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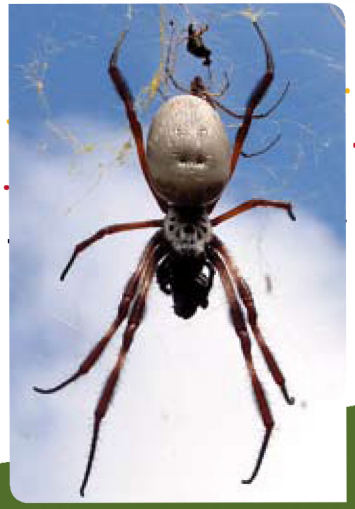
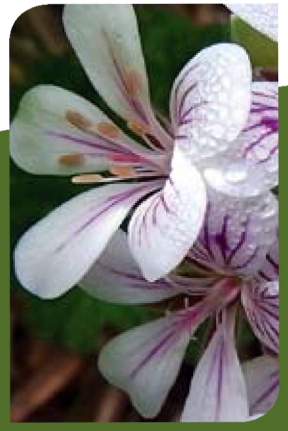
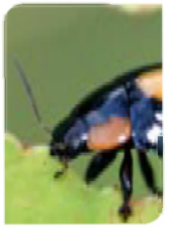






Numbers of Living Species in Australia and the World

2nd edition

Arthur D. Chapman
Australian Biodiversity Information Services
Toowoomba, Australia

Report for the Australian Biological Resources Study
Canberra, Australia
September 2009

australia's nature
there is more still to be discovered…

CONTENTS

FOREWORD

In Australia and around the world, biodiversity is under huge and growing pressure. The pressures are pervasive and chronic in many places — invasive species, habitat loss and climate change in particular.

But there's also good news. Every day we are making exciting new discoveries about the breadth and depth of Australia's biodiversity. Since the first edition of the *Numbers of Living Species in Australia and the World* was produced in 2006, we've discovered 48 reptiles, about 200 new fish species and 1,184 flowering plants.

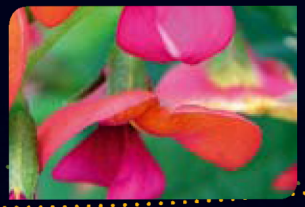
Understanding of the global significance of Australia's biodiversity is also on the increase. This comprehensive review of the endemism of Australia's plants and animals shows that a greater percentage of our plants and animals are found nowhere else in the world. Reptile endemism has jumped from 89 to 93 per cent, mammals from 83 to 87 and frogs from 93 to 94. And close to 92 per cent of our vascular plants, up from 90 per cent, are unique to Australia. It is vital that we forge new and innovative ways of conserving and protecting this unique biodiversity at a landscape level.

Harnessing core science and knowledge bases, like this report, will be key to creating new ways of meeting Australia's biodiversity challenges. Importantly, they provide a benchmark for assessing and monitoring the future effects of climate change on Australia's biodiversity.

As we move into the International Year of Biodiversity in 2010, Australia has the opportunity to show global leadership in biodiversity conservation. This report, the only one of its kind in the world, is a positive start.

Robyn Kruk
Secretary
Department of the Environment, Water, Heritage and the Arts

September 2009



INTRODUCTION

Estimates of the total number of species in the world vary from 5 million to over 50 million (May 1998). In this report figures of close to 11 million species worldwide and about 570,000 for Australia are accepted. Numbers for accepted published species in the world are given here as close to 1,900,000 and 147,579 for Australia.

The number of known species has been estimated by collating information from systematists, taxonomic literature, online resources and previous compilations. Species numbers referred to as 'described' in this report, relate to names of native taxa that have been validly published and are accepted, unless otherwise stated. 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). About 18,000 new species are being described each year (16,969 in 2006 and 18,516 in 2007—the last two years for which figures are available). About 75% of the new species described in 2007 were invertebrates, 11% vascular plants and nearly 7% were vertebrates (Connor 2009).

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 number of known or described 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, rather than being due to the discovery of new species (Groombridge and Jenkins 2002). Recently, molecular systematics has led to an increase in newly discovered species as genetic differences become more apparent. Estimates for the total number of species on earth vary from 3–5 million (Tangley 1997) to 50 million (May 1998) and even to as many as 100 million (Tangley 1997). This report settles on a figure of about 11 million.

In contrast, for groups of organisms that contain individuals that are small, difficult to collect, obscure, or of little direct public or economic interest, the total number of species is difficult to estimate and is likely to be much higher than the number of known described individuals (Hammond 1992, Groombridge and Jenkins 2002). Many of these groups have very few or no systematists working on them, although often there are undescribed species awaiting description in many collections.

Reliable estimates of the total number of species in many of the less well known taxonomic groups are unlikely to be made for many decades, although several 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 2009a) with the mandate to improve taxonomic knowledge through increasing the number of taxonomists and trained curators. 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 2009a) and through the identification and funding of nomenclatural and taxonomic gaps (GBIF 2009a). Other major projects that are looking at documenting names and taxa on a global basis are the *Species 2000*[2] project and the *Integrated Taxonomic Information System* (ITIS)[3] which together produce the annual *Catalogue of Life* listing (Bisby *et al.* 2009). The *International Plant Names Index* (IPNI)[4] documents the names of all vascular plant species, along with information on their place of publication. Recently, the Convention on Biological Diversity has been working on the *Global Strategy for Plant Conservation* (CBD 2009b) and this has led to an attempt to determine the size of the task and hence the number of species.

For the Prokaryota, Protoctista, Chromista and Viruses, estimating the number of species (both known and total) is made difficult by uncertainties in definition of a 'species'. Generally, for these groups species are determined on the basis of features shown in culture (Woese 1998, Ward 2002), and estimation of the total number of species in the world is almost impossible. 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 also difficult. All lists lag well behind discovery and taxonomic revision, and thus are likely to provide under-estimates. 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 IUCN Red Lists of Threatened Species (IUCN 2004, 2009b) and even though these include considerable error (Kirschner and Kaplan 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 lists of nationally threatened species maintained by the Australian Government (DEWHA 2009a, 2009b) under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), each State also maintains its own list. Species listed as threatened in one State may be common in another State. The list maintained by the Australian Government (http://www.environment.gov.au/biodiversity/threatened/index.html) is the only comprehensive list of 'nationally' threatened species. Some States (e.g. Western Australia) also list species under categories additional to those recognised by the International Union for Conservation of Nature (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.

The 2006 report generated considerable discussion and many individual scientists have sent me new information in personal communications. All these have allowed for much more accurate figures and adjustments for many of the estimates.

1 Global Biodiversity Information Facility http://www.gbif.org
2 *Species 2000* http://www.species2000.org
3 *Integrated Taxonomic Information System* http://www.itis.usda.gov/
4 *International Plant Names Index* http://www.ipni.org

In some cases numbers have increased, in others (for example the numbers of published species of insects in Australia) decreased. With the insects, for example, entomologists across Australia have collaborated on an extensive exercise to look at the numbers of insects in each Order (Yeates *et al.* 2003, Raven and Yeates 2007) and other entomologists have worked extensively on some individual Orders (for example, Oberprieler *et al.* (2007), ABRS (2009b)) and this has led to a much more accurate determination of both published numbers and estimates. In the previous report, figures for insects were based on reports at just the Class level as this was all that was consistently available at the time. In addition, international and national online databases and internet lists, including *Trichoptera World Checklist, World Spider Catalog, FishBase, AlgaeBase, AmphibiaWeb*, the *Interactive Catalogue of Australian Fungi*, and the *Australian Plant Census*, have provided valuable species statistics. These online species information systems are constantly being updated and improved, and are rapidly becoming definitive resources on species names and thus on the number of accepted species. They have assisted greatly in providing much more accurate and definitive numbers for this report. Still, many gaps and unknowns exist, and it will be years, if not decades, before we truly know how many species exist and how many are described and accepted as good species.

Many of the figures supplied in this report are estimates only. For each group details are given of how the estimates were determined. 'Unknown' is inserted into the tables of species numbers where no information could be obtained. Estimates of total species in Australia were often not easy to find, as were estimates of percentage endemism for many of the invertebrate groups and non plant and animal phyla. For some groups, estimates were made by suggesting that only a small percentage has been described, thus making the figures for total species just approximate.

The estimate of total species for the world was calculated by adding individual estimates, where cited. For a number of groups ranges are given and for these the upper figure is used for the calculation of totals in the Executive Summary. Throughout this report all textual references to the previous version of this report (first edition) are cited as the 'previous report' (http://www.environment.gov.au/biodiversity/abrs/publications/other/species-numbers/2006/index.html).

Arthur D. Chapman, 2009

EXECUTIVE SUMMARY

Numbers of Living Species in Australia and the World was first published in 2006. It was a collation of information from taxonomic literature, online resources and previous compilations, augmented by discussions with systematists. It is updated and revised in this new edition, taking into account newly published species, and refined estimates and corrections, again with considerable input from the taxonomic community. Insects are subdivided further than before, with separate figures being given for the component orders, and the algae and fungi are rearranged in line with more recent classifications.

The total number of accepted described species in the world is estimated to be close to 1,900,000, well above the 1,786,000 given in 2006. Worldwide, about 18,000 new species are being described each year and for the year 2007, 75% of these were invertebrates, 11% vascular plants and nearly 7% vertebrates.

For Australia a figure of 147,579 accepted described species is now determined, below the 2006 figure of 172,200, and the estimate of the number of species overall is 566,398. The reduction in numbers is due in large part to refinement of the estimates of numbers of insects, and feedback on the earlier edition of this report which led to more extensive collaboration to develop revised estimates. In a coarse breakdown of these figures, the estimates for Australia are 8,128 accepted described chordate species, 98,703 invertebrates, 24,716 plants (including plant algae and bryophytes), 11,846 fungi and around 4,186 in other groups. These figures include new records and newly described species for Australia for the past three years, among them approximately 1,184 vascular plants, 48 reptiles, 8 frogs and 8 mammals, 904 arachnids, 148 myriapods and 60 sponges. Endemism is high in some groups. For example, 41.3% of the chordates are endemic (including 87% of mammals, 45% of birds, 93% of reptiles, 94% of frogs) and some 92% of the vascular plants.

Nationally, the number of Australian species under threat are 246 chordates (3% of chordate species, including 20% of mammals and 14% of amphibians), 1,260 vascular plants (6.5%), 32 invertebrates, two algae and one bryophyte.

Chordates

Brusca and Brusca (2003) estimated that there are 49,693 published and accepted vertebrate species for the world, whereas Groombridge and Jenkins (2002) gave an estimate of 52,000 accepted vertebrate species and an estimate of about 55,000 chordate species in total. Adding up the individual estimates documented in the previous report provided a much higher figure of 60,979 published chordate species (Chapman 2006). This report has again increased that figure, to 64,791—an increase of about 6.2%. The group with the greatest increase was the fishes, but all groups have had new species published since the previous report. The number of published species in Australia has increased from 7,561 to ~8,128 (an increase of 7.5%) again with most of the increase in the number of fish species. It is estimated that just over 40% of Australian chordate species are endemic.

Taxon	World Descr./ Accepted	Australia Descr./ Accepted	Austral. Percent.	Estimate World	Estimate Australia	World Threat.[5]	World Threat. Percent.	Austral. Threat.[6]	Austral. Threat. Percent	% of World's Threat.	Percent. Endemic
Mammals	5,487	386	7.0%	~5,500	~390	1,141	20.8%	78	20.2%	6.8%	87%
Birds	9,990	828	8.3%	>10,000	~900	1,222	12.2%	50	6.0%	4.1%	45%
Reptiles	8,734	917	10.5%	~10,000	~950	423	4.8%	46	5.0%	10.9%	93%
Amphibia	6,515	227	3.5%	~15,000	~230	1,905	29.2%	31	13.7%	1.6%	94%
Fishes	31,153	~5,000	16.0%	~40,000	~5,750	1,275	4.1%	41	0.8%	3.2%	24%
Agnatha	116	5	4.3%	unknown	~10	0	0%	0	0%	–	60%
Cephalochordata	33	8	24.2%	unknown	~8	0	0%	0	0%	–	50%
Tunicata	2,760	757	27.4%	unknown	~850	0	–	0	–	–	50%
TOTAL (2005)	60,979	7,561	12.4%	~71,000	~8,444	5,188	8.5%	247	3.3%	4.8%	39%
TOTAL (2009)	64,788	~8,128	12.5%	~80,500	~9,088	5,966	9.2%	246	3.0%	4.1%	41.3%

5 The IUCN Red List of Threatened Species (2009b).

6 Includes listed Extinct and Vulnerable species (DEWHA 2009a, b).

Invertebrates

The number of published, accepted invertebrate species in the world has increased since the previous report to 1,359,367—largely due to an increase in the number of insects. In this report I have been able to report on the numbers of insects by Order and this has allowed for a more accurate estimate for the total number of species.

By contrast, the estimate for the total number of published insect species in Australia has decreased from approximately 80,000 to 62,000. The estimates for the total numbers of species, however, has altered very little. Estimates for endemism have now been supplied for many more groups, but an overall estimate is still not possible due to the unknowns in most of the larger groups, including the spiders, nematodes and platyhelminths.

Note: Where a range is given in number of species for a group the higher figure of the range is used in this table.

Taxon	World Descr./ Accepted	Australia Descr./ Accepted	Austral. Percent.	Estimate World	Estimate Australia	World Threat.[7]	World Threat. Percent.	Austral. Threat.	Austral. Threat. Percent	% of World's Threat.	Percent. Endemic
Hemichordata	108	17	15.7%	~110	22	0	–	0	–	–	~25%
Echinodermata	7,003	1,475	21.1%	~14,000	~2,000	0	–	0	–	–	31%
Insecta	~1,000,000	~62,000	6.2%	~5,000,000	~205,000	626	0.06%	8	0.01%	1.2%	~70%
Arachnida	102,248	6,615	6.5%	~600,000	31,338	18	0.02%	0	–	0%	unknown
Pycnogonida	1,340	215	16.0%	unknown	unknown	0	–	0	–	–	~50%
Myriapoda	16,072	553	3.4%	~90,000	~3,100	15	0.1%	0	–	0%	86%
Crustacea	47,000	7,266	15.5%	150,000	~9,500	606	1.3%	9	0.1%	1.5%	unknown
Onychophora	165	71	43.0%	~220	~80	9	5.5%	0	–	–	100%
Hexapoda	9,048	338	3.7%	52,000	~2,070	0	–	0	–	–	~17.6%
Mollusca	~85,000	~8,700	10.2%	~200,000	~12,250	978	1.2%	14	0.2%	1.4%	38%
Annelida	16,763	2,192	13.1%	~30,000	~4,230	6	0.04%	1	0.05%	16.7%	67%
Nematoda	<25,000	~2,060	8.2%	~500,000	~30,000	0	–	0	–	–	unknown
Acanthocephala	1,150	56	4.9%	~1,500	~160	0	–	0	–	–	unknown
Platyhelminthes	20,000	1,593	8%	(~80,000)	~10,000	0	–	0	–	–	unknown
Cnidaria	9,795	1,705	17.4%	unknown	~2,200	236	2.4%	0	–	–	unknown
Porifera	~6,000	1,476	24.6%	~18,000	~3,500	0	–	0	–	–	56%
Others	12,673	~2,371	18.7%	~20,000	~5,015	30	0.2%	0	–	0%	unknown
TOTAL (2005)	1,263,600	114,600	9.1%	~5,500,000	~250,000[8]	1,992	0.17%	14	0.01%	0.7%	unknown
TOTAL (2009)	~1,359,365	~98,703	7.3%	~6,755,830	~320,465	2,524	0.2%	32	0.04%	1.3%	unknown

7 The IUCN Red List of Threatened Species (2009b).

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

Plants

In this report, I have included plant algae, including the green algae, red algae and glaucophytes, making a direct comparison with the previous report impossible, however I have added a comparison for plants excluding the algae. Estimates for published species of the Magnoliophyta for the world have increased by about 10,000 since the previous edition, but the estimate for the total number of species has dropped considerably from ~422,000 to ~352,000 in line with recent research.

