



Animal biodiversity: An update of classification and diversity in 2013*

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Abstract

The kingdom Animalia is here estimated to have a total of 1,659,420 described species (including 133,692 fossil species) in 40 phyla. Among these, the most successful phylum Arthropoda alone represents 1,302,809 species, or about 78.5% of the total. The second largest phylum, Mollusca (118,061 species), is <10% of Arthropoda in diversity, but it is still much more diverse than other successful invertebrate phyla Platyhelminthes (29,488 species), Nematoda (25,043 species), Echinodermata (20,550 species), Annelida (17,426 species), Cnidaria (16,363 species), Bryozoa (11,474 species) and Porifera (10,876 species). The phylum Craniata, including the vertebrates, represents 85,432 species (including 19,974 fossil species): among these, 35,644 species of “fishes”, 7,171 species of amphibians, 15,507 species of reptiles, 11,087 species of birds, and 16,014 species of mammals.

Key words: Animals, taxonomy, diversity, phylum, species number

Introduction

Zootaxa is the most important journal in biodiversity research, publishing more biodiversity papers than any other journals in the world (Liu *et al.* 2012, based on data from *Journal Citation Reports* in 2009). *Zootaxa* publishes mostly descriptions of new taxa and taxonomic revisions of interest mainly to specialists. To reach a wider readership and to achieve a greater impact for taxonomy, we presented in a special volume (Zhang 2011b) basic taxonomic information which is also very important to applied users of biodiversity information: how many species have been described and how they are classified. The entire volume was published for open access at the cost of *Zootaxa*. A large team of over 100 taxonomists contributed 43 chapters on various taxa, but these new contributions only cover a quarter of the animal phyla. Many gaps remained to be filled by specialists and for many groups, the data were deficient in fossil taxa (Zhang 2011a).

After the publication of the special volume in 2011, we received offers from some specialists to contribute chapters on taxa missed in the first volume and also comments on errors in a few chapters. In this update, four new chapters were added (Phylum Brachiopoda by Emig *et al.* 2013; Phylum Bryozoa by Bock & Gordon 2013; Phylum Gastrotricha by Balsamo *et al.* 2013; Phylum Kinorhyncha by Sørensen 2013) and three chapters in Zhang (2011a) were updated with new taxonomic data (Phylum Arthropoda by Zhang 2013; Phylum Onychophora by Mayer & Oliveira 2013; Order Testudines by Fritz 2013). For taxa without new chapters or updates in this volume, diversity estimates in Zhang (2011b) were updated using various journal papers, books and taxonomic databases, and especially *Zoological Record*—its *Metrics* function from the website <http://www.organismnames.com/> where the option “Graphs of new taxa over time” was used to check new species-level taxa described in recent years (i.e. 2012 and 2013 if any); it should be noted that the 2013

data are incomplete because of the delay in indexing and also the fact that *Zoological Record* itself is incomplete (these may result in slight underestimates), but the count of new species includes subspecies (although the number of new subspecies described is very low compared to that of new species), and also new names for described species in some cases (these may result in slight overestimates).

Fossil taxon counts are not available for many taxa in the last volume. Here, for chapters without fossil data, I used Paleobiology Database to obtain estimates for these fossil taxa (search <http://paleodb.org/> using “Taxon Count” option, date of search provided as reference); these counts for fossil taxa may not be complete and should be viewed as underestimates in most cases.

With this update, the kingdom Animalia is here estimated to have a total of 1,659,420 described species (including 133,692 fossil species) in 40 phyla.

The chapters in the last volume (Zhang 2011b) were correctly cited by many authors and properly indexed by *Zoological Record*. However, they were not indexed by *Science Citation Index Expanded* available in the *Web of Science* due to the special format of the chapters (e.g. lack of abstracts/introductions and authors/addresses placed at the end). In this volume, the format for chapters is revised to ensure that they will be correctly cited and indexed. Future updates will be planned regularly, with the next one expected in 2015. We invite more colleagues to join us in outlining the classification and diversity estimates of animals.

