Biodiversity Committee

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

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

Mission: The Biodiversity Committee compiles and maintains the Mammal Diversity Database (MDD), an updatable online database of mammal taxonomic and biodiversity information hosted by ASM at http://mammaldiversity.org/. This database aims to provide the latest information on species-level and higher taxonomic changes, thereby promoting more rigorous study of mammalian biodiversity worldwide. The initial objective 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 include the expanded hosting of ecological, geographic, and taxonomic concept data. Overall, this initiative aims to promote the ASM's role as a leader in high quality research on mammalian biology.

Information items:

I. Activities of the ASM Biodiversity Committee from April 2021–May 2022 included:

a. We released 6 versions of the MDD taxonomy (v1.4 to v1.9) on an approximately bi-monthly schedule corresponding with every second new moon phase (see https://doi.org/10.5281/zenodo.4139722 for all versions):

Versions

Version 1.9 10.5281/zenodo.6407053	Apr 1, 2022
Version 1.8 10.5281/zenodo.5945626	Feb 1, 2022
Version 1.7 10.5281/zenodo.5651212	Nov 6, 2021
Version 1.6 10.5281/zenodo.5175993	Aug 10, 2021
Version 1.5 10.5281/zenodo.4926590	Jun 11, 2021
Version 1.4 10.5281/zenodo.4679816	Apr 11, 2021

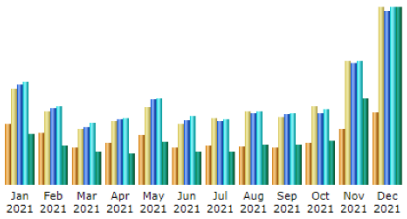
b. Starting with v1.4, we added a 'Tracked Differences' file with every release of the MDD taxonomy (e.g., v1.31-v1.4, v1.4-v1.5). These 'diff' files each detailed ~30–50 changes that were made to the accepted Mammalia taxonomy between versions, and included: the species name in each version, the category of change (e.g., split, de novo description, lump, synonymization, genus change, de-extinction, epithet change, range extension, flagged / unflagged), and references supporting those changes. The addition of these diff files is a major advance in the MDD taxonomy toward the explicit tracking of taxonomic concept changes in the literature. We next plan to create similar diff files between v1.0 and v1.31, and between MSW3 (2005) and MDD v1.0.

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

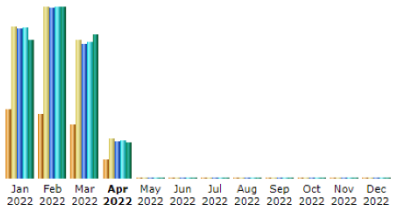
Nate Upham	**Connor Burgin**	**Jane Widness**	**Madelein e Becker**	**Camilla Parker**	**Schuyler Liphardt**	**Ingrid Rochon**	**David Huckaby**
Chair, Biodiversity Committee	Student Taxonomi c Curator	Student Research Assistant	Student Research Assistant	Student Research Assistant	Student Web Develope r	Type Specimen Curator	Chair, Mammal Images Library Committee
Arizona State University	University of New Mexico	Yale Universit y	George Mason University	Central New Mexico Community College	Universit y of New Mexico	Smithsonia n Mammals	California State University, Long Beach

d. Our MDD backend remains on Github for easy editing and transparency in an Open Science framework (https://github.com/mammaldiversity/mammaldiversity.github.io). This followed from last year's advice from Jorrit Poelen, web programmer for the Global Biotic Interactions database (GloBI), and the continued efforts of Student Web Programmer Schuyler Liphardt. This MDD website critically remains ***updatable directly by students and volunteers of the ASM Biodiversity Committee***.

e. From Jan–Dec 2021, the http://mammaldiversity.org website hosting the Mammal Diversity Database was accessed by 14,725 unique visitors, including 1,000–2,000 users per month (see Fig. 1). This number is up from an estimated ~2,500 unique visitors last year, which shows that the MDD is indeed gaining traction in a broader (global) user community. Note also that this Github-based site is well protected against automated bots, so we posit that these numbers are indeed accurate – including over 60,000 hits in the 2021 calendar year. It appears that beginning in Nov-Dec 2021, the MDD website has been receiving an even higher volume of users (Fig. 1), continuing this trend.



Month	Unique visitors	Number of visits	Pages	Hits	Bandwidth
Jan 2021	1,592	2,512	5,795	5,975	59.16 MB
Feb 2021	1,353	1,927	4,423	4,532	45.64 MB
Mar 2021	964	1,471	3,366	3,546	38.64 MB
Apr 2021	1,101	1,668	3,789	3,869	36.35 MB
May 2021	1,307	2,019	4,932	5,022	49.79 MB
Jun 2021	961	1,599	3,766	3,951	38.33 MB
Jul 2021	1,032	1,739	3,689	3,821	38.45 MB
Aug 2021	995	1,923	4,137	4,234	46.50 MB
Sep 2021	959	1,767	4,068	4,164	46.37 MB
Oct 2021	1,101	2,046	4,151	4,387	50.95 MB
Nov 2021	1,467	3,243	7,048	7,178	101.25 MB
Dec 2021	1,893	4,646	10,099	10,280	207.40 MB
Total	14,725	26,560	59,263	60,959	758.83 MB



