

Numbers of Living Species in Australia and the World

Arthur D. Chapman
Australian Biodiversity Information Services
Toowoomba, Australia

Report for the Department of the Environment and Heritage
Canberra, Australia
September 2005



Australian Government

Department of the Environment and Heritage



© Commonwealth of Australia 2006

ISBN (printed) 978 0 642 56849 6

ISBN (online) 978 0 642 56850 2

Contents

Introduction	2	Invertebrates	18	Plants	35	Summary Table	48
Executive Summary	4	Hemichordata (hemichordates)	18	Bryophyta (mosses, liverworts and hornworts)	35	Comparisons	49
Vertebrates	5	Echinodermata (starfish)	19	Ferns and Allies	36	Conclusion	52
Invertebrates	6	Insecta (insects)	20	Gymnosperms	37	Acknowledgments	53
Plants	7	Arachnida	21	(Coniferophyta, Cycadophyta, Gnetophyta and Gingkophyta)		References	54
Others	7	(spiders, scorpions, etc.)		Magnoliophyta	38		
All Species	8	Myriapoda	23	(flowering plants)			
Detailed discussion by Group	9	(millipedes and centipedes)					
Vertebrates	10	Crustacea (crabs, lobsters)	24	Others	39		
Mammalia (mammals)	10	Onychophora (velvet worms)	25	Lichens	39		
Aves (birds)	11	Mollusca (molluscs, shellfish)	26	Fungi (excluding lichens)	40		
Reptilia (reptiles)	12	Annelida (segmented worms)	27	Bacteria (Monera)	41		
Amphibia (frogs etc.)	13	Nematoda	28	Cyanophyta (Cyanobacteria)	42		
Pisces (fishes including Chondrichthyes and Osteichthyes)	14	(nematodes, roundworms)		Algae	43		
Agnatha (hagfish, lampreys and slime eels)	15	Acanthocephala	29	Viruses	45		
Cephalochordata (lancelets)	16	(thorny-headed worms)		Protoctista	46		
Tunicata or Urochordata (sea squirts, doliodids, salps)	17	Platyhelminthes (flat worms)	30				
		Cnidaria (jellyfish, sea anemones, and corals)	31				
		Porifera (sponges)	32				
		Other Invertebrates	33				



Introduction

The number of known species has been estimated by collating information from systematists, taxonomic literature, on-line resources and previous compilations. Although many scientific names are synonyms (thus there being more than one name applied to a species) the numbers of valid species for well-reviewed and familiar groups can be calculated with reasonable accuracy (Groombridge and Jenkins 2002). Most recent calculations for the total number of known (i.e. described) species in the world suggest a figure of around 1.75 million (Hawksworth and Kalin-Arroyo 1995), varying from about 1.5 million to 1.8 million (Tangley 1997).

For less well known groups, the total number of species is much more difficult to estimate, and any estimate will inevitably involve a high degree of uncertainty (Hammond 1992). In taxonomic groups where individuals are generally large, charismatic, easily visible, of economic importance, of public interest, or subject to extensive taxonomic interest, such as mammals, birds, and some higher plant groups, the total number of species is likely to be fairly close to the known or described number of species. On average, around 25 mammal species and five bird species have been described each year over recent times (Hammond 1992), with many of these new species resulting from

changes in taxonomic opinion and splitting and not due to the discovery of new species (Groombridge and Jenkins 2002). Estimates for the total number of species on earth varies from 3–5 million (Tangley 1997) to 14 million (Groombridge and Jenkins 2002) and even to as many as 100 million by some (Tangley 1997).

In contrast, for groups of organisms that contain individuals that are small, difficult to collect, obscure, or of no direct public or economic interest (such as many invertebrate taxa), the total number of species is difficult to estimate and is likely to be much much higher than the known number of described individuals (Groombridge and Jenkins 2002). Many of these taxonomic groups have very few or no specialist systematists working on them. In many cases there are undescribed species already in museum collections, but with no systematists available to characterise and describe them. In addition, new molecular techniques applied to some groups, and especially to microorganisms, are discovering new diversity and adding considerably to estimates of the number of species.

Reliable estimates of the total number of species in many of these taxonomic groups are unlikely to be made for many decades, although several



Photo: *Ficus* sp., Bunya Mountains, Queensland, Australia.

new initiatives are attempting to fill the gaps in knowledge. In 1998, the Convention on Biological Diversity established the Global Taxonomy Initiative (GTI) (ABRS 1998, CBD 2005) to try to improve taxonomic knowledge through increasing the number of taxonomists and trained curators, etc. The Global Biodiversity Information Facility (GBIF)¹ is attempting to collate, through collaboration, existing attempts to document the names of species of biodiversity through its ECAT program (GBIF 2005a), and through the identification and funding of nomenclatural and taxonomic gaps (GBIF 2005b). Other major projects that are looking at documenting names and taxa on a global basis are the Species 2000² project and the Integrated Taxonomic Information System (ITIS)³ project which combine to produce the annual Catalogue of Life CDs (Bisby *et al.* 2005), and the International Plant Names Index (IPNI).⁴

When it comes to Bacteria and the Archaea, trying to estimate the number of species (both known and total) is compounded by the difficulty in determining what delimits a 'species'. Generally, species are determined

based on features shown in culture (Woese 1998, Ward 2002), and any estimate of the total number of species in the world is just about impossible to make. Indeed, according to Curtis *et al.* (2002) 'The absolute diversity of prokaryotes is widely held to be unknown and unknowable at any scale in any environment.'

The listing of threatened species is not an easy matter. All lists lag well behind discovery and taxonomic revision, and thus are likely to provide under-estimates. Also, on a world basis, very few countries list undescribed species, and this again leads to under-estimation. The only lists available that are regularly updated on a world basis are the Red Lists of Threatened Species (IUCN 2004) produced by the IUCN Species Survival Commission and, even though these include considerable error (Kirschner and Kaplin 2002), I have relied on them for numbers of threatened species for the world.

Similarly, listing of threatened species in Australia is not simple. As well as the list of nationally threatened species maintained by the Australian Government

(DEH 2005a, b), each State also maintains a list for that State. The national list contains errors, and is always well behind discovery, taxonomic revision and often State listings, however it is the only comprehensive list of 'nationally' threatened species that is available. The national list has been used in this report.

State lists also contain errors, with some States listing species threatened in that State, but which may be common across the border in another State, and some lists are not consistently maintained and updated on a regular basis. Some States (e.g. Western Australia) also list species under categories additional to those recognised by the IUCN. Although these species may be of no less importance for regional conservation, they are not listed here as it is difficult to provide comparisons between the State lists and between the State lists and the National list. It is hoped that the development of the Australia's Virtual Herbarium (AVH)⁵ and Online Zoological Collections of Australian Museums (OZCAM)⁶ will lead to a more consistent approach to the development of both State and Commonwealth lists of threatened species.

1 <http://www.gbif.org>.
 2 <http://www.species2000.org>.
 3 <http://www.itis.usda.gov/>.
 4 <http://www.ipni.org>.
 5 <http://www.chah.gov.au/avh/>.
 6 <http://www.ozcam.gov.au/about.php>.



Executive Summary

Many of the figures supplied in this report are estimates only. Details of how the estimates were arrived at can be seen in the bulk of the paper. Estimates for total world species in many of the groups are difficult or impossible to find. Rather than make guestimates, 'unknown' is inserted where no information could be obtained. Estimates of total species in Australia were also often not easy to find, as were estimates of percentage endemism for many of the invertebrate groups and non plant and animal phyla.

Estimates for the total number of species in the world vary from 5 million to over 50 million (May 1998). I have settled on a figure of between 8 and 9 million with about 600,000–700,000 for Australia.

Vertebrates

Brusca and Brusca (2003) estimated that there were 49,693 published vertebrates for the world, while Groombridge and Jenkins (2002) gave an estimate of 52,000 published vertebrate species and an estimate of about 55,000 species in total. Adding up the individual estimates as documented in this report, a much higher figure of 60,979 has been determined for published species. The area of most uncertainty is within the fishes.

In this report, the estimate of total species for the world has been calculated by adding estimates where cited to published numbers and rounding to the nearest 1,000.

Taxon	World Descr.	Australia Descr.	Austral. Percent.	Estimate World	Estimate Australia	World Threat. ⁷	World Threat. Percent.	Austral. Threat. ⁸	Austral. Threat. Percent	% of World's Threat.	Percent. Endemic
Mammals	5,416	378	7.0%	unknown	~378	1,101	20%	75	20%	6.8%	83%
Birds	9,917	828	8.4%	~10,000	~828	1,213	12%	65	8%	5.3%	45%
Reptiles	8,300	869	10.5%	~10,000	~900	304	4%	42	5%	13.8%	89%
Amphibia	5,743	219	3.8%	~7,500	~220	1,770	31%	30	14%	1.7%	93%
Fishes	28,900	4,500	15.6%	~35,000	~5,250	800	3%	35	1%	4.4%	90%
Agnatha	114	5	4.4%	unknown	~10	0	—	0	—	—	40%
Cephalochordata	23	8	34.8%	unknown	~8	0	—	0	—	—	50%
Tunicata	2,566	754	29.4%	unknown	~850	0	—	0	—	—	25–30%
TOTAL	60,979	7,561	12.4	~71,000	~8,444	5,188	8.5%	247	3.3%	4.8%	79%

⁷ 2004 (IUCN Red Data List).

⁸ Includes listed Extinct and Vulnerable species (DEH 2005).



Invertebrates

Taxon	World Descr.	Australia Descr.	Austral. Percent.	Estimate World	Estimate Australia	World Threat. ⁹	World Threat. Percent.	Austral. Threat.	Austral. Threat. Percent ¹⁰	% of World's Threat.	Percent. Endemic
Hemichordata	106	17	16.0%	unknown	22	0	—	0	—	—	25–30%
Echinodermata	7,000	1,165	16.6%	~14,000	~1,406	0	—	0	—	—	31%
Insecta	950,000	~80,000	8.4%	~4,000,000	~95,000–204,743 ¹¹	559	0.06%	4	0.01%	0.7%	unknown
Arachnida	98,000	5,711	6.0%	166,000–600,000	~27,960	0	—	0	—	—	unknown
Myriapoda	12,200	405	3.3%	>85,000	~2,800	0	—	0	—	—	unknown
Crustacea	40,000	7,130	17.8%	150,000	~9,500	429	1.1%	7	0.1%	1.6%	unknown
Onychophora	165	71	43.0%	220	~80	0	—	0	—	—	unknown ¹²
Mollusca	70,000	~8,700	12.4%	120,000	~12,250	974	1.4%	2 ¹³	0.02%	0.2%	90%
Annelida	15,000	2,300	15.3%	25,000–30,000	~4,230	0	—	1	0.04%	—	67%
Nematoda	<25,000	~2,060	8%	~500,000	~30,000	0	—	0	—	—	unknown
Acanthocephala	1,000	56	5.6%	~1,600	~160	0	—	0	—	—	unknown
Platyhelminthes	20,000	1,593	8.0%	~80,000	~10,000	0	—	0	—	—	unknown
Cnidaria	9,000	1,705	18.9%	unknown	~2,200	0	—	0	—	—	unknown
Porifera	5,500	1,416	25.7%	~18,000	~3,500	0	—	0	—	—	56%
Others	10,573	2,213	20.9%	~20,000	~5,015	30	0.03%	0	—	0%	unknown
TOTAL (rounded)	1,263,700	114,600	9.1%	~5,500,000	~250,000 ¹⁴	1,992	0.17%	14	0.01%	0.7%	unknown

⁹ 2004 (IUCN Red Data List).

¹⁰ Includes listed Extinct and Vulnerable species (DEH 2005).

¹¹ See comments under Insecta discussion, later.

¹² Ponder pers. comm. 2006 suggested most if not all species could be endemic.

¹³ As mentioned in the Introduction the list of Australian threatened species have been derived from the national list and not from State or regional lists.

¹⁴ This figure is a midpoint between estimates of 200,000 to 300,000.

Plants

Taxon	World Descr.	Australia Descr.	Austral. Percent.	Estimate World	Estimate Australia	World Threat. ¹⁵	World Threat. Percent.	Austral. Threat. ¹⁶	Austral. Threat. Percent.	% of World's Threat.	Percent. Endemic
Bryophyta	16,600	1,852	11.1%	~22,000	~2,200	80	0.5%	1	0.05%	1.2%	25%
Vascular Plants	272,400	18,140	6.7%	~422,000	~20,500	8,241	3%	1,194	7.0%	14.5%	90%
<i>Ferns and allies</i>	(12,838)	(446)	(3.5%)	(~15,000)	(~500)	(140)	(1%)	(35)	(7.8%)	(25%)	(40%)
<i>Gymnosperms</i>	(~930)	(113)	(12.2%)	(~1,000)	(113)	(305)	(32%)	(20)	(17.7%)	(6.5%)	(96%)
<i>Magnoliophyta</i>	(258,650)	(17,580)	(6.8%)	(~320,000)	(19,000–21,000)	(7,796)	(3%)	(1,139)	(6.6%)	(14.6%)	(91%)
TOTAL	289,000	~20,000	6.9%	~444,000	23,000	8,321	2.9%	1,195	6.0%	14.4%	84%

Others

Taxon	World Descr.	Australia Descr.	Austral. Percent.	Estimate World	Estimate Australia	World Threat. ¹⁷	World Threat. Percent.	Austral. Threat. ¹⁸	Austral. Threat. Percent.	% of World's Threat.	Percent. Endemic
Lichens	17,000	3,227	19.0%	~25,000	~5,000	2	0.01%	0	0	0	34%
Fungi	72,000	5,672+	7.8%	1,500,000	160,000–250,000	0	—	0	—	—	90%
Bacteria	5,422	~40	0.7%	400,000–1,000,000	40,000	0	—	0	—	—	unknown
Cyanophyta	2,371	~50	1.7%	unknown	270	0	—	0	—	—	unknown
Algae	~35,000	~10,000	28.5%	200,000	12,000+	0	—	1	0.01%	—	unknown
Viruses	~2,000	~400	25%	400,000	unknown	0	—	0	—	—	unknown
Protoctista	42,540	~10,000	23.5%	<600,000	~65,000	0	—	0	—	—	unknown
TOTAL	~176,000	~30,000	17%	3–4 million	300,000–400,000	2	0.001%	1	0.003%	0.5%	unknown

15 2004 (IUCN Red Data List).

16 Includes listed Extinct and Vulnerable species (DEH 2005). NB This figure includes about 88 undescribed species; and excludes infraspecific taxa.

17 2004 (IUCN Red Data List).

18 Includes listed Extinct and Vulnerable species (DEH 2005).



All Species

Taxon	World Descr.	Australia Descr.	Austral. Percent.	Estimate World	Estimate Australia	World Threat. ¹⁹	World Threat. Percent.	Austral. Threat. ²⁰	Austral. Threat. Percent	% of World's Threat.	Percent. Endemic
Vertebrates	60,979	7,558	12.4%	~71,000	~8,444	5,188	8.5%	365	4.8%	7.0%	79%
Invertebrates	1,261,000	114,600	9.1%	5,500,000	250,000	1,992	0.16%	13	0.001%	0.7%	unknown
Plants	289,000	20,000	6.9%	~444,000	23,000	8,321	2.9%	1,195	6.0%	14.4%	84%
Others	~176,000	~30,000	17%	3–4 million	300,000–400,000	2	0.001%	1	0.003%	—	unknown
GRAND TOTAL	1,786,000	172,200	9.6%	8–9 million	580,000–680,000	15,503	1%	1,574	0.9%	10%	unknown

¹⁹ 2004 (IUCN Red Data List).

²⁰ Includes listed Extinct and Vulnerable species (DEH 2005). Does not include infraspecific or undescribed taxa.

Detailed discussion by Group



Vertebrates

Mammalia (mammals)

Mammals are a quite well known group, however estimates for the numbers of described species still vary considerably, ranging from 4,300 in *Biodiversity: the UK Action Plan* (Anon. 1994), through 4,630 (Groombridge and Jenkins 2002) to 5,416 (IUCN 2004). Although the UK Action Plan is over ten years old, the figures from it are still quoted extensively. For the purposes of this document, I have accepted the figure of 5,416 which accords well with the most recent figures from the IUCN and with the latest edition of *Mammals of the World* (Wilson and Reeder in press).

Australian mammal species are quite well known and thus the number of described species is stable at 378 (DEH in prep.). Estimates for the number of species yet to be described in Australia are between 0% and 1%, however, as noted previously, molecular studies may lead to some further splitting. In 2005 to date, one new species and one new subspecies were described. Because mammal species are so well known, the



number of Australian endemic species is also well known at 83% (calculated from Walton 1988).

There are 75 listed threatened species in Australia along with 41 subspecies, forms or populations including four undescribed subspecies (DEH 2005a).

World Descr. min.	World Descr. max.	World Accepted	Australia Described	Australia Percent.	Australia Estimated	Australia Endemic	World Threatened ²¹	Australian Threatened ²²	Australian Threatened as percentage of World Threatened
4,327	5,416	5,416	378	7.0–8.7%	378–380	83%	1,101 (~20%)	75 (20%)	6.8%

²¹ 2004 (IUCN Red Data List).

²² Includes listed Extinct and Vulnerable species (DEH 2005a).