Taxon	World Descr./ Accepted	Australia Descr./ Accepted	Austral. Percent.	Estimate World	Estimate Australia	World Threat.[9]	World Threat. Percent.	Austral. Threat.	Austral. Threat. Percent.	% of World's Threat.	Percent. Endemic
Bryophyta	16,236	1,847	11.4%	~22,750	~2,200	82	0.4%	1	0.05%	1.2%	25%
Algae (Plant)	12,272	~3,545	~29%	unknown	~3,000	9	0.07%	2	0.06%	22%	unknown
Vascular Plants	281,621	19,324	6.9%	~368,050	~21,645	8,366	3.0%	1,260	6.5%	15%	91.8%
Ferns and allies	*(~12,000)*	*(498)*	*(4.2%)*	*(~15,000)*	*(~525)*	*(139)*	*(1.2%)*	*(41)*	*(8.2%)*	*(29.5%)*	*(33.8%)*
Gymnosperms	*(~1,021)*	*(120)*	*(11.7%)*	*(~1,050)*	*(~120)*	*(323)*	*(31.6%)*	*(17)*	*(14.2%)*	*(5.3%)*	*(96%)*
Magnoliophyta	*(~268,600*	*(18,706)*[10]	*(7.0%)*	*(~352,000)*	*(~21,000)*	*(7,904)*	*(2.9%)*	*(1,202)*	*(6.4%)*	*(15.2%)*	*(93.25%)*
TOTAL 2009	~310,129	~24,716	7.9%	~390,800	26,845	8,457	2.7%	1,263	5.1%	14.9%	~86%
TOTAL 2005 excl. Algae (Plant)	289,000	~20,000	6.9%	~444,000	23,000	8,321	2.9%	1,195	6.0%	14.4%	84%
TOTAL 2009 excl. Algae (Plant)	297,857	21,171	7.1%	~390,800	23,845	8,448	2.8%	1,261	5.9%	14.9%	86%

Fungi

In the previous report, lichens were included as a separate group to the fungi. In this edition the lichens (or more correctly lichen-forming fungi) have been included under the fungi, although the numbers for lichens are included in the table in brackets. A number of groups previously regarded as fungi but which are now regarded as belonging to either Chromista or Protoctista have been excluded from the fungi and included under those groups respectively—in the previous report they were included in the fungi.

Taxon	World Descr./ Accepted	Australia Descr./ Accepted	Austral. Percent.	Estimate World	Estimate Australia	World Threat.[11]	World Threat. Percent.	Austral. Threat.	Austral. Threat. Percent.	% of World's Threat.	Percent. Endemic
Fungi	98,998	11,846	11.9%	1,500,000	50,000	3	>0%	0	0%	0%	unknown
Lichens	*(17,000)*	*(3,495)*	*(20.6%)*	*(~25,000)*	*(~4,500)*	*(2)*	*(0.01%)*	*(0)*	*0%*	*0%*	*(34%)*
TOTAL 2009	98,998	11,846	11.9%	1,500,000	50,000	3	>0%	0	0%	0%	unknown

Others

This group includes mainly single-celled, heterotrophic, eukaryotic organisms. It includes many species that were previously thought to be fungi or algae, but which are now regarded as belonging to Chromista or Protoctista. In the previous report, fungi and lichens were included within this category, but have now been transferred to a separate section. Algae were also included here, but have now been included under plants except for those species more correctly regarded as belonging to the Chromista, Protoctista or Cyanophyta, which are included here under those groups respectively.

Taxon	World Descr./ Accepted	Australia Descr./ Accepted	Austral. Percent.	Estimate World	Estimate Australia	World Threat.[12]	World Threat. Percent.	Australia Threat.[13]	Australia Threat. Percent.	% of World's Threat.	Percent. Endemic
Prokaryota	7,643	~40	0.5%	~1,000,000	40,000	0	–	0	–	–	unknown
Cyanophyta	2,664	270	10%	unknown	~500	0	–	0	–	–	unknown
Chromista	25,044	2,130	8.5%	~200,500	>15,000	6	0.02%	0	0%	0%	unknown
Viruses	2,085	~400	~19.2%	400,000	unknown	0	–	0	–	–	~50%
Protoctista	~28,871	>1,346	4.7%	>1,000,000	~65,000	0	–	0	–	–	unknown
TOTAL 2009	~66,307	>4,186	6.2%	~2,600,500	(~160,000)	6	0.01%	0	0%	0%	unknown

All Species

Taxon	World Descr./ Accepted	Australia Descr./ Accepted	Austral. Percent.	Estimate World	Estimate Australia	World Threat.[14]	World Threat. Percent.	Aust Threat.[15]	Austral Threat. Percent	% of World's Threat.	Percent. Endemic
Chordates	64,788	~8,128	12.5%	~80,500	~9,088	5,966	9.2%	246	3.0%	4.1%	41.3%
Invertebrates	1,359,365	98,703	7.3%	~6,755,830	~320,465	2,524	0.2%	32	0.04%	1.3%	unknown
Plants	310,129	24,716[16]	7.9%	~390,800	26,845	8,457	2.7%	1,263	5.1%	14.9%	86%
Fungi	98,998	11,846	11.9%	1,500,000	50,000	3	>0%	0	0%	0%	unknown
Others	~66,307	>4,186	6.2%	2,600,500	~160,000	6	0.01%	0	0%	0%	unknown
TOTAL 2009	1,899,587	147,579	7.8%	~11,327,630	~566,398	16,956	0.9%	1,541	1.1%	9.1%	unknown

9 The IUCN Red List of Threatened Species (2009b).

10 Does not include 824 undescribed species, but which have been given either manuscript or phrase names.

11 The IUCN Red List of Threatened Species (2009b).

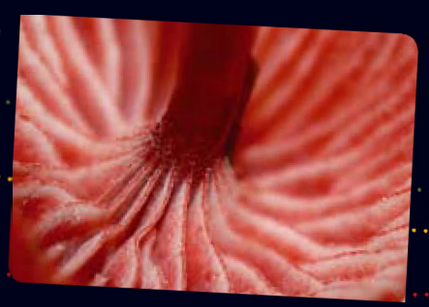
12 The IUCN Red List of Threatened Species (2009b).

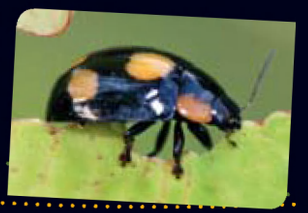
13 Includes listed Extinct and Vulnerable species (DEH 2005). NB This figure includes about 88 undescribed species, and excludes infraspecific taxa.

14 The IUCN Red List of Threatened Species (2009b).

15 Includes listed Extinct and Vulnerable species (DEWHA 2009a, b). Does not include infraspecific or undescribed taxa.

16 Includes an estimate of 3,236–3,545 accepted and described species of plant algae for Australia, and 12,205 for the world. This grouping was not included within the 'Plants' grouping in the previous report, but was treated within 'Algae' under the group 'Others'.





DETAILED DISCUSSION BY GROUP

Chordates

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), 5,416 (IUCN 2004), 5,419 (Wilson and Reeder 2005) to 5,487 (IUCN 2009a). For the purposes of this report, I have accepted the figure of 5,487 which accords well with the most recent figures from The IUCN Red List of Threatened Species although Hilton-Taylor (pers. comm.[17]) suggests that there are several additional recently described species. Although I can find no estimate of the total estimated number of species of mammals, based on the recent rate of description of new species, I estimate that it would be a little over 5,500 species.

Australian mammal species are quite well known and thus the number of described species is relatively stable at 386 in 48 familes and 150 genera (ABRS 2009a) although this number has increased by eight since the last edition. There are also 246 accepted subspecies. Estimates for the number of species yet to be described in Australia is <1%; however, as noted previously, molecular studies may lead to some further splitting. Mammal species are well known, and endemism in Australia was given as 83% in the previous report (calculated from Walton 1988). The percent endemism has been revised to 87% following recalculations based on new species described since 1988.

There are 78 listed threatened species in Australia along with 42 subspecies, forms or populations including four undescribed subspecies (DEWHA 2009a). Of these, 20 species and seven subspecies are listed as Extinct in the Wild, two species and two subspecies as Critically Endangered, 25 species, six subspecies, one form and one population as Endangered and 31 species, 19 subspecies, and six races, forms or populations as Vulnerable.

World Descr./ Accepted min.	World Descr./ Accepted max.	World Descr./ Accepted	World Estimated	Australia Descr./ Accepted	Australia Percent.	Australia Estimated	Australia Endemic	World Threatened[18]	Australian Threatened	Australian Threatened as percentage of World Threatened
4,300	5,487	5,487	~5,500	386	7.0%	~390	87%	1,141 (~20.8%)	78 (20.2%)	6.8%

17 pers. comm. Craig Hilton-Taylor, Manager The IUCN Red List of Threatened Species, IUCN, September 2008.

18 Plus another 1.4% which are regarded as Extinct in the Wild (The IUCN Red List of Threatened Species, 2009b).

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), through 9,750 (Groombridge and Jenkins 2002), 9,875 (BirdLife International 2005), 9,917 (IUCN 2004), 9,946 (Gaston and Blackburn 1997) to 9,990 (IUCN 2009b). I have accepted the figure of 9,990 which is consistent with the most recent figures from BirdLife International (2008) and IUCN (2009b). Total number of species of birds on earth is estimated at around 10,000 (BirdLife International 2004, 2008), although if one accepts the figure of 9,990 already described, this figure would appear a little low.

Australian species of birds are quite well known and thus the number of described extant species is stable at around 828 (Christidis and Boles 2008). An additional 13 species are listed by Christidis and Boles as Extinct in the Wild, and 27 as introduced. Because bird species are so well known, the number of Australian endemic species is also well known at 45% (DEH 2007). I have accepted the species numbers of Christidis and Boles as cited and accepted by Birds Australia (2009)[19]. ABRS (2009a) gives a figure of 869 which must include the Extinct and Introduced species. Including vagrants on the mainland and island territories, we arrive at a figure approaching 900 species (Boles pers. comm. 2009).

There are 50 listed threatened bird species in Australia, and 81 listed subspecies (including one undescribed) (DEWHA 2009a). Of these, nine species and 14 subspecies are listed as Extinct in the Wild, three species and three subspecies as Critically Endangered, 16 species and 25 subspecies as Endangered, and 22 species and 39 subspecies as Vulnerable. Due to a rearrangement of taxonomy, a number of previously listed species now appear as subspecies in accordance with the taxonomy of Christidis and Boles (2008).

World Descr./ Accepted min.	World Descr./ Accepted max.	World Descr./ Accepted	World Estimate	Australia Descr./ Accepted	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened[20]	Australia Threatened	Australian Threatened as percentage of World Threatened
9,000	9,990	9,990	>10,000	828	8.3%	~900	45%	1,222 (~12.2%)	50 (6%)	4.1%

19 *Birds Australia Checklist* (Birds Australia 2009) is derived from Christidis and Boles (2008). http://www.birdsaustralia.com.au/images/stories/birds/checklist2008_sm.pdf [Accessed13 March 2009].

20 The IUCN Red List of Threatened Species (2009b).

Reptilia (reptiles)

Reptiles are also quite a well known group, however the estimate of the number of described species varies considerably, ranging from 6,300 (Tangley 1997), through 8,002 (Groombridge and Jenkins 2002), 8,163 (IUCN 2004), 8,300 (EMBL Reptile Database[21]) to 8,734 (TIGR 2009). I have accepted the figure of 8,734 from the TIGR Reptile Database (TIGR 2009), the figure also accepted in The IUCN Red List of Threatened Species (IUCN 2009b). This is an increase of over 400 species since the previous report. The figures include 168 amphisbaenians, 5,079 lizards, 3,149 snakes, 313 turtles, 23 crocodiles and two tuataras.

The only estimate I have received of the total number of species is from the coordinator of the EMBL Reptile Database[22]. He stated that the number of new species described each year was fairly constant at around 70 per year, and estimated the total number of species at around 10,000.

The number of Australian reptile species has increased considerably in recent years and since the previous report, from 633 (DEH 2001) through 869 (DEH 2007) to 917 (ABRS 2009a). This is an increase of 48 species since 2006. ABRS (2009a) also lists 189 described subspecies. 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 950. Reptile species are well known and endemism is high, reported by Healey (2001) as round 89%. This figure is here revised to 93%.

There are 46 species and seven subspecies listed as threatened in Australia (DEWHA 2009a). The list includes two species listed as Critically Endangered, 11 species and three subspecies as Endangered and 33 species and four subspecies as Vulnerable.

World Descr./ Accepted min.	World Descr./ Accepted max	World Descr./ Accepted	World Estimate	Australia Descr./ Accepted	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened[23]	Australia Threatened	Australian Threatened as percentage of World Threatened
6,300	8,734	8,734	~10,000	917	10.5%	~950	93%	423 (4.8%)	46 (5.0%)	10.9%

21 *EMBL Reptile Database* (Aug. 2005)—http://www.embl-heidelberg.de/~uetz/. [NB This link is no longer operating and is replaced by the *TIGR Reptile Database*, (TIGR 2009)].

22 pers. comm. Peter Uertz, Coordinator, *EMBL Reptile Database*, Aug. 2005.

23 The IUCN Red List of Threatened Species (2009b).

Amphibia (frogs, etc)

Amphibia are also quite a 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), 5,802 (*AmphibiaWeb* 2005), 6,347 (IUCN 2009b) to 6,515 (*AmphibiaWeb* 2009). I have accepted the figure of 6,515 which is consistent with the most recent figures from *AmphibiaWeb* which maintains an up-to-date estimate. A recent paper by Alain Dubois in the journal *Alytes* predicts that there will be about 15,000 species of Amphibia in total (Wake pers. comm.[24]). Recent molecular work has shown considerable divergences between populations of 'species' (Wells pers. comm.[25]) and thus new species are likely to be split off in the future resulting in further increases in numbers both nationally and globally.

Australian amphibian species are quite well known and thus the number of described species is stable at around 227—an increase of just 8 species since the previous report (Doughty pers. comm.[26]). The estimate for the number of species yet to be described in Australia is around 1.5% (DEH 2007) which takes the estimated number of species to around 230. Amphibia are very well known and endemism is extremely high, given by as around 93% by Wong (1999) and DEH (2007). This figure is here revised to 94%.

There are 31 threatened species and one subspecies listed in Australia (DEWHA 2009a). Of these four are listed as Extinct, two Critically Endangered, 14 Endangered and 11 species and one subspecies as Vulnerable.

World Descr./ Accepted min.	World Descr./ Accepted max.	World Descr./ Accepted	World Estimate	Australia Descr./ Accepted	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened[27]	Australia Threatened	Australian Threatened as percentage of World Threatened
4,950	6,515	6,515	~15,000	227	3.5%	~230	94%	1,905 (~29.2%)	31 (13.7%)	1.6%

24 pers. comm. David B. Wake, University of California, Berkeley, May 2009.
25 pers. comm. Alice Wells, Australian Biological Resources Study, Canberra, July 2009.
26 pers. comm. Paul Doughty, Western Australian Museum, March 2009.
27 The IUCN Red List of Threatened Species (2009b).

Pisces (fishes including Chondrichthyes and Osteichthyes[28])

Fish are a less well known group, and the estimate of the number of described species has varied considerably over time, ranging from 25,000 (Groombridge and Jenkins 2002), through 28,900 (*FishBase* 2005) up to the present estimate of 31,153 (*FishBase* 2009 based on Eschmeyer and Fricke 2009). I have accepted the figure of 31,153 which is consistent with the most recent figures from *FishBase* as of March 2009. Eschmeyer (pers. comm.[29]) estimated that in 2005 there were probably around 35,000 species in total but in 2009[30] he stated that over 400 species are currently published every year (Eschmeyer and Frong 2009) and that the total number of species would be close to 32,000. He estimated that there were probably around 40,000 species in total.

