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Griffith, Jacob; James, Hannah; Cheung, Christina; Snoeck, Christophe

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Data Article

Incremental enamel and dentine isotopic data of faunal remains from the United Kingdom



Jacob I. Griffith^{a,b,*}, Hannah F. James^{a,b}, Christina Cheung^{a,b},
Christophe Snoeck^{a,b}

^a Research Unit: Analytical, Environmental & Geo-Chemistry, Department of Chemistry, Vrije Universiteit Brussel, Belgium

^b Maritime Cultures Research Institute, Department of Art Sciences and Archaeology, Vrije Universiteit Brussel, Belgium

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ABSTRACT

This paper collates previously published data from incremental isotopic studies performed on faunal remains found within the modern boundaries of the United Kingdom (UK). The dataset represents a complete collection of zooarchaeological incremental data from the UK, consisting of 1,092 data points, obtained from 152 faunal specimens from 20 archaeological sites, dating from 7960 BC to AD 1300. 59 of these values are from incrementally sampled dentine and present stable carbon and nitrogen isotope ratios ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$). The remaining 1,053 values are from incrementally sampled enamel, and present strontium ($^{87}\text{Sr}/^{86}\text{Sr}$, $n = 193$), and/or stable carbon and oxygen isotope ratios ($\delta^{13}\text{C}$ and $\delta^{18}\text{O}$, $n = 860$). This dataset is a convenient resource for future researchers, enabling comparisons based on faunal species, time, and geographical location. Further, the dataset acts as a mechanism for researchers to investigate the variety of incremental sampling methodologies (enamel and dentine) which have been applied to faunal remains across the United Kingdom. For ease of access, this dataset has been deposited on the open-access platform IsoArch (<https://isoarch.eu/>).

* Corresponding author.

E-mail address: jacob.griffith@vub.be (J.I. Griffith).

Social media: [@JBioarch](#) (J.I. Griffith), [@ToothDetective](#) (H.F. James), [@chris_tt_cheung](#) (C. Cheung), [@Christophe_Fire](#) (C. Snoeck)

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Specifications Table

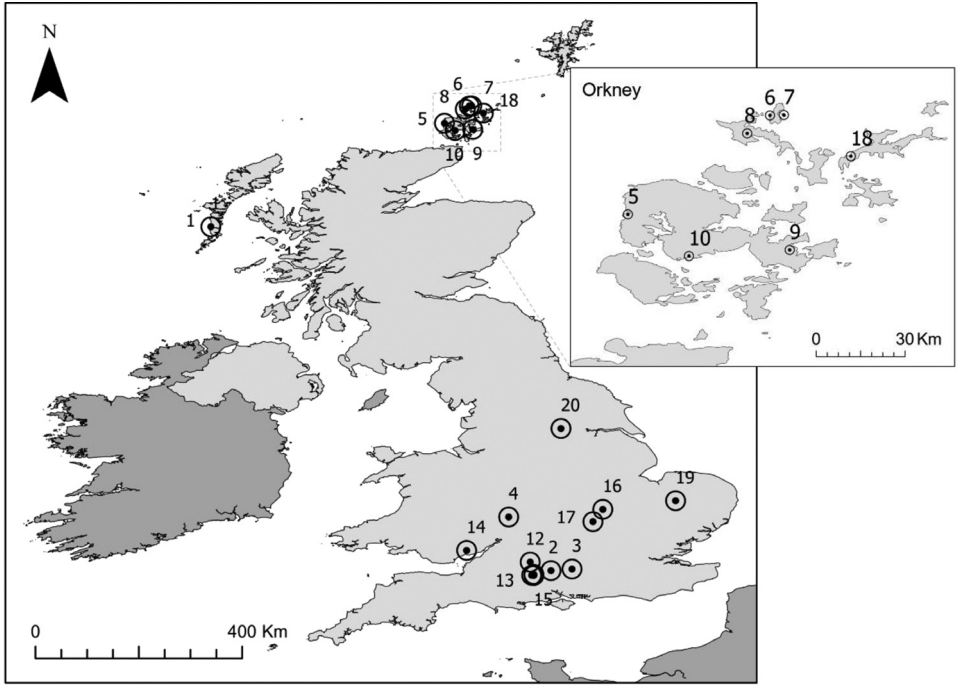
Subject	Social Sciences – Archaeology
Specific subject area	Sequential isotope analysis Incremental Enamel Sampling Incremental Dental Sampling Animal Collagen (dentine) Animal Bioapatite (enamel) Stable carbon Isotope analysis Stable nitrogen Isotope analysis Stable oxygen Isotope analysis Strontium Isotope analysis Animal Husbandry
Type of data	Tables Figures
How data were acquired	Collated from published articles and book chapters.
Data format	Raw
Parameters for data collection	Carbon and nitrogen isotopic data, taken from dentine collagen samples, were only included if the results were reported alongside atomic C/N ratios. Further, carbon and nitrogen isotopic values were only included if these fell within the following established parameters; %C between 15.3% and 47%; %N between 5.5% and 17.3%; and atomic C/N ratio between 2.9 and 3.6 [1–4]. Carbon and oxygen isotopic signatures, acquired from enamel bioapatite carbonates, have been inputted with their standard deviation value, where available. Strontium isotopic data is published alongside the SRM NBS 987 value used for their normalization and, where available, their 2SE value and their Sr concentration (ppm).
Description of data collection	A comprehensive literary review was conducted using Google Scholar, and included data published up until September 2021.
Data source location	This dataset consists of the previously published isotopic values of 152 animals which have had their enamel and/or dentine sequentially sampled. A total of 1,092 data points, from 206 teeth, including both entire isotopic sequences and average values (depending on how the source authors published their original data). 59 of these values are taken from incrementally sampled dentine and present stable carbon and nitrogen isotope ratios ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$). The remaining 1,053 values have been acquired from incrementally sampled enamel, and present strontium ($^{87}\text{Sr}/^{86}\text{Sr}$, $n=193$), and/or stable carbon and oxygen isotope ratios ($\delta^{13}\text{C}$ and $\delta^{18}\text{O}$, $n=860$). The dataset only includes incrementally sampled faunal remains uncovered in archaeological contexts from the United Kingdom. A total of 20 archaeological sites have been included, visualised in Table 1 and displayed in Figure 1. Details on the original data sources can be found in Table 1.
Data accessibility	This dataset is deposited in IsoArch [5] (www.isoarch.eu) with the following digital object identifier (DOI): https://doi.isoarch.eu/doi/2021.014 Data identification number: 10.48530/isoarch.2021.014 Data is available under the Creative Commons BY-NC-SA 4.0 license.

