

## 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  
*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 CT volumes were segmented and analyzed in VGSTUDIO MAX 3.2, no additional software was used for data collection.

Data analysis PAST 4.0 (Taphonomic directional analysis); TNT 1.5 (Phylogenetic analysis)

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](#)

*Provide your data availability statement here.*

# 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://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

*Briefly describe the study. For quantitative data include treatment factors and interactions, design structure (e.g. factorial, nested, hierarchical), nature and number of experimental units and replicates.*

### Research sample

*Describe the research sample (e.g. a group of tagged *Passer domesticus*, all *Stenocereus thurberi* within Organ Pipe Cactus National Monument), and provide a rationale for the sample choice. When relevant, describe the organism taxa, source, sex, age range and any manipulations. State what population the sample is meant to represent when applicable. For studies involving existing datasets, describe the data and its source.*

### Sampling strategy

*Note the sampling procedure. Describe the statistical methods that were used to predetermine sample size OR if no sample-size calculation was performed, describe how sample sizes were chosen and provide a rationale for why these sample sizes are sufficient.*

### Data collection

*Describe the data collection procedure, including who recorded the data and how.*

### Timing and spatial scale

*Indicate the start and stop dates of data collection, noting the frequency and periodicity of sampling and providing a rationale for these choices. If there is a gap between collection periods, state the dates for each sample cohort. Specify the spatial scale from which the data are taken*

### Data exclusions

*If no data were excluded from the analyses, state so OR if data were excluded, describe the exclusions and the rationale behind them, indicating whether exclusion criteria were pre-established.*

### Reproducibility

*Describe the measures taken to verify the reproducibility of experimental findings. For each experiment, note whether any attempts to repeat the experiment failed OR state that all attempts to repeat the experiment were successful.*

### Randomization

*Describe how samples/organisms/participants were allocated into groups. If allocation was not random, describe how covariates were controlled. If this is not relevant to your study, explain why.*

### Blinding

*Describe the extent of blinding used during data acquisition and analysis. If blinding was not possible, describe why OR explain why blinding was not relevant to your study.*

Did the study involve field work?  Yes  No

## Field work, collection and transport

### Field conditions

Annual rainfall is 307.5 mm and mean annual temperature is 6,5 C. These are not relevant for paleontological fieldwork studies (taphonomy, stratigraphy)

### Location

50° 42' 42.72" S /72° 32' 29, 08" W. Altitude 1128 M

### Access & import/export

Access and collection was carried out with permission of landowners and of the Chilean government through permit CMN° 6079 (18.12.2017) extended to Marcelo Leppe by the National Monuments Council (CMN, Consejo de Monumentos Nacionales), government of Chile.

### Disturbance

The study area consists of cold steppe, with sparse vegetation cover of altitudinal cushions and grasslands. The only transient disturbance was carried out by digging in soils not covered by vegetation, leaving the disturbed sites with the same appearance as before the intervention.

## 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 &amp; experimental systems

- |                                     |                               |
|-------------------------------------|-------------------------------|
| n/a                                 | Involved in the study         |
| <input checked="" type="checkbox"/> | Antibodies                    |
| <input checked="" type="checkbox"/> | Eukaryotic cell lines         |
| <input type="checkbox"/>            | Palaeontology and archaeology |
| <input checked="" type="checkbox"/> | Animals and other organisms   |
| <input checked="" type="checkbox"/> | Human research participants   |
| <input checked="" type="checkbox"/> | Clinical data                 |
| <input checked="" type="checkbox"/> | Dual use research of concern  |

## Methods

- |                                     |                        |
|-------------------------------------|------------------------|
| n/a                                 | Involved in the study  |
| <input checked="" type="checkbox"/> | ChIP-seq               |
| <input checked="" type="checkbox"/> | Flow cytometry         |
| <input checked="" type="checkbox"/> | MRI-based neuroimaging |

## Palaeontology and Archaeology

## Specimen provenance

The site of provenance (SP17) is located in the Río de Las Chinas Valley, which is part of the Cerro Guido farm, Última Esperanza Province, Magallanes Region, southern Chile. The fossil-bearing level is located within the lower to mid section of Dorotea Formation.