Aves (birds)



Birds are also a well known group, and the estimate of the number of described species appears quite stable, varying from as low as 9,000 (Tangley 1997), 9,750 (Groombridge and Jenkins 2002), 9,875 (Birdlife International 2005), 9,917 (IUCN 2004) to 9,946 (Gaston and Blackburn 1997). I have accepted the figure of 9,917 which is consistent with the most recent figures from Birdlife International (2005). Total number of species of birds on earth is estimated at around 10,000 (Birdlife International 2004).

Australian species of birds are quite well known and thus the number of described species is stable at between 826 (DEH in prep.) and 828 (ABRS 2005a). This latter figure is thought to include a number (32)

of introduced species. Estimates for the number of species yet to be described in Australia is around 0%. Because bird species are so well known, the number of Australian endemic species is also well known at 45% (DEH in prep.).

There are 65 listed threatened bird species in Australia (including one undescribed). There are also 64 listed subspecies or forms (DEH 2005a).

World Descr. min.	World Descr. max.	World Accepted	World Estimate	Australia Described	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened ²³	Australia Threatened ²⁴	Australian Threatened as percentage of World Threatened
9,000	9,946	9,917	~10,000	826–828	8.3–8.5%	826--828	45%	1,212 (~12%)	65 (8%)	5.3%

²³ Birdlife International <http://www.birdlife.net/action/science/species/index.html>.

²⁴ Includes listed Extinct and Vulnerable species (DEH 2005a).



Reptilia (reptiles)

Reptiles are also a quite well known group, however the estimate of the number of described species varies considerably, ranging from 6,300 (Tangley 1997), 8,002 (Groombridge and Jenkins 2002), 8,163 (IUCN 2004) to 8,300 (EMBL Reptile Database²⁵). I have accepted the figure of 8,300 from the EMBL Reptile Database.

The only estimate I have received of the total number of species is from the coordinator of the EMBL Reptile Database²⁶. He states that the number of new species described is fairly constant at around 70 per year, and estimates the total number of species at around 10,000.

Australian reptile species are quite well known and thus the number of described species is stable at between 869 (DEH in prep.) and 870 (ABRS 2005a). Estimates for the number of species yet to be described in Australia is around 3.5% which takes the estimated number of species to around 900. Because reptile species are so well known, the number of Australian endemic species is also well known at around 89% (Healey 2001).

The number of threatened species for Australia (DEH 2005a) is 42 species. Eight subspecies are also listed.



World Descr. min.	World Descr. max	World Accepted	World Estimate	Australia Described	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened ²⁷	Australia Threatened ²⁸	Australian Threatened as percentage of World Threatened
6,300	8,300	8,300	~10,000	869	10.5%	~900	89%	304 (~4%)	42 (5%)	13.8%

²⁵ EMBL Reptile Database (Aug. 2005) – <http://www.embl-heidelberg.de/~uetz/>.

²⁶ Pers. comm., Peter Uertz, Coordinator, EMBL Reptile Database, 9 Aug. 2005.

²⁷ 2004 (IUCN Red Data List).

²⁸ Includes listed Extinct and Vulnerable species (DEH 2005a).

Amphibia (frogs etc.)

Amphibia are also a quite well known group, however the number of undescribed species is quite large with more being discovered every year. The estimate of the number of described species varies from 4,950 (Groombridge and Jenkins 2002) through 5,743 (Frost 2004) to 5,802 (AmphibiaWeb 2005). I have accepted the figure of 5,802 which is consistent with the most recent figures from AmphibiaWeb which maintains an up-to-date estimate. With about 3% new taxa being described every year, the latest estimate of total species is about 7,500 (pers. comm. David B. Wake, Berkeley, 2005²⁹).

Australian amphibian species are quite well known and thus the number of described species is stable at 216 (ABRS 2005a, DEH in prep.), although recent information from ABRS³⁰ lists 3 new species taking the number of Australian species to 219. The estimate for the number of species yet to be described in Australia is around 1.8% (DEH in prep.) which takes

the estimated number of species (on top of 216 species) to around 220. Because amphibia species are so well known, the number of Australian endemic species is also well known at around 93% (Wong 1999, DEH in prep.).

Recent molecular work has shown considerable divergences between populations of 'species'³¹ and thus new species are likely to be split off in the future resulting in further increases in numbers both nationally and globally.

There are 30 listed threatened species in Australia and one subspecies (DEH 2005a).



World Descr. min.	World Descr. max. ³²	World Accepted	World Estimate	Australia Described	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened ³³	Australia Threatened ³⁴	Australian Threatened as percentage of World Threatened
4,950	5,802	5,802	~7,500	219	3.8%	~220	93%	1,770 (~31%)	30 (14%)	1.7%

²⁹ In 1985 there were 4,000 named species of amphibians. As of today we know of 5,802 valid species and the number grows weekly. There is no sense that the rate of description of new species is decreasing. It is hard to believe that a growth rate of about 3% per year will be sustained but at this point we do not know when it will start slowing. For example, we know that more than 50 new species will soon be described from Sri Lanka and many Madagascar species remain to be described. About 25 salamanders are known but so far undescribed from Middle America. There are still species described nearly every year from the United States. My 'educated guess' is that there are about 7,500 species of amphibians in the world if we continue to use current criteria (David B. Wake, pers. com. 2005).

³⁰ Pers. comm. Alice Wells, ABRS, 16 June 2005.

³¹ Pers. comm. Alice Wells, ABRS, 26 July 2005.

³² AmphibiaWeb (14 June 2005). <http://www.amphibiaweb.org/>.

³³ 2004 (IUCN Red Data List).

³⁴ Includes listed Extinct and Vulnerable species (DEH 2005a).



Pisces (fishes including Chondrichthyes and Osteichthyes)

Fish are also a reasonably well known group, however the estimate of the number of described species varies considerably, ranging from 25,000 (Groombridge and Jenkins 2002) to 28,900 (FishBase 2005). I have accepted the figure of 28,900 which is consistent with the most recent figures from *FishBase* as of March 2005. Bill Eschmeyer³⁵ (pers. comm.) estimates that there are probably around 35,000 species in total.

Australian species of fish are quite well known and thus the number of described species is stable at between 4,450 (ABRS 2005a) and 4,500 (DEH in prep.). Estimates for the number of species yet to be described in Australia is around 17% which takes the estimated number of species to around 5,250. The estimated percentage of endemic species in Australia is 90%.

Approximately 85% of southern Australia's fishes are endemic to the region and 11% are also found in New

Zealand waters (Poore 1995). Poore (1995) also reports that there are 3,400 marine species of fish in Australian waters.

There are 35 listed threatened species in Australia (five of which are undescribed). There are also four listed subspecies or populations (DEH 2005a).



World Descr. min.	World Descr. max.	World Accepted	World Estimate	Australia Described	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened ³⁶	Australia Threatened ³⁷	Australian Threatened as percentage of World Threatened
25,000	28,900	28,900	~35,000	4,450–4,500	15.6–18.4%	~5,250	90%	800 (~3%)	35 (1%)	4.4%

³⁵ Pers. comm. Bill Eschmeyer, Catalogue of Fishes, California Academy of Sciences, 22 Aug. 2005.

³⁶ 2004 (IUCN Red Data List).

³⁷ Includes listed Extinct and Vulnerable species (DEH 2005a).

Agnatha (hagfish, lampreys and slime eels)

FishBase (Fishbase 2005) lists 69 species of hagfish and 45 species of lamprey. Hickman and Roberts (1994) gave a figure of 70 species. I have accepted the figure of 114 as cited by Fishbase.

The Australian Biological Resources Study (ABRS 2005a) lists five Australian species with about another five species undescribed. Of the five species listed for Australia in FishBase, two are endemic to Australian waters.

World Descr. min.	World Descr. max.	World Accepted	World Estimate	Australia Described	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened ³⁸	Australia Threatened ³⁹	Australian Threatened as percentage of World Threatened
70	114	114	unknown	5	4.4%	~10	40%	0	0	—

³⁸ 2004 (IUCN Red Data List).

³⁹ Includes listed Extinct and Vulnerable species (DEH 2005a).



Cephalochordata (lancelets)

Very little information could be found on these animals. Three estimates were however found for the number of species worldwide. They included 20 (McCauley n.dat.), 23 (Groombridge and Jenkins 2002) and 36 species (Ponder *et al.* 2002).

The Australian Biological Resources Study (ABRS 2005a) lists eight Australian species in two genera, with about four being endemic (Richardson 1998).

World Descr. min.	World Descr. max.	World Accepted	World Estimate	Australia Described	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened ⁴⁰	Australia Threatened ⁴¹	Australian Threatened as percentage of World Threatened
~20	23	23	unknown	8	34.8%	~8	50%	0	0	—

40 2004 (IUCN Red Data List).

41 Includes listed Extinct and Vulnerable species (DEH 2005a).

Tunicata or Urochordata (sea squirts, doliodids, salps)

Estimates of the number of described Tunicates in the world vary, with figures of 1,400–2,000 (Groombridge and Jenkins 2002), 2,000 (Hickman *et al.* 2004) and 3,000 species (Brusca and Brusca 2003). Recent information (pers. comm. Karen Sanamyan, Kamchatka Branch of Pacific Institute of Geography, June 2005) states that there are 2,426 (± 50) described species of ascidian. In addition there are about 70 species of Thaliacea⁴² and about 60 (ABRS 2005b) or 70⁴³ species of Appendicularia making a total for the Phylum of about 2,566 species.

The Australian Biological Resources Study (ABRS 2005a) lists 536 Australian species without information on endemism, however Kott (1998) included about 280 endemic species in her treatment. Recent figures from ABRS⁴⁴ suggest that there are now 754 described species in 108 genera in Australia.

World Descr. min.	World Descr. max.	World Accepted	World Estimate	Australia Described	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened ⁴⁵	Australia Threatened ⁴⁶	Australian Threatened as percentage of World Threatened
~1,400	3,000	2,566	unknown	754	29.4%	~850	50%	—	—	—

42 <http://www.earthlife.net/inverts/thaliacea.html>.

43 <http://www.meer.org/M20.htm>.

44 Pers. comm. Alice Wells, ABRS, 16 June 2005.

45 2004 (IUCN Red Data List).

46 Includes listed Extinct and Vulnerable species (DEH 2005a).



Invertebrates

Hemichordata (hemichordates)

Burdon-Jones (1998) stated that there were 94 described species in 16 genera in the world, with many more undescribed, and 12 species in seven genera in Australia. Cameron (2004) lists 106 species for the World, Groombridge and Jenkins (2002) list c. 90 or 100, whereas Brusca and Brusca (2003) give only 85 species.

ABRS (2005a) now lists 17 species for Australia with an estimated 22 species in total. It would appear from the treatment by Burdon-Jones (1998) that at least three species are endemic to Australia. I have accepted the most recent figures of 106 for the world (Cameron 2004) and 17(22) (ABRS 2005a) for Australia.

World Descr. min.	World Descr. max.	World Accepted	World Estimate	Australia Described	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened ⁴⁷	Australia Threatened ⁴⁸	Australian Threatened as percentage of World Threatened
85	106	106	110+	17	16%	22	~25%	—	—	—

⁴⁷ 2004 (IUCN Red Data List).

⁴⁸ Includes listed Extinct and Vulnerable species (DEH 2005a).

Echinodermata (starfish)



Estimates of the number of echinoderms in the world vary from about 6,100 (Tangley 1997, Miyajima 2002) through 6,600⁴⁹ (ABRS 2005b, Rich Mooi pers. comm.) to 7,000 (Wray 1999, Groombridge and Jenkins 2002, Brusca and Brusca 2003, Mulcrone 2005). The figure of 7,000 has been accepted here as being the most common figure used in most publications, however, the figure of 6,600 seems to be strongly justified on the breakdown of the individual Classes. The breakdown of estimates are: Crinoidea—600; Asteroidea—1,800; Ophiuroidea—2,000; Echinoidea—800; Holothuroidea—1,400 (ABRS 2005b, Rich Mooi pers. comm.).

Estimating the total number of species is a difficult exercise. The main problem appears to be the unknown of the deep waters, and the enormous potential of molecular studies to 'discover' new

species⁵⁰. The figure here is estimated by doubling known numbers for most classes, and adding an extra 20–25% for the Ophiuroidea and Holothuroidea which are 'cryptic, diverse, relatively unstudied, and common in the deep sea'⁵¹.

Predictions place the number of Australian species at around 1,406 with 1,165 described (ABRS 2005a). The *Australian Faunal Directory* (ABRS 2005b) and others (Ponder *et al.* 2002) predict that there may be up to 2,000 species in Australian waters. I have seen estimates of endemism in Australia as high as 90% for southern waters and 15% for tropical waters (Ponder *et al.* 2002), but working through the currently published species (Rowe and Gates 1995), the figure comes out at around 31%.

World Descr. min.	World Descr. max.	World Accepted	World Estimate	Australia Described	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened ⁵²	Australia Threatened ⁵³	Australian Threatened as percentage of World Threatened
6,100	7,000	7,000	~14,000	1,165	16.6%	~1,406	31%	—	—	—

⁴⁹ <http://www.deh.gov.au/cgi-bin/abrs/fauna/details.pl?pstrVol=ECHINODERMATA;pstrTaxa=1;pstrChecklistMode=1>.

⁵⁰ 'We have seen only a tiny fraction of the abyss, and then, usually only the very top layers. Cryptic forms have remained, by and large, inaccessible for the vast majority of bottom-typing imagery and even dredging. Ground-truthing these studies is fraught with difficulty and expense. However, we do know one thing — virtually every time we look carefully, something new crops up. Now imagine if we could do the same type of molecular work on deep sea forms as we have done for those easily accessed shallow-water forms.

Another observation: many of the new species in some groups come out of historical collections in which unrecognized forms have lain for many years. I just recently found 4 new species among about 300 specimens from worldwide collections of a single genus without ever getting my feet wet—thereby doubling the number of taxa in that particular genus. So discovery is of course not necessarily going out there and finding something in the wild in every case—it depends on the level of acumen by researchers more than anything else, in my opinion. If the same level of acumen and interest is brought to every group, would that turn up the same thing? Should we be doubling all our present estimates? Extrapolating from that alone, clearly we should be at least doubling our estimates for some groups. But the question remains, which ones?' (pers. comm. Rich Mooi, California Academy of Sciences, 17 June 2005).

⁵¹ Pers. comm. Rich Mooi, California Academy of Sciences, 17 June 2005.

⁵² 2004 (IUCN Red Data List).

⁵³ Includes listed Extinct and Vulnerable species (DEH 2005a).



Insecta (insects)

Estimates of the number of insects in the world vary from about 751,000 (Tangley 1997) through 800,000 (Nieuwenhuys 1999), 948,000 (Brusca and Brusca 2003), 950,000 (IUCN 2004) to more than 1 million (Myers 2001a). Groombridge and Jenkins (2002) provide the figure of 963,000 for insects plus myriapods. Estimates for the total numbers of insects vary widely from several million to around 8 million (Groombridge and Jenkins 2002). Calculations based on extrapolations from species of Coleoptera and Lepidoptera in New Guinea by Novotny *et al.* (2002) produced a figure of between 3.7 and 5.9 million for the total number of arthropods in the world. Some workers, however have estimated that there could be as many as 100 million beetles alone (Tangley 1997), but this would appear to be a gross over-estimation. The figure of 950,000 has been accepted here as being the most commonly cited figure in many recent publications, along with an estimate of about 4 million (May 2000) for the total number of

species. As stated by Miller *et al.* (2002):

‘Current evidence from the major museum collections of sorted and labeled insect species, whether described or undescribed, does not support larger estimates, and insect taxonomists broadly concur from this that although there may be up to five million species of insect in the world, there are probably less than 10 million (Nielsen and Mound 2000). In a recent review, May (2000) settled on a best guess of four million species.’

The number of described species in Australia would appear to be around 80,000 (DEH in prep.) with the total number of species varying from about 95,000 (DEH in prep.) to nearly 205,000 (Yeates *et al.* 2003). Further discussions need to be held prior to determination of a reasonable estimate, so I have reported the range.

There are four listed threatened species of insect in Australia—one of which is undescribed. There is also one listed subspecies (DEH 2005a).



World Descr. min.	World Descr. max.	World Accepted	World Estimate	Australia Described	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened ⁵⁴	Australia Threatened ⁵⁵	Australian Threatened as percentage of World Threatened
751,000	>1 million	950,000	4,000,000	~80,000	8.4%	~95,000–204,743	unknown	559 (0.06%)	4 (0.005%)	0.7%

⁵⁴ 2004 (IUCN Red Data List).

⁵⁵ Includes listed Extinct and Vulnerable species (DEH 2005a).

Arachnida (spiders, scorpions, etc.)

Estimates of the number of described arachnids vary from 60,000 (Myers 2001a, Brusca and Brusca 2003), 70,000 species (Nieuwenhuys 1999), 74,000 (Groombridge and Jenkins 2002) to 75,000 (Hawksworth and Kalin-Arroyo 1995, May 2000). There do not seem to be many estimates for the total number of spiders in the world, however Coddington and Levi (1991) predicted that there may be as many as 170,000 species.