Value of the Data

- The dataset presents all published incremental isotopic measurements from archaeological faunal remains ($n = 152$) from the UK. It highlights the growing importance of such type of analyses and represents the first collection of measurements from incrementally sampled enamel and dentine introduced in the IsoArch database [5].
- This dataset is of value to archaeologists and ecologists that are investigating incremental isotope sampling methodologies, climate [6], ethology [7,8], and past animal-human interactions [9,10].
- This dataset provides researchers with a reference point of all the currently published incremental isotopic analysis onto faunal remains in the United Kingdom, straightforward comparisons with their current research. Parallels between both results and archaeological interpretation can be made, based upon species, time period, and geographical location.
- This paper further highlights the differing incremental enamel and dentine sampling methodologies that are currently published, giving researchers a platform to review which technique may be the most appropriate for their intended samples and research questions.

1. Data Description

This data collection consists of 1,092 data points; representing 152 faunal individuals (114 Cattle, 2 Horses, 31 Sheep, 1 Pig, and 1 Dog), and 206 sampled teeth, which have had their enamel and/or dentine incrementally sampled. Fifty-nine of the data points are from dentine collagen, and present stable carbon and nitrogen isotope ratios ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$). The remaining 1,053 values are tooth enamel bioapatite samples, and present strontium ($^{87}\text{Sr}/^{86}\text{Sr}$, $n=193$), and stable carbon and oxygen ratios ($\delta^{13}\text{C}$ and $\delta^{18}\text{O}$, $n= 860$). The data has been collected from 15 previously published peer-reviewed journal article and book chapters. This dataset only includes incrementally sampled archaeological faunal remains from within the modern borders of the United Kingdom. A total of 20 sites are included within the dataset, with their geographical location displayed in Fig. 1. The dataset was inputted into a excel (.xlsx) file and deposited on the open-access data platform IsoArch [5], DOI: <https://doi.isoarch.eu/doi/2021.014>. Within the excel file, spreadsheets 'human_bio' and 'human_funerary' have been intentionally left blank, as no isotopic values from human tissue have been included in the dataset. Table 1 summarises the included archaeological sites; faunal species, number of individuals analysed, and the dentine or enamel sampling methodology.