Classification

Kingdom **Animalia** (1,659,420 species; including †133,692)¹

Phylum †**Trilobozoa** (5 species, including †5)²

Phylum 1 **Ctenophora** (187 species, including †0)³

Phylum 2.1 **Porifera** (10,876 species, including †2,217)⁴

Phylum 2.2 1 **Placozoa** (1 species, including †0)

Phylum 2.2.2.1 **Cnidaria** (16,383 species, including †6,180)⁵

Phylum 2.2.2.2 **Myxozoa** (2,425 species, including †0)^{6,7}

1. The classification used here is the evo-Linnaean classification of animal phyla in Zhang (2011a), which reflects the consensus phylogenetic relationships in Edgecombe *et al.* (2011). The total number of described species (extant + fossil) are presented for each phylum (synonyms not included) and these should be considered incomplete for some taxa, as the number of species for fossil taxa (with prefix †) is underestimated for some taxa.
2. The poorly known extinct phylum †Trilobozoa was not numbered in the hierarchical system of Zhang (2011a) because of its uncertain phylogenetic placement. Fossil taxa are represented in 10 genera and 5 species (Data from Paleobiology Database on 27 August, 2013 using “Taxon Count” search)—note that these data are incomplete as 5 genera do not include species with taxonomic classification data.
3. There are five competing hypotheses on phylogenetic relationships among five major basal taxa: Ctenophora, Porifera, Placozoa, Cnidaria and Bilateria (Edgecombe *et al.* 2011; Dohrmann & Wörheide 2013). Thus any nomenclature and classifications at the levels of subkingdom to superphylum will be unstable due to the problems at the most basal positions. Zhang (2011a)’s classification listed phyla only to avoid this problem. Ctenophora was placed as sister group to the remaining animals (Porifera (Placozoa (Cnidaria, Bilateria))) in phylogenomic analyses by Dunn *et al.* (2008) and Hejnol *et al.* (2009); this was favoured over other hypotheses. Diversity estimate for Ctenophora here is updated using statistics (accepted non-fossil marine species) in Appeltans *et al.* (2012).
4. Hooper *et al.* (2011) estimated 8,346 species, but without the number of fossil species, although an attempt was made to integrate the classification of Recent and fossil Porifera. The diversity estimate here updated using statistics (accepted non-fossil marine species and non-marine species) in Appeltans *et al.* (2012). Fossil taxa are represented in 58 orders, 211 families, 2,046 genera and 2,217 species (Data from Paleobiology Database on 27 August, 2013 using “Taxon Count” search)—note that these data are incomplete as 956 genera do not include species with taxonomic classification data.
5. Zhang (2011a) estimated 10,105 extant species based on Daly *et al.* (2007), Crowther (2011) and *Zoological Record*; here updated to 10,203 species using *Zoological Record*. Fossil Cnidaria are represented in 38 orders, 268 families, 2,713 genera and 6,180 species (Data from Paleobiology Database on 27 August, 2013 using “Taxon Count” search)—note that these data are incomplete as 1,357 genera do not include species with taxonomic classification data.
6. Zhang (2011a) estimated 2,402 species based on Lom & Dykova (2006), with updates using *Zoological Record*. Here updated again using *Zoological Record*.

- Phylum 2.2.2.3.1.1 **Xenoturbellida** (2 species, including †0)⁸
 Phylum 2.2.2.3.1.2 **Acoelomorpha** (428 species, including †0)⁹
 Phylum 2.2.2.3.2.1 **Orthonectida** (29 species, including †0)¹⁰
 Phylum 2.2.2.3.2.2 **Rhombzoa** (107 species, including †0)¹¹
 Phylum 2.2.2.3.3.1.1.1 **Cephalochordata** (33 species, including †0)¹²
 Phylum 2.2.2.3.3.1.1.2.1 **Tunicata** (2,804 species, including †0)¹³
 Phylum 2.2.2.3.3.1.1.2.2 **Craniata** (85,432 species, including †19,974)¹⁴
 Phylum 2.2.2.3.3.1.2.1 **Echinodermata** (20,550 species; including †13,000)¹⁵
 Phylum 2.2.2.3.3.1.2.2 **Hemichordata** (126 species; including †23)¹⁶
 Phylum 2.2.2.3.3.2.1 **Chaetognatha** (186 species; including †16)¹⁷

