

# Differentiating Frugivore and Folivore Diets using Sr/Ca Ratios and Non-Destructive XRF Analysis



M. HAMILTON<sup>1,2</sup>, S.V. NELSON<sup>2</sup>, AND B. LEE DRAKE<sup>2</sup>

<sup>1</sup>UNIVERSITY OF NORTHERN COLORADO <sup>2</sup>UNIVERSITY OF NEW MEXICO



## ABSTRACT

This pilot study uses non-destructive X-ray fluorescence (XRF) to compare the strontium and calcium concentration ratios (Sr/Ca) in tooth enamel from 6 primate species in Kibale National Park, Uganda.

Our data show that primates with a folivorous dietary preference have higher Sr/Ca ratios than frugivores primates.

Quantified strontium concentrations in fruits and leaves from trees in Kibale National Park show that leaves have much higher Sr concentration than fruit, explaining the pattern observed in the primates.

These data establish a reliable, non-destructive methodology for determining folivory vs frugivory in both contemporary and fossil species.

## INTRODUCTION

Strontium is a non-essential element that has an ionic radius similar to calcium. Mammals discriminate against strontium in the formation of bioapatite and other tissues. Sr/Ca ratios in carnivores are therefore decreased relative to herbivores within a food chain (Blum et al 2000).

Within plants themselves, roots and underground storage organs have higher Sr/Ca ratios than leaves and fruit due to discrimination during xylem transport (Burton et al 1999, Sillen et al 1995).

Interest in radioactive strontium absorption led to a few early studies comparing strontium uptake in leaves versus fruiting bodies, showing a steep drop in the concentration of strontium found in fruits compared to leaves (Haghini 1964, Rao 1979). However, this latter observation has not yet been applied to dietary reconstructions.

Kibale National Park is an evergreen rainforest in southwestern Uganda. It is home to numerous communities of chimpanzees as well as many other primates and non-primate fauna.

## MATERIALS AND METHODS

Tooth enamel element concentrations were measured in situ on skeletal collections housed with the Kibale Chimpanzee Project, using a S1 Titan 800 handheld XRF unit (Bruker Nano) and quantified using the Rowe et al 2012 calibration.



Leaves and fruit were collected by S. Nelson and M. Hamilton during field seasons in summer 2014 and 2015. Samples were dried within 24 hours of collection using a Nesco food dehydrator and later manually homogenized. The strontium concentrations for each sample were measured using a Tracer 3 SD (Bruker Nano).

## CONCLUSIONS AND DISCUSSION

This method to assess folivory vs. frugivory could add greatly to debates in primate evolution:

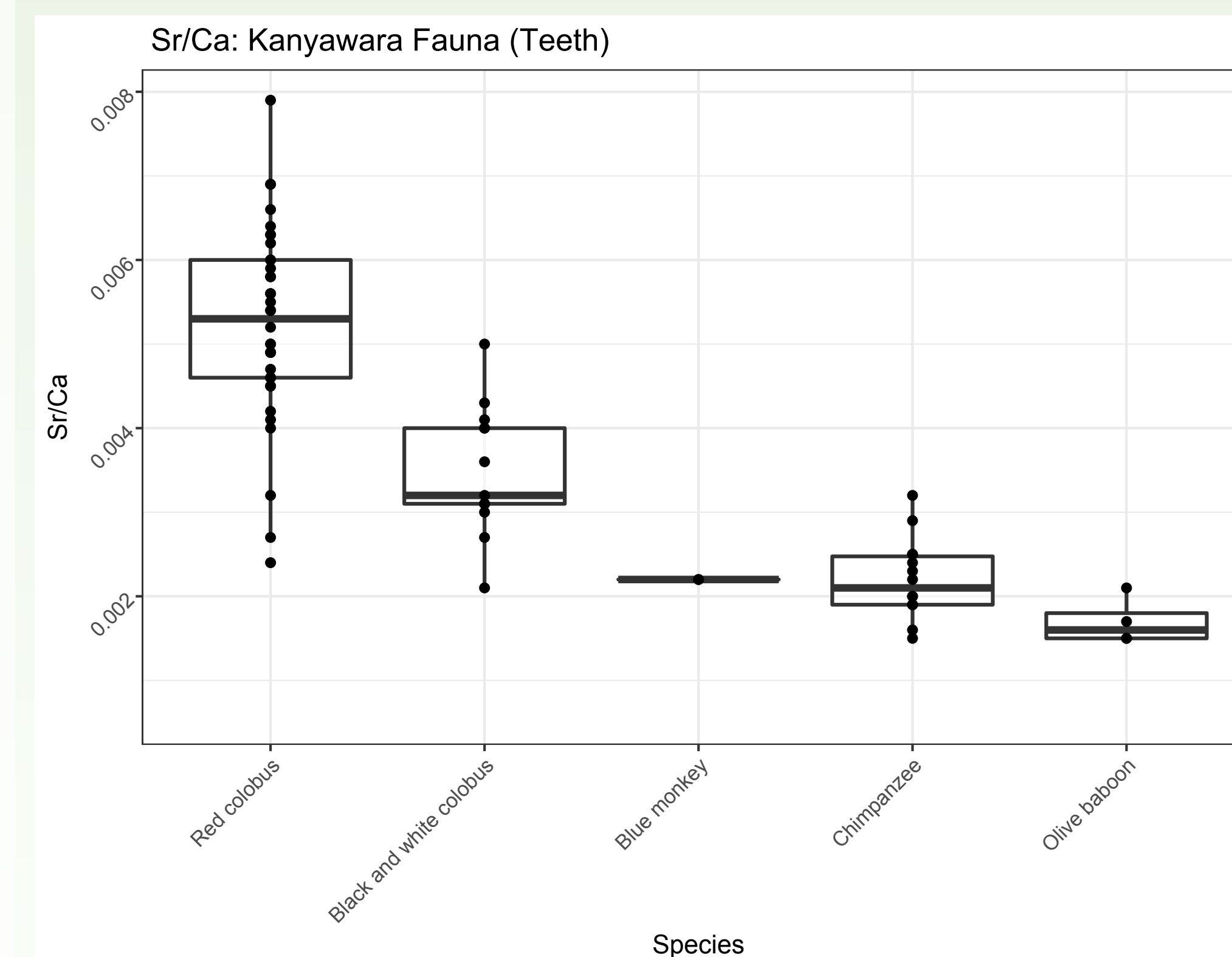
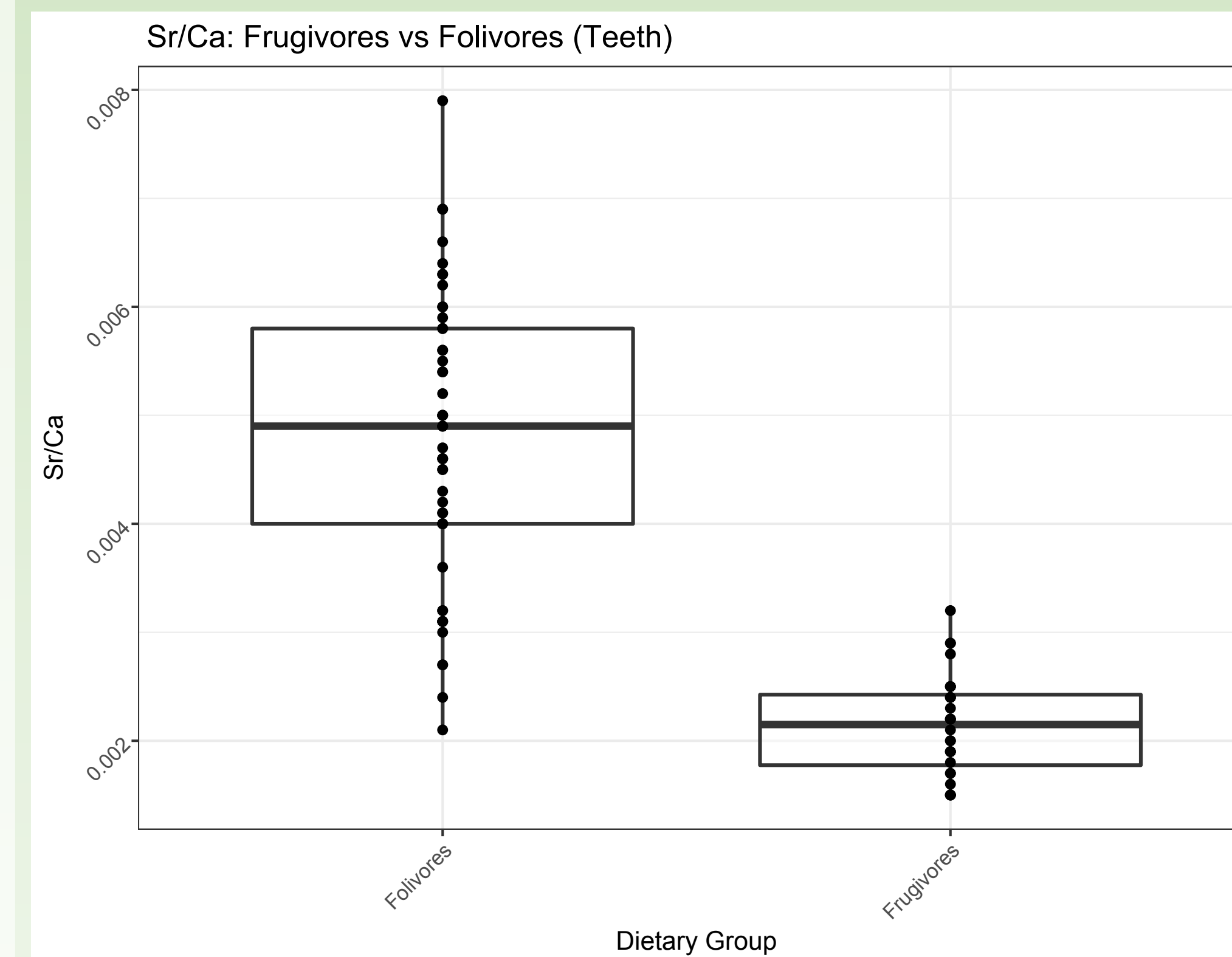
1. Was the first primate radiation due to exploiting arboreal insects or fruits with the radiation of angiosperms?
2. What were the diets of earliest catarrhines before a clear split of colobines and cercopithecines?
3. For Miocene apes, when tools such as stable isotope analyses allow us to place apes into specific habitats, what was degree of reliance on fruits vs. leaves within those habitats?