Australian species of fish are also reasonably well known, however the number of described species continues to climb, from 4,450–4,500 listed in the previous report (Chapman 2006) to 4,597 (Hoese *et al.* 2005, 2006) and recently to 4,696 with a further 200 species known but as yet unnamed, and this does not include some of the island territories such as Norfolk, Christmas and Cocos/Keeling which would add another approximately 300 species. The rate of growth over the past 40 years is around 50 species a year (Hoese pers. comm.[31]). The number of known species is therefore well over 4,900 and sure to be well above 5,000 before long. Estimates for the number of species yet to be described in Australia is around 15% which takes the estimated number of species to around 5,750.

Endemism in Australia is estimated to be 24% (Hoese *et al.* 2006). Approximately 47% of southern Australia's fishes are endemic to the region. In freshwater fishes endemism is high, given as 61% by Hoese *et al.* (2006). For all fishes in Australia these authors list 4,107 marine, 443 estuarine and 258 freshwater species.

There are 41 listed threatened fish species in Australia (three of which are undescribed). Two listed subspecies and two populations are also listed (DEWHA 2009a). One species is listed as Extinct in the Wild, one Critically Endangered, 17 Endangered, and 24 Vulnerable.

World Descr./ Accepted min.	World Descr./ Accepted max.	World Descr./ Accepted	World Estimate	Australia Descr./ Accepted	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened[32]	Australia Threatened	Australian Threatened as percentage of World Threatened
25,000	31,153	31,153	~40,000	~5,000	16.0%	~5,750	24%	1,275 (4.1%)	41 (0.8%)	3.2%

28 Encompasses Superclass Pisces as used by ABRS (Hoese ***et al***. 2007), and includes a range of paraphyletic groups as recognised by others.
29 pers. comm. Bill Eschmeyer, Catalogue of Fishes, California Academy of Sciences, August 2005.
30 pers. comm. Bill Eschmeyer, Catalogue of Fishes, California Academy of Sciences, May 2009.
31 pers. comm. Doug Hoese, Australian Museum, Sydney, March 2009.
32 The IUCN Red List of Threatened Species (2009b).

Agnatha (hagfish, lampreys, slime eels)

FishBase (2009) lists 74 species of hagfish and 42 species of lamprey for the world. Hickman and Roberts (1994) gave a figure of 70 species for the combined groups. I have accepted the figure of 116 described species as cited by *FishBase*.

ABRS (ABRS 2009a) lists five Australian species in three genera with about another five species undescribed. Of the five species listed for Australia in *FishBase*, three are endemic to Australian waters and one other occurs only in Australian and New Zealand waters.

There are no species listed as threatened in Australia (DEWHA 2009a).

World Descr./ Accepted min.	World Descr./ Accepted max.	World Descr./ Accepted	World Estimate	Australia Descr./ Accepted	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened[33]	Australia Threatened	Australian Threatened as percentage of World Threatened
70	116	116	unknown	5	4.3%	~10	60%	0	0	–

33 The IUCN Red List of Threatened Species (2009b).

Cephalochordata (lancelets)

Very little information could be found on these animals. Three estimates were found, however, for the number of described species worldwide: 20 (McCauley n.dat.), 23 (Groombridge and Jenkins 2002) and 36 species (Ponder *et al.* 2002). The *Catalogue of Life* 2009 Checklist (Bisby *et al.* 2009) lists 33 accepted and one provisionally accepted species. I have accepted this figure.

ABRS (ABRS 2009a) lists eight Australian species in two genera, with about four being endemic (Richardson 1998).

There are no species listed as threatened in Australia (DEWHA 2009a).

World Descr./ Accepted min.	World Descr./ Accepted max.	World Descr./ Accepted	World Estimate	Australia Descr./ Accepted	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened[34]	Australia Threatened	Australian Threatened as percentage of World Threatened
20	36	33	unknown	8	24.2%	~8	50%	0	0	–

34 The IUCN Red List of Threatened Species (2009b).

Tunicata or Urochordata (sea squirts, doliolids, 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), 3,000 (Brusca and Brusca 2003), and 4,900 for Ascideacea alone (Bouchet 2006). Sanamyan (pers. comm.[35]) states that there are 2,590 (±20) described species of ascidian. In addition there are about 100 species of Thaliacea (Kott 2005) and 70 species of Appendicularia[36] making a total for the Subphylum of about 2,760 species.

The previous report listed 754 species for Australia (Chapman 2006). In 2006, this figure was updated to 757 (Kott 2006). About 50% of the Australian species are thought to be endemic.

There are no species listed as threatened in Australia (DEWHA 2009a).

World Descr./ Accepted min.	World Descr./ Accepted max.	World Descr./ Accepted	World Estimate	Australia Descr./ Accepted	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened[37]	Australia Threatened	Australian Threatened as percentage of World Threatened
~1,400	>5,000	2,760	unknown	757	27.4%	~850	50%	–	0	–

35 pers. comm. Karen Sanamyan, Kamchatka Branch of Pacific Institute of Geography, May 2009.

36 MEER Database http://www.meer.org/M20.htm [Accessed 30 June 2009].

37 The IUCN Red List of Threatened Species (2009b).

Invertebrates

Hemichordata (hemichordates)

Burdon-Jones (1998) stated that there are 94 described species in 16 genera in the world, with many more undescribed, and 12 species in seven genera in Australia. Cameron (2008) lists 108 species for the world in three Classes, seven families and 18 genera. This is an increase of two over his 2004 list cited in the previous report. Groombridge and Jenkins (2002) reported c. 90 or 100 species, whereas Brusca and Brusca (2003) gave only 85 species and Bouchet (2006) gave 106.

DEH (2007) 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 108 for the world (Cameron 2008) and 17(22) (DEH 2007) for Australia. The Australian numbers have not increased since the previous report.

There are no listed threatened species for Australia (DEWHA 2009a).

World Descr./ Accepted min.	World Descr./ Accepted max.	World Descr./ Accepted	World Estimate	Australia Descr./ Accepted	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened[38]	Australia Threatened	Australian Threatened as percentage of World Threatened
85	108	108	~110	17	15.7%	22	~25%	0	0	–

38 The IUCN Red List of Threatened Species (2009b).

Echinodermata (starfish, sea cucumbers, etc)

Estimates of the number of described echinoderms in the world vary from about 6,100 (Tangley 1997, Miyajima 2002) through 6,600 (Mooi pers. comm.[40]) to 7,000 (Wray 1999, Groombridge and Jenkins 2002, Brusca and Brusca 2003, Mulcrone 2005, Bouchet 2006). Charles Messing's Crinoid Web (Messing n.dat.) lists 540 for comatulids and ~95 species of stalked crinoids giving a total of ~635 species for Crinoidea. The *World Asteroidea database* (Mah 2009) gives a current figure of 1,859 species for the Asteroidea. The *World Ophiuroidea database* (Stöhr and O'Hara 2007) provides a figure of 2,139 for the Opiuroidea. Follo and Fautin (2001) cited 940 for Echinoidea. The *Tree of Life* (Ker 2000), in a breakdown of Orders, listed 1,430 species of Holuthuroidea—I have found no more recent definitive figures. Adding these figures up gives a total of 7,003.

Estimating the total number of species is a difficult exercise. The main problems appear to be the unknown species of the deep waters, the difficulty in finding and identifying very cryptic species and the enormous potential of molecular studies to 'discover' new species[39]. 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'[40].

The number of Australian described species is placed at around 1,475 (O'Hara pers. comm. 2009[41]). The *Australian Faunal Directory* (ABRS 2009a) and others (Ponder *et al.* 2002) predict that there may be up to 2,000 species in Australian waters. O'Hara (pers. comm.) states that the number of species in the Australian Economic Exclusion Zone is still a large unknown. 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% for Australia as a whole.

There are no listed threatened species.

World Descr./ Accepted min.	World Descr./ Accepted max.	World Descr./ Accepted	World Estimate	Australia Descr./ Accepted	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened[42]	Australia Threatened	Australian Threatened as percentage of World Threatened
6,100	7,003	7,003	~14,000	1,475	21.1%	~2,000	31%	0	0	–

39 pers. comm. Rich Mooi, California Academy of Sciences, 17 June 2005 and 16 March 2009.
40 pers. comm. Rich Mooi, California Academy of Sciences, 17 June 2005.
41 pers. comm. Tim O'Hara, Museum of Victoria, March 2009.
42 The IUCN Red List of Threatened Species (2009b), but note that they do list one 'Near Threatened' species.

Insecta (insects)

Estimates of the number of described insects in the world vary from about 720,000 (May 2000) through 751,000 (Tangley 1997), 800,000 (Nieuwenhuys 1998, 2008), 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 around 2 million (Nielsen and Mound 2000), 5–6 million (Raven and Yeates 2007) to around 8 million (Hammond 1995, 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 have estimated that there could be as many as 100 million beetles alone (Tangley 1997), but this would appear to be a gross over-estimate. In the table below, I have attempted to document the numbers for each of the Orders. This leads to a figure between 965,000 and 1,015,000 so I have adopted a figure here of ~1 million as a mid point. This is consistent with previous estimates, but a little higher than the previous report for the number of described species for the world. I have been unable to get individual estimates for the total number of species by Order except for a few Orders, and have thus accepted the figure of about 5 million as given by Grimaldi and Engel (2005) and Raven and Yeates (2007). This is higher than the 4 million given in the previous report which was based on May (2000). 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).'*

Based on the table below, the number of described species in Australia would appear to be around 62,000 with the total number of species varying from about 195,000 to 215,000. I have accepted the figure of nearly 205,000 given by Yeates *et al.* (2003) and Raven and Yeates (2007). The difference between the numbers is due to the variation in estimates for Coleoptera of 80,000 and 100,000 (Yeates *et al.* 2003).

Little appears to have been written on endemism in Australian insects, however Ridsdill-Smith (2004) stated that '*up to 70% of insects are endemic to Australia.*'

There are eight listed threatened species of insect in Australia and one undescribed subspecies. Three are listed as Critically Endangered, four as Endangered, and one as Vulnerable with the subspecies listed as Endangered (DEWHA 2009a).

Insecta (insects) *continued*

Order	World Descr./ Accepted	Reference	World Estimate	Australia Descr./ Accepted	Reference	Australia Estimate	Reference
Archaeognatha	470	Hallan (2003)		10	ABRS (2009a)	14	Yeates *et al.* (2003)
Blattodea	3,684–4,000	Hallan (2003), ABRS (2009a)		534	ABRS (2009a)	587	Yeates *et al.* (2003)
Coleoptera	360,000–~400,000	CSIRO[43], Oberprieler[44]	1,100,000	22,901	Yeates *et al.* (2003)	80,000–100,000	Yeates *et al.* (2003), Oberprieler[45]
Dermaptera	1,816	Hallan (2003)		91	ABRS (2009a)	121	Yeates *et al.* (2003)
Diptera	152,956	Thompson 2008	240,000[46]	7,482	ABRS (2009a)	30,000	Yeates *et al.* (2003), Austin *et al.* (2004)
Embioptera	200–300	ABRS (2009a), Wikipedia[47]	2,000	26	ABRS (2009a)	28	Yeates *et al.* (2003)
Ephemeroptera	2,500–<3,000	Wikipedia[48], ABRS (2009a)		113	ABRS (2009a)	333	Yeates *et al.* (2003)
Grylloblattaria	24	Hallan (2003)		0		0	
Hemiptera	80,000–88,000	Discover Life[49], Hallan (2003)		5,150–~6,000	ABRS (2009a)	11,580	Yeates *et al.* (2003)
Hymenoptera	115,000	Hymenoptera Online Database[50]	>300,000	9,155	ABRS (2009a)	44,000	Yeates *et al.* (2003), Austin *et al.* (2004)
Isoptera	2,600–2,800	Wikipedia[51], Hallan (2003)	4,000[51]	263[52]	ABRS (2009a)	455	Yeates *et al.* (2003)
Lepidoptera	174,250	Lepidoptera Taxome Project[53]	300,000–500,000[54]	10,586	Yeates *et al.* (2003)	20,000	Yeates *et al.* (2003)
Mantodea	2,200	Encyclopedia Britannica[55]		105	ABRS (2009a)	114–160	Yeates *et al.* (2003), ABRS (2009a)
Mecoptera	481	Hallan (2003)		30	ABRS (2009a)	30	Yeates *et al.* (2003)
Megaloptera	250–300	Hallan (2003), ABRS (2009a)		26	ABRS (2009a)	26	Yeates *et al.* (2003)
Neuroptera	~5,000	ABRS (2009a)		553–>600	ABRS (2009a)	800	Yeates *et al.* (2003)
Odonata	6,500	Trueman & Rowe (2008)		321	ABRS (2009a)	330	Yeates *et al.* (2003)
Orthoptera	24,380	Eades & Otte (2009)		1,835	Yeates *et al.* (2003)	2,800	Yeates *et al.* (2003)
Phasmatodea (Phasmida)	2,500[56]–3,300	ABRS (2009a), Hallan (2003)		105	ABRS (2009a)	115–150	Yeates *et al.* (2003), ABRS (2009a)
Phthiraptera	>3,000–~3,200	Smith & Page (1997), ABRS (2009a)		465	ABRS (2009a)	648	Yeates *et al.* (2003)
Plecoptera	2,274	Hallan (2003)		192	ABRS (2009a)	196	Yeates *et al.* (2003)
Psocoptera	3,200–~3,500	Hallan (2003), ABRS (2009a)		293	ABRS (2009a)	293 plus many more	ABRS (2009a)
Siphonaptera	2,525	ABRS (2009a)		84	ABRS (2009a)	92	Yeates *et al.* (2003)
Strepsiptera	596	Kathirithamby (2002)		42	ABRS (2009a)	58–159	Yeates *et al.* (2003), ABRS (2009a)
Thysanoptera	~6,000	ABRS (2009a)		750	ABRS (2009a)	~1500	ABRS (2009a)
Trichoptera	12,627	Trichoptera World Checklist[57]		719	ABRS (2009a)	800	Yeates *et al.* (2003)
Zoraptera	28	Hallan (2003)		1	ABRS (2009a)[58]	1	–
Zygentoma (Thysanura)	370	Mendes (2002)		36	ABRS (2009a)	38	Yeates *et al.* (2003)
TOTAL	965,431–1,015,897			61,868–62,765		~194,959–215,141	

World Descr./ Accepted min.	World Descr./ Accepted max.	World Descr./ Accepted	World Estimate	Australia Descr./ Accepted	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened[59]	Australia Threatened	Australian Threatened as percentage of World Threatened
720,000	>1,000,000	~1,000,000	~5,000,000	~62,000	6.2%	~205,000	up to 70%	626 (0.06%)	8 (0.01%)	1.2%

43 CSIRO: Beetle Research. http://www.csiro.au/science/Beetle-Research.html [Accessed 18 March 2009].

44 Oberprieler *et al.* (2007) and pers. comm., November 2008. Oberprieler's figures included 62,000 and 220,000 for the number of described and estimated species of Curculionoidea weevils respectively with 4,188 described for Australia out of an estimated 20,000 species.

45 Oberprieler *et al.* (2007) and pers. comm., November 2008.

46 *Wikipedia* (2009): Diptera. http://en.wikipedia.org/wiki/Diptera [Accessed 18 March 2009].

47 *Wikipedia* (2009): Embioptera. http://en.wikipedia.org/wiki/Embioptera [Accessed 18 March 2009].

48 *Wikipedia* (2009): Ephemeroptera. http://en.wikipedia.org/wiki/Mayfly [Accessed 18 March 2009].

49 *Discover Life* (2009): Hemiptera. http://www.discoverlife.org/mp/20o?search=Hemiptera [Accessed 18 March 2009].

50 *Hymenoptera Online Database* http://osuc.biosci.ohio-state.edu/HymOnline/ [Accessed on 18 March 2009].

51 *Wikipedia* (2009): Termite. http://en.wikipedia.org/wiki/Termite [Accessed 18 March 2009].

52 At least 348 species now recognised, but many as yet to be formally described (ABRS 2009a).

53 *Taxonomy of the Lepidoptera: the scale of the problem*. http://www.ucl.ac.uk/taxome/lepnos.html [Accessed 18 March 2009].

54 *Moth and butterfly (Lepidoptera). research at CSIRO* http://www.csiro.au/science/ps1e7.html [Accessed 18 March 2009].

