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7

8 **Running Header:** How many mammal species are there now?

9

10 **How many mammal species are there now? Updates and trends in taxonomic,**
11 **nomenclatural, and geographic knowledge.**

12

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40

41 **Teaser Text:** The Mammal Diversity Database 2.0, listing 6,759 mammal species and 50,230
42 species-level synonyms, unifies 267 years of taxonomic, nomenclatural, and geographic data to
43 track global mammal biodiversity and provide a continually updated resource for the
44 mammalogical community. **Teaser Image:** Figure 3.

ABSTRACT

The Mammal Diversity Database (MDD) is an open-access resource providing up-to-date taxonomic, nomenclatural, and geographic data for global mammal species. Since its launch in 2018, the MDD has transformed the traditionally static process of updating mammalian taxonomy into regular online releases reflecting the latest published research. To build on this foundation, we here present version 2.0 of the MDD (MDD2), which catalogues 6,759 living and recently extinct mammal species, representing net increases of 4.1% and 24.8% over MDD version 1.0 and *Mammal Species of the World*, 3rd edition (MSW3), respectively. Additionally, we identify a net increase of 68.8% (+2,754; 3,149 splits + de novo, 395 lumps) species since 1980 at a rate of ~65 species/year based on past totals from 14 mammalian compendia, leading to projections of ~7,084 species by 2030 and ~8,382 by 2050 if these trends continue. Key updates in MDD2 include: (i) codings of US state, country, continent, and biogeographic realm geographic categories for each species; (ii) a comprehensive nomenclatural dataset for 50,230 valid and synonymous species-rank names, curated with type locality and specimen information for the first time; and (iii) integration between the MDD and the databases Hesperomys and Batnames for greater data accuracy and completeness. These updates bridge critical gaps in the taxonomic and nomenclatural information needed for ongoing revisions and assessments of mammalian species diversity. Using these data, we evaluate temporal and geographic trends over the past 267 years, identifying four major time periods of change in mammalian taxonomy and nomenclature: (i) the initial monographic description of traditionally charismatic species (1758–1880); (ii) the peak of descriptive taxonomy, describing subspecies, and publishing in journals (1881–1939); (iii) the shift toward revisionary taxonomy and polytypic species (1940–1999); and (iv) the current technology-driven period of integrative revisionary taxonomy (2000–present). Geographically, new species recognition since MSW3 has been concentrated in equatorial, mountainous, and island regions, highlighting areas of high mammal endemism (e.g., Madagascar, Philippines, Andes, East Africa, Himalayas, Atlantic Forests). However, gaps in 21st century taxonomic activity are identified in West and Central Africa, India, and some parts of Indonesia. Currently lagging conservation assessments are alarming, with 25% of the MDD2-recognized mammal species allocated to the 'understudied' conservation threat categories of Data Deficient (11%) or Not Evaluated (14%), underscoring the need for greater taxonomic integration with conservation organizations. Governance advancements in MDD2 include the establishment of external taxonomic subcommittees to guide data collection and curation, a rewritten website that improves access and scalability, a cross-platform application that provides offline access, and new partnerships to continue linking MDD data to global biodiversity infrastructure. By providing up-to-date mammalian taxonomic and nomenclatural data—including links to the text of original name descriptions, type localities, and type specimen collections—the MDD provides an integrative resource for mammalogists and conservationists to more easily track the status of their study organisms.

Key Words: biodiversity, conservation, distribution, extinction, species, mammal, nomenclature, integrative taxonomy, database, biodiversity infrastructure

89 **INTRODUCTION**
90   Species are the central unit of biodiversity research, providing evolutionary and ecological
91   context for zoonotic disease monitoring, conservation policymaking, and other societally critical
92   topics (Cook et al. 2020; Upham et al. 2021; Wang et al. 2021; Colella et al. 2023). Delimiting
93   species is fundamental for understanding biodiversity, allowing researchers to conceptualize
94   meaningful discontinuities among organisms, communities, and ecosystems. Species form the
95   foundation of biodiversity infrastructure that ranges from physical biocollections and digital
96   databases to the knowledge contained in publications (Cook and Light 2019; Galbreath et al.
97   2019; Heberling et al. 2021). However, species boundaries are constantly changing over time
98   via advances in taxonomy-related fields, leading to the lumping, splitting, and new description of
99   species. In mammals, recent advances in the morphometric, molecular, statistical, and
100 ecological tools used to distinguish previously cryptic taxa, coupled with the increasing
101 globalization of mammalogical research efforts, have led to widespread taxonomic changes
102 (Patterson 2000; Reeder et al. 2007; Burgin et al. 2018; Álvarez-Castañeda et al. 2019).
103 Although modifying species boundaries to match current evidence of evolutionary relationships
104 is an essential step for studying that history (Sterner 2019), conflict has arisen in mammalogy
105 when various authors have presented different evidence and perspectives on the same taxa
106 (e.g., Frankham et al. 2012; Groves et al. 2017; Zachos 2018a, b; Padial and De la Riva 2021).
107 This plurality of taxonomic views is not unique to mammalogy; instead, this dynamic aspect of
108 biodiversity science emphasizes the importance of rigorous real-time tracking of accepted
109 species names and the associated biological data that signifies their taxonomic meaning (Franz
110 and Sterner 2018; Miralles et al. 2020; Sterner et al. 2020b; Upham et al. 2022a; Sterner et al.
111 2023). Progress in this arena is critical because identifying which species are recognized, and
112 how they are defined, affects inferred biodiversity patterns at local, regional, and global scales,
113 including assessments of conservation priorities and threats (Mace 2004; Thomson et al. 2018).
114 Thus, broad dissemination of the latest knowledge of species designations and their geographic
115 distributions provides an essential foundation for advancing our collective understanding of
116 mammals globally.
117
118 To further this mission, the American Society of Mammalogists launched the *Mammal Diversity*
119 *Database* (MDD) in 2018, which recognized ~20% more mammal species (+1,251 and –172
120 species) compared to the previous authoritative compendium, the *Mammal Species of the*
121 *World*, third edition (MSW3; Wilson and Reeder 2005; Burgin et al. 2018). Subsequent versions
122 of the MDD have continued to track changes in species- and higher-rank mammal taxonomy as
123 reported in peer-reviewed literature, providing an up-to-date biodiversity resource available
124 online at https://mammaldiversity.org, with past versions archived on Zenodo (MDD 2018, 2019,
125 2020a, 2020b, 2021a, 2021b 2021c, 2021d, 2021e, 2022a, 2022b, 2022c, 2022d, 2023, 2024a,
126 2024b, 2024c). The MDD's rapid online taxonomic updates contrast with the previous reliance
127 on the periodic publication of taxonomic compendia, such as the three MSW editions, nine
128 volumes of the *Handbook of the Mammals of the World* series (HMW), and the two-volume
129 *Illustrated Checklist of the Mammals of the World* (CMW) (Honacki et al. 1982; Wilson and
130 Reeder 1993, 2005; Wilson and Mittermeier 2009, 2011, 2014, 2015, 2018, 2019; Mittermeier et
131 al. 2013; Wilson et al. 2016, 2017; Burgin et al. 2020). Although these compendia provided
132 snapshots of mammalian taxonomy and nomenclature based on published literature and expert

133 opinion, their irregular publication intervals delayed the integration of taxonomic changes and
134 new species descriptions into global biodiversity infrastructure. For example, conservation
135 organizations like the International Union for the Conservation of Nature (IUCN) and community
136 science platforms like iNaturalist rely upon authoritative mammal taxonomies in their decision-
137 making processes (Di Cecco et al. 2021; Cazalis et al. 2022). Establishing the MDD helped
138 create a mammalian taxonomic, nomenclatural, and geographic resource that is comparable to
139 that of other taxon or biome-specific online databases (e.g., World Registry of Marine Species;
140 WoRMS—Vandepitte et al. 2018; Reptile Database; AmphibiaWeb—Uetz et al. 2021; World
141 Flora Online—Borsch et al. 2020; World Checklist of Vascular Plants—Govaerts et al. 2021).
142
143 Species' geographic ranges underlie diverse biological questions, both applied (e.g., where is
144 this species found?) and theoretical (e.g., why are species unevenly distributed?), and are a
145 direct way of communicating the taxonomic meaning of species names. For example, the name
146 *Peromyscus maniculatus* (Wagner, 1845) was long applied to deermouse populations across
147 most of North America, but two proposals in 2019 argued that this species only occurs east of
148 the Mississippi River, with western populations now comprised of *P. sonoriensis* (Le Conte,
149 1853), *P. labecula* Elliot, 1903, and *P. gambelii* (Baird, 1857) (Bradley et al. 2019; Greenbaum
150 et al. 2019). Because no consistent morphological characters are known to differentiate eastern
151 *P. maniculatus sensu stricto* from the three newly recognized western species, descriptions of
152 each species' geographic range are essential for communicating this new taxonomic
153 perspective (Sterner et al. 2020a). In general, geographic ranges can be communicated
154 categorically (often via political boundaries; e.g., "Panhandle of Alaska and across N Canada"
155 as used in MSW editions) or using range-map drawings (i.e., geospatial polygons, as used in
156 HMW, CMW, and other compendia). Both types of range information coarsely approximate a
157 species' true distribution and thus are only accurate at coarse spatial scales, usually ≥100-km
158 resolution (Hurlbert and Jetz 2007; see also recent exchange on this topic by Arbogast and
159 Kerhoulas 2024 and Marsh et al. 2024. In 2008, the IUCN completed the landmark Global
160 Mammal Assessment (GMA), which made range maps available for ~95% of the species
161 recognized in MSW3 (5,489 species; Schipper et al. 2008). The IUCN Red List subsequently
162 provided the sole source of digital range maps for mammals until Marsh et al. (2022) digitized
163 range maps aligned to three alternative taxonomies: HMW (6,253 species), CMW (6,431
164 species), and MDD version 1.2 (6,362 species; note that each taxonomy also contains
165 unmapped species that are extinct or data deficient—see Tables 1 and 2 for more detailed
166 totals). Comparison among these datasets documents how the geographic concepts of species-
167 rank mammal taxa have changed over relatively short time periods—mostly from taxonomic
168 changes, in contrast to actual range shifts over longer periods (but see Pacifici et al. 2020).
169 Because geographic knowledge is expected to keep evolving, the MDD taxonomy now tracks
170 categorical changes in the country, continent, and biogeographic realm distributions of accepted
171 species as a core aspect of taxonomic curation.
172
173 The MDD's taxonomic curation also hinges on tracking associated nomenclatural data from
174 historical publications. Nomenclature and taxonomy intersect at the type specimen, which bears
175 the name of the taxon under study (Pyle and Michel 2008). Type specimens provide a stable
176 baseline for subsequent taxonomic revisions given that species names are always linked to

177 name-bearing type specimens (see Definitions Box). The requirement to designate type
178 specimens when defining scientific names, which became common practice in the late 19th
179 century, has created consistency for biological nomenclature. For all animal taxa, the rules of
180 nomenclature are governed by the International Commission on Zoological Nomenclature
181 (ICZN), which created the ICZN Code (ICZN 1999) to standardize how zoological taxonomists
182 create and designate scientific names. Despite historical changes in how researchers define
183 species and other taxa, the system initially proposed by Linnaeus (1758) and now specified by
184 the ICZN Code has allowed for the consistent use of scientific names across centuries of
185 publications. However, despite the critical role of nomenclature in taxonomic curation, it is often
186 difficult for researchers to access these data, including species synonyms, named subspecies,
187 name authority citations, type localities, type specimen identifier(s) and physical location(s)
188 (typically in natural history collections), and original description texts. This is especially true for
189 scientific names that were described in older literature (e.g., before 1900), in journals that have
190 no online repository, in languages other than English, or using type specimens in museums
191 without online catalogs—collectively constituting a type of biodiversity 'dark data' whose
192 absence hinders integrative research efforts (Heidorn 2008; Upham et al. 2021). These
193 nomenclatural details are crucial for conducting taxonomic revisions, because identifying
194 whether there is an existing available specific epithet for a potentially valid new species or
195 whether a new name is needed is a key step in the process of defining taxonomic units. The
196 MDD, therefore, jointly tracks the associated taxonomic, nomenclatural, and geographic data
197 that pertain to all mammal scientific names, aiming to make this often difficult-to-access
198 information more accessible and thereby accelerate the process by which integrative taxonomic
199 research can be conducted globally.
200
201 In this paper, we introduce version 2.0 of the MDD, a major release that for the first time
202 includes a curated list of species-rank synonyms (including name combinations) for global
203 mammals. We also summarize changes to the public interface and contents of the taxonomic
204 listing during the seven years since MDD version 1.0 was released. We analyze trends that
205 emerged from three of the MDD's new features: (i) species distributional data, (ii) species-rank
206 synonyms through time, and (iii) associated nomenclatural metadata. We also describe recent
207 collaborations that have greatly improved the quality of MDD data involving the taxonomic and
208 nomenclatural databases the Hesperomys Project (hereafter 'Hesperomys';
209 https://hesperomys.com) and Bats of the World (hereafter 'Batnames'; https://batnames.org).
210 These collaborations highlight the importance of data sharing and the need to continue building
211 open forums for communicating biodiversity information globally, which can dramatically
212 streamline taxonomic research efforts. Lastly, we describe recent and upcoming changes to the
213 MDD governance structure to invite greater editorial oversight from globally distributed groups of
214 taxonomic experts. The MDD aims to continue providing an authoritative, open-access, and
215 community-driven resource for advancing mammalogical research and conservation worldwide.
216

217 **METHODS**
218 Version 1.0 of the MDD (MDD1) was released in 2018 with a taxonomic cutoff date of 15 August
219 2017 (Burgin et al. 2018). Support from the American Society of Mammalogists (ASM) and
220 VertLife Terrestrial NSF project (DEB: 1441737) enabled the creation of an online database with

221   the aim of providing a continuously updated compendium of the world's extant and recently
222   extinct mammal species and higher-rank taxa. Since then, the MDD database and public web
223   interface have been continually hosted at https://mammaldiversity.org with species-specific
224   pages that include comments and citations relating to taxonomic and nomenclatural changes
225   that have occurred since the MSW3 cutoff of 2004 (Wilson and Reeder 2005). Additional
226   content of the MDD1 release included valid species names, authority author and year, species
227   higher-rank taxonomy, biogeographic realm distribution, extinct/extant status, and taxonomy
228   notes. Subsequent versions of the MDD added species IUCN conservation statuses, English
229   common names, and type localities (version 1.2). Coarse synonym listings also began being
230   curated with version 1.2, consisting of all unique available and unavailable species-rank names
231   included under each species and their respective authorities (previously called
232   'nominalNames'), as did type specimens and geographic categories of country and offshore
233   territory distributions. The present publication describes the version 2.0 release of the MDD
234   (MDD2), which focuses on summarizing the global patterns that arise from the more recent
235   fields added to the MDD, including data pertaining to nomenclatural availability, type localities,
236   type specimens, original description citations and links, and original name combinations when
237   available for each species and synonym. A cutoff date of 15 August 2024 was set for including
238   taxonomic, nomenclatural, and geographic distribution changes in MDD2.
239
240   During the seven years since MDD1 was released, 16 incremental releases of the MDD (Table
241   2) have been published as CSV files with associated metadata and are archived on Zenodo
242   (see Supplemental Data SD3 for complete species lists of all previous MDD versions). Since
243   MDD version 1.3.1, a separate 'diff' CSV file has listed major changes between the current and
244   previous versions. Starting with MDD2, a synonym-specific CSV file is included that lists every
245   species-rank scientific name applicable to extant and recently extinct mammal species,
246   including all associated nomenclatural data for each name. Collaborations with other
247   biodiversity databases have been critical for expanding and improving the curation of data
248   included in the MDD. Integration of nomenclatural data from Hesperomys (Zijlstra 2024) – an
249   online database cataloging the nomenclature of living and extinct animals, with a focus on
250   mammals – has greatly strengthened the MDD. These data were primarily integrated into the
251   MDD species-rank synonym data, resulting in expanded coverage of type localities, type
252   specimens, and other nomenclatural data detailed below. Coordination with Batnames
253   (Simmons and Cirranello 2024) has also been critical to standardize the taxonomic arrangement
254   of the Order Chiroptera so that, starting in January 2024 with MDD v1.12 and Batnames v1.5,
255   all MDD species- and higher-rank taxa of bats are matching between these databases
256   (however, subspecies of bats are currently only listed in Batnames). A further collaboration with
257   Yale University researchers enabled the digitization of geographic range maps as polygon
258   shapefiles for all mammal species, as matched to the taxonomies of MDD v1.2, HMW series,
259   and CMW (see Marsh et al. 2022 and map downloads updated to MDD v1.4 via the 'mddmaps'
260   R package; Robles-Fernández 2024). Lastly, efforts to coordinate with the ASM Mammal
261   Images Library have aligned the taxonomic names and concepts used in the expert-identified
262   images to each new release of the MDD (see https://www.mammalogy.org/image-library).
263

264   The MDD's taxonomic, nomenclatural, and geographic data will continue to be updated with
265   new publications in forthcoming database releases. Continued changes are expected regarding
266   species' taxonomic status, nomenclatural information, geographic distributions, and common
267   names, given the steady rate of new taxonomic evidence being gathered and integrated relative
268   to older publications. The MDD is a living database, and feedback from mammalogists
269   regarding errors, missing information, and potential updates is openly welcome. The MDD
270   currently accepts public feedback in two ways: (i) emails to mammaldiversity@gmail.com; and
271   (ii) GitHub issues: https://github.com/mammaldiversity/mammaldiversity.github.io/issues.
272   Feedback is reviewed and acted upon regularly by the MDD team.
273
274   ***Taxonomic Decision-Making.***
275   A fundamental goal of the MDD has been to maintain an updated taxonomic checklist of the
276   world's currently recognized extant and recently extinct mammal species. To do so, the MDD
277   team has continuously tracked mammal taxonomic literature with the aid of Google Scholar
278   email alerts, periodic examination of journal webpages, and users directly sending publications.
279   The MDD curation team, including all authors of this paper, consists of student research
280   assistants and web developers (paid by the ASM), along with volunteers and consultants. This
281   group is collectively advised by the ASM Biodiversity Committee
282   (https://www.mammalsociety.org/committees/biodiversity). MDD taxonomic curation has
283   emphasized changes since the publication of MSW3 in 2005. Most taxonomic changes
284   incorporated into the MDD have, thus far, closely followed the most recent empirical evidence
285   given in peer-reviewed articles, which each represent the current best hypothesis of species
286   boundaries. By consistently following the most recent evidence from peer-reviewed literature,
287   the MDD's taxonomy is designed to collectively reflect the most up-to-date taxonomic
288   perspective of the global mammalogical community and thereby minimize subjective biases
289   coming from the MDD team.
290
291   Nevertheless, occasionally controversial issues in the peer-reviewed literature have required the
292   MDD team to make subjective decisions regarding the most justified current taxonomy. In cases
293   where there is insufficient evidence to support a taxonomic change or if multiple conflicting
294   taxonomic arrangements are published in rapid succession, the MDD team provides
295   justifications and citations on the relevant per-species pages with summaries given on the About
296   page at https://mammaldiversity.org. In cases of ongoing controversy, a 'flag' designation is
297   noted in the CSV file. Most subjective taxonomic decisions have been made internally by the
298   MDD team. However, beginning with v1.10 (December 2022), the MDD piloted a protocol for
299   publishing taxonomic opinion 'white papers' on Zenodo in collaboration with members of the
300   Global Bat Taxonomy Working Group, which is part of the IUCN SSC Bat Specialist Group and
301   aligned with Batnames. Three subjective decisions were issued: (i) on the species status of
302   *Myotis evotis* in relation to *Myotis keenii* (Lausen et al. 2019, 2021; Morales et al. 2021) by
303   Upham et al. (2022b), (ii) on recognizing *Aeorestes*, *Dasypterus*, and *Lasiurus* as either
304   subgenera or genera (Baird et al. 2015, 2017, 2021; Ziegler et al. 2016; Novaes et al. 2018;
305   Teta 2019) by Francis et al. (2023), and (iii) on whether the five *Myotis lucifugus* subspecies
306   should be recognized as subspecies or species (Morales and Carstens 2018) by Francis et al.
307   (2022). This third white paper was issued without MDD involvement but is still followed in the

308   MDD taxonomy. The goal of formally issuing subjective decisions is to transparently evaluate
309   the available taxonomic evidence, present a detailed justification for choosing one taxonomic
310   arrangement over another, and then make recommendations for gathering evidence to reach
311   more definitive conclusions. The approach of self-publishing on Zenodo was chosen to avoid
312   furthering arguments in the peer-reviewed literature and to incentivize stakeholders to gather
313   new data to support their claims.
314
315   Two other major subjective decisions have been made by the MDD team. The first was to
316   exclude almost all the new taxonomic arrangements proposed in Groves and Grubb's *Ungulate*
317   *Taxonomy* (Groves and Grubb 2011; Groves et al. 2011; Burgin et al. 2020—change made in
318   MDD v1.2). Groves and Grubb (2011) recommended a large number of taxonomic changes
319   within Perissodactyla and terrestrial Artiodactyla that were largely based on qualitative
320   morphological characteristics with small sample sizes. These changes have been controversial
321   within the mammalogical community, and many specialists have subsequently reverted to the
322   taxonomy presented in MSW3 (e.g., Holbrook 2013; Gutiérrez and Garbino 2018). The
323   exception was for the MDD to retain changes that have been subsequently validated by peer-
324   reviewed research (e.g., *Nanger* gazelles; Lorenzen et al. 2007; Siegismund et al. 2013).
325   Second, the MDD excluded several recently suggested taxonomic changes and new species,
326   subspecies, and generic names described by Raymond Hoser, who has prolifically named
327   species in a self-published journal, generally using data from other publications as justification.
328   These changes were previously restricted to reptiles, amphibians, and a few spiders and fish,
329   but 46 mammalian names were described between 2018 and the MDD2 cutoff date. Based on
330   the suggestions of Wüster et al. (2021), the MDD considers these names as examples of
331   'taxonomic vandalism' that should be ignored other than being listed in the synonym dataset
332   (given the nomenclatural status of 'rejected_by_fiat' to signify that the broader taxonomic
333   community rejects these names, not the ICZN Code).
334
335   ***Species Pages and Distributional Data.***
336   Each species in the MDD has a separate webpage that includes the accepted scientific name;
337   authority author(s) and year; higher-rank taxonomic arrangement; primary and alternative
338   English common names; original description citation and link to original description article; type
339   locality, type specimen catalog number, and link to the type specimen in a natural history
340   collection; list of species-rank synonyms and associated nomenclatural data; country-level
341   distribution and accompanying map of listed countries; taxonomic notes and associated
342   citations; IUCN Red List status (see *Conservation Status* section below); whether the species is
343   extant or extinct, wild or domesticated, or has a 'flagged' designation denoting an ongoing
344   taxonomic controversy; and an associated permanent hyperlink (permalink) to access the
345   species page directly. The nomenclatural data presented on species pages are sourced from
346   the synonym CSV file, and those data are detailed under the *Nomenclatural Metadata* section
347   below.
348
349   *Higher-rank Taxa.* The MDD also tracks the higher-rank taxonomy of living and recently extinct
350   mammal species, including the ranks of class, subclass, infraclass, magnorder, superorder,
351   order, suborder, infraorder, parvorder, superfamily, family, subfamily, tribe, genus, and

