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Reporting Summary

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Statistics

For all statistical analyses, confirm that the following items are present in the figure legend, table legend, main text, or Methods section.

n/a	Confirmed	
☐	☒	The exact sample size (*n*) for each experimental group/condition, given as a discrete number and unit of measurement
☒	☐	A statement on whether measurements were taken from distinct samples or whether the same sample was measured repeatedly
☐	☒	The statistical test(s) used AND whether they are one- or two-sided *Only common tests should be described solely by name; describe more complex techniques in the Methods section.*
☒	☐	A description of all covariates tested
☒	☐	A description of any assumptions or corrections, such as tests of normality and adjustment for multiple comparisons
☐	☒	A full description of the statistical parameters including central tendency (e.g. means) or other basic estimates (e.g. regression coefficient) AND variation (e.g. standard deviation) or associated estimates of uncertainty (e.g. confidence intervals)
☐	☒	For null hypothesis testing, the test statistic (e.g. *F*, *t*, *r*) with confidence intervals, effect sizes, degrees of freedom and *P* value noted *Give P values as exact values whenever suitable.*
☒	☐	For Bayesian analysis, information on the choice of priors and Markov chain Monte Carlo settings
☒	☐	For hierarchical and complex designs, identification of the appropriate level for tests and full reporting of outcomes
☒	☐	Estimates of effect sizes (e.g. Cohen's *d*, Pearson's *r*), indicating how they were calculated

Our web collection on statistics for biologists contains articles on many of the points above.

Software and code

Policy information about availability of computer code

Data collection	Microsoft Excel, Digital Surfs Mountians
Data analysis	Microsoft Excel, R (version 4.4.1), JMP (version 17), VizualAge UcomPbine, DQPB software

For manuscripts utilizing custom algorithms or software that are central to the research but not yet described in published literature, software must be made available to editors and reviewers. We strongly encourage code deposition in a community repository (e.g. GitHub). See the Nature Portfolio guidelines for submitting code & software for further information.

Data

Policy information about availability of data

All manuscripts must include a data availability statement. This statement should provide the following information, where applicable:

- Accession codes, unique identifiers, or web links for publicly available datasets
- A description of any restrictions on data availability
- For clinical datasets or third party data, please ensure that the statement adheres to our policy

All data are available in the main text and supplementary information.

Research involving human participants, their data, or biological material

Policy information about studies with human participants or human data. See also policy information about sex, gender (identity/presentation), and sexual orientation and race, ethnicity and racism.

Reporting on sex and gender	n/a
Reporting on race, ethnicity, or other socially relevant groupings	n/a
Population characteristics	n/a
Recruitment	n/a
Ethics oversight	n/a

Note that full information on the approval of the study protocol must also be provided in the manuscript.

Field-specific reporting

Please select the one below that is the best fit for your research. If you are not sure, read the appropriate sections before making your selection.

☐ Life sciences ☐ Behavioural & social sciences ☒ Ecological, evolutionary & environmental sciences

For a reference copy of the document with all sections, see nature.com/documents/nr-reporting-summary-flat.pdf

Ecological, evolutionary & environmental sciences study design

All studies must disclose on these points even when the disclosure is negative.