Perhaps the best way to determine the numbers of described species is to make a breakdown of the various orders. Spiders are probably the best known, and Platnick (2005) lists 38,834 described species of spider in *The World Spider Catalog*. One of the largest of the arachnoid groups includes the mites and ticks and here the numbers vary greatly. Hickman *et al.* (2004) estimated 40,000 described species with a total of 500,000 to 1 million. Halliday *et al.* (2000) estimated that there were 48,200 described species of Acarina and a total fauna of about 0.5 million. Walter *et al.* (1996) on the *Tree of Life* website estimated 45,000 described species and suggested that that may only be about 5% of the total species alive today. Other estimates from the 1960s and 1970s (see Haliday *et al.* 2000) vary from 17,500 to 30,000. Other Orders include Amblypygi (136—Harvey 2003), Opiliones (around 5,000 species—Myers 2001a; 6,000 species—Harvey 2002), Palpigradi (c. 78—Harvey 2003, to 80 species⁵⁶), Pseudoscorpionida (>2,000

species⁵⁷ and Myers 2001a; >3,239 species—Harvey 2002), Ricinulei (57 species—Amrine 2005), Schizomida (219⁵⁸), Scorpionida (1,260⁵⁹), Solifugae (1,088—Savary n.dat.; >1,075 species—Harvey 2003), Uropygi (>106 species—Fox 2005). Summation of these figures gives a total of over 95,500 described species, considerably higher than the estimates cited above, with estimates of the total number of species varying between 160,000 to about 1 million (Hawksworth and Kalin-Arroyo 1995). Hawksworth and Kalin-Arroyo (1995) accepted a working figure of 750,000 species.

Halliday *et al.* (2000) conducted an extensive literature survey of mites in Australia and concluded that there were about 2,700 described species and by extrapolating from recent revisions estimated that the total mite fauna in Australia may be in the order of 7,800. They then further suggested that this may be a gross under-estimation as many of the lesser known groups were likely to include many more species. Their final estimate for the total Australian mite species was in excess of 20,000 species.

The Australian Biological Resources Study (ABRS 2005a) reports numbers of described and estimated Australian species as shown in the Table on the following page, except for the number of 7,800 for the estimated Araneae which comes from Halliday *et al.* (2000). Estimates for the total number of the described



Australian Arachnid fauna varies from 5,666 (DEH in prep.) to 5,711 (ABRS 2005a) and for the total number of Arachnid fauna from 20,937 (using Halliday's number for the Acarina) through 27,837 (using the ABRS figure for the Acarina) to 27,960 (DEH in prep.). No estimates of the percentage of Australian endemics has been found.

56 As of 2000 - Wikipedia - The Free Encyclopedia (2005) <http://en.wikipedia.org/wiki/Palpigradi>.

57 As of 2000 - Wikipedia - The Free Encyclopedia (2005) <http://en.wikipedia.org/wiki/Pseudoscorpionida>.

58 As of 2000 - Wikipedia - The Free Encyclopedia (2005) <http://en.wikipedia.org/wiki/Schizomid>.

59 Museum of Cape Town, South Africa <http://www.museums.org.za/bio/scorpions/>.



Arachnida (spiders, scorpions, etc.) *continued*

Order	World Described	World Estimated	Australian Described	Australian Estimated
Acari	48,200	~100,000–500,000	2,399	11,500
Amblypygi	136	~100	4	10
Araneae	38,384	50,000–70,000	2,871	7,800–15,000
Opiliones	~5,000	6,000	199	500
Palpigradi	~80		2	2
Pseudoscorpiones	~3,239		150	600
Ricinulei	57		0	0
Scorpiones	1,260	~2,400	40	150
Schizomida	219		46	75
Solifugae	1,089		0	0
Uropygi	286		0	0
TOTAL	97,950	166,000–600,000	5,711	20,637–27,837

World Descr. min.	World Descr. max.	World Accepted	World Estimate	Australia Described	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened ⁶⁰	Australia Threatened ⁶¹	Australian Threatened as percentage of World Threatened
60,000	96,711	98,000	166,000–600,000	5,711	6.0%	27,960	unknown	—	—	—

⁶⁰ 2004 (IUCN Red Data List).

⁶¹ Includes listed Extinct and Vulnerable species (DEH 2005a).

Myriapoda (millipedes and centipedes)



Brusca and Brusca (2003) gave an estimate of 11,460 described species of Myriapoda in the world.

Yeates *et al.* (2003) estimated the total number of described Myriapod species in Australia at 2,539. This is slightly higher than that estimated by ABRS (2005a).

1. Symphyla

Although little information could be obtained on this group, it would appear that there are about 200 described species of Symphyla in the world (ABRS 2005b). Brusca and Brusca (2003) estimated that there are 160 species.

ABRS (2005a) lists 26 species for Australia and estimates about 150 species in total. Yeates *et al.* (2003) provided a figure of 200 for the total number of species.

2. Diplopoda

Estimates of the number of described species of Diplopoda (millipedes) vary from 5,000⁶², through 8,000 (Brusca and Brusca 2003) to 10,000 (Geoffroy 2001). I have accepted the figure of 8,000 as given by Myers (2001b) and Brusca and Brusca (2003). Geoffroy (2001) estimates the total number of species at between 80,000 and 90,000.

3. Chilopoda

Estimates of the number of described species of Chilopoda (centipedes) vary from 2,500 (Hoffman 1982, Myers 2001c), 2,800 (Brusca and Brusca 2003) to about 5,000⁶³. I have accepted the figure of 3,300 as provided in an application to the Global Biodiversity Information Facility (GBIF) for the development of *A World Catalogue of Centipedes (Chilopoda) for the Web*⁶⁴.

4. Pauropoda

The number of described Pauropoda of the world is between 500 (Brusca and Brusca 2003) and 715 (ABRS 2005b), with 18 species described for Australia (50% of which are endemic), but with an estimated total number of greater than 500 (ABRS 2005b). I have accepted the ABRS figure of 715 for the world.

	World Descr. min.	World Descr. max.	World Accepted	World Estimate	Australia Described	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened ⁶⁵	Australia Threatened ⁶⁶	Australian Threatened as percentage of World Threatened
1	120	200	200	unknown	26	13.0%	150	unknown	0	0	—
2	5,000	10,000	8,000	80,000–90,000	230	2.9%	2,000	unknown	0	0	—
3	2,500	5,000	3,300	unknown	131	4.0%	150	unknown	0	0	—
4	500	715	715	unknown	18	2.5%	500	50%	0	0	—
Total	8,120	15,915	12,215	85,000+	405	3.3%	2,800	unknown	0	0	—

62 http://www.xs4all.nl/~ednieuw/Spiders/InfoNed/The_spider.html.

63 http://www.xs4all.nl/~ednieuw/Spiders/InfoNed/The_spider.html.

64 http://www.gbif.org/Stories/STORY1103211930/#Project_Coordinator:_Alessandro_Minelli.

65 2004 (IUCN Red Data List).

66 Includes listed Extinct and Vulnerable species (DEH 2005a).



Crustacea (crabs, lobsters)

The estimated number of described species of Crustacea in the world varies from 30,000 (Myers 2001d), more than 30,000 (Ponder *et al.* 2002), 40,000 (with 38,000 marine species) (Hawksworth and Kalin-Arroyo 1995, May 2000, Groombridge and Jenkins 2002), 55,000 (Wikipedia 2005)⁶⁷ to 67,000 (Brusca and Brusca 2003). I have accepted the figure of 40,000 described species based on a detailed figure of 38,701 given by Abele (1982), and assuming that that figure would have increased somewhat since 1982. Abele's figures were based on nine Cephalocarida, 821 Branchiopoda, one Remipedia, 9,589 Maxillopoda, 5,650 Ostracoda and 22,651 Malacostraca. Further information on individual taxa can be found in *Crustacea.net* coordinated by the Australian Museum (Lowry *et al.* 1999 onwards).

The estimated total number of world species is 150,000 (May 2000, Groombridge and Jenkins 2002) with a range of from 75,000 to 200,000 (Hammond 1995, Hawksworth and Kalin-Arroyo 1995). Brusca and Brusca (2003) stated that there could be from 5–10 times the number of described species giving a figure of 300,000–600,000 for their estimate. There are an estimated 7,130 described species in Australia out of a total estimated 9,500 species (DEH in prep.). There are seven listed threatened species in Australia (DEH 2005a).



World Descr. min.	World Descr. max.	World Accepted	World Estimate	Australia Described	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened ⁶⁸	Australia Threatened ⁶⁹	Australian Threatened as percentage of World Threatened
30,000	67,000	40,000	150,000	7,130	17.8%	~9,500	unknown	429 (1%)	7 (0.1%)	1.6%

⁶⁷ Wikipedia - The Free Encyclopedia (2005). <http://en.wikipedia.org/wiki/Crustacean>.

⁶⁸ 2004 (IUCN Red Data List).

⁶⁹ Includes listed Extinct and Vulnerable species (DEH 2005a).

Onychophora (velvet worms)

The number of described species of Onychophora would appear to be around 120, with estimates varying from about 70 (Hickman *et al.* 2004), 90⁷⁰, 100 (Groombridge and Jenkins 2002), 110⁷¹ (Brusca and Brusca 2003) to about 120 (Monge-Najera 2000). Reid in the *Australian Faunal Directory* (ABRS 2005b) stated that there were 75 species in the Peripatidae and 90 in the Peripatopsidae making a total world described fauna of 165 species. This is the figure I have used here, even though it is considerably higher than the other estimates. Estimates for the total fauna include about 200 (Geoffroy 2001) and 220 (Brusca and Brusca 2003).

In Australia, ABRS (2005a) estimated that there are about 71 described species with perhaps another nine undescribed species.

Given that all species have very narrow ranges it has been suggested by Ponder, pers. comm. 2006, that most if not all species could be endemic.

World Descr. min.	World Descr. max.	World Accepted	World Estimate	Australia Described	Australia Percent.	Australia Estimate	Australia Endemic ⁷²	World Threatened ⁷³	Australia Threatened ⁷⁴	Australian Threatened as percentage of World Threatened
70	165	165	~220	71	43%	~80	unknown	0	0	—

70 <http://www.ucmp.berkeley.edu/onychoph/onychophora.html>.

71 <http://www.peripatus.gen.nz/Taxa/Arthropoda/Onychophora.html>.

72 W. Ponder pers. comm. 2006 suggested most if not all species could be endemic.

73 2004 (IUCN Red Data List).

74 Includes listed Extinct and Vulnerable species (DEH 2005a).



Mollusca (molluscs, shellfish)

Estimates of the number of described species of molluscs in the world vary from nearly 50,000 living species (Tangley 1997, Hickman *et al.* 2004), ?70,000 (Hawksworth and Kalin-Arroyo 1995), 70,000–75,000 (with possibly more than 100,000) (Groombridge and Jenkins 2002), 93,195 (Brusca and Brusca 2003) to 120,000 (Ponder *et al.* 2002). Hawksworth and Kalin-Arroyo (1995) and Groombridge and Jenkins (2002) estimated a possible total of around 200,000 species, and May (2000) provided an estimate of about 120,000. I have accepted a figure of 70,000 described species (after Groombridge and Jenkins 2002) and a total of 120,000 species (after May 2000).

Estimates for Australia are approximately 8,700 described species out of a total of about 12,250 (DEH in prep.).

Endemism of about 90% is reported in the 2001 Australian *State of the Environment Report* (SOE), however Ponder *et al.* (2002) report that for marine taxa only about 10% of tropical species, and 95% of temperate species are endemic. The non-marine fauna is mostly endemic (at least 97%) according to Ponder (pers. comm. 2006).

There are two listed threatened molluscs in Australia (DEH 2005a).



World Descr. min.	World Descr. max.	World Accepted	World Estimate	Australia Described	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened ⁷⁵	Australia Threatened ⁷⁶	Australian Threatened as percentage of World Threatened
50,000	120,000	70,000	120,000–200,000	8,700	12.4%	~12,250	90%	974 (1.4%)	2 (0.03%)	0.2%

⁷⁵ 2004 (IUCN Red Data List).

⁷⁶ Includes listed Extinct and Vulnerable species (DEH 2005a). As mentioned in the Introduction the list of Australian threatened species have been derived from the national list and not from State or regional lists.

Annelida (segmented worms)

Estimates for the number of described species of Annelida in the world vary from 12,000 (Tangley 1997), 13,000 (with only about 8,000 reliable species) (Hutchings and Fauchald 2000), 13,500 (Myers 2001e), 15,000 (May 1998, Hickman *et al.* 2004), c. 16,000 (Groombridge and Jenkins 2002) to 16,600 (Brusca and Brusca 2003). Myers (2001e) reported about 10,000 species of Polychaeta, 3,000 species of Oligochaeta and about 500 species of Hirudinea, and a total of about 13,500 species.

An estimate for the total number of species is between 25,000 and 30,000 (Snelgrove *et al.* 1997 as reported by Ponder *et al.* 2002).

The number of described Australian species is about 2,300 out of an estimated total of about 4,230 (DEH in prep.). The percentage of endemics is unknown, but it is reported that southern Australia has about 67% endemism (Poore 1995).

There is one listed threatened worm species in Australia (DEH 2005a).

World Descr. min.	World Descr. max.	World Accepted	World Estimate	Australia Described	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened ⁷⁷	Australia Threatened ⁷⁸	Australian Threatened as percentage of World Threatened
12,000	16,500	15,000	25,000–30,000	2,300	15.3%	~4,230	67%	30 (0.02%)	1 (0.04%)	3.3%

⁷⁷ 2004 (IUCN Red Data List).

⁷⁸ Includes listed Extinct and Vulnerable species (DEH 2005a).



Nematoda (nematodes, roundworms)

Estimates for the number of described species of Nematoda vary from around 12,000 (Myers 2001f, Hickman *et al.* 2004) to 20,000–25,000 (Groombridge and Jenkins 2002), fewer than 25,000 (Baldwin *et al.* 2000), and 25,000 (Hawksworth and Kalin-Arroyo 1995, Brusca and Brusca 2003). Estimates for the total numbers of species, however, are much larger with estimates ranging from 400,000 (Hawksworth and Kalin-Arroyo 1995, Groombridge and Jenkins 2002), about 500,000 (Myers 2001f, Hickman *et al.* 2004) to 500,000 to 1 million (Baldwin *et al.* 2000) and ‘several times’ their estimate of 25,000 (Brusca and Brusca 2003). Baldwin *et al.* (2000) state that ‘Although 4,000–5,000 marine nematode species have been named and described, full surveys of marine habitats probably will reveal many millions of previously unknown species’. They also provide references to estimates for the total number varying from 100,000 (Hawksworth and Kalin-Arroyo 1995) to as many as 10 million.

Estimates for the number of described Australian species vary from 1,200 (ABRS 2005a) to a recent estimate of about 2,060 (DEH in prep.). Estimates for the number of unknown species again vary from c. 30,000 (DEH in prep.) to 70,000 (ABRS 2005a). I have found no published estimates for the percentage of endemics.

World Descr. min.	World Descr. max.	World Accepted	World Estimate	Australia Described	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened ⁷⁹	Australia Threatened ⁸⁰	Australian Threatened as percentage of World Threatened
12,000	25,000	<25,000	~500,000	~2,060	8%	~30,000	unknown	0	0	—

⁷⁹ 2004 (IUCN Red Data List).

⁸⁰ Includes listed Extinct and Vulnerable species (DEH 2005a).

Acanthocephala (thorny-headed worms)

Estimates for the number of described species in the world vary from more than 500 (Hickman *et al.* 2004), 850 (Wikipedia⁸¹), over 1,000 (Groombridge and Jenkins 2002) to 1,100 (Brusca and Brusca 2003).

Groombridge and Jenkins (2002) suggested that only a low to moderate proportion of the group is known, suggesting perhaps a total of around 1,500.

ABRS (2005a) reports 57 described species for Australia and an estimated 157 total, whereas DEH (in prep.) has figures of 56 described species out of a total of about 160.

World Descr. min.	World Descr. max.	World Accepted	World Estimate	Australia Described	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened ⁸²	Australia Threatened ⁸³	Australian Threatened as percentage of World Threatened
~500	1,100	1,000	1,500	56	5.6%	~160	unknown	0	0	—

⁸¹ <http://www.biology.missouri.edu/courses/Bio10/Acanthocephala.html>.

⁸² 2004 (IUCN Red Data List).

⁸³ Includes listed Extinct and Vulnerable species (DEH 2005a).



Platyhelminthes (flat worms)

Estimates for the number of described species in the world are of around 20,000 (Hawksworth and Kalin-Arroyo 1995, Groombridge and Jenkins 2002, Brusca and Brusca 2003). Myers (2001g) reports 3,000 species of Turbellaria, 9,000 species of Trematoda and 5,000 species of Cestoda, while Ponder *et al.* (2002) provided a figure of 3,000–4,000 Monogenea which would give a total of 20,000–21,000 species. I have accepted the lower of these in line with the majority of reports.

I have found one estimate of the total number of species at over 80,000.

Estimates for the number of described Australian species vary from 1,506 (DEH in prep.) to 1,593 (ABRS 2005a) with estimates for total species of around 10,000 (DEH in prep.) and 10,806 (ABRS 2005a) although these estimates appear high (pers. comm. Alice Wells, ABRS June 2005). Endemism is likely to be low in parasitic forms in birds, marine fishes and in free-living marine forms and high in parasites of marsupials, reptiles and frogs, and in free-living freshwater forms (pers. comm. Alice Wells, ABRS, June 2005).

