Biodiversity Committee

Committee members: E. Abreu, J. Alston, T. Androski, M. Becker, C. Burgin, C. Calderón-Acevedo, S. Castañeda, M. Chua, J. Colella, E. Craig, G. D'Elia, T. Demos, J. Esselstyn, P. Fabre, A. Feijó, A. Ferguson, J. Frey, K. Gorman, M. Hawkins, S. Hess, A. Hinckley, D. Huckaby, B. Kohli, D. Land, T. Lee, S. Liphardt, S. Maher, V. Mathis, M. McDonough, S. Mech, P. Moehlman, D. Morales, A. Mychajliw, J. Nations, R. Norris, G. Oliver, C. Parker, B. Patterson, N. Pradhan, D. Reeder, I. Rochon, M. Rodríguez-Posada, L. Ruedas, B. Tanis, H. Taylor, N. Upham (chair), J. Widness, J. Zijlstra

Cross-committee links: African Research Fellowship (Alston, Demos, Ferguson, McDonough, Norris); Conservation (Ferguson, Upham), Human Diversity (Alston), Informatics (Maher, Kohli, Tanis), Nomenclature (Burgin, McDonough, Norris, Pradhan, Reeder), Mammal Images Library (Huckaby, Tanis), Public Education (Mech), Publications (Ruedas), Systematic Collections (D'Elia, Upham).

Mission:

The American Society of Mammalogists' (ASM) Biodiversity Committee compiles and maintains the Mammal Diversity Database (MDD), an updatable online database of mammal taxonomic and biodiversity information hosted at http://mammaldiversity.org/. This database aims to provide the latest information on species-level and higher taxonomic changes in extant and recently extinct species, thereby promoting more rigorous study of mammalian biodiversity worldwide. The objective since 2016 has been to aggregate, curate, and compile new citations on species descriptions and taxonomic revisions into regular releases that are downloadable in comma-delimited format. Downstream goals, on which current work is focusing, include the expanded hosting of ecological, geographic, and taxonomic concept data for mammal species. Overall, the MDD initiative aims to promote the ASM's role as a leader in high quality research on mammalian biology. The MDD continues to release taxonomy versions every few months. See here for full version tracking from v1.0 (Feb 2018) to v1.12 (Jan 2024).

Member changes since June 2023 (+4, -1):
Add: M. Chua, S. Castañeda, D. Land, D. Morales | Drop: V. Hayssen

Information items:

I. Activities of the ASM Biodiversity Committee from April 2023 – May 2024 included:

a. We released 2 versions of the MDD taxonomy (v1.10 and v1.11; see https://doi.org/10.5281/zenodo.4139722 for all versions, and Table 1):

Version 1.12	10.5281/zenodo.10463715	Jan 5, 2024
Version 1.11	10.5281/zenodo.7830771	Apr 15, 2023

b. Our core group of taxonomic curators consisted of the following people, as tied together via regular contact on a Slack group that we formed in 2020:

Nate Upham	Connor Burgin	Jane Widness	Madeleine Becker	Jelle Zijlstra	David Huckaby
Chair, Biodiversity Committee	Student Taxonomic Curator	Student Research Assistant	Student Research Assistant	Volunteer Research Assistant	Chair, Mammal Images Library
Arizona State University	University of New Mexico	Yale University	George Mason University	Hesperomys Project	Emeritus, CSU Long Beach

Table 1. Comparison of taxonomies: Mammal Species of the World (MSW), International Union for the Conservation of Nature (IUCN), and 13 versions of the ASM Mammal Diversity Database (MDD).

Taxa	MSW3 2005	IUCN 2008	MDD v1.0 2018	MDD v1.1 2019	MDD v1.2 2020	MDD v1.3 2020	MDD v1.4 2021	MDD v1.5 2021	MDD v1.6 2021	MDD v1.7 2021	MDD v1.8 2022	MDD v1.9 2022	MDD v1.10 2022	MDD v1.11 2023	MDD v1.12 2024
Species															
Total	5,416	5,513	6,495	6,526	6,485	6,513	6,533	6,554	6,557	6,567	6,591	6,596	6,615	6,649	6,718
Extinct	75	79	96	100	103	103	103	103	103	101	101	101	101	105	107
Living	5,341	5,436	6,399	6,426	6,382	6,410	6,430	6,451	6,454	6,466	6,490	6,495	6,514	6,544	6,611
Domestic	0	0	16	17	19	19	19	19	19	19	19	19	20	18	17
Flagged	0	0	212	212	29	29	29	29	29	28	28	34	33	21	27
Wild & valid	5,341	5,436	6,171	6,197	6,334	6,362	6,382	6,403	6,406	6,419	6,443	6,442	6,461	6,505	6,567
Genera	1,230	1,226	1,314	1,322	1,331	1,330	1,332	1,335	1,341	1,343	1,342	1,342	1,347	1,345	1,351
Families	153	149	167	167	167	167	167	167	167	167	167	167	167	167	167
Orders	29	24	27	27	27	27	27	27	27	27	27	27	27	27	27