55 *Encyclopedia Britannica* http://www.britannica.com/EBchecked/topic/362942/mantid [Accessed 18 March 2009].

56 Many species may have been described twice as males and females can be vastly different (Kevan 1982 from ABRS 2009a).

57 *Trichoptera World Checklist* http://entweb.clemson.edu/database/trichopt/ [Accessed 18 March 2009].

58 The one species described for Australia occurs only on Christmas Island.

59 The IUCN Red List of Threatened Species (2009b).

Arachnida (spiders, scorpions, etc)

Estimates of the number of described arachnids vary from 60,000 (Myers 2001a, Brusca and Brusca 2003) through 70,000 species (Nieuwenhuys 1999), 74,000 (Groombridge and Jenkins 2002), 75,000 (Hawksworth and Kalin-Arroyo 1995, May 2000), 98,000 (Chapman 2006) to 102,248 (this report). There do not seem to be many estimates for the total numbers 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 number of described arachnid species is to make a breakdown of the various Orders. Spiders are probably the best known, and Nieuwenhuys (2008) gives 40,462 species while Platnick (2008) lists 40,700 described species in *The World Spider Catalog*. One of the largest of the arachnid groups includes the mites and ticks (Acarina) 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 Halliday *et al.* 2000) varied from 17,500 to 30,000. Other Orders include Amblypygi (136 (Harvey 2003)), Opiliones (around 5,000 species (Myers 2001a), 6,400 (Pinto-da-Rocha *et al.* 2007)), Palpigradi (c. 78 (Harvey 2003), to 80 species[60]), Pseudoscorpionida (>3,300 species[61]), Ricinulei (57 species (Amrine 2005)), Schizomida (>230[62]), Scorpionida (1,764 (Rein 2009)), Solifugae (1,095 (Savary 2006)) and Uropygi (286 (Fox 2006)). Summation of these figures gives a total of over 102,248 described species, considerably higher than the estimates cited above, with estimates of the total number of species varying between 160,000 and 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 are likely to include many more species. Their final estimate for the total Australian mite species was in excess of 20,000 species.

ABRS (ABRS 2009a) reports numbers of described and estimated Australian species as shown in the following table, except for the number of 10,000 for the estimated Araneae which comes from Raven (pers. comm.[63]) who stated that the figure of 20,000 in Yeates *et al.* (2003) was a gross over-estimate. Raven also supplied an updated figure of 3,300 for the number of described species of Araneae. Estimates for the total number of the described Australian Arachnid fauna varies from 5,666 (DEH 2001) through 5,711 (DEH 2007) to 6,615 (this publication) and for the total number of Arachnid fauna from 20,937 (using Halliday's number for the Acarina) through 22,838 (this publication) to 27,837 (using the ABRS figure for the Acarina) and 27,960 (previous report). Harvey (pers. comm.[64]) agrees that this is a good summary of current knowledge. No estimates of the percentage of Australian endemics has been found.

There are no species of spider listed as threatened for Australia (DEWHA 2009a).

60 *Wikipedia* (2000): Palpigradi. http://en.wikipedia.org/wiki/Palpigradi [Accessed 23 March 2009].
61 *Wikipedia* (2000): Pseudoscorpion. http://en.wikipedia.org/wiki/Pseudoscorpiones [Accessed 23 March 2009].
62 *Wikipedia* (2005): Schizomida. http://en.wikipedia.org/wiki/Schizomida [Accessed 23 March 2009].

Order	World Described	World Estimated	Australian Described	Australian Estimated
Acarina	48,200	~100,000–500,000	2,851	20,000
Amblypygi	136	150	5	10
Araneae	40,700	80,000[65]	3,300	10,000
Opiliones	6,400	10,000	199	500
Palpigradi	<80	unknown	3	3
Pseudoscorpionida	~3,300	unknown	161	600
Ricinulei	57	unknown	0	0
Scorpionida	1,764	~2,400	43	150
Schizomida	>230	unknown	53	75
Solifugae	1,095	unknown	0	0
Uropygi	286	unknown	0	0
TOTAL	~102,248	~200,000–600,000	6,615	31,338

World Descr./ Accepted min.	World Descr./ Accepted max.	World Descr./ Accepted	World Estimate	Australia Descr./ Accepted	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened[66]	Australia Threatened	Australian Threatened as percentage of World Threatened
60,000	102,248	102,248	200,000–600,000	6,615	6.5%	31,338	unknown	18 (0.02%)	0	0%

63 pers. comm. Robert Raven, Queensland Museum, March 2009.

64 pers. comm. Mark Harvey, Western Australian Museum, July 2009. With reference to Harvey (2002), Harvey (2007), Harvey (2009).

65 Raven and Yeates (2007) reporting a pers. comm. from N.I.Platnick (2004).

66 The IUCN Red List of Threatened Species (2009b).

Pycnogonida (sea spiders)

There are around 1,340 described species of Pycnogonida in the world (Arango pers. comm.[67]). Bamber and Nagar (2009) list 1,308 species (as of early April 2009), but this does not include the recently described Australian species.

A recent study by Arango at the Queensland Museum (Arango pers. comm.[67]) has identified 215 species for Australia, and predicts that this number will increase rapidly with many newly discovered species. Examining the species listed in the *Australian Faunal Directory* (ABRS 2009a), just under 50% are identified as endemic. This figure will increase with the addition of the newly described species.

No species are identified as threatened in Australia at this stage (DEWHA 2009a).

World Descr./ Accepted min.	World Descr./ Accepted max.	World Descr./ Accepted	World Estimate	Australia Descr./ Accepted	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened[68]	Australia Threatened	Australian Threatened as percentage of World Threatened
1,300	1,340	1,340	unknown	215	16.0%	unknown	~50%	0	0	–

67 pers. comm. Claudio Arango, Queensland Museum, April 2009.

68 The IUCN Red List of Threatened Species (2009b).

Myriapoda (millipedes, 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 lower than the ABRS estimate of 2,800 (DEH 2007).

There are no myriapod species listed as threatened in Australia (DEWHA 2009a).

Chilopoda (centipedes)

Estimates of the number of described species of Chilopoda vary from 2,500 (Hoffman 1982, Myers 2001c) through 2,800 (Brusca and Brusca 2003) to about 5,000 (Nieuwenhuys 2008). I have accepted the figure of 3,149 in 429 genera for the world as cited in *Chilobase* (Bonato *et al.* 2006). ABRS (2009a) lists 131 species of Chilopoda for Australia and a number have been added recently (Edgecombe pers. comm.[69]). Yeates *et al.* (2003) provided an estimate of about 446 for total species in Australia. Calculations from ABRS (2009a) and Edgecombe (pers. comm.[69]) lead to a figure of around 81.4% endemism.

Diplopoda (millipedes)

Estimates of the number of described species of Diplopoda vary from 5,000 (Nieuwenhuys 2008) through 8,000 (Myers 2001b, Brusca and Brusca 2003), 10,000 (Geoffroy 2001) to 12,000 (Sierwald and Bond 2007). I have accepted the figure of 12,000 as given by Sierwald and Bond (2007) as this appears to be 'very solid' (Mesibov pers. comm.[70]). Geoffroy (2001) estimated the total number of species at betweeen 80,000 and 90,000. These figures appear to be based on Hoffman (1980) and are regarded as probably an under-estimate (Mesibov pers. comm.[70]). Mesibov (2008 and pers. comm.[70]) provides figures of 366 species for Australia and an estimate of around 2,000 in total. Endemism in the 230 species listed in ABRS (2009a) is 91.3%.

Pauropoda (centipede-like arthropods)

The number of described Pauropoda of the world is between 500 (Brusca and Brusca 2003) and 715 (ABRS 2009a), with 18 species described for Australia (55% of which are endemic), but with an estimated total number of >500 (ABRS 2009a). I have accepted the ABRS figure of 715 for the world.

Symphyla (glasshouse symphylans)

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 2009a). Brusca and Brusca (2003) estimated that there are 160 species and Hallan (2003) gave 208 species.

ABRS (2009a) listed 26 species for Australia, of which 24 are endemic, and estimates about 150 species in total. Yeates *et al.* (2003) provided a figure of 29 described species with 200 for the total number of species.

69 pers. comm. Greg Edgecombe, Natural History Museum, London, UK, March 2009.

70 pers. comm. Bob Mesibov, Queen Victoria Museum and Art Gallery, Launceston, Tasmania, March 2009.

Myriapoda (millipedes, centipedes) *continued*

	World Descr./ Accepted min.	World Descr./ Accepted max.	World Descr./ Accepted	World Estimate	Australia Descr./ Accepted	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened[71]	Australia Threatened	Australian Threatened as percentage of World Threatened
Chilopoda	2,500	5,000	3,149	unknown	140	4.0%	446	81.4%		0	
Diplopoda	5,000	12,000	12,000	80,000–90,000	366	2.9%	2,000	91.3%		0	
Pauropoda	500	715	715	unknown	18	2.5%	>500	55.5%		0	
Symphyla	160	208	208	unknown	29	13.9%	150	92.3%		0	
Total	8,160	17,923	16,072	~90,000	553	3.4%	~3,100	86.0%	15 (0.1%)	0	0%

71 The IUCN Red List of Threatened Species (2009b).

Crustacea (crabs, lobsters, etc)

The estimated number of described species of Crustacea in the world varies from 25,000 (Nieuwenhuys 2008), 30,000 (Myers 2001d), >30,000 (Ponder *et al.* 2002), 38,732 (Hallan 2003), 40,000 (with 38,000 marine species) (Hawksworth and Kalin-Arroyo 1995, May 2000, Groombridge and Jenkins 2002), 44,950 marine species (Bouchet 2006), 52,000+ (Martin and Davis 2001, Wikipedia[72]) to 68,171 (Brusca and Brusca 2003). I have accepted a figure of approximately 47,000 described species based on the detailed breakdown given by Bouchet (2006), and adding the approximate 2,000 non-marine species (including 1,608 Ostracoda). One of the big increases since the previous report appears to be with the Ostracoda where Bouchet gives 6,400 marine species plus 1,608 non-marine species as opposed to 5,650 given by Abele (1982) and 10,000–15,000 by Martin and Davis (2001). The recently published checklist of Brachyuran Crabs (Ng *et al.* 2008) gives a figure of 6,793 (species and subspecies) for the crabs. It would appear, however, that there are very few accepted subspecies in the list so 6,793 is fairly close to the number of species. Wilson (2008) states that there are about 950 described species of freshwater isopod crustaceans with another possible 1,400 species remaining to be described out of a total of about 10,300 in all habitats. Further information on individual taxa can be found in *Crustacea.net* coordinated by the Australian Museum (Lowry *et al.* 1999 onwards). The *World List of Marine, Freshwater and Terrestrial Isopod Crustaceans* lists 5,300 species of marine and freshwater isopod crustaceans from 10,659 names (Schotte *et al.* 2009).

The estimated total number of world species is 150,000 (May 2000, Groombridge and Jenkins 2002) with a range of 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.

In 2007, DEH gave an estimate 7,130 described species for Australia and a total number of 9,500 species. The number given by ABRS (2009a) is 6,467 excluding barnacles and a further 799 species are now known for the Australian fauna. This brings the total number of accepted described species to 7,266.

Overall endemism is unknown, however a count of the Decapoda produced a figure of 25.9% endemism for Australia; and some 69% of Branchiopoda are endemic.

Nine crustacea are listed as threatened species in Australia—two are listed as Critically Endangered, three as Endangered and four as Vulnerable (DEWHA 2009a).

World Descr./ Accepted min.	World Descr./ Accepted max.	World Descr./ Accepted	World Estimate	Australia Descr./ Accepted	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened[74]	Australia Threatened	Australian Threatened as percentage of World Threatened
25,000	68,171	47,000	150,000	7,266	15.5%	~9,500	unknown	606 (1.3%)	9 (0.1%)	1.5%

72 *Wikipedia* (2009): Crustacean. http://en.wikipedia.org/wiki/Crustacean [Accessed 19 May 2009].

73 pers. comm. Peter Davie, Queensland Museum, March 2009.

74 The IUCN Red List of Threatened Species (2009b).

Onychophora (velvet worms)

The number of described species of Onychophora would appear to be around 165, with estimates varying from about 70 (Hickman *et al.* 2004), 100 (Groombridge and Jenkins 2002), 110 (Brusca and Brusca 2003, Hallan 2003, Peripatus Web[75]), about 120 (Monge-Najera 2000), 155 (Wikipedia[76]) to about 200 (Geoffroy and Ruhberg 2006). Reid in the *Australian Faunal Directory* (ABRS 2009a) states that there are 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 many of the other estimates. Estimates for the total fauna include about 200 (Geoffroy 2001), 220 (Brusca and Brusca 2003) and 300 (Wikipedia[84]).

In Australia, ABRS (DEH 2007, ABRS 2009a) estimated that there are about 71 described species with perhaps another nine undescribed species. It appears that all 71 are endemic to Australia (ABRS 2009a).

There are no species of Onychophora listed as threatened for Australia (DEWHA 2009a).

World Descr./ Accepted min.	World Descr./ Accepted max.	World Descr./ Accepted	World Estimate	Australia Descr./ Accepted	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened[77]	Australia Threatened	Australian Threatened as percentage of World Threatened
70	200	165	~220	71	43.0%	~80	100%	9 (5.5%)	0	0%

75 *Peripatus.gen.nz Web site: Onychophora* http://www.peripatus.gen.nz/Taxa/Arthropoda/Onychophora.html [Accessed 19 May 2009].

76 *Wikipedia* (2009): Onychophora. http://en.wikipedia.org/wiki/Onychophora [Accessed 15 May 2009].

77 The IUCN Red List of Threatened Species (2009b).

Hexapoda (proturans, springtails)

The three Classes covered here include Protura, Collembola and Diplura. Yeates *et al.* (2003) estimated the total number of species in Australia at between about 2,000 and 3,000, with 382 species described. By far the greatest number of these are the Springtails—Collembola. In the previous report this group was inadvertantly omitted.

Collembola

ABRS (2009a) identifies 357 described species of which about 78 are introduced, and an estimated total fauna of about 2,000 species. Bellinger *et al.* (2009) state that there are about 7,900 described species in the world, however Greenslade (ABRS 2009a) suggests that this figure may include many synonyms. Janssens (pers. comm.[78]), one of the managers of the Website *Collembola.org* (Bellinger *et al.* 2009), suggests a more conservative figure of c. 7,500. Hallan (2003) gives a figure of 6,000 species. Hopkin (1997) suggested the total number of species in the world is about 50,000.

Diplura

ABRS (2009a) identifies 28 species for Australia and 800 for the world. There is little further information currently available. Yeates *et al.* (2003) gave a figure of 38 for estimated number of species for Australia.

Protura

Szeptycki (2007) listed 31 described species for Australia one of which appeared dubious, whereas ABRS (2009a) lists 32—four of which are probably introduced. Szeptycki (2007) listed 748 species for the world. Twenty-five of the 31 species listed by Szeptycki (2007) are endemic.

There are no species currently listed as threatened in Australia (DEWHA 2009a).

	World Descr./ Accepted	World Estimate	Australia Descr./ Accepted	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened[79]	Australia Threatened	Australian Threatened as percentage of World Threatened
Collembola	~7,500	50,000	279	34.7%	~2,000	6.1%	0	0	–
Diplura	800	unknown	28	3.5%	38	92.8%	0	0	–
Protura	748	unknown	31	4.1%	32	80.6%	0	0	–
ALL HEXAPODA	~9,048	52,000	338	3.7%	~2,070	~17.6%	0	0	–

78 pers. comm. Frans Janssens, *Collembola.org*, University of Antwerp, Belgium, May 2009.

79 The IUCN Red List of Threatened Species (2009b).

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) through 52,525 marine species (Bouchet 2006), ?70,000 (Hawksworth and Kalin-Arroyo 1995), 70,000–75,000 (with possibly more than 100,000) (Groombridge and Jenkins 2002), 81,000 (IUCN 2009b), 93,195 (Brusca and Brusca 2003), 110,000 (Hallan 2003) to 120,000 (Ponder *et al.* 2002). Hawksworth and Kalin-Arroyo (1995), Groombridge and Jenkins (2002) and Rosenberg (pers. comm.[80]) estimated a possible total of around 200,000 species, and May (2000) provided an estimate of about 120,000. I have accepted a figure for the world of c. 85,000 described species based on 52,525 marine (Bouchet 2006), and 24,000 terrestrial molluscs and 7,000 freshwater molluscs (Lydeard *et al.* 2004), with a total world estimate of 200,000 species (Rosenberg pers. comm.[80]).