Future studies should examine the Sr/Ca ratio of underground storage organs and animals who rely on them. They should have significantly higher strontium concentrations than fruits or leaves; tissues of animals reliant on them should have higher Sr/Ca ratios than frugivores or folivores. These items may have played an important role in hominin evolution and identifying their utilization in fossil hominins would be beneficial.

Handheld XRF analysis is an accurate, non-destructive way to reconstruct degree of frugivory in fossil primate diets. In modern contexts, elements preserved in other tissues (ex: Rb/P in hair or feces) compliment Sr/Ca data for a more detailed picture.

## RESULTS AND CONCLUSIONS

Tooth enamel measurements show that folivore Sr/Ca ratios are significantly higher than frugivore ratios (Student's t-test,  $p < 0.001$ ; frugivore mean Sr/Ca ratio = .002,  $N=29$ ; folivore mean Sr/Ca ratio = .005,  $N=49$ ):

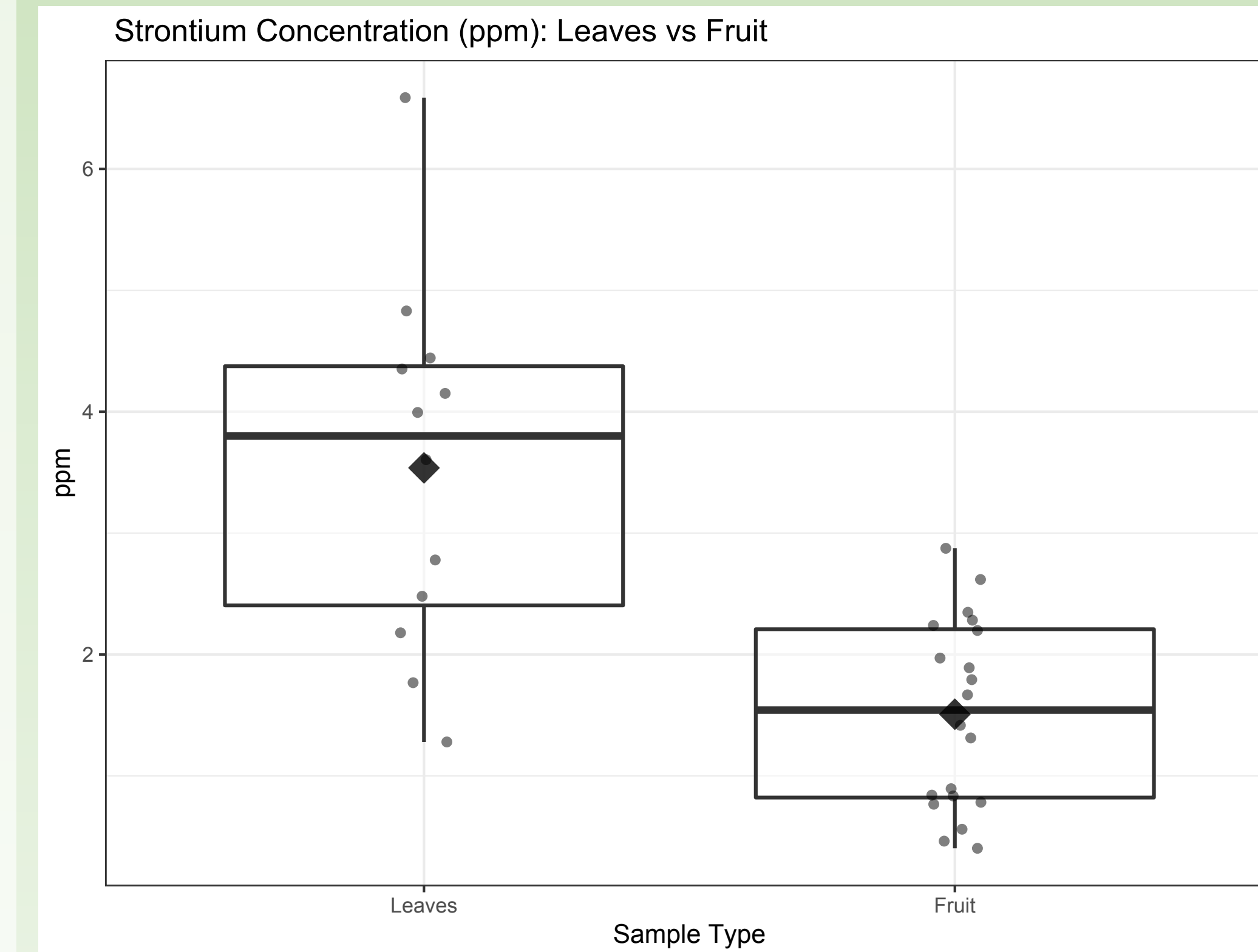


## REFERENCES

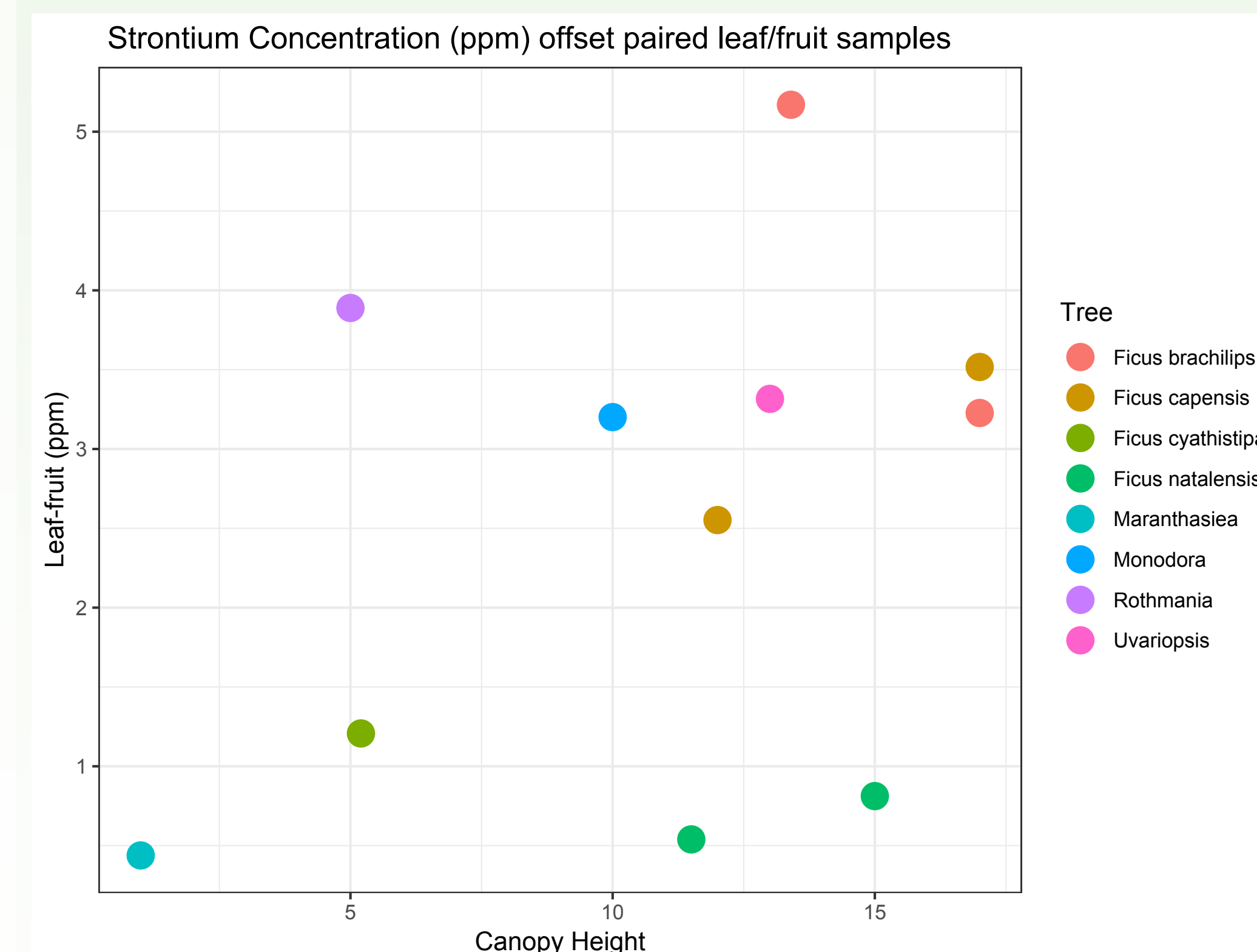
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## RESULTS AND CONCLUSIONS (CONT)

Strontium concentrations in fruit are significantly lower than strontium concentrations in leaves (Student's t-test,  $p < 0.01$ ,  $n=32$ ):



8 trees included paired fruit and leaves sampled from canopy heights between one and 17 meters above the forest floor. Strontium concentration and fruit-leaf offsets were not impacted by canopy height:



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