## Specimen deposition

CPAP-3165 is housed in the Palaeontological Collection of Antarctica and Patagonia of the Instituto Antártico Chileno (INACH), Punta Arenas, Chile

## Dating methods

No new dates are provided. Datation is based on previously published studies: U-Pb maximum depositional age above and below the fossil-bearing horizons provides values between  $71.7 \pm 1.2$  Ma and  $74.9 \pm 2.1$  Ma (Gutiérrez et al., 2017) <http://dx.doi.org/10.1016/j.tecto.2016.12.014>

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 or guidance was required. Ethical aspects deal with access and collection of fossils which was carried out with the appropriate legal permits detailed above.

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

## Editorial Policy Checklist

This form is used to ensure compliance with Nature Portfolio editorial policies related to research ethics and reproducibility. For further information, please see our [editorial policies](#) site. All relevant questions on the form must be answered.

### Competing interests

Policy information about [competing interests](#)

#### Competing interests declaration

In the interest of transparency and to help readers form their own judgements of potential bias, Nature Portfolio journals require authors to declare any competing financial and/or non-financial interest in relation to the work described in the submitted manuscript.

- We declare that none of the authors have competing financial or non-financial interests as defined by Nature Portfolio.
- We declare that one or more of the authors have a competing interest as defined by Nature Portfolio.

### Authorship

Policy information about [authorship](#)

Prior to submission all listed authors must agree to all manuscript contents, the author list and its order and the author contribution statements. Any changes to the author list after submission must be approved by all authors.

- We have read the Nature Portfolio Authorship Policy and confirm that this manuscript complies.

### Data availability

Policy information about [availability of data](#)

#### Data availability statement

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](#)

- We have provided a full data availability statement in the manuscript.

#### Mandated accession codes ([where applicable](#))

Confirm that all relevant data are deposited into a public repository and that accession codes are provided.

- All relevant accession codes are provided  Accession codes will be available before publication  No data with mandated deposition

### Code availability

Policy information about [availability of computer code](#)

#### Code availability statement

For all studies using custom code or mathematical algorithm that is deemed central to the conclusions, the manuscript must include a statement under the heading "Code availability" describing how readers can access the code, including any access restrictions. Code availability statements should be provided as a separate section after the data availability statement but before the References.

- We have provided a full code availability statement in the manuscript

## Data presentation

For all data presented in a plot, chart or other visual representation confirm that:

n/a	Confirmed
<input checked="" type="checkbox"/>	<input type="checkbox"/> Individual data points are shown when possible, and always for $n \leq 10$
<input checked="" type="checkbox"/>	<input type="checkbox"/> The format shows data distribution clearly (e.g. dot plots, box-and-whisker plots)
<input checked="" type="checkbox"/>	<input type="checkbox"/> Box-plot elements are defined (e.g. center line, median; box limits, upper and lower quartiles; whiskers, 1.5x interquartile range; points, outliers)
<input checked="" type="checkbox"/>	<input type="checkbox"/> Clearly defined error bars are present and what they represent (SD, SE, CI) is noted

## Image integrity

Policy information about [image integrity](#)

- We have read Nature Portfolio's image integrity policy and all images comply.

Unprocessed data must be provided upon request. Please double-check figure assembly to ensure that all panels are accurate (e.g. all labels are correct, no inadvertent duplications have occurred during preparation, etc.).

Where blots and gels are presented, please take particular care to ensure that lanes have not been spliced together, that loading controls are run on the same blot, and that unprocessed scans match the corresponding figures.

## Additional policy considerations

Some types of research require additional policy disclosures. Please indicate whether each of these apply to your study. If you are not certain, please read the appropriate section before selecting a response.

Does not apply	Involved in the study
<input checked="" type="checkbox"/>	<input type="checkbox"/> Macromolecular structural data
<input checked="" type="checkbox"/>	<input type="checkbox"/> Unique biological materials
<input checked="" type="checkbox"/>	<input type="checkbox"/> Research animals and/or animal-derived materials that require ethical approval
<input checked="" type="checkbox"/>	<input type="checkbox"/> Human embryos, gametes and/or stem cells
<input checked="" type="checkbox"/>	<input type="checkbox"/> Human research participants
<input checked="" type="checkbox"/>	<input type="checkbox"/> Clinical data
	<input checked="" type="checkbox"/> Archaeological, geological, and palaeontological materials

## Archaeological, geological, and palaeontological materials

Policy information about studies involving [archaeological, geological, and palaeontological materials](#)

- We affirm that archaeological, geological, and palaeontological materials samples were collected (and, where applicable, exported) in a responsible manner and in accordance with relevant permits and local laws, and that this information is detailed within the manuscript.

I certify that all the above information is complete and correct.

Typed signature Alexander O. Vargas Milne

Date August 17th 2021