Estimates for Australia are approximately 8,700 described species out of a total of about 12,250 (DEH 2007).

Endemism of about 90% is reported in the 2001 Australian *State of the Environment Report* (DEH 2001), however Ponder *et al.* (2002) reported that only about 10% of tropical species (i.e. about 2/3 of all Australian species) and 95% of temperate species are endemic, making a total of about 38% endemism.

There are 14 listed threatened mollusc species in Australia (one undescribed) and one undescribed subspecies (DEWHA 2009a). Ten (plus the subspecies) are listed as Critically Endangered and four as Endangered.

World Descr./ Accepted min.	World Descr./ Accepted max.	World Descr./ Accepted	World Estimate	Australia Descr./ Accepted	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened[81]	Australia Threatened	Australian Threatened as percentage of World Threatened
50,000	120,000	~85,000	~200,000	~8,700	10.2%	~12,250	38%	978 (1.2%)	14 (0.2%)	1.4%

80 pers. comm. Gary Rosenberg, Academy of Natural Sciences, Philadelphia, Sept. 2008.

81 The IUCN Red List of Threatened Species (2009b).

Annelida (segmented worms)

Estimates for the number of described species of Annelida in the world vary from 12,000 (Tangley 1997, Bouchet 2006) through 12,070 (Hallan 2003), 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), 16,600 (Brusca and Brusca 2003) to 16,763 (this report). 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. Wilson and Capa (pers. comm.[82]) report around 8,350 species in 1,093 genera for Polychaeta, although figures for a number of families are approximate. The figures I have used are c. 8,432 polychaete species, from Beesley *et al.* (2000) who give a detailed breakdown by family; 147 species of Pogonophora from the *Catalogue of Life* (Bisby *et al.* 2009); 7,684 Oligochaeta from Blakemore (2008 and pers. comm.[86]) and 500 Hirudinea from Myers (2001i)—making a total of 16,763. Glasby (pers. comm.[83]) suggests that higher figures often given for Polychaetes (i.e. around 13,000) are more related to names than species and don't take into account synonymy, whereas the lower figures (around 8,000) are more accurate for the number of 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).

According to DEH (2007), the number of described Australian species is about 2,300 out of an estimated total of about 4,230. Adding up the species in each Order, however, gives a figure of about 2,192 made up of 1,139 polychaetes (ABRS 2009a, Wilson and Capa pers. comm.[82]), 22 Myzostomida (ABRS 2009a), 10 Pogonophora (which should now be included in the Polychaete family Siboglinidae)[84], 962 oligochaetes[85] and 59 Hirudinea (ABRS 2009a). Many of these figures do, however, appear to be quite fuzzy. The percentage of endemics is unknown, but it is reported that southern Australia has about 67% endemism (Poore 1995). Blakemore (pers. comm.[86]) states that there are probably around 2,000 endemic species of megadriles in Australia, of which 650 are currently described.

There is one listed threatened worm species in Australia, listed as Vulnerable (DEWHA 2009a).

World Descr./ Accepted min.	World Descr./ Accepted max.	World Descr./ Accepted	World Estimate	Australia Descr./ Accepted	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened[87]	Australia Threatened	Australian Threatened as percentage of World Threatened
12,000	16,763	16,763	25,000–30,000	2,192	13.1%	~4,230	67%	6 (0.04%)	1 (0.05%)	16.7%

82 pers. comm. R.Wilson, Museum of Victoria and M.Capa, Australian Museum—made up of 981 described, 144 known undescribed and 14 Antarctic species, April 2009.

83 pers. comm. Chris Glasby, Museum and Art Gallery of the Northern Territory, Darwin, April 2009.

84 pers. comm. R.Wilson, Museum of Victoria and M.Capa Australian Museum—who state that most of these are probably new, undescribed species, April 2009.

85 650 native (and 75 exotic) (terrestrial) megadriles—ref. Rob Blakemore pers. comm. (2009) and 270 microdriles (ABRS 2009a).

86 pers. comm. Rob Blakemore, Tasmania, Sept. 2008.

87 The IUCN Red List of Threatened Species (2009b).

Nematoda (nematodes, roundworms)

Estimates for the number of described species of Nematoda vary from around 12,000 (Myers 2001f, Hickman *et al.* 2004) through 20,000 (Hodda 2000), 20,000–25,000 (Groombridge and Jenkins 2002), fewer than 25,000 (Baldwin *et al.* 2000), 25,000 (Hawksworth and Kalin-Arroyo 1995, Brusca and Brusca 2003), over 80,000 of which over 15,000 are parasitic (Wikipedia[88]). Bouchet (2006) accepted a figure of 12,000 for marine species based largely on Hugot *et al.* (2001). Estimates for the total numbers of species, however, are much larger, ranging from 400,000 (Hawksworth and Kalin-Arroyo 1995, Groombridge and Jenkins 2002) through about 500,000 (Myers 2001f, Hickman *et al.* 2004) to 500,000–1 million (Baldwin *et al.* 2000) and 'several times' their estimate of 25,000 (Brusca and Brusca 2003). Baldwin *et al.* (2000) stated 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 provided 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 numbers of described Australian species vary from 1,200 (ABRS 2005) to about 2,060 (DEH 2007). The current version of the *Australian Faunal Directory* (ABRS 2009a) lists just 358 species, but I am informed that this is very incomplete and includes mostly just the free-living nematodes. Estimates for the total number of species are around 30,000 (DEH 2007). I have found no published estimates for the percentage of endemics.

There are currently no listed threatened species of nematode in Australia (DEWHA 2009a).

World Descr./ Accepted min.	World Descr./ Accepted max.	World Descr./ Accepted	World Estimate	Australia Descr./ Accepted	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened[89]	Australia Threatened	Australian Threatened as percentage of World Threatened
12,000	>80,000	<25,000	~500,000	~2,060	8.2%	~30,000	unknown	0	0	–

88 *Wikipedia* (2009): Nematode. http://en.wikipedia.org/wiki/Nematode [Accessed 19 May 2009].

89 The IUCN Red List of Threatened Species (2009b).

Acanthocephala (thorny-headed worms)

Estimates for the number of described species of Acanthocephala in the world vary from more than 500 (Hickman *et al.* 2004), 842 (Hallan 2003), over 1,000 (of which 600 are marine) (Groombridge and Jenkins 2002, Bouchet 2006), 1,100 (Brusca and Brusca 2003) to 1,150 (Wikipedia[90]).

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 species.

DEH (2007) reports figures of 56 described species for Australia out of a total of about 160.

There are no listed threatened species of Acanthocephala for Australia (DEWHA 2009a).

World Descr./ Accepted min.	World Descr./ Accepted max.	World Descr./ Accepted	World Estimate	Australia Descr./ Accepted	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened[91]	Australia Threatened	Australian Threatened as percentage of World Threatened
~500	1,150	1,150	~1,500	56	4.9%	~160	unknown	0	0	–

90 *Wikipedia* (2009): Acanthocephala. http://en.wikipedia.org/wiki/Acanthocephala [Accessed 19 May 2009].

91 The IUCN Red List of Threatened Species (2009b).

Platyhelminthes (flat worms)

Estimates for the number of described species of flat worms in the world are around 20,000 (Hawksworth and Kalin-Arroyo 1995, Groombridge and Jenkins 2002, Brusca and Brusca 2003), although Hallan (2003) gives an unsubstantiated figure of 25,000. Myers (2001g) reported 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 (20,000) in line with the majority of reports. About 15,000 of these are marine species (Bouchet 2006).

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

Estimates for the number of described Australian species vary from 1,506 (DEH 2001) to 1,593 (DEH 2007) with estimates for total species of around 10,000 (DEH 2007) and 10,806 (DEH 2001) although these estimates appear high (Wells pers. comm.[92]). The *Australian Faunal Directory* (ABRS 2009a) lists just 465 species, however this is very incomplete as not all Classes have been covered. 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 (Wells pers. comm.[92]).

There are no listed threatened species of Platyhelminthes, however The IUCN Red List of Threatened Species (IUCN 2009b) lists one Extinct species of Turbellaria.

World Descr./ Accepted min.	World Descr./ Accepted max.	World Descr./ Accepted	World Estimate	Australia Descr./ Accepted	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened[93]	Australia Threatened	Australian Threatened as percentage of World Threatened
20,000	25,000	20,000	(~80,000)	1,593	8%	~10,000	unknown	0	0	–

92 pers. comm. Alice Wells, Australian Biological Resources Study, Canberra, July 2009.

93 The IUCN Red List of Threatened Species (2009b).

Cnidaria (jellyfish, sea anenomes, corals)

Estimates for the number of described species of Cnidaria in the world vary from 9,000 (Groombridge and Jenkins 2002, Hickman *et al.* 2004) through 9,500 (Hallan 2003), 9,795 (Bouchet 2006), 10,000 (Groombridge and Jenkins 2002) to 10,000–11,000 (Brusca and Brusca 2003). I have accepted the figure of 9,795 as it appears to be the most thoroughly researched and reliable. I am not sure if these include the Myxozoa, which are included here under the Protoctista and of which there are about 1,200 species (Adl *et al.* 2007). I have accepted that these were most likely not included by Bouchet in his publication.

The number of described Australian species reported varies from 1,270 (DEH 2001) to 1,705 (DEH 2007) with estimates of the total Australian fauna consistent at about 2,200 (DEH 2007), made up of 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.

There are no listed threatened species of Cnidaria in Australia (DEWHA 2009a) but 231 Anthozoa and five Hydrozoa are listed in The IUCN Red List of Threatened Species for the world.

World Descr./ Accepted min.	World Descr./ Accepted max.	World Descr./ Accepted	World Estimate	Australia Descr./ Accepted	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened[94]	Australia Threatened	Australian Threatened as percentage of World Threatened
9,000	11,000	9,795	unknown	1,705	17.4%	~2,200	unknown	236 (2.4%)	0	0%

94 The IUCN Red List of Threatened Species (2009b).

Porifera (sponges)

Estimates for the number of described species of Porifera in the world vary from 5,500 (Myers 2001h, Brusca and Brusca 2003, Bouchet 2006) through 5,000–10,000 (Groombridge and Jenkins 2002), 6,000 (ABRS 2009a), to 10,000 (Hallan 2003, Ramel 2009a). ABRS (2009a) also estimates that the figure of 6,000 described species is perhaps only about one-third of the total number of extant species. I have accepted the figure of 6,000 as given by ABRS (2009b).

Described species in Australia number between 1,320 and 1,476. Hooper and Wiedenmayer (1994) provided figures of 1,320–1,335 with 56% endemic and DEH (2001, 2007) estimated that there were 1,416 described species in Australia with the total number of species in Australian waters at about 3,500. The *Australian Faunal Directory* (ABRS 2009a) has now updated this figure to 1,476. Ponder *et al.* (2002) stated that about 45% of species on the Great Barrier Reef are endemic.

There are currently no listed threatened Porifera species in Australia (DEWHA 2009a).

World Descr./ Accepted min.	World Descr./ Accepted max.	World Descr./ Accepted	World Estimate	Australia Descr./ Accepted	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened[95]	Australia Threatened	Australian Threatened as percentage of World Threatened
5,500	10,000	~6,000	~18,000	1,476	24.6%	~3,500	56%	0	0	–

95 The IUCN Red List of Threatened Species (2009b).

Other Invertebrates

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

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), Hickman *et al.* (2004) and Bouchet (2006). Those for Australia are from ABRS (2009a) with the exception of the Rotifera supplied by Shiel (pers. comm.[96]). The Phylum Monoblastozoa listed in the following table is, according to Meeûs and Renaud (2002), of doubtful existence, and Hickman *et al.* (2002) stated that the Phylum Chaetognatha was not supported by molecular evidence. They have, however, been included in the table. Guidetti and Bertolani (2005) listed 980 species of tardigrade for the world, of which 147 were marine. Bouchet (2006) stated that there were 212 marine species making a new total of 1,045 species in total.

Information for Australia on Tardigrada (water bears) was supplied by Claxton (pers. comm.[97]). 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 suggested that there are at least 500 species in total for Australia.

Most estimates for the world total of described species of Mesozoa are around 90–106, whereas ABRS (2005) stated 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 28 supplied by Kristensen (pers. comm.[98]).

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 Nemertea (Ponder *et al.* 2002).

Ponder *et al.* (2002) stated that about 87% of the Australian species of Entoprocta are endemic. Other endemism figures are largely determined from ABRS (2009a).

There are two species of Nemertea (ribbon worms) listed as Vulnerable in The IUCN Red List of Threatened Species, but no species are currently listed as threatened in Australia (DEWHA 2009a).

96 pers. comm. Russell Shiel, University of Adelaide, Nov. 2008.
97 pers. comm. Sandra Claxton, New South Wales, Aug. 2008.
98 pers. comm. Reinhardt Kristensen, University of Copenhagen, June 2009.

Other Invertebrates *continued*

Phylum	Common name	World				World Descr./ Accepted	World Estimate	Australia Descr./ Accepted	Australia Percent.	Australia Estimate	Australia Endemic
		Hickman *et al.*	Brusca and Brusca[99]	Groombridge and Jenkins	Bouchet (marine only)						
Placozoa		1	1	1	–	1	–	0	0	0	0
Monoblastozoa		–	1	–	–	1	–	–	–	–	–
Mesozoa (Rhombozoa, Orthonectida)	mesozoans	accepted?	90	~90	106	106	–	100	94%	100	–
Ctenophora	comb jellies	<100	100	~100	166	166	200	10	6%	60	–
Nemertea (Nemertina)	ribbon worms	650	900	~900	1180–1230	1,200	5,000–10,000	81	7%	281	65%
Rotifera	rotifers	~1,800	1,800	~2,000	50 marine	2,180[100]	–	683	31%	1,300	45%
Gastrotricha	gastrotrichs	~400	450	~400	390–400	400	–	45	11%	45	–
Kinorhyncha	kynorhinchs	75	150	~150	130	130	–	8	6%	8	–
Nematomorpha	horsehair worms	250	320	~240	5 marine	331[101]	~2,000	32	10%	32	–
Entoprocta (Kamptozoa)	kamptozoans	150	150	~150	165–170	170	170	16	9%	>16	87%
Gnathostomulida	gnathostomulids	>80	80	~80	97	97	–	8	8%	8	–
Priapulida	priapulans	18	16	17	8 marine	16	–	2	12%	2	–
Loricifera	loriciferans	few	10	~100	18 marine	28[102]	>100	4	14%	6	50%
Cycliophora	cycliophorans	?1	1	accepted?	1	1	–	0	0	0	–
Sipuncula	peanut worms	~330	320	~150	144	144[103]	–	48	33%	48	–
Echiura	spoon worms	140	135	~140	176	176	–	13	7%	13	54%
Tardigrada	water bears	300–400	800	~750	212 marine	1,045[104]	–	112 (228)	11–22%	~500	56%
Phoronida	phoronids	~10	20	16	10	10	–	6	60%	6	–
Ectoprocta (Bryozoa)	moss animals	~4,000	4,500	~4,000	5,700	5,700	~5,000	1,000	18%	~2,500	50%
Brachiopoda	lamp shells	~325	335	~350	550	550	–	58	11%	70	~70%
Pentastomida	tongue worms	~90	~130[105]	accepted?	–	100	–	10	10%	10	–
Chaetognatha	arrow worms	–	100	~70	121	121	–	19	16%	10	0%
TOTAL		~8,820	~10,409	~9,704	9,229–9,294	12,673	~20,000	2,255–2,371	18.7%	~5,015	unknown

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

100 1,570 Monogonata, 461 Bdelloidea (Segers 2008) plus at least 70 (maybe as high as 190) marine species (Russell Shiel pers. comm. 2009). Fontaneto ***et al.*** (2006) state that 148 species have been found in saltwater only—both marine and inland saltwater lakes. Another species was described in Fontaneto ***et al.*** (2008).