Study description	This analyzed faunal remains from multiple Early Pleistocene fossil localities from the Oltet Valley of Romania with the goal of undertaking a complete taphonomic analysis, identifying dates for the localities, and describing the climate at the time the fossil sites were deposited.
Research sample	This study analyzed a total of 4,746 specimens from four fossil localities (Grăunceanu= 4,524, La Pietriș=114, Fântâna lui Mitilan=68, and Fântâna Alortetei=40).
Sampling strategy	95%+ of the existing collections for the fossil localities analyzed were included in this study. Specimens not included were those that had not been accessioned yet or have been lost.
Data collection	Taphonomy analysis: Specimens were examined for bone surface modifications (BSMs) under strong, low-angled light from a gooseneck lamp both macroscopically and with a 10x hand-lens by one of four analysts (SC, BP, SG, CET), in constant consultation with each other. Results were compiled in a Microsoft Excel Spreadsheet. Impressions were taken of marks observed during the qualitative analysis using Coltene President Jet light body dental molding material. Marks of interest were molded several times, and the second set of molds were used in this analysis, since adhering sediment on some specimens was removed in the first round of molding. 3D models were created by MP directly from molds using a S Neox 3D optical profilometer (manufactured in 2018) located in the 3D imaging and analysis lab at Colorado State University. All models were produced using a 5x lens that has a z axis resolution of 75 nm. The 5x lens has a numerical aperture of .15, a working distance of 23.5 mm, a field of view of 3400 um x 2837 um, a spatial sampling of 2.76 um, and an optical resolution of .93 um. Processing and analysis of 3D models was carried out using Digital Surf's Mountains® following Pante et al. Processing included removing outliers, filling in missing data points, and removing the underlying form of the bone with the mark excluded from the form removal process. Data collected through the analysis from the entire 3D model of the BSM were volume, surface area, maximum depth, mean depth, maximum length, and maximum width. Additional data were collected from a profile taken from the deepest point of the BSM including area of the hole, depth of the profile, width, roughness (Ra), opening angle, and radius of the hole. Isotopic analysis: Enamel powder from the upper cheek teeth series (P2-M3) of an Equus sp. specimen (VGr.0974) was sampled sequentially by VD along the growth layers using a dental drill, at a resolution of 1.5-2.5 mm, after removing the cementum. Stable isotopes of oxygen and carbon in the structural carbonate of the third molar (M3) were analyzed at the University of Arkansas Stable Isotope Laboratory, USA (UASIL), while the premolars (P2-P4) and the remaining molars (M1-M2) were analyzed at the University of Northumbria, UK by VE. Both laboratories use Thermo Delta V Advantage isotope ratio mass spectrometers coupled to GasBench II sample preparation devices. Prior to analysis, samples were treated with 1M acetic acid, rinsed with deionized water, and dried. The Northumbria University stable isotope laboratory uses an analysis method adapted from Spötl and Venneman70. 2000±20 µg of sample were loaded into 12 mL borosilicate vials capped with butyl rubber septa (LabcoTM), and flushed with helium for 480 seconds at 1.8 bar on a bespoke flushing box supplied by Sercon Ltd. Carbon. Individual measurement sequences ('runs') consisted of 80 measurements, including standards, and all samples were reacted with 102 wt% orthophosphoric acid at a temperature of 70°C, with a reaction time of 104 minutes prior to measurement to ensure equilibration. For data evaluation, standards were measured at the beginning, end, and approximately every 10 samples in each run. An in-house laboratory calcite standard (Plessen) was used for linearity and drift correction (δ13C = 2.40 ‰, δ18O = -1.31 ‰, n = 10 per run), alongside international standards NBS18 and IAEA603 for stretching correction (each n >= 3 per run). Nominal values from Kim et al.71 were used for NBS18 (δ13C = -5.01 ‰, δ18O = -23.01 ‰), while values stated by the IAEA were used for IAEA603 (www.iaea.org; δ13C = 2.46 ‰, δ18O = -2.37 ‰). One sample of

an in-house calcite standard (Pol2, δ13C = -7.14 ‰, δ18O = -9.22 ‰) was added to each run and used to evaluate long-term performance. Based on this secondary standard, for the measurement period relevant to the samples reported here, reproducibility is better than 0.1 ‰ for both δ13C and δ18O. All stable isotope data was initially reported on the VPDB scale, but for climate calculations δ18O values were transferred to the VSMOW scale using the equation δ18O(VSMOW)=δ18O(VPDB) x 1.03092 + 30.92. At UASIL, an international standard (NBS19) and an in-house standard (UASIL 22) were used for corrections, each in 8 aliquots analyzed during the entire run. NBS19 standard values are δ13C = 1.95 ‰ VPDB, δ18O = 28.72 ‰ VSMOW, while UASIL 22 values are δ13C = -35.6 ‰ VPDB, δ18O = 13.31 ‰ VSMOW. The standard deviation values for NBS19 and UASIL 22 during the analysis of this set of samples were δ13C-0.09‰ and δ18O-0.17‰, and δ13C-0.08‰ and δ18O-0.13‰, respectively. Oxygen stable isotopes in the phosphate component of the enamel of M3 were analyzed at UASIL in six samples and reported on the VSMOW scale. The phosphate was precipitated as Ag3PO4 and analyzed in a Thermo Delta V Advantage IRMS coupled to a TC-EA. Four standards were measured along with this batch of samples: NIST 120c, USGS 80, USGS 81, and an in-house Ag3PO4 standard, with values of 21.93‰, 13.12‰, 34.78‰, and 6.57‰ VSMOW respectively. Their within-run standard deviation values were 0.60‰, 0.37‰, 0.54‰, and 0.29‰.