352   subgenus. All currently recognized species on the MDD have been assigned within an order,
353   family, and genus, with intermediary higher and lower ranks assigned when suggested in the
354   literature. For now, taxonomic changes at the family and genus ranks are noted in the
355   taxonomic notes for species affected by those changes, while changes at the order rank are
356   noted in the 'About' page on the MDD website (e.g., use of the order names Eulipotyphla and
357   Artiodactyla instead of Lipotyphla and Cetartiodactyla; Asher and Helgen 2010). In cases where
358   an intermediate rank is used (e.g., subfamily, tribe) and there are lower-rank taxa that are not
359   confidently placed within that intermediate rank, the term *incertae sedis* is used. For example,
360   within the subfamily Sigmodontinae, most genera are grouped within tribes, but the genus
361   *Abrawayaomys* has yet to be placed into any recognized sigmodontine tribe (Ventura et al.
362   2013), so the tribal affiliation for that genus is *incertae sedis*.
363
364   *Common Names.* The primary English common names (also called vernacular names) for all
365   species were initially sourced from the HMW and CMW series, which employed a standardized
366   naming convention. Because common names are not formally regulated for mammals, there is
367   some leeway for modifications. However, the MDD aims to maintain consistent naming
368   conventions. The primary common name reflects the most widely used or uncontroversial
369   common name for a species while avoiding repeated common names or 'names-within-names'
370   (e.g., 'Common Hippopotamus' rather than 'Hippopotamus' used for *Hippopotamus amphibius*
371   to avoid potential confusion with the 'Pygmy Hippopotamus', which also includes the term
372   'Hippopotamus'). For species not included in the HMW or CMW series or that required a
373   common name change due to taxonomic revisions, the MDD team generates a new or revised
374   common name (e.g., when the Nine-banded Armadillo, *Dasypus novemcinctus*, was split into
375   multiple species, the MDD used 'Mexican Long-nosed Armadillo' as the common name for
376   *Dasypus mexicanus* and 'Southern Long-nosed Armadillo' for *Dasypus novemcinctus sensu*
377   *stricto*; Barthe et al. 2024). Common names suggested by the species name authority or
378   taxonomic change publications are prioritized, but if no common name has been suggested or if
379   the suggested name conflicts with the primary common name of another accepted species, then
380   a new common name based on the species' diagnostic features, geographic distribution, or
381   scientific name etymology is generated. The MDD also maintains consistent common name
382   components within each genus when appropriate (e.g., 'deermouse' for all *Peromyscus* species)
383   and capitalizes all words of the common name as proper nouns (e.g., Aztec Deermouse for
384   *Peromyscus aztecus*). The 'other common names' field includes other known common names
385   that have been used in English either widely or locally or used for subspecies within that
386   species, as initially sourced from the HMW and CMW series, with additional names added as
387   they were found while searching the literature. The MDD also lists names from other languages
388   if they are widely used, but this list is not exhaustive. The MDD team expects to continue adding
389   and revising common names regularly as they are found or updated.
390
391   *Conservation Status.* IUCN Red List statuses (Least Concern [LC], Near Threatened [NT],
392   Vulnerable [VU], Endangered [EN], Critically Endangered [CR], Extinct in the Wild [EW], Extinct
393   [EX], Data Deficient [DD], Not Evaluated [NE]) are listed for each species, as currently sourced
394   from version 2024-1 of the IUCN Red List (IUCN 2024a). If a species is recognized under a
395   different scientific name by the IUCN than what is used in the MDD (e.g., different genus or

396 spelling differences), the scientific name used by the IUCN is given in parentheses following the
397 status in the 'iucnStatus' field (e.g., 'VU (as *Onychogalea fraenata*)' for *Onychogalea frenata*).
398 Additional fields with binary coding are included for whether a species is extant or recently
399 extinct and wild or domesticated. All species that are believed to have been extant after the year
400 1500 CE according to evidence published in the peer-reviewed literature are included in the
401 MDD. The representatives of 17 mammal species that were domesticated by humans during
402 prehistoric times are considered separate species from their ancestors in the MDD, all but two
403 of which (*Bos primigenius* and the unknown ancestor of *Camelus dromedarius*) are extant. The
404 MDD's recognition of these domestic forms as distinct species contradicts much of the
405 evolutionary and taxonomic research on these taxa, which has shown that the wild and
406 domestic forms should be considered a single species in most cases (e.g., Driscoll et al. 2007;
407 Groenen 2016; Jackson et al. 2019, 2020). However, the MDD has chosen to recognize these
408 specific domestic forms as distinct species to avoid confusion regarding which forms are being
409 discussed in both political and conservation situations. Recognizing domestic species also
410 emphasizes the wild forms as an entity to be separately considered and protected. Thus, the
411 MDD acknowledges that recognizing these 17 domestic forms as species is a deviation from the
412 species recognition standards outlined in the *Taxonomic Decision-Making* section above and
413 follows the naming conventions for domestic species and their wild ancestors outlined by Gentry
414 et al. (2004).
415
416 *Geographic Distributions.* The MDD started tracking the native continental and country and
417 offshore territory distributions of all currently valid and wild mammal species starting with v1.2.
418 As of MDD2, four scales of geographic distribution are documented: (i) countries and offshore
419 territories, (ii) country subregions, (iii) continents, and (iv) biogeographic realms. The regional
420 distributions of all terrestrial species are defined by individual organisms physically existing
421 within the boundaries of the defined region. Aquatic marine or freshwater species (all
422 cetaceans, sirenians, pinnipeds, and marine mustelids) are defined as existing either along the
423 shoreline of a given region or in an inland water body within or bordering the defined region; the
424 one exception is for biogeographic realm distributions, where aquatic species are only included
425 if they are found in inland water bodies within the biogeographic realm (marine distributed
426 species are listed as 'Marine' in that distribution field).
427
428 Species distributional data was initially sourced from the IUCN, HMW, and CMW, as
429 supplemented with records published in peer-reviewed literature and regional taxonomic and
430 geographic compendia. Recently introduced and extinct populations are not included in the
431 distribution of living mammals, although the former distribution is listed for globally extinct
432 species, as well as ancient introductions (before 1500 CE) of extant species (e.g., Iberian
433 populations of *Genetta genetta* represent ancient human-introduced populations and are
434 included in the MDD; Delibes et al. 2019). All distributional listings are generally supported by a
435 confirmed record of the species living there (i.e., a museum specimen or photographic
436 evidence), although, if a species is suspected to occur in a region but there is no evidence to
437 confirm its presence, a question mark is listed after the region name. A coarse country- and
438 offshore territory-level map is also included on the webpage for each species—this should not
439 be confused with a more fine-grained 'expert range map' of the species, which are currently not

440   hosted directly by the MDD (but see the R package by Robles-Fernández 2024). Region
441   naming conventions generally follow the International Organization for Standardization (ISO),
442   with occasional exceptions to match abbreviated naming conventions or for regions not covered
443   by the ISO (see Supplementary Data SD7 for a list of regions used in the MDD).
444
445   The list of countries and offshore territories includes all United Nations member and observer
446   states, as well as relevant offshore territories geographically separated from their governing
447   country (e.g., French Guiana is listed separately from France). Country subregions include all
448   the states, provinces, territories, and other applicable subregions for larger countries. As of
449   MDD2, country subregions of species have only been implemented for the United States (all 50
450   states and the District of Columbia). However, country subregions have been fully implemented
451   in tracking the higher geography of type localities on the synonym sheet (see *Nomenclatural*
452   *Metadata* section below).
453
454   MDD species distributions are coded for seven continents with the following definitions: North
455   America (North and Central America to the border between Panama and Colombia, Greenland,
456   Bermuda, and all of the Greater and Lesser Antilles except Aruba, Bonaire, Curaçao, and
457   Trinidad and Tobago); South America (continent south of the border between Panama and
458   Colombia, including Aruba, Bonaire, Curaçao, Trinidad and Tobago, Galapagos Islands, and
459   Falkland Islands); Europe (Eurasia west of the Ural mountains and river, north of the Caucasus
460   mountains, and north and west of the Black and Caspian seas, including the Azores and all the
461   islands in the Mediterranean except Cyprus); Asia (Eurasia east of the Ural mountains and river,
462   east of the Bosporus and Dardanelles and including Cyprus, south of the Caucasus mountains,
463   and south and east of the Black and Caspian seas, east of the Suez Canal, and west of
464   Weber's Line, including Christmas Island); Africa (continental Africa west of the Suez Canal,
465   including Madagascar, Madeira, Canary Islands, Ascension, Tristan da Cunha, and Saint Helen,
466   amongst other offshore islands); Oceania (continental Australia, and Melanesia, Polynesia, and
467   Micronesia east of Weber's Line, including Hawai'i); and Antarctica (continental Antarctica and
468   all Subantarctic islands, including South Georgia and the South Sandwich Islands).
469
470   The MDD considers eight terrestrial biogeographic realms, as defined by Olson et al. (2001):
471   Nearctic, Neotropical, Palearctic, Afrotropical, Indomalayan, Australasian, Oceanian, and
472   Antarctic; because these are terrestrial biogeographic realms, marine distributed species are
473   listed as 'Marine'. In some cases, the MDD deviates from Olson et al. (2001) when a small
474   portion of a biogeographic realm is geographically separate from the primary area of the realm,
475   such as including southern Florida in the Nearctic rather than Neotropical realm and southern
476   Iran in the Palearctic rather than Afrotropical realm.
477
478   ***Nomenclatural Metadata.***
479   MDD2 includes a newly curated list of species-rank synonyms – created in collaboration with
480   Hesperomys (Zijlstra 2024) – for every mammal species in the MDD, totaling 50,230 synonyms.
481   The full synonym list is available on Zenodo and as Supplementary Data SD2. The synonym list
482   includes available and unavailable names; spelling variants and name combinations; and
483   names that are associated with currently valid species, subspecies, synonyms, *nomina dubia*, or

484   *species inquirendae*. Nomenclatural availability of each name was determined based on
485   application of the ICZN Code (ICZN 1999) as well as executive decisions made by the ICZN on
486   the protection or rejection of specific names when applicable. The MDD follows the ICZN Code
487   to inform issues of the nomenclatural availability and spelling of scientific names, which has led
488   to changes in the spelling of specific epithets on the MDD that occasionally differ from the
489   published literature, typically involving changes in gender agreement. These cases are usually
490   noted in the taxonomic notes for species if these changes affect the spelling of a valid species
491   name, and all such spelling changes between MDD1 and MDD2 are listed in Supplementary
492   Data SD5.
493
494   *Literature Search.* Nomenclatural information included in both the MDD and Hesperomys was
495   collected by manually and programmatically searching the primary taxonomic literature,
496   *Mammalian Species* accounts, and secondary global (e.g., MSW, HMW, CMW) and regional
497   taxonomic compendia (e.g., Gardner 2008; Jackson and Groves 2015; Patton et al. 2015).
498   Baseline synonym information was sourced from MSW3, which listed the specific epithet and
499   authority for the synonyms of each species (Wilson and Reeder 2005). These searches
500   spanned multiple online publication repositories, including Google Scholar
501   (https://scholar.google.com), the Biodiversity Heritage Library
502   (https://www.biodiversitylibrary.org), HathiTrust (https://www.hathitrust.org), the Internet Archive
503   (https://archive.org), and Gallica (https://gallica.bnf.fr).
504
505   The primary goal of this ongoing search is to verify the existence, nomenclatural status, and
506   associated data of every name applied to an extant or recently extinct mammal species. In
507   cases where the MDD team has found an earlier citation for a name, differences in spelling or
508   authority, or differing type localities from those listed in recent literature, this information is
509   updated between the MDD and Hesperomys synonym datasets, along with the valid species if
510   applicable. These efforts have also located names that were not included in recent taxonomic
511   compendia (e.g., MSW3), which are added to the MDD-Hesperomys synonym dataset. Each
512   name has been associated with its original description citation, including the original name
513   combination, page of first use, type locality, and type specimen when available. Much of the
514   initial nomenclatural data and citations were sourced from the major compendia mentioned
515   above, but these sources often provided abbreviated citations that can be difficult to decipher
516   and track, which required additional data acquisition directly from the original references.
517
518   *Names and Authorities.* The MDD catalogs the verbatim original name combination from the
519   original description of each name, as well as the taxonomic rank the name was initially
520   described as and the current spelling of the specific epithet based on application of the ICZN
521   Code (termed the 'rootname'). The MDD lists the currently accepted primary higher taxonomy
522   (order, family, genus, and species) from the species data for each name, using *incertae sedis*
523   for names not assignable to any of these taxonomic ranks (i.e., *nomina dubia*, *species*
524   *inquirendae*). The authority for each scientific name is given in a standardized format, including
525   parentheses around the authority name and year when applicable (see Definitions Box). All
526   authors in the author line are included in the authority and an 'in' statement is used when an
527   authority is listed in the publication that differs from the author line (e.g., Kitchener in Kitchener

528   & Maryanto). When multiple authors have the same surname, their first and middle initials are
529   included before their surname to differentiate between each of them (e.g., J. A. Allen versus G.
530   M. Allen; J. Eric Hill versus J. Edwards Hill).

531

532   *Original Citations.* To verify each name's citation and associated nomenclatural data, the MDD
533   team has examined the original descriptions of each name, including the page number where
534   the name or description first occurs and the exact month or day of publication when available.
535   Citations are considered verified when either a PDF of the cited source is obtained or when a
536   member of the MDD team has physically examined the cited source. If the citation has not been
537   verified, the MDD usually lists citation information found in other publications and compendia
538   until the citation can be verified.

539

540   When available, the MDD also links names to an online version of the original description
541   publication, as well as the corresponding page on Hesperomys. For most names initially
542   described or mentioned in publications published before 1925, the MDD team searches for links
543   on the Biodiversity Heritage Library (BHL). Because the BHL provides permalinks associated
544   with individual pages of digitized publications, links can be found for the exact page on which
545   the name was first mentioned or described. Many of these links were found programmatically by
546   using metadata in the BHL, such as the original description volume and page numbers (often
547   sourced from compendia) and then were either verified programmatically or manually by
548   checking for the presence of the name in the text for the page on the BHL website. For older
549   publications not available on the BHL but available from other online literature repositories (e.g.,
550   HathiTrust, Internet Archive, Gallica), the MDD provides manually sourced direct links to either
551   the first page on which the name was mentioned or to the entire paper when no page-specific
552   links are available. For names described in more recent publications (usually after the year
553   2000), the MDD provides a Digital Object Identifier (DOI) linking the name to the journal article's
554   webpage instead of a direct link. No link is provided when an original citation is not available
555   online or has not yet been located by the MDD team, although the citation might have been
556   verified by other means of obtaining a Portable Document Format (PDF) file (e.g., through
557   interlibrary loan).

558

559   *Nomenclatural and Taxonomic Status.* For each name, the MDD summarizes both the
560   nomenclatural and taxonomic status. The nomenclatural status field includes an array of
561   designations relating to the ICZN Code, such as whether a name is available or unavailable
562   (and why it is unavailable if applicable) or if it is preoccupied or a *nomen novum*, spelling
563   variant, or name combination (see Definitions Box). For names that are variants of previously
564   published names, such as spelling variants and name combinations, the MDD records the
565   accepted species name for which it is a variant. For names that are preoccupied by an earlier
566   name through primary or secondary homonymy, the MDD records the preoccupying name. The
567   validity field lists whether a name is a valid species name, a synonym of a valid species,
568   currently unassigned to a single valid species, or having type material of composite or hybrid
569   origin. The MDD also plans to include whether a name is a valid subspecies in future releases
570   but has thus far refrained from tracking subspecies designations due to their inconsistent use
571   and multiple definitions in the published literature (see Burbrink et al. 2022). See Supplementary

572 Data SD8 for a list of all nomenclatural and validity statuses in the MDD2 and Hesperomys
573 synonym listing.

574

575 *Type Localities.* The MDD records type localities for all applicable names as they are added to
576 the MDD synonym sheet. Type localities were initially sourced from the HMW and CMW series,
577 which listed the localities in a standardized format and included type locality restrictions and
578 citations. On the current synonym sheet, the MDD has now verified and copied the verbatim
579 type locality from the original description text for names with verified citations. When the MDD
580 has not verified the verbatim original type locality, type localities are listed as obtained from
581 other primary and secondary sources.

582

583 The MDD team has placed each type locality into its modern country borders (or higher
584 geographical region when no country was specified or determinable from the original
585 description). For many larger countries, the MDD also records the geographic subdivision where
586 the type locality is located (e.g., US states, Chinese provinces, specific islands of archipelagic
587 countries like the Philippines and Indonesia). The region naming conventions and boundaries
588 follow the same conventions as the distributional data of species-rank taxa described in the
589 *Geographic Distributions* section above. In cases where geographic coordinates are given for
590 the type locality in the original description or later publications, the MDD separately records
591 these in decimal degrees. For all names described since the year 2000 that did not already
592 have coordinates present in the original description publication, the MDD team geolocated the
593 type locality using GeoLocate (www.geo-locate.org) or WikiMedia Geohacks location
594 coordinates.

595

596 *Type Specimens.* The MDD and Hesperomys aim to link each available name with its type
597 material. These links are often sourced from type catalogs published by various museums (e.g.,
598 Lawrence 1993; Borisenko et al. 2001), along with original species descriptions and taxonomic
599 revisions. The MDD lists type specimens in a standardized format for each institution, along with
600 the kind of type specimens (holotype, lectotype, neotype, syntypes, or nonexistent). When
601 available, the MDD provides a link to the online collection database for the institution where the
602 specimen is housed. In some cases, only the collection where a specimen is located could be
603 determined and not the complete specimen number, in which case it is labeled as
604 'unnumbered'.

605

606 ***Data Presentation and Applications.***
607 Several changes have been introduced to the MDD website with the release of MDD2, including
608 a new cross-platform application: the MDD app. Co-author HH wrote the MDD app using the
609 Flutter framework (https://flutter.dev/) and the Rust programming language (https://www.rust-
610 lang.org/). It supports iOS, iPadOS, Android, Windows, Linux, and macOS. Details on installing
611 the app are available at https://github.com/mammaldiversity/mdd_app. Critically, the MDD app
612 allows offline access to MDD data, which makes it convenient to access during remote fieldwork
613 when an internet connection is unavailable. The MDD app also features an export function for a
614 whole or subset of MDD data to a CSV file, which can then be shared. We revamped the
615 website, including a migration from Jekyll (https://jekyllrb.com/) to the Astro web-framework

616   (https://astro.build/) with TypeScript (https://www.typescriptlang.org/), and Tailwind CSS
617   (https://tailwindcss.com/) integration. The new website offers better extensibility to add new
618   features, improved user interface and performance, and the integration of taxonomic synonyms.
619   The website layout is adaptive to the screen size of the browser, allowing for easy viewing on
620   small devices such as smartphones or tablets. This layout also supports dark and light themes
621   that are adaptive to the users' browser appearance setting. The website provides a permalink
622   for each taxon that third-party websites can easily access given that it follows a standard format
623   using the MDD ID for each taxon. For example, the permalink for *Ornithorhynchus anatinus* is
624   https://www.mammaldiversity.org/taxon/1000001.
625
626   ***Analyses.***
627   To summarize taxonomic trends, the MDD2 taxonomy was compared to other major
628   compendia, including Corbet and Hill's first (C&H1), second (C&H2), and third (C&H3) editions
629   of *A World List of Mammalian Species* (Corbet and Hill 1980, 1986, 1991), editions four through
630   six of *Walker's Mammals of the World* (WMW; Nowak and Paradiso 1983; Nowak 1991, 1999),
631   Anderson and Jones' *Orders and Families of Recent Mammals of the World* (A&J; Anderson
632   and Jones 1984), Duff and Lawson's *Mammals of the World: A Checklist* (D&L; Duff and
633   Lawson 2004), MSW1 (Honacki et al. 1982), MSW2 (Wilson and Reeder 1993), MSW3 (Wilson
634   and Reeder 2005), CMW (Burgin et al. 2020) and the IUCN (IUCN 2024a), as well as across all
635   18 versions of the MDD. Additionally, total species counts were extracted from each source
636   (other than IUCN version totals, which are not representative of all recognized mammals at their
637   time of versioning) and used to estimate the rate of new mammal species recognition from 1980
638   to 2024 using linear regression. The equation generated for the linear regression line was then
639   used to estimate total recognized mammal species by 2030, 2050, and 2100 if the observed
640   trends were to continue. Corbet and Hill (1980) is the first publication to include a complete list
641   of contemporarily recognized mammal species in the 20th century, which is why we use that
642   publication as the starting point.
643
644   The dates of all available name and valid name descriptions were plotted to visualize the history
645   of species-rank mammal descriptions since 1758. The proportion of species-rank names that
646   were originally described as either species or subspecies and names that have been either
647   lumped or split since their original descriptions were also summarized using 10-year running
648   means from 1 January 1758 to 15 August 2024. Geographic trends in accepted species
649   richness, conservation status (threatened and understudied species), species endemism, new
650   species description, and available name type localities were also evaluated, including across
651   continents and biogeographic realms. State-level species richness across the United States and
652   the global distribution of type localities for names described after the year 2000 were plotted to
653   investigate biodiversity patterns. Lastly, total species per IUCN Red List category were
654   summarized to estimate the proportion that are Low Risk (LC and NT species), Understudied
655   (DD and NE species), Threatened (VU, EN, CR, EW species), and Extinct (EX species)
656   according to the IUCN. The R code used to analyze these data, plot figures, and create
657   supplementary files is available in a GitHub repository accessible at
658   https://github.com/mammaldiversity/MDDv2_ms.
659

RESULTS

Taxonomic Change and Global Biodiversity.