101 326 freshwater species (Poinar 2008) plus five marine species (Bouchet 2006); and an estimated total of about 2,000 species (Poinar 2008).

102 pers. comm. Reinhardt Kristensen, University of Copenhagen, 8 Aug. 2005, June 2009—includes four species from Australian caves, and two species from waters between Australia and New Caledonia.

103 Bisby ***et al.*** (2009).

104 Guidetti and Bertolani (2005) list 980 species of which 147 are marine. Bouchet (2006) states that there are 212 marine species, making a new total of 1,045 species.

105 Included under Crustacea.

Plants

Magnoliophyta (flowering plants)

Estimates for the number of described species of flowering plants in the world vary from 223,300 (Scotland and Wortley 2003) through 248,000 (Tangley 1997), 258,650 (Thorne 2002, IUCN 2004), about 270,000 (Groombridge and Jenkins 2002) to about 315,903 (Kier *et al.* 2009). The latter figure was calculated using range equivalents of vascular plants for all 90 regions of the world and representing 'a conservative estimate on the number of species of vascular plants known to science today' (Croft pers. comm.[106]). The IUCN (2004) and Groombridge and Jenkins (2002) estimated that the total flora was about 320,000 species. IUCN (2009b) are now using the figures from Thorne (2002) citing the figure of 258,650. There have been 9,932 new species (excluding new combinations and *nom. nov.*) added to the *International Plant Names Index* (IPNI 2009) over the past five years (Nicolson pers. comm.[107]). For this report, I have accepted the figure of 258,650 used in the previous report, plus the additional 9,932 species published since then. This gives a new figure of 268,600 when rounded to the nearest one hundred.

Govaerts (2002) estimated that there are 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. In 2001, Prance (2001) estimated that there are between 300,000 and 320,000 species, whereas more recently Paton *et al.* (2008) have estimated that there are around 352,000 species in their work for Target 1 of the *Global Plant Strategy* (CBD 2009b). I have accepted the figure of 352,000 as the most likely, given the number of known published species and the rate of description over recent years, particularly in areas of Asia (e.g. New Guinea) and in tropical Central and South America. I believe figures in the low 300,000s are too low, and figures in the 400,000s too high.

Australian figures for flowering plants have varied from 15,638 (Walter and Gillett 1998, Williams 2001, Groombridge and Jenkins 2002) through 18,140 (DEH 2007) to 18,821 (Sjöström and Gross 2006). Sjöström and Gross (2006) 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 18,448 native species on the Australian mainland and 18,706 when the offshore islands were included. Since the previous report, there have been many new taxa described, and a lot of work on developing and improving the *Australian Plant Census* (CHAH 2009a) and the *Australian Plant Name Index* (ANBG 2009). This has led to considerably higher numbers than those cited in the previous report. Confusion does arise with knowing whether some species are introduced or native, and whether some species I have regarded as endemic may not also occur in neighbouring Malesian regions including Papua New Guinea. I do, however, believe that the figures cited here of 18,448 and 18,706 (±1.0%) are realistic. The *Australian Plant Name Index* also lists around another 824

106 pers. comm. Holger Croft, University of California, San Diego, April 2009.
107 pers. comm. Nicola Nicolson, Royal Botanic Gardens, Kew, April 2009.

Magnoliophyta (flowering plants) *continued*

species as phrase or manuscript names[108]—i.e. known but as yet unpublished species, and over 2,793 introduced and naturalised species. When all these are included, the total number of native species is 19,530 with 22,210 including 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 referred to figures estimated in 1990. I expect that other estimates of around 22,000–25,000 include as many as 3,000 introduced species. The total number of native Australian flowering plants species would now appear to be somewhere between 20,000 and 21,000 or possibly slightly higher.

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).

In the previous report (Chapman 2006), I provided a figure of 91% endemism, with about 91.7% when the offshore islands were excluded. Since that report, many new species have been described, most being endemics. In addition many new species have been added as phrase names awaiting formal description. If we assume most of these are good species, calculated endemism in the Australian flora is 93.25% or 93.8% when offshore islands are excluded[109]. These figures are based on counts carried out for this project using the *Australian Plant Census* (CHAH 2009a), *What's Its Name* (Australian National Herbarium *et al.* 2005), published hard-copy and online volumes of the *Flora of Australia* (ABRS 2009b), the *Australian Plant Name Index* (Chapman 1991), the electronic *Australian Plant Name Index* (ANBG 2009) and the *Census of Australian Vascular Plants* (Hnatiuk 1990). The total number of endemic species needs to be recalculated once the new *Australian Plant Census* of Australian vascular plant species is completed, and as most species still to be described are likely to be endemics, the percentage of endemism is expected to increase from these figures.

There are 1,202 listed threatened species of flowering plant in Australia, of which 52 are undescribed. There are also 104 listed infraspecific taxa of which four are undescribed (DEWHA 2009b). These lists include 37 species and two infraspecific taxa listed as Extinct; 72 species (six undescribed) and seven infraspecific taxa (one undescribed) listed as Critically Endangered; 475 species (34 undescribed) and 48 infraspecific taxa (one undescribed) listed as Endangered; and 618 species (12 undescribed) and 47 infraspecific taxa (two undescribed) listed as Vulnerable.

World Descr./ Accepted min.	World Descr./ Accepted max.	World Descr./ Accepted	World Estimate	Australia Descr./ Accepted[110]	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened[111]	Australia Threatened	Australian Threatened as percentage of World Threatened
223,300	315,903	~268,600	352,000	18,706	7.0%	~20,000–21,000	93.25%	7,904 (2.9%)	1,202 (6.4%)	15.2%

108 Manuscript and phrase names are not included in the tables on numbers of species.

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

110 Does not include 824 undescribed species that have been given either manuscript or phrase names.

111 The IUCN Red List of Threatened Species (2009b).

Gymnosperms (Coniferophyta, Cycadophyta, Gnetophyta and Ginkgophyta)

There are a number of contrasting recent estimates for the number of described species of Gymnosperms in the world. Groombridge and Jenkins (2002) gave a figure of 846 while Christopher Earle in *The Gymnosperm Database* (Earle 2009) listed 956 species, the IUCN (2009b) gives a total of 980 species based on Donaldson (2003), Farjon (2001) and Mabberley (1997) and Paton *et al.* (2008 and pers. comm.[112]) list 1,001 species.

Hill and Stevenson (2004) in their *World List of Cycads* listed 275 known species of Cycad. The *International Plant Names Index* (IPNI 2009) has added another eight species since 2004 making 283 species in total. The *World Checklist of Selected Plant Families* (RBG, Kew 2009) lists 65 species of *Ephedra* (compared with 35 given in Earle (2009)), 41 species of *Gnetum*, one species of *Welwitschia* and one *Ginkgo*. Paton (pers. comm.[112]) states that there are 630 species of Coniferales (rather than the 1,016 listed in Paton *et al.* (2008)). This gives a total of 1,021 species of Gymnosperm—the figure I have accepted here.

No estimates for the total number of Gymnosperms has been found, but it is unlikely to much greater than 1,050.

Figures for the Australian Gymnosperms include: Coniferophyta 44 (39 of which are endemic) (Hill 1998a); and Cycadophyta 76 (all of which are endemic) (Hill 1998b, CHAH 2009a). 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 17 listed threatened species in Australia and one threatened subspecies. These include seven species and one subspecies listed as Endangered and ten species listed as Vulnerable (DEWHA 2009b).

World Descr./ Accepted min.	World Descr./ Accepted max.	World Descr./ Accepted	World Estimate	Australia Descr./ Accepted	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened[113]	Australia Threatened	Australian Threatened as percentage of World Threatened
846	1,021	1,021	~1,050	120	11.7%	~120	96%	323 (31.6%)	17 (14.2%)	5.3%

112 pers. comm. Alan Paton, Royal Botanic Gardens, Kew, May 2009.
113 The IUCN Red List of Threatened Species (2009b).

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 from Groombridge and Jenkins (2002), who report numbers of c. 1,000 Lycophyta, c. 12,000 Filicinophyta, 10 Psilophyta and 15 Sphenophyta. Other estimates include 12,838 in the *Checklist of Ferns and Fern Allies* (Hassler and Swale 2002)—the figure accepted by IUCN (2009b). 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. Bostock (pers. comm.[114]) suggests that there could be somewhere about 15,000 species worldwide, however there is considerable uncertainty associated with hybridisation. In the previous report I 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 (pers. comm.[114]). I am now inclined to believe that the 'Species in Checklist' of Hassler and Swale (2002) really refers to names, whereas their 'Species estimate' refers to accepted species. I have thus now accepted a figure of c. 12,000 which they cite on their CD-ROM (Hassler and Swale 2001).

Bostock (pers. comm.[114]) suggests that for Australia (including Tasmania) there are 454 species of ferns (excluding hybrids and intergrades but including nothospecies i.e. *Drynaria* × *dumicola*). This increases by 25 if Lord Howe Island is included, by a further nine additional species when Norfolk Island is included, by eight more for Christmas Island, and two more when Macquarie Island is covered. There have been two new species published since 1998. In addition there are about 36 naturalised species. It is estimated that about 33.8% are endemic. Bostock (pers. comm.[114]) suggests a figure of about 525 as the total fern flora for Australia.

There are 41 listed threatened species and one listed variety in Australia. Nine are listed as Extinct, two as Critically Endangered, 16 as Endangered and 14 species and one variety as Vulnerable (DEWHA 2009b).

World Descr./ Accepted min.	World Descr./ Accepted max.	World Descr./ Accepted	World Estimate	Australia Descr./ Accepted	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened[115]	Australia Threatened	Australian Threatened as percentage of World Threatened
10,000	15,000	~12,000	~15,000	498	4.2%	~525	33.8%	139 (1.2%)	41 (8.2%)	29.5%

114 pers. comm. Peter Bostock, Queensland Herbarium, June 2009.
115 The IUCN Red List of Threatened Species (2009b).

Bryophyta (mosses, liverworts, 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 (Bryopsida), the hornworts (Anthocerotopsida) and the liverworts (Marchantiopsida).

Estimates of the number of described species vary from 13,370 (Paton *et al.* 2008) through 15,000 (Hallingbäck and Hodgetts 2000), 16,000 (IUCN 2009b) to 23,000 (Helzner 2002). The University of Auckland (2009) provides figures of c. 10,000 for mosses, 6,500–7,000 for liverworts and c. 100 for hornworts, giving an estimate of 16,600–17,100 in total. Groombridge and Jenkins (2002) also provided estimates of 6,000 for liverworts and 600 for hornworts. De Luna *et al.* (2003) as part of the *The Tree of Life* project also provided an estimate for mosses of 10,000 species. Crosby *et al.* (1999) gave a figure of 12,754 for the mosses but many of these are synonyms. Crosby (pers. comm.[116]) is currently working on a new edition of the *Checklist of Mosses* and suggests that the final number of accepted species of mosses will be close to 11,000. There is considerable variation in reported numbers for the liverworts—ranging from 5,000 to 9,000. On the *Discover Life* website (Buck *et al.* 2009) it states that there are between 7,500 and 9,000 species with over 7,500 currently listed. After a thorough count of the number of species in each genus, Stotler and Crandall-Stotler (2009) have now arrived at a figure of c. 5,000 (Stottler pers. comm.[117]). I have accepted c. 11,000 for mosses (Crandall-Stotler 2008), c. 5,000 for liverworts (Stotler & Crandall-Stotler 2009) and 236 for hornworts (Konrat *et al.* 2009 and Söderström and Hagborg pers. comm.[118]), totalling c. 16,236 species.

I have not found a published estimate for the total number of species for bryophytes, however Groombridge and Jenkins (2002) suggested that the proportion of the groups known is moderate to high for the mosses and moderate for both the hornworts and liverworts. Crandall-Stotler (2008) states that there are up to 15,000 species of moss recognised. Wikipedia[119] suggests that there may be as many as 10,000 liverworts, however given that the number of published species is much lower than previously thought, this number is more likely to be closer to the lower end of the *Discover Life* estimate of 7,500. This would make a total somewhere around 22,600 for the bryophytes. This agrees with

116 pers. comm. Marshall Crosby, North Carolina, May 2009.

117 pers. comm. Ray Stotler, University of Southern Illinois, June 2009. There are still some genera for which numbers are not known so this is an approximation.

118 pers. comm. Lars Söderström, Department of Biology, NTNU, Norway, and Anders Hagborg, Field Museum, Chicago, June 2009.

119 *Wikipedia* (2009): Marchantiophyta. http://en.wikipedia.org/wiki/Marchantiophyta [Accessed 16 May 2009].

Bryophyta (mosses, liverworts, hornworts) *continued*

comments from McCarthy (pers. comm.[120]) and Cargill (pers. comm.[121]) who suggest that the number would be much lower than the figure of 25,000 used in the previous report.

In Australia there are 976 species of moss (Klazenga pers. comm.[122]) and 871 accepted species of liverworts and hornworts (McCarthy 2003, 2006). Of the 976 species of moss in Australia, 923 occur on the Australian mainland, with the remainder on offshore islands or in the Australian Antarctic Territory. There are an estimated 222 endemic species of moss (Klazenga pers. comm.[122]) (22.7% endemism) and between 200 and 250 endemic species of liverworts and hornworts[123] (23–28% endemism). DEH (2007) estimated the number of Australian species described at around 1,950, with about 2,500 species in total, but this would appear to be a little high.

There are two threatened bryophyte species listed as Vulnerable for Australia (DEWHA 2009b).

I am accepting the numbers in the lower line of the table which are an amalgam of Paton *et al.*'s (2008) estimate for World Described/Accepted species and Helzener (2002) for Accepted Maximum and my numbers derived from numerous estimates.

	World Descr./ Accepted min.	World Descr./ Accepted max.	World Descr./ Accepted	World Estimate	Australia Descr./ Accepted	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened[124]	Australia Threatened	Australian Threatened as percentage of World Threatened
Liverworts	5,000	9,000	~5,000	~7,500	841	16.8%	–	~23–28%	–	–	–
Hornworts	100	600	236	~250	30	12.7%	–		–	–	–
Mosses	10,000	12,754	~11,000	~15,000	976	8.9%	–	22.7%	82	1	1.2%
ALL BRYOPHYTA	13,370	23,000	~16,236	~22,750	1,847	11.4%	~2,200	25%	82 (0.4%)	1 (0.05%)	1.2%

120 pers. comm. Patrick McCarthy, Australian Biological Resources Study, Canberra, May 2009.
121 pers. comm. Christine Cargill, Centre for Plant Biodiversity Research, Canberra, June 2009.
122 pers. comm. Niels Klazenga, Royal Botanic Gardens, Melbourne, May 2009.
123 pers. comm. Patrick McCarthy, Australian Biological Resources Study, Canberra, Sept. 2005.
124 The IUCN Red List of Threatened Species (2009b).

Plant Algae (including green algae, red algae, glaucophytes)

Following more recent treatments, and the arrangements in *AlgaeBase* (Guiry and Guiry 2009), I have treated the algae of the previous report as plant algae (the red algae, green algae and glaucophytes—included here) and chromistan 'algae' under Chromista. Some species are treated under Protoctista. Both Chromista and Protoctista are treated later in this report.

The number of plant algae for the world is largely taken from *AlgaeBase* (Guiry and Guiry 2009). The total for the world is 12,272 made up of five Glaucophyta, 6,097 Rhodophyta, 2,125 Charophyta, and 4,045 Chlorophyta. As of 2005 the *AlgaeBase* database (Guiry *et al.* 2005) had only completed about 70% of taxa (with Rhodophyta and Phaeophyta 95% complete; and 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*'). Since 2005, the database has been considerably improved and updated and is now much closer to completion in these groups.

Estimates for total numbers are mostly non-existent, although Metting (1996) includes figures for Rhodophyta of from 5,500–20,000, 20,500 for Charophyta and in the order of 13,000–100,000 for Chlorophyta. When compared to more recent figures for published species, many of these numbers appear to be on the high side.