World Descr. min.	World Descr. max.	World Accepted	World Estimate	Australia Described	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened ⁸⁴	Australia Threatened ⁸⁵	Australian Threatened as percentage of World Threatened
20,000	21,000	20,000	80,000+	1,593	8.0%	~10,000	unknown	0	0	—

⁸⁴ 2004 (IUCN Red Data List).

⁸⁵ Includes listed Extinct and Vulnerable species (DEH 2005a).

Cnidaria (jellyfish, sea anenomes, and corals)



Estimates for the number of described species in the world vary from 9,000 (Groombridge and Jenkins 2002, Hickman *et al.* 2004), 10,000 (Groombridge and Jenkins 2002) to 10,000–11,000 (Brusca and Brusca 2003). I have accepted the figure of 9,000 as it is the figure most commonly cited in recent literature.

The number of described Australian species reported varies from 1,270 (ABRS 2005a) to 1,500 (DEH in prep.) with estimates of the total Australian fauna consistent at about 1,760 (ABRS 2005a, DEH in prep.). Recent information (pers. comm. Pam Beesley, ABRS, June 2005) indicated that there are probably around 1,043

species of Anthozoa, 51 species of Scyphozoa, nine of Cubozoa and perhaps around 600 species of Hydrozoa (Ponder *et al.* 2002), making a total of around 1,705 described species and around 2,200 species in total.

World Descr. min.	World Descr. max.	World Accepted	World Estimate	Australia Described	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened ⁸⁶	Australia Threatened ⁸⁷	Australian Threatened as percentage of World Threatened
9,000	11,000	9,000	unknown	1,705	18.9%	~2,200	unknown	0	0	—

⁸⁶ 2004 (IUCN Red Data List).

⁸⁷ Includes listed Extinct and Vulnerable species (DEH 2005a).



Porifera (sponges)

Estimates for the number of described species of Porifera in the world vary from 5,500 (Myers 2001h, Brusca and Brusca 2003), 5,000–10,000 (Groombridge and Jenkins 2002), 6,000 (ABRS 2005b), 9,000⁸⁸ to 10,000⁸⁹. ABRS (2005b) also estimates that the figure of 6,000 described species is perhaps only about one-third of the total number of extant species.

Described species in Australia number 1,320–1,335 with about 56% endemic (Hooper and Wiedenmayer 1994). ABRS (2005a) and DEH (in prep.) estimate that there are 1,416 described species in Australia with the total number of species in Australian waters at about 3,500. Ponder *et al.* (2002) stated that about 45% of species on the Great Barrier Reef are endemic.

World Descr. min.	World Descr. max.	World Accepted	World Estimate	Australia Described	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened ⁹⁰	Australia Threatened ⁹¹	Australian Threatened as percentage of World Threatened
5,500	10,000	5,500	~18,000	1,416	25.7%	~3,500	56%	0	0	—

88 <http://www.biology.iastate.edu/Courses/201L/Porif/%20Porifindx.htm>.

89 <http://www.earthlife.net/inverts/porifera.html>.

90 2004 (IUCN Red Data List).

91 Includes listed Extinct and Vulnerable species (DEH 2005a).

Other Invertebrates

A difficulty in listing this group is determining what belongs here, and what belongs in the Protoctista (see below).

Estimates for the number of described species in the various phyla in the world are given in the next Table and are compiled from Groombridge and Jenkins (2002), Brusca and Brusca (2003) and Hickman *et al.* (2004). Those for Australia are from ABRS (2005a) with the exception of the Entoprocta (Kamptozoa) and Sipuncula which are updated figures supplied by ABRS (pers. comm. Alice Wells, ABRS June 2005).

Tardigrade information was supplied by Sandra Claxton (pers. comm. Aug. 2005). She reported that an unpublished paper by her and Reinhardt Kristensen listed 46 marine species for Australia in 1998, and that her PhD (submitted in 2004) identified 182 terrestrial

species of which 69 have been published in the literature. About 56% of the 182 species are endemic. She suggests that there are at least 500 species in total for Australia.

Most estimates for the world total of described species of Mesozoa are around 90, whereas ABRS (2005a) states that there are 100 described species for Australia. I have contacted several researchers around Australia, and all have the view that there is probably no-one in Australia who knows the number of described species in Australia. Similarly, the figure of 100 for the Loricifera reported by Groombridge and Jenkins (2002) does not fit with figures of around 10 reported by other researchers, or 22 supplied by Reinhardt Kristensen (pers. comm.⁹²).

Other figures that differ from those given in the cited papers are 1,200 described species out of a worldwide total of 5,000–10,000 in Nermertea (Ponder *et al.* 2002).

92 Pers. comm. Reinhardt Kristensen, University of Copenhagen, Copenhagen, Denmark, 8 Aug. 2005.



Other Invertebrates *continued*

Phylum	Common name	Hickman <i>et al.</i>	Brusca and Brusca ⁹³	Groombridge and Jenkins	World Accepted	World Estimate	Australia described	Australia Percent.	Australia Estimate	Australia Endemic
Placozoa		1	1	1	1		0	0	0	0
Monoblastozoa ⁹⁴		—	1	—	1		—	—	—	—
Mesozoa	mesozoans	accepted?	90 ⁹⁵	~90 ⁹²	90		100	110%	100	
Ctenophora	comb jellies	<100	100	~100	100	150	10	10%	60	
Nemertea	ribbon worms	650	900	~900	900	5,000–10,000	81	9%	281	
Rotifera	rotifers	~1,800	1,800	~2,000	1,800		650	36%	1,300	
Gastrotricha	gastrotrichs	~400	450	~400	450		45	10%	45	
Kinorhyncha	kynorhinchs	75	150	~150	150		8	5%	8	
Nematomorpha	horsehair worms	250	320	~240	320		32	10%	32	
Entoprocta (Kamptozoa)	kamptozoans	150	150	~150	150	170	16	11%	16	87% ⁹⁶
Gnathostomulida	gnathostomulids	>80	80	~80	80		8	10%	8	
Priapulida	priapulans	18	16	17	18		2	12%	2	
Loricifera	loriciferans	few	10	~100 ⁹⁷	22 ⁹⁸	>100	4 ⁹⁴	18%	6	50%
Cycliophora	cycliophorans	?1	1	accepted?	1		0	0%	0	
Sipuncula	peanut worms	~330	320	~150	320		48	15%	48	
Echiura	spoon worms	140	135	~140	135		13	10%	13	
Tardigrada ⁹⁹	water bears	300–400	800	~750	980 ¹⁰⁰		112 (228)	11–23%	~500	56%
Phoronida	phoronids	~10	20	16	20		6	30%	6	
Ectoprocta (Bryozoa)	moss animals	~4,000	4,500	~4,000	4,500	5,000+	1,000	22%	~2,500	50%
Brachiopoda	lamp shells	~325	335	~350	335		58	17%	70	
Pentastomida	tongue worms	~90	~130 ¹⁰¹	accepted?	100		10	10%	10	
Chaetognatha ¹⁰²	arrow worms		100	~70	100		10	10%	10	
TOTAL		8,800	10,409	~9,700	10,573		2,213	20.9%	5,015	

92 Pers. comm. Reinhardt Kristensen, University of Copenhagen, Copenhagen, Denmark, 8 Aug. 2005.

93 Brusca and Brusca (2003) treat the Placozoa, Monoblastozoa, Rhombozoa and Orthonectida as phyla of uncertain relationships.

94 Of doubtful existence (Meeûs and Renaud 2002).

95 Split into 70 Rhombozoa and 20 Orthonectida.

96 87% endemic to Australian and New Zealand waters (Ponder *et al.* 2002).

97 Appears to be a very high number – see comments under 'Accepted'.

98 Pers. comm. Reinhardt Kristensen, University of Copenhagen, Copenhagen, Denmark, 8 Aug. 2005 – two species from Australian caves, and two species from waters between Australia and New Caledonia.

99 Figures unless indicated from Sandra Claxton, pers. comm. See comments on previous page.

100 Guidetti and Bertolani (2005) list 980 species of which 147 are marine.

101 Included under Crustacea.

102 Hickman *et al.* (2002) state that this phylum is not supported by molecular evidence.

Plants



Bryophyta (mosses, liverworts and hornworts)

Estimates for the Bryophyta are complicated somewhat by the definition of the group (i.e. Phylum or Division). In some cases the category is circumscribed to include only the mosses, in others to include the hornworts, and liverworts, etc; hence the discrepancy in some of the cited numbers. Here, I am using it in the broader sense to include the true mosses (Bryophyta/Bryopsida), the hornworts (Anthocerotophyta/Anthocerotopsida) and liverworts (Hepatophyta/Marchantiopsida).

Estimates of the number of described species vary from 15,000 (Hallingbäck and Hodgetts 2000, IUCN 2004) to 23,000 (Helzner 2002). The University of Auckland (n.dat.) provides figures of c. 10,000 for the mosses, 6,500–7,000 for liverworts and c. 100 for the hornworts, giving an estimate of 16,600–17,100 species in total. Other estimates for mosses vary from 9,500 to 12,000 with the figure of 10,000 usually accepted (e.g. Groombridge and Jenkins 2002). Groombridge and Jenkins (*loc. cit.*) also provide estimates of 6,000 for liverworts (Hepatophyta), and 600 for the hornworts (Anthocerotophyta). De Luna *et al.* (2003) as part of *The Tree of Life* project also provided an estimate for mosses of 10,000 species. Numbers of c. 10,000 for mosses, c. 6,500 for liverworts and c. 100

for hornworts have been accepted here, providing a total of c. 16,600 species.

I have not found a published estimate for the total number of species, however Groombridge and Jenkins (2002) suggested that the proportion of the groups known is moderate to high for the Bryophyta and moderate for both the Anthocerotophyta and Hepatophyta. Christine Cargill (pers. comm.¹⁰³) provided a figure of 20,000–25,000, however, Patrick McCarthy (pers. comm.¹⁰⁴) suggested that the figure was more likely at the lower end of this range.

There are 983 species of moss (Neils Klazenga pers. comm.¹⁰⁵), and 869 accepted species of liverworts and hornworts (McCarthy 2003). There are an estimated 250 endemic species of moss¹⁰⁶ (25.4% endemism) and between 200 and 250 endemic species of liverworts and hornworts¹⁰⁷ (23–28% endemism). DEH (2005) estimated the number of Australian species described at around 1,950, with about 2,500 species in total. The DEH figure would appear to be a little high.

There is one threatened species listed for Australia (DEH 2005b).

World Descr. min.	World Descr. max.	World Accepted	World Estimate	Australia Described	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened ¹⁰⁸	Australia Threatened ¹⁰⁹	Australian Threatened as percentage of World Threatened
15,000	23,000	16,600	~22,000	1,852	11.2%	~2,200	25%	80 (0.5%)	1 (0.05%)	1.3%

¹⁰³ Pers. comm. Christine Cargill, Centre for Plant Biodiversity Research, Canberra, Sept. 2005.

¹⁰⁴ Pers. comm. Patrick McCarthy, Australian Biological Resources Study, Canberra, Sept. 2005.

¹⁰⁵ Pers. comm. Neils Klazenga, Royal Botanic Gardens, Melbourne via Christine Cargill, Centre for Plant Biodiversity Research, Canberra.

¹⁰⁶ Pers. comm. Neils Klazenga, Royal Botanic Gardens, Melbourne via Christine Cargill, Centre for Plant Biodiversity Research, Canberra.

¹⁰⁷ Pers. comm. Patrick McCarthy, Australian Biological Resources Study, Canberra, Sept. 2005.

¹⁰⁸ 2004 (IUCN Red Data List).

¹⁰⁹ Includes listed Extinct and Vulnerable species (DEH 2005b).



Ferns and Allies

Ferns and fern allies here have been taken to include the true ferns (Filicinophyta/Polypodiopsida), the club mosses, spike mosses, quillworts (Lycophyta, Lycopodiophyta/Lycopodiopsida, Selaginellopsida, Isoetopsida), spike horsetails (Sphenophyta/Sphenopsida) and whisk ferns (Psilophyta/Psilopsida) as recognised by various authors. Estimates for the numbers of described taxa include 13,025 (Groombridge and Jenkins 2002), who report numbers of c. 1,000 Lycophyta, c. 12,000 Filicinophyta, 10 Psilophyta and 15 Sphenophyta. This is also the number accepted by the IUCN (2004). Other estimates include 12,838 in the *Checklist of Ferns of the World* (Hassler and Swale 2002). Interestingly, they also estimate a total number of species as between 10,614 and 12,001 which is less than the described number of species they include in the Checklist. Previous estimates from Swale (2000) were for between 10,000 and 15,000 species. Peter Bostock (pers. comm.¹¹⁰) suggests that there could be somewhere between

15,000 and 20,000 species worldwide, however there are complications with hybridisation, and with species on islands that may or may not be conspecific with mainland species (i.e. vicariant species complex). I have accepted the figures of Hassler and Swale (2002) for known species, and an estimate of 15,000 based on the figures of Swale (2000) and Bostock (ibid.).

Figures for Australia include 391 Filicinophyta, 47 Lycophyta (including Selaginellopsida and Isoetopsida), and eight Psilophyta (ABRS 1998). In addition there are about 36 naturalised species. It is estimated that about 40% are endemic. Bostock (pers. comm.) suggests a figure of about 500 as the total fern flora for Australia.

There are 35 listed threatened species in Australia (DEH 2005b).



World Descr. min.	World Descr. max.	World Accepted	World Estimate	Australia Described	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened ¹¹¹	Australia Threatened ¹¹²	Australian Threatened as percentage of World Threatened
12,000	15,000	12,838	15,000	446	3.5%	~500	40%	140 (1%)	35 (7.9%)	25%

¹¹⁰ Pers. comm. Peter Bostock, Queensland Herbarium, June 2005.

¹¹¹ 2004 (IUCN Red Data List).

¹¹² Includes listed Extinct and Vulnerable species (DEH 2005b).

Gymnosperms (Coniferophyta, Cycadophyta, Gnetophyta and Ginkgophyta)

Estimates for the number of described species in the world are about 630 Coniferophyta, 145 Cycadophyta, about 70 Gnetophyta and one Ginkgophyta (Groombridge and Jenkins 2002). The IUCN (2004) reported a total of 980 species of Gymnosperms based on Donaldson (2003), Farjon (2001) and Mabberley (1997) which is a higher figure than those provided by Groombridge and Jenkins (2002). *Land Plants On-line*¹¹³ list around 600 species of Coniferophyta, whereas Hill (1998c, 2004) estimates that there about 250 known species of Cycad and c. 600 species of Pinophyta (Hill 1998b), 71 species of Gnetophyta and one of Ginkgophyta (Hill 1998a). These figures seem to indicate a total figure for Gymnosperms of about 950 (600 conifers, 250 cycads, 71 gnetophytes and one ginkgo). No estimates for the total number of Gymnosperms has been found, but it would probably be in the order of 1,000 species.

Figures for the Australian Gymnosperms include: Coniferophyta 44 (39 of which are endemic) (Hill 1998b); and Cycadophyta 69 (all of which are endemic) (Hill 1998c). Groombridge and Jenkins (2002) provided an estimate of 90 species for Australia, which is too low. No estimate of the total gymnosperm flora of Australia has been found, but it is unlikely to be much higher than the presently known figure.

There are 20 listed threatened species in Australia and one threatened subspecies (DEH 2005b).

World Descr. min.	World Descr. max.	World Accepted	World Estimate	Australia Described	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened ¹¹⁴	Australia Threatened ¹¹⁵	Australian Threatened as percentage of World Threatened
846	980	~930	~1,000	113	12.2%	113	96%	305 (32%)	20 (17.7%)	6.6%

¹¹³ <http://www.science.siu.edu/landplants/Coniferophyta/coniferophyta.taxa.html>.

¹¹⁴ 2004 (IUCN Red Data List).

¹¹⁵ Includes listed Extinct and Vulnerable species (DEH 2005b).



Magnoliophyta (flowering plants)

Estimates for the number of described species of flowering plants in the world vary from 248,000 (Tangley 1997), 258,650 (Thorne 2002, IUCN 2004) to about 270,000 (Groombridge and Jenkins 2002). The IUCN (2004) and Groombridge and Jenkins (2002) estimated that the total flora was about 320,000 species. In 2001, Govaerts (Govaerts 2002) estimated that there were 422,127 species of flowering plants based on the first volumes of his *World Checklist of Seed Plants*, whereas Bramwell (2002), using different methods, estimated a total of 421,968 species. Bramwell suggested that '*it would seem safe to say that the world has about 422,000 species of flowering plants*'.

Australian figures for flowering plants vary from 15,638 (Walter & Gillett 1998, Williams 2001, Groombridge and Jenkins 2002), 18,821 (Sjöström & Gross submitted) to about 20,000 (DEH in prep.). Sjöström & Gross, *loc. cit.*, reported a total of 18,821 species including 1,997 introduced species, thus giving a total of 16,824 native species. A count carried out as part of this report produced a figure of 17,023 native species on the Australian mainland and 17,281 when the offshore islands were included. Confusion does arise with knowing whether some species are introduced or native, and *What's Its Name* (ANH *et al.* 2005) includes a number of species where more than one name (synonyms) is

listed as current and it does include some extra-Australian species (especially in the Orchidaceae). I do, however, believe that the figure cited here of 17,281 ($\pm 0.5\%$) is realistic. *What's Its Name* (*loc. cit.*) also lists around 298 species as formulae names or manuscript names—i.e. known but as yet unpublished species, and over 2,100 introduced and naturalised species. When these are included, the total number of native species is 17,580 with 19,680 total native and naturalised species.

