Journal of Archaeological Science: Reports xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Journal of Archaeological Science: Reports

journal homepage: www.elsevier.com/locate/jasrep

IsoArcH.eu: An open-access and collaborative isotope database for bioarchaeological samples from the Graeco-Roman world and its margins

Kevin Salesse[a,b,*], Ricardo Fernandes[c,d,*], Xavier de Rochefort[e], Jaroslav Brůžek[b,f], Dominique Castex[b], Élise Dufour[g]

[a] Université Libre de Bruxelles, Unité d'Anthropologie et de génétique humaine, CP192, Avenue F.D. Roosevelt 50, 1050 Bruxelles, Belgique
[b] Université de Bordeaux, CNRS, UMR 5199: "PACEA - De la Préhistoire à l'Actuel: Culture, Environnement et Anthropologie", bâtiment B8, allée Geoffroy St. Hilaire, CS 50023, F-33615 Pessac cedex, France
[c] Max Planck Institute for the Science of Human History, Kahlaische Strasse 10, D-07745 Jena, Germany
[d] McDonald Institute for Archaeological Research, University of Cambridge, Cambridge CB2 3ER, United Kingdom
[e] Independent scholar, 4 le bourg, F-47200 Marcellus, France
[f] Charles University, Department of Anthropology and Human Genetics, Viničná 7, 128 43 Praha 2, Czech Republic
[g] Archéozoologie, Archéobotanique: sociétés, pratiques et environnements (UMR 7209), Sorbonne Universités, Muséum national d'Histoire naturelle, CNRS, CP55, 55 rue Buffon, 75005 Paris, France

ARTICLE INFO

Keywords:
Classical Antiquity
Iron age
Diet
Mobility
Paleoenvironments
Georeferenced database
Isotopic proxies

ABSTRACT

This paper describes IsoArcH, a new web-based database of isotopic data for bioarchaeological samples from the Graeco-Roman world and its margins. IsoArcH was designed as a cooperative platform for the dissemination of isotopic data and associated archaeological information. IsoArcH follows the open access model and is freely accessible online (http://www.isoarch.eu). Created for paleodietary, paleomobility and paleoenvironmental reconstruction research purposes, IsoArcH compiled to this day published isotopic data for human, animal, and plant remains, as well as organic residues, from nearly 300 sites. All data have been georeferenced allowing for their display on ancient world maps and placement into their contemporaneous geopolitical background. In this paper, several data-driven examples are shown to illustrate the research potential offered by IsoArcH.

1. Introduction

Isotopic proxies are widely recognized as a powerful tool to improve knowledge of past human and animal diet and mobility patterns, to ascertain ancient crop and animal management practices, and to reconstruct paleoenvironments (Drucker et al., 2012; Knudson et al., 2012; Bogaard et al., 2013; Müldner, 2013; Touzeau et al., 2013; Knipper et al., 2016; De Cupere et al., 2017). Within archaeological studies isotopic data has allowed for a better understanding of the social structure, political organisation, economy, technology, and environmental contexts of past human groups (*e.g.* Prowse et al., 2004; Craig et al., 2009; Crowe et al., 2010; Pollard et al., 2011; Mays and Beavan, 2012; Salesse et al., 2013, 2014; Salesse, 2015; Killgrove and Tykot, 2017). The number of archaeological publications containing isotopic data has surged during the past 20 years (Pestle et al., 2014; Szpak et al., 2017). However, the number of isotope web databases remains surprisingly low. There are several databases of radiocarbon data (*e.g.* RADON, Kneisel et al., 2013; CARD, Martindale et al., 2016), databases of modern environmental samples (*e.g.* IsoMAP, Bowen et al., 2017; IRHUM, Willmes et al., 2014) or archaeological artefacts (*e.g.* OXALID, Stos-Gale and Gale, 2009). However, only a few databases have gathered bioarchaeological isotope data, and even less include data from human remains (*e.g.* KIK-IRPA, van Strydonck and de Roock, 2011; dIANA, Etu-Sihvola et al., 2015; IsoMemo, Fernandes et al., 2017).