The numbers for Australia are derived from Entwisle and Huisman (1998) and Cowan (2006). I have reported the numbers by Class following the classification used by *AlgaeBase*. The total for Australia is between 3,236 and 3,545 made up of one Glaucophyta, 1,040–1,099 Charophyta, 654—904 Chlorophyta (Entwisle and Huisman 1998), and 1,541 Rhodophyta (Cowan 2006).

The percentage endemism within Australia is unknown.

There are two threatened species listed for Australia (DEWHA 2009b)—one listed as Extinct in the Wild and one as Endangered.

World Descr./ Accepted min.	World Descr./ Accepted max.	World Descr./ Accepted	World Estimate	Australia Descr./ Accepted	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened[125]	Australia Threatened	Australian Threatened as percentage of World Threatened
12,205	12,272	12,272	unknown	3,236–3,545	26—29%	~3,000	unknown	9 (0.07%)	2 (0.06%)	22%

125 The IUCN Red List of Threatened Species (2009b).

Plant Algae (including green algae, red algae, glaucophytes) *continued*

Phylum	Class	World (AlgaeBase[126])	Australia (Entwisle & Huisman 1998)[127]
Charophyta	Charophyceae	294	30–89
	Klebsormidiophyceae	65	10
	Mesostigmatophyceae	8	–
	Zygnematophyceae	1,758	1,000
Chlorophyta[128]	Bryopsidophyceae	520	150
	Chlorophyceae	2,238	279–479
	Incertae sedis	3	–
	Nephroselmidophyceae	23	–
	Pedinophyceae	22	5
	Pleurastrophyceae	4	–
	Prasinophyceae	135	43
	Trebouxiophyceae	170	–
	Ulvophyceae	930	177–227
	Zygnemophyceae	0	–
Glaucophyta[129]	Glaucocystales	5	1
Rhodophyta[130]	Bangiophyceae	134	12–16
	Compsopogonophyceae	63	–
	Florideophyceae	5,878	1,079–1,274
	Rhodellophyceae	4	–
	Stylonematophyceae	18	–

126 *AlgaeBase* (Guiry & Guiry 2009).

127 Many of these figures would appear to be estimates only and not accepted species.

128 Corliss (2000) gives ~3,800, and Groombridge and Jenkins (2002) give ~16,000—compared to the *AlgaeBase* figure here of 3,913.

129 Corliss (2000) gives 15.

130 Corliss (2000) gives 4,250, and Groombridge and Jenkins (2002) give ~4,000—compared to the *AlgaeBase* figure here of 6,072.

Fungi

In the previous report the lichens were included as a separate group; however, in this edition I have included the lichens, or more correctly the lichen-forming fungi, under the fungi. Because a lot of publications still maintain the use of lichens as a separate group, I have included a separate table for lichen-forming fungi at the end of this section. In line with recent research, some of what have in the past been called micro-fungi are now regarded as more correctly placed under Chromista and Protoctista. These include such groups as the slime moulds, downy mildews, etc. They are thus treated under those groups in this report.

Fungi (excluding taxa treated under Chromista and Protoctista)

Estimates for the number of fungi in the world vary and figures 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), 97,330 (Kirk *et al.* 2008), over 300,000 (Rossman 2003) and 405,000 (Adl *et al.* 2007) have been found. In the 10th edition of the *Dictionary of the Fungi,* Kirk *et al.* (2008) provide figures for the number of fungi in their table 4 of 64,056 Ascomycota, 31,503 Basidiomycota, 706 Chytridiomycota and 1,065 Zygomycota but in the text there are additional figures of 179 for Blastocladiomycota, 169 for Glomeromycota, more than 1300 for Microsporidia and 20 for Neocallimastigomycota, for a total of 98,998. 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). I have accepted the figure of 98,998 as compiled from the *Dictionary of the Fungi* (10th edition) as this would appear to be the most reliable and thoroughly researched of all the varying numbers. More than 1,500 of these species are marine (Hyde *et al.* 1998), and many more are likely to be found in that environment.

Brusca and Brusca (2003) suggested 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) provided 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. Adl *et al.* (2007) provide some huge numbers for the fungi—estimating 'n' million fungi plus another 1.5 million Zygomycota; however the numbers they gave for known extant species are much higher than given by other researchers and thus these estimates would appear to be gross over-estimations.

In Australia the number of accepted and described fungi is estimated as 11,846: Ascomycetes (7,187) of which 3,488 are lichenised and a further 1,648 are anamorphs (asexual states) for which the teleomorph (sexual state) is not known from Australia; Basidiomycota (3,730) of which seven are lichenised; Blastocladiomycota (9); Chytridiomycota (15); Glomeromycota (28); Neocallimastigomycota (2); Zygomycota (119); and 626 species not placed to Phylum (based on counts from *Interactive Catalogue of Australian Fungi*[131] for the macrofungal Basidiomycota and draft catalogue treatments of other groups by May pers. comm.[132]). For the two most diverse groups of fungi, the Ascomycota and the Basidiomycota, known Australian species form very similar proportions of the known world species at 11.2% and

131 *Interactive Catalogue of Australian Fungi* http://www.rbg.vic.gov.au/research_and_conservation/fungi/cat [Accessed June 2009].
132 pers. comm. Tom May, National Herbarium of Victoria, June 2009.

Fungi (excluding taxa treated under Chromista and Protoctista) *continued*

11.8% respectively. The Microsporidia have only recently been treated as true fungi (Kirk *et al.* 2008) and May (pers. comm[133]) estimates 130 described species for Australia.

Previous estimates for the total number of described Australian fungi varied from 5,672 (Chapman 2006, DEH 2007) to about 12,500 species (Pascoe 1990, Williams 2001).

Estimates for the total number of fungal species in Australia vary from around 50,000 (DEH 2007) 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.[134]) suggested 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. ACIL Consulting did not give a detailed breakdown, and many of these will have now been treated under Chromista and Protoctista in this report. I have followed the figures given in the 2006 State of the Environment Report (DEH 2007).

There are only three species listed as threatened in the world—two are lichen-forming fungi (IUCN 2009b), none are listed for Australia (DEWHA 2009b).

I am accepting the numbers in the lower line of the table which are an amalgam of Groombridge and Jenkins (2002) estimate for World Described/Accepted species and Rossman (2003) for Accepted Maximum and my numbers derived from numerous estimates.

	World Descr./ Accepted min.	World Descr./ Accepted max.	World Descr./ Accepted	World Estimate	Australia Descr./ Accepted	Australia Percent.	Australia Estimate	Australia Percent. Endemic	World Threatened[135]	Australia Threatened
Ascomycota			64,056		7,187[136]	11.2%				
Basidiomycota			31,503		3,730[137]	11.8%	10,000			
Blastocladiomycota			179		9	5.0%				
Chytridiomycota			706	<2,000[138]	15	2.1%				
Glomeromycota			169		28	16.6%				
Microsporidia			>1,300		130					
Neocallimastigomycota			20		2	10.0%				
Zygomycota			1,065		119	11.2%				
Unplaced to Phylum					626					
ALL THE ABOVE GROUPS	45,173	300,000	98,998	1,500,000	11,846[139]	11.9%	50,000	unknown	3 (>0%)	0 (0%)

133 pers. comm. Tom May, National Herbarium of Victoria, July 2009.
134 pers. comm. Tom May, National Herbarium of Victoria, 2005.
135 The IUCN Red List of Threatened Species (2009b).
136 Includes 3,488 lichen-forming fungi—see table.
137 Includes seven lichen-forming fungi—see table.
138 Adl *et al.* (2007).
139 Includes 3,495 lichen-forming fungi—see table.

Lichen-forming fungi

The numbers for the lichen-forming fungi listed below are included under the Fungi (see previous).

Estimates for the number of lichens vary from about 10,000 (IUCN 2004) through 13,500 to 17,000 (Deacon 2005 and n.dat.) to over 20,000[140]. I have accepted a figure of c. 17,000 as it appears one of the most common numbers cited and is the figure given in *Biodiversity: the UK Action Plan* (Anon. 1994).

Estimates for the number of described species in Australia are around 3,495 (McCarthy 2009) out of a total of perhaps 4,500 species (pers. comm. McCarthy[141]) of which 1,191 (34%) are thought to be endemic (McCarthy 2009). Seven of the lichenised fungi are Basidiomycota the remainder are Ascomycota.

World Descr./ Accepted min.	World Descr./ Accepted max.	World Descr./ Accepted	World Estimate	Australia Descr./ Accepted	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened[142]	Australia Threatened	Australian Threatened as percentage of World Threatened
10,000	20,000	17,000	~25,000	3,495	20.6%	~4,500	34%	2 (0.01%)	0	0%

140 *BC Biodiversity: Lichens*. http://www.bcbiodiversity.homestead.com/lichens.html.

141 pers. comm. Patrick McCarthy, Australian Biological Resources Study, Canberra, July 2009.

142 The IUCN Red List of Threatened Species (2009b).

Others

The other groups are difficult to determine and characterise. Many are generally included among the protists—a loose assemblage of primarily single-celled, both autotrophic and heterotrophic, eukaryotic organisms of which the colourless forms were previously called protozoa (Brusca and Brusca 2003, Hallegraeff pers. comm.[143]). 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 or whether (as in the case of Chromista etc) they form a Kingdom of their own. Molecular phylogenetic and cladistic studies have resulted in major reorganisations of eukaryotic groups of organisms (see Meeûs and Renaud 2002). Many species previously included with algae or fungi have now been split from those groups and are included in this report under the Chromista, Cyanophyta or Protoctista. The green algae, red algae and glaucophytes, etc treated under the 'Others' section in the previous report, have been included under plant algae in this report. The fungi that were treated under the 'Others' section in the previous report, have been placed in a separate section of their own, excluding the chromistan and protoctistan fungi which are treated separately.

Prokaryota (Bacteria [Monera] of previous report[144])

The estimates of numbers of Prokaryota 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 treated separately.

The estimated number of described bacteria species in the world varies from 3,000–4,000 (Hawksworth and Colwell 1992) through 4,000 (Hawksworth and Kalin-Arroyo 1995), 4,760 (McNeely *et al.* 1990), 5,432 (Euzéby 2004), 7,643 (Euzéby 2009) to 10,000 (Groombridge and Jenkins 2002). I have accepted the figures of Euzéby (2009). Shimura (2004) provided a figure of 8,500 species, but from Euzéby (2004) it is obvious that these are names, and as stated by Euzéby (2009) of the 9,435 currently validly published species names, these apply to just 7,643 currently accepted species names.

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-estimate for the number of described species. No further information has become available since the previous report (Chapman 2006).

World Descr./ Accepted min.	World Descr./ Accepted max.	World Descr./ Accepted	World Estimate	Australia Descr./ Accepted	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened[145]	Australia Threatened	Australian Threatened as percentage of World Threatened
3,000	10,000	7,643	400,000–1,000,000	~40	0.5%	40,000	unknown	0	0	–

143 pers. comm. Gustaaf Hallegraeff, School of Plant Science, University of Tasmania, July 2009.

144 Change recommended by J.P.Euzéby, Société de Bactériologie Systématique et Vétérinaire (SBSV), France (pers. comm.).

145 The IUCN Red List of Threatened Species (2009b).

Cyanophyta (Cyanobacteria)

The Cyanophyta are an important group in Australia, although comparatively little is known of them.

Watanabe *et al.* (2004) gave the number of described species in the world at about 3,234. Groombridge and Jenkins (2002) reported that there are about 1,000 genera. Hoek *et al.* (1995) gave 150 genera and about 2,000 species for the Class Cyanophyceae, whereas *AlgaeBase* (Guiry and Guiry 2009) lists 2,664 species in the Class. I have accepted the figure from *AlgaeBase* which is lower than the figure I cited in the previous report (Chapman 2006).

Actual diversity is very difficult to determine, but the total number of species of cyanobacteria in Australia is unlikely to exceed 500 (McCarthy pers. comm.).

Entwisle and Huisman (1998) provided an estimate for the blue-green algae (Cyanobacteria) in Australia of 270 made up of 10 Chamaesiphonales; 60 Chroococcales and 200 Nostocales/Oscillatoriales.

Order	World (AlgaeBase) Descr./Accepted	Metting (1996) Estimate	Australia (Entwisle & Huisman 1998)
Chroococcales	711		60
Nostocales	686	1000	200
Oscillatoriales	584	1000	
Pseudanabaenales	325		–
Stigonemetales	3		–
Synechococcales/Chamaesiphonales	355		10
TOTAL	2,664	unknown	270

World Descr./ Accepted min.	World Descr./ Accepted max.	World Descr./ Accepted	World Estimate	Australia Descr./ Accepted	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened[146]	Australia Threatened	Australia Threatened as percentage of World Threatened
3,234	3,234	2,664	unknown	270	10%	~500	unknown	0	0	–

146 The IUCN Red List of Threatened Species (2009b).

Chromista (including some species previously included under either algae or fungi)

Again, it is difficult to estimate the number of species of chromistans, partly due to varying circumscriptions of the group. Summaries for the various classes and phyla, where available, are given in the accompanying table.

Estimates for the number of described species of chromistan 'algae' (i.e. chromistan species previously regarded as algae) are difficult to determine due to the circumscriptions of different authors, and the separation into Plantae and Chromista by some but not others. The biggest deficiency is in the Bacillariophyta (diatoms) where *AlgaeBase* (Guiry and Guiry 2009) records just 5,530 species '*but no clarity on what is what*' (Guiry pers. comm.[147]). Guiry (pers. comm.) goes on to estimate that there are about 20,000 published species of diatoms. Hallegraeff (pers. comm.[148]) states that diatoms exhibit prominent morphological diversity of characters but molecular sequencing is now indicating that they have been overclassified. I have used the figure of 23,605 for the world for the chromistan 'algae' based on the numbers in *AlgaeBase*—see table below. Chromista species previously regarded as fungi (chromistan 'fungi') are also not well known. Kirk *et al.* (2008) report 1,039 species for the world. Recently, Class Opalinea has been moved into the Chromista (Nishi *et al.* 2005) but with little certainty of where it is placed within the group. Some authors (e.g. GBIF 2009b) still retain it in the Protoctista under the Phylum Sarcomastigophora. Both Corliss (2000) and Adl *et al.* (2007) reported figures of 400 published species of Opalinea, while Patterson (pers. comm.[149]) suggests that there are about 300 species worldwide.

Few estimates of the total number of chromistan 'algae' have been found, however Hawksworth and Kalin-Arroyo (1995) gave a figure of 400,000 (for all algae) with cited estimates ranging from 150,000 to 1 million, while *Biodiversity: the UK Action Plan* (Anon. 1994) suggested that there could be up to 10 million species of diatoms. Michael Guiry (pers. comm.[147]), 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). For Opalinea, Adl *et al.* (2007) provided an estimate of about 500 species. I have no estimates for the total number of world Chromista species previously regarded as fungi.

I have found no comprehensive list of Australian species of Chromista. For the species previously regarded as algae I have relied largely on *AlgaeBase* (Guiry and Guiry 2009), but not all species there have distribution records, so where other data are available, I have cited those in preference. Scott and Marchant (2005) list 187 species of diatoms in the Class Bacillariophyceae for the Australian Antarctic Territory.

Estimates for the total number of species of chromistan 'algae' in Australia have been taken largely from Entwisle and Huisman (1998). Patterson (pers. comm.[149]) states that there are about 20 species of Opalinea in Australia. It would appear that most of the Australian species occur as parasites of the intestines of frogs. May (pers. comm.[150]) provided the figures for chromistan species previously regarded as fungi.

DEH (2001) and ABRS (2004) reported that there are 10,000–12,000 species known for Australia, but ABRS (2004) suggested that '*this is certainly an underestimate*'. I have followed the figures of Entwisle and Huisman (1998), but using the higher of their estimates in most cases.