MDD2 catalogs the taxonomy and distribution of 6,759 valid mammal species (6,629 wild extant; 113 extinct; 17 domestic), along with nomenclatural data for 50,230 valid and synonymous species-rank scientific names (Fig. 1; summarized in the *Nomenclatural Metadata* section below). MDD2 includes 267 more species (+4.1% over 7 years) than the 6,495 species recognized in MDD1 and 1,343 more (+24.8% over 20 years) than the 5,416 in MSW3 (Table 1). In contrast, the 2024-1 IUCN Red List includes 5,983 species, which is 776 fewer (-11.5%) than MDD2 despite being released the same year. The ~25% increase over 20 years in recognized mammal species is comparable to the 31.1% increase (+1,246 species) over a 22-year period from the 1982 release of MSW1 to the 2004 taxonomic cutoff of MSW3. Over a broader time period, MDD2 recognizes 2,754 more species (+68.8% over 44 years; 3,149 splits + de novo, 395 lumps) than the 4,005 species recognized in 1980 by C&H1, which was the first modern mammal taxonomic compendium to include a complete list of living and recently extinct mammal species. Linear regression of estimates across 14 compendia recovered a significant increase in mammal species recognition from 1980 to 2024 (y = 64.86x – 124581.37; R^2 = 0.98; Fig. 1). Projecting this rate of species recognition out to the future, there will be ~7,084 species by 2030, ~7,733 species by 2040, ~8,382 species by 2050, and ~11,625 species by 2100. Details of the full MDD2 taxonomy, including associated citations, metadata, and geographic assignments, are provided in Supplementary Data SD1. Additionally, a count-based summary of taxon numbers, available names, new species, and IUCN status categories per mammal family and order in MDD2 is provided in Supplementary Data SD6.

The 18 total releases of the MDD from MDD1 to MDD2 included 15 primary releases (i.e., 1.X and 1.XX releases) and 3 patch releases (i.e., 1.X.X releases) from Aug 2017 to Aug 2024 (Table 2). Over this period, the MDD cataloged a total of 305 de novo species (newly described names), 392 split species (existing synonymous or subspecies names reevaluated as valid species), and 435 lumped species (species subsumed into synonymy at the species rank), which includes some taxa that were first split and re-lumped and vice versa across versions (see Table 2 for taxon totals and version differences, and Supplementary Data SD4 for all per-version MDD 'diff' files). When comparing the differences between MDD1 and MDD2 directly (see Supplementary Data SD5 for an MDD1-to-MDD2-specific 'diff' file), there were 296 de novo species, 321 split species, 357 lumped species, 11 missing species that were subsequently added (mostly recently extinct and domestic species), 6 removed species (all either extinct species that did not survive recently enough for inclusion, or names now considered unavailable or *nomina dubia*), 227 generic changes, 17 specific epithet name changes, and 148 spelling changes and corrections. The highest number of taxonomic changes between two MDD versions occurred between versions 1.1 (Mar 2019) and 1.2 (Sep 2020), versions 1.9.1 (Jun 2022) and 1.10 (Dec 2022), and versions 1.10 and 1.11 (Apr 2023) (Table 2). The largest single-version difference, between versions 1.1 and 1.2, is largely attributed to the removal of the Groves and Grubb (2011) taxonomy for Perissodactyla and terrestrial Artiodactyla (see *Taxonomic Decision-Making* section in Methods), which makes MDD v1.2 the only version that cataloged more species lumps than additions. Version 1.11 is also notable because it marked the beginning of collaborations between the MDD and Hesperomys and Batnames, which

704   involved considerable efforts to reconcile information across the three databases, leading to
705   many changes in taxonomy (15 de novo; 49 splits; 29 lumps) and nomenclature (e.g., spelling
706   changes to 52 species-rank specific epithets) despite a gap of only 5 months between MDD
707   v1.10 and v1.11 release dates.
708
709   Between MDD1 and MDD2, there were net differences of 37 more genera (1,316 to 1,353) and
710   1 more family (166 to 167) recognized, with no changes to the 27 orders. The families
711   Callitrichidae and Aotidae were recognized as distinct, while Eschrichtiidae was lumped into
712   Balaenopteridae since MDD1. In contrast, the MDD2 taxonomy documents a net increase of
713   339 (27.6%) genera, 38 (29.5%) families, and 6 (28.6%) orders since C&H1 and a net increase
714   of 123 (10.0%) genera and 14 (8.4%) families since MSW3 (Table 1). MDD2 recognizes 2 fewer
715   orders than MSW3 because Soricomorpha and Erinaceomorpha are now lumped into a single
716   order (Eulipotyphla), and Cetacea is now lumped into Artiodactyla. The IUCN version 2024-1
717   recognizes 1,308 genera and 164 families, which is a net difference of 45 (3.3%) fewer genera
718   and 3 (1.8%) fewer families than MDD2 but recognizes the same 27 orders. MDD2 includes 8
719   families that the IUCN does not (†Archaeolemuridae, Cetotheriidae, Choloepodidae,
720   Heterocephalidae, †Megaladapidae, Potamogalidae, Zapodidae, and Zenkerellidae) while the
721   IUCN includes 5 families that MDD2 does not (Capromyidae, Eschrichtiidae, Megalonychidae,
722   Myocastoridae, Neobalaenidae—note that Cetotheriidae/Neobalaenidae and
723   Choloepodidae/Megalonychidae are alternative names for the same extant species
724   compositions; Fordyce and Marx 2013; Marx and Fordyce 2016; Delsuc et al. 2019). See Table
725   1 and 2 for further generic, familial, and ordinal comparisons among major mammal compendia
726   published since 1980 and among MDD versions.
727
728   The three most speciose mammal orders are still Rodentia (2,747 species; 536 genera; 35
729   families), Chiroptera (1,485 species; 236 genera; 21 families), and Eulipotyphla (599 species;
730   61 genera; 5 families), collectively making up 71.5% of total mammal species richness in MDD2.
731   These orders are followed by Primates (522 species; 84 genera; 19 families), Artiodactyla (371
732   species; 138 genera; 23 families), and Carnivora (319 species; 129 genera; 16 families); all
733   other mammal orders have fewer than 200 recognized species. Tubulidentata is currently the
734   only mammal order with a single living species, since Microbiotheria now includes two species
735   (although the exact species count has been hotly debated and ranges from one to three; D'Elía
736   et al. 2016; Valladares-Gómez et al. 2017; Martin 2018; Suárez-Villota et al. 2018; Quintero-
737   Galvis et al. 2022). The most speciose mammalian families are Muridae (876 species; 156
738   genera), Cricetidae (869 species; 162 genera), Vespertilionidae (535 species; 60 genera),
739   Soricidae (488 species; 28 genera), Sciuridae (321 species; 64 genera), Phyllostomidae (231
740   species; 61 genera), and Pteropodidae (202 species; 46 genera). All other mammal families
741   have fewer than 200 species, with 24 families having only 1 extant species (including
742   Dugongidae and Thylacomyidae, which currently include 1 recently extinct and 1 extant species
743   each). The three most speciose genera are *Crocidura* (220 species), *Myotis* (139 species), and
744   *Rhinolophus* (114 species), which are also the only mammal genera exceeding 100 extant or
745   recently extinct species; *Crocidura* exceeded 200 species and *Rhinolophus* exceeded 100
746   species as a result of new species recognized since MSW3.
747

748 Since MSW3, there have been 1,579 more species recognized as distinct (23.4% of all currently
749 valid species), including 805 de novo species and 774 split species listed in MDD2, while 226
750 species have been lumped or removed, leading to a net increase of 1,353 species (+24.8%).
751 Over this same 20-year period, at least one new species has been recognized in 20 out of 27
752 orders and 98 out of 167 families of mammals (this is likely to increase further as
753 Pholidota/Manidae, which hasn't had a new species recognized since MSW3, appears to have
754 two additional species; Gu et al. 2023; Wangmo et al. 2025). The orders with the most species
755 newly recognized since MSW3 are Rodentia (595 species; 21.7% relative to the order total in
756 MDD2), Chiroptera (410 species; 27.6%), Eulipotyphla (166 species; 27.7%), and Primates (161
757 species; 30.8%). Of orders with over 100 species, Didelphimorphia (50 species; 39.7%) and
758 Primates have the largest proportion of new species recognized since MSW3 relative to MDD2
759 totals; whereas Carnivora (50 species; 11.3%), Diprotodontia (18 species; 11.3%), and
760 Artiodactyla (51 species; 13.8%) have the smallest proportion of new species recognitions. The
761 families with the most new species recognized since MSW3 are Cricetidae (243 species;
762 27.7%), Vespertilionidae (173 species; 32.3%), Muridae (162 species; 19.9%), Soricidae (129
763 species; 26.4%), Phyllostomidae (76 species; 32.9%), and Didelphidae (50 species; 39.7%); all
764 other families added fewer than 50 valid new species. Of families with over 100 total species,
765 Didelphidae, Rhinolophidae (38 species; 33.3%) and Phyllostomidae have the largest proportion
766 of new species recognized since MSW3.
767
768 Considering higher taxa, there has been a net increase of 123 recognized genera since MSW3
769 (+178 and –55), including 26 genera that appear to be de novo descriptions by having all
770 included species described after MSW3 (*Alpiscaptulus*, *Antillomys*, *Baletemys*, *Calassomys*,
771 *Chimaerodipus*, *Chingawaemys*, *Cordimus*, *Dryadonycteris*, *Drymoreomys*, *Eudiscoderma*,
772 *Gracilimus*, *Halmaheramys*, *Hyorhinomys*, *Laonastes*, *Mictomicrotus*, *Mirzamys*, *Musseromys*,
773 *Pattonimus*, *Paucidentomys*, *Pennatomys*, *Rungwecebus*, *Saxatilomys*, *Setirostris*,
774 *Tonkinomys*, *Waiomys*, *Xeronycteris*). Diatomyidae is the only mammal family recognized since
775 MSW3 where all extant species were described since MSW3 (originally named as a new family
776 name, Laonastidae, but later shown to be a living representative of the Oligocene-Miocene
777 fossil family Diatomyidae; Jenkins et al. 2005; Dawson et al. 2006).
778
779 ***Regional Biodiversity.***
780 Across terrestrial biogeographic realms (Fig. 2A; Table 3), the Neotropical realm harbors the
781 greatest number of currently recognized mammal species (1,839 terrestrial species), followed
782 by the Afrotropical (1,505 species), Palearctic (1,143 species), Indomalayan (1,090 species),
783 Australasian (860 species), Nearctic (716 species), and Oceanian (21 species) realms; the
784 Antarctic biogeographic realm has no permanently terrestrially distributed mammal species.
785 However, in terms of species density per land area, Indomalaya has the highest density of
786 mammal species, followed by the realms of Australasia, Neotropic, Afrotropic, Nearctic,
787 Palearctic, and Oceania (Table 3; note that the corrigendum to Burgin et al. 2018 corrected a
788 previous error, also finding that Indomalaya has the highest density of mammal species; Burgin
789 et al. 2019). As with species richness, the Neotropics also contain the most newly recognized
790 species since MSW3 (563 species: 302 de novo, 261 split), followed by the realms of Afrotropic
791 (294 species: 183 de novo, 111 split), Indomalaya (268 species: 144 de novo, 124 split),

792   Palearctic (265 species: 92 de novo, 173 split), Australasia (131 species: 69 de novo, 62 split),
793   Nearctic (114 species: 16 de novo, 98 split), and Oceania (3 species: 2 de novo, 1 split). The
794   Neotropical biogeographic realm has the largest proportion of species that were recognized
795   since MSW3 (30.6% of total species), while Oceania contains the smallest proportion (14.3%).
796   Unlike other regional scales discussed below, MDD2 species totals for biogeographic realms do
797   not incorporate marine-distributed species (all cetaceans, sirenians, pinnipeds, and marine
798   mustelids), which encompasses 132 species (including 15 new species since MSW3), although
799   5 of these marine-distributed species also have inland populations that are included in
800   biogeographic realm totals (specifically *Trichechus manatus*, *T. senegalensis*, *Pusa hispida*,
801   *Orcaella brevirostris*, and *Neophocaena phocaenoides*).
802
803   At the continental scale (Fig. 2B; Table 3), Asia contains the most recognized mammal species
804   (2,104 species), followed by Africa (1,622 species), South America (1,586 species), North
805   America (1,123 species), Oceania (775 species), Europe (321 species), and Antarctica (45
806   species). Of these, Oceania has the highest species density when weighted by continental land
807   area, followed by South America, Africa, Asia, North America, Europe, and Antarctica (Table 3).
808   Asia also has the highest number of newly recognized species since MSW3 (501 species; 246
809   de novo, 255 split), followed by South America (462 species; 261 de novo, 201 split), Africa
810   (303 species; 184 de novo, 119 split), North America (234 species; 60 de novo, 174 split),
811   Oceania (109 species; 54 de novo, 55 split), and Antarctica (0 species). The continent with the
812   largest proportion of newly recognized species is South America (29.1% of total species), while
813   the smallest other than Antarctica is Europe (14.0% of total species), closely followed by
814   Oceania (14.1% of total species).
815
816   Between countries and offshore territories, the ten most speciose countries (Fig. 4A) are
817   Indonesia (775 species), Brazil (768 species), China (671 species), Mexico (581 species), Peru
818   (570 species), Colombia (520 species), Democratic Republic of the Congo (474 species),
819   United States (468 species), Ecuador (438 species), and India (422 species). Many of these
820   countries also occupy a similar placement in the amount of new species recognized since
821   MSW3 (Fig. 4B), the top ten being Brazil (169 species; 22.0% of MDD2 species for that
822   country), China (167 species; 24.9%), Peru (133 species; 23.3%), Indonesia (122 species;
823   15.7%), Colombia (120 species; 23.1%), Ecuador (118 species; 26.9%), Mexico (116 species;
824   20.0%), Vietnam (88 species; 25.6%), Madagascar (82 species; 32.3%), and Venezuela (72
825   species; 17.6%). Madagascar, Ecuador, and China have proportionately the most new species
826   since MSW3 relative to total species in their country (see Fig. 4B). The number of endemic
827   mammal species (i.e., found only in one country, including marine species), is highest in
828   Indonesia (342 species; 44.1%), followed by Australia (286 species; 73.7%), Brazil (248
829   species; 32.1%), Madagascar (215 species; 84.7%), Mexico (209 species; 36.0%), China (156
830   species; 23.3%), Philippines (149 species; 63.4%), United States (123 species; 26.3%),
831   Argentina (92 species; 23.2%), and Papua New Guinea (92 species; 31.2%). The countries with
832   the highest proportion of mammal species endemism are Madagascar, Australia, Philippines,
833   Indonesia, and Mexico (Fig. 4F).
834

835   Among states of the United States (Fig. 5), California has the most recognized mammal species
836   (207 species), followed by New Mexico (150 species), Texas (148 species), Oregon (145
837   species), and Arizona (143 species). Hawai'i has the lowest species richness (28 species),
838   having only 2 terrestrial and 1 non-cetacean marine mammal species recorded in the state (the
839   rest being cetaceans); however, the terrestrial total will decrease by 1 in future MDD versions
840   given recent evidence that all Hawaiian bat populations are attributable to *Lasiurus semotus*
841   (Pinzari et al. 2023). The states with the most newly recognized species since MSW3 are
842   California (20 species; 9.7% of total MDD2 species in state), Washington (18 species; 13.9%),
843   Oregon (17 species; 11.7%), Texas (17 species; 11.5%), and New Mexico (17 species; 11.3%);
844   by contrast, Alabama and the District of Columbia have only 1 species newly recognized since
845   MSW3, and 11 other states only have 2 newly recognized species. The states with the most
846   endemic species are California (17 species; 8.2%), Florida (5 species; 6.4%), Washington (4
847   species; 3.1%), and Alaska (4 species; 4.0%). See Supplementary Data SD7 for a numeric
848   summary of nomenclatural data and species totals for all geographic regions, and
849   Supplementary Data SD10 for a species matrix of country and offshore territory occurrences
850   based on the MDD2 species list.
851
852   ***Conservation Status.***
853   Of the 6,742 wild mammal species (excluding the 17 domestic species not assessed by the
854   IUCN) recognized in MDD2, 14.0% (943 species) are Not Evaluated (NE) on the IUCN Red List
855   because they are not recognized in the IUCN taxonomy (IUCN 2024a; see Fig. 6). The IUCN
856   currently recognizes 5,983 mammal species, 5,799 of which are shared with MDD2 while 184
857   are considered by MDD2 to be synonyms of other species. Of the total species recognized in
858   MDD2, 19.2% (1,295 species) are threatened with extinction (VU, EN, CR, and EW IUCN
859   statuses) and 11.5% (773 species) are classified as Data Deficient (DD). Thus, fully 25.5%
860   (1,716 species) of MDD2-accepted mammal species are either listed as DD or are NE relative
861   to the IUCN Red List (collectively termed 'understudied species' later in this section, Fig. 4E,
862   and Fig. 6). It should be noted that the total threatened species proportions listed above (and
863   those later in this section) are calculated based on MDD2 totals, which include 943 wild NE
864   species; however, the total proportion of threatened species would increase to 22.4% (1,339
865   species) and DD species to 14.0% (837 species) if considering only those MDD2 species listed
866   on the IUCN and the IUCN species total of 5,983.
867
868   MDD2 considers 113 species to be recently extinct and documents the extinction of 25 entire
869   genera and 7 entire families since the year 1500. In contrast, the IUCN lists 84 recently extinct
870   species, 79 of which are shared with MDD2, leaving 32 recently extinct species listed in MDD2
871   that are NE by the IUCN, and 5 recently extinct species in the IUCN not recognized by MDD2
872   due to taxonomic revisions (e.g., *Cryptonanus ignitus* is now a synonym of *C. chacoensis*; Teta
873   and Díaz-Nieto 2019). Furthermore, 2 species considered extinct in MDD2 are currently
874   considered extant by the IUCN (*Dasycercus cristicauda* as NT; *Tonatia saurophila* as LC)
875   despite taxonomic revisions elevating the extant populations to valid species under different
876   names and restricting the original name to extinct populations (Basantes et al. 2020; Newman-
877   Martin et al. 2023).
878

879   The orders with the largest number of threatened extant species are Primates (335 species;
880   64.2% of total MDD2 species), Rodentia (313 species; 11.4%), Chiroptera (217 species;
881   14.6%), and Artiodactyla (122 species; 32.9%). Of orders with over 100 total species, Primates
882   have the highest proportion of threatened species, followed by Artiodactyla, Diprotodontia (51
883   species; 32.1%), and Carnivora (75 species; 23.5%). All living species of Pholidota (8 species),
884   Proboscidea (3 species), and Sirenia (4 species, plus 1 extinct) are considered threatened by
885   the IUCN. The families with the most threatened species are Muridae (120 species; 13.8%),
886   Cercopithecidae (114 species; 69.1%), Cricetidae (83 species; 9.5%), and Pteropodidae (73
887   species; 35.6%). Of families with over 100 species, Cercopithecidae, Pteropodidae, Bovidae (50
888   species; 32.1%), and Rhinolophidae (18 species; 15.8%) have the largest proportion of
889   threatened species. There are 18 families where every species in the family is considered
890   threatened by the IUCN, the most speciose of which are Lepilemuridae (25 species), Lemuridae
891   (21 species), Hylobatidae (20 species), and Indriidae (19 species); note that all four of these
892   families are within Primates, three being Madagascar endemic lemurs. Another 18 families have
893   50% or more of their species considered threatened on the IUCN.
894
895   Considering the most understudied species per clade relative to IUCN status, the orders with
896   the highest proportion of DD species are Scandentia (5 species; 21.7% of total MDD2 species),
897   Macroscelidea (4 species; 20%), and Cingulata (5 species; 20%), while Rodentia (371 species;
898   13.5%), Chiroptera (215 species; 14.4%), and Eulipotyphla (105 species; 17.5%) have the
899   highest raw numbers of DD species. The orders with the highest proportion of MDD2-accepted
900   species that are NE by the IUCN are Microbiotheria (1 species; 50%), Pilosa (7 species;
901   41.2%), and Didelphimorphia (39 species; 30.9%); whereas, Rodentia (458 species; 16.7%),
902   Chiroptera (184 species; 12.4%), and Eulipotyphla (113 species; 18.9%) have the highest raw
903   numbers of NE species. Combining these DD and NE categories, the orders with the most
904   understudied species are Rodentia (829 species; 30.2%), Chiroptera (399 species; 26.9%), and
905   Eulipotyphla (218 species; 36.4%). Only 8 of 27 orders and 72 of 167 families of mammals are
906   currently 'completely evaluated' by the IUCN, meaning that all MDD2-accepted species in that
907   family are ranked in categories other than DD or NE.
908
909   Across terrestrial biogeographic realms, there are 378 NE species distributed in the Neotropical
910   (20.6% of total MDD2 species in that region), 196 in the Palearctic (17.2%), 135 in the
911   Indomalayan (12.4%), 122 in the Afrotropical (8.1%), 94 in the Nearctic (13.1%), 63 in the
912   Australasian (7.3%), and 1 in the Oceanian (4.8%). Similarly, the number of total understudied
913   species is highest in the Neotropical (627 species; 34.1%), followed by the Afrotropical (306
914   species; 20.3%), Palearctic (293 species; 25.6%), Indomalayan (287 species; 26.3%),
915   Australasian (159 species; 18.5%), Nearctic (107 species; 14.9%), and Oceanian (2 species;
916   9.5%). The most species threatened with extinction are located in the Afrotropical (348 species;
917   23.1%), followed by the Indomalayan (283 species; 26.0%), Neotropical (237 species; 12.9%),
918   Australasian (214 species; 24.9%), Palearctic (127 species; 11.1%), Nearctic (92 species;
919   12.9%), and Oceanian (10 species; 47.6%). The biogeographic realms with the most recently
920   extinct species in MDD2 are the Neotropical (46 species, including 37 in the Caribbean) and the
921   Australasian (39 species, including 33 species in Australia), with all other regions including 8 or
922   less recently extinct species.

923

924 Among continents, South America has the most species that are NE by the IUCN (290 species;
925 18.2%), followed by Asia (284 species; 13.5%), North America (192 species; 17.1%), Africa
926 (130 species; 8.0%), Oceania (55 species; 7.1%), Europe (32 species; 10.0%), and Antarctica
927 (0 species). However, Asia has the overall most understudied species (549 species, 26.1%),
928 followed by South America (519 species, 32.7%), Africa (328 species, 20.2%), North America
929 (241 species, 21.5%), Oceania (122 species, 15.7%), Europe (38 species, 11.8%), and
930 Antarctica (2 species, 11.8%). The continent with the most species threatened with extinction is
931 Asia (432 species; 20.5%), followed by Africa (363 species; 22.4%), South America (205
932 species; 12.9%), Oceania (178 species; 23.0%), North America (147 species; 13.1%), Europe
933 (42 species; 13.1%), and Antarctica (6 species; 13.1%). The continents with the most recently
934 extinct species in MDD2 are North America (41 species, including the same 37 species in the
935 Caribbean as in the Neotropical biogeographic realm) and Oceania (40 species, including the
936 same 33 species in Australia as in the Australasian biogeographic realm), with all other
937 continents including 11 or fewer recently extinct species. These figures highlight the high totals
938 of recent mammal extinctions in the Caribbean and Australia (see Woinarski et al. 2015; Cooke
939 et al. 2017).