c. We continued to release **'Tracked Differences' files** with every release of the MDD, which contain detailed changes made to the recognized Mammalia taxonomy between MDD versions. These 'diff' files have become more extensive due to the continued partnerships with the batnames.org and hesperomys.com databases, which has led to ~150 changes between each of the last three versions (versus ~30 changes among prior versions). Most recently, v1.12 of the MDD included 77 new species (38 de novo, 38 split, 1 revalidation), 8 synonymizations (lumps), 31 species with genus name changes, 7 genus additions (*Bisbalus, Passalites, Subulo, Neoeptesicus, Mictomys, Cnephaeus, Cordimus*) and 1 genus lump *(Nesoromys*), and 1 removed domestic species (*Homo sapiens*, given a revised MDD definition of domestication to be 'domesticated by human artificial selection'). In total, there was a net increase of 69 species and net increase of 6 genera of recognized extant or recently extinct mammals since MDD v1.11.

d. A key source of continued activity comes from two partnerships with external databases, established in 2023: (i) batnames.org (also called "Bat Species of the World: A taxonomic and geographic database") as run by Nancy Simmons and Andrea Cirranello and advised by the Global Bat Taxonomy Working Group of the IUCN SSC Bat Specialist Group; and (ii) hesperomys.com (also called "The Hesperomys Project") as run by Jelle Zijlstra. Both partnerships have continued to focus on pairwise comparisons with MDD data on accepted and synonymous taxonomic names to uncover errors of omission, orthography, gender, and new literature that had previously been overlooked.

i. **Batnames.org is now fully matching with the MDD taxonomy of global bat species**, which started with MDD v1.12 and batnames v1.5. This harmonization is the result of two years of consistent conversations between Connor, Nate, Nancy, and the Global Bat Taxonomy Working Group, resolving discrepancies and ultimately reaching consensus (see the MDD About page for details).
ii. Connor and Jelle made additional progress on standardizing gender agreement between genus and species epithet names of accepted mammal species, working to apply ICZN rules consistently. They are writing a framework to explain these rules to a wider audience and prevent future gender inconsistencies.

e. Species-level range maps aligned to the MDD v1.2 taxonomy (version of September 2020; published in Marsh et al. 2022) are now available for easy download by species or higher taxa via the **'mdd_maps' R package** developed by ASU PhD student Ángel Luis Robles Fernandez (Upham Lab; Github profile). This R package is available for public use, and will soon be submitted to CRAN with an associated publication: https://alrobles.github.io/mdd/
i. These maps are now being updated sequentially to each MDD version (e.g., v1.3, v1.4, … v1.12) by Upham lab members, with planned completion by end 2024.

f. A resources page has been added to the MDD ('Links to Mammal Data') to centralize access and promote use: https://www.mammaldiversity.org/linksToData.html

g. We worked with professional web developer Jorrit Poelen (of Global Biotic Interactions database, GloBI) to continue to improve the MDD webpage interface, as run via Github (https://github.com/mammaldiversity/mammaldiversity.github.io). Changes included:
i. Addition of 'tree view' for comparing the taxonomic hierarchy to MSW3: https://www.mammaldiversity.org/tree.html
ii. Addition of country-level maps for each species, which are generated from the 'countryDistribution' field of the taxonomy file as cross-referenced with a folder of GeoJSON files for each country in the world. These pages have been pre-rendered for fast loading, which appears to be working well, e.g.: https://www.mammaldiversity.org/taxon/1000004 — Future work will aim to have these coarse country-level maps transition to actual range maps, once the maps are updated to the current MDD taxonomy (see item I.d.i., above).

h. The MDD taxonomy has been formally adopted by the IUCN Small Mammal Specialist Group (SMSG) for their upcoming re-assessments, which are set to be completed in 2025. Nate is serving as the 'Deputy Chair for Systematics and Taxonomy' to facilitate MDD-to-SMSG coordination.

