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A Quarter Century of Reptile and Amphibian Databases

In 2020, the Reptile Database (RDB) and AmphibiaWeb (AW) celebrated their 25th and 20th anniversaries, respectively. Here, we briefly review their history and highlight the biodiversity informatics context in which AmphibiaWeb and the Reptile Database have grown for a quarter century. More specifically, we outline the similarities and differences of each project, their operation and content, and review their histories, activities, users, and shared challenges.

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Amphibians and reptiles represent almost one-third of all vertebrates, and may contain more species than birds and mammals combined (but see Dickinson and Christidis 2014, Dickinson and Remsen 2014, Barrowclough et al. 2016, Padial and de la Riva 2021). Conservation concerns, a growing body of literature, and the rise of the internet in the 1990s led to the creation of several major efforts to provide online biodiversity databases, including AW and the RDB (Table 1).

Why Databases?

The tenth edition of *Systema Naturae*, published by Linneaus in 1758, contained data on more than 4000 animal species, which one could view as the first taxonomic database. As research and exploration ramped up in the 19th century, so did taxonomy, the discipline of classifying and identifying species. Taxonomic advances were facilitated by the founding of the Zoological Record in 1864, which aided efforts to collect all published zoological literature. In 1900, the Zoological Record listed about 260 papers published on reptiles and amphibians. By 1925, that number had reached about 800 per year, with steady increases throughout the 20th and 21st centuries to what is now thousands of new articles *per year*. During the 20th century, data generation also steadily increased with better technology for research, travel, and publications, eventually leading to digital publications, online journals, and databases. Prior to the 1990's, there were few alternatives to making daily library forays and searching through numerous books and journals before the internet revolutionized information retrieval in the last three decades.

By the early 2000s, numerous projects had started to collect a diversity of biological data, ranging from taxonomic surveys (e.g., Constable et al. 2010, Catalog of Life) and geographic maps (e.g., Grenyer et al. 2006), to conservation (e.g., Hofmann et al. 2010) and DNA sequences (e.g., Schoch et al. 2020). The information challenge for researchers has moved beyond issues of convenience and speed and is now a matter of handling increasingly large data sets and analyses that are organized and easily accessible. AmphibiaWeb and Reptile Database have been working on these issues and here we reflect on our success and work yet to come. But how did it all get started?

Origins

The Reptile Database started in 1995 as a side project at the European Molecular Biology Laboratory (EMBL) in Heidelberg, Germany, where Peter Uetz was a graduate student from 1993–1997. EMBL had just set up its first online DNA sequence database and had already included taxonomic data. While the precursor of RDB was a simple species list on a static web page in 1995, a searchable version went online in early 1996 as the *EMBL Reptile Database*. While the first few versions of the database had little more than species names, families, and basic distribution data, it was already linked to the EMBL DNA sequence database.

Table 1. Major taxonomic databases for vertebrates, with approximate number of species, accessed 7 January 2021. *Ornithologists have multiple global species checklists available via Avibase. EBird (https://ebird.org) has a searchable database but summary data and species lists are not readily available.

Database	Website	Species
Fishbase	https://www.fishbase.de/	34,500
Catalog of Fishes	http://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp	35,704
AmphibiaWeb	https://amphibiaweb.org	8,275
Amphibian Species of the World	https://amphibiansoftheworld.amnh.org/	8,275
Reptile Database	http://www.reptile-database.org	11,440
Avibase	https://avibase.bsc-eoc.org/	~10,720*
ASM Mammal Database	https://www.mammaldiversity.org/	6,513
	All vertebrates total	~72,000

Unfortunately, EMBL closed the database when the last person on the original team, Ramu Chenna, left EMBL in 2006; hence, the RDB had to move to a different server. When Uetz worked at The Institute of Genomic Research (TIGR), the database operated briefly as TIGR Reptile Database until he left TIGR in 2010. The main server moved to the Czech Republic where it has been operated by Jiří Hošek since then (see Uetz and Etzold 1996, Uetz 2016 for more details).

AmphibiaWeb's origin was motivated by a University of California Berkeley (UCB) seminar on amphibian declines led by David Wake in 1998, attended by Vance Vredenburg and Joyce Gross. Vredenburg was then a graduate student studying declines in high-elevation Sierra Nevada frog species (*Rana muscosa* and *R. sierrae*), and Gross was a programmer for the UCB Digital Library Project. The seminar participants saw the need for a central resource for biological, life history, taxonomic, and conservation status for all amphibians. Simultaneously in the early 2000s, museum informatics were increasingly moving information and their access online and were becoming more robust in aggregating data (e.g., HerpNET, VertNet), allowing AW to incorporate data-driven, species-level information including maps as well as other web services. AmphibiaWeb thus began producing comprehensive snapshots of species information, with a dedicated web page for every species of amphibian.

Around the same time, Amphibian Species of the World (ASW), another taxonomic database, came online. ASW was founded and managed by Darrel Frost at the American Museum of Natural History and has its 22nd anniversary this year (Frost, pers. comm). The original Amphibian Species of the World database actually dates to a book published in 1985 with the same title (Frost 1985). The focus of the ASW database is to comprehensively track taxonomy and literature. Both AW and ASW reciprocally link to each other from species pages.

