

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

For synchrotron tomographic data reconstruction, we used the ESRF software PyHST2. Data concatenation and formatting was performed with dedicated codes in Matlab 7 (available at the ESRF). The software MIMICS was used to segment the data. Rendering of the models was made in Cinema 4D 15.

Data analysis

ESRF software PyHST2, Matlab 7, MIMICS 15 & 17, Cinema 4D 15.

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

Tomographic data from the ESRF will be publicly accessible on the open access ESRF database (<http://paleo.esrf.eu>). Surface files (PLYs) will be publicly accessible on <http://phenome10k.org>.

Restriction on data availability: Please cite the original articles linked to the data you are using, as well as the repository institutions and the public databases. Non-commercial use only, no distribution to third-party.

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	We describe the neurocranial structures in different developmental stages of the coelacanth <i>Latimeria chalumnae</i> .
Research sample	5 specimens (= 5 developmental stages) of the coelacanth <i>Latimeria chalumnae</i> . Sample size was determined based on the specimens available in natural history collections. The specimens are all housed in the natural history collections of public institutions, and all have a collection number. Details on the specimens are provided below and in supplementary information. No new specimens were collected on the field for the present study.
Sampling strategy	Sample size was determined based on the specimens available in natural history collections, and their preservation. 5 specimens representing 5 different developmental stages of <i>L. chalumnae</i> were sampled. To our knowledge, this is to date the most extensive growth series gathered for <i>L. chalumnae</i> . Information on the specimens are provided below in Animals and other organisms Section, as well as in Supplementary information. No statistical methods were used in the present study and no sample-size calculation was performed.
Data collection	Tomography using conventional (by technical staff at the MNHN) and synchrotron (by PT and HD) sources, as well as MRI (by MS). HD segmented all the scans, and produced the 3D reconstructions.
Timing and spatial scale	Timing and spatial scale were not relevant and applicable to the analyses.
Data exclusions	No data were excluded from the analyses.
Reproducibility	Digital reconstructions of the specimens were obtained from tomographical data. We did not repeated the tomographical acquisitions because of: the length of the tomographical acquisitions, the fragility of the material studied, and/or the necessity to keep the X-ray dose as low as possible. Raw tomographical slices will be available on public depositories, allowing our peers to make direct observations and to segment the image stacks.
Randomization	Due to sample size, randomization was not relevant to the study. No statistical analyses were performed.
Blinding	Due to sample size, blinding was not relevant to the study. No statistical analyses were performed.
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

Animals and other organisms

Policy information about [studies involving animals](#); [ARRIVE guidelines](#) recommended for reporting animal research

Laboratory animals	No laboratory animals were used in this study.
Wild animals	The specimens are all housed in the natural history collections of public institutions. For each specimen, we provide the

Wild animals

specimen collection number given by the host institution, as well as the Coelacanth Conservation Council (CCC) number. Further details on the specimens used in this study can be found in the updated inventory of all known specimens of *Latimeria* spp. (Nulens et al 2011 - *Smithinia* Special Publication 3, 12 September 2011), using the CCC number.

The earliest developmental stage of *L. chalumnae* known so far is a 5 cm long fetus (SAIAB 76199). The specimen is preserved in a solution of ethanol (70%), and housed in the collection of the SAIAB, Grahamstown, South Africa. The specimen was found in the oviduct of a large female registered as CCC 202 (Nulens et al 2011), caught on January 12, 2005 in Kange reef, Muheza District, Tanzania (Benno et al 2006). The female was carrying 36 fetuses but all the rest of the fetuses appear to have been lost. The specimen was loaned to the MNHN, France for imaging under the CITES permit 125502.

The first pup P1 (MNHN C26.5, CCC 29.5) is a 30.5 cm long individual with a yolk sac, preserved in formalin (7 %) and housed in the Collections de Pièces anatomiques en Fluides at the MNHN, Paris. The specimen weighs 0.530 g and was found in the oviduct of a female caught on January 8, 1962, offshore Anjouan, Comoro Islands. The specimen was estimated to be 12 months old based on the observation of the growth lines on the surface of the scales (Hureau & Ozouf 1977).