II. Public usage of Mammal Diversity Database data:

a. To obtain reliable usage numbers, on 19 May 2023 we set up a Google Analytics tracker to detail user activities on https://mammaldiversity.org. In the 1 year from 19 May 2023 to 18 May 2024, this Google tracker logged over 16,000 visits to the website from a whopping 157 countries — with the US (~5k), Brazil (~2k), and China (~1k) leading the way, but extending to Cambodia (10) and Eswatini (1 visit; see report with full listing).

Fig. 1 shows anomalously high MDD web traffic on 3 Oct 2023, mostly in the USA, which might relate to a mammal-related class assignment at a large university.

Figure 1. One year of user traffic at https://mammaldiversity.org, with detail on the 157 countries with site visits.

b. The archived versions of MDD taxonomy on Zenodo have also garnered many total views (27,563) and downloads (12,810) since this page was launched in 2020. Notably, both views and download numbers have *doubled* in the last year (14,515 and 6,880, respectively), indicating an increasing uptake of the MDD taxonomy by the global mammalogical community. The v1.12 of the MDD taxonomy has been downloaded 1,506 times since being released on 5 Jan 2024 (i.e., ~8 times per day).

c. The 2018 *Journal of Mammalogy* article about v1.0 of the Mammal Diversity Database taxonomy ("How many species of mammals are there?") has now been viewed >109,000 times and cited 1008 times (+206 since last year). This summary remains one of the ASM's most visible products.

III. Plans for a summary article of the forthcoming v2.0 MDD taxonomy:

a. The MDD team is now writing an article titled "**How many species of mammals are there now? An update of geographic and taxonomic diversity**" relative to the considerably updated information in the MDD as compared to 2018 when the last article was published. This article is led by Connor Burgin, and aims to summarize newly curated data in the following areas:

i. **Per species geographic information**. Our team has been curating country-level and US State geographic ranges for each species in the MDD taxonomy since 2022. That effort, led by Connor Burgin, Madeleine Becker, and David Huckaby, has involved updating the listings from *Checklist of the Mammals of the World* using additional literature and IUCN records to match the taxonomic concepts in the MDD. Jelle has additionally vetted these data recently using automated scripts. These data are now in pipe-separated format in the 'countryDistribution' and 'subregionDistribution' fields of the CSV download and are being summarized for the publication.

ii. **Synonyms**. Our team has been curating this data since 2018, but we ramped up efforts in 2023 with the addition of Jelle to the team. As a result, the current listing now contains 33,238 synonyms and their accepted species equivalency (up from ~27k previously). Also listed for each synonym—with varying levels of completeness—are data on name authority, year, availability, original combination and rank, full citations and links, type locality, and type specimen. This rich resource will be released with the v2.0 MDD taxonomy, later this year.

IV. Synergistic activities of the Biodiversity Committee:

a. In Sept 2023, an Ad Hoc Digital Publications Committee was formed on the directive of ASM President Felisa Smith with the goal of investigating how best to transition the journal *Mammalian Species* to a format of real-time updatable species accounts for free and open distribution online. Membership includes: Link Olson, Meredith Hamilton, Sean Maher, Tom Lacher, Jake Goheen, and Nate Upham (Chair). A key possibility linked to the Biodiversity Committee's goal of issuing subjective taxonomic decisions is the ability for the ASM to publish formal "nano-" or "micro-publications" on mammal natural history and biodiversity — which could then be a home for updating *Mammalian Species* accounts through time. We held meetings with OUP representative Fiona McDonald and will generate a summary report for the June Board of Directors meeting.

b. In May 2024, Connor and Nate attended the GBatNet meetings in Houston, Texas, in part representing the MDD and Biodiversity Committee. This Global Union of Bat Diversity Networks is an NSF RCN project seeks to unite a global 'network of networks' of bat researchers and conservationists, including representatives from over 50 countries. Issues at the intersection of bat taxonomy and ecology were extensively discussed, including the potential for the MDD to become solely responsible for the IUCN Bat Specialist Group taxonomy over the next few years, contingent on also keeping track of subspecies allocations (on the front or back end of data curation). We also discussed ways to ensure that Bat1K genome assemblies are published with sufficient geographic and morphological metadata to enable future taxonomic updates of those samples.

