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The original descriptions of reptiles

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Abstract

By September 2009 an estimated 9084 species of extant reptiles have been described by a total of 4579 papers and books which are listed in a supplementary file. In this review I summarize the history of these species beginning with Linnaeus in 1758. While it took 80 years to reach the first 1000 species in 1838, species descriptions since then have been added roughly at the rate of 1000 new species every 20 years, with a significant acceleration only during the past two decades. The top 40 most productive herpetologists (in terms of "species output") have described 4780 species, amounting to over half of all species. George Albert Boulenger leads this elite list with 573 species that are still recognized today. Historically, 18 classic works of the 18th and 19th century can be singled out, describing almost 1000 species still recognized, including the *Erpétologie Générale*, published between 1834 and 1854 in nine volumes. The top 25 journals have published more than 3600 species descriptions in the past 250 years (including 169 in *Zootaxa*, ranked sixth), corresponding to about 40% of all species.

Key words: journals, bibliography, species number, species concepts, snakes, lizards, turtles, crocodiles

Introduction

Species are the backbone of biology. Although a number of species concepts have been proposed, most contemporary biologists tend to use either a biological or an evolutionary species concept even though historically typological or morphological concepts have dominated (reviewed in De Queiroz 2007; González-Forero 2009; Knapp *et al.*, 2005). These concepts will not be discussed here but it should be kept in mind that many species lists most likely contain species recognized according to either one or both concepts and are thus constantly subject to change.

The aim of this paper is to compile all original descriptions of extant reptiles (i.e. lizards, snakes, turtles, tuataras and crocodilians but not birds), as well as some analysis of their authors and sources. Since original descriptions serve as definitions of a species, particular efforts are required so that future discoveries are not made difficult or ambiguous. The art of describing species is reviewed by Winston (1999) and will not be discussed here. Equally important is the availability of species descriptions. New species are often described in obscure journals and books of low print runs. While the problem of obscurity has been solved to some extent by online publications, older descriptions are often still difficult to obtain. A solution to this problem is the digitization of historical literature and I will summarize attempts along these lines.

Material and methods

The species list and references of this study were taken from the TIGR/JCVI Reptile Database (http://www.reptile-database.org as of 9 September 2009, Uetz *et al.* 2007). On this date, the database contained 9084 species and their original references. The species list and bibliography is available for download at http://www.reptile-database.org/data/originaldescriptions2009.xls.

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This database of species is not an "official" list. In particular, the database has been somewhat conservative when it comes to species concepts and tends to favor a biological species concept over evolutionary concepts that are purely based on diagnosable lineages. While many of the 4411 subspecies (of 1295 species with subspecies) have been elevated to full species by some authors, they are still listed as subspecies in this database. Only full species are considered here.

This list of 9084 species will be incomplete by the time this paper is published, given that about two new species are described every week. In fact, all numbers in Tables 1–3 are subject to change if subspecies are elevated to full species or if synonyms are revalidated. However, the overall statistics should remain relatively stable for some time, given that the main authors, key works, and major journals only change slowly.

A number of cases involve authors who describe new species as parts of other author's works. For example, Zug and Vindum described *Calotes htunwini* in Zug *et al.* (2006). In these cases only the actual describers are considered as authors, here "Zug & Vindum".

The authors

Reptile alpha-taxonomy has often been dominated by a few highly productive individuals. In fact, just 40 individuals described at least 50 species, together amounting to more than half of all currently recognized reptile species (Table 1)! The list is led by a large margin by George Albert Boulenger (1858–1937) who described 573 reptile species that are still recognized today, in addition to many amphibians and fish. Remarkably, about 20% of the top-40 are alive, often remaining productive. In addition, several authors are close to the cut-off chosen here and likely will reach 50 species descriptions soon, including Lee Grismer (47 species), Ronald Nussbaum (49 species) or Wolfgang Böhme (47) .

The classics

Most of the outstanding taxonomists listed in Table 1 gained their claim to fame by publishing a number of classic works that often remain key sources even today. In fact, their 18 main works (Table 2) contain descriptions of 986 species still recognized — more than 10% of all living reptile species. Starting in 1758, Carl von Linné (typically cited as "Linnaeus") not only founded taxonomy as a science, but also described 149 new reptile species in the several editions of his *Systema Naturae* (including one authored by Johann Gmelin) that are still recognized today (Linnaeus 1758, 1766; Gmelin 1789).