The estimates of 15,638 as cited by several authors, appear to have all been sourced from the Australian National Botanic Gardens (ANBG 2004) which refers to figures estimated in 1990. I expect that other estimates of around 20,000 include as many as 3,000 introduced species. Estimates for the total number of Australian flowering plants species vary from 20,000 to 25,000 (DEH in prep.), but again I suspect that these figures include introduced species, and I would be reluctant to include a figure greater than 19,000–21,000 for native species.

Estimates for endemism vary from about 85% (Williams 2001), 90% (Groombridge and Jenkins 2002) to 92% (Wong 1999). Groombridge and Jenkins (2002) cited a figure of 14,074 endemic species out of their total of 15,638 giving an endemism of 89%. In 1998, Conservation International provided a figure of 14,458



endemic species (Wong 1999). Given a total number of 17,281 species accepted here, that would indicate percentage endemism of approximately 85. A count carried out for this project using the *Australian Plant Census* (CHAH 2005), *What's Its Name* (ANH *et al.* 2005), published hard-copy and on-line volumes of the *Flora of Australia* (ABRS 2005d), the *Australian Plant Name Index* (Chapman 1991) and the *Census of Australian Vascular Plants* (Hnatiuk 1990) produced a figure of 91.7% endemism for mainland Australia and 91% once the offshore island floras are added in¹¹⁶. The total number of endemic species needs to be recalculated once the new *Australian Plant Census* of Australian vascular plant species is completed.

There are 1,139 listed threatened species of flowering plant in Australia, of which 95 are undescribed. There are also 106 listed infraspecific taxa of which three are undescribed (DEH 2005b).

World Descr. min.	World Descr. max.	World Accepted	World Estimate	Australia Described ¹¹⁷	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened ¹¹⁸	Australia Threatened ¹¹⁹	Australian Threatened as percentage of World Threatened
235,000	425,000	258,650	~422,000	17,580	6.8%	~19,000–21,000	91%	7,796 (3.0%)	1,139 (6.5%)	14.6%

¹¹⁶ NB. These figures do not take into account introduced and naturalised species which would drop the figure down to about 82%.

¹¹⁷ Includes 280 undescribed species, but which have been given either manuscript or formulae names.

¹¹⁸ 2004 (IUCN Red Data List).

¹¹⁹ Includes listed Extinct and Vulnerable species (DEH 2005b). NB This figure includes about 95 undescribed species; and excludes infraspecific taxa.

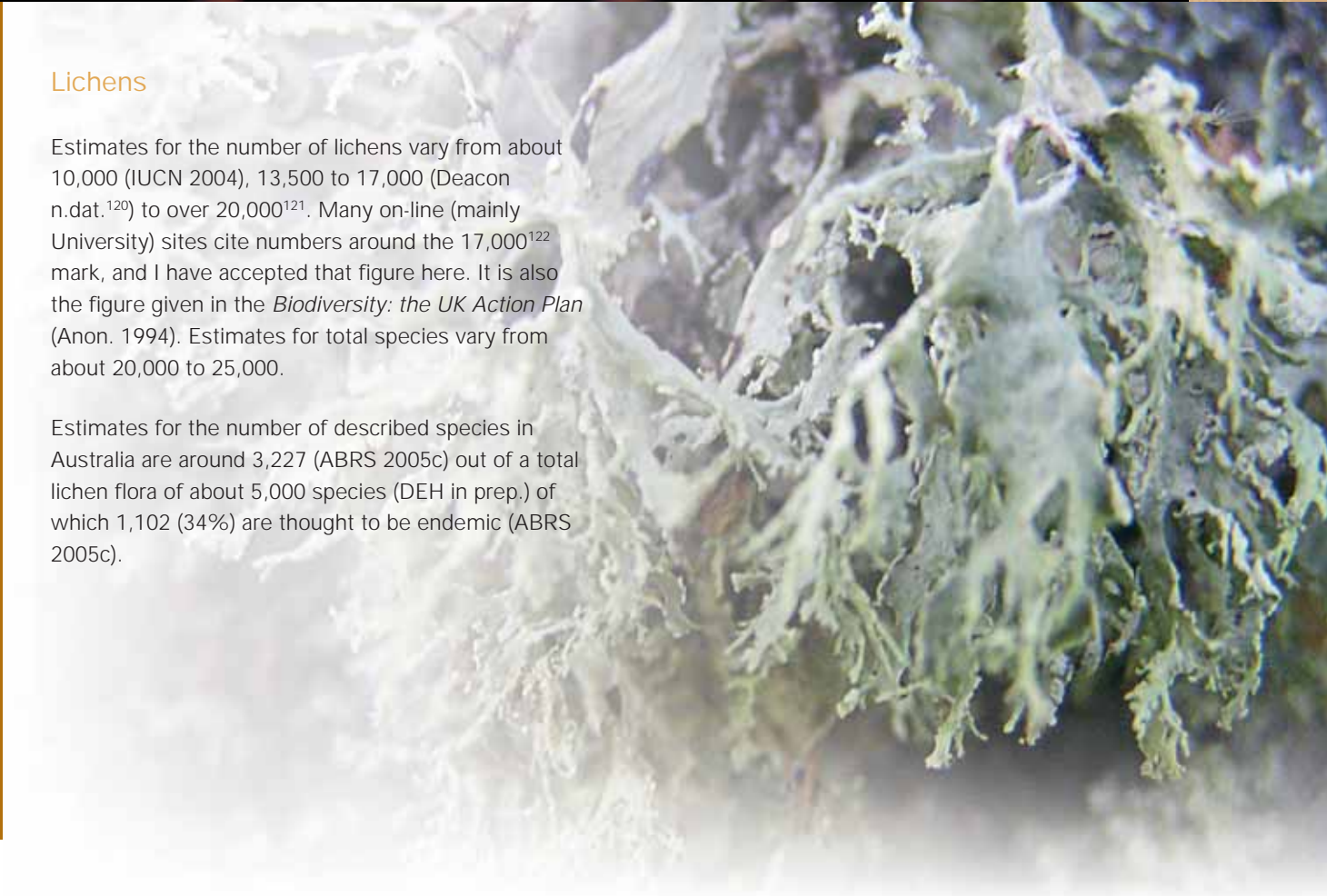
Others

The other groups are difficult to determine and characterise. Many are generally included among the Protists—a loose assemblage of primary single-celled, heterotrophic, eukaryotic organisms many of which were previously called Protozoa (Brusca and Brusca 2003). It is often difficult to know what constitutes a species in many groups, and to determine in what Kingdom the various Phyla should be placed. Molecular phylogenetic and cladistic studies have resulted in major reorganisations of eukaryotic groups of organisms (see Meeüs and Renaud 2002). I have included the algae in this group rather than in the Plantae, although in reality, they should be split between the Plantae and this group.

Lichens

Estimates for the number of lichens vary from about 10,000 (IUCN 2004), 13,500 to 17,000 (Deacon n.dat.¹²⁰) to over 20,000¹²¹. Many on-line (mainly University) sites cite numbers around the 17,000¹²² mark, and I have accepted that figure here. It is also the figure given in the *Biodiversity: the UK Action Plan* (Anon. 1994). Estimates for total species vary from about 20,000 to 25,000.

Estimates for the number of described species in Australia are around 3,227 (ABRS 2005c) out of a total lichen flora of about 5,000 species (DEH in prep.) of which 1,102 (34%) are thought to be endemic (ABRS 2005c).



World Descr. min.	World Descr. max.	World Accepted	World Estimate	Australia Described	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened ¹²³	Australia Threatened	Australian Threatened as percentage of World Threatened
10,000	20,000	17,000	~25,000	3,227	19.0%	~5,000	34%	2 (0.01%)	0	0

¹²⁰ <http://helios.bto.ed.ac.uk/bto/microbes/lichen.htm>.

¹²¹ <http://www.bcbiodiversity.homestead.com/lichens.html>.

¹²² <http://www.casebio.com/lichens/whatarelichens.htm>.

¹²³ 2004 (IUCN Red Data List).



Fungi (excluding lichens)

Estimates for the number of world fungi vary due to lack of knowledge, their occurrence in virtually every habitat, and uncertainty as to what should be included in the group. In reality the microfungi should probably be separated out and split between the Protoctista and Chromista (Corlis 2000).

Estimates of 45,173 (Groombridge and Jenkins 2002), 46,983 (McNeely *et al.* 1990), 69,000 (Tangley 1997), 72,000 (Hawksworth and Kalin-Arroyo 1995, Brusca and Brusca 2003) and over 300,000 (Rossman 2003) have been found. Groombridge and Jenkins (2002) give figures of c. 30,000 Ascomycota, 22,250 Basidiomycota and c. 1,100 Zygomycota. In addition, under the Protoctista, they include c. 1,000 Chytridiomycota, 23 Hyphochytriomycota and c. 800 Microspora that Corliss (2000) places in the fungi. There may be other taxa (such as the Pseudofungi, Oomycota and Labyrinthulata which Corliss places in his Chromista) that haven't been included in the figures supplied by Groombridge and Jenkins (*loc. cit.*). These could add another 1,200–1,300 species. The figure of 300,000 by Rossman (2003) although very high appears to have been based on some thorough searching of names in the literature and accords with a figure of 120,000 described species by

1931 as identified by Reed and Farr (1993). Settling on a number, even of described species, is very difficult when one sees the vast variation in estimates. I have accepted the figure of 72,000 as reported in Hawksworth and Kalin-Arroyo (1995) and Brusca and Brusca (2003). About 500 of these species are marine, and many more are likely to be found in that environment.

Brusca and Brusca (2003) suggest that their figure of 72,000 is only about 5–10% of the total number of species, while Hawksworth (1991), Hawksworth and Kalin-Arroyo (1995) and Groombridge and Jenkins (2002) estimated that there may be as many as 1.5 million species. Rossman (2003) provides further strong supporting evidence for a figure of around 1.5 million. Hawksworth and Kalin-Arroyo (1995) reported estimates varying between 200,000 and 2.7 million.

There are 3,072 described Basidiomycetes (May 2003, May pers. comm.¹²⁴), c. 300 Ascomycetes in Australia (Lepp 2003) and estimates of 2,300+ microfungi.

The total number of known Australian fungi has been estimated as c. 12,500 species¹²⁵ (Pascoe 1990, DEH in prep.).

Estimates for the total number of fungal species in Australia vary from around 50,000 (DEH in prep.) to about 250,000 (Pascoe 1990, May and Grgurinovic 1995, Williams 2001, Ramsey 2005) with about 90% thought to be endemic (Williams 2001). May (pers. comm. 2005) suggests that there are about 10,000 species of basidiomycete macrofungi in Australia in total, and about 1,200–2,400 ascomycete macrofungi, while ACIL Consulting (2002) suggested a total for the microfungi of between 150,000 and 240,000. This would put the total for all Australian fungi at between 160,000 and 250,000.



	World Descr. min.	World Descr. max.	World Accepted	World Estimate	Australia Described	Australia Percent.	Australia Estimate	Australia Percent. Endemic
Microfungi			~20,000		2,300+	11.5%	150,000–240,000	
Macrofungi (Basidiomycetes)			~22,250		3,072	5.8%	10,000	
Macrofungi (Ascomycetes)			~30,000		300	1.0%	1,200–2,400	
Total	45,173	300,000	~72,000	1,500,000	5,672+	7.8%	160,000–250,000	90%

¹²⁴ Pers. comm. Tom May, National Herbarium of Victoria, June 2005.

¹²⁵ Based on an assumption that there are at least ten times as many fungi as vascular plants and that we know less than 5% of these fungi. It is difficult to estimate the number of microfungi in Australia, as there is no complete checklist of Australian microfungi (ACIL Consulting 2002).

Bacteria (Monera) (excluding Cyanobacteria)

The estimates of numbers of bacteria in the world (and in Australia) are complicated by many factors. It is generally believed that many species cannot be cultivated or identified, using existing techniques. The Cyanophyta (Cyanobacteria) have been separated out into a different section in this report.

The estimated number of described bacteria species in the world varies from 3,000–4,000 (Hawksworth and Colwell 1992), 4,000 (Hawksworth and Kalin-Arroyo 1995), 4,760 (McNeely *et al.* 1990), 5,432 (Euzeby 2004) to 10,000 (Groombridge and Jenkins 2002). I have accepted the figures of Euzeby (2004). Shimura (2004) provided a figure of 8,500 species, but from Euzeby (2004) it is obvious that these are names, and as stated by Euzeby (*loc. cit.*) of the 6,832 currently validly published species names, these apply to just 5,432 currently accepted species names. His figures include the Archaea of which there are about 10 species (Corliss 2000).

Estimates of the total number of species (described and undescribed) vary from 50,000 to 3 million (Hawksworth and Kalin-Arroyo 1995) with generally accepted figures varying from 400,000 (Groombridge and Jenkins 2002) to 1 million (Hawksworth and Kalin-Arroyo 1995).

Figures for Australia are virtually non-existent other than an estimate of 40,000 for the total number of species in Australia by Saunders *et al.* (1996). These authors also gave a figure of 0.1% described which would indicate a figure of about 40 species. This appears to be a gross under-estimation for the number of described species.

World Descr. min.	World Descr. max.	World Accepted	World Estimate	Australia Described	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened ¹²⁶	Australia Threatened	Australian Threatened as percentage of World Threatened
4,000	10,000	~5,422	400,000–1,000,000	~40	0.7%	40,000	unknown	0	0	—

¹²⁶ 2004 (IUCN Red Data List).



Cyanophyta (Cyanobacteria)

The Cyanobacteria are an important group in Australia, although very little is known of them. Species concepts in the group are difficult (without sexual reproduction) so many of the numbers cited vary widely. The Cyanobacteria form about 4% of the total number of bacteria in Australia according to ACIL Consulting (2002). Figures supplied here appear to be guesstimates only and could be out by factors of hundreds, if not thousands.

The number of described species in the world is about 3,234 (Watanabe *et al.* 2004). Groombridge and Jenkins (2002) report that there are about 1,000 genera.

ACIL Consulting (2002) state that '*An estimate made during consultations suggests that the total number of species could be between 12 000 and 40 000. – based on cyanobacteria being around 4% of total number of bacteria species potentially to be found in Australia. It is concluded that the majority of the species are yet to be described.*' This would make the total number of bacteria in Australia between 400,000 and 1 million. ACIL Consulting (2002) suggest that the number

of identified species in Australia (not necessarily described) is between 200 and 2,000. Given that the estimate of the total described species for the world is 3,234, it would appear that a number in the thousands for described species in Australia is unlikely.

Entwisle & Huisman (1998) estimated a figure of 270 species in Australia, although lower than many other estimates it would appear to be a more realistic figure. Entwisle (pers. comm.)¹²⁷ suggests c. 50 species as described for Australia.

World Descr. min.	World Descr. max.	World Accepted	World Estimate	Australia Described	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened ¹²⁸	Australia Threatened ¹²⁹	Australian Threatened as percentage of World Threatened
3,234	3,234	3,234	unknown	~50	unknown	270	unknown	0	0	—

¹²⁷ Pers. comm. Tim Entwisle, Botanic Gardens Trust, NSW, March 2006.

¹²⁸ 2004 (IUCN Red Data List).

¹²⁹ Includes listed Extinct and Vulnerable species (DEH 2005b).

Algae (excluding Cyanobacteria)



Again, it is difficult to estimate the number of species of algae, partly due to varying circumscriptions. Some estimates for the number of species worldwide, along with the different circumscriptions, are given in the accompanying table (next page). From that table it can be seen that Corliss (2000) separates algae into both Plantae and Chromista.

Estimates for the number of described species of algae include 26,900 (Tangley 1997), 27,000 (Entwisle 1997), 34,500 (Groombridge and Jenkins 2002), 33,000–44,000 (Corliss 2000), about 35,000 (*AlgaeBase*—Michael Guiry, pers. comm.¹³⁰) and 40,000 (possibly including

Cyanophyta) (Hawksworth and Kalin-Arroyo 1995). The *AlgaeBase* database (Guiry *et al.* 2005) has only completed about 70% of taxa to date (Rhodophyta and Phaeophyta 95% complete; Chlorophyta with 95% marine and 50% freshwater complete 'being deficient in the area of small freshwater greens, including the desmids. For the Haptophyta, Euglenophyta, Chrysophyta, Prasinophyta and Cryptophyta and other small phyla/classes we reckon about 80%' complete. The biggest deficiency is in the Bacillariophyta (diatoms) where 8,500 names are recorded 'but no clarity on what is what' (Guiry, pers. comm.¹³⁰). For this reason, I have accepted a figure of c. 35,000 based largely on the figures supplied by Groombridge and Jenkins (2002) and Corliss (2000) (see table below), and by extrapolation of the figures from *AlgaeBase*.