940

941 Among countries and offshore territories, the most understudied species (Fig. 4E) are in Brazil
942 (174 species; 22.7% of MDD2 total for that country), Indonesia (171 species; 22.1%), China
943 (168 species; 25.0%), Peru (136 species; 23.9%), Colombia (121 species; 23.3%), Ecuador
944 (117 species; 26.7%), Mexico (113 species; 19.5%), Argentina (99 species; 24.9%), Vietnam
945 (73 species; 21.2%), and Democratic Republic of the Congo (72 species; 15.2%). Ecuador,
946 China, and Argentina contain the highest proportion of understudied species relative to the
947 MDD2 total for that country. The greatest concentrations of species threatened with extinction
948 (Fig. 4D) are found in Indonesia (211 species; 27.2%), Madagascar (131 species; 51.6%), Brazil
949 (94 species; 12.2%), Mexico (88 species; 15.2%), India (82 species; 19.4%), China (77 species;
950 11.5%), Malaysia (77 species; 22.0%), Australia (68 species; 17.5%), Thailand (63 species;
951 18.9%), and Colombia (57 species; 11.0%). The countries with the highest proportion of
952 threatened species relative to the MDD2 total are Madagascar, Solomon Islands (24 species;
953 30.4%), and Mauritius (7 species; 29.2%). The countries and offshore territories with the most
954 recently extinct species recognized in MDD2 are Australia (33 species), Dominican Republic (14
955 species), Haiti (14 species), Cuba (8 species), and Madagascar (6 species), further highlighting
956 the recent extinctions in Australia and the Caribbean. A total of 44 countries and offshore
957 territories have had at least one species go extinct that was partly or wholly distributed within its
958 borders since 1500 CE.

959

960 ***Nomenclatural Metadata.***
961 MDD2 contains a curated dataset of 50,230 species-rank names that are applicable to all
962 currently recognized mammal species (including *nomina dubia* and *species inquirendae* that
963 were meant to apply to extant or recently extinct mammals when described). In terms of
964 nomenclatural status, these names consist of 28,382 available names (including 925 available
965 *nomina nova*, 1,100 preoccupied names, and 39 suppressed names; this total includes all
966 names initially described as available and those that were subsequently made unavailable due

967 to being preoccupied or suppressed), 2,127 unavailable names (including all names used with
968 the intent of being available for taxonomic purposes that are unavailable from publication
969 according to the ICZN Code), 3,445 spelling variants, 16,182 name combinations, and 435
970 instances of other subsequent name use (Table 4; see also Supplementary Data SD8). There
971 are 23,973 more species-rank names listed in MDD2/Hesperomys compared to MSW3, which
972 listed 26,257 such names. This difference is primarily due to the inclusion of more unavailable
973 names, spelling variants, and name combinations (i.e., names not usable for taxonomic
974 purposes), although a number of available names described subsequent to, or omitted from,
975 MSW3 have been added to the MDD2/Hesperomys synonym list as well.

977 Authority authors are included for all names and valid species in MDD2, but authority year is
978 missing for 8 names (all are synonyms of *Equus* species, 7 of which have been found after the
979 MDD2 cutoff date and will be included in later versions). For nearly all synonymous names and
980 every valid species, MDD2 includes original name combination, taxonomic rank, and some
981 degree of citation information (99.8% of all names). Citation information has been fully verified
982 for 88.6% of names (91.0% of valid species), and the page number on which the name first
983 appears or is described is included for 88.3% of names (and all but 3 valid species). For 75.1%
984 of names (86.1% of valid species) a hyperlink to the full text of the original description was
985 located, and for 51.2% of names (68.3% of valid species) direct links were included to the page
986 that name was first mentioned or described on the BHL.

988 Type localities were also recorded for almost all applicable names (99.6% of originally available
989 names and all valid species) and have been verified in the original description for 66.5% of
990 available names and 78.2% of valid species. MDD2 also includes coordinates of the type
991 localities in decimal degrees for 9.8% of available names and 27.4% of valid species (including
992 almost all names described after the year 2000). Type specimen locations were gathered for
993 73.3% of originally available names (87.9% of valid species), 46.4% of which (53.5% of valid
994 species) are linked to the specimen's database entry in an online collections catalog. Most
995 species descriptions designate a single type specimen (the holotype), which MDD2 records for
996 18,396 names. However, there are also 1,111 names based on multiple type specimens
997 (syntypes) and 1,092 for which a lectotype has been selected from among a series of syntypes.
998 There are 144 cases where the original type material has been lost or was nonexistent in the
999 first place, resulting in a neotype being designated. There are also 289 names in MDD2
1000 recorded as having nonexistent type specimens, which will require future neotype designation.
1001 We estimate that MDD2's coverage is nearly complete for type specimens housed in North
1002 America, where almost all major institutions have published type catalogs. Most of the names
1003 for which we have not yet recorded type specimen information likely have no surviving types or
1004 were based on types housed in a European collection.

1006 **Historical Taxonomy and Nomenclature.**
1007 Species-rank available names were described from 1758 to 2023 at an average rate of 106.2
1008 names per year (Fig. 1; raw data and running means available in Supplementary Data SD9).
1009 However, when divided into roughly 50-year time bins, the following average rates of yearly
1010 naming emerge: 32.7 (1758–1799), 95.0 (1800–1849), 117.8 (1850–1899), 248.4 (1900–1949),

1011   53.1 (1950–1999), and 48.5 (2000–2023). The time bins with the lowest naming rates were
1012   1758–1799 and 2000–2023, although this latter time bin is about half as long, while the highest-
1013   rate periods were 1900–1949 and 1850–1899. From 1758–1800, there were 19 years where
1014   fewer than 10 available names were described and four years where none were described
1015   (1759, 1762, 1763, 1764; although 1762 has unavailable names). Sustained rates of species-
1016   rank name description were not reached until 1819, after which every year had >30 available
1017   name descriptions until 1973. Yearly peaks associated with single publications occurred in 1827
1018   (206 names), 1842 (287 names), 1860 (255 names), and 1867 (238 names). During the 1890s,
1019   most years had >200 described names, peaking at 366 in 1898. This trend continued into the
1020   first decades of the 20th century, leading to 1913 as the year with the most documented new
1021   name descriptions across the ~267 years of taxonomic history (529 available names described).
1022   The mid-20th century experienced a sustained decrease in naming rates, with only three years
1023   since 1943 having more than 100 available name descriptions (1946 with 120, 1955 with 127,
1024   and 1956 with 108). Only 24 names were described in 1973, making it the year with the least
1025   name descriptions since the early 19th century (only 12 of which are currently valid species).
1026   The proportion of names that are currently recognized as valid species in MDD2 increased from
1027   the 1970s to the 21st century as rates of subspecies name description decreased. The year
1028   2021 has the most names described during the 21st century (69 names) and 2001 had the least
1029   (33 names). There have been 28 species-rank names described in 2024 prior to the MDD2
1030   cutoff date of August 15th (including 24 currently valid species; increasing to 42 valid species
1031   during the writing of this manuscript).
1032
1033   Considering the history of taxonomic rank use over time, most species-rank names described
1034   before the 20th century were described as species rather than subspecies, forms, or varieties
1035   (Fig. 1; forms and varieties before 1900 were often equivalent to the subspecies rank and are
1036   treated equivalently here). Over 70% of names were described initially as species until the time
1037   bin of 1895–1904, after which it steadily fell until a resurgence in the 21st century. While species
1038   were the primary taxonomic unit used for name descriptions during the 18th and 19th centuries,
1039   there were significant jumps in subspecific name descriptions (generally as forms or varieties) in
1040   1788 (61.4% of available names described that year were subspecies), 1792 (62.0%), 1801
1041   (73.9%), and 1860 (69.8%). The early 20th century marked an increase in the prevalence of
1042   polytypic species (species with multiple subspecies), with >50% of all names described as
1043   subspecies from 1922 to 1973, peaking in 1948 at 89.0%. Following this period, the prevalence
1044   of subspecies name descriptions began to decrease, dropping below 50% in 1974. This time
1045   period lasted until 1999 when subspecies descriptions consistently dropped to below 50% of all
1046   yearly name descriptions. Subspecies descriptions became considerably less common after
1047   2003, decreasing to only 6.4% of names described in 2014 and not again exceeding 25% of
1048   yearly names.
1049
1050   The majority of all available mammal names are considered synonyms of valid species on
1051   MDD2 (i.e., 21,254 names; 74.9% of available names). Of those, 17,906 names (63.1%) were
1052   initially described at the species rank while 10,367 (36.5%) were initially described as
1053   subspecies, forms, or varieties. Furthermore, 11,508 names (40.6%) described as species have
1054   been lumped, while 698 names (2.5%) described as subspecies have been subsequently split.

1055 There are 6,055 names (21.3%) described as species that are recognized as valid species in
1056 MDD2, although it should be noted that this total does not consider that many of these names
1057 have been treated as synonyms or subspecies before being revalidated later.
1058
1059 Most names that were described as species and since lumped (i.e., now synonymous names in
1060 MDD2) were published before 1920, with the 10-year running mean of this statistic consistently
1061 over 50% from 1785 to 1920. From 1927 to 2023 (other than 1976 and 2001), fewer than 25%
1062 of the available species-rank names described per year were lumped. In contrast, the rate of
1063 taxa that were initially described as subspecies that have since been elevated to species (i.e.,
1064 split out from another valid species and now recognized in MDD2) was highest throughout the
1065 20th century, with a 10-year running mean of ~1–4% from 1886 to 1958 compared to ~5–9%
1066 from 1959 to 2001. Few years before 1886 and after 2009 include names described as
1067 subspecies that are now recognized as species, with most yearly rates ranging from ~0–1%
1068 during these time periods. It should be noted that these rates are based on the taxonomic rank
1069 at which each name was originally described and whether it is now considered a synonym or
1070 valid species in MDD2. Thus, these values do not capture when each name was split or lumped
1071 or whether a name was split or lumped multiple times throughout their taxonomic history.
1072
1073 Across terrestrial biogeographic realms, the Palearctic has the most available names with type
1074 localities in that region (20.5% of total available names), followed by the Afrotropical (19.7%),
1075 Neotropical (19.4%), Indomalayan (15.4%), Nearctic (10.9%), Australasian (7.4%), Oceanian
1076 (0.2%), and Antarctic (<0.1%) (Fig. 2C; Table 3). The continent with the most available names is
1077 Asia (27.1%), followed by Africa (22.3%), North America (18.4%), South America (14.3%),
1078 Europe (9.7%), Oceania (6.3%), and Antarctica (<0.1%) (Fig. 2D; Table 3). The ten countries
1079 with the most available name type localities are the United States (2,552 names), Indonesia
1080 (1,732), Mexico (1,301), Brazil (1,088), China (1,084), Russia (975), South Africa (916),
1081 Australia (895), India (689), and Kenya (523) (Fig. 4C).
1082
1083 Type localities of new species-rank names described since 2000 have a global distribution, but
1084 there is a strong latitudinal gradient, with a larger proportion of names described from tropical
1085 over temperate regions (Fig. 3). Species-rank name type localities are concentrated throughout
1086 high-elevation regions (e.g., Andes, East African and Ethiopian highlands, and Himalayas),
1087 islands (e.g., Madagascar, the Philippines, and Sulawesi), and in biodiversity hotspots (e.g.,
1088 Atlantic Forest). Conversely, there appear to be gaps or lower concentrations of new type
1089 localities from regions that may be expected to have similarly unexplored mammal faunas, such
1090 as Central and South Asia, West and Central Africa, portions of the Amazon Basin, and various
1091 Indonesian islands (e.g., Java, Sumatra, Borneo). Few newly described names from the 21st
1092 century have type localities in northern North America, Europe, and northern Asia, and most
1093 that do are either subspecific names or names now regarded as synonyms. The 5 countries with
1094 the most type localities of valid species described during the 21st century are Brazil (98 names),
1095 Madagascar (78), Indonesia (57), China (53), and Peru (52).
1096
1097 ***Website and Database Usage.***

1098 The MDD website located at https://mammaldiversity.org increasingly serves a global audience
1099 of users. Over a recent 17-month period, it was visited by 1,200–2,900 users/month for a total of
1100 25,991 unique users that were located in 170 different countries (Google Analytics: 19 May
1101 2023 to 19 October 2024). The countries with the highest overall usage during this period were
1102 the United States (34.3% of users), Brazil (6.7%), Mexico (6.2%), and China (5.4%), which
1103 topped the 12 countries with over 500 users and the 50 countries with over 50 users (see
1104 Supplementary Data SD11 for complete usage data). Global usage rates rose from an average
1105 of ~450 weekly users (months 1–10 of tracking) to ~700 (months 11–17). A large spike in MDD
1106 website traffic on 15-17 July 2024 involving 1,326 weekly users likely stemmed from the release
1107 of the MDD v1.13 taxonomy on 13 July 2024. The archived versions of the MDD taxonomy that
1108 are hosted on Zenodo at https://doi.org/10.5281/zenodo.4139722 have garnered 33,208 total
1109 page views and 17,159 downloads over the past four years (Sep 2020–Oct 2024).
1110
1111 **DISCUSSION**
1112 The Mammal Diversity Database version 2.0 (MDD2) is a digital compendium of global mammal
1113 taxonomic, nomenclatural, and geographic information that is more complete and accessible
1114 than prior efforts, standing as a stepping stone on the path to greater knowledge about
1115 mammals. MDD2 provides an online overview of taxonomic and distributional studies authored
1116 by mammalogists worldwide over the past 267 years (1758–2024), jointly illuminating the latest
1117 advances in taxonomic understanding of this charismatic vertebrate clade. The release of
1118 MDD1 seven years ago marked a shift from decadal printed volumes to semi-annual online
1119 versions (Burgin et al. 2018). However, continued advances to the MDD have required
1120 improved strategies to find, extract, and link relevant information from the disparate sources
1121 needed to assemble real-time updates to global mammal taxonomy. Because much of the
1122 information used to update the MDD is in rare archives, offline sources, or behind paywalls,
1123 manual data curation by a dedicated team of students and volunteers has been crucial in
1124 collating these data and linking their contained biodiversity knowledge.
1125
1126 ***Documenting 267 Years of Change: Historical Perspectives on Mammalian Taxonomy.***
1127 The curatorial efforts of MDD2 and Hesperomys have uncovered extensive information relevant
1128 to the taxonomic and nomenclatural history of mammals, such as type localities, type
1129 specimens, and original description citations and textual links. These data remain important for
1130 modern taxonomic revisions when considering the identity and status of previously published
1131 names but also paint a broad trajectory of mammalogical study spanning from the dawn of
1132 Linnaean taxonomy to the present. The MDD2 dataset allows for novel explorations of how the
1133 recognized taxonomy of mammal species and higher taxa has changed through time, which is
1134 briefly summarized here.
1135
1136 The history of mammalian taxonomic and nomenclatural descriptions shows an arc of changing
1137 biodiversity knowledge from 1758 to 2024 (Fig. 1). This history is here broken into four major
1138 eras: (i) 1758–1880, when many large, widespread, and charismatic mammals were described
1139 sporadically in monographs; (ii) 1881–1939, the peak of descriptive taxonomy associated with
1140 greater use of subspecies and journal-based, taxon- or region-specific publications; (iii) 1940–
1141 1999, a period of decreasing taxonomic descriptions, peak use of subspecies, and transition

1142   toward revisionary taxonomy; and (iv) 2000-present, the current period of technology-driven
1143   research advances in integrative revisionary mammalian taxonomy. We discuss each of these
1144   historical eras in the following sections, leading to the current era, which is discussed in a
1145   separate section (see *Mammalian Systematics in the Modern Era*).

1146

1147   *(i) 1758–1880*. The late 18th century featured the first publications to describe binomial names
1148   for many charismatic mammal species (e.g., ungulates, carnivores, cetaceans; particularly in
1149   Europe), setting the foundation for the development of modern taxonomic and nomenclatural
1150   practices. Binomial nomenclature and taxonomy for mammals and other animals starts with C.
1151   Linnaeus in Sweden (1758), whose *Systema Naturae* (10th edition) still holds the title of
1152   proposing the largest number of currently valid mammal species in a single publication. These
1153   species were initially placed in 8 orders, but only Primates is still in use today, and 39 genera,
1154   all of which are still in use except *Simia*, which is suppressed for nomenclatural use (ICZN
1155   1929). During this period, there was little standardization in the use of taxonomic units other
1156   than orders, genera, and species, with many genera having species compositions equivalent to
1157   modern mammal families, suborders, or orders (e.g., *Vespertilio* was used for all bats by
1158   Linnaeus). The use of families as a taxonomic grouping between orders and genera would not
1159   be applied to mammals until G. Cuvier's (1797) *Tableau Élémentaire de l'Histoire Naturelle des
1160   Animaux* and would not be given the consistent suffix '-idae' in mammals until J.E. Gray (1821).
1161   There are considerably fewer species-rank names described from this period compared to the
1162   19th and 20th centuries, although there are two notable single-year spikes in species
1163   descriptions associated with single publications: Linnaeus (1758) with 208 names (152 currently
1164   valid species) and R. Kerr in Britain (1792) with 202 names (27 currently valid species). Other
1165   foundational authors and publications describing mammal species richness during the late 18th
1166   century include P.S. Pallas in Russia (1766, 1767–1774), and J.C.P. Erxleben (1777), J.F.
1167   Gmelin (1788), and J.C.D. von Schreber in Germany (1774–1844; some sections published
1168   posthumously). Most of these publications were monographs adding to or revising previously
1169   published global animal or mammal taxonomies rather than journal articles describing individual
1170   species or clades.

1171

1172   During this period, many species were renamed or described multiple times across publications,
1173   resulting in many synonymous names for single species. Some names were even described
1174   from the same type material or just to replace previously published names with the authors'own
1175   (e.g., *Mandrillus sphinx* having six available names in the 1700s alone). Species-rank names
1176   described during this period were often based on illustrations or firsthand accounts of living or
1177   recently deceased animals without reference to voucher specimens, but museum specimens
1178   would become the preferred reference material for biological descriptions later in the 19th and
1179   early 20th century (i.e., museum-based type material). Early in the 19th century, taxonomic
1180   works were mostly published in Europe, involving prolific authors such as É. and I. Geoffroy
1181   Saint-Hilaire, G. and F. Cuvier, and A.G. Desmarest in France, J.E. Gray and G.R. Waterhouse
1182   in Britain, L. Fitzinger in Austria, and J.A. Wagner and W.C.H. Peters in Germany. However,
1183   through the 19th century, some researchers of European heritage working elsewhere started
1184   publishing taxonomic literature, including S.F. Baird, C.S. Rafinesque, and E. Coues in the
1185   United States, A. Smith in South Africa, and E. Blyth and B.H. Hodgson in India. Although

1186   publications through the 19th century were moving away from large monographs and toward
1187   journal articles, some monographic works still contributed to major individual peaks in taxonomic
1188   activity during four major single-year peaks in species-rank name descriptions from 1800–1890:
1189   those of R.P. Lesson in France (1827, 1842) and Fitzinger (1860, 1867; although most of
1190   Fitzinger's names were domestic breeds proposed as forms or varieties).
1191
1192   The 19th century also saw significant philosophical advances in evolutionary theory, which
1193   drove further advances in the understanding of mammal biodiversity. The higher classification of
1194   mammals began to take shape with H.M.D. de Blainville, who used reproductive biology and
1195   skull and skeletal features to group mammals into distinct subclasses: monotremes
1196   (Ornithodelphes), marsupials (Didelphes), and placentals (Monodelphes) (de Blainville 1816,
1197   1864). These works paralleled the evolutionary ideologies expressed in C. Darwin's *Origin of*
1198   *Species* (1859) through the emphasis of skeletal similarities and adaptive alterations among
1199   related taxa, which were further emphasized by other contemporary works focused on the
1200   classification of mammals and other animals based on tooth morphology (Giebel 1855), brain
1201   structure (Bonaparte 1840), and reproductive biology (Owen 1868). The modern terms for these
1202   three extant mammal clades were established by T.N. Gill (1872), who initially proposed
1203   Prototheria for monotremes and Eutheria for marsupials and placentals, and T.H. Huxley
1204   (1881), who then termed Metatheria for the marsupials (albeit not initially intended as a scientific
1205   name), leaving placental mammals in Eutheria. The terms Prototheria, Metatheria, and Eutheria
1206   have varied in definition both historically and in modern use, but are usually given a broader
1207   cladistic definition, respectively including the living and related stem group fossil relatives (e.g.,
1208   de Queiroz and Gauthier 1992) of the (i) monotremes (now often included under the clade
1209   Australosphenida, treating Prototheria as a defunct paraphyletic clade name), (ii) marsupials
1210   (often called Marsupialia for the crown clade), and (iii) placentals (often called Placentalia for the
1211   crown clade). Prototheria, Metatheria, and Eutheria are retained in the MDD to match the most
1212   common use of the names of extant mammals for the time being. A more detailed account of
1213   the early history of mammalian taxonomic research is available in Burke (1968).
1214
1215   *(ii) 1881–1939*. Prior to the 1890s, taxonomic and nomenclatural practices were
1216   unstandardized, leading to differential naming systems and confusion regarding a given species'
1217   proper name, especially as many authors knowingly renamed already-named species. The lack
1218   of structure spurred the need for standardized nomenclatural and taxonomic rules for zoological
1219   taxonomy, which culminated in the publication of the *International Rules of Zoological*
1220   *Nomenclature* in 1905 (Blanchard et al. 1905) that would eventually develop into the first edition
1221   of the ICZN Code in 1961 (ICZN 1961). These documents established fundamental
1222   nomenclatural rules that are still used today, including the principle of priority for scientific
1223   names, the use of physical type material and type localities to define species-rank names, and
1224   the rule that names must be published according to the ICZN Code to be considered available.
1225   Thus, this period is further characterized by the appearance of more seriously cataloged
1226   museum type specimens and more precisely defined type localities (rather than broadly defined
1227   type localities at the country or continent level).
1228