Operations, Funding, and Governance

Both RDB and AW continue to be administered from academic units at the respective universities of the principals, Virginia Commonwealth University and the Museum of Vertebrate Zoology at the University of California Berkeley, respectively. This serves the practical needs of hosting a website, database maintenance, and providing updated and new content on a spare budget. Because neither project has independent funding, direct donations and grant support are essential. Grant support for "maintenance" is difficult to obtain and this has been true of the limited grants awarded to AW. With the exception of its seed funding from the Turner Foundation in 1999, awards to AW have been to support specific research (e.g., AmphibiaTree) development and integration projects, mainly from the National Science Foundation (NSF). Similarly, RDB was initially funded by the EU through a partner program of the Catalogue of Life / Species 2000 project (approximately 2004–2006, with follow-up approximately 2008–2010). Both projects depend on stable university employment for PIs, support staff, and students. Equally important are volunteer contributions for governance and content (e.g., content, literature curation and data collection).

From its launch in 2000, AW has been run as a collaborative project within the Museum of Vertebrate Zoology, where three AW principals (Director David Wake, Associate Director Michelle Koo, Coordinator Ann Chang) have appointments. Other leads include programmer Gross of the Berkeley Natural History Museums and Associate Director Vredenburg, now a professor at San Francisco State University. AW is governed by its directors, who consult with a steering committee made of amphibian experts from several institutions in the US and Australia. The AW members will often break into smaller working groups, which may include students and other volunteers to focus on specific immediate or long-term goals.

RDB is managed by a central Editor (Uetz) who coordinates with experts, the Scientific Advisory Board (SAB), photo editor Paul Freed, and content contributors. The SAB advises on general strategic decisions as well as on controversial taxonomic issues. RDB currently has four part-time core staff who are responsible for taxonomic content, photos, and technical infrastructure.

Taxonomy Tracking and Sharing

A central activity of both projects has been to properly track taxonomy. Both databases use three main routes to track new species and the taxonomic literature in general: 1) by following specific journals and their content alerts (e.g., Zootaxa, etc.), 2) by using Google Scholar alerts and sources such as Zoological Record, and 3) by direct communication from experts.

AmphibiaWeb relies on a subcommittee of taxonomists originally led by David Wake, which includes David Blackburn, David Cannatella, and Jodi Rowley, to track the literature, add new species, and make recommendations on taxonomic updates. They function by consensus and contact experts in difficult cases (AmphibiaWeb 2020 Taxonomy). AW has explicitly outlined its criteria for taxonomic decisions, with these central

Table 2. Comparing AmphibiaWeb and Reptile Database. Data accessed 20 December 2020.

	AmphibiaWeb	Reptile Database	Notes
Species number / subspecies number	8,268*	11,440 / 2,213	Total ssp. without nominate ssp. *AW does not track subspecies
Species descriptions	3,338	5,299	Number of species with descriptions / diagnosis
Photos available	41,510*	16,740	*includes habitat photos
Species with photos	4,674 (56%)	5,568 (48%)	
Ranges available	6,650 (~80%)	~8,000 maps via IUCN	
Synonyms	11,971	~44,000	Total unique names/combinations
Life history accounts	3,000	~9,000	*Not separated out into categories
—diet		267	
—reproduction		8,819	
References	7,703*	~56,000	*Stored in AW database, other references are tracked in a public Zotero group
Etymology	~ 2,250	6,192	
Web Services	Taxonomy, synonymy (XML, JSON); species accounts (XML)	Taxonomy, synonymy (JSON)	

considerations: 1) monophyly; 2) stability of continuing name associations (this is important for policy and conservation); 3) expertise of authors; 4) usefulness or general acceptance by the amphibian community; 5) ranked taxa; 6) degree of divergence (whether genetic or phenotypic, with respect to time since separation for its sister taxa), especially balancing long-term name usage and monophyly; 7) degree of support, which includes the quality of evidence provided as well as how well supported are any provided phylogenetic models (AmphibiaWeb 2020 Taxonomy).

The RDB uses similar criteria, although not explicitly written out, given the heterogeneity of the literature, with each issue requiring individual, and often preliminary, decisions. Uetz leads the literature curation at RDB, although he routinely contacts experts in specific cases, or the Scientific Advisory Board (SAB), which is made up of taxonomic experts from around the world, for more general or more wide-ranging decisions (e.g., whether the ~400 species of *Anolis* should be split into 8 genera, whether lab-created species should be recognized, how to deal with taxonomic vandalism).

Literature curation and taxonomic decisions pose particular challenges for these projects. Inevitably, taxonomic organization, which almost always relies on incomplete data, can require subjective decisions. A common issue faced by both projects occurs when a new publication makes conclusions about the taxonomic organization of a clade that overreach the quality or quantity of available data. For instance, species are often superficially described or documented, sometimes based on only one or a few specimens (Meiri et al. 2017), or only on mitochondrial data, which can create misleading phylogenetic patterns that are later revised when more data become available (e.g., compare trees in Poe et al. 2017 and Reynolds et al. 2018). Nonetheless, RDB and AW have to make decisions on whether or not to include these taxonomic changes, and if so, whether to include decision-making notes in their comments. With increasing splitting of species, it becomes more difficult to make objective decisions about their validity, especially with low DNA sequence differences or little morphological differentiation, a problem that is exacerbated by small numbers of specimens or large geographic variation (e.g., see the recent controversy over kingsnake classification; Chambers and Hillis 2019).