Few estimates of the total number of algae have been found, however Hawksworth and Kalin-Arroyo (1995) gave a figure of 400,000 with cited estimates ranging from 150,000 to 1 million, while the *Biodiversity: the UK Action Plan* (Anon. 1994) suggested that there could be up to 10 million species of diatoms. Michael Guiry (pers. comm.¹³⁰), the manager of *AlgaeBase* (<http://www.algaebase.org>), reports that there are about 20,000 described species of diatoms with about another 80,000 undescribed species. The data from *AlgaeBase* indicate

that a figure of 400,000 is too high, and I have settled on a figure of about 200,000 (assuming 100,000 species of diatom) which is at the lower end of the range reported by Hawksworth and Kalin-Arroyo (1995).

Estimates for the number of described species in Australia include 5,000 (Williams 2001) and 10,000 (DEH in prep.). Entwisle & Huisman (1998) provide estimates of from 5,714–17,937 with the large variation due mainly to estimates for diatom of from 1,300–13,000. ACIL Consulting (2002) suggested a figure of 3,000 for freshwater algae, but don't go further. Guiry *et al.* (2005) list 7,167 species and infraspecies for Australia in *AlgaeBase*, but to date they have only covered about 70% of the algae taxa (Guiry pers. comm.¹³⁰). Extrapolation from the *AlgaeBase* figures suggests that there are about 10,000 described Australian taxa (species and infraspecies).

DEH (in prep.) provide an estimate of 11,000 to 12,000 for the total number of algae species, ABRS (2004) report that there are 10,000–12,000 species known for Australia, but that 'this is certainly an underestimate', while ACIL Consulting (2002) provide a figure of 10,000 to 100,000 based on a figure of 1/10 of the total world species. Using my figure of 200,000 total for the world, this provides a figure of about 20,000 for Australia.

World Descr. min.	World Descr. max.	World Accepted	World Estimate	Australia Described	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened ¹³¹	Australia Threatened ¹³²	Australian Threatened as percentage of World Threatened
26,900	44,000	~35,000	200,000	~10,000	20.4%	12,000+	unknown	0	1	—

¹³⁰ Pers. comm. Michael Guiry, *AlgaeBASE*, June 2005. <http://www.algaebase.org>.

¹³¹ 2004 (IUCN Red Data List).

¹³² Includes listed Extinct and Vulnerable species (DEH 2005).



Algae (excluding Cyanobacteria) *continued*

Name as used by Groombridge and Jenkins (2002)	Name as used by Corliss (2000)	Kingdom of Corliss (2000)	Numbers (Groombridge and Jenkins 2002)	Numbers (Corliss 2000)	AlgaeBase (per Michael Guiry pers. comm.)
	Charophyta (Conjugatophyceae, Gamophyceae, Zygonematophyceae + others)	Plantae		~11,700	
Gamophyta (conjugating green algae)			Several thousand		
Chlorophyta (green algae)	Chlorophyta	Plantae	~16,000	~3,500	
Eustigmatophyta (green eyespot algae)			accepted?		
	Glaucophyta	Plantae		15	
	Prasinophyta	Plantae		~300	
Rhodophyta (red algae)	Rhodophyta	Plantae	~4,000	4,250	
	Ultrapolyta	Plantae		>300	
Xanthophyta (yellow-green algae)			~600		
Chrysomonada (Chrysophyta)	Bicosoecae (previously in Chrysophyta)	Chromista	accepted?	~40	
Cryptomonada (Cryptophyta)	Cryptomonada (Cryptophyta)	Chromista	accepted?	~200	
Diatoms	Diatomae (Bacillariophyta, Diatomea, Diatomophyceae)	Chromista	~10,000	10–20,000	20,000 described plus 80,000 undescribed
	Dictyochae (Dictyochophyceae) (formerly in Chrysophyta)	Chromista		~200	
	Bicosoecae (previously in Chrysophyta)	Chromista		~40	
	Chrysophyta (golden-brown algae)	Chromista		~1,250	
Haptomonada (Pymnesiophytes) (yellow brown algae)	Haptomonada (Coccolithophora, Haptophyta, Prymnesiophyta)	Chromista	accepted?	500	
Phaeophyta (brown algae)	Phaeophyta (Fucophyceae, Melanophyceae)	Chromista	~900	>1,600	
	Rhaphidophyta (Chloromonadophyceae)	Chromista		<36	

Viruses

The main problem in estimating the number of species of viruses is knowing just what constitutes a species in the group. In general, virus species are taken as being a collection of isolates with similar characteristics (ICTV 2002). In a recent report from the International Committee on Taxonomy of Viruses, Mayo *et al.* (2005) reported on 5,450 viruses belonging to 2,000 species, 287 genera, 73 families and three orders. The International Committee on Taxonomy of Viruses currently recognises about 900 species of plant viruses (Melcher 2005). A full list of virus species can be found at <http://www.ncbi.nlm.nih.gov/ICTVdb/index.htm>.

Estimates for the number of described species of viruses range from about 2,000 (Mayo *et al.* 2005), 4,000 (Hawksworth and Kalin-Arroyo 1995) to 5,000 (Anon. 1994), with estimates of the total number at about 400,000 (varying from 50,000 to 1 million) (Hawksworth and Kalin-Arroyo 1995). I have accepted the official numbers from the International Committee on the Taxonomy of Viruses (Mayo *et al.* 2005).

The only figures I have been able to find for Australia are a list of 178 plant viruses (Büchen-Osmond 1988). I have not come across a similar list for animal viruses so, extrapolating, one obtains a figure of about 400 species in total.

World Descr. min.	World Descr. max.	World Accepted	World Estimate	Australia Described	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened ¹³³
2,000	5,000	~2,000	400,000	~400	20%	unknown	unknown	—

133 2004 (IUCN Red Data List).



Protoctista (mainly Protozoa—others included under fungi, algae, etc.)

The main problem in estimating numbers of Protoctista is identifying the inter-relationship between different treatments—see table next page.

Estimates for the number of Protozoa range from >20,000 (Anon. 1994) to 30,800 (Tangle 1997).

The following table has been created from information in Corliss (2000), Groombridge and Jenkins (2002) and Brusca and Brusca (2003). Groombridge and Jenkins (*loc. cit.*) estimate that there are 80,000 described Protoctista with an estimated total of 600,000 species, however these figures include non-protist taxa such as the diatoms, Chlorophyta, and some fungal groups.

Figures for the number of Australian species have been hard to find, however there are estimates for the total number of species in Australia of 65,000 (Saunders *et al.* 1996) and 80,000 (ACIL Consulting 2002). See Scott and Marchant (2005) (*non vid.*) for information on Antarctic Marine Protists.

Protoctista (mainly Protozoa—others included under fungi, algae, etc.) *continued*

Name as used by Groombridge and Jenkins (2002)	Name as used by Corliss (2000) (except for species included under Fungi and Algae)	Name as used by Brusca and Brusca (2003)	Kingdom of Corliss (2000)	Numbers (Groombridge and Jenkins 2002)	Numbers (Corliss 2000)	Brusca and Brusca 2003
Archaeoprotista (Amitochondriates)	Archamoebae (Karyoblastea)	Diplomonadida	Protozoa	accepted?	10	~100
Discomitochondria (Flagellates, zoomastigates)	Neomonada	(Included in Diplomonadida)	Protozoa	accepted?	30	—
Rhizopoda (amastigote amoebas and cellular slime moulds)	Rhizopoda (Amaeoboza)	Rhizopoda (amoebas)	Protozoa	~200	5,000	~200
Myxomycota (Plasmodial slime moulds)	Mycetozoa	Excluded (fungi?)	Protozoa	~500	900	
Granuloreticulosa (Foraminifera and reticulomyxids)	Foraminifera (Granuloreticulosa)	Granuloreticulosa	Protozoa	~4,000	~5,000	~40,000 (incl. many fossils)
Xenophyophora (Xenophyophores)	(under Foraminifera)	(under Granuloreticulosa)	—	42	—	—
(under Actinopoda)	Heliozoa	(under Actinopoda)	Protozoa	—	~4,000	—
Actinopoda (Radiolarians)	Radiozoa (Radiolaria)	Actinopoda (incl. Polycistina = Radiolaria, Phaeodaria, Heliozoa, Acantharia)	Protozoa	~4,000	1,700–4,000	~4,240
	Percolozoa	Excluded (fungi?)	Protozoa	—	100	—
	Euglenozoa	Euglenida	Protozoa		1,600	1,600
	(under Euglenozoa)	Kinetoplastida (trypanosomes)				600
Dinomastigota (Dinoflagellates)	Dinozoa	Dinoflagellata	Protozoa	~4,000	~2,000	4,000
	Metamonada	(under Dinoflagellata)	Protozoa		300	
	Parabasala	Parabasilida (Trihomonads and Hypermastigotes)	Protozoa		400	~300
Apicomplexa (Sporozoa)	Apicomplexa	Apicomplexa	Protozoa	~5,000	~5,000	~5,000
<i>Haplospora</i>	(under Apicomplexa)		Protozoa	33		
<i>Plasmodiophora</i>	(under Apicomplexa)		Protozoa	29		
<i>Paramyxa</i>	(under Apicomplexa)		Protozoa	6		
Ciliophora (Ciliates)	Ciliophora		Protozoa	~10,000	7,800	12,000
	Opalinata (Protociliata, Paraflagellata)	Opalinida	Chromista		200	150
Myxospora (Myxosporidians) ¹³⁴	Myxozoa (Myxosporidia, Myxospora)	Microspora	Animalia	~1,100	>1,200	800

134 Included as a Protist by many researchers.



Summary Table

	Other names and inclusions	World Descr. min.	World Descr. max.	World Accepted	World Estimate	Australia Described	Australia Percent.	Australia Estimate	Australia Endemic
Diplomonadida	Archaeoprotista, Archamoeba, Karyoblastea, Amitochondriates, Discomitochondria, Neomonada	40	100	100					
Rhizopoda	Amoebas, Amoebozoa (uncertain taxonomic boundaries (Corliss 2000))	200	5,000	200					
Mycetozoa	Myxomycota (Plasmodial slime moulds)	~500	900	900					
Granuloreticulosa	Foraminifera 45,000 species, c. 89% are fossils, so about 5,000 extant species)	4,000	5,000	4,000					
Actinopoda	Radiozoa, Radiolaria, Polycistina, Phaeoaria, Heliozoa, Acantharia	~4,000	8,000	4,240					
Euglenida	Euglenozoa, Kinetoplastida	1,000	1,600	1,600					
Dinoflagellata	Dinozoa, Dinomastigota	~2,000	4,000	4,000					
Parabasilida	Parabasala, Trichomonads, Hypermastigates	300	400	300					
Apicomplexa	Sporozoa, Haplospora, Plasmodiophora, Paramyxa	5,000	5,000	5,000					
Ciliophora	Ciliates	7,800	12,000	10,000					
Opalinida	Opalinata, Protociliata, Paraflagellata	150	200	200					
Myxozoa	Myxospora, Myxosporidia, Microspora	800	>1,200	12,000					
TOTAL		~25,790	~43,000	42,540	<600,000	unknown		65,000	unknown

Comparisons

When one compares Australia against the rest of the world, it can be seen that Australia has a relatively high index of biodiversity. The Overall Diversity Index (DI) for Australia, as calculated by Groombridge and Jenkins (2002), is 0.608. This index is based on richness and endemism and places Australia third after only Brazil (0.74) and Indonesia (0.731). A more realistic placing, using the Arrhenius equation (AI) which takes into account area relationships (Groombridge and Jenkins 2002), places Australia 11th, with a figure of 1.268, after Indonesia (1.844), Colombia (1.685), Mexico (1.621), Ecuador (1.519), Brazil (1.436), Venezuela (1.398), Costa Rica (1.358), Peru (1.344), Malaysia (1.28) and Madagascar (1.277).

A detailed study of comparisons with other countries has not been made, however the following table from the Brazil Ministry of the Environment (1999) which looks at biodiversity in Brazil (a country similar in size to Australia), may be of interest. It may be possible to update and improve this information for later versions of this document. Also see Appendix 4 in Groombridge and Jenkins (2002).

Table 2-2. Species richness and endemism of Brazilian vertebrates and higher plants in relation to other megadiversity countries

Number of species	Freshwater fish	Vertebrates (except fish)	Birds	Mammals	Reptiles	Amphibians	Flowering plants	Total
Total	>3,000	3,131	1,622	524	468	517	~50,000	
Ranking	1 st	2 nd	3 rd	1 st	5 th	2 nd	1 st	1 st
Endemic	n/a	788	>191	131	172	294	~17,500	
Rank		4 th	3 rd	4 th	5 th	2 nd	1 st	2 nd

n/a = data not available.

Source: Mittermeier *et al.* (1997).



Also the following table comparing biodiversity in a number of countries.

Table 2-3. Diversity and endemism of higher plant species^a

Country	Total diversity	Endemism	Endemism as % of global diversity of higher plants ^b
Brazil	~50,000– ~56,000	~16,500–18,500	6.6–7.4
Indonesia	~37,000	14,800–18,500	5.9–7.4
Colombia	~45,000– ~51,000	15,000–17,000	6.0–6.8
Mexico	18,000– 30,000	10,000–15,000	4.0–6.0
Australia	15,638	14,458	5.8
Madagascar	11,000–12,000	8,800–9,600	3.5 –3.8
China	27,100–30,000	~10,000	~4.0
Philippines	8,000–12,000	3,800–6,000	1.5–2.4
India	>17,000	7,025–7,875	2.8–3.2
Peru	18,000–20,000	5,356	2.1
Papua New Guinea	15,000–21,000	10,500–16,000	4.2–6.4
Ecuador	17,600–21,100	4,000–5,000	1.6–2.0
United States	18,956	4,036	1.6
Venezuela	15,000–21,070	5,000–8,000	2.0–3.2
Malaysia	15,000	6,500–8,000	2.6–3.2
South Africa	23,420	16,500	6.6
Dem. Rep. of Congo	11,000	3,200	1.3

Source: Mittermeier *et al.* (1997).

a Taking into account a total of 250,000 species in the world.

b The 17 megadiversity countries have between 155,475 and 183,025 endemic species, that is, from 62.2% to 73.2% of global higher plant diversity.

Table 2-4. Diversity and endemism of vertebrate species in megadiversity countries

Country	Mammals	Birds	Reptiles	Amphibians	Vertebrates (except fish)	Non endemic endemic	Endemism as % of global diversity: all vertebrates (excluding fish)	Freshwater fish ^a
Brazil	524 (131) ^b	1,622 (>191)	468 (172)	517 (294)	3,131 (788)	3.97:1	~3.3	>3,000
Indonesia	515 (201)	1,531 (397)	511 (150)	270 (100)	2,827 (848)	3.33:1	3.5	1,400
Colombia	456 (28)	1,815 (>142)	520 (97)	583 (367)	3,374 (634)	5.32:1	2.6	>1,500
Mexico	450 (140)	1,050 (125)	717 (368)	284 (169)	2,501 (802)	3.12:1	~3.3	468
Australia	282 (210)	751 (355)	755 (616)	196 (169)	1,984 (1,350)	1.47:1	~5.6	183
Madagascar	105 (77)	253 (103)	300 (274)	178 (176)	836 (630)	1.33:1	2.6	75
China	499 (77)	1,244 (99)	387 (133)	274 (175)	2,404 (484)	4.97:1	2.0	1,010
Philippines	201 (116)	556 (183)	193 (131)	63 (44)	1,013 (474)	2.14:1	1.98	330
India	350 (44)	1,258 (52)	408 (187)	206 (110)	2,222 (393)	5.65:1	1.6	750
Peru	344 (46)	1,703 (109)	298 (98)	241 (>89)	2,586 (342)	7.56:1	1.4	855
Papua New Guinea	242 (57)	762 (85)	305 (79)	200 (134)	1,509 (355)	4.25:1	1.5	282
Ecuador	271 (21)	1,559 (37)	374 (114)	402 (138)	2,606 (310)	8.41:1	1.3	>44
United States	428 (101)	768 (71)	261 (90)	194 (126)	1,651 (388)	4.34:1	1.6	790
Venezuela	288 (11)	1,360 (45)	293 (57)	204 (76)	2,145 (189)	11.35:1	0.8	1,250
Malaysia	286 (27)	738 (11)	268 (68)	158 (57)	1,450 (163)	8.90:1	0.7	600
South Africa	247 (27)	774 (7)	299 (76)	95 (36)	1,415 (146)	9.69:1	0.6	153
Dem. Rep. of Congo	415 (28)	1,094 (23)	268 (33)	80 (53)	1,857 (137)	13.55:1	0.6	962

The 17 megadiversity countries have 8,443 species of endemic vertebrates excluding fish, or 33.1% of the global diversity of these groups.

Source: Mittermeier *et al.* (1997).

^a Data on endemism in freshwater fish are not available. Freshwater fish are included only in the total species diversity.

^b Numbers in parentheses refer to endemic species.



Conclusion

The figures and estimates given here are those obtained from the literature (including the internet) and from discussions with a number of experts. In all cases sources are referenced.

Many of the figures are very loose, and no reliability can or should be put on them, especially with the lower groups of plants and animals, invertebrates, fungi, algae and protists. In most cases, I have supplied a maximum and minimum figure, and if one calculated an error based on these figures it would be in the order of about 25% for most groups.

Total figures for most groups are extremely inaccurate as one is adding error to error, and approximations to approximations. However, the figures supplied here are at least as good as those that have arisen from other sources.