With a particular interest in isotopic studies concerning the Greco-Roman world *sensu lato*, we build IsoArcH, a web isotope database covering a wide chronological range (12th c. BCE–8th c. CE) for bioarchaeological samples from European, Middle Eastern and North African contexts. IsoArcH is also a member of the IsoMemo initiative (Fernandes et al., 2017). The IsoMemo initiative follows a collaborative model for data sharing and project building that brings together different isotope databases within the research fields of ecology, environmental sciences, and archaeology.

IsoArcH is the first and main isotope web database fully dedicated to the Greco-Roman world and its margins. Furthermore, IsoArcH offers unique features, such as data display on ancient world maps, which are not available elsewhere and are of special research interest in the study of the focus region and time period.

* Corresponding authors.
E-mail addresses: ksalesse@ulb.ac.be (K. Salesse), fernandes@shh.mpg.de (R. Fernandes).

http://dx.doi.org/10.1016/j.jasrep.2017.07.030
Received 31 March 2017; Received in revised form 18 July 2017; Accepted 30 July 2017

2. Description of IsoArcH

IsoArcH was designed as a web-based isotope database for bioarchaeological samples from Iron Age, Classical Antiquity and Late Antiquity (*i.e.* 12th c. BCE to 8th c. CE). It is hosted on a server relying entirely on open-source software solutions and implemented following a relational database model. The database structure of IsoArcH is divided according to four different types of bioarchaeological samples: human, animal, plant, and organic residues. Isotopic ratios (δD, $\delta^{13}C$, $\delta^{15}N$, $\delta^{18}O$, $\delta^{34}S$ and $^{87}Sr/^{86}Sr$) and associated quality control indicators are recorded following two main divisions: organic or mineral fractions on different kinds of samples (*e.g.* bone, tooth, hair, calculus, *etc.*). The isotopic data is supplemented by archaeological and chronological information relative to the sample (*e.g.* identification number, date range, description of archaeological context, *etc.*). The selection of data fields for supporting information depends on the type of sample. For example, for human samples supporting information includes the description of sex, age at death, stature, and type of burial. Full citation details are provided for collected published data. IsoArcH compiled to this day isotopic data for 4000 + humans, 2000 + animals, 100 + plants, and 10 + organic residues from nearly 300 archaeological sites. Detailed information on database organisation and web database architecture is provided in supplementary files 1 and 2.

IsoArcH is a collaborative database accessible to both researchers and the non-academic audience. Users can freely query the database and download the resulting output. Furthermore, users can contribute to expand IsoArcH by uploading complied or their own generated data. IsoArcH administrators check each new submission to ensure the maintenance of data consistency and quality. Once newly submitted data is approved, it is then added to the database and made available online. More information on database collaborative platform is given in supplementary file 3.

As a spatial database dedicated to the Graeco-Roman world and its margins (*i.e.* Europe, Near and Middle East, and North Africa), all stored isotopic data is georeferenced. Using a web-mapping capability, samples can be framed within the contemporary geopolitical context through their display on ancient world maps. Available ancient world maps include those for the Persian, Alexander's, Roman and Byzantine empires, plus for many other chrono-cultural entities. These maps serve as backgrounds on which archaeological sites are projected (Fig. 1). In addition, the projected maps are interactive and can be used to explore the database with or without an initial query. Through the selection of a site, users can have a summary of available data for that site (*e.g.* site name, number of referenced individuals, population means for isotope values, and references). Detailed information on web-mapping tool architecture is provided in supplementary file 4.

An open-access database policy is followed by IsoArcH which means that data is made available free of restrictions on both access and use. IsoArcH is a public website, accessible at http://www.isoarch.eu, with no login requirement for data visualisation. However, a login is required for database querying and data downloading. The content of IsoArcH is licensed under the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License (CC BY-NC-SA 4.0). Users are free to copy and redistribute the data from IsoArcH in any medium or format. They can also modify and build upon available data but they must distribute their contributions under the same license as the original. The licensor cannot revoke these freedoms as long as the license terms are followed. Under the previous terms, users must give in their productions 1) appropriate credits (*i.e.* this publication and "Salesse, K., Fernandes, R., de Rochefort X., Brůžek J., Castex D., Dufour É., (2017), www.isoarch.eu (v.1.0), accessed mm/dd/yyyy"), 2) provide a link to the license (https://creativecommons.org/licenses/by-nc-sa/4.0/), and 3) indicate if any changes were made. Material obtained from IsoArcH cannot be used for commercial purposes.

