Life on the edge: New tools to track animal-forest trophic interaction across intact to degraded ecosystems

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INTRODUCTION

- Lemur-forest trophic interactions can be monitored through organic geochemical analysis of lemur faeces.
- Collection and testing of faecal material has many advantages as it requires no contact between the lemur and the collector, and therefore provides no disruption or stress to the subject lemur/s.
- To test the robustness of these techniques in this application, samples from captive lemurs with known diets were sampled.
- Three subject species were tested, each representing a different common lemur feeding strategy:

Black-and-white ruffed lemur

FRUGIVORE /FRUIT EATER

Ring-tailed lemur

OMNIVORE

Coquerel's sifaka

FOLIVORE /LEAF EATER

AIMS

1. **Determine the effectiveness of faecal organic biomarkers in determining the diets of captive lemurs.**
2. **Assess trophic interactions through faecal biomarker content and stable isotopic compositions.**
3. **Apply these techniques to wild lemurs in combination with observational techniques to assess the effectiveness in wild subjects.**

IMPORTANCE

- Malagasy forest health and lemur activities go hand in hand. Lemurs provide essential ecosystem services such as seed dispersal, pollination and nutrient cycling, owing to the wide variety of niches they occupy.
- Due to the close relationship between lemurs and their habitat, forest degradation and lemur loss from anthropogenic activities result in a destructive positive feedback loop that will only increase and reach irreversible levels if they continue as they are.
- **There is no healthy Malagasy forest without lemurs to maintain it, and 94% of lemur species are listed as threatened.**
- Through the tracking of lemur dietary changes within these degraded forests, we can track current and future forest health and function in the face of decline.

METHODS

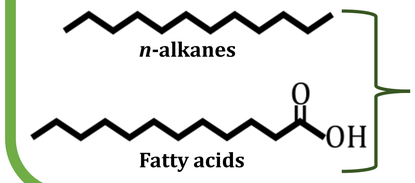
How have the diets of lemurs been determined in the past?

- Previously, behavioural observation has been used to document and monitor lemur diets. This is expensive and labour-intensive work to undertake, and essential information is often missed or misinterpreted.

Geochemical faecal analysis

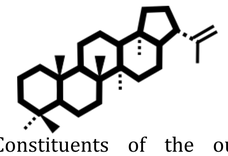
- Can provide information on not only diet, but also gut microbiota and processes, and therefore animal health. It also provides information on the processes acting within the ecosystem.
- Primarily used in palaeoclimate studies, these molecules are perfect for faecal analysis because, if they can survive in sediments for millions of years, they will survive passage through the gut.

TARGET BIOMARKERS:



Leaf and fruit wax constituents

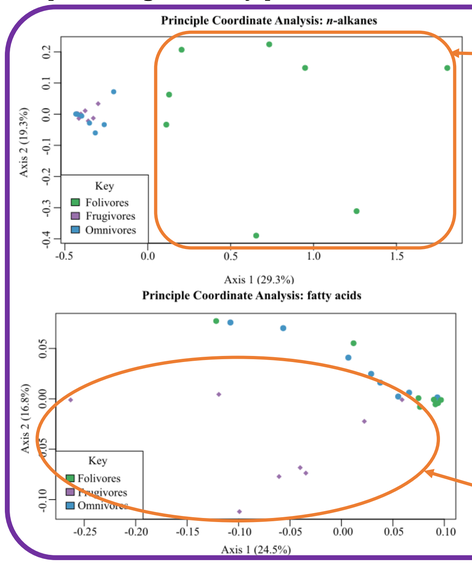
Hopanoids



Constituents of the outer membrane of Gram-negative bacteria

INITIAL RESULTS AND CONCLUSIONS

- A pilot study comprising 24 faecal samples was carried out to determine the effectiveness of these simple biomarkers in providing a dietary profile.



Clear separation of the folivores here by *n*-alkane signatures.

→ These biomarkers show promise in differentiating lemur feeding strategies from one another. These results also demonstrate that a degree of individual preference can be deciphered.

Clear separation of the frugivores by fatty acid profile.

→ A hopane, methyldiploptene, was identified and indicates gut methanotrophy when present. This compound shows promise in indicating levels of folivory within lemur groups.

→ Additionally, compound richness provides an indication of dietary diversity. This could be a good measure of a lemur species' flexibility to changes in food supply and habitat resulting from degradation and climate change.

FUTURE WORK

- Conduct a larger study investigating a greater number of compounds and paired with isotopic data.
- Apply faecal biomarker profiles of captive lemur populations to those of wild lemurs.
- Developing an experiment using stable isotope labelled plants as a marker to determine gut transit time.
- Testing of known captive diet food elements to decipher results.

REFERENCES:
Dove, H., Mayes, R.W. & Freer, M. 1996. Effects of species, plant part, and plant age on the n-alkane concentrations in the cuticular wax of pasture plants. *Australian Journal of Agricultural Research*, **47**, 1333-1347; Gaines, S.M., Eglinton, G. & Rullkotter, J. 2008. *Echoes of Life: What Fossil Molecules Reveal about Earth History*. Oxford University Press: Oxford; Colles, A., Liow, L.H. & Prinzing, A. 2009. Are specialists at risk under environmental change? Neoecological, paleoecological and phylogenetic approaches. *Ecology Letters*, **12**, 849-863; Quéméré, E., Hibert, F., Miquel, C., Lhuillier, E., Rasolondraibe, E., Champeau, J., Rabarivola, C. *et al*. 2013. A DNA Metabarcoding Study of a Primate Dietary Diversity and Plasticity across its entire Fragmented Range. *PLoS One*, **8**(3); Estrada, A., Garber, P.A., Rylands, A.B., Roos, C., Fernandez-Duque, E., Di Fiore, A., Nekaris, K.A., *et al*. 2017. Impending extinction crisis of the world's primates: Why primates matter. *Science Advances*, **3**; McKenney, E.A., O'Connell, T.M., Rodrigo, A. & Yoder, A.D. 2018. Feeding Strategy shapes gut metagenomic enrichment and functional specialization in captive lemurs. *Gut Microbes*, **9**(3), 202-217; Greene, L.K., Williams, C.V., Junge, R.E., Mahefarisoa, K.L., Rajaonarivelo, T., Rakotondrainibe, H., O'Connell, T.M. & Drea, C.M. 2020. A role for gut microbiota in host niche differentiation. *The ISME Journal*, **14**, 1675-1687

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