1229   This standardization contributed to the rapid increase in mammalian taxonomic activity during
1230   the late 19th and early 20th century, which was also characterized by an increasing prevalence
1231   in the use of the subspecies rank (replacing forms and varieties). Mammal-focused expeditions
1232   also occurred more frequently, generally associated with colonial exploration, resulting in
1233   specimens being sent to museums in Europe and North America (rarely in the country of
1234   collection; e.g., see Mohammed et al. 2022). These trends continued into the first decades of
1235   the 20th century, expanding to researchers of European heritage in Germany (e.g., P.
1236   Matschie), the United States (e.g., C.H. Merriam, J.A. Allen, W.H. Osgood, G.S. Miller), Russia
1237   (e.g., S.I. Ognev), China (e.g., P.M. Heude), and South Africa (e.g., A. Roberts). Additionally,
1238   some of the first researchers of non-European heritage started publishing mammal names, such
1239   as Yang Zhongjian (then known as C.C. Young) from China and K. Kishida and T. Mori from
1240   Japan (Japanese was also the first non-European language known to feature a mammal name
1241   description). However, this rapid increase is most prominently associated with O. Thomas and
1242   other researchers at the British Museum of Natural History. Thomas, who initially wanted to
1243   study echinoderms, was the most prolific mammalian taxonomist in history, describing ~2,900
1244   genus- and species-rank names from 1880–1929 (Hill 1990), including 2,725 available species-
1245   rank names (9.6% of available names), 937 of which are currently valid species in MDD2.
1246
1247   By the 1920s, new taxonomic descriptions usually appeared in articles focused on individual
1248   taxa, regions, or expeditions published in journals instead of monographic books. A single
1249   journal, the *Annals and Magazine of Natural History*, published the descriptions of 3,434
1250   available species-rank mammal names from 1841–1959, 12.1% of available names in MDD2
1251   (including 990 currently valid species). Other prolific journals during and after the late 19th
1252   century include the *Proceedings of the Biological Society of Washington* with 1,500 available
1253   species-rank names from 1886–2021 (more consistently before the 1970s) and the *Proceedings*
1254   *of the Zoological Society of London* with 1,483 available species-rank names from 1831–1962.
1255   Additionally, the American Society of Mammalogists, and the associated *Journal of Mammalogy*
1256   (including 616 available species-rank names), was founded in 1919, establishing a nexus for
1257   focused mammalogical research in the United States and eventually the Americas more
1258   broadly.
1259
1260   A large proportion of the names proposed as species during this time period are now treated as
1261   subspecies or synonyms (Fig. 1, upper panel). A prime example of the frequency with which
1262   now-synonymous names were proposed during this period is Merriam's (1918) treatment of the
1263   Brown Bear (*Ursus arctos*) as ~74 distinct species in North America alone, as opposed to the
1264   currently defined single Holarctic species. Researchers primarily described mammal species
1265   based on relatively few specimens sent to museums from widely separated localities.
1266   Additionally, species were often described based on subtle morphological distinctions, and
1267   some of the traits used for species diagnoses at this time are now known to vary substantially
1268   within species relative to environmental factors (e.g., pelage coloration). These dynamics
1269   contributed to the description of many names initially proposed as species or subspecies that
1270   are now recognized as a single species with intraspecific variation (e.g., over 200 available
1271   synonymous names referable to *Thomomys bottae*, as currently defined). Furthermore, most of
1272   the names described during this period were not actively cataloged in global-scale compendia

1273   (other than E.-L. Trouessart's series cataloging living and fossil mammals earlier in the period;
1274   Trouessart 1897, 1899, 1905). In retrospect, this practice of not cataloging all described names
1275   has made it difficult to estimate how many mammal species were actively recognized across
1276   different time periods, particularly so in the early 20th century. Thus, subsequent efforts were
1277   needed to both catalogue and review the influx of new names, ushering in the next era in
1278   mammalian taxonomy and biodiversity research, which was characterized by a shift from
1279   descriptive to revisionary taxonomy.
1280
1281   *(iii) 1940–1999*. Descriptive taxonomic activity began decreasing after the 1920s, and especially
1282   into the late 1930s and 1940s following the Great Depression and leading into World War II.
1283   During this period, fewer names were being described, and even fewer are now considered
1284   valid species (e.g., only 3 currently valid species were described in 1961). In contrast to the
1285   previous period, proportionately more new names described during the mid- to late 20th century
1286   were described as subspecies, and many names described earlier as species were joined
1287   together into polytypic species with many subspecies. This decrease in species-rank name
1288   descriptions likely stems from many factors, including global political instability that shifted
1289   research funding away from systematics. There were also significant advances in the
1290   philosophy of species concepts, evolutionary theory, availability of specimens, and molecular
1291   methods during this period that contributed to a shift from descriptive to revisionary taxonomy.
1292
1293   To organize the large number of names coined in previous decades, several major regional
1294   compendia were published, such as Allen (1939) for Africa, Ellerman and Morrison-Scott (1951)
1295   for Eurasia, Miller and Kellogg (1955) for North America, and Cabrera (1958, 1961) for South
1296   America, among others. Although the taxonomic information in these treatises is now dated,
1297   they still remain invaluable as sources of bibliographic and geographic information for mammal
1298   names historically described in these regions (these have been significant resources in
1299   collecting synonyms and their metadata for Hesperomys and the MDD). Higher-level mammal
1300   taxonomy also began to take shape at this time. The publication of G.G. Simpson's *The*
1301   *Principles of Classification and a Classification of Mammals* (1945), which is the foundation of
1302   modern mammalian ordinal and familial arrangements, is based on a more complete
1303   consideration of the deep time evolutionary history of both living and extinct mammals.
1304   Collectively, these compendia helped organize mammal taxonomy following the prior peak in
1305   descriptive taxonomy, contributing to the creation of global compendia like Walker et al. (1964;
1306   and 6 subsequent editions), Morris (1965), and Anderson and Jones (1967, 1984), which
1307   provided some of the first estimates for total extant mammal species richness. Subsequently,
1308   the three editions of *A World List of Mammalian Species* (C&H1, C&H2, C&H3; Corbet and Hill
1309   1980, 1986, 1991) and three editions of *Mammal Species of the World* (MSW1, MSW2, MSW3;
1310   Honacki et al. 1982; Wilson and Reeder 1993, 2005) provided the first complete taxonomic
1311   compendia of the modern era, each explicitly listing all contemporarily recognized extant and
1312   recently extinct mammal species.
1313
1314   A testament to the rapid transition from descriptive to revisionary taxonomic research is
1315   illustrated by comparing estimated mammal species totals from across this period (Fig. 1, upper
1316   panel). The earliest known estimate following the descriptive peak is ~15,000 extant mammal

1317 species in the first edition of Storer's *General Zoology* (Storer 1943). Although Storer does not
1318 mention how this count was determined, it can be treated as a rough estimate of the number of
1319 mammal names described as species and subspecies up to that point. We base this on the fact
1320 that Storer (1943) gave 25,000 as a combined estimate for bird species and subspecies but
1321 then reduced these numbers to 8,600 bird species and 4,400 mammal species in Storer's
1322 (1951) second edition. Mammal species estimates further decreased to 4,237 species in Morris
1323 (1965), who based his total on various compendia plus recent primary literature that had
1324 synonymized names described in previous decades. Morris also expressed a resounding
1325 sentiment of mid-1960s mammal taxonomists:
1326   *As more and more specimens became available and as the concept of*
1327   *reproductively isolated species became accepted, so the tide was turned and the*
1328   *"splitters", as they were called, were replaced by the modern "lumpers". They set*
1329   *about the task of cleaning up the enormous mess and sank name after meaningless*
1330   *name into oblivion.* (Morris 1965:18).
1331 Estimates of total mammal species richness continued to decrease before reaching a low in
1332 1980, when Corbet and Hill listed 4,005 recent mammal species (C&H1), being the first known
1333 publication since the peak of mammalian descriptive taxonomy to include a complete list of
1334 every then-recognized valid mammal species. C&H1 marks the shift from predominantly
1335 lumping species back to predominantly splitting species, as total estimates of extant mammal
1336 species richness began increasing thereafter (Table 1, Fig. 1).
1337
1338 The 20th century also saw transformative advancements in the theory and methods used to
1339 delimit species, which directly influenced mammalian systematics. Population genetics theory
1340 established the first quantitative framework for understanding the genetic variation within and
1341 between populations, providing a genetic basis for re-interpreting previously defined
1342 morphological variation (Charlesworth and Charlesworth 2017). The shift from phenetics to
1343 cladistics introduced a phylogenetic approach to analyzing shared derived traits, offering a
1344 means of reconstructing taxonomic relationships based on evolutionary theory (Hennig 1966).
1345 Understanding of the evolutionary significance of genetic heritability helped inspire formal
1346 species concepts, such as the Biological Species Concept (BSC; Dobzhansky 1937; Mayr
1347 1942) that emphasized reproductive isolation as the basis for species limits, and the
1348 Phylogenetic Species Concept (PSC; Cracraft 1983) that diagnosed the monophyly of lineages
1349 to define species. The development of the General Lineage Concept (GLC; de Queiroz 1998)
1350 near the end of the period advocated for the definition of species as independently evolving
1351 lineages along a continuum, which helped clarify operational issues with the BSC, PSC, and
1352 other species concepts. The application of species concepts was aided by new empirical
1353 methods, including karyology, protein electrophoresis, and eventually DNA sequencing.
1354 Molecular genetic sequencing and computational phylogenetic analysis revolutionized taxonomy
1355 in the late 20th century, resolving many longstanding questions in mammalian systematics and
1356 opening the doors to comparative genomics (O'Brien et al. 1999). The shift toward a
1357 phylogenetic and cladistic framework for taxonomy sparked the development of McKenna and
1358 Bell's (1997) *Classification of Mammals Above the Species Level*, the first phylogeny-informed
1359 higher-level mammal taxonomy and the last publication to consider all clades of living and fossil
1360 mammals. Additionally, this period saw more taxonomically focused specimen collections,

1361   advancing knowledge of species distributions to aid in further revisionary studies (Dunnum et al.
1362   2018). Together, these innovations enabled the modern era of mammal systematics, in which
1363   the names and taxa described in previous decades would again be revised to create more
1364   uniformly meaningful units.
1365
1366   ***Mammalian Systematics in the Modern Era.***
1367   The 44 years since the publication of C&H1 (Corbet and Hill 1980) have seen a nearly 70%
1368   increase in the number of recognized mammal species (Table 1). Similarly, total recognized
1369   species richness has increased by ~46% in the four decades since MSW2 (Wilson and Reeder
1370   1993; Cole et al. 1994), ~25% since MSW3 (Wilson and Reeder 2005; Reeder et al. 2007), and
1371   ~4% since the release of MDD1 (Burgin et al. 2018). The recent and rapid net increase in
1372   recognized mammal species is comparable to activity in other major clades of life (e.g., reptiles:
1373   +49% from 1995–2024, Uetz 2016, Uetz et al. 2024; amphibians: +60% from 1985–2024,
1374   AmphibiaWeb 2024; foraminifera: +21% from 1987–2020, Hayward et al. 2020). Parallel
1375   taxonomic efforts have focused on cataloging hyperdiverse clades (e.g., vascular plants, ~1.3
1376   million names for ~0.35 million accepted species; Borsch et al. 2020) or parsing among
1377   competing taxonomic perspectives (birds: four main lists differing by ~20% or more; Conix et al.
1378   2024). Thus, in this section we consider recent advances in mammal taxonomy relative to two
1379   more general advances in taxonomic research: (i) new kinds of data and increased data
1380   resolution; and (ii) more sophisticated methods of species delimitation.
1381
1382   The shift to integrating molecular and morphological data to diagnose species limits in the late
1383   20th and early 21st century spurred the resurgence of taxonomic study across many clades, a
1384   period regarded as the "taxonomic renaissance" (Mallet and Willmott 2003; Sites and Marshall
1385   2003; Miller 2007). Mammals typify activities of this renaissance in two ways: (i) increased
1386   splitting of existing species through taxonomic revisions (774 species split since MSW3); and (ii)
1387   proportionately more names described as new species rather than subspecies (83.4% of
1388   available names since 2000 are described as new species rather than subspecies, versus
1389   36.1% from 1950–1999). Despite controversy over whether this shift constitutes "taxonomic
1390   inflation" (e.g., Zachos et al. 2013; Groves 2014), the recent changes to mammal taxonomy
1391   have been bidirectional, often involving both synonymization and new species recognition. For
1392   example, 226 species-rank names that were recognized as species in MSW3 have since been
1393   synonymized, or about 1 lump for every 6 newly recognized species from 2004-2024
1394   (considering both de novo and split names). Similarly, there has been a net increase of 123
1395   recognized genera since MSW3, typically to establish generic monophyly, which has also been
1396   bidirectional (+178 and -55 genera). There are 26 genera with all included species described
1397   after MSW3, indicating that they were added based on the discovery of new species
1398   descriptions rather than splits. These generic revisions have changed the binomial names of at
1399   least 514 species that are recognized in both MDD2 and MSW3, a conservative estimate that
1400   does not consider generic changes to the many post-MSW3 species recognitions. Even the
1401   recognized species richness of groups such as *Microcebus* mouse lemurs, which rose from 2 to
1402   25 species over four decades (Franz et al. 2020), was recently reduced to 19 species after an
1403   integrative taxonomic revision (van Elst et al. 2024—published after the MDD2 cutoff date).
1404   Thus, like the preceding time period discussed above, revisionary taxonomy is perhaps the

1405   most appropriate characterization of mammal taxonomic change in this modern era (albeit with
1406   more frequent splitting than lumping).
1407
1408   Additional shifts from single-gene to genome-scale molecular analyses, and from linear and
1409   geometric morphometrics to computed tomographic (CT) scans, have revolutionized how
1410   species-rank units are being delimited in mammals and other taxa. The increasing use of
1411   integrative taxonomic approaches—defined as delimiting taxa via independent lines of evidence
1412   (e.g., comparing phylogeographic, morphological, ecological, and behavioral data; Dayrat 2005;
1413   Padial et al. 2010)—coupled with more rigorous statistical methods for delimiting species
1414   (reviewed in Smith and Carstens 2022) has led to revised species richness estimates within
1415   many taxa (Jörger and Schrödl 2013; Fišer et al. 2018). Documenting previously cryptic
1416   evolutionary structure has increased the informativeness of the species unit for downstream
1417   questions (e.g., biogeography, conservation; Vences et al. 2024). However, some researchers
1418   have pushed back against this movement, arguing that the recognition of "less distinct" species
1419   with histories of hybridization is a type of "taxonomic anarchy" that hampers conservation
1420   (Garnett and Christidis 2017). In response, others have emphasized that science-based
1421   taxonomy that "follows the evidence" is essential for the integrity of conservation efforts (Raposo
1422   et al. 2017; Thomson et al. 2018). Additionally, the loss of intermediate populations through
1423   human-mediated habitat fragmentation may lead to the recognition of previously connected
1424   populations as distinct species, which some argue as contributing to artificial taxonomic inflation
1425   (e.g., Clavero et al. 2024), while others express that this reflects a natural evolutionary shift that
1426   should be considered in taxonomic inferences ("speciation-by-extinction"; Seeholzer and
1427   Brumfield 2023). Establishing more formal governance structures for taxonomic decision
1428   making, at least partially mirroring the formal regulation of zoological nomenclature, is viewed by
1429   some as the path forward (Thiele et al. 2021). Others highlight the need for more pluralistic
1430   approaches, such as by developing tools to allow biodiversity databases to accommodate
1431   multiple taxonomic identifications for the same specimens and related data (Franz and Sterner
1432   2018; Sen et al. 2021; Montoya 2022). We later discuss how this interplay among biodiversity
1433   informatic disciplines impacts decision making (see *Mammal Taxonomy in Conservation and*
1434   *Biodiversity Infrastructure* section below).
1435
1436   New data and tools have not quieted the debate regarding "how distinct" a given population
1437   should be to be recognized as a separate species, especially given the substantial histories of
1438   introgressive hybridization that are now being uncovered within some mammal clades.
1439   Throughout the 21st century, phylogenetic reconstructions based on one or a few genes have
1440   been used to justify species limits among mammals. However, it may matter more *which* rather
1441   than *how many* characters or genomic regions are shared versus distinct among putative
1442   species. That is because some mammal species can retain phenotypic and ecological
1443   distinctiveness from related species in the face of moderate to extensive histories of
1444   introgressive hybridization (e.g., mustelids, felids, bats; Li et al. 2019; Colella et al. 2021; Foley
1445   et al. 2024). Comparative genomic evidence in cats (Bredemeyer et al. 2021) and house mice
1446   (Forejt et al. 2021) suggests that some regions on the X chromosome are "protected" from
1447   recombination, causing hybrid male offspring to be sterile if altered, thereby reinforcing the
1448   distinction among lineages. In contrast, 17–93% of the genomes of European *Myotis* bats

1449   apparently have introgressive origins (Foley et al. 2024), suggesting that many genomic regions
1450   can be freely exchanged without compromising the distinctiveness of a given species.
1451   Nevertheless, broadening such conclusions into generalities about mammals is likely
1452   premature. Many taxa lack sufficient geographic and taxonomic sampling to identify and
1453   interpret such hybridization histories (e.g., in the case of *Myotis keenii* and *M. evotis*; (Lausen et
1454   al. 2019, 2021; Morales et al. 2021; Upham et al. 2022b). Sampling difficulties are often
1455   exacerbated by the costs of fieldwork, specimen curation, and genome sequencing, but
1456   newfound efficacy sequencing genomes from preserved museum specimens promises to soon
1457   fill many populational gaps (e.g., Card et al. 2021; Raxworthy and Smith 2021; Benham and
1458   Bowie 2023). In a possible future where population genomic data are available for most
1459   mammal species, following the evidence about what genomically constitutes a different species
1460   may continue to surprise us.
1461
1462   Overall, trends in modern taxonomic research appear to reflect a paradigm shift in how
1463   systematists define the species unit (reviewed in Padial and De la Riva 2021). Suggested
1464   reimaginations of the subspecies rank to avoid species inflation (Hillis 2020; Dufresnes et al.
1465   2023) are balanced against the uneven history of subspecific classification that may render
1466   these categories ambiguous (Patton and Conroy 2017; Burbrink et al. 2022). For now, the MDD
1467   has refrained from formally recognizing subspecies in the taxonomy of mammals but may start
1468   doing so in some groups (e.g., bats) where species-to-subspecies relationships have been
1469   extensively tracked and thus retain meaning (Simmons and Cirranello 2024). More broadly, it is
1470   remarkable that the once-vigorous philosophical debate surrounding the validity of different
1471   species concepts is now largely superseded by integrative taxonomic approaches. We
1472   acknowledge that the historical discourse is important for understanding the current state of
1473   mammal systematics, but we defer to other sources that discuss it in depth (see Bradley and
1474   Baker 2001; Gippoliti and Groves 2012; Gippoliti et al. 2013, 2018; Zachos and Lovari 2013;
1475   Zachos et al. 2013, 2020; Zachos 2015, 2018a, 2018b; Gippoliti 2019; Taylor et al. 2019).
1476   Contemporary mammal systematics now focuses on evaluating how many independent lines of
1477   evidence simultaneously support a taxon's distinctiveness (i.e., integrative taxonomy; Dayrat
1478   2005; Padial and De la Riva 2021). To this end, recent efforts have sought to establish a "traffic-
1479   light system" to evaluate levels of taxonomic support for felid species (Kitchener et al. 2022),
1480   which parallels a proposed "scoring system" for bird species delimitation (Tobias et al. 2010,
1481   2021). This shift toward integrative taxonomy as opposed to choosing a single species concept
1482   underscores the importance of sharing key information in up-to-date taxonomic databases.
1483   Considering these trends, the relevance of integrating the latest evidence regarding mammal
1484   species boundaries into biological research and conservation efforts worldwide is only expected
1485   to grow.
1486

1487   ***Patterns and Shortfalls in Global Mammal Biodiversity.***
1488   Despite recent progress, considerable gaps remain in our collective knowledge of mammal
1489   species-rank taxonomy and geographic distributions—termed the Linnaean and Wallacean
1490   shortfalls, respectively (Hortal et al. 2015). These shortfalls pose hurdles to zoonotic disease
1491   and other biomedical research (Upham et al. 2021) as well as to the implementation of species
1492   conservation and management plans (Senior et al. 2024). This is particularly true for mammals

1493 given that they often serve as sentinels of change in threatened ecosystems (Moore 2008;
1494 Marneweck et al. 2022) or key nodes in zoonotic disease networks (Plowright et al. 2021;
1495 Venkatesan 2023; Weber et al. 2023). Through the compilation and curation of up-to-date
1496 taxonomic, geographic, and nomenclatural data, the MDD aims to continue lessening these
1497 shortfalls for mammalogical research. This curatorial work is synergistic with two parallel efforts
1498 in the biodiversity research community: (i) at the specimen level, where holistic specimens
1499 (Cook et al. 2016) and their derived data are becoming linked to form "digitally extended
1500 specimens" (Lendemer et al. 2020; NAS 2020); and (ii) at the publication level, where related
1501 data from publications are being extracted and linked to form "digitally accessible knowledge"
1502 (Fawcett et al. 2022). The non-copyrightability of primary research findings, particularly of the
1503 parts of articles that describe how names are conceptually applied to taxa (i.e., taxonomic
1504 treatments; Agosti and Egloff 2009; Benichou et al. 2023), provides an explicit legal framework
1505 for continuing to integrate these kinds of liberated and linked biodiversity data into the MDD.
1506
1507 Efforts to study the Linnaean shortfall typically estimate how many undescribed species likely
1508 exist and how long until the gap will be filled, using estimates for current rates of description
1509 based on authority years of species epithets. Using this approach in 2018, the MDD team
1510 estimated that recognized extant and recently extinct mammal richness will increase to 7,409
1511 species by 2050 and to 9,009 by 2100 if observed trends in historical species descriptions were
1512 to continue (Burgin et al. 2018). That pace exceeded the previous estimate of 7,500 total
1513 species based on the same method (Reeder et al. 2007). However, those estimates were both
1514 based on partial histories of mammal species description that ignore taxonomic changes
1515 resulting from species splitting and lumping, instead only focusing on de novo species
1516 descriptions. Lessa et al. (2024) reviewed this problem in detail, concluding that "relevant
1517 estimates of the number of known and unknown species will only be achieved by accounting for
1518 the dynamic nature of the taxonomic process itself" (p. 1365). Indeed, if we reconsider the
1519 predictions of Burgin et al. (2018) using the same approach, the expectation for 418 valid de
1520 novo species descriptions from 2010-2019 compares to only 369 currently valid species that
1521 were actually described de novo (i.e., with an authority year during this interval). That decadal
1522 total compares to 315 during 2000-2009 (originally 341 species in Burgin et al. 2018 but
1523 reduced by synonymizations in MDD2). Thus, these data reinforce the perspective that rates of
1524 de novo species description are only part of the "discovery rates" story, with the other major
1525 component being rates of species splitting and lumping that result from revisionary taxonomic
1526 efforts.
1527
1528 To more fully investigate this dynamic for mammals, we calculated the rate of new species
1529 *recognition* based on the estimated species totals reported in authoritative taxonomic
1530 compendia through time. These totals each represent the net outcome of species splits, lumps,
1531 and de novo descriptions at a given time point. Conducting a linear regression of mammal
1532 species totals sourced from 14 taxonomic compendia over 44 years (1980 to 2024; Table 1, Fig.
1533 1 upper panel) reveals a rate of 64.9 species recognized per year, which is higher than the rate
1534 of 27.4 species/year reported in Burgin et al. (2018) based on de novo descriptions alone. If this
1535 trend continues, we estimate that the total recognized mammal species richness will increase to
1536 ~7,084 species by 2030 and ~8,382 species by 2050. Both of these estimates are considerably

