of Tsimane children demonstrated that both boys and girls develop approximately 25% of their total lifetime food procurement skills by the age of ten, and that children beginning around age five are capable of supplementing their provisioned diet with food items they've procured.

As the ethnographic examples above illustrate, children may engage in foraging behavior that aids adult efforts and may even supplement their predominantly adul*t*-provisioned diet. However, the resources that children pursue may not be included in the predicted diet breadth for adults. The diet breadth model, as originally conceived and applied in biology and human behavioral ecology, predicts the food items foragers will choose to exploit with the assumption that foragers are optimizing a currency (typically energy, or kilocalories) with direct fitness results (Charnov, 1976; Kaplan and Hill, 1992; MacArthur and Pianka, 1966; Maynard Smith, 1976; Schoener, 1971). The model depicts foraging as divisible into two discrete, mutually exclusive components – search and handling time. The search time is the period devoted to looking for a food item, while handling time involves post-encounter pursuit, procurement, processing, and consumption of that food item (Bettinger, 2009; Kaplan and Hill, 1992). An optimal diet will incorporate food items that maximize energetic return per unit time of search and handling. A diet breadth model scaled to body size has demonstrated that child foragers conform to a predicted diet breadth that differs from adults as a result of the inclusion of resources that adults would likely ignore due to low return rates (Bird and Bliege Bird, 2000, 2002, 2005; Bliege Bird and Bird, 2002; Bliege Bird et al., 1995). The diet breadth model and its ethnographic applications suggest that children foraging independently will exploit a different suite of resources than adults, or incorporate a higher proportion of low-return foods into their diet than adults would.

While many species of mammals, including humans, learn and practice foraging skills through play-acting as juveniles (Harako, 1980; Hewlett and Cavalli-Sforza, 1986; Kamei, 2005; Turnbull, 1962), the degree to which children supplement their adult-provisioned diet may be used as a proxy for parental investment. Lower levels of parental provisioning due to an emphasis on somatic maintenance or sibling care would cause a reduction in the quality and/or quantity of foods provided by parents to their juvenile offspring.

1.1. Child foraging patterns

For the purposes of this study we delineate two primary types of child foraging behavior – assistive and independent – based on the ethnographic observations of child foraging patterns summarized above. Assistive child foraging occurs when a child accompanies a parent or alloparent during their foraging activities and assists in a portion of the gathering or processing of the resource or resources being exploited. This may include, for example, a child helping to gather acorns with his or her mother.

While unweaned infants and toddlers are typically carried by their mother on foraging trips to permit breastfeeding, weaned children can participate in assistive foraging by accompanying an adult, typically a parent of the same sex, during resource procurement activities. These children will therefore consume diets that are identical, either to the general adult population of their group, or identical to adult members of their sex within their group.

Independent child foraging observed ethnographically is defined by small, typically mixed age-cohorts of children aged 5–9 foraging separately from adult food-getting activities, and in relatively close proximity to their group's settlement (Bird and Bliege Bird, 2000, 2002, 2005; Bliege Bird and Bird, 2002; Bliege Bird et al., 1995; Blurton Jones, 2005; Blurton Jones et al., 1994; Crittenden et al., 2013). Children engaged in independent foraging will exploit foods that require no, or minimal, processing and that are typically not included in, or are a minor component of, an adult forager's diet breadth. Children supplementing their diets with foods foraged independently from adult foraging activities will consume a diet that differs slightly from that of adults within their group.

We seek to detect possible instances of childhood foraging behavior among a prehistoric foraging population in Central California by capitalizing on recent advancements in the archaeological application of stable isotope analysis to reconstruct the early childhood diet of 24 individuals from the Late Holocene archaeological site CA-ALA-554 (Fig. 1), using collagen extracted from serial micro-samples of first molar dentin. Permanent first molars record information about dietary practices when an individual was an infant and child. As a result, serial section data permit the detection of dietary shifts in individuals while they were still children. This includes life history events such as weaning, post-weaning parental provisioning, and child foraging behavior.

1.2. Archaeological context

Archaeological site CA-ALA-554 was excavated in 2011 by William Self and Associates (WSA), in what is now Pleasanton, California, within the ethnographic territory of the Ohlone peoples. At the time of prehistoric occupation, CA-ALA-554 was located along the southern shoreline of a freshwater marsh between two small watercourses within the California Coast Range. Excavations recovered 187 individuals from 165 burial features, as well as 24 non-burial features, including house floors, rock concentrations, and fire, or roasting pits (Estes et al., 2012).

Although earlier periodic occupations date to the Middle Period (2160–940 BP), the site was continuously occupied year-round for approximately 600 years, from the MLT (940–740 years BP) into the Late Period 2 (440–180 BP), when it was abruptly abandoned. CA-ALA-554 experienced its largest spatial extent and highest population density during the Late Period 1 (740–440 BP) (Estes et al., 2012). Occupation of CA-ALA-554 is coincident with the Medieval Climatic Anomaly (MCA) (1100–700 BP), which is associated with episodic drought and increased climate variability in the region (Benson et al., 2002; Cook et al., 2004; Graumlich, 1993; Stine, 1994).

Because data recovery conducted by WSA at CA-ALA-554 was focused on burials and features in imminent threat of destruction from construction activities, floral and faunal materials are limited to those encountered in burial and feature matrices. Terrestrial fauna, with a high percentage of artiodactyl and leporid remains, dominate the site's faunal assemblage. Waterfowl and rodents are less abundant, but likely contributed to the prehistoric residents' diet. Very few fish and shellfish remains were recovered (Estes et al., 2012).

The archaeobotanical assemblage is dominated by acorn, including *Quercus lobata*, *Quercus kelloggii*, and *Quercus agrifolia*; and small seeds, including hairgrass (*Deschampsia* spp.), fescue (*Vulpia* spp.), clover (*Trifolium* spp.), farewell to spring (*Clarkia* spp.), red maids (*Calandrinia* spp.), and goosefoot (*Chenopodium* spp.). Flora found in lower concentrations that likely constituted a minor portion of the diet include geophytes (e.g. *Brodiaea*), bay (*Umbellularia californica*), buckeye (*Aesculus californica*), and hazel (*Corylus cornuta* var. *californica*), fiddleneck (*Amsinckia* spp.), saltbush (*Atriplex* spp.), brome grass (*Bromus* spp.), miners lettuce (*Claytonia* spp.), elderberry (*Sambucus mexicana*), tarweed (*Madia* spp.), maygrass (*Phalaris* spp.), and dock (*Rumex* spp.) (Estes et al., 2012).

The faunal and archaeobotanical evidence suggest a strong focus on the exploitation of terrestrial plants at CA-ALA-554, with terrestrial animal resources, as well as freshwater fish and waterfowl from the nearby watercourses and marsh constituting a minor portion of the diet (Estes et al., 2012). This evidence conforms to a larger regional pattern of Late Holocene resource intensification driven by increased population densities and the depletion of high-ranking resources, with an attendant diet breadth expansion in Central California (Broughton, 1994a, 1994b, 2004; Groza, 2002; Hildebrandt and Jones, 2002; Hylkema, 2002; Milliken et al., 2007; Wohlgemuth, 1996, 2004). Also