Although RDB and AW necessarily make taxonomic decisions as part of their database maintenance, neither project considers itself a taxonomic authority. Nevertheless, RDB and AW taxonomy are often adopted as reference taxonomy databases. Hence we highlight that for controversial taxonomic decisions, users are encouraged to refer to the primary literature to decide whether or not they would follow our recommendation. While the RDB and AW try to represent and reflect the scientific literature, decisions by the projects can reverberate through other databases and be adopted by authors themselves, thus risking an unintended positive feedback loop.

AW and the Amphibian Species of the World (ASW) can sometimes differ in conclusions; however, these disagreements on taxonomy are generally few in number. Reciprocal links from each respective website allow users the opportunity to compare taxonomies and decisions. In contrast, the RDB often uses authoritative checklists as preferred data sources (especially for species names), such as the Turtle Taxonomy Working Group (2017) or SSAR checklists (Crother 2017) for turtles and North American reptiles, respectively.

Media

Images, sound recordings, and videos attract users to biodiversity databases and enhance their value. Both AW and the RDB have substantial collections of images, either hosted by their respective databases or by external sources (such as CalPhotos or iNaturalist). Both projects rely on volunteer contributors who

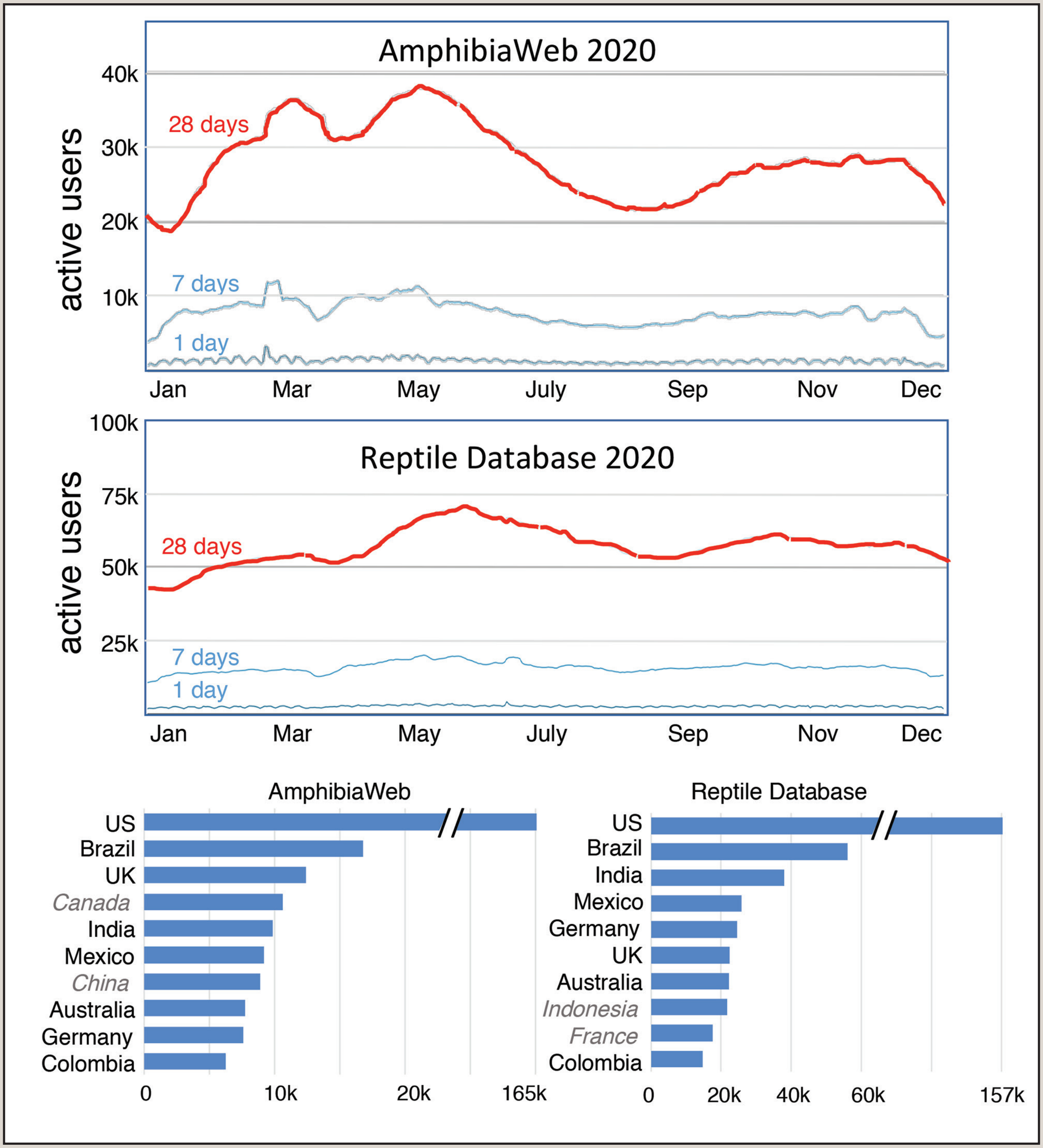

Fig. 1. AmphibiaWeb and Reptile Database users in 2020. Top panel: active users in 1, 7, and 28 day moving windows during 2020. Note seasonal (and possibly Covid-related) fluctuations, including weekly fluctuations in the 1-day series (with user numbers dropping on weekends). Bottom panel: most active countries as measured by active users in 2020. Note overlap between databases with only a few countries not present among the top-10 countries in the other database (shown in gray italics). All data based on Google Analytics.