c. Obtaining non-ASM funding support: In July 2022, Nate re-submitted a collaborative proposal to the NSF-DBI-ICBR (Capacity: Cyberinfrastructure) program along with D. Reeder (Bucknell), N. Simmons (AMNH), and J. Cook (UNM) as PIs, with the goal of establishing long-term funding support for the Mammal Diversity Database and related efforts. This proposal, titled "**Collaborative Research: Mammal Species of the World Next (MSWx): platform for curating taxonomic intelligence to extend biodiversity data**," was first submitted in Sept 2021 and declined in April 2022. In Jan 2023, our re-submission was also declined, this time with mixed feedback of Excellent, Good, and Fair. The 'meritorious' panel ranking suggested that the while "the design of the project is outstanding" it "will likely not be a tool that is adopted and sustained by the community." Our team is now considering two paths, which we will discuss at the 2024 ASM meeting:

i. Question-driven approach that would build infrastructure to directly address core phylogenetic and geospatial questions (NSF DEB Systematics target);
ii. Community-building approach seeking to unite stakeholders of mammal data around the infrastructure needed to address key questions (NSF RCN target).

V. Goals for work the ASM Mammal Diversity Database (2024 and beyond):

a. Type specimens. We now have type specimen information for 5,750 accepted species in the mammal taxonomy — up from 2,731 at this time last year! — which is due to the scripting efforts of Jelle Zijlstra in particular. Prior work by Ingrid Rochon helped bring in type specimen data from the Smithsonian Mammal Collections, and work by Bruce

Patterson and Madeleine Becker aligned these data for Field Museum Mammal types. Through this work, we have identified 87 species with untraced holotypes (number not known), which are likely non-existent and thus in need of neotypes. We will continue to trace the type specimens associated with all accepted and synonymous mammal names.

b. Type localities. We now have type locality information for all species in the MDD accepted list and are working to gather decimal latitude and longitude for all type localities. We currently have geocoordinates for only 1,781 species of the ~6,700 total.

VI. Establishment of External Taxonomic Subcommittees for the ASM MDD (2023-2025):

a. Draft guidelines for Taxonomic Subcommittees now complete. In July 2023 at the IMC/ASM meeting, we hosted a workshop titled "Mammal Species of the World Next: workshop for extended taxonomic data curation" in which we gathered a wide range of feedback about how to push the MDD to the next level of becoming a global taxonomic authority. The key need of establishing external groups of experts to advise us on issues of taxonomic conflict became clear, as did several paths for doing so. In May 2024, Nate and Connor finished drafting a set of guidelines that summarize many of the points of discussion during the IMC/ASM workshop. Four main goals were identified to guide the work of the taxonomic subcommittees:

1. **Track the literature** for articles newly or previously published that are relevant to the taxonomy of the focal group, compiling full references and PDFs.
    a. Each subcommittee will be expected to perform careful tracking of new and previously published articles relevant to their focal taxa, with particular emphasis on the species and subspecies levels of organization. The most recent version of MDD taxonomic data will be provided, as subset to the group's focal taxa.
2. **Organize and issue subjective decisions** in cases for which taxonomic conflict among one or more published articles is identified, and for which a justified ruling from the MDD is needed to promote taxonomic clarity and resolve cases of ambiguity.
    a. As a growing taxonomic authority, the MDD will increasingly have the responsibility to arbitrate cases of taxonomic conflict among published articles. To do so, we aim to issue 'micropublication' reports that outline the relevant taxonomic evidence and make rulings to resolve conflicts. This micropublication process was piloted from 2022-2023 through a collaboration between the MDD and the Global Bat Taxonomy Working Group of the IUCN SSC Bat Specialist Group, which resulted in the issuance of subjective decisions for three taxa of bats: (i) *Myotis keenii* and *M. evotis*; (ii) *M. lucifugus*; and (iii) *Lasiurus*.
3. **Summarize evidence for species recognition** contained in those articles, by performing a categorization of the quality of taxonomic evidence using the grading rubric outlined below (Genetics-Ecology-Morphology [GEM] framework).
    a. This goal is inspired by the Kitchener et al. (2022) proposal for a 'traffic-light system' based on quantifying the number of independent **types**, or lines, of evidence supporting a given species. We aim to extend this system to capture additional key dimensions of taxonomic evidence that will help users assess how the confidence in species-level recognition varies across mammals. We propose a more detailed **quality rubric** that grades the data sampling and statistical strength of evidence relative to 9 evidence categories, yielding an overall GEM score for

the recognition of given species. This system is currently being evaluated by Biodiversity Committee members