Month	Unique visitors	Number of visits	Pages	Hits	Bandwidth
Jan 2022	2,018	4,411	10,293	10,370	242.91 MB
Feb 2022	1,856	4,982	11,731	11,786	299.57 MB
Mar 2022	1,560	4,027	9,247	9,410	252.30 MB
Apr 2022	538	1,161	2,527	2,587	62.89 MB
May 2022	0	0	0	0	0
Jun 2022	0	0	0	0	0
Jul 2022	0	0	0	0	0
Aug 2022	0	0	0	0	0
Sep 2022	0	0	0	0	0
Oct 2022	0	0	0	0	0
Nov 2022	0	0	0	0	0
Dec 2022	0	0	0	0	0
Total	5,972	14,581	33,798	34,153	857.67 MB

Figure 1. Summary of usage statistics on mammaldiversity.org for 2020-2021.

f. 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 >74,000 times and cited 591 times. This summary remains one of the most visible recent products of the ASM, suggesting that it filled an open niche of taxonomic synthesis that our committee should continue developing.

II. Continued plans for a summary article of the forthcoming v2.0 MDD taxonomy:

a. In a series of versions since MDD v1.0, our group has been focusing on unifying the cumulative taxonomy from the Handbook of the Mammals of the World series (Volumes 1-9) and Checklist of the Mammals of the World (2020) with our independent understanding from MDD literature surveys. Our MDD taxonomy particularly diverges from the ~300 additional species of ungulates recognized by Groves & Grubb (2011), a departure which we have justified on the new "About" page: https://www.mammaldiversity.org/about.html.

b. Those taxonomic updates are now joined by parallel efforts to assign and curate ***country-level geographic ranges*** to each species in the MDD taxonomy. 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. This information is now present in pipe-separated format in the 'countryDistribution' field of the CSV download.

i. Using this data, we are now writing an article titled "How many species of mammals are there now? An update of geographic and taxonomic diversity" relative to this updated information. Our plan is to submit this article to the *Journal of Mammalogy* at the end of summer 2022.

Table 2. Taxonomies compared among previous compendia: Mammal Species of the World (MSW), International Union for the Conservation of Nature (IUCN), and versions of the 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
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
Extinct	1	79	96	100	103	103	103	103	103	101	101	101
Living	5,415	5,436	6,399	6,426	6,382	6,410	6,430	6,451	6,454	6,466	6,490	6,495
Domestic	0	0	16	17	19	19	19	19	19	19	19	19
Flagged	0	0	212	212	29	29	29	29	29	28	28	34
Wild & valid	5,415	5,436	6,171	6,197	6,334	6,362	6,382	6,403	6,406	6,419	6,443	6,442
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
Families	153	149	167	167	167	167	167	167	167	167	167	167
Orders	29	24	27	27	27	27	27	27	27	27	27	27

III. Continued goals for work Mammal Diversity Database (2022 and beyond):

a. **Synonyms.** Our work in this area has been strong, led by Madeleine Becker, Connor Burgin, and Jane Widness. Due to their efforts in the last year, we now have a vetted synonym list containing 27,431 equivalencies to accepted MDD species names. This information is not yet published, but will be included in the v2.0 MDD release.

b. **Type specimens.** Thanks to the expert volunteer efforts of Ingrid Rochon, we now have all of the species-level holotypes from the Smithsonian Mammal Collections allied to our MDD taxonomy, plus additional holotype listings from some other collections – this totals 2,662 accepted species with specimens listed for the 'holotypeVoucher' field.

c. **Type localities.** We now have type locality information for ***all species in the MDD accepted list***, but are now working to gather latitude and longitude information in decimal degrees for the type localities of these taxa. We currently have geocoordinates of type specimens for only 1,164 species of the ~6,500 total.

d. Formation of per-taxon subcommittees. We have continued to curate an initial list of per-clade ASM members and non-member specialists to help vet and provide editorial curation as the MDD taxonomy continues to evolve. We are aiming to form these subcommittees across 25 major taxa (see this Google Sheet for a draft view). However, we have yet to formally reach out to these individuals either individually or as a group, because we still lack the organizational infrastructure to properly use their efforts. We still need a plan for coordinating the major tasks of subcommittees, including (1) method of communication (email, or Slack, Trello, other); (2) method of collecting feedback from the per-taxon subcommittees (e.g., Google Sheets or Google Forms); (3) method of integrating the resulting feedback into the MDD, including the need to publish *subjective* opinions (those not found already in the published literature) for some taxonomic decisions; and (4) method of paying for the hourly effort of student

researchers in coordinating the previous 4 tasks. Overall, we maintain that the goal of creating per-taxon subcommittees is a core step in the MDD's future.