generously share their images and expertise. Both AW and RDB use CalPhotos, an online image sharing site developed and maintained by the Berkeley Natural History Museums. In turn, CalPhotos uses the taxonomy of both RDB and AW, checking any uploaded identification to ensure that the name exists in the respective taxonomy. Identifications of any CalPhotos image can be updated or commented publicly through its online system. As of December 2020, RDB had photos of 49% of all reptile species, or close to 70%, when external links are included (Marshall et al. 2020b). In addition to over 41,500 images of amphibians (close to 57% of known species, see Table 2), AW also serves over 510 videos (on Youtube and in the database) and over 820 sound files. The sound files are important for identification, especially in frogs, although videos are as important for all groups to document behaviors or other dynamic features.

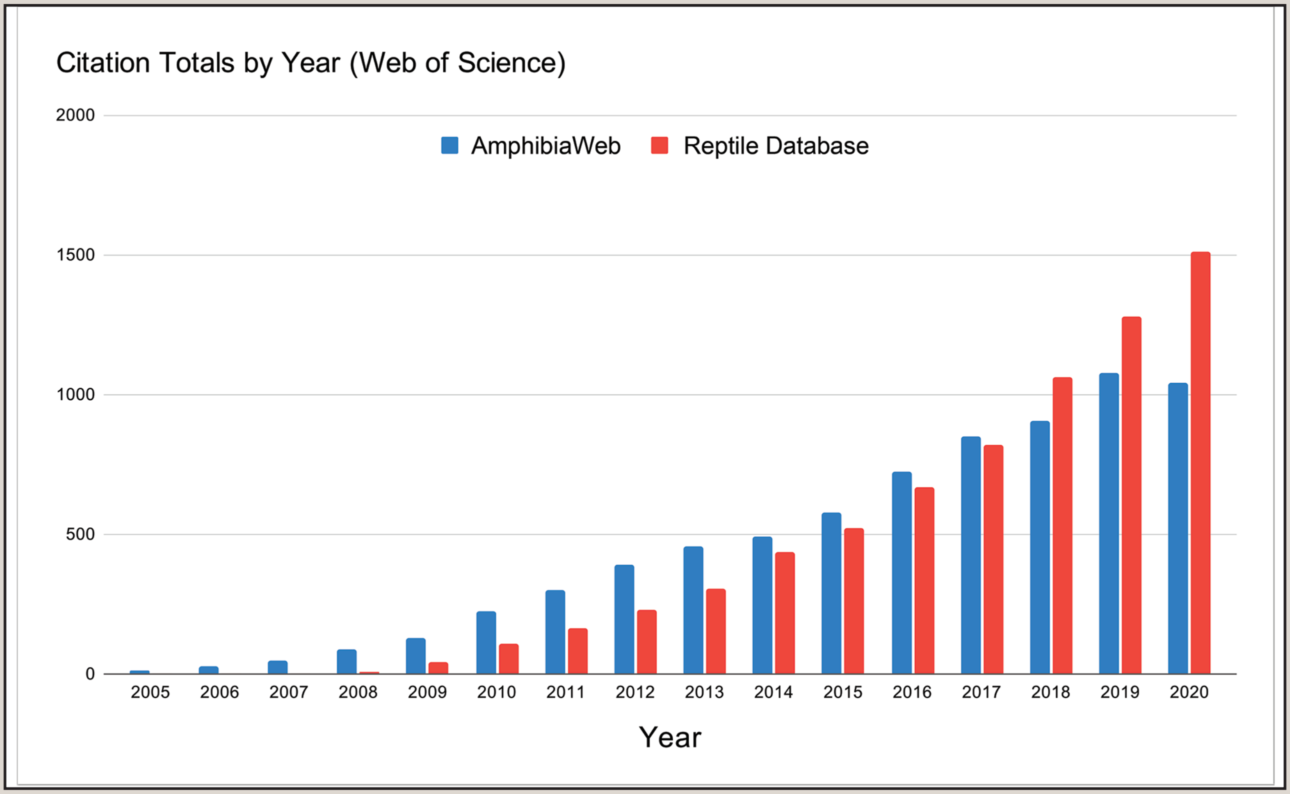

Fig. 2. Number of citations (2005–2020) for AmphibiaWeb and Reptile Database from Web of Science (WoS).