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7. Zrzavy *et al.* (1998) placed it within Cnidaria based on morphological and 18S ribosomal DNA evidence, and Evans *et al.* (2010), using phylogenomic and ribosomal data sets, showed existence of two relatively stable placements for myxozoans: within Cnidaria or the alternative hypothesis at the base of Bilateria. Cnidarian taxonomists currently do not consider myxozoans as cnidarians (Daly *et al.* 2007).
 8. Tyler & Schilling (2011) treated this phylum as a subphylum of Xenacoelomorpha, following Philippe *et al.* (2011), who proposed the name Xenacoelomorpha for Xenoturbellida + Acoelomorpha.
 9. Diversity estimate here updated using statistics (accepted non-fossil marine species and non-morine species) in Appeltans *et al.* (2012); 430 minus 2 = 428.
 10. Edgecombe *et al.* (2011) recognised two subgroups of Mesozoa, Orthonectida and Rhombzoa, as phyla but did not include them in the phylogenetic tree. The placement of Mesozoa here follows Noordijk *et al.* (2010). Diversity estimate here updated using statistics (accepted non-fossil marine species and non-morine species) in Appeltans *et al.* (2012).
 11. Diversity estimate here updated using statistics (accepted non-fossil marine species and non-morine species) in Appeltans *et al.* (2012).
 12. Zhang (2011a) listed 33 species based Chapman (2009). No new species after that.
 13. Also as Urochordata. Diversity estimates based on Chapman (2009) with updates using *Zoological Record*.
 14. Zhang (2011a) listed 64,832 species for Recent taxa, except for amphibians (with both extant and fossil species). Eschmeyer & Fong (2011) listed 31,958 “fish” extant species; it is updated to 32,834 based on Eschmeyer, W.N. & Fong, J.D. Species by Family/subfamily. (<http://research.calacademy.org/research/ichthyology/catalog/SpeciesByFamily.asp>). Electronic version accessed 5 Aug 2013. Here the counts on fossil taxa are based on “Data from Paleobiology Database on 28 August, 2013 using “Taxon Count” search”: 2,810 species (Myxini: 1 species; Cephalaspidomorphi: 5 species; Elasmobranchii: 1,186 species; Holocephali: 162 species; Actinopterygii: 1,235 species; Sarcopterygii: 221 species). Blackburn & Wake (2011) provided a classification for Amphibia with diversity estimates (extant and fossil). Blackburn & Wake (2012) published additions and corrections but without updated diversity estimates. This new estimate for total species number is from AmphibiaWeb <http://amphibiaweb.org/> (accessed 28 Aug. 2013): 7,171 species in total. Here the data on fossil taxa are based on “Data from Paleobiology Database on 28 August, 2013 using “Taxon Count” search”: 340 species. Wilson & Reeder (2011) estimated 5,750 of species of Mammalia (extant); this is here updated to 5,898 using *Zoological Record*. Fossil taxa are represented in 10,116 species (Data from Paleobiology Database on 27 August, 2013 using “Taxon Count” search)—note that these data are incomplete as 1,247 genera do not include species with taxonomic classification data. Zhang (2011a) estimated 9,990 species of birds based on Chapman (2009); this is here updated to 10,055 species using *Zoological Record*. Fossil taxa are represented in 1,032 species (Data from Paleobiology Database on 27 August, 2013 using “Taxon Count” search)—note that these data are incomplete as 122 genera do not include species with taxonomic classification data. Zhang (2011a) estimated 9,413 extant species of reptiles; this is updated using Uetz & Hošek (2013) to 9,831 species; it should be noted that this database listed 328 species of Testudines, whereas only 317 species of Testudines in Fritz (2013 this volume). Fossil reptiles are represented in 5,673 species (Data from Paleobiology Database on 27 August, 2013 using “Taxon Count” search)—note that these data are incomplete as 122 genera do not include species with taxonomic classification data; this should add 3 fossil species (Mesosauridae).
 15. Updated using *Zoological Record* from Pawson (2007), who estimated 7,000 living and 13,000 fossil species.
 16. Zhang (2011a) listed 120 species based on Chapman (2009) with updates using *Zoological Record*. Here updated using Appeltans *et al.* (2012) for extant species. Fossil taxa are represented in 8 orders, 7 families, 299 genera and 23 species (Data from Paleobiology Database on 27 August, 2013 using “Taxon Count” search)—note that these data are incomplete as 281 genera do not include species with taxonomic classification data.
 17. Zhang (2011a) listed 186 species (including †7) based on Noordijk *et al.* (2010) with updates using *Zoological Record*. Fossil taxa are represented in 1 order, 10 genera and 16 species (Data from Paleobiology Database on 27 August, 2013 using “Taxon Count” search)—note that these data are incomplete as 4 genera do not include species with taxonomic classification data.