- | | | |
|---|---|------------------------------|
| 1. Bornais (<i>Bornish</i>), Scotland | 8. Point of Cott, Scotland | 14. Caerleon, Wales |
| 2. Bury Hill, England | 9. Mine Howe, Scotland | 15. Blick Mead, England |
| 3. Rooksdown, England | 10. Earl's Bu, Scotland | 16. Irthlingborough, England |
| 4. Worcester (The Hive), England | 11. Durrington Walls, England | 17. Gayhurst, England |
| 5. Skara Brae, Scotland | 12. West Kennet Palisade Enclosure, England | 18. Pool, Scotland |
| 6. The Knap of Howar, Scotland | 13. Stonehenge, England | 19. Grimes Graves, England |
| 7. Holm of Papa Westray, Scotland | | 20. Ferry Fryston, England |

Fig. 1. Map of the United Kingdom displaying all sites included in this collection. Numbers (1-20) reference Site IDs, given in detail in [Table 1](#).

Table 1

Summary of site IDs, site names and locations, references, time periods, species and number of specimens incrementally analysed, and if the dentine and/or enamel was sampled. Site IDs correspond with the numbers presented on Fig. 1. S and P in enamel columns refer to the sampling technique used to extract increments, P=powdered, S= Sliced (see section: 2.1). In the dentine column a citation is given to the methodology used for incremental sampling, *= adapted from. N/A= Sampling protocol was not stated in the publication.

Site ID	Site	Location (Modern)	Time Period	Species					No. of Individuals	Enamel ($^{87}\text{Sr}/^{86}\text{Sr}$)	Enamel ($\delta^{13}\text{C}$ & $\delta^{18}\text{O}$)	Dentine ($\delta^{13}\text{C}$ & $\delta^{15}\text{N}$)
				Cattle	Horse	Sheep	Pig	Dog				
1	Bornais (<i>Bornish</i>) [10,11]	Scotland	1000-1400AD	X					5		P	[11]
2	Bury Hill [12]	England	400-100BC		X				1	S		
3	Rooksdown [12]	England	400-100BC		X				1	S		
4	Worcester [13]	England	100-300AD	X					6	P	P	
5	Skara Brae [14]	Scotland	3400-2500BC	X		X			15		P	
6	The Knap of Howar [15]	Scotland	3600-3500BC	X		X			9		P	
7	Holm of Papa Westray [15]	Scotland	3000-2900BC			X			6		P	
8	Point of Cott [16]	Scotland	3000-2000BC			X			3		P	
9	Mine Howe [16,17]	Scotland	400-100BC			X			6		P	
10	Earl's Bu [16]	Scotland	900-1000 AD			X			3		P	
11	Durrington Walls [18, 19]	England	2000-1600BC	X					62	S	S	
12	West Kennet Palisade Enclosure [18]	England	~3300BC	X					4	S	S	
13	Stonehenge [18,20]	England	3340-2920 BC	X					1	S	S	
14	Caerleon [21]	Wales	90-600 AD	X			X		7	N/A	N/A	
15	Blick Mead [22]	England	7960-4045 BC					X	1			[26]*
16	Irthlingborough [23]	England	~2000BC	X					5		S	
17	Gayhurst [23]	England	~2000BC	X					5		S	
18	Pool [17,24]	Scotland	800-950AD	X					6		S	
19	Grimes Graves [17]	England	~1100BC	X					5		S	
20	Ferry Fryston [25]	England	400-100AD	X					1	S		

2. Experimental Design, Materials and Methods

2.1. Incremental sampling

Incremental (also known as “sequential” or “serial”) isotope analysis follows the principle that mammalian dental tissues (enamel and dentine) form in a chronological sequence [26]. By taking incremented samples along these tissues’ axes of growth, stable isotope ratios specific to chronological points in an individual’s life can be identified [10]. As a result, the approach can produce time-series isotopic data, allowing researchers to reconstruct and examine how they may fluctuate over (part of) the life of an animal.

In principle, these techniques can be applied to the majority of mammals (i.e., kangaroo [8], domestic dogs [22], human [27–28]). However, the most common subjects are domesticated mammals, predominantly those with hypsodont molars — high crowning teeth that mineralise over a longer period, subsequently giving an elongated isotopic timeline (e.g. cattle, sheep) [29]. Following eruption patterns, inter-tooth analysis of an individual can be performed on succeeding hypsodont molars, allowing for an extended isotopic timeline to be produced [30]. The reconstruction of a high-resolution isotopic timeline over a substantial period allows for a determination of how domestic faunas’ diets and geographical locales may change on an annual cycle [31]. As such, these methodologies hold a great potential to create a detailed reconstruction of past husbandry systems, and how they may seasonally change.