Spatial Data on Species

From its inception, AW incorporated distribution data into its species accounts, as either static maps from the literature or from atlases. Later the website began to display locality data from HerpNET (later updated to VertNet) as species range estimates in an interactive web map using a service called BerkeleyMapper. These range polygons are based on both the IUCN Red List assessment maps and curated species ranges produced by AmphibiaWeb GIS assistants or volunteers, mainly for newly described species, North American species, and species without Red List assessments. Additionally, AW tracks type localities for newly described species; these are also viewable from their species page. Currently over 80% of species have distributional data. Given the sources of the spatial data (unvetted point data from collections via VertNet, range maps based on expert opinion or the literature), some errors are inevitable, but presenting the data with links to original provenance allows users to decide how best to use these data. Range maps are still invaluable to species accounts and for describing family distributions, which are viewable as cartographic products and downloadable as PDFs on AW. Both AW and RDB maintain country checklists based on the literature. While maps are currently not directly available on RDB, locations are searchable by country (and often smaller subdivisions such as states) and links to maps on the IUCN site are provided.

How the Community Uses the Reptile Database and AmphibiaWeb

We assess usage data from website statistics (Google Analytics), direct user feedback, citation data, and focused user surveys. The AW website currently has an average of 28,000 users per month making 2.6 million page views in 2020 (Fig. 1). By far, most of the visitors land on AW after using a search engine (ca. 72% of total visitors), and then visit AW to search for information on a specific species (through its species search page). A consistent proportion (5%) of visitors to AW result from Google searches for 'amphibian declines' or related 'disease' or 'chytrid' information. The COVID-19 pandemic has not appreciably changed AW site traffic except for modest increases overall in users (ca. +5%) and sessions (+2%); however, there were large increases in page views (+33%) and pages per session (+30%) compared to previous years. Five regions comprised over 60% of traffic, namely the US, followed by Brazil, Mexico, India and Europe. Many AW users were researchers and students who requested help via emails with identification of amphibians encountered in backyards or in the wild.

The RDB had about 60,000 active users per month in 2020, resulting in 2000 to 3000 searches per day. Most of the users hailed from the US, Brazil, India, and Europe. Perhaps unsurprisingly, 8 of the 10 most active countries on the two sites are the same, with only two countries not represented among the top-10 on the other site. It is also encouraging that some of the most biodiverse countries (Brazil, India, Mexico, Indonesia, Australia, China) are among the heaviest users of both databases (Fig. 1).

Every year, herpetology courses in the US rely on AW and RDB as sources of species' information, and AW has made concerted effort to include and create content useful to both professors and students. Material beyond the species accounts used in courses include family summary pages with richness maps, a family tree, a primer on amphibians, a primer on taxonomy and phylogeny including lessons on how to read a phylogenetic tree, and several articles on conservation and declines of amphibians. Many of these are downloadable as PDFs. AmphibiaWeb also engages directly with herpetology courses by offering professors the option of assigning students to write species accounts. AW provides an account template and research tips for students; these species accounts are edited and reviewed by AW staff before publishing online with author credit for these students. AW also runs an undergraduate apprenticeship program through UC Berkeley where students are trained in writing species accounts, conducting literature researches, and using GIS to help create and update content.

The RDB is less focused on authored content, mainly because the database tries to produce more structured data as opposed to free text. Hence, RDB focuses on adding data from outside sources, such as published supplementary data files. Nevertheless, RDB receives an average of three or four emails a day (>1000 per year) referring to specific content, requiring frequent updates or additions to the database.

Another metric of usage is citations of AW and RDB in publications. Both projects have been increasingly cited since their launch either as a website (AW) or as both a website and publication (RDB) (Fig. 2).

Who Uses Reptile Database?

Based on a long-term user survey (2016–2020), RDB is used by professional biologists, students and by a significant percentage of casual visitors and hobbyists (Fig. 3). However, this survey is not really representative, given that recipients of the RDB newsletter (mostly professionals) were actively encouraged to participate. Professional users are thought to be the most likely to respond to such surveys.

The most common use cases involved searches for names (or lists of names), synonyms, distribution data and literature (Fig. 3B). The most wanted features were distribution maps and help with species identification. Links to other data such as phylogenetic trees, GBIF or VertNet were also high on the wish-lists of users. Among the free-text responses, a variety of "wanted items" were provided, ranging from sellers of reptile pets and care sheets to venom information, country checklists, and quick photos guides.

Greatest Needs and Challenges in the Next 25 Years

Scientific publishing.—The limiting step for any modern scientific database is to convert relevant information from published papers (or other sources) into a structured, machine-readable format, so it can be further processed, ideally by both computers and human users. Currently *all* data on AW and most data on RDB are hand-curated by humans, an expensive and inefficient process. Numerous attempts have been proposed to automate text-mining but the available tools are not ready for routine use. Nevertheless, standards have been proposed and will be incrementally implemented by journals (Leaman et al. 2020). Importantly, journals need to require authors to structure their papers in a way that information can be more easily extracted. *Herpetological Review* (*HR*) could become a role model for such improvements by formatting geographic or natural history notes by (visible or invisible) tags so that species names, geographic locations, or certain key words may be easier to extract by either humans or computers. An early effort to make *HR* content more accessible to databases (by Paul Freed) includes a complete indexed listing of all the scientific names of amphibians and reptiles from the very first issue of *HR* to the present (pending), which would help automated linking of relevant *HR* content to AW and RDB. However, we are working with *HR* to automate this further so that species names and localities can be extracted semi-automatically from future articles. Similarly, species descriptions, published in any journal, need to be standardized, so that each description has the same minimal data (type specimens, character tables, localities, etc.), formatted so that information can be easily imported into a database and displayed spatially and on species account pages. This is a bottleneck for AW; with more than 150 new amphibian species described each year, it is laborious to stay updated. Ultimately, scientific publishing needs to adapt to modern data processing so that published data can be more easily transferred into electronic databases (see below).