Phylum 2.2.2.3.3.2.2.1.1 **Nematoda** (25,043 species, including †10)¹⁸
 Phylum 2.2.2.3.3.2.2.1.2 **Nematomorpha** (354 species, including †15)¹⁹
 Phylum 2.2.2.3.3.2.2.2 **Tardigrada** (1,335 species, including †168)²⁰
 Phylum 2.2.2.3.3.2.2.3.1 **Onychophora** (187 species, including †4)²¹
 Phylum 2.2.2.3.3.2.2.3.2 **Arthropoda** (1,302,809 species; †45,769)²²
 Phylum 2.2.2.3.3.2.2.4.1 **Priapulida** (20 species, including †1)²³
 Phylum 2.2.2.3.3.2.2.4.2 **Loricifera** (30 species, including †0)²⁴
 Phylum 2.2.2.3.3.2.2.4.3 **Kinorhyncha** (196 species, including †0)²⁵
 Phylum 2.2.2.3.3.2.3.1.1 **Bryozoa** (11,474 species; including †5,466)²⁶
 Phylum 2.2.2.3.3.2.3.1.2.1 **Entoprocta** (172 species, including †1)²⁷
 Phylum 2.2.2.3.3.2.3.1.2.2 **Cycliophora** (2 species, including †0)²⁸
 Phylum 2.2.2.3.3.2.3.2.1.1 **Annelida** (17,426 species, including †38)²⁹
 Phylum 2.2.2.3.3.2.3.2.1.2 **Spincula** (147 species, including †0)³⁰
 Phylum 2.2.2.3.3.2.3.2.1.3 **Echiura** (198 species, including †0)³¹
 Phylum 2.2.2.3.3.2.3.2.2 **Mollusca** (118,061 species, including †33,084)³²
 Phylum 2.2.2.3.3.2.3.2.3 **Nemertea** (1,358 species, including †0)³³

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18. Hodda (2011) estimated 24,783 species. Here updated using *Zoological Record*.
 19. Zhang (2011a) estimated 351 species based on Poinar (2008) with updates using *Zoological Record*. Here updated again using *Zoological Record*. Fossil taxa are represented in 2 families, 18 genera and 15 species (Data from Paleobiology Database on 27 August, 2013 using “Taxon Count” search)—note that these data are incomplete as 9 genera do not include species with taxonomic classification data.
 20. Guidetti & Bertolani (2011) provided a classification of extant taxa: Heterotardigrada 444 species, Eutardigrada 712 species, Mesotardigrada 1 species. Vicente & Bertolani (2013) updated the total to 1167 species. Fossil taxa are represented in 3 families (Megalonychidae, Megatheriidae, Mylodontidae), 86 genera and 168 species (Data from Paleobiology Database on 27 August, 2013 using “Taxon Count” search)—note that these data are incomplete as 18 genera do not include species with taxonomic classification data.
 21. Mayer & Oliveira (2011) is now updated with Mayer & Oliveira (2013, this volume).
 22. Updated using Zhang (2013).
 23. 19 extant species in Zhang (2011a) and also in Appeltans *et al.* (2012). Fossil taxa are represented in 14 genera and 1 species (Data from Paleobiology Database on 27 August, 2013 using “Taxon Count” search)—note that these data are incomplete as 13 genera do not include species with taxonomic classification data.
 24. Zhang (2011a) listed 30 species based on Chapman (2009) & Gad (2009a,b). No new species after that.
 25. Zhang (2011a) listed 179 species based on Neuhaus *et al.* (2011). Here updated with Sørensen (2013)
 26. Zhang (2011a) listed 10,941 species; including †5,455 based on Phil Bock (personal communication). Bock & Gordan (2013) updated extant species to 5,869. However, the number of extant species listed in statistics (accepted non-fossil marine species) in Appeltans *et al.* (2012) is 6008, which is considered the most updated and used here. Fossil species updated using Paleobiology Database classification on 27 August, 2013.
 27. Also as Kamptozoa; Diversity estimate here updated using statistics (accepted non-fossil marine species) in Appeltans *et al.* (2012). Fossil taxa are represented in 2 genera and 1 species (Data from Paleobiology Database on 27 August, 2013 using “Taxon Count” search).
 28. Based on Funch & Kristensen (1995) and Obst *et al.* (2006).
 29. Zhang (2011a) estimated 17,210 species based on Chapman (2009) with updates of new names in *Zoological Record*. Here updated again using *Zoological Record*. Fossil taxa are represented in 9 orders, 4 families, 262 genera and 38 species (Data from Paleobiology Database on 27 August, 2013 using “Taxon Count” search)—note that these data are incomplete as 193 genera do not include species with taxonomic classification data.
 30. There are recent evidence that this phylum, along with, Echiura and Siboglinidae, is part of Annelida (Struck *et al.* 2011). Last estimate of 1507 species is incorrect (which was the total names). Current diversity estimate here updated using statistics (accepted non-fossil marine species) in Appeltans *et al.* (2012).
 31. Diversity estimate here updated using statistics (accepted non-fossil marine species) in Appeltans *et al.* (2012).
 32. Based on Noordijk *et al.* (2010) with updates of 2010 to 2013 new names in *Zoological Record*. Fossil taxa are represented in 146 orders, 1,288 families, 13,639 genera and 33,084 species (Data from Paleobiology Database on 27 August, 2013 using “Taxon Count” search)—note that these data are incomplete as 5,967 genera do not include species with taxonomic classification data.
 33. Diversity estimate here updated using statistics (accepted non-fossil marine species) in Appeltans *et al.* (2012).