1537   higher than those given by Burgin et al. (2018) and Reeder et al. (2007) but are nonetheless
1538   realistic owing to the combined consideration of species splits, lumps, and de novo descriptions.
1539   The estimate of ~11,625 species by 2100 seems more far-fetched given that this trend is likely
1540   to level off at some point, but the ~70% increase over the current MDD2 total would be
1541   equivalent to the 1980–2024 increase from C&H1.
1542

1543   The potential for unidentified cryptic mammal species remains high, particularly within small-
1544   bodied and wide-ranging taxa. Parsons et al. (2022) used mitochondrial genetic data from a
1545   subset of 4,310 mammal species to find which covariates best predict unrecognized cryptic
1546   species, with body mass and range size ranking the highest. A meta-analysis across metazoans
1547   similarly supported this conclusion (Cahill et al. 2024). Unsurprisingly, rodents, bats, and
1548   eulipotyphlans are predicted to be the largest reservoirs of unrecognized cryptic mammal
1549   species despite the high rate of new species recognition in these clades. However, less
1550   specious mammal taxa like Hyracoidea, Scandentia, Pilosa, Pholidota, Lagomorpha, and
1551   Perissodactyla that have received comparatively less taxonomic attention in the 21st century
1552   are also more likely to contain cryptic species (Parsons et al. 2022). Within Pholidota, for
1553   example, a potentially new species was identified from DNA derived from tissue confiscated
1554   from the illegal pangolin trade (Gu et al. 2023), and another new species was also recently
1555   described (described as *Manis indoburmanica*, but *Manis aurita* Hodgson, 1836 may have
1556   nomenclatural priority; Wangmo et al. 2025). Similarly, a new species of Hyracoidea was
1557   described with evidence that further cryptic hyrax species exist (*Dendrohyrax interfluvialis*;
1558   Oates et al. 2022). Didelphimorphia stands out as having both a high degree of potential for
1559   cryptic species and extensive recent taxonomic research, with over 50 new species recognized
1560   since MSW3 (39.7% of valid Didelphimorphia species in MDD2). Conversely, the order Primates
1561   likely has considerably less remaining cryptic species, owing to focused and ongoing taxonomic
1562   research during the 21st century (161 new species since MSW3, 30.8% of valid Primates
1563   species in MDD2). Clade-specific taxonomic research thus remains imperative across the
1564   mammalian phylogeny, even in groups like Perissodactyla and Artiodactyla that are historically
1565   thought to be well-studied but still mostly lack integrative taxonomic revisions.
1566

1567   Geographically, recent progress in bridging the Linnaean shortfall for mammals has followed a
1568   latitudinal gradient, with more newly split species and de novo descriptions coming from tropical
1569   regions (Fig. 2, Table 3). The Neotropics and Indomalaya have particularly high proportions of
1570   newly recognized mammal species since MSW3, including 9 of the top 10 most new species-
1571   rich countries (Fig. 2A and 4B) and similarly at the continental scale (South America and Asia;
1572   Fig. 2B). Only around half of these newly recognized tropical species are splits, as opposed to
1573   in the Nearctic/North America and the Palearctic/Europe where split species form a higher
1574   proportion of new species recognitions since MSW3. These geographic patterns of taxonomic
1575   activity are consistent with previous estimates (Patterson 2000; Reeder et al. 2007; Burgin et al.
1576   2018; Moura and Jetz 2021). In contrast, some geographic regions have fewer newly
1577   recognized species than expected given their latitudinal location, habitat type, and total species
1578   richness. This is most evident in parts of Africa and Asia, such as West and Central Africa,
1579   Central Asia, most of India, and some Indonesian islands, supporting calls for taxonomic work in
1580   those regions (e.g., Klopper et al. 2002; Chatterjee et al. 2020; Monadjem et al. 2024). In terms

1581   of new species descriptions over the 21st century (Figs. 3), de novo species descriptions
1582   appear to be most concentrated in areas of high species endemism, such as mountains (e.g.,
1583   Andes, Himalayas, East African Highlands), islands (e.g., Madagascar, Philippines, Indonesia),
1584   and other biodiversity hotspots (e.g., Atlantic Forest). However, some of these patterns likely
1585   represent regional biases in taxonomic research and museum specimen collection. India, the
1586   Indonesian islands of Borneo, Sumatra, and Java, and West Africa have comparatively low
1587   rates of de novo species description but include large land areas with diverse habitat types
1588   conducive to endemism. The regions discussed above also appear to represent "biodiversity
1589   blindspots" according to a recent global assessment of digitized records in natural history
1590   collections (Ball et al. 2025), further highlighting the need for both specimen collection and
1591   digitization in these regions.
1592
1593   The Wallacean shortfall of incomplete geographic knowledge pertains to both newly described
1594   and previously recognized mammal species. As with earlier eras of mammal species
1595   descriptions (e.g., the peak of descriptive taxonomy in the early 19th century), some of the
1596   newly described species, particularly those known from fewer specimens, are likely to be
1597   synonymized in the future as additional populations and characters are sampled (Alroy 2002).
1598   Natural history collections and biorepositories play a central role in bridging geographic
1599   shortfalls by maintaining the core collections of voucher specimens used to document species
1600   distributions over time and space (Bakker et al. 2020). However, historical biases in mammal
1601   surveys have left large sampling gaps in tropical regions despite their high biodiversity and rates
1602   of recent species description (Fig. 4A, 4B). In addition, most specimens from those regions are
1603   housed in Europe and North America (see figure 2 in Heberling et al. 2021). This imbalance
1604   between where mammals live and where their specimens are preserved helps to perpetuate
1605   geographic disparities in biodiversity knowledge and conservation outcomes (see Pritchard et
1606   al. 2022). Thus, investing in resources like the MDD that digitally link and distribute this
1607   knowledge is a key step toward expanding access to research materials in highly biodiverse
1608   regions.
1609

1610   ***Mammal Taxonomy in Conservation and Biodiversity Infrastructure.***
1611   Despite advances in the understanding of species-rank taxonomy and geographic distributions
1612   since MSW3, ~25% of wild mammal species are 'understudied' by the IUCN Red List — either
1613   Not Evaluated (i.e., unclassified; ~14%) or classified as Data Deficient (~11%; Fig. 6). The IUCN
1614   Red List has assessed the conservation status of 5,983 mammal species as of version 2024-1,
1615   which is only 494 species more than were assessed in the 2008 IUCN Red List version (5,489
1616   species; summarized in Schipper et al. 2008). The total number of IUCN-assessed species is
1617   also 759 fewer than recognized in MDD2 (excluding domestic species not assessed by the
1618   IUCN). This IUCN-to-MDD2 gap is due to multiple factors, both infrastructural and sociological,
1619   that lead to delays in the integration of the latest research findings into the IUCN taxonomy.
1620   Unfortunately, delayed IUCN assessments are not unique to mammals and are viewed as a top
1621   priority for improving conservation outcomes globally (reviewed in Bachman et al. 2019). This
1622   lag in taxonomic change integration is also not unique to the IUCN, reflecting other ongoing
1623   challenges in biodiversity data science related to the linking and dissemination of primary
1624   research findings (e.g., Lendemer et al. 2020; Upham et al. 2021; Benichou et al. 2023; Sterner

1625   et al. 2023). The MDD is working to make progress in this domain via the curation and regular
1626   versioning of the collective implications of recent taxonomic publications. However, there is
1627   potential for much closer integration of MDD efforts with downstream biodiversity resources like
1628   the IUCN Red List. Failing to do so risks unnoticed species declines or population extinctions,
1629   particularly for the ~25% of mammal species that are understudied. Untracked taxonomic
1630   rearrangements also risk the misallocation of resources (e.g., for species like *Sylvilagus*
1631   *mansuetus* that the IUCN lists as CR but is not recognized in MDD2 due to synonymization with
1632   *S. bachmani*; Álvarez-Castañeda and Lorenzo 2016). Thus, greater MDD-to-IUCN integration
1633   carries potential for both speeding up processes of assessment and improving outcomes in
1634   mammal conservation.
1635
1636   Conservation practices in mammals often prioritize named taxonomic units like species and
1637   subspecies as the primary units of conservation, as seen in global frameworks like the IUCN
1638   Red List and national frameworks like the United States Endangered Species Act and Canadian
1639   Species at Risk Act. However, this practice can overlook finer-scale intraspecific diversity (Des
1640   Roches et al. 2021) and taxonomically unrecognized cryptic species in understudied taxa (i.e.,
1641   "dark extinctions"; Boehm and Cronk 2021), resulting in the loss of cryptic biodiversity (see
1642   review on cryptic species conservation by Hending 2024). To address these issues, some
1643   researchers and managers have argued for formally recognizing intraspecific variation as
1644   subspecies (e.g., Dufresnes et al. 2023) or non-Linnaean conservation units (e.g., Evolutionarily
1645   Significant Units, ESUs; Casacci et al. 2014). However, others have pointed out that although
1646   some conservation organizations recognize subspecies and other infraspecific conservation
1647   units (e.g., the IUCN and United States Endangered Species Act), the species rank has
1648   remained the primary "currency of conservation" in various mammal clades (Rylands and
1649   Mittermeier 2014; Gippoliti et al. 2018). Ideally, all units along the population-to-species
1650   continuum would receive some conservation protections regardless of their taxonomic rank, but
1651   the finite resources available for conservation and the incomplete assessments of global
1652   biodiversity have prevented this reality (Gippoliti and Amori 2007; Coates et al. 2018). As a
1653   result, some researchers have used conservation priorities to guide taxonomic practices rather
1654   than vice versa, leading either to the splitting of species into multiple smaller conservation units
1655   or the lumping of species to conserve those same units as subspecies or ESUs. The
1656   relationship between taxonomy and conservation is dynamic, and debate over the extent to
1657   which conservation concerns should influence the science of taxonomy will last long into the
1658   future.
1659
1660   The recent taxonomic history of primates and terrestrial ungulates (Perissodactyla and non-
1661   cetacean Artiodactyla) best illustrates the impact that conservation can have on species
1662   recognition. Both groups have been at the center of splitting versus lumping debates (e.g.,
1663   Rylands and Mittermeier 2014; Gippoliti et al. 2018) and both groups include many traditionally
1664   charismatic mammal species that are threatened with extinction (~64% of primates and ~40% of
1665   wild ungulates in MDD2 are listed as threatened by the IUCN). Both groups also have had their
1666   taxonomies updated more regularly by the IUCN than other groups of mammals (only ~3% of
1667   primates and ~8% of wild ungulates in MDD2 are Not Evaluated by the IUCN). However, the
1668   similarities end there, as these two groups have experienced considerably different taxonomic

1669   trajectories thus far in the 21st century. Primates experienced more species splitting starting

1670   with the publication of Groves' (2001) *Primate Taxonomy*, which was controversial at the time

1671   but initiated a wave of taxonomic revisions that massively increased the recognized primate

1672   species richness (176 species in Napier and Napier 1967 versus 376 in MSW3 and growing to

1673   522 in MDD2; see Groves 2014). The publication of Groves and Grubb's (2011) *Ungulate*

1674   *Taxonomy*, which split many ungulate species, served as a similar catalyst for taxonomic

1675   revision within ungulates. However, the outcome of that major shakeup in ungulate taxonomy

1676   did not have the same effect as in primates, since later authorities (including the MDD after

1677   version 1.2) have generally reverted to pre-2011 taxonomies and focused on making taxonomic

1678   changes based on more integrative taxonomic revisions (see *Taxonomic Decision-Making*

1679   section of Methods for further details). For example, recognized *Giraffa* diversity has ranged

1680   from 1–11 species, but most workers now recognize 4 species based on integrative taxonomic

1681   approaches (Winter et al. 2018; Petzold and Hassanin 2020; Coimbra et al. 2021; Kargopoulos

1682   et al. 2024). Both primates and ungulates require further taxonomic research, but the non-

1683   uniformity of taxonomic ideologies being applied remains a hotly debated topic (e.g., Taylor et

1684   al. 2019; Zachos et al. 2020).

1685

1686   The MDD taxonomy increasingly serves as an arbiter of species recognition for conservation

1687   organizations at global (e.g., IUCN), national (e.g., NatureServe), and regional levels (e.g., state

1688   agencies). Additionally, the MDD aims to serve as a foundational taxonomic connection

1689   between other biodiversity resources, such as species record aggregators (e.g., GBIF, Map of

1690   Life, iNaturalist), digitized museum archives (e.g., Arctos, Symbiota, iDigBio), and various other

1691   biological databases (e.g., GenBank, NCBI Virus, FuTRES, Morphosource, Global Biotic

1692   Interactions—GloBI). Efficient communication and application of biodiversity knowledge

1693   between conservation and biodiversity resources requires agreed-upon organismal units that

1694   can serve as foundational designations for conservation decisions made on those units. Most

1695   often these units are species (but specimens or individuals are also commonly used). The value

1696   of accurately communicating 'species' categories highlights the basal importance of taxonomy

1697   and nomenclature in biodiversity infrastructure (Grieneisen et al. 2014; Sterner et al. 2020a).

1698   However, as discussed throughout this article, taxonomy and nomenclature are by no means

1699   static—the creation of species lists is plagued by gaps in biodiversity knowledge (i.e., the

1700   Linnean and Wallacean shortfalls), differing taxonomic opinions, failure to track and digitally

1701   integrate those changing taxonomies, and inconsistencies in how the ICZN Code is

1702   implemented (Garnett and Christidis 2017; Raposo et al. 2017, 2021; Franz and Sterner 2018;

1703   Upham et al. 2021). Nevertheless, the value of updated species lists to biodiversity science

1704   outweighs the pitfalls of maintaining them. The value of species-centric taxonomic databases

1705   like the MDD grows in proportion to the number of disparate sources of biodiversity knowledge

1706   they can effectively integrate. Doing so improves the rigor of a wide range of studies in

1707   conservation, biodiversity, and biomedical sciences that rely on accurate taxonomy, facilitating

1708   work that might otherwise go undone.

1709

1710   ***Governance.***

1711   Moving forward, the MDD is in the process of forming external taxonomic subcommittees that

1712   are scheduled to begin activity in early 2026. Subcommittee members will include global

1713 representation of taxon-specific experts to help with the ongoing process of curating mammal
1714 taxonomic, geographic, and nomenclatural information, serving an advisory role to the ASM's
1715 Biodiversity Committee in coordinating the MDD. Initial plans have divided mammal clades
1716 across 25 subcommittees, each one focusing on a clade or composite taxonomic group ranging
1717 in size from 18 species (Perissodactyla) to over 800 species (Cricetidae, Muridae). Each
1718 subcommittee will have members shared with one or more IUCN Species Survival Commission
1719 Specialist Group, of which there are currently 36 for mammals (IUCN 2024b), aiming to facilitate
1720 direct coordination between MDD taxonomic changes and the IUCN Red List assessment
1721 process. MDD taxonomic subcommittees will also be encouraged to formally issue 'subjective
1722 decisions' in cases of taxonomic conflict in the primary literature, following the model of Zenodo
1723 self-publishing previously established for bats (see *Taxonomic Decision-Making* section in the
1724 Methods—Francis et al. 2022, 2023; Upham et al. 2022b). A key goal of subcommittee efforts is
1725 to organize archives that contain full citations and textual links to all the publications used to
1726 justify taxonomic decisions in the MDD. These archives can then be directly shared with outside
1727 research groups to lower barriers to access and catalyze further research. A pilot of this
1728 approach is available on https://batlit.org, containing >20,000 publications pertaining to bat
1729 taxonomy and ecology that are a mix of open and closed access works uploaded to Zenodo for
1730 controlled sharing with collaborators (Sherman et al. 2024). Expanding this pilot effort to
1731 encompass publications relevant to taxonomic decisions across Mammalia would parallel
1732 similar initiatives in drosophilid flies (Bächli 2024) and reptiles (Uetz et al. 2023). Collectively,
1733 the formation of MDD taxonomic subcommittees aims to create a structured community of
1734 experts for sharing literature and curating taxonomic knowledge of mammals globally. ASM
1735 membership will not be required for inclusion, which underscores the expected global breadth of
1736 participant expertise as well as the need to effectively coordinate subcommittee activities using
1737 online collaboration tools.
1738
1739 Overall, the MDD team currently strives to "follow the science" and update the MDD based on
1740 peer-reviewed scientific articles as they are published and with as few subjective decisions as
1741 possible. However, this can result in taxonomic revisions that are ricochetal, bouncing between
1742 article-and-response cycles (e.g., recent back-and-forth debates concerning the bat genus
1743 *Lasiurus*; Baird et al. 2015, 2017, 2021; Ziegler et al. 2016; Novaes et al. 2018; Teta 2019). It
1744 may also result in revisions that the broader mammalogical community see as weakly
1745 corroborated. With these limitations in mind, we recommend that conservation authorities and
1746 other biodiversity databases use the MDD as a starting point to build species lists for policy
1747 creation and as a backbone for inter-database connectivity. Soon, the MDD team aims to work
1748 with the taxonomic subcommittees to establish a multi-dimensional 'grading system' that will
1749 summarize information on both the *extent* and *quality* of corroborating taxonomic evidence for
1750 particular species. This grading system will expand on Kitchener et al.'s (2022) proposed 'traffic-
1751 light' categories by establishing a continuous rubric for grading the completeness of data
1752 sampling and statistical strength of that taxonomic evidence. The number of independent
1753 datasets that support species recognition (e.g., genetic, ecological, morphological) would still be
1754 considered, but the new quality rubric will add degrees of nuance that are hidden within the
1755 traffic-light system's categories (green, yellow, red, and black—only one of which is "go").
1756 Building this grading system will provide a more flexible means of synthesizing the extent to

1757   which integrative taxonomic evidence supports a given species as being distinct from others.
1758   Once established, the contained evidence of this grading system will allow researchers,
1759   conservationists, and policymakers to compare support and identify gaps in knowledge of
1760   different taxa. This will, in turn, enable better-informed decision making, including in cases
1761   where an organization chooses to deviate from the recognized MDD taxonomy. Enabling a
1762   plurality of taxonomic viewpoints rather than enforcing a single one is a feature that we contend
1763   will maximize the equitability of biodiversity outcomes (see reviews by Franz and Sterner 2018;
1764   Montoya 2022; Sterner et al. 2023).
1765
1766   ***Future Directions and Conclusion.***
1767   Continued improvements to the MDD are targeted in three areas: (i) curating new and existing
1768   data sources; (ii) linking those curated data to other public databases; and (iii) informing future
1769   curation using those newly linked resources (Fig. 7). This iterative process will help establish the
1770   MDD as an open-access portal for mammalogical research globally. We aim for each MDD
1771   species page to eventually serve as the primary hub for connecting researchers to external
1772   biodiversity information about that mammal species. Much of this content will be hosted on other
1773   websites indexed using versions of the MDD taxonomy. Databases such as the Integrated
1774   Taxonomic Information System (ITIS 2025) and Catalog of Life (CoL 2025) are increasingly
1775   critical for national and international processes of biodiversity decision-making, but they still
1776   primarily rely on MSW3-based taxonomies and synonymies for mammals. The MDD's
1777   continuously curated data now presents an excellent opportunity for greater cross-linking among
1778   various databases that contain mammal biodiversity information. National Center for
1779   Biotechnology Information (NCBI) resources like GenBank, RefSeq, and NCBI Virus will
1780   especially benefit from greater cross-linking of deposited genetic data with updated taxonomies
1781   for mammals and other taxa (Garg et al. 2019). Currently, only record authors or administrative
1782   batch edits can update NCBI taxonomy (Schoch et al. 2020), but if the MDD team can identify
1783   cases where taxonomic updates are unambiguous, then feeding batch recommendations to
1784   NCBI curators could allow for greater integration.
1785
1786   Considering MDD plans relative to broader activities of the American Society of Mammalogists
1787   (ASM), which generously supports the MDD through the Biodiversity Committee, there is
1788   potential for greater taxonomy-related coordination across Society efforts. Leaders of the Public
1789   Education Committee that curates a US state list of mammals and the Mammal Images Library
1790   (MIL) Committee that curates expert-identified photographs of mammals both regularly
1791   communicate with the MDD team, but the activities of those committees are not directly
1792   integrated with MDD taxonomic updates. For example, hosting MIL images on MDD species
1793   pages may help flag needed naming updates, enabling the maintenance of the MIL's current
1794   hand-harmonization with the MDD taxonomy. Similarly, the long-time ASM publication
1795   *Mammalian Species* (*MS*; 1969-present) may benefit from being directly indexed using the MDD
1796   taxonomy, which would help flag *MS* species accounts needing updates after taxonomic
1797   changes. Lastly, MDD efforts could help address ethical concerns over the use of eponyms in
1798   mammalogy (i.e., species named after people). Recent discussions over whether eponyms
1799   should be changed regardless of whether they were named after controversial figures do not
1800   have easy solutions (e.g., DuBay et al. 2020; Guedes et al. 2023; Thiele 2023; Winker 2024).