Other biological data.—A major gap in current biodiversity databases, including AW and RDB, is the lack of structured trait data, both morphological and otherwise, such as life history or genome data (see also Meiri 2018, Grundler 2020). Structured trait data would allow users to identify species, refine phylogenetic studies, or do more biological research, e.g., into the relationship between genotype and phenotype and thus evolutionary adaptations. Ecomorphology of *Anolis* is a perfect example for the evolutionary and biological insights to be gained by integrating trait data (Losos 2009). Similarly, there is relatively little structured habitat data, and distribution data is still sparse and not easily available in machine-readable formats (despite the fact that Roll et al. 2017 have provided a large number of range maps for reptiles, but their polygons are still too coarse for many studies). AmphiBIO (Oliveira et al. 2017) compiled a useful set of 17 traits for many species of amphibians, using AW as a data source, but for the vast majority of species, such data are still missing. We predict that fewer natural history data will be traditionally published in journal articles but rather directly deposited into specifically created databases, such as NSF-funded FuTRES (https://futres.org), which has established itself as a vertebrate morphological trait database with strict ontology rules. Similar with publications, we need new attribution technologies, so that small contributions and deposited data can have authors and thus citations, features that will remain important especially for academic careers.

Integration of databases and collections.—A critical goal of biodiversity informatics is to connect the numerous data sets to their original physical entities, such as the voucher specimens, DNA samples, associated pathogen or parasite samples, or localities, often referred to as the "extended-specimen networks" (e.g., Lendemer et al. 2020; Webster 2017). Creating and maintaining these specimen and dataset networks is especially challenging with respect to tracking taxonomic histories and changing species concepts or delimitations, many of which are not reflected in physical museum collections or their database management systems. AW and RDB can serve as a central nexus to support the extended specimen network specifically with an updated taxonomy and its respective links to these biodiversity resources (Fig. 4), including genetic and genomic repositories at GenBank, specimen aggregators (e.g., VertNet), taxonomy resources (e.g., Catalog of Life, NCBI, Amphibian Species of the World), species traits (e.g., Encyclopedia of Life), conservation (e.g., assessments at Amphibian Ark and IUCN Red List), and, most fundamentally, to the primary scientific literature. AW and RDB thus become an extended *species* network serving connected data for biodiversity research.

Long-term funding and maintenance.—Few agencies fund scientific databases or their maintenance. Databases are long-term projects that require regular maintenance and management, to which funders are reluctant to commit—a problem that is even true for major model organism databases (Kaiser 2016). Hence, a large number of databases cease to exist