The full advantages of the database are expected to arise from its collaborative approach. IsoArcH plans to become a new efficient tool at the service of the scientific community to provide an overview of the state of paleodiet, paleomobility, and paleoenvironmental research in the ancient Mediterranean. IsoArcH is part of a broadly-based concept of data centralization that should elicit new discussions and encourage stronger interdisciplinary collaboration. The online interface provides easy access to a library of embedded data organised in multiple layers that facilitates the building of local isotopic baselines plus regional and temporal comparisons of data. Finally, IsoArcH will monitor the release of publications pertaining to the Greco-Roman world and collect newly available isotopic data.

3. Research applications

Isotopic data, together with associated chronological and other supporting information, collected at IsoArcH allows for numerous research applications. These may include large scale comparative studies of human diet or mobility following multiple selection criteria (*e.g.* chronology, region, social variables). Whereas stored animal isotopic data can contribute to the reconstruction of local environmental and human impact histories. For instance, herbivore collagen carbon or nitrogen stable isotope values can be used as proxies to establish past vegetation types (C_3 or C_4), levels of aridity, and forest density (Schwarcz et al., 1999; Kelly, 2000; Bonafini et al., 2013). IsoArcH can also be used to identify data gaps for certain regions, time periods, or sample types. Concerning the latter, there is presently a clear insufficiency of published plant isotopic data although this has a great research potential. Carbon and nitrogen stable isotope data for cultivated plants can be used to assess water availability and soil fertility which are also determined by human farming practices such as irrigation and manuring (Aguilera et al., 2008; Szpak, 2014; Styring et al., 2016). In addition, both plant and animal isotopic data are required to define temporal and regional baselines for the accurate quantification of human diets in isotope-based studies (Fernandes et al., 2015).

Within this section a few illustrative examples are given and briefly discussed to demonstrate research uses for the data made available at IsoArcH. Oxygen isotopes measured in human teeth and bone chiefly reflect the isotopic composition of drinking water and have been frequently used in Roman mobility studies (see Killgrove and Montgomery, 2016 and references therein). A simple temporal comparison was made of human oxygen isotopic data from the Italian peninsula. Selected for comparison was tooth $\delta^{18}O$ data (a single tooth per individual, mostly third molars) from human remains dating between 400 BCE and 400 CE. The selection was further limited to individuals for which the difference between the upper and lower limit of the assigned chronological boundaries was lower than 200 years. The individuals were grouped into two broad chronological groups ($< \sim$200 CE and $\geq \sim$200 CE) using as criterion the median of the chronological boundaries assigned to each individual. Different types or reported measurements and units of reported $\delta^{18}O$ tooth data ($\delta^{18}O$ carbonate or phosphate relative to VPDB or VSMOW standards) were subjected to necessary calculations to report these as $\delta^{18}O$ precipitation values relative to the VSMOW standard (Chenery et al., 2012). Boxplots for selected human data $\delta^{18}O_{precip}$ are shown in Fig. 2a.

The inter quartile ranges of $\delta^{18}O_{precip}$ values shown in Fig. 2a for the younger and older chronological groups are contained within modern day ranges of $\delta^{18}O_{precip}$ values observed for the Italian peninsula (Lightfoot and O'Connell, 2016). However, both chronological groups show a wide range of $\delta^{18}O_{precip}$ values, larger for the younger group, which is indicative of a high degree of mobility. The $\delta^{18}O_{precip}$ mean for the younger group (mean $\delta^{18}O_{precip} = -6.8 \pm 1.7$‰) is slightly smaller than that of the older group (mean $\delta^{18}O_{precip} = -6.3 \pm 1.6$‰) but the difference is not statistically significant (Welch two sample *t*-test: t = 1.1863, df = 41.56, p-value = 0.2422). The chronology of the individuals from the younger group roughly coincides with a broadly warmer period (from *ca.* 250 to 400 CE) for which higher $\delta^{18}O_{precip}$ values are observed relative to the