The *Erpétologie Générale* (1834–1854), published over 20 years in nine volumes by André Marie Constant Duméril (1774–1860), his son Auguste Henri André Duméril (1812–1870), and Marie Gabriel Bibron (1806–1848) attempted to summarize the knowledge about all amphibian and reptile species known at the time (Duméril *et al.*, 1834–1854). These volumes described hundreds of new species of which 223 are still recognized today. Remarkably, the Dumérils added another key volume in 1851 while the *Erpétologie Générale* had not even been completed—the *Catalogue Méthodique*, which described another 30 new species (Duméril & Duméril 1851).

The third key opus in reptile taxonomy comprises Boulenger's catalogues, published in seven volumes from 1885 to 1896, in which he attempted a similarly comprehensive survey of all known reptiles with a focus on those held by the British Museum. The catalogues of lizards and snakes describe 124 new species that are still recognized today (Boulenger 1885–1887;1893–1896).

Notably, two other herpetologists at the British Museum added two more classics of this all-time list: In 1858 Albert Günther published the *Catalogue of Colubrine Snakes of the British Museum* (Günther 1858) and shortly afterwards the *The Reptiles of British India* (Günther 1864). Together these two volumes contain 88 new species still recognized today. Günther's predecessor at the Museum, John Edward Gray, had previously published the first catalogue of lizards in the British Museum (Gray 1845), with 71 new species.