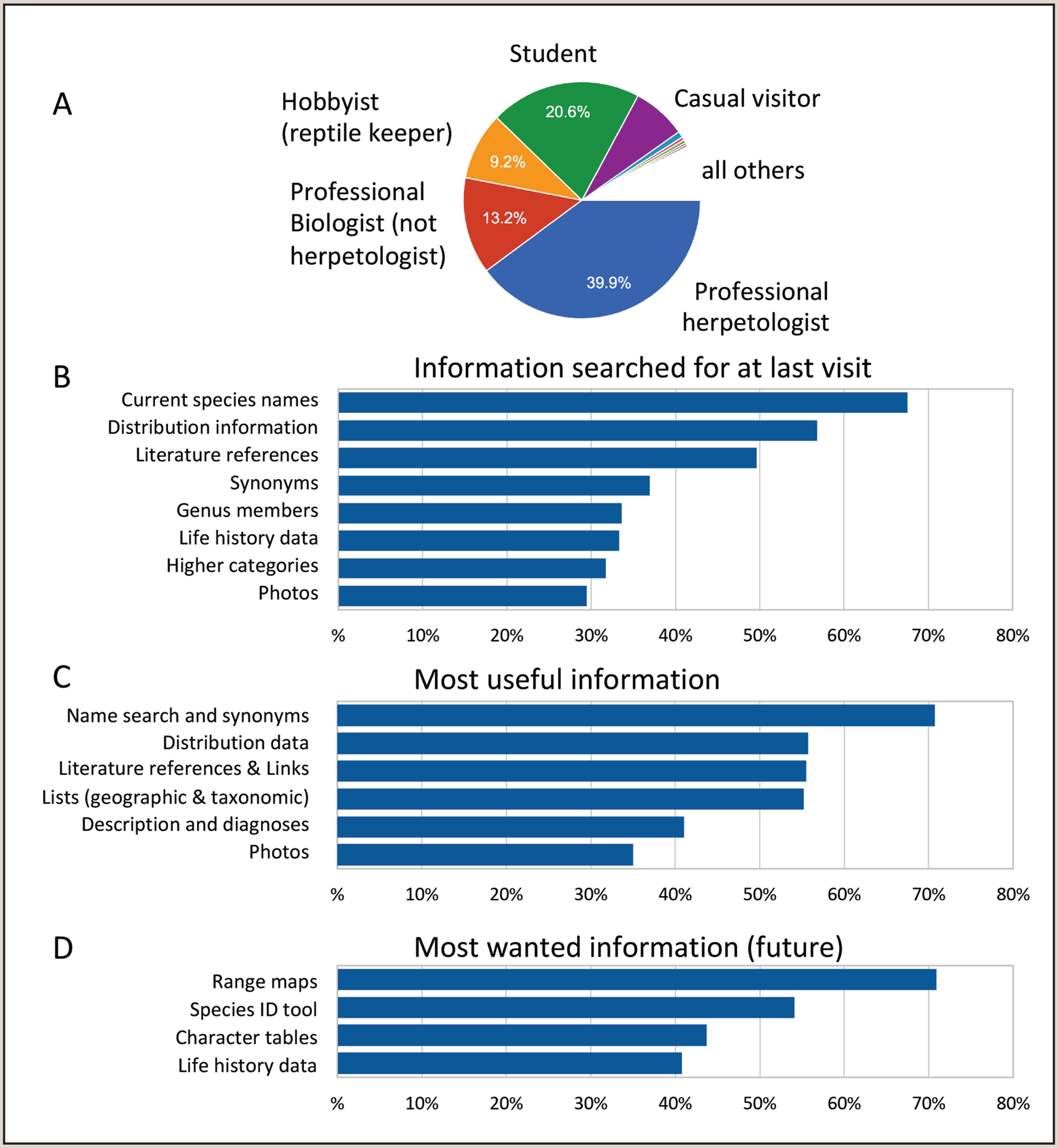

Fig. 3. Reptile Database user survey results: A) User types; B) information searched for at last visit; C) most useful features in RDB; D) most wanted features in RDB. Survey based on ~700 responses [not all questions were always answered], 2016–2020). The survey was launched both on the RDB website and through its newsletter, with the latter being dominated by professional herpetologists and biology students.

after a few years (Wren et al. 2017). Long-term maintenance is thus critical, especially since new data on species is steadily growing.

Can AmphibiaWeb and Reptile Database help to solve the biodiversity crisis?—Successful conservation actions require up-to-date and complete information about species identities, species ranges, taxonomic nomenclature, and conservation status. This information is especially important when conservation is focused on hyperdiverse biodiversity hotspots where hundreds or thousands of species may occur (Roll et al. 2017). Both the Reptile Database and AmphibiaWeb work with conservation organizations such as IUCN and Red List teams to coordinate for correct taxonomies, and they link to conservation assessment data from the respective websites. However, new research is constantly changing the landscape of taxonomy. For example, a new species of amphibian has been described on average every week from 1980 to the present, and there are increasing instances of species splitting, which can complicate