The second pup P2 (ZSM 28409, CCC 162.21) is older than P1 as the yolk sac is resorbed, and housed at the Zoologische Staatssammlung München, Germany. This specimen measures 35.6 cm in length and weighs 417 g. The specimen was found in the oviduct of a female (CCC 162) caught on August 11, 1991, offshore Quelimane, province of Zambezia, Mozambique. The specimen was fixed in formalin, and preserved in this fixative until 2010 before being transferred to a solution of ethanol (75 %). When transferred from formalin to ethanol, the specimen passed through a 20 %, 40 %, and 60 % ethanol solution before being put in 75 % ethanol.

The juvenile (MNHN C79, CCC 94) is a female that measures 42 cm and weighs 800 g. The specimen is preserved in formalin (6 to 7 %) and housed in the Collections de Pièces anatomiques en Fluides at the MNHN, Paris. The specimen was caught on August 18, 1974, near Iconi, Comoro Islands. The specimen was estimated to be 6-months postpartum (Hureau & Ozouf 1977).

The adult specimen (A1), housed in the Collections de Pièces anatomiques en Fluides at the MNHN, Paris, is preserved in formalin (8 %). The specimen is a male (MNHN C24, CCC 27) that measures 132 cm and weighs 38 kg. This specimen was caught on August 4, 1961 offshore Grande Comoro, Comoro Islands.

Field-collected samples

No specimens were collected on the field for this study. Digital reconstructions are only based on specimens housed in museum collections. Provenance and deposition of specimens is provided above and in the supplementary information.

Ethics oversight

No ethic guidance was necessary for this study. The fetus of *L. chalumnae* (5 cm stage) was sent from South Africa to France for PPC-SRµCT under the CITES permit 125502 provided by SAIAB. The specimen has been returned to its institution after the experiment.

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

Magnetic resonance imaging

Experimental design

Design type

MRI of formalin fixed brain and whole head of a juvenile specimen of *L. chalumnae*.

Design specifications

NA

Behavioral performance measures

NA

Acquisition

Imaging type(s)

Structural

Field strength

11.7 T

Sequence & imaging parameters

MRI was performed with a Bruker Biospec System (Bruker, Germany).

Isolated brain: A 72-mm birdcage resonator was used for emission (Bruker, Germany) and a 4-channel phased-array coil was used for signal reception (Bruker, Germany). Images were acquired with a 3D Flash sequence with an isotropic resolution of 40 µm. Field of View = 3.84*1.28*1.28 cm³; Matrix size = 960*320*320; TR/TE (ms) = 40/6.4; Flip Angle = 15°; Spectral Width = 100 kHz; Number of averages = 74; Total acquisition time = 84 hours and 11 minutes;

Whole head: A 72-mm birdcage resonator was used for both emission and reception (Bruker, Germany). Images acquired with a 3D Flash sequence with an isotropic resolution of 130 µm. Field of View = 10.4*83.2*6.66 cm³; Matrix size = 800*640*512; TR/TE (ms) = 12/5.13; Flip Angle = 10°; Spectral Width = 100 kHz; Number of averages = 24; Total acquisition time = 26 hours and 13 minutes.

Area of acquisition

Isolated brain of a juvenile *L. chalumnae* and whole head of a juvenile of *L. chalumnae*.

Diffusion MRI

☐ Used

☒ Not used

Preprocessing

Preprocessing software

Bruker Biospec System (Bruker, Germany) running Paravision 6.0.1.

Normalization

NA

Normalization template

NA

Noise and artifact removal

NA

Volume censoring

NA

Statistical modeling & inference

Model type and settings

NA

Effect(s) tested

NA

Specify type of analysis: ☐ Whole brain ☒ ROI-based ☐ Both

Anatomical location(s)

Whole head and isolated brain of a juvenile coelacanth *L. chalumnae*.Statistic type for inference
(See [Eklund et al. 2016](#))

NA

Correction

NA

Models & analysis

n/a

Involved in the study

☐ Functional and/or effective connectivity☐ Graph analysis☐ Multivariate modeling or predictive analysis