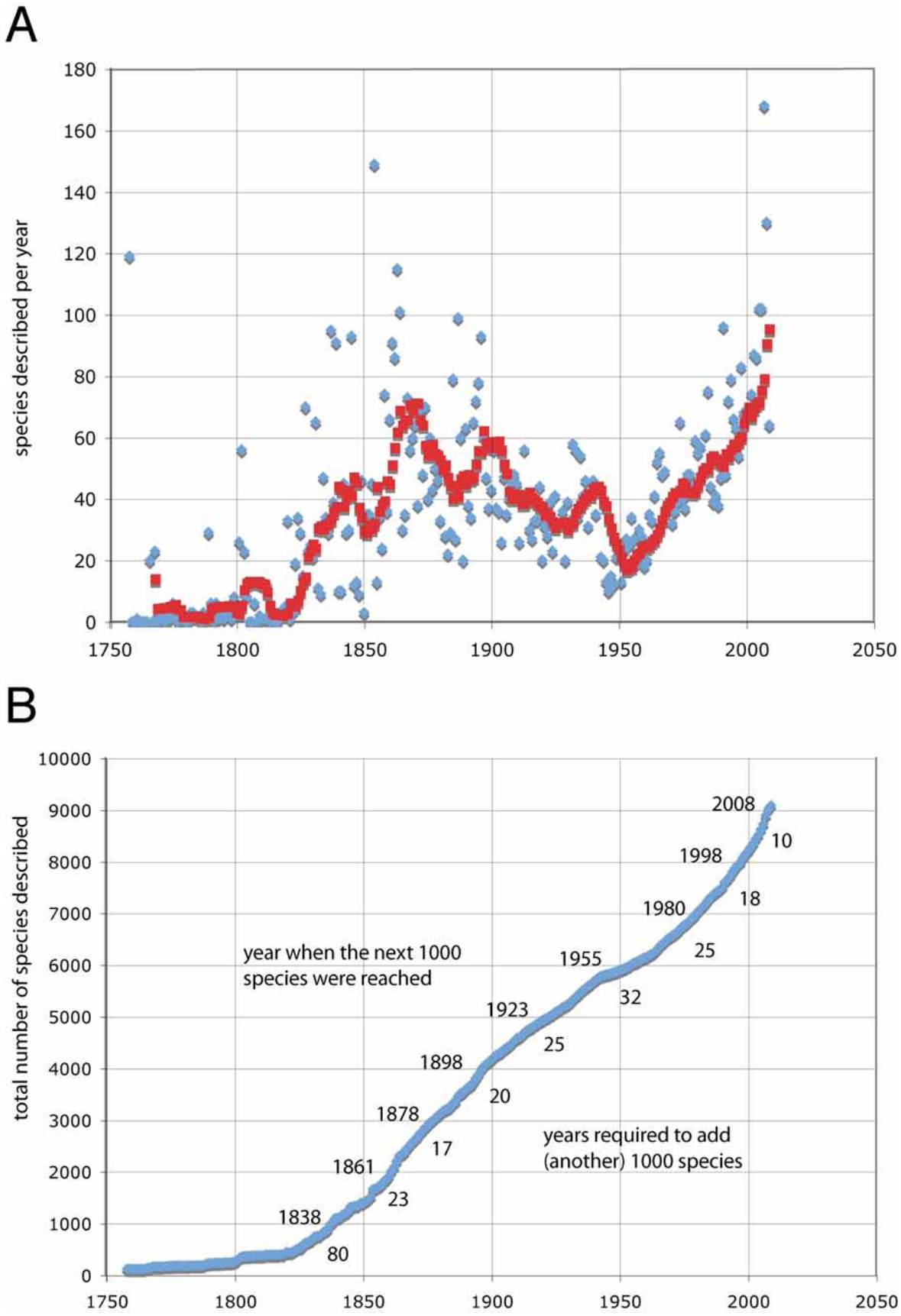

FIGURE 1. Species numbers during 250+ years of reptile taxonomy. A. diamonds represent the number of species described per year. squares represent average species numbers over the previous 10 years. **B.** Total number of species. The numbers to the left of the line indicate the years when milestones of multiples of 1000 were reached. The numbers to the right indicate the time span between these milestones. Note that the species numbers include only species still recognized today.

TABLE 1. On the shoulders of giants: the top-40 most productive alpha-taxonomists and the number of reptiles they have described (column **species described**). Only authors that have described 50 or more species are included here. Only species that are still considered as valid are considered. These 40 individuals described 4780 and thus more than half of all species! Biographic information on these individuals can be found in (Adler, 1989; 2007). * Authors whose last name is shared by other taxonomists who have also described new reptile species, e.g. Hobart M. Smith and Malcolm A. Smith.

Name	lifespan	Species described
BOULENGER, G.A.	1858–1937	573
GÜNTHER*, A.	1830–1914	333
GRAY, J.E.	1800–1875	306
COPE, E.D.	1840–1897	302
PETERS*, W.C.H.	1815–1883	281
DUMÉRIL*, A.M.C.	1774–1860	256
BIBRON, G.	1805–1848	232
STORR, G.M.	1921–1990	179
LINNAEUS, C.	1707–1778	139
DUMÉRIL*, A.H.A.	1812–1870	135
TAYLOR, E.H.	1889–1978	115
WERNER*, F.	1867–1939	107
SMITH*, H.M.	alive	102
BAUER, A.M.	alive	98
BOETTGER, O.	1844–1910	90
JAN, G.	1791–1866	81
SCHLEGEL, H.	1804–1884	80
BROADLEY, D.G.	alive	73
LOVERIDGE, A.	1891–1980	70
SCHMIDT, K.P.	1890–1957	69
SMITH *, A.	1797–1872	65
BROWN*, W.C.	1913–2002	65
BARBOUR, T.	1884–1946	65
STEJNEGER, L.	1851–1943	65
SMITH *, M.A.	1875–1958	64
THOMAS, R.	alive	64
GREER, A.E.	alive	62
MOCQUARD, F.	1834–1917	61
HALLOWELL, E.	1808–1860	60
BAIRD, S.F.	1823–1887	57
SADLIER, R.A.	alive	56
BOCAGE, J.V.B.	1823–1907	55
DAUDIN, F.M.	1774–1804	55
GIRARD, C.	1822–1895	55
RODRIGUES, M.T.	alive	53
WIEGMANN, A.F.A.	1802–1841	53
MERTENS, R.	1894–1975	52
PARKER*, H.W.	1897–1968	52
WILLIAMS, E.E.*	1914–1998	50
RAXWORTHY, C.J.	alive	50
Total		**4780**

TABLE 2. The classics. Books and articles in which more than 20 species were described that are still considered valid. These 18 works contain a total of 983 species descriptions. See references for complete citations.

