

Reporting Summary

Nature Research 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 Research policies, see [Authors & Referees](#) 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

Microsoft Excel 2016 MSO x64

Data analysis

MrBayes v.3.2.6 x64. Code provided in supplementary files.

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 data generated or analysed during this study are included in this published article (and its supplementary information files).

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	The study involves collection, description and phylogenetic analysis of fossil material from the middle Cambrian of Canada (Burgess Shale).
Research sample	Our sample includes all specimens of <i>Mollisonia plenovenator</i> sp. nov. collected by ROM expeditions at the locality of Marble Canyon (main quarry). The <i>M. symmetrica</i> specimen had been collected by a previous ROM expedition to the Raymond Quarry (Fossil Ridge). <i>M. gracilis</i> MCZ 1811 comes from the collections of the Harvard Museum of Comparative Zoology.
Sampling strategy	All fossils of this type found were collected.
Data collection	Fossils were collected horizon by horizon, with record of stratigraphic data, by ROM expedition teams, then stored at the ROM and curated by Jean-Bernard Caron.
Timing and spatial scale	Collection of these fossils started in 2012 and is ongoing.
Data exclusions	No data exclusion.
Reproducibility	All material will be made available upon publication.
Randomization	No data randomization.
Blinding	No blinding.
Did the study involve field work?	☒ Yes ☐ No

Field work, collection and transport

Field conditions	Fossils were carefully packed and stored following field collection.
Location	Marble Canyon quarry site near Marble Canyon, Kootenay National Park, British Columbia, Canada. Canadian Rockies, alt. ca. 2700m.
Access and import/export	Fossils for this study were collected by Royal Ontario Museum field parties under several Parks Canada Research and Collections permits to JBC (YNP2012-12054, KOONIP 2014-16317; YNP-2016-21639).
Disturbance	As per agreement with Parks Canada, disturbances to the camp and quarry sites were minimized.

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	Marble Canyon quarry site near Marble Canyon, Kootenay National Park, British Columbia, Canada
Specimen deposition	Royal Ontario Museum Invertebrate Palaeontology Collections, Toronto, Ontario, Canada.
Dating methods	N/A
☐ Tick this box to confirm that the raw and calibrated dates are available in the paper or in Supplementary Information.	