

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

Original measurements for our Datasets 1 and 2 were taken on pictures using ImageJ 2.0.0 (Open Source) and compiled in Microsoft Excel 16.16.14 (Microsoft Corporation, WA, US). The phylogenetic trees used in the analyses were compiled in Mesquite 3.6 (Open Source). SEM and EDS images were collected using JSM-6490LV (JEOL, Ltd., Japan) and AZtecOne 3.3 (Oxford Instruments, UK). XRD data were acquired using Rigaku R-Axis SPIDER (Applied Rigaku Technologies, TX, USA) and analyzed using EVA (Bruker Corporation, MA, USA). ICP-MS data were acquired using Agilent 7500ce ICP-MS (Agilent Technologies, Inc., CA, USA) and analyzed using Iolite v3.1 (University of Melbourne) and IGOR Pro 8 (WaveMetrics, OR, USA). All image were compiled and edited using Adobe Photoshop CS6 13.0 and Illustrator CS6 16.0.0 (Adobe Inc., CA, US). CT scan images were analyzed in Avizo 2019.1 (Thermo Fischer Scientific, MA, USA). All additional information is available in the Supplementary Methods.

Data analysis

All analyses were performed in R 3.6.2 (Open Source), using specific packages available on the online CRAN repository. Specific R packages used for analyses are: ape v5.3 (Paradis et al., 2019), nlme v3.1-144 (Pinheiro et al., 2020), AICcmodavg v2.2-2 (Mazerolle, 2019), phytools v0.6-99 (Revell, 2019), MPSEM v0.3-6 (Guénard, 2019), and phylopath v1.1.2 (van der Bijl, 2019).

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/reviewers. We strongly encourage code deposition in a community repository (e.g. GitHub). See the Nature Research [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 list of figures that have associated raw data
- A description of any restrictions on data availability

All measurements collected for this study are available as individual datasets, labelled Supplementary Tables 1, 2, and 3 in the Supplementary Information of this

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	This study describes a new fossil egg taxon from Antarctica, and examines its characteristics in relations with other amniote eggs. Dataset of egg measurements were compiled from new specimens and the literature to perform such comparisons (see below).
Research sample	The research sample includes two datasets of (respectively) 259 lepidosaur species and 148 amniote species (some of which are included in both datasets; see Supplementary Tables 1–3), representing the vertebrate clades Lepidosauria and Amniota, respectively. A detailed list of all specimens collected for this study, all species used in this study, and all references in the literature from which data were collected, is available in Supplementary Tables 1–3 and associated references.
Sampling strategy	Lepidosaur egg measurements are scarcely available in existing literature. We performed a comprehensive review of available studies on quantitative analyses of such measurements in lepidosaurs to build a preliminary dataset, and completed it with measurements assembled from research collections in the United States (AMNH, CAS, UT Austin). This represents the largest existing dataset, and the only one including species of each major clade of lepidosaurs, for extant soft-shelled egg measurements. Also see Supplementary Methods.
Data collection	All data was collected at UT Austin by L. J. Legendre. Specimens of extant lepidosaur eggs collected for this study were loaned from their original host institutions by curators of corresponding research collections (see Acknowledgments, Supplementary Table 2). Samples of the eggshell of the new specimen described as <i>Antarcticoolithus bradyi</i> were collected by D. Rubilar-Rogers and S. N. Davis in the Museo Nacional de Historia Natural (Santiago, Chile). Analyses of eggshell microstructure were performed at the Jackson School of Geosciences, UT Austin, TX, USA (see Supplementary Methods).
Timing and spatial scale	Specimens were obtained, sampled, processed, scanned, and imaged over a period of six months (January–June 2019) at the Jackson School of Geosciences, UT Austin, TX, USA (see Supplementary Methods).
Data exclusions	All data collected were included in the final sample used in this study and available as Supplementary Information (Supplementary Tables 1–3)
Reproducibility	When available, several extant lepidosaur eggs, and/or several eggshell fragments for each egg were thin-sectioned and looked at using light microscopy and SEM (see Supplementary Methods; Supplementary Table 2). For <i>Antarcticoolithus bradyi</i> , multiple eggshell fragments were sampled and analysed for each procedure (Supplementary Methods; Extended Data Figure 1). The structures described and the measurements obtained for each fragment were consistent for each sampled species in the dataset (Fig. 1, 2; Supplementary Methods; Extended Data Fig. 1, 2; Supplementary Table 1–3).
Randomization	We tested the allometric scaling relationships for each of the two samples, to compare <i>Antarcticoolithus</i> to both other soft-shelled eggs (Dataset 1) and other amniotic eggs in general (Dataset 2). We also separated Dataset 1 in two groups based on reproductive strategy (oviparity/viviparity) to test for a significant difference in eggshell thickness between them using phylogenetic ANOVAs (see Supplementary Methods). No other subset of the data were performed.
Blinding	Not applicable (this study did not include any comparison between a test group and a control group; see Supplementary Methods).
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
☒	☐ Animals and other organisms
☒	☐ Human research participants
☒	☐ Clinical data

Methods

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

Palaeontology

Specimen provenance	The specimen SGO.PV 25.400 was recovered in siltstone sediments in the Late Maastrichtian of Seymour Island, Antarctica (López de Bertodano Formation) during the 47th Antarctic Scientific Expedition (2011), organized by the Chilean Antarctic Institute (INACH). The specimen was collected with permits in accordance with the Antarctic Treaty, provided by the Chilean Antarctic Institute Authorities (permits: INACH 065-2011) to Anillo de Ciencia Antártica (ACT-105, Conicyt-Chile). Logistical support for fieldwork was provided by INACH. Research on the fossil once repositied in Chile was funded by an Anillo grant (CONICYT-PIA: National Commission for Scientific and Technological Research Program of Associative Investigation; ACT172099).
Specimen deposition	Specimen SGO.PV 25.400 is permanently repositied at the Museo Nacional de Historia Natural, Santiago, Chile.
Dating methods	Not applicable (no new dates were estimated for this study).
☐ Tick this box to confirm that the raw and calibrated dates are available in the paper or in Supplementary Information.	