IV. Obtaining non-ASM funding support:

a. In September 2021, Chair Upham submitted a collaborative proposal to the NSF-DBI-IIBR (Informatics) program along with DeeAnn Reeder (Bucknell), Nancy Simmons (AMNH), and Joe Cook (UNM) as PIs, with the goal of establishing long-term funding support for the Mammal Diversity Database and related efforts. The proposal was titled "Collaborative Research: Mammal Species of the World Next: platform for curating taxonomic intelligence to extend biodiversity data" and included three years of funding. In April 2022, we received notice that the proposal was declined, having received a 'meritorious' ranking from the panel (2 VG, 3 G) with feedback that the ICBR (Capacity) call was likely a better fit for our project. We are now working on resubmission, which if successful, would fund the unification of *Mammal Species of the World*, *Bats of the World*, and the *Mammal Diversity Database*, with specimen-based taxonomic curation efforts feeding back into the Arctos Collections Management System. It is envisioned that this NSF funding would allow major advances in taxonomic infrastructure for mammals, including the creation of a community-based platform for the curation of taxonomic concept-representative metadata (e.g., species range maps, exemplar DNA sequences with vetted identifications, type specimens, referred specimens, and taxonomic treatment articles from primary sources). This 'leap' would then set the stage for continued low levels of funding from the ASM to sustain the student-driven coordination of database activities and web development.

V. Pandemic preparedness / One Health work of the Biodiversity Committee:

a. In July 2021, Chair Upham received an NIH R21 grant as PI with DeeAnn Reeder titled 'Intelligently predicting viral spillover risks from bats and other wild mammals.' The two-year grant is for work to improve the taxonomic and ecological metadata associated with mammal host-virus interaction data housed in NIH-funded Bioinformatics Resources Centers (e.g., NCBI Virus). Work on this project has been in collaboration with the CETAF-DiSSCo Taskforce, a group of ~20 core scientists from the US and Europe aiming to curate museum-based biodiversity information for the biomedical research community. This project has so far yielded a perspective piece in *The Lancet Planetary Health* (https://doi.org/10.1016/S2542-5196(21)00196-0) and is funding an ASU PhD student, Ángel Robles, for work on host-virus data curation and modeling.

RECAP OF BUDGET 2021

1. Website maintenance:

- Website stability, updates to content and interface, feature modifications
  - 2021 approved (~60 hrs @ $20/hr) ……...… $1,200.00
  - Spent during 2021 (Liphardt) ……..... $0.00

2. Student research assistant(s):

- Four student assistants employed at ~5/hrs per week to facilitate integration of updated taxonomic data in this ASM initiative.

- 2021 approved (~5 hrs/w @ $15/hr, 4 graduate students, 18 weeks) ….. $5,400.00
- Spent during 2021 (Burgin, Widness, Parker, and Becker) ……..…….…...…… $3,345.00

TOTAL BUDGET APPROVED (2021) …….. $6,600.00
Spent during 2021 …….…… $3,345.00

TO DATE BUDGET 2022*

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*Note: The 2022 budget of the Biodiversity Committee was only approved in Dec 2021.

1. Website maintenance:

- Website stability, updates to content and interface, feature modifications
  - 2022 approved (~60 hrs @ $20/hr) ….……...… $1,200.00
  - Spent to date (not yet hired) ……. …. $0.00

2. Student research assistant(s):

- Four student assistants employed at ~5/hrs per week to facilitate integration of updated taxonomic data in this ASM initiative.
  - 2022 approved (~5 hrs/w @ $15/hr, 4 graduate students, 18 weeks) ….. $5,400.00
  - Spent to date (Burgin, Widness, Parker, and Becker) ……..…….…...……. $975.00

TOTAL BUDGET APPROVED (2022) …….. $6,600.00
Spent to date (May 2022) ….……..…… $975.00

PROPOSED BUDGET 2023

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1. Website maintenance:

- Website stability, updates to content and interface, feature modifications
  - 2023 proposed (~60 hrs @ $20/hr) ……...… $1,200.00

2. Hiring of student research assistant(s):

- 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 in this ASM initiative. Specifically, student assistants will perform functions of:
  - (i) "bottom-up" data gathering from recent and historical publications relevant to mammal taxonomic changes;
  - (iii) "top-down" data gathering efforts in terms of parsing, matching, and curating global mammal databases (e.g., VertNet) relative to the data already in the MDD.
  - Note: We will need to **<u>hire new student researchers</u>** in 2022 to replace Liphardt and Widness, who have graduated.

☐ Therefore, we request funds for continued efforts in curating the taxonomy database:
  - 2023 proposed (~5 hrs/w @ $15/hr, 2-4 students, 18-36 weeks) …….. $5,400.00

TOTAL BUDGET REQUESTED (2023) …….. $6,600.00

SUMMARY

Overall, we expect that the MDD will continue to stabilize as a global authority for mammal taxonomy in 2022-2023. As the Covid-19 pandemic has demonstrated, there is an overarching need for updated taxonomic information about the mammalian hosts of zoonotic pathogens. The ASM Biodiversity Committee is well positioned to contribute to the accuracy and completeness of this information, and should continue to do so as a leader in the study of mammalian biology. 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.

Respectfully submitted,

Nathan S. Upham, Chair
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