#	Author(s)	year	Short title	species
1	Duméril & Bibron	1835	Erpétologie Générale 2 (10 species)	223
	Duméril & Bibron	1836	Erpétologie Générale 3 (21 species)	
	Duméril & Bibron	1837	Erpétologie Générale 4 (38 species)	
	Duméril & Bibron	1839	Erpétologie Générale 5 (48 species)	
	Duméril & Bibron	1844	Erpétologie Générale 6 (15 species)	
	Duméril & Bibron	1854	Erpétologie Générale 7/1 (49 species)	
	Duméril & Bibron	1854	Erpétologie Générale 7/2 (41 species)	
	Duméril & Bibron	1854	Erpétologie Générale 9 (1 species)	
2	Linnaeus	1758	Systema naturæ […] 10th ed. (117 species)	149
	Linnaeus	1766	Systema naturæ […] 12th ed. (21 species)	
	Gmelin*	1789	Systema naturæ […] 13th ed. (11 species)	
3	Boulenger	1885	Catalogue of the Lizards in the British Museum I (20)	124
	Boulenger	1885	Catalogue of the Lizards in the British Museum II (18)	
	Boulenger	1887	Catalogue of the Lizards in the British Museum III (39)	
	Boulenger	1893	Catalogue of the snakes in the British Museum I (7)	
	Boulenger	1894	Catalogue of the snakes in the British Museum II (16)	
	Boulenger	1896	Catalogue of the snakes in the British Museum III (24)	
4	Gray	1845	Catalogue of […] lizards in the British Museum	71
5	Schlegel	1837	Essai sur la physionomie des serpens	48
6	Günther, A.**	1858	Catalogue of Colubrine snakes […] of the British Museum.	45
7	Günther, A.**	1864	The Reptiles of British India.	43
8	Boie, F.	1827	Bemerkungen über Merrem's Versuch […] (Ophidier)	39
9	Gray	1831	A synopsis of the species of Class Reptilia	34
10	Duméril & Duméril	1851	Catalogue méthodique […]	30
11	Peters, W.C.H.**	1854	Diagnosen neuer Batrachier	29
12	Smith, A.**	1849	Illustrations of the Zoology of South Africa. 3	23
13	Cope	1864	Contributions to the herpetology of tropical America.	23
14	Laurenti	1768	Specimen medicum […]	22
15	Shaw	1802	General Zoology	22
16	Cope	1868	[…] Reptilia and Batrachia obtained by the Orton Expedition […]	21
17	Wiegmann	1834	Herpetologia Mexicana	20
18	Baird & Girard	1853	Catalogue of North American Reptiles (1 Serpents)	20
			Total:	**986**

Notes: The *Erpétologie Générale* volume 1 is an introductory volume without species descriptions; *Erpétologie Générale* volume 8 deals with amphibians. Boulenger's catalog of chelonians and crocodiles is not included here as there are no new species descriptions in it. * Gmelin's book is sometimes considered as an edited version of Linnaeus' Systema Naturae. ** Initials are given when other herpetologists share the same last name.

These key works highlighted the role of the museums in London and Paris which, together with the Berlin Museum (with Wilhelm Carl Hartwig Peters (1815–1883), the leading German herpetologist of the 19th century), were the centers of herpetology in Europe. Independently, Edward Drinker Cope (1840–1897) dominated North American herpetology, at least when measured by the number of species descriptions, although he did not publish any book with a significant number of new species but described almost all of his new species in journal articles.

TABLE 3. Top-25 journals in which new species descriptions have been published (including 4 additional journals of equal rank). Journals with the same number of species descriptions are listed on the same rank. These 29 journals have published 3603 species descriptions, corresponding to 39.6% of all 9084 species. **Availability** = electronic availability: **RDB** = All pre-1900 articles are available on CD at http://www.reptile-database.org. **BHL** = All or many volumes are available digitally from the Biodiversity Heritage Library (http://www.archive.org/, lower case "bhl" indicates only few selected volumes). **G** = selected volumes are available from http://books.google.com, **J** = http://www.jstor.org, **B** = http://www.bioone.org, **AM** = American Museum website: http://digitallibrary.amnh.org/dspace/handle/2246/9, **MP** = Magnolia Press, www.mapress.com/zootaxa/; dashes indicate no consistent electronic availability. All sites accessed 23 Nov 2009.