- Phylum 2.2.2.3.3.2.3.2.4.1 **Brachiopoda** (7,390 species, including †6,998)³⁴
 Phylum 2.2.2.3.3.2.3.2.4.2 **Phoronida** (16 species, including †0)³⁵
 Phylum 2.2.2.3.3.2.3.3.1 **Gastrotricha** (794 species, including †0)³⁶
 Phylum 2.2.2.3.3.2.3.3.2 **Platyhelminthes** (29,488 species, including †1)³⁷
 Phylum 2.2.2.3.3.2.3.3.3.1 **Gnathostomulida** (97 species, including †0)³⁸
 Phylum 2.2.2.3.3.2.3.3.3.2 **Micrognathozoa** (1 species, including †0)³⁹
 Phylum 2.2.2.3.3.2.3.3.3.3.1 **Rotifera** (2,049 species, including †0)⁴⁰
 Phylum 2.2.2.3.3.2.3.3.3.3.2 **Acanthocephala** (1,199 species, including †2)⁴¹

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34. Based on Emig *et al.* (2013) for 392 extant species. Fossil taxa are represented in 26 orders, 415 families, 1,140 genera and 6,998 species (Data from Paleobiology Database on 27 August, 2013 using “Taxon Count” search)—note that these data are incomplete as 2,289 genera do not include species with taxonomic classification data.
35. Emig (2011) estimated 10 species. Diversity estimate here updated using statistics (accepted non-fossil marine species) in Appeltans *et al.* (2012).
36. Zhang (2011a) estimated 790 species based on Schwank & Bartsch (1990) with updates of new ones described since 1990. Current estimate from Balsam *et al.* (2013, this volume).
37. 29,285 species according to Seth Tyler (Personal communication in Dec 2011); here updated to 29,488 species using *Zoological Record*. Fossil with 1 species (Data from Paleobiology Database on 27 August, 2013 using “Taxon Count” search)
38. Diversity estimate here updated using statistics (accepted non-fossil marine species) in Appeltans *et al.* (2012).
39. Based Kristensen & Funch (2000), who originally proposed it as a class.
40. Segers (2011) estimated three species for Seisonida, 461 species for Bdelloidea and 1583 species for Monogononta. Updated here with *Zoological Record*.
41. Edgecombe *et al.* (2011) subsumed this phylum into Rotifera, however, specialists of Rotifera and Acanthocephala have not yet fully accepted this (Segers 2011 & Monks 2011). Monks (2011) estimated 1,194 species, including †2. Updated here with *Zoological Record*.

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