

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	Our dataset comprises 3D morphometric data for 13 skeletal units in 228 species, providing a phylogenetically- and ecologically broad sample of extant avian diversity. Specimens were accessioned from several museum collections across the globe (Table S1, specimens used and collection numbers). Digital skeletal models were segmented from high-resolution micro-CT (computed-tomography) scans of complete skeletons in Avizo 9.3. We placed landmarks and curve semilandmarks on these models (total of 207,245 individually placed coordinates), yielding a dense, quantitative representation of each element's geometry and thereby providing a broad representation skeletal form (shape and size) compared to previous studies.
Data analysis	We used a combination of several recent approaches aimed to study different characteristics of the modes of disparity through time, adapted to multivariate data. Our analyses were conducted in R version 4.0.2 using functions primarily from the packages ape version 5.5, geomorph version 4.0.1, RRPP version 0.6.2, and geiger version 5.3, as well as custom code (Files S3 and S4).

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 used can be freely accessed in our OSF Repository (link: <https://osf.io/wjk3m/>), Morphosource (links in Table S1) and Online Materials in Nature portal. This includes raw landmark data, custom code and original three-dimensional digital meshes for the skeletal elements studied.

Human research participants

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

Reporting on sex and gender

Use the terms sex (biological attribute) and gender (shaped by social and cultural circumstances) carefully in order to avoid confusing both terms. Indicate if findings apply to only one sex or gender; describe whether sex and gender were considered in study design whether sex and/or gender was determined based on self-reporting or assigned and methods used. Provide in the source data disaggregated sex and gender data where this information has been collected, and consent has been obtained for sharing of individual-level data; provide overall numbers in this Reporting Summary. Please state if this information has not been collected. Report sex- and gender-based analyses where performed, justify reasons for lack of sex- and gender-based analysis.

Population characteristics

Describe the covariate-relevant population characteristics of the human research participants (e.g. age, genotypic information, past and current diagnosis and treatment categories). If you filled out the behavioural & social sciences study design questions and have nothing to add here, write "See above."

Recruitment

Describe how participants were recruited. Outline any potential self-selection bias or other biases that may be present and how these are likely to impact results.

Ethics oversight

Identify the organization(s) that approved the study protocol.

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

Ecological, evolutionary & environmental sciences study design

All studies must disclose on these points even when the disclosure is negative.

Study description

We studied the patterns of accumulation of skeletal disparity of the living radiation of birds since their origin in the Late Cretaceous to the present time. Critically, we evaluate some predictions of macroevolutionary theory and avian palaeontology concerning the patterns of morphological evolution in the wake of the K-Pg. For this we assembled one of the largest datasets ever assembled for birds and undertook the most comprehensive study of the skeletal phenotype in any group of vertebrates using a combination of geometric morphometrics and phylogenetic comparative methods, including methodological contributions of our own.

Research sample

Our dataset comprises 3D morphometric data for 13 skeletal units in 228 species, providing a phylogenetically and ecologically broad sample of extant avian diversity.

Sampling strategy

Our sampling follows that of the two most comprehensive phylogenomic studies which sampled most lineages of living birds (therefore, being an accurate representation of most deep nodes in the avian tree).

Data collection

Digital skeletal models were segmented from high-resolution micro-CT (computed-tomography) scans of complete skeletons in Avizo 9.3. Thereafter, We placed landmarks and curve semilandmarks on these models, yielding a dense, quantitative representation of each element's geometry. We used this raw information to generate several datasets. We analysed data representing structure at four hierarchical levels of organisation: 1) Overall skeletal form, as the combined relative sizes and allometry-corrected shapes (= 'forms') of all skeletal elements, or subsets representing the head (skull, mandible), pectoral limb (scapula, coracoid, sternum, humerus, ulna, radius, carpometacarpus), and pelvic limb (synsacrum, femur, tibia, tarsometatarsus) ; 2) Overall skeletal proportions

represented by a matrix containing the relative sizes of individual elements across the skeleton and for subsets (head, pectoral limb, pelvic limb); 3) The allometry-corrected shapes of individual skeletal elements; and 4) Local shape variation of elements, both individually and combined together per region.

Timing and spatial scale	Not applicable.
Data exclusions	Not applicable.
Reproducibility	All the raw data and code are fully available with the manuscript to allow full reproducibility of our results.
Randomization	Multivariate simulations are used in all the analyses to ensure comparisons against a meaningful macroevolutionary baseline.
Blinding	Not applicable

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 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