African hominin stable isotopic data do not necessarily indicate grass consumption

A series of three papers published in the early PNAS edition of June 3, 2013 (1) evaluate the diet of numerous species of fossilized hominins who lived in Africa from 4.1 to 1.4 million y ago.

These three studies (1) have been interpreted by many in the popular press to suggest that these early hominins were regular consumers of grass and grass seeds (cereal grains), which is an incorrect assumption.

The measurement of δ13C and δ12C was made from samples of dental enamel in these extinct hominins, and δ13C was calculated relative to a standard value (2). Indeed, δ13C values in enamel ultimately indicate the isotopic dietary carbon source, from plants using either the C3 (trees, shrubs, herbs, and bushes) or C4 (grasses and sedges) photosynthetic pathways.

A number of fundamental limitations exist with δ13C analysis to evaluate diet, because it cannot determine the exact species of either C3 or C4 plants that were consumed. Furthermore, δ13C values cannot distinguish if the C3 or C4 signatures originated from the direct consumption of plants or from the indirect consumption of animals that consumed these plants.

The point in time (~3.5 Mya) at which the C4 signature begins to increase occurs simultaneously with the earliest known use (before 3.39 Mya) of stone tools to cut flesh from animal carcasses and to extract marrow from their bones (3). In addition, the gathering of small animals, invertebrates, and fish likely contributed to early hominin diet. Hence, by triangulating this archaeological information with stable carbon isotope data, it is virtually certain that δ13C values present in hominin enamel were enriched partially or perhaps mainly from increasing consumption of animals that ate C4 plants.

Other lines of evidence indicate that early African hominins were increasingly consuming more animal foods during the same time interval (3.5 Mya to 1.5 Mya) that δ13C had become enriched. The “expensive tissue hypothesis” suggests a reduction in hominin gut size and metabolic activity and a concurrent increase in brain size starting ~2.5 Mya that was resultant from increased animal food consumption with higher dietary quality (4), although this hypothesis has been recently disputed. Furthermore, grass leaves and seeds are devoid of arachidonic acid (20:4n6) and docosahexanoic acid (22:6n3), which are necessary structural fatty acids required for the synthesis of brain and neural tissues (5). The conversion of linoleic acid (18:2n6) and α-linolenic acid (18:3n3), which are found in plant foods, to arachidonic acid and docosahexanoic acid, respectively, are inefficient pathways with low product to substrate ratios. Likely candidate animal foods, which simultaneously increased the dietary quality and provided arachidonic acid and docosahexanoic acid, were scavenged de-fleshed long bones (marrow), skulls (brains), and aquatic animals. Other nutrients essential to present day Homo sapiens (and presumably for hominins) are vitamin B12 and iodine, which are scarce or nonexistent in plant foods, but abundant in animal flesh and organs. These foods, along with meals from grazing animals, likely represent the dominant dietary source for the increasing C4 signature in our African ancestors.

Maelán Fontes-Villalbaa1, Pedro Carrera-Bastosb, and Loren Cordainb Q:4.7

"Faculty of Medicine, Center for Primary Health Care Research, Lund University, Malmö, Sweden; and bDepartment of Health and Exercise Science, Colorado State University, Fort Collins, CO


Author contributions: M.F.-V., P.C.-B., and L.C. wrote the paper.

The authors declare no conflict of interest.

To whom correspondence should be addressed. E-mail: maelan.fontes_villalba@med.lu.se.
Q: 1. Please contact PNAS_Specialist.djs@sheridan.com if you have questions about the editorial changes, this list of queries, or the figures in your article. Please include your manuscript number in the subject line of all e-mail correspondence; your manuscript number is 201311461.

Q: 2. Please (i) review the author affiliation and footnote symbols carefully, (ii) check the order of the author names, and (iii) check the spelling of all author names, initials, and affiliations. Please check with your coauthors about how they want their names and affiliations to appear. To confirm that the author and affiliation lines are correct, add the comment "OK" next to the author line. This is your final opportunity to correct any errors prior to publication. Misspelled names or missing initials will affect an author’s searchability. Once a manuscript publishes online, any corrections (if approved) will require publishing an erratum; there is a processing fee for approved erratum.

Q: 3. Please review and confirm your approval of the short title: African hominin isotopic data & grass consumption. If you wish to make further changes, please adhere to the 50-character limit.

Q: 4. If your article contains links to Web sites (other than the SI links for your article), please verify that the links are valid and will direct readers to the proper Web page.

Q: 5. Please review the information in the author contribution footnote carefully. Please make sure that the information is correct and that the correct author initials are listed. Note that the order of author initials matches the order of the author line per journal style. You may add contributions to the list in the footnote; however, funding should not be an author’s only contribution to the work.

Q: 6. Please verify the accent in author M.F.-V.

Q: 7. Author names may have been edited to match those provided during article submission; please check carefully and note your approval in the margin. (Your article cannot be published until your approval has been received.)

Q: 8. Please verify affiliation of M.F.-V. (Sweden vs. Spain)

Q: 9. Please provide a departmental affiliation for affiliation "a" and provide a postal code for both affiliations.

Q: 10. Please provide an issue number for ref. 4, if applicable.