Some major differences from previous estimates occur with the vascular plants where I have provided an estimate of about 20,500 species (including naturalised

species) with 17,580 being native species. Previous estimates were in the order of 25,000. The estimate of 50,000 for total fungi species in Australia as suggested in the draft for the 2006 SOE report is, I believe, low, and this is backed up by several experts. Previous estimates of 250,000 may be on the high side, but it appears that a figure somewhere between about 160,000 and 250,000 is realistic. Another difference is in the estimated number of described species of vertebrates in the world, which I give to be around 61,000. This is about 11,000 greater than most previous estimates. The greatest area of unknown in this group is with the fishes.

I have added more detail for some groups than has generally been supplied, and this has helped in determining the numbers for the larger groupings (insects, arachnids, fungi, algae, protists, etc.).

No figures for endemism in Australia have been found for many groups, although some additional figures have been supplied. For the first time, a robust calculation

for endemism in the flowering plants has been made, with estimates of 91% overall, and 91.7% for the Australian mainland determined.

Interestingly, for some of the better known groups (e.g. the vertebrates), it has been difficult to find estimates for the number of undescribed species, however for many of these groups (mammals, birds) it is likely to be quite low.

Acknowledgments

Many people have been very helpful in supplying information to me without hesitation. I would like to acknowledge their assistance. In particular, I would like to thank the ABRs staff, Helen Thompson, Pam Beesley, Patrick McCarthy and Alice Wells for responding to all my queries, and Per de Place Bjørn from the Global Biodiversity Information Facility, who unhesitatingly supplied me with his database of taxa, numbers and references. This information was extremely helpful in finding relevant sources and references. Those people I would like to thank include:

Pam Beesley, Australian Biological Resources Study, Canberra, Australia.

Simon Bennett, ERIN Unit, Department of the Environment and Heritage, Canberra, Australia.

Per de Place Bjørn, Global Biodiversity Information Facility, Copenhagen, Denmark.

Peter Bostock, Queensland Herbarium, Brisbane, Australia.

Christine Cargill, Centre for Plant Biodiversity Research, Canberra, Australia.

Sandra Claxton, NSW, Australia.

William N. Eschmeyer, Catalogue of Fishes, California Academy of Sciences, San Francisco, USA.

Rainer Froese, Fishbase, Leibniz-Institut für Meereswissenschaften, Kiel, Germany.

Cheryl Grgurinovic, Biosecurity Australia, Canberra, Australia.

Caroline Gross, University of New England, Armidale, NSW, Australia.

Michael Guiry, AlgaeBase, National University of Ireland, Galway, Ireland.

Neils Klazenga, Royal Botanic Gardens and National Herbarium of Victoria, Melbourne, Australia.

Reinhardt Kristensen, University of Copenhagen, Copenhagen, Denmark.

Patricia Mather, Queensland Museum, Brisbane, Australia.

Tom May, National Herbarium of Victoria, Melbourne, Australia.

Patrick McCarthy, Australian Biological Resources Study, Canberra, Australia.

Scott Miller, Smithsonian Institution, Washington, USA.

Rich Mooi, Californian Academy of Sciences, San Francisco, USA.

Winston Ponder, Australian Museum, Sydney, Australia.

Karen Sanamyan, Kamchatka Branch of Pacific Inst. of Geography, Kamchatka, Russia.

Helen Thompson, Australian Biological Resources Study, Canberra, Australia.

Peter Uetz, Coordinator EMBL Reptile Database, Germany.

David B. Wake, Museum of Vertebrate Zoology, University of California at Berkeley, USA.

Alice Wells, Australian Biological Resources Study, Canberra, Australia.

Librarian staff, University of Southern Queensland, Toowoomba, Australia.



References

- Abele, L.G. (1982). *The Biology of Crustacea*. Volume 1. *Systematics, the Fossil Record, and Biogeography*. NY: Academic Press.
- ABRS (1998). *The Global Taxonomy Initiative: Shortening the Distance between Discovery and Delivery*. Canberra: Australian Biological Resources Study, Environment Australia, Department of the Environment and Heritage.
- ABRS (2004). *Algae Subprogramme*. Canberra: Australian Biological Resources Study. <http://www.deh.gov.au/biodiversity/abrs/sub-programs/algae/index.html> [Accessed 28 June 2005].
- ABRS (2005a). *Australian Faunal Directory: Estimated Numbers of the Australian Fauna*. Canberra: Australian Biological Resources Study. <http://www.deh.gov.au/biodiversity/abrs/online-resources/fauna/afd/stats-est.html> [Accessed 15 June 2005].
- ABRS (2005b). *Australian Faunal Directory*. Canberra: Australian Biological Resources Study. <http://www.deh.gov.au/biodiversity/abrs/online-resources/fauna/afd/> [Accessed 17 June 2005].
- ABRS (2005c). *Checklist of the Lichens of Australia and its Island Territories*. Canberra: Australian Biological Resources Study. <http://www.anbg.gov.au/abrs/lichenlist/introduction.html> [Accessed 21 Aug. 2005].
- ABRS (2005d). *Flora of Australia*. Canberra: Australian Biological Resources Study—various published volumes as well as *Flora of Australia Online*. <http://www.anbg.gov.au/abrs/online-resources/flora/index.html> [Accessed 23 Sept. 2005].
- ACIL Consulting (2002). Integrated research priorities for algae, protists and fungi with a focus on microorganisms. *A Summary Report for the Australian Biological Resources Study*. <http://www.deh.gov.au/biodiversity/abrs/publications/other/acil/report.html#blue> [Accessed 28 June 2005].
- AmphibiaWeb (2005). *AmphibiaWeb. Information on amphibian biology and conservation*. Berkeley, California: AmphibiaWeb. <http://www.amphibiaweb.org/> [Accessed 15 June 2005].
- Amrine, J. (2005). *Synopsis of the Described Rinulei of the World*. Austin, TX: Department of Entomology, Texas A&M University. <http://insects.tamu.edu/research/collection/hallan/acari/Ricinulei1.htm> [Accessed 20 June 2005].
- ANBG (2004). *Australian Flora and Vegetation Statistics*. Canberra: Australian National Botanic Gardens. <http://www.anbg.gov.au/anbg/australian-flora-statistics.html> [Accessed 21 Aug. 2005].
- Anon. (1994). *Biodiversity: the UK Action Plan*. HMSO, London.
- Australian National Herbarium (ANH), Australian National Botanic Gardens and Australian Biological Resources Study (2005). *What's Its Name?* <http://www.anbg.gov.au/win/index.html> [Accessed 24 Aug. 2005].
- Baldwin, J.G., Nadler, S.A. and Wall, D.H. (2000). Nematodes: Pervading the Earth and Linking all Life. p. 176–191 in Raven, P.H. and Williams, T. (eds) *Nature and Human Society: The Quest for a Sustainable World*. Washington, DC: National Academy Press.
- Birdlife International (2004). *State of the world's birds 2004: indicators for our changing world*. Cambridge, UK: BirdLife International.
- Birdlife International (2005). *More birds slipping towards extinction*. Cambridge, UK: BirdLife International. http://www.birdlife.net/news/news/2005/06/red_list_update.html [Accessed 15 June 2005].
- Bisby, F.A., Ruggiero, M.A., Wilson, K.L., Cachuela-Palacio, M., Kimani, S.W., Roskov, Y.R., Soulier-Perkins, A. and van Hertum, J. (eds) (2005). *Species 2000 & ITIS Catalogue of Life: 2005 Annual Checklist*. CD-ROM. Reading, U.K.: Species 2000. Also available as an on-line searchable database: <http://annual.sp2000.org/2005/search.php> [Accessed 17 June 2005].
- Bramwell, D. (2002). How many plant species are there? *Plant Talk* 28. <http://www.plant-talk.org/stories/28bramw.html> [Accessed 23 Sept. 2005].
- Brazil. Ministry for the Environment (1999). *The Status of Brazilian Biodiversity Chapter 2 in First National Report for the Convention on Biological Diversity – Brazil*. Brasilia: Ministry of the Environment. <http://www.mma.gov.br/port/sbfb/chm/doc/chapter2a.pdf> [Accessed 24 June 2005].
- Brusca, R.C. and Brusca, G.J. (2003). *Invertebrates*. 2nd edn. Sunderland MA: Sinauer Assoc. 936 pp.
- Büchen-Osmond, C. (1988). *Viruses of Plants in Australia*. <http://www.ncbi.nlm.nih.gov/ICTVdb/Aussi/ausiname.htm> [Accessed 29 June 2005].

- Burdon-Jones, C. (1998). *Hemichordata* in Wells, A. and Houston, W.W.K. (eds) (1998). *Zoological Catalogue of Australia*. Vol. 34 *Hemichordata, Tunicata, Cephalochordata*. Melbourne: CSIRO Publishing.
- Cameron, C.B. (2004). *A comprehensive list of extant Hemichordata with links to images*. <http://cluster3.biosci.utexas.edu/faculty/cameronc/Hemichordate.Species.html> [Accessed 16 June 2005].
- Chapman, A.D. (1991). Australian Plant Name Index. *Australian Flora and Fauna Series* Nos. 12–15. Canberra: Australian Government Publishing Service. 3056 pp. Also available as an on-line searchable database <http://www.anbg.gov.au/cpbr/databases/apni.html> [Accessed 29 Aug. 2005].
- Coddington, J.A. and Levi, H.W. (1991). Systematics and evolution of spiders (Araneae). *Annual Review of Ecology and Systematics* 22: 565–592.
- Convention on Biological Diversity (CBD) (2004). *Global Strategy for Plant Conservation. Stakeholder consultation on: Target 1: A widely accessible working list of known plant species, as a step towards completing a world flora*. Facilitated by the Royal Botanic Gardens, Kew, at the request of the CBD Secretariat February 2004. www.plants2010.org/files/2/15/target%201%20updated%202%20feb%2004.doc [Accessed 23 Sept. 2005].
- Convention on Biological Diversity (CBD) (2005). *Global Taxonomy Initiative — Background*. <http://www.biodiv.org/programmes/cross-cutting/taxonomy/> [Accessed 17 June 2005].
- Corliss, J.O. (2000). Biodiversity, Classification, and Numbers of Species of Protists. pp. 130–155 in Raven, P.H. & Williams, T. (eds) *Nature and Human Society: The Quest for a Sustainable World*. Washington, DC: National Academy Press.
- Council of Heads of Australian Herbaria (CHAH) (2005). *Australian Plant Census*. <http://www.chah.gov.au/chah/apc/index.html> [Accessed 23 Sept. 2005].
- Curtis, T.P., Sloan, W.T. and Scannell, J.W. (2002). Estimating prokaryotic diversity and its limits. *Proceedings of the National Academy of Sciences* 99(16): 10494–10499. <http://www.pnas.org/cgi/content/full/99/16/10494> [Accessed 17 June 2005].
- DEH (2005a). *EPBC Act List of Threatened Fauna*. Canberra: Department of the Environment and Heritage. <http://www.deh.gov.au/cgi-bin/sprat/public/publicthreatenedlist.pl?wanted=fauna> [Accessed 15 June 2005].
- DEH (2005b). *EPBC Act List of Threatened Flora*. Canberra: Department of the Environment and Heritage. <http://www.deh.gov.au/cgi-bin/sprat/public/publicthreatenedlist.pl?wanted=flora> [Accessed 15 June 2005].
- DEH (in prep.). *SOE report: species numbers in Australia*. Updated in April 2005 from Table 46 of the 2001 State of the Environment Report. Canberra: Department of the Environment and Heritage.
- De Luna, E., Newton, A.E. and Mishler, B.D. (2003). *Bryophyta*. Tree of Life Web Project. <http://tolweb.org/tree?group=Bryophyta&contgroup=Embryophytes%20Efrain%20De%20Luna,%20Angela%20E.%20Newton,%20and%20Brent%20D.%20Mishler> [Accessed 25 June 2005].
- Donaldson, J. (ed.) (2003). *Cycads. Status Survey and Conservation Action Plan*. IUCN/SSC Cycad Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK.
- Entwistle, T.J. (1997). *Algae* in Scott, G.A.M., Entwistle, T.J., May, T.W. and Stevens, G.N. *A Conservation Overview of Australian Non-marine Lichens, Bryophytes, Algae and Fungi*. Canberra: Department of the Environment and Heritage. <http://www.deh.gov.au/biodiversity/threatened/action/cryptogams/9.html> [Accessed 21 Aug. 2005].
- Entwistle, T.J. & Huisman, J. (1998). Algal Systematics in Australia, *Australian Systematic Botany* 11: 203–214.
- Euzeby, J.P. (2004). *BIOS – Bacteriology Insight Orienting System*. <http://www-sp2000ao.nies.go.jp/english/bios/> [Accessed 28 June 2005].
- Farjon, A. (2001). *World Checklist and Bibliography of Conifers*. 2nd edn. World Checklists and Bibliographies, 3. Royal Botanic Gardens, Kew.
- FishBase (2005). *FishBase. A Global Information System on Fishes*. <http://www.fishbase.org/home.htm> [Accessed 15 June 2005].



- Fox, R. (2005). *Invertebrate Anatomy OnLine. Thelyphonus. Whip Scorpion*. <http://www.lander.edu/rsfox/310ThelyphonusLab.html> [Accessed 20 June 2005].
- Frost, D.R. 2004. *Amphibian Species of the World: an Online Reference*. Version 3.0 (22 Aug. 2004). Electronic Database accessible at <http://research.amnh.org/herpetology/amphibia/index.html>. American Museum of Natural History, New York. [Accessed 15 June 2005].
- Gaston, K.J. and Blackburn, T.M. (1997). How many birds are there? *Biodiversity and Conservation* 6: 615–625.
- GBIF (2005a). *ECAT. Electronic Catalogue of Names of Known Organisms*. Copenhagen: Global Biodiversity Information Facility. <http://www.gbif.org/prog/ecat> [Accessed 17 June 2005].
- GBIF (2005b). *The ECAT Gap Analysis*. Copenhagen: Global Biodiversity Information Facility. http://www.gbif.org/prog/ecat/gap_analysis [Accessed 17 June 2005].
- Geoffroy, J.-J. (2001). *Diplopoda // Chilopoda // Pauropoda // Symphya // & also Onychophoras*. Centre International de Myriapodologie. <http://www.mnhn.fr/assoc/myriapoda/> [Accessed 20 June 2005].
- Govaerts, R. (2002). How many species of seed plants are there? *Taxon* 50: 1085–1090.
- Groombridge, B. and Jenkins, M.D. (2002). *World Atlas of Biodiversity*. Prepared by the UNEP World Conservation Monitoring Centre. University of California Press, Berkeley, USA.
- Guidetti, R. and Bertolani, R. (2005). Tardigrade taxonomy: an updated check list of the taxa and a list of characters for their identification. *Zootaxa* 845: 1–46.
- Guiry, M.D., Nic Dhonncha, E. and Rindi, F. (2005). *AlgaeBase version 3.0*. World-wide electronic publication, National University of Ireland, Galway. <http://www.algaebase.org> [Accessed 28 June 2005].
- Halliday, R.B., O'connor, B.M. and Baker, A.S. (2000). Global Diversity of Mites pp. 192–203 in Raven, P.H. and Williams, T. (eds) *Nature and Human Society: The Quest for a Sustainable World*. Washington, DC: National Academy Press.
- Hallingbäck, T. and Hodgetts, N. (2000). *Mosses, Liverworts, and Hornworts: Status Survey and Conservation Action Plan for Bryophytes*. (IUCN/SSC Bryophyte Specialist Group, eds.). Cambridge, UK: IUCN.
- Hammond, P.M. (1992). *Species inventory* pp. 17–39 in Groombridge, B. (ed.) *Global biodiversity: Status of the earth's living resources*. London: Chapman and Hall.
- Hammond, P.M. (1995). The current magnitude of biodiversity pp. 113–128 in Heywood, V.H. (ed.) *Global biodiversity assessment*. Cambridge, UK: Cambridge University Press.
- Harvey, M.S. (2002). The neglected cousins: what do we know about the smaller arachnid orders? *Journal of Arachnology* 30: 352–372.
- Harvey, M.S. (2003). *Catalogue of the Smaller Arachnid Orders of the World – Amblypygi, Uropygi, Schizomida, Palpigradi, Ricinulei and Solifugae*. Collingwood, Vic. CSIRO Publishing.
- Hassler, M. and Swale, B. (2002). *Checklist of the Ferns of the World*. <http://homepages.caverock.net.nz/~bj/fern/> [Accessed 27 June 2005].
- Hawksworth, D.L. (1991). The fungal dimension of biodiversity: magnitude, significance, and conservation. *Mycological Research* 95: 641–655.
- Hawksworth, D.L. and Colwell, R.R. (1992). Biodiversity amongst microorganisms and its relevance. *Biodiversity and Conservation* 1: 221–345.
- Hawksworth, D.L. and Kalin-Arroyo, M.T. (1995). Magnitude and Distribution of Biodiversity pp. 107–191 in Heywood, V. (ed.) (1995). *Global biodiversity assessment*. Cambridge, UK: Cambridge University Press.
- Healey, J. (ed.) (2001). Biodiversity. *Issues in Science* Vol. 145. Thirroul, NSW: The Spinney Press.
- Helzner, C. (2002). *Bryophyta*. http://www.personal.psu.edu/users/c/a/cah288/Bryophyta_CynthiaHelzner_BIOL110H.htm [Accessed 25 June 2005].
- Hickman, C.P. and Roberts, L.S. (1994). *Biology of Animals*, Sixth Edition. Dubuque, Iowa, USA: Wm.C.Brown Publishers.