1801   Wholesale changes to scientific names are untenable without more sophisticated biodiversity
1802   infrastructure for renaming millions of species observations (Ceríaco et al. 2023). However, in
1803   mammals at least, eponymous *common names* would be much easier to begin changing given
1804   that they are unregulated by any governing body (in contrast to birds; Winker 2024). As a result,
1805   Chen-Kraus et al. (2021) recently proposed changing the eponymous common names of 140
1806   primate species. Clearly there is a need to seriously consider such proposals, and the MDD
1807   could function as a community-based platform to help reach consensus on this and other
1808   controversial issues.
1809
1810   In conclusion, MDD2 and future versions offer a platform for the community curation of often
1811   hard-to-access but fundamentally important data that underpins biodiversity knowledge of living
1812   and recently extinct mammals. With 6,759 recognized mammal species and >50,000 species-
1813   rank names, MDD2 provides a comprehensive resource that not only lessens aspects of the
1814   Linnean and Wallacean shortfalls but also highlights critical remaining knowledge gaps. The
1815   hard-won nomenclatural metadata included in MDD2 provide researchers with the foundational
1816   tools needed to conduct taxonomic revisions, resolve nomenclatural conflicts, and refine
1817   species boundaries. By ensuring that these metadata are linked to broader biodiversity
1818   infrastructure, the MDD supports more robust and integrative approaches to mammalian
1819   taxonomy and conservation planning than would otherwise be possible. MDD2 also reveals a
1820   pressing conservation challenge: the ~25% of mammal species that remain understudied on the
1821   IUCN Red List raises alarms about the need to address these knowledge gaps and prevent
1822   unrecognized biodiversity loss (Ceballos et al. 2017). By establishing taxonomic subcommittees
1823   and fostering global collaborations, the MDD is positioned to continue providing authoritative
1824   taxonomic updates that advance both scientific and conservation priorities. The MDD and
1825   parallel databasing efforts across the Tree of Life underscore the general recognition across the
1826   biological sciences that high-quality curated information regarding how species are classified
1827   (taxonomy), how names are applied (nomenclature), and where those species live
1828   (biogeography) is critical for the accuracy of downstream research. Species, their natural
1829   histories, and our scholarly history of investigating those boundaries are key for advancing
1830   humanity's collective knowledge of biodiversity.
1831

1845 history collections community in particular for their collective efforts to document mammal
1846 diversity, as well as continued support, feedback, and diligence in sending the MDD team
1847 publications to incorporate into the MDD.
1848

DATA AVAILABILITY

1850 The R code used to analyze these data, plot figures, and create supplementary files is available
1851 in a GitHub repository accessible at https://github.com/mammaldiversity/MDDv2_ms.
1852

SUPPLEMENTARY DATA

1854 Supplementary Data SD1.—MDD2 species list, plus associated metadata, in a zipped folder.
1855 Supplementary Data SD2.—MDD2 synonym list, plus associated metadata, in a zipped folder.
1856 Supplementary Data SD3.—All MDD version species lists, plus associated metadata, in a
1857 zipped folder.
1858 Supplementary Data SD4.—All MDD 'diff' files, plus associated metadata, in a zipped folder.
1859 Supplementary Data SD5.— 'Diff' file specifically between MDD1 and MDD2, plus associated
1860 metadata, in a zipped folder.
1861 Supplementary Data SD6.—Summary of nomenclatural data and species totals by taxonomic
1862 group, plus associated metadata, in a zipped folder.
1863 Supplementary Data SD7.—Summary of nomenclatural data and species totals by geographic
1864 region, plus associated metadata, in a zipped folder.
1865 Supplementary Data SD8.—Summary of nomenclatural data totals by nomenclatural and
1866 validity status, plus associated metadata, in a zipped folder.
1867 Supplementary Data SD9.—Total available and valid names described per year since 1758 and
1868 summary of 10-year running means used to create Figure 1, plus associated metadata, in a
1869 zipped folder.
1870 Supplementary Data SD10.—Occurrence matrix for species country and offshore territory
1871 distribution data in a zipped folder.
1872 Supplementary Data SD11.—Per country usage of the MDD website at mammaldiversity.org in
1873 a zipped folder.
1874

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2576

2577 **TABLES**

2578 **Table 1**. Taxon counts for major mammalian taxonomic compendia since 1980 (see Fig. 1 for
2579 graphical representation of species totals not including IUCN totals), including the three editions
2580 of Corbet and Hill's (C&H) *A World List of Mammalian Species*, editions four through six of
2581 *Walker's Mammals of the World* (WMW), Anderson and Jones' *Orders and Families of Recent*
2582 *Mammals of the World* (A&J), Duff and Lawson's *Mammals of the World: A Checklist* (D&L),
2583 three editions of the *Mammal Species of the World* (MSW), *Illustrated Checklist of the Mammals*
2584 *of the World* (CMW), International Union for the Conservation of Nature (IUCN) 2008 and 2024-
2585 1 listings, and two major versions of the Mammal Diversity Database (MDD1 and MDD2).
2586

Taxa	C&H1 1980	MSW1 1982	WMW4 1983	A&J 1984	C&H2 1986	C&H3 1991	WMW5 1991	MSW2 1993	WMW6 1999	D&L 2004	MSW3 2005	IUCN 2008[c]	MDD1 2018	CMW 2020	IUCN 2024	MDD2 2024
Species	4,005[a]	4,170	4,151	4,199	4,231	4,336	4,444	4,631[b]	4,809	5,115	5,416	5,489	6,495	6,554	5,983	6,753
Wild Extant	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5,338	5,410[d]	6,382	6,451	5,899[d]	6,629
Recently Extinct	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	75	79	96	103	84	113
Domestic	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	3	0[e]	17	20	0[e]	17
Genera	1,014	1,033	1,017	1,057	1,055	1,066	1,116	1,135	1,192	1,117	1,230	1,241	1,316	1,343	1,308	1,353
Families	129	135	133	131	132	131	135	132	146	128	153	156	166	167	164	167
Orders	21	20	20	21	20	21	21	26	28	27	29	27	27	27	27	27

[a] Lists 4,007 species, but we identified two duplicates (what is now *Brucepattersonius iheringi* is listed under both *Microxus* and *Oxymcterus*, and *Prosciurillus leucomus* is listed under both *Prosciurillus* and *Callosciurus*)

[b] Corrected total per Solari and Baker (2007)

[c] IUCN 2008 totals based on Schipper et al. (2008)

[d] Includes species classified as Extinct in the Wild and does not include humans

[e] The IUCN does not assess domestic species

2587

2588

2589 **Table 2**. Taxon counts for all 18 versions of the MDD from the initial release of MDD1 in 2018 to

2590 the present release of MDD2. Species-level differences ('diffs') between versions are noted with

2591 the terms 'de novo' (additions that coined a new species epithet), 'split' (additions that applied

2592 an existing species epithet to a newly recognized taxon), and 'lump' (removals that combined

2593 two or more existing species-rank taxa). Totals of split species do not include names

2594 erroneously excluded from earlier versions, and total lumped species do not include names

2595 removed due to being considered *nomina dubia* or unavailable. See Supplementary Data SD4

2596 for all MDD version 'diff' files and Supplementary Data SD5 for the 'diff' file between MDD1 and

2597 MDD2 specifically.

2598

Taxa	MDD1.0 Feb 2018	MDD1.1 Mar 2019	MDD1.2 Sep 2020	MDD1.3 Dec 2020	MDD1.3.1 Jan 2021	MDD1.4 Apr 2021	MDD1.5 Jun 2021	MDD1.6 Aug 2021	MDD1.7 Nov 2021
Species	6,495	6,527	6,485	6,513	6,513	6,533	6,554	6,557	6,567
Wild Extant	6,382	6,410	6,363	6,391	6,391	6,411	6,432	6,435	6,447
Recently Extinct	96	100	103	103	103	103	103	103	101
Domestic	17	17	19	19	19	19	19	19	19
Diff: De Novo	NA	+22	+98	+14	0	+13	+11	+5	+13
Diff: Split	NA	+33	+154	+15	0	+18	+10	+3	+6
Diff: Lump	NA	-31	-285[a]	-4	0	-10	0	-5	-8
Genera	1,316	1,323	1,331	1,330	1,330	1,332	1,335	1,341	1,343
Families	166	168	167	167	167	167	167	167	167

Taxa	MDD1.8 Feb 2022	MDD1.9 Apr 2022	MDD1.9.1 Jun 2022	MDD1.10 Dec 2022	MDD1.11 Apr 2023	MDD1.12 Jan 2024	MDD1.12.1 Jan 2024	MDD1.13 Jul 2024	MDD2.0 Aug 2024
Species	6,591	6,596	6,596	6,615	6,649	6,718	6,718	6,753	6759
Wild Extant	6,471	6,476	6,476	6,494	6,526	6,594	6,594	6,623	6629
Recently Extinct	101	101	101	101	105	107	107	113	113
Domestic	19	19	19	20	18	17	17	17	17
Diff: De Novo	+21	+8	0	+22	+15	+37	0	+24	+2 (296)[b]
Diff: Split	+6	+7	0	+26	+49	+36	0	+25	+4 (321)[b]
Diff: Lump	-3	-10	0	-30	-29	-8	0	-12	0 (357)[b]
Genera	1,342	1,342	1,342	1,347	1,345	1,351	1,351	1,353	1353
Families	167	167	167	167	167	167	167	167	167

[a] Most of the ungulate revisions from Groves & Grubb (2011) were removed except where corroborated by later publications

[b] Total differences between MDD1 and MDD2 in parentheses

2601

2602 **Table 3**. Summary of total species, available name type localities (including preoccupied,

2603 replacement, and suppressed names), and new species descriptions and split species since

2604 MSW3 found in each of the eight terrestrial biogeographic realms (not including marine species,

2605 other than for available name type localities) and seven continents (including marine species for

2606 all metrics), as well as the land area (in million km^2) and species density (in species per million

2607 km^2). Land areas for biogeographic realms come from Olson et al. (2001) (other than the

2608 Antarctic, which was recalculated to include all of continental Antarctica) and continents come

2609 from estimates listed on the Wikipedia pages of each continent. See Figure 2 for the graphical

2610 representation of this data.

2611

Region Name	Total Species[a]	Available Names	New Species Descriptions	Split Species	Land Area (million km²)	Species Density (per million km²)[b]
Biogeographic Realm						
Neotropic	1,839	5,496	302	261	19.00	96.79
Afrotropic	1,505	5,579	183	111	22.10	68.10
Palearctic	1,143	5,812	92	173	54.10	21.13
Indomalaya	1,090	4,359	144	124	7.50	145.33
Australasia	860	2,106	69	62	7.60	113.16
Nearctic	716	3,092	16	98	22.90	31.27
Oceania (Biorealm)	21	47	2	1	1.00	21.00
Antarctic	0	18	0	0	14.20	0.00
Continent						
Asia	2,104	7,676	246	255	44.60	47.17
Africa	1,622	6,338	184	119	30.40	53.36
South America	1,586	4,068	261	201	17.80	89.10
North America	1,123	5,224	60	174	24.20	46.40
Oceania (Continent)	775	1,786	54	55	8.50	91.18
Europe	321	2,738	6	39	10.00	32.10
Antarctica	45	18	0	0	14.20	3.17

[a] Total Species includes recently extinct species but not domesticated or introduced species

[b] Species Density calculated as Total Species / Land Area

2612

2613

2614 **Table 4**. Summary of nomenclatural metadata released in MDD2 separated into nomenclatural
2615 status and validity status. Totals for available names include preoccupied names, *nomina nova*,
2616 and suppressed names (all of which are also summarized separately). Totals for unavailable
2617 names include all nomenclatural status conditions that are not some form of subsequent use,
2618 while name combinations, spelling variants, and other miscellaneous subsequent uses are
2619 summarized separately (see Supplementary Data SD8 for a full list of nomenclatural and validity
2620 statuses and finer scale numeric summaries). Multiple nomenclatural labels can be applied to a
2621 single name, while only one validity status can be applied to a name, so column totals
2622 summarize the validity statuses.

2623

Status	Total Names	Authority Author	Authority Year	Names Since 2000	Original Combination	Original Rank	Authority Citation	Verified Authority Citation
Nomenclature Status								
Total Available Names	28,382	28,382	28,374	1,191	28,297	28,297	28,316	23,493
Nomina Nova	925	925	925	13	925	925	925	791
Preoccupied Names	1,100	1,100	1,100	5	1,095	1,095	1,093	812
Suppressed Names	39	39	39	0	39	39	39	29
Total Unavailable Names	2,127	2,127	2,127	122	2,119	2,119	2,119	1,696
Spelling Variants	3,445	3,445	3,445	718	3,437	3,437	3,439	3,114
Name Combinations	16,182	16,182	16,182	8,466	16,182	16,182	16,182	16,135
Other Subsequent Usages	435	435	435	2	434	434	433	386
Validity Status								
Synonymous Names	42,880	42,880	42,872	9,494	42,783	42,783	42,798	37,821
Valid Species	6,759	6,759	6,759	899	6,759	6,759	6,759	6,150
Species Inquirendae	94	94	94	0	94	94	94	88
Nomina Dubia	475	475	475	29	470	470	475	414
Composite Type Material	10	10	10	0	10	10	10	7
Hybrid Type Material	12	12	12	1	12	12	12	12
Total								
Total Names	50,230	50,230	50,222	10,423	50,128	50,128	50,148	44,492

Status	Authority Page	Authority Link	Authority Page Link	Type Locality	Original Type Locality	Type Coordinates	Type Specimen	Type Specimen Link
Nomenclature Status								
Total Available Names	28,024	21,823	18,483	28,259	18,877	2,771	20,811	13,179
Nomina Nova	913	721	615	913	691	31	498	242
Preoccupied Names	1,071	763	679	1,086	719	19	390	178
Suppressed Names	39	29	29	36	25	0	8	1
Total Unavailable Names	2,076	1,480	1,249	1,243	720	28	196	54
Spelling Variants	3,412	2,572	1,502	245	85	1	9	5
Name Combinations	10,728	11,714	4,301	100	61	0	10	4
Other Subsequent Usages	431	363	319	226	127	0	6	3
Validity Status								
Synonymous Names	37,001	31,393	20,679	22,886	14,247	943	14,977	9,600
Valid Species	6,756	5,820	4,619	6,759	5,282	1,852	5,941	3,617
Species Inquirendae	93	80	63	79	71	1	18	3
Nomina Dubia	467	393	328	327	255	4	92	25
Composite Type Material	9	7	6	10	6	0	3	0
Hybrid Type Material	12	10	8	6	6	0	1	0
Total								
Total Names	44,338	37,703	25,703	30,067	19,867	2,800	21,032	13,245

2626

2627 **FIGURES**

2628 **Box 1**. Definitions for taxonomic and nomenclatural terms relevant to this publication.

2629 **Definitions Box**:

2630 **Taxonomy** - the science of naming, defining, and classifying organisms into taxonomic entities,
2631 dealing with both species- (**Alpha Taxonomy**; species, subspecies) and higher-rank taxonomic
2632 groups (**Beta Taxonomy**; genus, family, order, etc.); taxonomic changes result in changes to
2633 biological concepts, by lumping taxa together (**Lump**), splitting a taxon into multiple taxa (**Split**),
2634 descriptions of new names for previously undescribed taxa (**De Novo**), or moving taxa between
2635 different higher taxa (e.g., species moving between genera).

2636

2637 **Taxon/Taxa** - a set of organisms together forming a single defined biological grouping at any
2638 taxonomic rank, with each ranking nested within the rank above; **Species-rank Taxa** include
2639 species, subspecies, and formerly used infrasubspecific rank names (e.g., forms, varieties);
2640 **Higher-rank Taxa** include all taxonomic rankings above the species-rank (class to subgenus
2641 applicable for the MDD).

2642

2643 **Nomenclature** - the process of assigning scientific names to taxa based on a set of
2644 standardized rules in which each species has a two part name, starting with a genus and ending
2645 in a specific epithet (**Binomial Nomenclature**); nomenclatural changes result in changes to the
2646 name used for a taxon that do not change its taxonomic concept; zoological nomenclature for
2647 species-, genus-, and family-rank names are governed by the rules published in the **ICZN Code**
2648 (ICZN 1999), written by the International Commission on Zoological Nomenclature (ICZN).

2649

2650 **Authority** - the surnames of the author(s) of the original description of a scientific name
2651 followed by the year that name was described; for species-rank names, parentheses are added
2652 around the entire authority when a specific epithet was described in a different genus than it
2653 currently resides; the year listed in the authority should be the year the name was published
2654 according to the ICZN Code (although the year of description does not always match what is
2655 printed on the publication itself).

2656

2657 **Name-bearing Type** - a biological entity that is permanently attached to a scientific name,
2658 acting as a reference to identify which taxon a scientific name belongs to; for species-rank
2659 names, the type is usually a single animal, some part of which or its entirety is usually preserved
2660 as a museum specimen (**Holotype**), or two or more animals preserved as museum specimens
2661 (**Syntypes**); syntypes can be later restricted to a single type specimen within the series as
2662 needed (**Lectotype**); when the original type material for a species-rank name has been lost or
2663 destroyed, one or more specimens should be designated as a **Neotype**; family-rank names
2664 have a **Type Genus** and genus-rank names have a **Type Species**, which are not based on
2665 physical biological materials.

2666

2667 **Type Locality** - the geographic locality from which the type material for a species-rank name
2668 originated, which may be later restricted or redefined if necessary.

2669

2670 **Valid Name/Taxon** - a scientific name that represents the correct name for a biological taxon as
2671 defined by the rules in the ICZN Code and recognized by a particular authority; usually but not
2672 always the oldest available name.
2673
2674 **Synonym** - a scientific name that has been identified as representing a specific taxon, but is not
2675 the valid name for that taxon; synonyms can be names initially meant to represent a new taxon
2676 (both Available and Unavailable Names for nomenclatural use, as defined below), or may
2677 represent later use of those names (Name Combinations or Spelling Variants; see definitions of
2678 these terms below).
2679
2680 **Available Name** - a scientific name that meets the standards for nomenclatural availability as
2681 defined by the ICZN Code; some names may be available for nomenclatural use but are not
2682 assignable to a single species, such as a **Nomen Dubium/Nomina Dubia** (a name completely
2683 unidentifiable to a valid taxon), **Species Inquirenda/ae** (a name not currently identified to a
2684 valid taxon, but with the potential to be), or names based on a **Composite** (type material from
2685 multiple individuals of different valid species) or **Hybrid** type material (type specimen of
2686 interspecific hybrid origin).
2687
2688 **Unavailable Name** - a scientific name that does not meet the standards for nomenclatural
2689 availability according to the ICZN Code, often resulting from the name being improperly
2690 published (**Unpublished Name**) or published without a taxonomic description (**Nomen
2691 Nudum/Nomina Nuda**), among other reasons.
2692
2693 **Preoccupied Name** - an otherwise available scientific name that matches the spelling of an
2694 older name within the same taxonomic rank, making it unavailable for nomenclatural use; in
2695 species-rank names, the preoccupying name can either be originally described in the same
2696 genus (**Primary Homonym**), or subsequently moved into that genus (**Secondary Homonym**);
2697 when the name for a currently recognized species is preoccupied, a **Nomen Novum/Nomina
2698 Nova** (new name) should be described to replace the preoccupied name.
2699
2700 **Name Combination** - the unique combination of a genus and specific epithet (or subspecific
2701 epithet) to form the scientific name of a then-valid species or subspecies (and forms or varieties
2702 in older literature); name combinations are synonymous names that are not currently recognized
2703 because they are not type-bearing or valid, but they can represent the history of taxonomic
2704 change associated with a name across genera, species, and subspecies.
2705
2706 **Spelling Variant** - a difference in spelling from a scientific name's original spelling, which can
2707 be incorrect in the original publication (**Incorrect Original Spelling**) or later publications
2708 (**Incorrect Subsequent Spelling**), or a purposeful change considered to be unjustified
2709 (**Unjustified Emendation**) or justified (**Justified Emendation**) according to the ICZN Code;
2710 justified spelling changes are usually those of specific epithets with adjective etymological roots,
2711 which change to match the etymological gender of the genus, or to Latinized names with non-
2712 standard characters (e.g., ñ, ö), although there are other rare exceptions allowing for justified
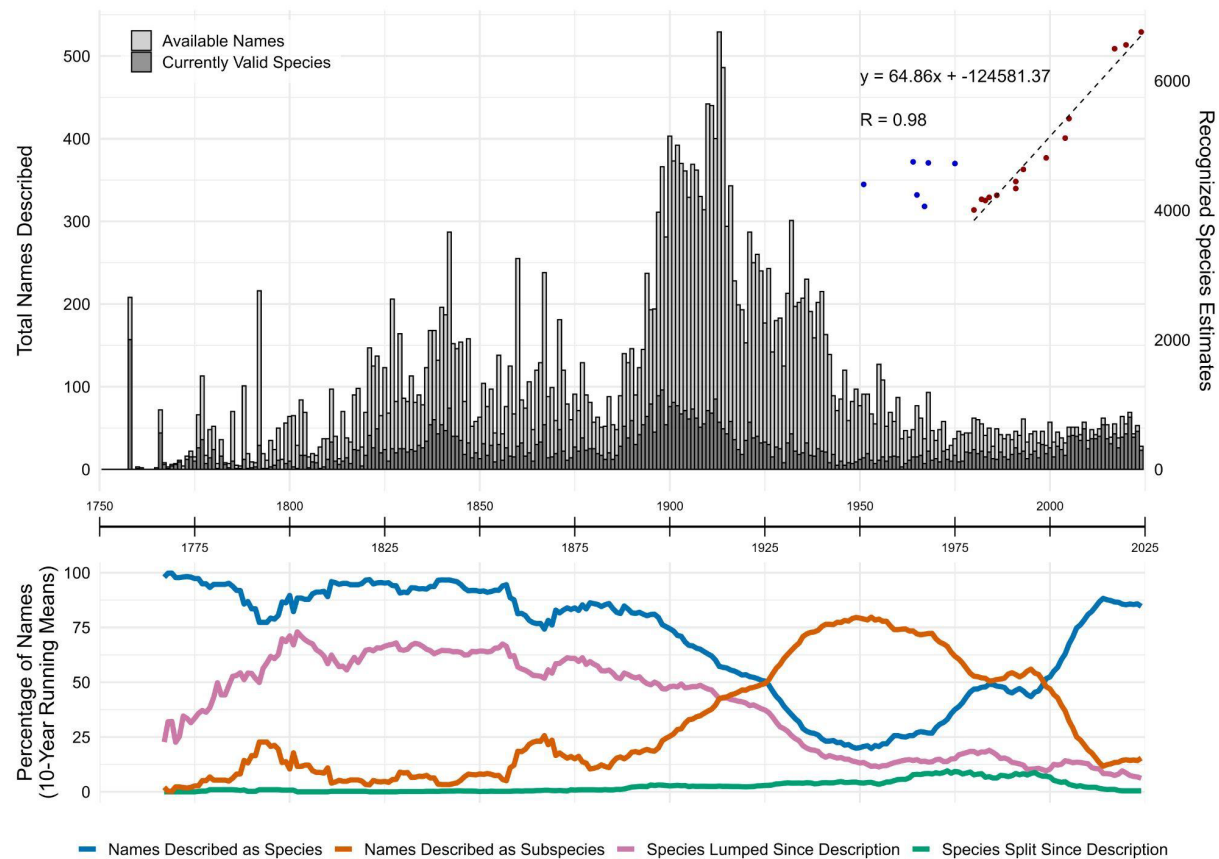2713 emendations to a name's original spelling.