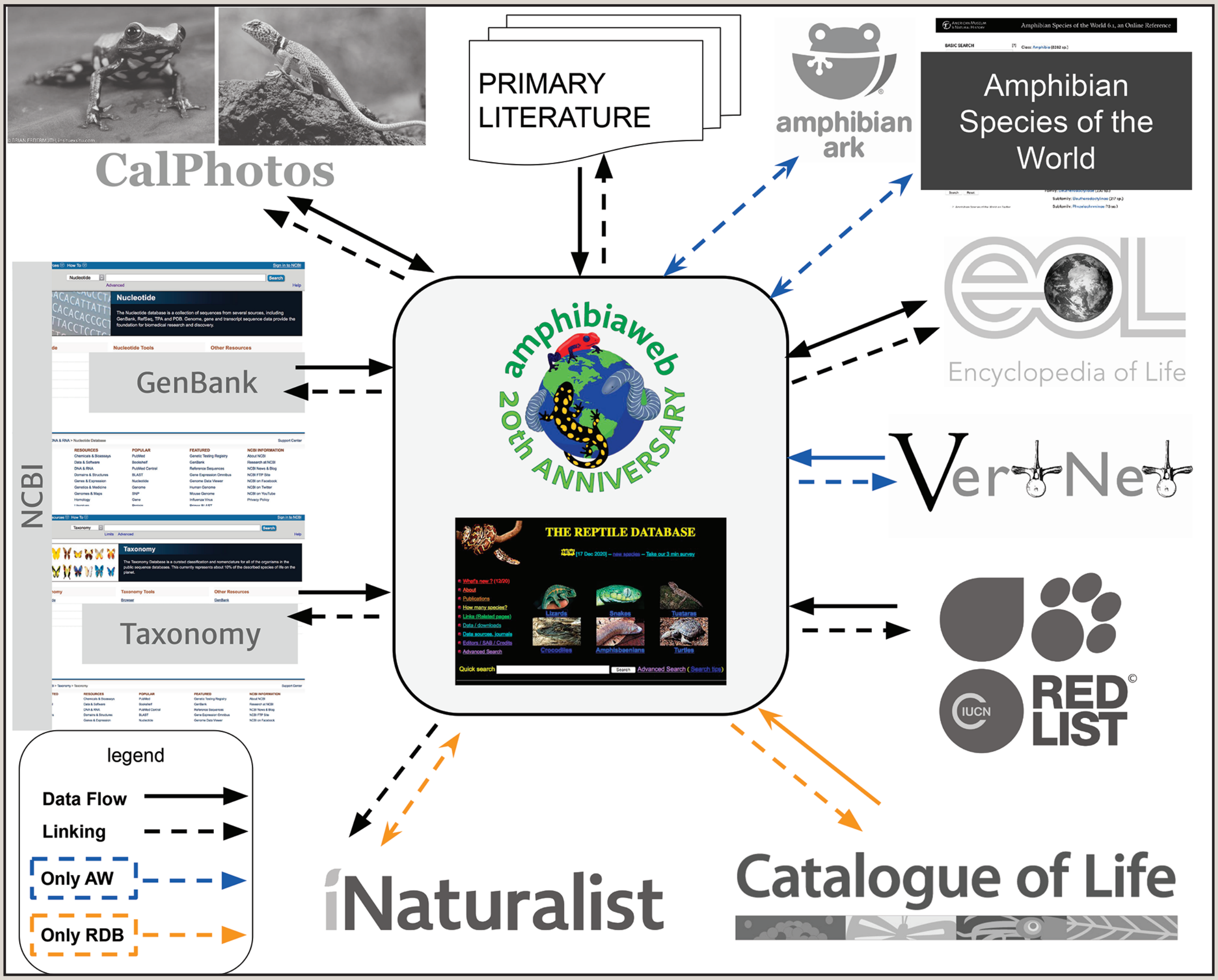

Fig. 4. Relations between AmphibiaWeb (AW) and Reptile Database (RDB) to genetic, scientific, conservation and taxonomic resources and websites. Arrows indicate relationship type and direction. Solid Black: data flow direction for both AW and RDB; Dotted Black: web links on both AW and RDB (e.g., links on species detail pages); Solid and Dotted Orange: Links and data only for RDB; Dotted Blue: Links only for AW. (CalPhotos images of *Hyperolius bolifambae* by Brian Freiermuth; *Crotaphytus bicinctores* by William Flaxington)

conservation efforts further. Thus, updating taxonomies has become a critical but ever-increasing challenge that we can only solve by encouraging close cooperation between scientists and conservationists. Further, the informatic expertise and infrastructure our databases can provide may be extremely valuable for conservation data. For example, emerging infectious diseases are recognized as a growing threat to wildlife all over the world (Daszak 2007). For amphibians, the disease chytridiomycosis, which is caused by a fungal pathogen (Berger et al. 1998), has decimated many species on all continents save Antarctica (Fisher et al. 2009). AW has provided overall summaries of our knowledge on chytridiomycosis, a bibliography on the fungal pathogen, instructional videos on sampling live and preserved amphibians for the pathogen, and many more actions to address this crisis. AW has also provided summaries and links to peer-reviewed literature and media explaining monitoring protocols that can be used to test museum or wild specimens for infection status (e.g., Cheng et al. 2011), and thus track pathogen invasion over the past century (e.g., Huss et al. 2013; Vredenburg et al. 2013; Fong et al. 2015; Sette et al. 2015; Talley et al. 2015; Vredenburg et al. 2019). In 2013, with the discovery of a second chytrid fungus fatal to amphibians, *B. salamandrivorans* (Martel et al 2013), AW principals (Koo and Vredenburg) joined the international North American Bsal Task Force (https://salamanderfungus.org) to work with governmental agencies and others to coordinate research, surveillance and chytrid data. The resulting predictive models (in part using AW data) helped convince federal authorities to limit international trade in live amphibians as pets (Yap et al. 2015). Unfortunately, even the best scientific information can be misused. For example, biodiversity databases often provide type localities (and other locality records) and have been suspected of being used by poachers to harvest newly described species or threatened species illegally (Marshall et al. 2020a).

Can AmphibiaWeb and Reptile Database address inequities in science?—Like the extended-specimen network, we represent the extended-species network (see Fig. 4). And similar to the efforts to democratize museum collections through digitization, we, too, see opportunities to correct imbalances of knowledge access (Drew et al. 2017). Specifically AW and RDB aim to address issues of equity and inclusion by making scientific species information freely and openly available. This is especially important in biodiversity hotspots, which, for amphibians and reptiles, are often in countries where academic resources may be limited, especially access to literature and scientific references. As a community-based resource—both projects rely on contributions of media, content, and feedback from users—we recognize that some of our most valuable contributions come from students and citizen scientists from these regions.

How can you contribute?—Databases such as AW and RDB are made for their users, yet equally depend on them, both for feedback on utility and needs, but also for content and quality control. Given the constant funding shortages, volunteers are a critical part of most database efforts and users like you can help in many ways, such as submitting data (e.g., papers or photos) but even more importantly, by helping to curate new or published data into machine-readable content (e.g., data tables), and being sure to reference or cite usage of AW and RDB. More specifically, AW and RDB are increasingly collecting trait data (morphological and ecological), and AW always needs help with species accounts. We welcome contributions. As we have shown (Fig. 2), citations are critical to demonstrate use and acknowledge the value of our efforts. Please contact the authors of this paper if you want to get involved, provide feedback on our sites, or sign up for our newsletters.

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