4. **Communicate about all of the above** on the appropriate MDD Slack channels, which can host up to 250 members thanks to a nonprofit Pro membership through the ASM.
    a. We are collecting comments on a draft listing of per-clade specialists and contact information across a proposed division of 25 Taxonomic Subcommittees.

b. To facilitate the above plans, we soon plan to **hire two Student Organizers for Taxonomic Subcommittees (StOaTS)**, who will be tasked with managing correspondence with subcommittee members via email/Slack, coordinating group efforts, and leading data integration task with the broader MDD.

RECAP OF BUDGET 2023

1. Website maintenance:

- Approved (~60 hrs @ $20/hr) ……..… $1,200.00
- Spent during 2023 ……..…….…… …. $0.00

2. Student research assistant(s):

- Approved (~5 hrs/w @ $15/hr, 4 graduate students, 18 weeks) …….. $5,400.00
- Spent during 2023 (Burgin, Becker) ……..... $3,320.00

Approved (2023) …….. $6,600.00
Spent during 2023 ….……..…… $3,320.00

TO DATE BUDGET 2024 (Jan – May)

1. Website maintenance:

- Approved (8 hrs @ $150/hr) ….……..... $1,200.00
- Spent to date (Jorrit Poelen) ……. $1,200.00

2. Student research assistants / Student organizers for taxonomic subcommittees:

- Approved (~5 hrs/w @ $15/hr, 4 graduate students, 18 weeks) …….. $5,400.00
- Spent to date (Burgin, Becker) …….……..... $ 900.00

2. Student Organizers for Taxonomic Subcommittees (StOaTS):

- Approved (~2.5 hrs/w @ $20/hr, 2 students, 18-21 weeks) ……..….. $2,100.00
- Spent to date (not yet hired) …….……..... $0.00

TOTAL BUDGET APPROVED (2024) …….. $9,000.00
Spent to date 2024 ……..…… $2,100.00

PROPOSED BUDGET 2025

1. Professional website maintenance:

- Website stability, updates to content and interface, feature modifications
    - Proposed (10 hrs @ $150/hr) ……..…….……...… $1,500.00

2. Student research assistants:

- We plan to continue needing 2-4 student assistants employed at ~5/hrs per week. These student assistants will facilitate integration of updated taxonomic data.
    - Proposed (~5 hrs/w @ $20/hr, 2-4 students, 18-27 weeks) ……..….. $5,400.00

3. <u>S</u>tudent <u>O</u>rganizers for <u>T</u>axonomic <u>S</u>ubcommittees (StOaTS):

- We plan to continue with 2 student organizers at ~2.5/hrs per week.
    - Proposed (~2.5 hrs/w @ $20/hr, 2 students, 18-21 weeks) ……..... $2,100.00

TOTAL BUDGET REQUESTED (2025) ……..….. $9,000.00

SUMMARY

Overall, we expect that the MDD will continue establishing value as a global authority for mammal taxonomy in 2024-2025. We now have both the IUCN Small Mammal Specialist Group and Bat Specialist Group planning to adopt the MDD taxonomy, which is a tangible type of impact that the ASM is having on the quality of mammal biodiversity research globally. Through this work, the ASM is serving up-to-date information to the IUCN RedList, Intergovernmental Panel on Biodiversity and Ecosystem Services (IBPES), the UN Biodiversity Conference (COP), as well as to similar efforts at country, state, and local levels. Given the central role of mammal biodiversity in understanding ecosystem health, we expect that real-time taxonomic knowledge about mammalian species will continue to be essential for policymakers and researchers alike. Keeping track of "How many species of mammals are there?", "in which countries?", "according to who?", and "with what ecologies?" are questions that are only growing in importance in our changing world. Continued ASM support for the MDD initiative is critical to advancing these meaningful goals. The ASM Biodiversity Committee is well positioned to lead curation efforts for the accuracy and completeness of this knowledge and should continue to do so.

Respectfully submitted,

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