2714

Figure 1. A graphical history of mammalian species-group name descriptions since the start of zoological nomenclature on 1 January 1758, incorporating all 28,382 available names (including preoccupied, replacement, and suppressed names) and 6,759 names currently recognized as valid species in MDD2. The histogram summarizes the number of available names (light gray) and valid species names (dark gray) described each year from 1 Jan 1758 to 15 Aug 2024 (a ~267 year period). The lines in the bottom panel summarize the 10-year running means (starting 1768) for the proportion of names initially described at the ranks of species (blue) and subspecies (orange), as well as the proportions of names initially described as species and then lumped into another species (pink) or initially described as subspecies, forms, or varieties and then split into their own species (turquoise). Since all four lines were smoothed by taking 10-year running means, each point on these lines represents a mean generated from the previous 10 years of data. See Supplementary Data SD9 for the raw data and running means used to create the line graph in this figure. Total recognized mammal species estimates are included from major compendia since Corbet and Hill (1980; red points), including all taxonomic compendia listed in Table 1 other than IUCN totals (which are not representative of the actual recognized mammals at the time of versioning). A linear regression line, equation, and R^2 value of these data are included on the graph. Six additional pre-1980s species estimates are also included for comparison (blue points), which are from resources that do not include full species lists (4,400 species in Storer 1951; 4,748, 4,732, and 4722 species in Walker et al. 1964, 1968, 1975; 4,237 species in Morris 1965; 4,060 species in Anderson and Jones 1967).
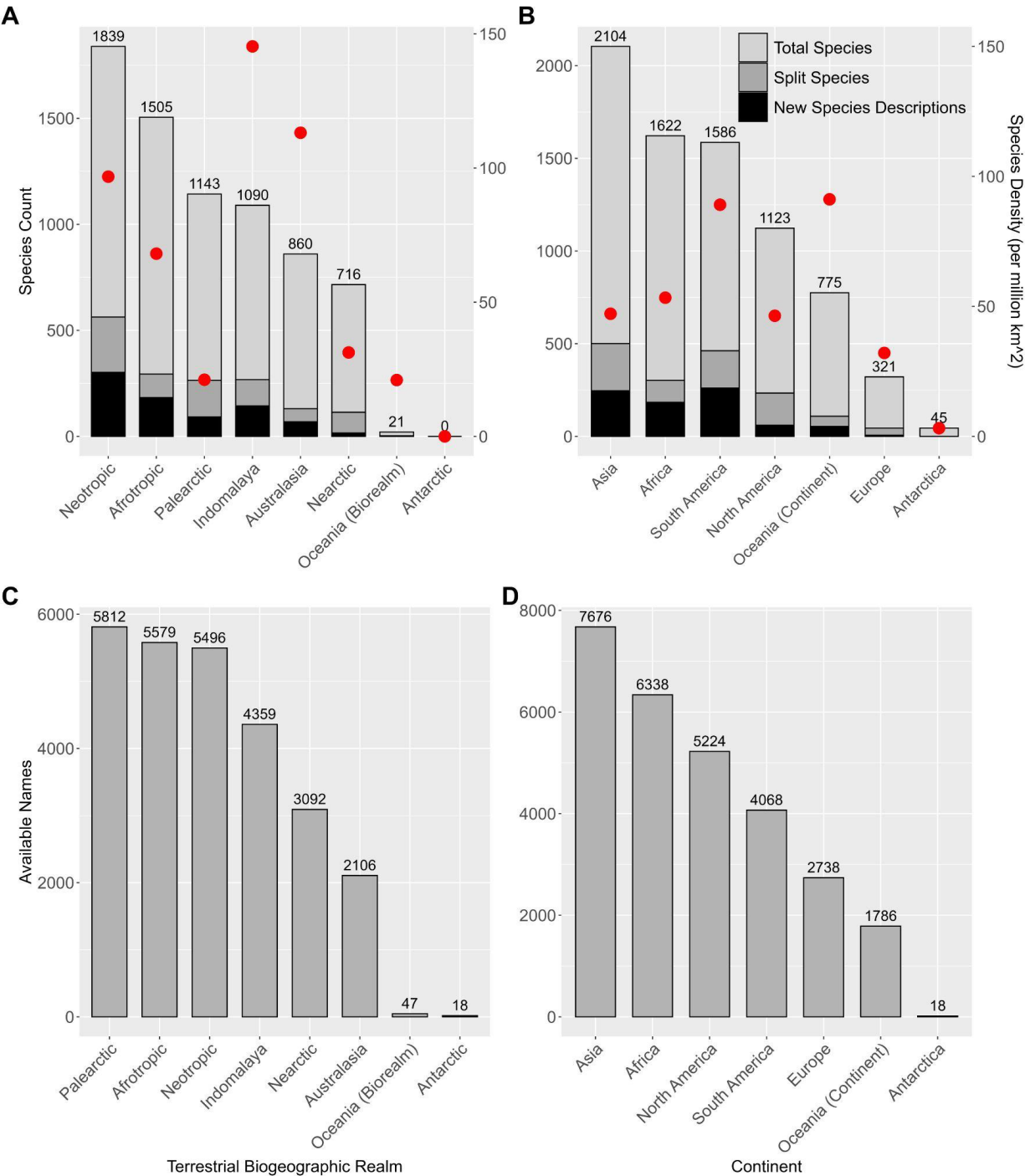
Figure 2. Summary of mammal species-rank taxonomy and nomenclature by terrestrial biogeographic realm and continent, including: A) total native, wild species (including recently extinct species) distributed within each region (excluding fully marine distributed species) with totals listed above each bar (broken into total species and species split or newly described since MSW3 was published), with total species density per region marked with red dots in species per million km^2; B) total native, wild species distributed within and in the waters surrounding each continent with symbols given analogously to graph A; C) available names (including

2743   preoccupied, replacement, and suppressed names) with type localities within each terrestrial

2744   biogeographic realm with totals listed above each bar; and D) available names with type

2745   localities within each continent with totals listed above each bar. It should be noted that species

2746   are often distributed across multiple regions while available name type localities only appear in

2747   a single region. See Table 3 for numeric summaries of species richness and available name

2748   type localities relative to regional land areas.
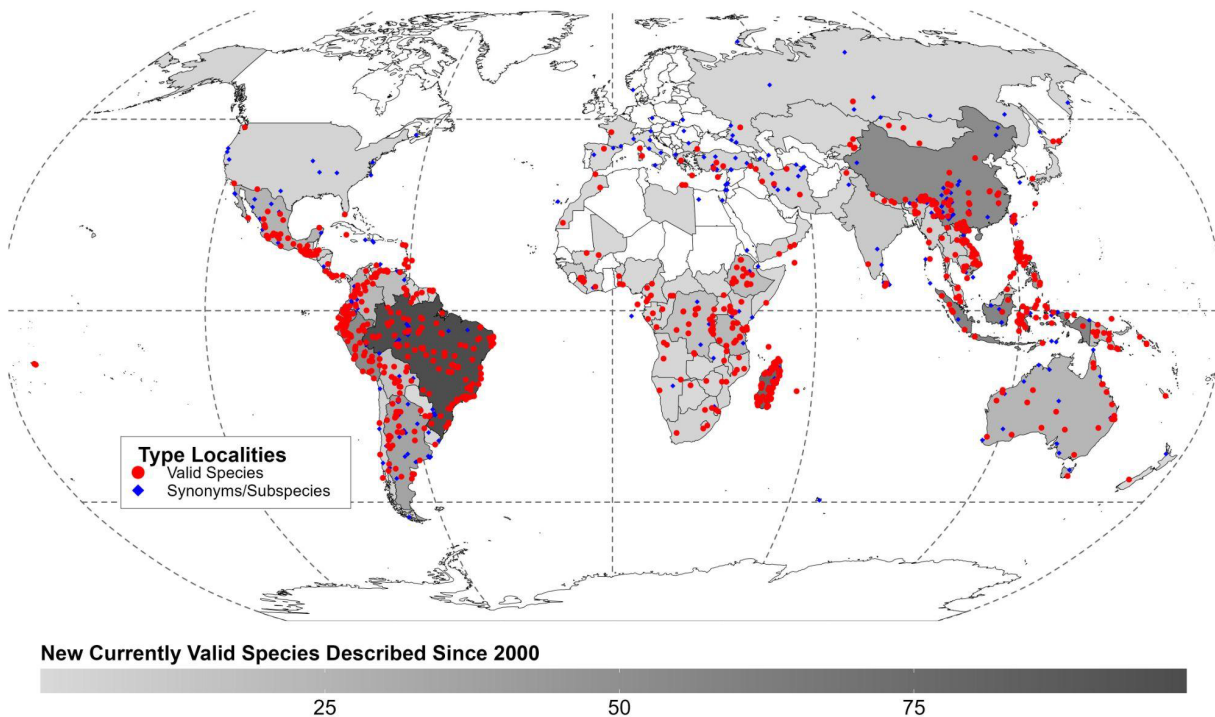
Figure 3. Type locality locations for species-rank mammal taxa described from 1 January 2000 to 15 August 2024. Map gray-scale country coloration represents the total number of currently valid species type localities found per country described within this period. Colored dots represent the exact georeferenced type locality of all currently valid species (red circles) and names currently considered synonyms and subspecies (blue diamonds) in MDD2. Most coordinates were generated from the original description of each name when included directly in publication, while others were georeferenced using GeoLocate or WikiMedia GeoHack place coordinates when not included in the original description publication. The georeferenced localities were mapped and both programmatically and visually vetted for accuracy. Latitude and longitude in decimal degrees is included for each of the names mapped here in the MDD2 synonym list, Supplementary Data SD2.
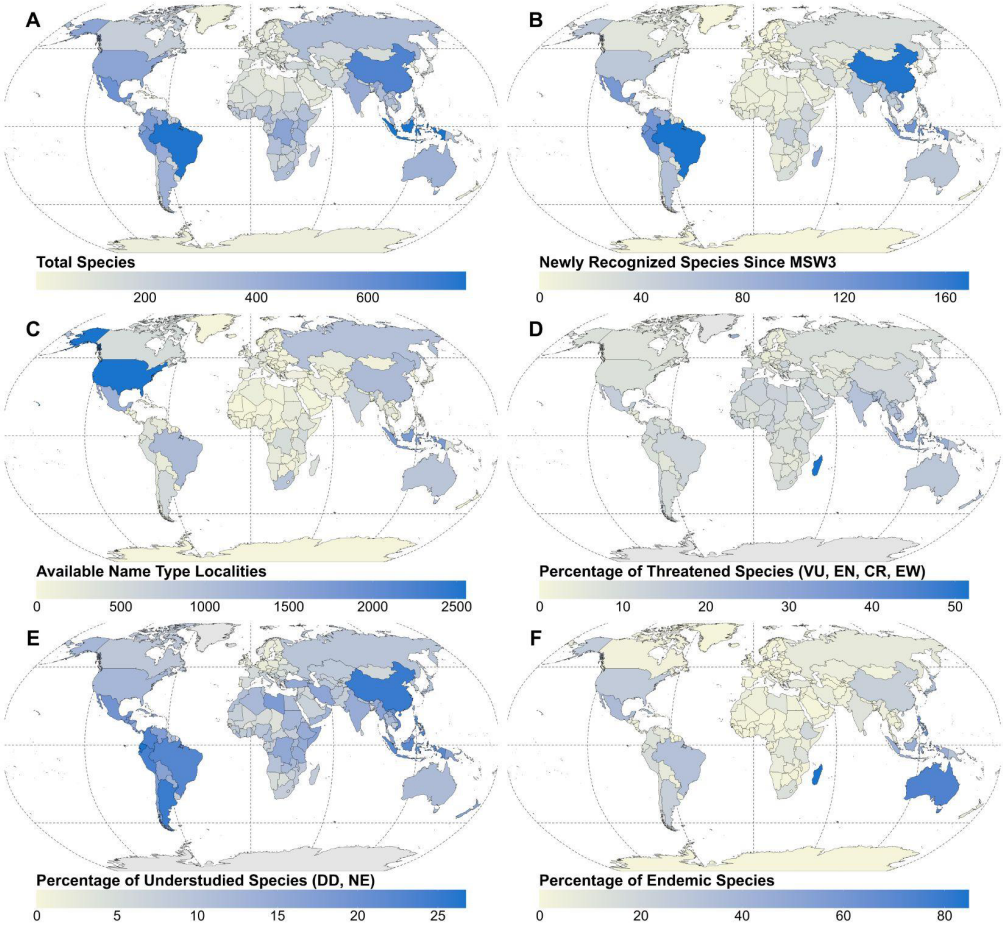
Figure 4. A) Total number of wild extant and recently extinct mammal species distributed within and in the waters surrounding each country and offshore territory. B) Total number of newly recognized species (both de novo and split) distributed within each country and offshore territory. C) Total number of available names (including preoccupied, replacement, and suppressed names) with type localities within each country and offshore territory. D) Percentage of species distributed in each country and offshore territory that are categorized as threatened (VU, EN, CR, EW) on the IUCN Red List (version 2024-1). E) Percentage of species distributed in each country and offshore territory that are either categorized as Data Deficient (DD) or Not Evaluated (NE) on the IUCN Red List, considered 'understudied' here. F) Percentage of species distributed in each country and offshore territory that are endemic to each region (only found in a single region).
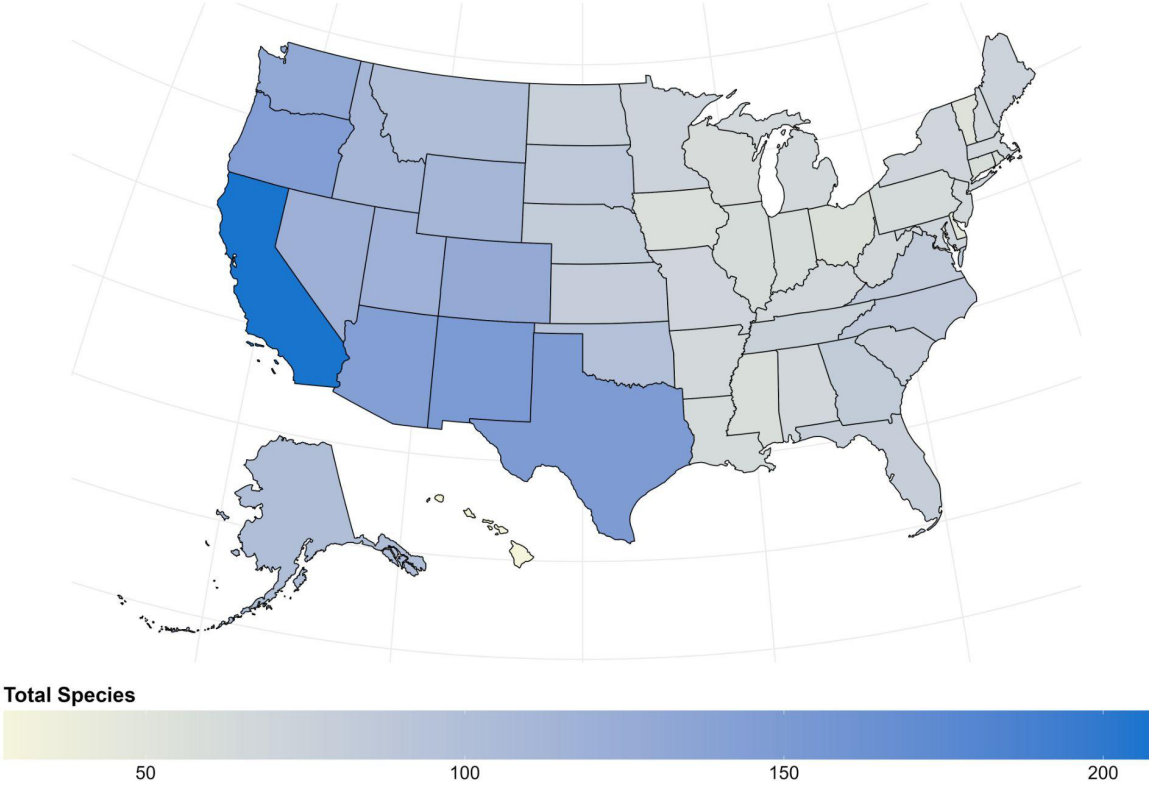
Figure 5. Mammal species richness across the 50 states of the United States, including both terrestrial mammals and marine mammals found along the coast of coastal states. State-level species totals are included in Supplementary Data SD7.
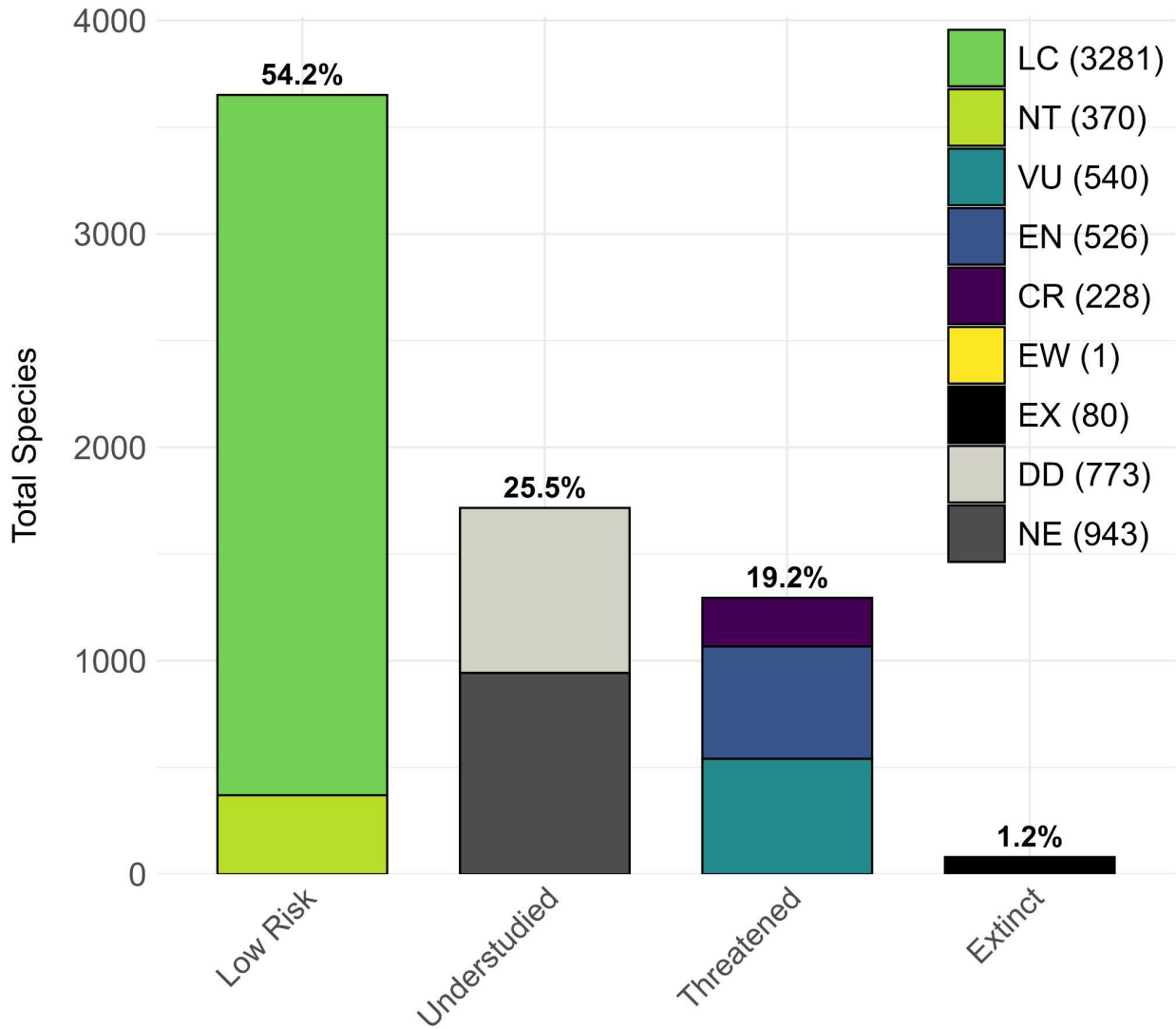
Figure 6. Proportion of the 6,742 wild mammal species (not including domestic species) recognized in MDD2 categorized by IUCN Red List category (version 2024-1): 54.2% (3651 species) are considered 'Low Risk' (Least Concern [LE] or Near Threatened [NT]); 25.5% (1716 species) are considered 'Understudied' (Data Deficient [DD] and Not Evaluated [NE]); 19.2% (1295 species) are considered 'Threatened' (Vulnerable [VU], Endangered [EN], Critically Endangered [CR], or Extinct in the Wild [EW—not visible]); and 1.2% (80 species; note that some MDD2 extinct species are NE on the IUCN) are considered globally Extinct (EX) on the IUCN. Total species per category are listed next to the category abbreviation in the figure legend while percent of total MDD2 species per column appears above each column.
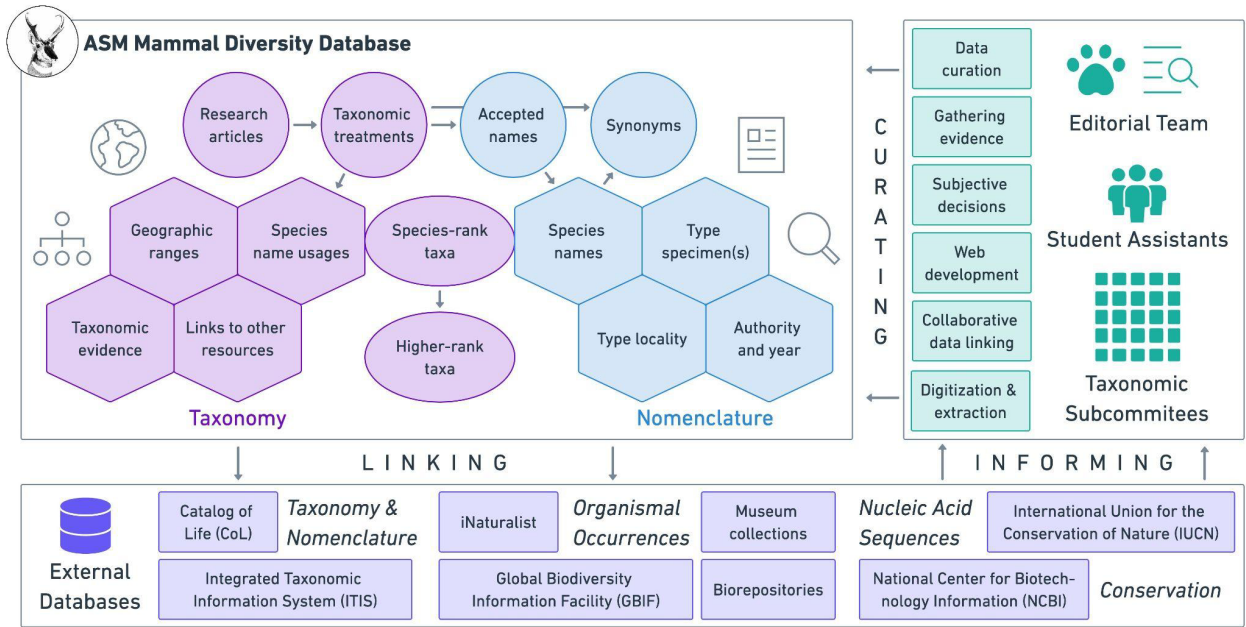
Figure 7. Overview of the MDD's structure and governance for future versions. Taxonomic knowledge will continue being extracted from research articles, each of which presents peer-reviewed evidence in support of a perspective on the limits of species- and higher-rank taxa. Nomenclatural information in those taxonomic treatments will also be curated, including the status of available names for a given taxon and the associated physical evidence for those names in the form of one or more type specimens. The MDD editorial team, consisting of both volunteers and paid student assistants, will be advised by new sets of taxonomic subcommittees that will help gather and curate data while providing expert guidance in cases where subjective decisions need to be issued. Linking of the resulting MDD data with external databases will remain a top priority, both to provide up-to-date information to those sources and to inform the taxonomic curation process itself.