- Hickman, C.P., Roberts, L.S., Larson, A. and I'Anson, H. (2004). *Integrated Principles of Zoology*. 12th edn. Boston, MA: McGraw Hill. 872 pp.
- Hill, K. (1998a). 'Gymnosperms'—The Paraphyletic Stem of Seed Plants. *Flora of Australia* 48: 505–525. Melbourne: ABR/CSIRO Australia.
- Hill, K. (1998b). Pinophyta. *Flora of Australia* 48: 545–596. Melbourne: ABR/CSIRO Australia.
- Hill, K. (1998c). Cycadophyta. *Flora of Australia* 48: 597–661. Melbourne: ABR/CSIRO Australia.
- Hill, K. (2004). *The Cycad Pages. Introduction to Cycads*. Sydney: Royal Botanic Gardens. <http://plantnet.rbgsyd.gov.au/PlantNet/cycad/cycintro.html> [Accessed 27 June 2005].
- Hoffmann, R.L. (1982). Chilopoda. pp. 681–688 in Parker, S. (ed.) *Synopsis and Classification of Living Organisms*. New York : McGraw-Hill Vol. 2
- Hooper, J.N.A. and Wiedenmayer, F. (1994). Porifera in Wells, A. and Houston, W.W.K. (eds) *Zoological Catalogue of Australia*, Vol. 12. Melbourne: CSIRO Australia. 624 pp.
- ICTV (2002). *The Universal Virus Database of the International Committee on Taxonomy of Viruses*. <http://www.ncbi.nlm.nih.gov/ICTVdb/index.htm> [Accessed 28 June 2005].
- IUCN (2004). *The IUCN Red List of Threatened Species. Summary Statistics*. <http://www.redlist.org/info/tables/table1.html> [Accessed 15 June 2005].
- Kirschner, J. and Kaplan, Z. (2002). Taxonomic manuscripts in relation to global red lists. *Taxon* 51(1): 155–158.
- Kott, P. (1998). *Tunicata* in Wells, A. and Houston, W.W.K. (eds) (1998). *Zoological Catalogue of Australia*. Vol. 34 *Hemichordata, Tunicata, Cephalochordata*. Melbourne: CSIRO Publishing.
- Lepp, H. (2003). *Truffle-like fungi in Australia*. Australian National Botanic Gardens Fungi Web Site. <http://www.anbg.gov.au/fungi/truffle-like.html> [Accessed 28 June 2005].
- Lowry, J.K. et al. (1999 onwards). 'Crustacea, the Higher Taxa: Descriptions, Illustrations, Identification, and Information Retrieval.' Version: 2 October 1999. <http://crustacea.net/> [Accessed 20 June 2005].
- Mabberley, D.J. (1997). *The Plant-Book. A portable dictionary of the higher plants*. 2nd end. Cambridge University Press, Cambridge.
- May, R.M. (1998). How many species are there on earth? *Science* 241(4): 1441–1449. <http://infoserver.ciesin.org/docs/002-253/002-253.html> [Accessed 15 June 2005].
- May, R.M. (2000). The Dimensions of Life on Earth. pp. 30–45 in Raven, P.H. & Williams, T. (eds) *Nature and Human Society: The Quest for a Sustainable World*. Washington, DC: National Academy Press.
- May, T. (2003). The number of Australian macrofungi: an estimate and prospects for documentation. *Abstract from: 150th Conference / 6th Australasian Mycological Society Conference, Melbourne, 2nd October 2003*.
- May, T. and Grgurinovic, C. (1995). Fungal Conservation in Australasia. *Fungi and Conservation Newsletter* No. 3: 6. IUCN. http://www.rbg.vic.gov.au/iucnsscfungi/_data/page/507/FAC4.pdf [Accessed 28 June 2005].
- Mayo, M.A., Maniloff, J., Desselberger, U., Ball, L.A. and Fauquet, C.M. (eds) (2005). *Virus Taxonomy: VIIIth Report of the International Committee on Taxonomy of Viruses*. 2nd edn. Academic Press.
- McCarthy, P.M. (2003). Catalogue of Australian Species of Liverworts and Hornworts. *Flora of Australia Supplementary Series*. No. 21. Canberra: Australian Biological Resources Study.
- McCauley (n.dat.). *Urochordata and Cephalocordata*. [Accessed 15 June 2005].
- McNeely, J.A. et al. (1990). *Conserving the World's Biological Diversity*. International Union for Conservation of Nature and Natural Resources, Gland, Switzerland: Wildlife Research Institute, World Wildlife Fund, Conservation International, and the World Bank, Washington, D.C.
- Meeüs, T. de and Renaud, F. (2002). Parasites within the new phylogeny of eukaryotes. *Trends in Parasitology* 18(6): 247–251. <http://gemi.mpl.ird.fr/cepm/SiteWebESS/Fr/deMeeus/deMeeus&RenaudTIP2002.pdf> [Accessed 29 Aug. 2005].



- Melcher, U. (2005). *Plant Virus Diversity and Ecology*. <http://opbs.okstate.edu/virevol/homepvbe.html> [Accessed 28 June 2005].
- Miller, S.E., Novotny, V. and Basset, Y. (2002). Case studies of Arthropod Diversity and Distribution pp. 407–413 in Chazdon, R.L. and Whitmore, T.C. (eds) *Foundations of Tropical Forest Biology. Classic papers with commentaries*. Chicago: University of Chicago Press.
- Miyajima, K. (2002). *The Biodiversity Crisis*. Winnipeg, Canada: University of Winnipeg. <http://io.uwinnipeg.ca/~simmons/CHAP5598/> [Accessed 29 Aug. 2005].
- Monge-Najera, J. (2000). *The Onychophora of Mexico in Artropodos de Mexico*, volume 2. Universidad Nacional Autonoma de Mexico UNAM, Mexico.
- Mulcrone, R. (2005). 'Echinodermata' (On-line), *Animal Diversity Web*. <http://animaldiversity.ummz.umich.edu/site/accounts/information/Echinodermata.html> [Accessed 17 June 2005].
- Myers, P. (2001a). 'Insecta' (On-line), *Animal Diversity Web*. <http://animaldiversity.ummz.umich.edu/site/accounts/information/Insecta.html> [Accessed 17 June 2005].
- Myers, P. (2001b). 'Diplopoda' (On-line), *Animal Diversity Web*. <http://animaldiversity.ummz.umich.edu/site/accounts/information/Diplopoda.html> [Accessed 17 June 2005].
- Myers, P. (2001c). 'Chilopoda' (On-line), *Animal Diversity Web*. <http://animaldiversity.ummz.umich.edu/site/accounts/information/Chilopoda.html> [Accessed 17 June 2005].
- Myers, P. (2001d). 'Crustacea' (On-line), *Animal Diversity Web*. <http://animaldiversity.ummz.umich.edu/site/accounts/information/Crustacea.html> [Accessed 17 June 2005].
- Myers, P. (2001e). 'Anellida' (On-line), *Animal Diversity Web*. <http://animaldiversity.ummz.umich.edu/site/accounts/information/Annelida.html> [Accessed 23 June 2005].
- Myers, P. (2001f). 'Nematoda' (On-line), *Animal Diversity Web*. <http://animaldiversity.ummz.umich.edu/site/accounts/information/Nematoda.html> [Accessed 23 June 2005].
- Myers, P. (2001g). 'Platyhelminthes' (On-line), *Animal Diversity Web*. <http://animaldiversity.ummz.umich.edu/site/accounts/information/Platyhelminthes.html> [Accessed 23 June 2005].
- Myers, P. (2001h). 'Porifera' (On-line), *Animal Diversity Web*. <http://animaldiversity.ummz.umich.edu/site/accounts/information/Porifera.html> [Accessed 24 June 2005].
- Nielsen, E.S. and Mound, L.A. (2000). Global Diversity of Insects: The Problems of Estimating Numbers. pp. 213–222 in Raven, P.H. & Williams, T. (eds) *Nature and Human Society: The Quest for a Sustainable World*. Washington, DC: National Academy Press.
- Nieuwenhuys, E. (1999). The spider. http://www.xs4all.nl/~harhiem/The_spider.pdf [Accessed 17 June 2005].
- Novotny, V., Basset, Y., Miller, S.E., Weiblen, G.D., Bremer, B., Cizek, L. and Drozd, P. (2002). Low host specificity of herbivorous insects in a tropical forest. *Nature* 416: 841–844.
- Pascoe, I.G. (1990). History of systematic mycology in Australia pp. 259–264 in Short, P.S. (ed.) *History of Systematic Botany in Australia*. South Yarra, Australia: Australian Systematic Botany Society.
- Platnick, N.I. (2005). *The world spider catalog*, version 5.5. American Museum of Natural History, online at <http://research.amnh.org/entomology/spiders/catalog/index.html> [Accessed 17 June 2005].
- Ponder, W., Hutchings, P. and Chapman, R. (2002). *Overview of the Conservation of Australian Marine Invertebrates*. Canberra: Environment Australia. http://www.amonline.net.au/invertebrates/marine_overview/index.html [Accessed 23 June 2005].
- Poore, G.C.B. (1995). Biogeography and diversity of Australia's marine biota. in Zann, L.P. *State of the Marine Environment Report for Australia: The Marine Environment – Technical Annex 1*. Great Barrier Reef Marine Park Authority for the Department of the Environment, Sport and Territories.
- Ramsey, D. (2005). *Rainforest Fungi*. <http://rainforest-australia.com/fungi.htm> [Accessed 28 June 2005].

- Reed, C.F. and Farr, D.F. (1993). *Index to Saccardo's Sylloge Fungorum Volumes I–XXVI IN XXIX 1882–1972*. Darlington, Maryland: Reed Herbarium.
- Richardson, B.J. (1998). *Cephalochordata* in Wells, A. and Houston, W.W.K. (eds) (1998). *Zoological Catalogue of Australia*. Vol. 34 *Hemichordata, Tunicata, Cephalochordata*. Melbourne: CSIRO Publishing.
- Rossmann, A.Y. (2003). A Strategy for an All-Taxa Inventory of Fungal Biodiversity. Chapter 14. pp. 169–194 in Peng, C.-I. and Chou, C.H. (eds) *Biodiversity and Terrestrial Ecosystems. Inst. Botany, Acad. Sinica Monograph Series No. 14*. 1994. <http://nt.ars-grin.gov/sbmlweb/Research/Publications/StrategyATBI/Index.cfm> [Accessed 28 June 2005].
- Rowe, F.W.E. and Gates, J. (1995). *Echinodermata* in Wells, A. and Houston, W.W.K. (eds) *Zoological Catalogue of Australia*. Vol. 33: Melbourne: CSIRO Australia.
- Saunders, D., Beattie, A., Elliott, S., Fox, M., Hill, B., Pressey, B., Veal, D., Venning, J., Maliel, M. and Zammit, C. (1996). Chapter 4: Biodiversity in *Australia: State of the Environment 1996*. Canberra: <http://www.deh.gov.au/soe/soe96/pubs/chap04.pdf> [Accessed 28 June 2005].
- Savary, W. (n.dat.). *WWW.SOLPUGID.COM. A source of information on the arachnid order Solifgae*. <http://www.solpugid.com/index.htm> [Accessed 20 June 2005].
- Scott, F.J. and Marchant, H.J. (eds) (2005). *Antarctic Marine Protists*. Canberra: Australian Biological Resources Study and Australian Antarctic Division.
- Shimura, J. (2004). Bacteriology Insight Orienting System (BIOS) in Bisby, F.A., Froese, R., Ruggiero, M.A. and Wilson, K.L. (eds) *Species 2000 & ITIS Catalogue of Life, Annual Checklist 2004: Indexing the world's known species*. CD-ROM, Species 2000: Los Baños, Philippines.
- Sjöström, A. and Gross, C.L. (submitted manuscript). *Life history characters and phylogeny are correlated with extinction risk in the Australian angiosperms*. 39 pp.
- Snelgrove, P.V.R., Blackburn, T.H., Hutchings, P.A.A., Alongi, D.M., Grassle, J.F., Hummel, H., King, G., Koike, I., Lamshead, P.J.D., Ramsing, N.D. and Solis-Weiss, V. (1997). The importance of marine sediment biodiversity in ecosystem processes. *Ambio* 26: 578–584.
- Swale, B. (2000). *Checklist of World Ferns*. <http://homepages.caverock.net.nz/~bj/fern1.htm> [Accessed 27 June 2005].
- Tangley, L. (1997). How many species are there? *US News and World Report* Aug. 18, 1997. http://www.findarticles.com/p/articles/mi_m1218/is_n7_v123/ai_n12437495 [Accessed 17 June 2005].
- Thorne, R.F. (2002). How many species of seed plants are there? *Taxon* 51: 511.
- University of Auckland (n.dat.). *Bryophytes Overview in New Zealand Plants* http://www.sbs.auckland.ac.nz/info/schools/nzplants/moss_overview.htm [Accessed 25 June 2005].
- Walter, D.E., Krantz, J. and Lindquist, E. (1996). *Acari. The Mites*. Tree of Life website. <http://tolweb.org/tree?group=Acari&contgroup=Arachnida> [Accessed 20 June 2005].
- Walter, K.S. and Gillett, H.J. (eds) (1998). *1997 IUCN Red list of threatened plants*. Compiled by the World Conservation Monitoring Centre. Ixiv + 862 pp. IUCN – The World Conservation Union, Gland, Switzerland and Cambridge, UK.
- Walton, D.W. (ed.) (1988). *Zoological Catalogue of Australia* Vol. 5. *Mammalia*. Canberra: Australian Government Publishing Service.
- Ward, B.B. (2002). How many species of prokaryotes are there? *Proceedings of the National Academy of Sciences* 99(16): 10234–10236. <http://www.pnas.org/cgi/content/full/99/16/10234> [Accessed 17 June 2005].
- Watanabe, M.M. et al. (2004). *BIOS – Bacteriology Insight Orienting System*. <http://www-sp2000ao.nies.go.jp/english/bios/> [Accessed 28 June 2005].
- Wikipedia (2005). *Wikipedia. The Free Encyclopedia*. http://en.wikipedia.org/wiki/Main_Page [Accessed 20 Aug. 2005].



- Williams, J. (2001). Extracts from State of the Environment Report 2001 (Theme Report: Biodiversity). Canberra: Department of the Environment and Heritage. <http://www.deh.gov.au/soe/2001/biodiversity/summary.html#protectingbiodiversity> [Accessed 23 June 2005].
- Wilson, D.E. and Reeder, D.M. (eds) (in press). *Mammal Species of the World. A Taxonomic and Geographic Reference*. 3rd edn. Smithsonian Institution Press, Washington, DC.
- Woese, C.R. (1998). Default Taxonomy. *Proceedings of the National Academy of Sciences* 95: 11043–11046.
- Wong, A. (1999). *Australia's Biodiversity – A Summary*. Hobart, Tasmania: The Wilderness Society. <http://www.wilderness.org.au/campaigns/policy/biodivsum/> [Accessed 21 Aug. 2005].
- Wray, G.A. (1999). Echinodermata. Spiny-skinned animals: sea urchins, starfish, and their allies. *Tree of Life* Web site: <http://tolweb.org/tree?group=Echinodermata> [Accessed 17 June 2005].
- Yeates, D.K., Harvey, M.S. and Austin, A.D. (2003). New Estimates for Terrestrial Arthropod Species-Richness in Australia. *Records of the South Australian Museum Monograph Series Number* 7: 231–242.

Montage Director of National Parks; Australian Institute of Marine Science; David Harasti; Australian National Botanic Gardens; CSIRO Plant Industry; Theresa Ardler.

Watermark Fiona Scott, Sany Molloy, David Thomas, Geraldine Nash — Australian Government Antarctic Division © Commonwealth of Australia.


Pages All photographs are copyright Arthur D. Chapman.

Design template Design Direction.

Layout B.Kuchlmayr, Australian Biological Resources Study (ABRS).

Publisher Australian Biological Resources Study (ABRS).

Printer Goanna Print.



Contacts

For more information about genetic resources management in Commonwealth areas in Australia:
<http://www.deh.gov.au/biodiversity/science/access/index.html>

Or contact:

Director
Genetic Resources Management Policy
Department of the Environment and Heritage
GPO Box 787
Canberra ACT 2601
Australia
Email: grm@deh.gov.au
Fax: +612 6274 2309
Tel: +612 6274 2528

This publication is available online at:

<http://www.deh.gov.au/biodiversity/abrs/publications/other/species-numbers/index.html>

For additional hard copies please contact the Department of the Environment and Heritage, Community Information Unit

Community Information Unit
Department of the Environment and Heritage
GPO Box 787
Canberra ACT 2601
Email: ciu@deh.gov.au
Fax: +612 6274 1970
Freecall: 1800 803 772

or

ABRS (Publications)
GPO Box 787
Canberra ACT 2601
Email: abrs@deh.gov.au
Fax: +612 6250 9448
Tel: +612 6250 9435



Australian Government

Department of the Environment and Heritage