Case Study

Reconstructing diets of extinct primate species with the TRACER 5 handheld XRF to shed light on human evolution.

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Evolutionary anthropology is the study of the evolution of humankind as well as the evolution and biology of other modern, living primates. Humans are part of the primate family, grouped phylogenetically with apes. Consequently, studying the ecology and behavior of similar living primates can provide clues into our own evolutionary past.

Within primates, including human ancestors millions of years ago, a significant division exists between frugivores (those who eat fruit) and folivores (those who eat leaves). Frugivores tend to have larger brains, live in smaller social groups, be more hierarchical, have stronger and more aggressive dominance structures, and have more hours of activity and movement during the day compared to folivores.

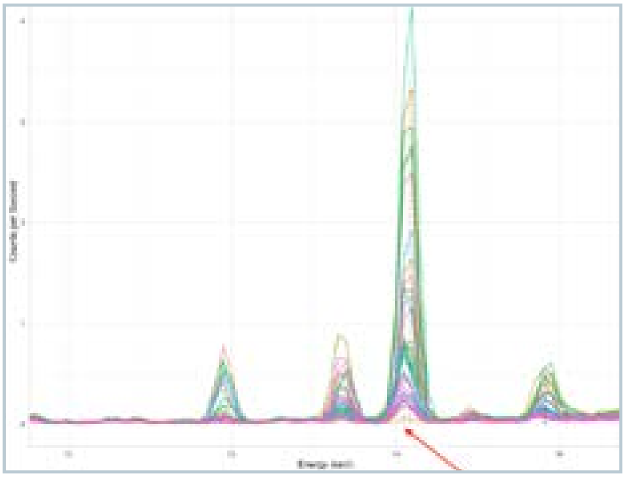
Brain size, social group dynamics, levels of aggression, and activity levels in fossil species from millions of years ago do not directly fossilize. Therefore, indirect proxies that imply or correlate with these features are needed to reconstruct them for extinct species. Diet is something we can find direct evidence for in the fossil record that correlates with these more invisible behavioral traits.

Dr. Marian Hamilton, author, at the University of Northern Colorado's Department of Anthropology was awarded a Bruker sponsored grant, including use of a TRACER 5 handheld XRF, to help expand her research.

How does Bruker's TRACER handheld XRF help reconstruct diets of extinct species?

Previous research demonstrated that folivorous primates in Uganda have higher strontium/calcium (Sr/Ca) ratios in their teeth and bones than frugivorous primates providing a method for dietary reconstruction. But before applying this model to fossil data, it's important to understand the ecological and physiological reason why this pattern exists, to ensure that we'd expect to see it everywhere and throughout time.

Since a TRACER handheld XRF can measure low levels of Sr and Ca in leaves, fruits, teeth, and bones, it is an ideal tool to use for reconstruction studies in remote locations.



2015 TRACER measurements of fruit and leaf samples for Sr at 14.165 keV show detection of levels as low as 0.4 ppm (brown line).

"Handheld XRF is a simple, inexpensive, safe, and nondestructive method to collect data at remote sites without having to transport floral and faunal material across national boundaries."

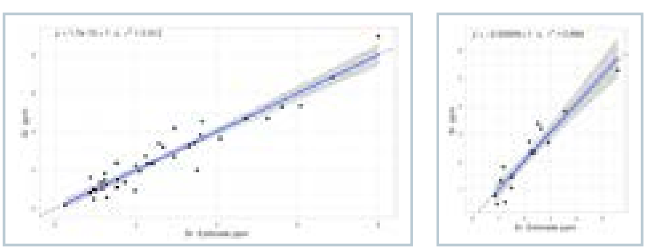
Dr. Marian Hamilton

Creating regressions for the analysis of strontium in fruits and leaves for a TRACER handheld XRF

In 2015, data were collected in Kibale National Park, a protected evergreen rainforest in southwest Uganda and home to the Kibale Chimpanzee Project. Its continuous canopy and fairly extreme topography has dense forest crisscrossed by small streams and large rivers.

Lab ICP-MS is the 'gold standard' for quantitative analysis; however, it's not scalable for large sample sets or field studies. Therefore, handheld XRF results needed to be correlated to ensure robust analytical performance.

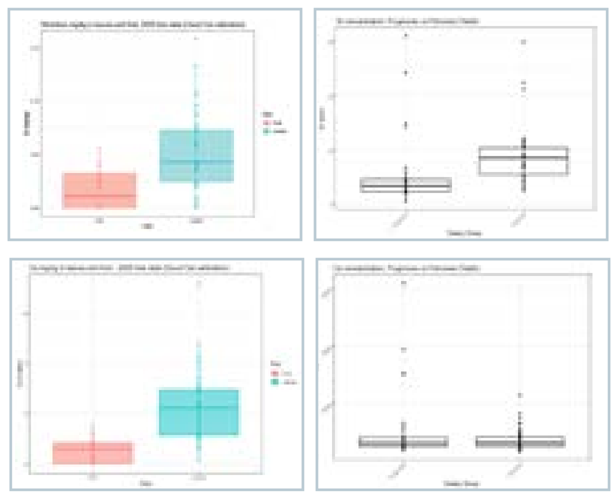
An initial regression was built to quantify Sr concentration using Cloud Cal, an open-source calibration software, resulting in a very respectable R^2 of 0.912. It was then cross-validated using 60% of the data to build the regression model which was then used to predict values of the remaining 40% randomly withheld data. The dotted line protruding at the top shows what a perfect one-to-one correlation would look like and the gray banded area shows a 90% confidence interval. TRACER data is robust.



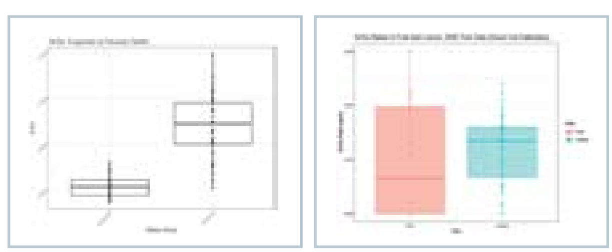
For our 2020 study, Ca data was also needed; so, a new regression was built measuring fruits and leaves from the same field site with a Tracer 5i and an optimized filter balancing sensitivity for both Ca and Sr. Quantification was based on a micronutrient plant calibration built from 40 plant standards assayed by ICP-MS from Uganda and elsewhere, with Lucus Tooth and Price (1961) method.

Results from Sr/Ca studies of fruits and leaves using the TRACER 5 handheld XRF

Data shows leaves have more Ca and Sr than fruit; and, folivores have more Sr than frugivores in their teeth, but have about the same amount of Ca.



Formation of hydroxyapatite, which makes up tooth enamel, takes up a set amount of Ca regardless of the quantity in food. However, Sr, a non-essential element, is taken up proportionate to what is in a food source. This physiological regulation on Ca coupled with the proportionate uptake of Sr leads to a difference in the Sr/Ca ratio which clearly differentiates fruit and leaf eaters, even though that ratio is not different in the foods themselves, thus providing an ecological basis for a pattern. It's all about the strontium!



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