Timing and spatial scale	Data were collected across multiple field seasons from 2012 to 2022. Isotopic analyses were conducted between 2017 to 2024.
Data exclusions	We did not exclude any data for analysis.
Reproducibility	Fossils are not reproducible
Randomization	n/a
Blinding	n/a

Did the study involve field work? ☐ Yes ☒ No

Reporting for specific materials, systems and methods

We require information from authors about some types of materials, experimental systems and methods used in many studies. Here, indicate whether each material, system or method listed is relevant to your study. If you are not sure if a list item applies to your research, read the appropriate section before selecting a response.

Materials & experimental systems

n/a	Involved in the study
☒	☐ Antibodies
☒	☐ Eukaryotic cell lines
☐	☒ Palaeontology and archaeology
☒	☐ Animals and other organisms
☒	☐ Clinical data
☒	☐ Dual use research of concern
☒	☐ Plants

Methods

n/a	Involved in the study
☒	☐ ChIP-seq
☒	☐ Flow cytometry
☒	☐ MRI-based neuroimaging

Palaeontology and Archaeology

Specimen provenance	Excavations at Grăunceanu were undertaken from 1960-1966, with some additional test excavations and/or collection as early as 1959 and as late as the 1970s. Excavations were conducted by the "Emil Racoviţă" Institute of Speleology in Bucharest, Romania and the Museum of Oltenia in Craiova, Romania. All work conducted as part of this research was enabled by existing Memorada of Understandings and collaboration with the "Emil Racoviţă" Institute of Speleology in Bucharest, Romania and the Museum of Oltenia in Craiova, Romania. Permissions for export related to isotopic and dating analyses were provided by the "Emil Racoviţă" Institute of Speleology.
Specimen deposition	M)aterials from the ORV localities (n=4746), are currently split between the "Emil Racoviţă" Institute of Speleology in Bucharest, Romania and the Museum of Oltenia in Craiova, Romania.
Dating methods	Samples for U-Pb dating were analyzed by JW at the University of Melbourne. Samples were mounted in resin blocks, polished down to reveal internal structures and arranged in the S155 large-format ablation cell of an Applied Spectra RESOlution-SE ablation system based around an ATL Atlex 193 nm excimer laser. A beam expander was employed for any laser spots above 200 microns. This sample introduction system was coupled to a Nu Instruments Attom-ES high resolution magnetic sector ICP-MS operating in deflector jump mode. Laser fluence was typically adjusted to ~ 2–3 J cm−2, with a laser repetition rate of 5 Hz. Spot sizes were highly variable in the range 20-200 microns dependent upon sample U contents, which were also highly variable. A brief pre-ablation using a larger spot size was conducted prior to every analysis. Baseline measurement for 30 s was followed by 40 s acquisition during each spot ablation. For the disequilibrium measurements (conducted by JH), initially, relatively large samples of 2–3 mg were drilled from six teeth which returned successful U-Pb isochrons, using a tungsten carbide dental bit. These were dissolved in concentrated HNO3, dried down and re-dissolved in 1.0 ml of 5 % HNO3 / 0.5 % HF, 0.01 ml aliquots of which were further diluted in the same acid to 0.8 ml, spiked with a mixed 229Th–233U–236U tracer and equilibrated on a hotplate overnight. These were introduced directly to a Nu Instruments Plasma MC-ICP-MS and measured using a mass jumping routine using mixed Faraday cups and secondary electron multipliers. The procedure was repeated on a second aliquot of each sample, giving inconsistent 230Th/238U ratios but good replication of 234U/238U. An insoluble organic microparticulate Th-bearing fraction was inferred to be present in the bulk solutions, invalidating 230Th/238U measurements on spiked aliquots of dissolved samples, so all teeth were resampled using a 350 um tungsten carbide microdrill to a depth of 350 um giving samples of approximately 75 ug (equivalent to ~10–100 ng U). These were dissolved in concentrated HNO3 and refluxed overnight before addition of 5 drops of conc H2O2 to oxidize the inferred insoluble organic phase, with effervescence observed. Samples were then dried down and redissolved in 0.8 ml of 5 % HNO3 / 0.5 % HF, spiked and equilibrated and analyzed as above.

☒ Tick this box to confirm that the raw and calibrated dates are available in the paper or in Supplementary Information.

Ethics oversight	No ethical approval was required since all work was conducted on previously excavated remains.

Note that full information on the approval of the study protocol must also be provided in the manuscript.

Plants

Seed stocks	n/a
Novel plant genotypes	n/a
Authentication	n/a