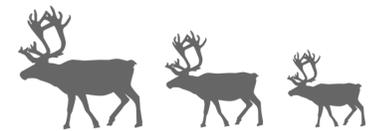


Wisdom from the teeth: What reindeer were eating during the Late Pleistocene



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1) Reindeer are known to be flexible feeders...

- Reindeer (*Rangifer tarandus*, Linnaeus, 1758) are considered to show **dietary plasticity**, i.e. the adaptation of diet based on local vegetation availability.
- During the Pleistocene, **abrupt** climate changes produced **rapidly changing** environments.
- This study compares **Pleistocene reindeer** diet using **teeth** recovered from two levels at Gully Cave in Somerset and **3** other **contemporary** sites in Britain, spanning around 60,000-11,500 years ago, with average summer temperatures between **8°C and 11°C**, and between **-16°C and -22°C** in winter.

2) And we can use dental wear analysis to determine their Pleistocene diet...

Dental Mesowear Analysis

How: Judging **sharpness** and **relief** of tooth cusp apex by eye, scoring from 0 (sharp) to 6 (blunt). Tooth cusps are made **blunt** by **grazing**, but kept **sharp** by **browse** feeding.

Timespan of diet observed: months-year before death

Dental Microwear Analysis

How: Microscopic analysis of the **tooth enamel surface**, and quantifying the different types of scars left by food items. **Scratches** are indicative of **grass** feeding, **pits** are indicative of **browse** feeding.

Timespan of diet observed: hours-days before death

3) It shows reindeer may alter diet due to local environmental factors...

Dental Mesowear Results

Site	Mesowear average	Grazing signal	Do long and short term diets match?
Gully Cave	1.56	Less grass More grass	80%
Church Hole	2.0		50%
Pin Hole	2.0		90%
Wookey Hole	2.43		57%

- **Mesowear** score indicates in the few months before death, the deer ranged from **browse dominated mixed feeders** (Gully Cave) to **mixed feeders** (Church Hole, Pin Hole and Wookey Hole).
- The **stronger consistency** between mesowear and microwear results of Pin Hole and Gully Cave indicates the reindeer were eating their **usual** diet at time of death and these sites.

Dental Microwear Results

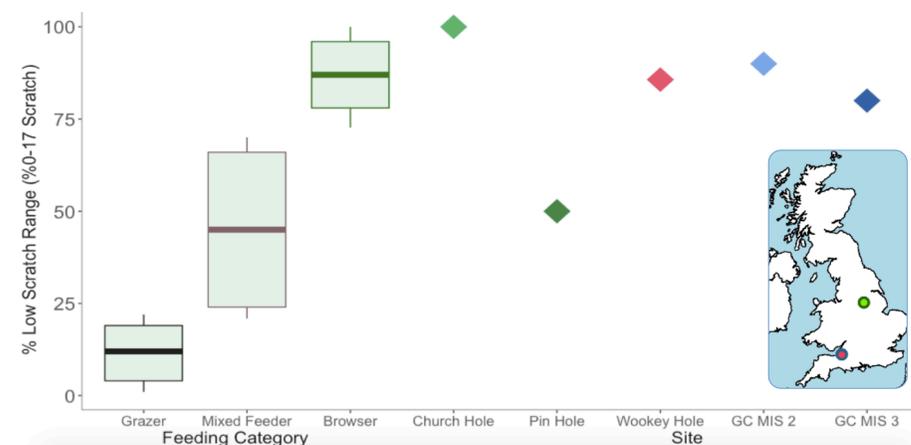


Figure 1 Indications of reindeer diet using low scratch scores at various sites, compared to feeding categories of modern ungulate taxa.

- Assemblages with **many** individuals (i.e. 75-100% of individuals in a group) showing a **low** scratch score (y-axis) is indicative of a group of **browsers**.
- Here, we can see reindeer were mostly browsing in the few days before death, however at Pin Hole, they are classed as **mixed-feeders**, eating both browse and grasses in more equal quantities.

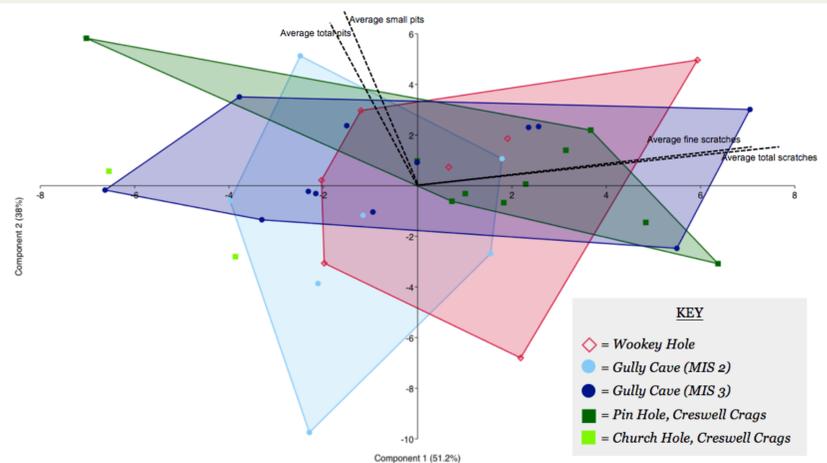


Figure 2 PCA of Wookey Hole, Gully Cave, Pin Hole and Church Hole reindeer, showing the range of microwear scores at different sites, indicating subtle shifts in diet.

- The **convex hulls** (shaded shapes) can be considered as the **niche** of the species at a site.
- The PCA shows that the niches of the reindeer were **variable** depending on site.
- For example, Wookey Hole reindeer had a **wide range of pits** (y-axis) whereas the Gully Cave reindeer during MIS 3 had a **wide range of scratches** (x-axis).

4) What might have caused these patterns?

Geographic, competitive and ontogenic influences on diet

- The more similar **average** diets of deer at Wookey Hole and Gully Cave (Figure 1) compared to more **distant** sites (Pin Hole and Church Hole at Creswell Crags), may indicate that the prevailing flora in the area could have **influenced** their dietary choices.
- However, the **variation** in the **spread** of microwear scores (Figure 2) could indicate these individuals are showing microwear from **different seasons**, or that other factors influenced their diet, such as **competition** from other herbivores.
- Juvenile reindeer with a **winter** season of death had **higher** pit numbers and gouges, characteristic of **lichen** feeding.

5) Why is this important?

- This adaptation may allow reindeer to tolerate various environments and occupy different **niches** depending on the dietary patterns of **other** sympatric herbivores, allowing them to adapt to the **changing environments** of the Pleistocene.
- These results not only shed light on the nature of the local vegetation of a site (particularly important since palaeobotanical proxies are **rarely preserved** in caves) but also highlight the **resilience** of the species to **current** environmental change.

With thanks to:

- Fortelius, M. and Solounias, N. (2000). Functional Characterization of Ungulate Molars Using the Abrasion-Attrition Wear Gradient: A New Method for Reconstructing Paleodiets. *American Museum Novitates*, **3301**, 1-36.
- Rivals, F. and Lister, A. (2016). Dietary flexibility and niche partitioning of large herbivores through the Pleistocene of Britain. *Quaternary Science Reviews*, **146**, 116-133.
- Solounias, N. and Semperebon, G. (2002). Advances in the Reconstruction of Ungulate Ecomorphology with Application to Early Fossil Equids. *American Museum Novitates*, **3366**, 1-49.
- Reindeer photo for background – Unsplash.com. Free to use under the Unsplash License. Credit @Febiyanr



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