Illustrated in Table 1, there are a variety of sampling methodologies that have been constructed to sample either enamel or dentine increments. Currently, in the United Kingdom, the majority of published incremental sampling studies have focused on enamel, and as such strontium, carbon and oxygen isotopic biographies. The methods to sample increments vary between researchers, studies, and sampled fauna, but can generally be split into two broad sampling categories: powder sampling (P) and slice sampling (S) (Table 1). Powder sampling, based originally upon Balasse 2002 [32], uses a hand drill to extract small, powdered enamel samples along the growth axis. Sliced sampling removes solid portions of enamel along the growth axis, with either a scalpel or a saw. Often, the entire crown is cut, including dentine, and then the enamel is removed [25]. Both techniques hold their advantages; powdered sampling leave the dentine core in-tact for future analysis, whereas sliced sampling produces more enamel increments. A preference can be made by the researcher, and what their intended aims are, or what their tooth samples may limit them to. For example, Griffith and Mulville [10] elect to used powdering enamel sampling on their five cattle, to maintain the dentine core for further incremental dentine analysis. Whereas Evans *et al.* 2019 [18], elect to perform the slicing methodology to obtain enough material for both strontium isotopic analysis and carbon and oxygen isotopic analysis.

Incremental dentine sampling is notably less frequent in zooarchaeology than its enamel counterpart, in both the United Kingdom, and the international field [11]. Of the two studies included in this dataset [10,22], both methodologies are drastically different, as they are applied to teeth with notably different morphology. Though some sampling protocols have been published for specific animals (i.e cattle: Zazzo *et al.* 2006 [33]), it is only with increased application that more specific protocols will be produced, that are better suited for specific species with different tooth morphologies.

Our data collection highlights that researchers will often adapt the basic principles of these analyses to their research questions and limitations, be that: species, tooth type, and how higher resolution isotopic biography they wish to produce. This paper encourages researchers to review the referenced papers, to understand what the best methodology would be for their own specimens and research aims.

2.2. Data collection

Data were collected using the academic search engine ‘Google Scholar’ (<https://scholar.google.com>), using the keywords “incremental isotopic analysis”, “sequential isotopic analysis”, “enamel”, “dentine”, “United Kingdom”, “zooarchaeology”. Concurrently, data were also collected through professional correspondence with colleagues. Search results included peer-reviewed journal articles and book chapters. With the ever-increasing application of incremental methodologies on faunal remains, this data set is inclusive of all the publications published until September 2021, to the best of the authors’ knowledge. This dataset focused on incrementally analysed animal dentition which were uncovered from archaeological contexts, as such, publications that concern modern specimens were excluded from the dataset. Further, isotopic data was only included for faunal remains found within the contemporary countries and borders of the United Kingdom. This dataset will enable comparisons of sampling techniques, results, and interpretation based upon faunal species, technological period, and geographical location.

Regarding the dentine collagen isotopic values included within this dataset, all $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values have been published with their respective atomic C/N ratios. Further, all incremented dentine samples had atomic C/N ratios between 2.9 and 3.6, confirming *in vivo* collagen signals, rather than being affected by post-depositional alterations [1].

For carbon ($\delta^{13}\text{C}$) and oxygen ($\delta^{18}\text{O}$) isotopic values acquired from enamel increments, the standard deviation has also been inputted where available. Oxygen isotopic values have been reported to either the VPDB and V-SMOW standards, and are presented in our dataset in their original format with the indicated standards. Strontium ($^{87}\text{Sr}/^{86}\text{Sr}$) values taken from enamel increments have been reported alongside the SRM NBS 987 value used, 2SE value (if published), and, where available, their Sr concentrations (ppm).

It is generally accepted that collagen isotope compositions do not vary depending on extraction protocols [34]. The same can be said for the extraction for strontium isotopes. However, studies have shown that different pre-treatment protocols impact the carbon and oxygen isotope ratios of bioapatite carbonates differently [35–36]. As such, one should be careful when comparing data obtained from samples pre-treated in different ways. The pre-treatment methodologies for all studies included in this dataset are available in the original sourced reports. Regardless, the relative values and general isotopic trends observed within, and between, individual teeth should remain valid.

Lastly, this dataset aimed to include the isotopic values of every increment that had been analysed within each study. In some publications, only the mean [14–15,21] or maximum [16] of the isotopic sequence has been published. In these circumstances, instead of the entire incremented sequence being recorded into the dataset, only the mean/max value is included.

Ethics Statement

This study does not involve any modern human or animal subject.

CRedit Author Statement

Jacob I. Griffith: Conceptualization, Project Administration, Methodology, Data Curation, Investigation, Visualization, Writing (Original Draft). **Hannah F. James:** Visualization, Writing (Review & Editing). **Christina Cheung:** Writing (Review & Editing). **Christophe Snoeck:** Supervision, Funding acquisition, Writing (Review & Editing).

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships which have or could be perceived to have influenced the work reported in this article.

Data Availability

[Incremental Enamel and Dentine Isotopic Data of Faunal Remains from the United Kingdom \(Original data\)](#) (IsoArch).

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