#	Name	Availability	species
1	Annals and Magazine of Natural History	RDB	507
2	Proceedings of the Academy of Natural Sciences Philadelphia	RDB	337
3	Proceedings Zoological Society of London	G	308
4	Monatsberichte der Königlich-Preuss. Akademie der Wiss.	bhl	206
5	Herpetologica	J, B	201
6	Journal of Herpetology	J, B	169
	Zootaxa	MP	169
8	Records of the Western Australian Museum	--	153
9	Proceedings of the Biological Society of Washington	BHL	144
10	Copeia	J	127
11	Zoologischer Anzeiger	RDB	125
12	American Museum Novitates	AM	101
13	Proceedings of the California Academy of Sciences	bhl	99
14	Breviora	BHL	90
15	Journal of the Asiatic Society Bengal	G	84
	Bulletin of the Museum of Comparative Zoology (Harvard)	BHL	84
16	Bulletin du Muséum d'Histoire Naturelle, Paris	G	80
17	Isis von Oken	BHL	63
18	Annali del Museo Civico di Storia Naturale di Genova	bhl	61
19	Senckenbergiana biologica	--	60
20	Papeis Avulsos de Zoologia (Sao Paulo)	--	59
21	University of Kansas Science Bulletin	BHL	57
	Records of the Australian Museum	bhl	57
22	Proceedings of the American Philosophical Society	BHL	55
23	Occasional Papers of the Museum of Zoology (Univ. Michigan)	BHL	54
	Memoirs of the Queensland Museum	bhl	54
24	Memorias do Instituto Butantan (Sao Paulo)	--	52
25	Proceedings of the US National Museum (Washington DC)	bhl	47
	Total		**3603**

The journals

Just as a large fraction of all descriptions can be ascribed to a small number of individuals, the top 29 journals (in 25 ranks) account for almost 40% of all species descriptions (Table 3). The top journal in this group, the *Annals and Magazine of Natural History,* alone published 506 descriptions whose species are still considered valid.

Not surprisingly, the top authors (Table 1) also had their favorite journals. Boulenger, Günther, and Gray preferentially published in the *Annals and Magazine of Natural History* and the *Proceedings of the Zoological Society of London* (ranked 3). These two journals thus owe their prominent role in reptile taxonomy to just a few authors. Similarly, Wilhelm Peters published most of his papers in the *Monatsberichte der Königlich-Preussischen Akademie der Wissenschaften* (monthly reports of the Royal Prussian Academy of Science). All of these journals have lost their dominance in systematic herpetology with the loss of their most prolific authors. I have not tried to compile data for other taxonomic groups besides reptiles, so it remains unclear how other taxa are represented in these publications.

Availabilty of original descriptions and their digitization

A number of efforts have been started to digitize the older scientific and popular literature and make it available online. According to the Berne Convention on Copyright, EU countries and the United States typically grant copyright protection for 70 years after the death of an author. Table 3 lists online sources for original reptile descriptions, including freely available historical papers. The most important ones are the *Biodiversity Heritage Library* (BHL) operated by the *Internet Archive,* and *Google Books* which is now also incorporated into other web sites including the BHL. These sites also provide many of the books listed in Table 2. Note that some of these sites are commercial or link to commercial sites. Current journals and publications usually require a fee, including Magnolia Press, the publisher of *Zootaxa*. Other services such as JSTOR or BioOne require a (paid) membership or subscriptions to journals. I have started another digitization project covering journals including the *Annals and Magazine of Natural History* and others (Uetz 2002) which are available online or on CD-ROM.

A number of attempts has been made to compile papers of certain authors in "*Collected works of…*" (e.g., Bauer *et al.* 1995 for the papers of Wilhelm Peters). Unfortunately few of them are available in digital format, hence I do not cover them here in more detail.

Since the JCVI/TIGR Reptile Database is actively collecting digital copies of historical papers, I am happy to trade papers for ones that are still missing from our collection. The goal of these efforts is to provide a website or DVD with all original reptile descriptions. The JCVI/TIGR Reptile Database and this article hopefully provide a basis for such efforts.

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Supplementary TABLE 1. All currently recognized species by the TIGR/JCVI Reptile Database and their original references. The file contains 10 TAB-separated fields: **species**, **author**, **year**, **original_genus** (if no, author and year should be in brackets), **ref_number** (internal reference number), **authors**, **title**, **source**, **new_species** (number of species described in this publication), **unique_ref** ("yes" only for the first instance of a reference, so that a non-redundant list can be extracted).
Available at http://www.reptile-database.org/data/originaldescriptions2009.xls.