

Reporting Summary

Nature Portfolio wishes to improve the reproducibility of the work that we publish. This form provides structure for consistency and transparency in reporting. For further information on Nature Portfolio policies, see our [Editorial Policies](#) and the [Editorial Policy Checklist](#).

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
<i>Only common tests should be described solely by name; describe more complex techniques in the Methods section.</i> |
| ☒ | ☐ 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
<i>Give P values as exact values whenever suitable.</i> |
| ☒ | ☐ 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	Granulometry analysis, GRADISTAT 4.0; Radiometric dating, Isoplot 4.15; Photogrammetry, Agisoft PhotoScan 1.21; Structured light 3D scanning, SHINING EXScan Pro 3.7.0.3 (EinScan Pro HD) and Artec Studio 15 Professional; CT data, Bruker SkyScan1272 with Control software 1.1.13 and NRecon 1.7.1.6
Data analysis	See the code at https://github.com/eliason/ColossalCode . Compactness and CT-based bone volume analyses, Fiji (ImageJ 1.52h). Statistical analyses: R 4.2.1 with packages ape (5.7-1), nlme (3.1-162), piecewiseSEM (2.3.0), viridis (0.6.3), ggplot2 (3.4.2) Surface models: Blender 3.0.1 and MeshLab 2022.02

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 generated or analysed during this study are included in this published article (and its supplementary information files) as well as the following public repositories:

- Three-dimensional surface models of the holotype of *Perucetus peruvianus* as well as *Cynthiacetus peruvianus* MNHN.F.PRU10 are available on MorphoMuseum: 3D models related to the publication: A heavyweight early whale pushes the boundaries of vertebrate morphology. MorphoMuseum e187 (2023) doi:10.18563/journal.m3.187.
- Newly acquired CT data are available on MorphoSource (<https://doi.org/10.17602/M2/M510260>).
- The existing database AnAge was also used: Tacutu, R. et al. Human Ageing Genomic Resources: Integrated databases and tools for the biology and genetics of ageing. Nucleic Acids Res. 41, D1027–D1033 (2013).

Human research participants

Policy information about [studies involving human research participants and Sex and Gender in Research](#).

Reporting on sex and gender

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](https://www.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

Description of a new fossil specimen; scaling analysis of the skeletal mass and body mass in mammals; estimations of total skeletal and body masses in extinct species.

Research sample

New species: fossil specimen; Scaling analysis: museum specimens and published data.

Sampling strategy

The comparative analysis encompasses all published data combining per-specimen skeletal mass and body mass in mammals. This was augmented by new data to complete the sample evenly the range of mammalian sizes, making our dataset the largest of its kind.

Data collection

Granulometry and radiometric dating analyses: Giulia Bosio; Photogrammetry: Eli Amson; Surface 3D scanning: Alberto Collareta, Eli Amson, Marco Merella, Rebecca Bennion; CT data, Eli Amson. See details in Methods and Supplementary Methods.

Timing and spatial scale

Data collection took place in 2022-2023. Spatial scale is not relevant, except for the fossil collection which was restricted to the type locality.

Data exclusions

No data were excluded from the analysis.

Reproducibility

Studied specimens are curated in public institutions. The raw data and code necessary to reproduce the analyses are provided.

Randomization

This does not apply to this comparative analysis.

Blinding

Did the study involve field work? ☒ Yes ☐ No

Field work, collection and transport

Field conditions

Location

Access & import/export

Disturbance

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

Methods

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

Palaeontology and Archaeology

Specimen provenance

Specimen deposition

Dating methods

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

Ethics oversight

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