	World Descr./ Accepted min.	World Descr./ Accepted max.	World Descr./ Accepted	World Estimate	Australia Descr./ Accepted	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened[151]	Australia Threatened	Australian Threatened as percentage of World Threatened
Chromistan 'algae'	23,605	44,000	~23,605	200,000	2,044	8.7%	<14,000	unknown	6 (0.03%)	0	0%
Opalinea	300	400	400	500	~12	3.0%	~20	unknown	–	0	–
Chromistan 'fungi'	1,039	1,039	1,039	unknown	74	7.0%	unknown	unknown	–	0	–
TOTAL	24,944	45,439	~25,044	~200,500	~2,130	8.5%	>15,000	unknown	6 (0.02%)	0	0%

147 pers. comm. Michael Guiry, *AlgaeBase*, June 2005.

148 pers. comm. Gustaaf Hallegraeff, School of Plant Science, University of Tasmania, July 2009.

149 pers. comm. David Patterson, *Encyclopedia of Life*, July 2009.

150 pers. comm. Tom May, National Herbarium of Victoria, July 2009.

151 The IUCN Red List of Threatened Species (2009b).

152 Scott and Marchant (2005).

153 Cowan (2006).

154 Data for Diatoms in *AlgaeBase* are not complete—pers. comm. Michael Guiry (*AlgaeBase*) who provided the figures of about 20,000 with about a further 80,000 undescribed.

Chromistan 'algae' (species previously included in the algae)

Phylum	Class	World Descr./Accepted			World Estimate	Australia Descr./Accepted	Australia Estimate
		AlgaeBase (Guiry & Guiry 2009)	Corliss (2000)	Adl *et al.* (2007)	Adl *et al.* (2007)	*AlgaeBase* (Guiry and Guiry 2009) unless otherwise noted	Entwisle & Huisman (1998)
Bacillariophyta (diatoms)	Bacillariophyceae	4,256				187[152]	
	Coscinodiscophyceae	933				57[153]	
	Fragilariophyceae	339					
	ENTIRE GROUP	~20,000[154]	10,000–20,000	10,000–20,000	200,000	1,300[155]	13,000
Cryptophyta (cryptomonads)	Cryptophyceae	127				14	50
	ENTIRE GROUP	127	~200	70	200	14	50
Haptophyta (yellow brown algae)	Haptophyta (incertae sedis)	123				10	–
	Pavlovophyceae	15				1	4
	Prymnesiophyceae	273				42	155
	ENTIRE GROUP	411	500	350	<400	53	159
Heterokontophyta (golden and brown algae)	Aurearenophyceae	1	–	–	–	0	–
	Bicosoecophyceae	21	~40	72	100	3[156]	16[162]
	Bodonophyceae	28	–	–	–	1[156]	–
	Bolidophyceae	2	–	–	–	0	–
	Chrysophyceae	374	~1,250	1,000	2,000	80[157]	300
	Dictyochophyceae	44	~200	15	30	4	20
	Eustigmatophyceae	35	–	15	30	4	–
	Pelagophyceae	10	–	12	20	0	–
	Phaeophyceae (Fucophyceae)	1,778	<1,600	1,500–2,000	2,000	451[158]	308–318
	Phaeothamniophyceae	26	–	25	40	1	–
	Pinguiophyceae	6	–	5	20	1[159]	10
	Raphidophyceae	23	<36	20	40	2	–
	Schizocladiophyceae	4	–	–	–	0	–
	Synchromophyceae	1	–	–	–	0	–
	Synurophyceae	284	–	200	350	60[160]	40
	Tribophyceae/Xanthophyceae	430	–	600	800	70[161]	25
	ENTIRE GROUP	3,067	3,126	3,464–3,964	5,430	677	790–800
TOTAL		~23,605	~13,826–23,826	~13,884–24,384	~206,030	2,044	~13,999–14,009

155 Data for diatoms in Australia is very sketchy. In the absence of other information, I have used the lower of the figures cited by Entwisle and Huisman (1998), (1,300) but actual number of published species of diatoms in Australia is likely to be much lower.

156 GBIF (2009b).

157 McCarthy and Orchard (2007) give a figure of 80 published species of which two are endemic.

158 AMANI (Cowan 2006).

159 *AlgaeBase* (Guiry and Guiry 2009) list only one species from Australia.

160 Many of the Australian non-marine distribution records in *AlgaeBase* (Guiry and Guiry 2009) are based on Day *et al.* (1995).

161 Entwisle and Huisman (1998) do not include this Class, however McCarthy & Orchard (2007) list 70 species for Australia.

162 pers. comm. David Patterson, *Encyclopedia of Life*, February 2009.

Chromista (including some species previously included under either algae or fungi) *continued*

Opalinea

Phylum	Class	World Descr./Accepted		World Estimate	Australia Estimate
		Corliss (2000)	Adl *et al.* (2007)	Adl *et al.* (2007)	Patterson (pers. comm.[162])
Incertae sedis	Opalinea	400	400	500	~20
	TOTAL	400	400	500	~20

Chromistan 'fungi' (species previously included in the fungi)

Phylum	World Kirk *et al.* (2008)	Australia (May pers. comm.[163])
Hyphochytriomycota	24	1
Labyrinthista	56[164]	0
Oomycota (water moulds and downy mildews)	956	73
Incertae Sedis	3	0
TOTAL	1,039	74

163 pers. comm. Tom May, National Herbarium of Victoria, July 2009.

164 Adl *et al.* (2007) give a figure of 40 and an estimate of <100 for the Labyrinthulomycetes.

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). There are many more virus names than there are 'species'. There are about 2,000–2,500 species currently recognised by the ICTV, but there are more than 40,000 to 50,000 recorded virus names. Most publications do not differentiate between virus species and virus names (Büchen-Osmond pers. comm.[165]). A full list of virus species can be found at http://www.ictvonline.org/virusTaxonomy.asp?version=2008. Many viruses occur in the marine areas of the world, but very few of these are as yet specified (Büchen-Osmond pers. comm.[165]).

Estimates for the number of described species of viruses range from about 2,000 (Mayo *et al.* 2005) through 2,085 (ICTV 2008), 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* (ICTV 2008).

The only figure I have been able to find for Australia is 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. Büchen-Osmond (pers. comm.[165]) suggests that 10–20% of the total would occur in Australia at one time or another, with less than 5% Australia/Australasia specific. Those figures suggest about 200–400 Australian species with somewhat less than 50% of those endemic. These figures are very inaccurate and should not be relied upon.

There are no species of virus listed as threatened.

World Descr./ Accepted min.	World Descr./ Accepted max.	World Descr./ Accepted	World Estimate	Australia Descr./ Accepted	Australia Percent.	Australia Estimate	Australia Endemic	World Threatened[166]
2,000	5,000	2,085	400,000	200–400	9.6–19.2%	unknown	40–50%	–

165 pers. comm. Cornelia Büchen-Osmond, ICTVdB Management (retired), Columbia University, April 2009.

166 The IUCN Red List of Threatened Species (2009b).

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

The main problem in estimating numbers of Protoctista is in identifying the inter-relationship between different treatments—see following table. There is considerable overlap between what some authors include under Protoctista and what others include as algae, fungi or Chromista. Trying to sort out relationships between the treatments of different authors has not been easy, but the following table is used to enable comparisons with the previous report. For the summary, I have used the data from this table along with data from a number of other sources.

The order of arrangement in the summary table below is to allow for comparisons only and is not meant to imply a taxonomic classification. A lot more work needs to be done to determine accurate numbers for the Protoctista, and the numbers given here are very rough and not to be relied upon. Estimates for the number of Protoctista range from >20,000 (Anon. 1994) through 30,800 (Tangley 1997) to 34,000 (Adl *et al.* 2007), but these often depend on what groups are included or excluded.

Since the previous report a paper has been published that gives some detailed figures for the protists (Adl *et al.* 2007), and I have relied heavily (but not exclusively) on the figures given therein for this report. The *Dictionary of the Fungi* (10th edition) (Kirk *et al.* 2008) includes 1,165 Protoctista that were previously included as fungi.

The following table has beeen created from information in Corliss (2000), Groombridge and Jenkins (2002), Brusca and Brusca (2003), and Adl *et al.* (2007). Groombridge and Jenkins (2002) estimated that there are 80,000 described Protoctista with an estimated total of 600,000 species, however these figures include non-protoctistan 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) for information on Antarctic marine protists. Patterson (pers. comm.[167]) prepared a list of known species and collections for Australia prior to 2005. I have used that unpublished list to determine some of the numbers in the table below, but again, I have found difficulties in fitting the numbers from various sources into the different classifications. It is also obvious that the list contains a number of nomenclatural synonyms and orthographic variants that have not been combined. With the Patterson list there are many undescribed species, and it is clear that the list is far from complete for some groups. It is, however, a good starting point. May (pers. comm.[168]) reports that there are 192 Australian species of fungoid protoctista (predominantly Mycetozoa, and a few Plasmidiophorales).

167 pers. comm. David Patterson, ***Encyclopedia of Life***, February 2009.

168 pers. comm. Tom May, National Herbarium of Victoria, July 2009.

169 The arrangement does not follow the classification used in Adl ***et al.*** (2007) which is a more modern classification than the others, but has been modified to allow comparisons with the earlier publications. I apologise to the authors for the liberties I have taken and mistakes made in doing this.

170 Included as Choanomonada and Mesomycetozoa in the Amoebozoa.

171 Rhizaria (excl. Foraminifera)—includes Cercozoa: <500 ($n \times 10^3$); Haplosporidia: 31 ($n \times 10^2$); Acantharia: 160 (<200); Polycistinea 700–1000 (1,500); Nucleohelea 160–180 (200); Actinophyryidae 5 (<10).

172 Excavata (includes Fornicata) 146 (<200); Preaxostyla 96 (<120); Jakobida 10 (200); Heterobosea 80 (200); Euglenozoa 1,520 (2,000).

Names as used by			Numbers			
Groombridge and Jenkins (2002)	Corliss (2000) (except for species included under Fungi, Algae or Chromista)	Brusca and Brusca (2003)	Groombridge and Jenkins (2002)	Corliss (2000)	Brusca and Brusca (2003)	Adl *et al.* (2007) (estimates in brackets) See other species under Algae[169]
Archaeoprotista (Amitochondriates)	Archamoebae (Karyoblastea)	Diplomonadida	accepted?	10	~100	–
Discomitochondria (flagellates, zoomastigates)	Neomonada	(under Diplomonadida)	accepted?	30	–	120 (300)[170]
Rhizopoda (amastigote amoebae and cellular slime moulds)	Rhizopoda (Amaeobozoa)	Rhizopoda (amoebas)	~200	5,000	~200	>3,006 (~13–23,000)
Myxomycota (Plasmodial slime moulds)	Mycetozoa	Excluded (fungi?)	~500	900	–	Peronosporomycetes 676 (10^3–10^4), Mesomycetozoa 47 (thousands)
Granuloreticulosa (Foraminifera and reticulomyxids)	Foraminifera (Granuloreticulosa)	Granuloreticulosa	~4,000	~5,000	~40,000 (incl. many fossils)	>10,000 (15,000)
Xenophyophora (Xenophyophores)	(under Foraminifera)	(under Granuloreticulosa)	42	–	–	–
(under Actinopoda)	Heliozoa	(under Actinopoda)	–	~4,000	–	–
Actinopoda (Radiolarians)	Radiozoa (Radiolaria)	Actinopoda (incl. Polycistina = Radiolaria, Phaeodaria, Heliozoa, Acantharia)	~4,000	1,700–4,000	~4,240	Rhizaria[171] (excl. Foraminifera) 1556–1876 (thousands)
	Percolozoa	Excluded (fungi?)	–	100	–	–
	Euglenozoa	Euglenida	–	1,600	1,600	–
	(under Euglenozoa)	Kinetoplastida (trypanosomes)	–	–	600	–
			–	–	–	Excavata (except Parabasala)[172] 1,852 (2,720)
Dinomastigota (Dinoflagellates)	Dinozoa	Dinoflagellata	~4,000	~2,000	4,000	2,000 (<3,000)
	Metamonada	(under Dinoflagellata)		300	–	
	Parabasala	Parabasilida (Trihomonads and Hypermastigotes)		400	~300	466 (500)
Apicomplexa (Sporozoa)	Apicomplexa	Apicomplexa	~5,000	~5,000	~5,000	6,000 (1.2–10 million)
Haplospora	(under Apicomplexa)		33			
Plasmodiophora	(under Apicomplexa)		29			
Paramyxa	(under Apicomplexa)		6			
Ciliophora (Ciliates)	Ciliophora	Ciliophora	~10,000	7,800	12,000	3,500 (30,000)

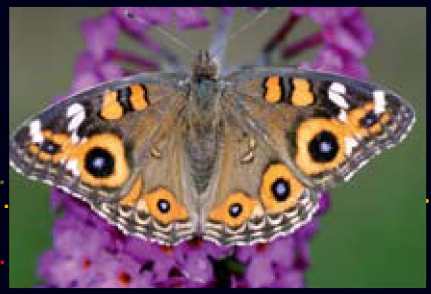
Protoctista (mainly Protozoa—others included under fungi, algae, Chromista, etc) *continued*

Summary Table[173]

	Other names and inclusions	World Descr./ Accepted	World Estimate	Australia Descr./ Accepted	Australia Percent.	Australia Estimate	Australia Endemic
Amoebozoa (incl. cellular slime moulds, excl. fungoid protists)		~3,006	13,000–23,000	~305	10.1%	–	–
Apicomplexa	(parasitic protists)	~5,000	>1,000,000	unknown	unknown	–	–
Ciliata	(protists with cilia)	~4,000	~30,000	151[174]	3.8%	–	–
Flagellata	(protists with flagella)	~2,200	~3,300	675	25.9%	–	–
Foraminifera	(foraminiferans incl. Radiolaria	>13,500	>18,000	>23	0.2%	–	–
Fungoid protists	Mycetozoa, Myxomycota, Plasmodiophoromycota	1,165	thousands	192	16.5%	–	–
TOTAL		~28,871	>1,000,000	>1,346	4.7%	~65,000	unknown

173 Numbers are approximate only, and have often been hard to place into a category.

174 Scott and Marchant (2005) list 151 species for the Australian Antarctic Territory. I have no figures for the rest of Australia.



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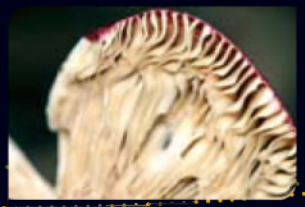

REFERENCES

Abele, L.G. (1982). *The Biology of Crustacea*. Volume 1. *Systematics, the Fossil Record, and Biogeography*. NY: Academic Press.

ABRS—Australian Biological Resources Study (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—Australian Biological Resources Study (2004). *Algae Subprogram*. http://www.deh.gov.au/biodiversity/abrs/sub-programs/algae/index.html [Accessed 28 June 2005—no longer available July 2009, but available via *Internet Archive: Way Back Machine* at http://web.archive.org/web/20060911153744/http://deh.gov.au/biodiversity/abrs/online-resources/fauna/afd/stats-est.html [Accessed 6 July 2009].

ABRS—Australian Biological Resources Study (2005). *Australian Faunal Directory: Estimated Numbers of the Australian Fauna*. http://www.deh.gov.au/biodiversity/abrs/online-resources/fauna/afd/stats-est.html [Accessed 15 June 2005—no longer available July 2009, but available via *Internet Archive: Way Back Machine* at http://web.archive.org/web/20050719011413/http://www.deh.gov.au/biodiversity/abrs/sub-programs/algae/index.html [Accessed 6 July 2009].

ABRS—Australian Biological Resources Study (2009a). *Australian Faunal Directory*. http://www.environment.gov.au/biodiversity/abrs/online-resources/fauna/afd/home [Accessed 18 March 2009].

ABRS—Australian Biological Resources Study (2009b). *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 10 April 2009].

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.environment.gov.au/biodiversity/abrs/publications/other/acil/pubs/abrs-acil.pdf [Accessed 4 July 2009].

Adl, S.M., Leander, B.S., Simpson, A.G.B., Archibald, J.M., Anderson, O.R., Bass, D., Bowser, S.S., Brugerolle, G., Farmer, M.A., Karpov, S., Kolisko, M., Lane, C.E., Lodge, D.J., Mann, D.G., Meisterfeld, R., Mendoza, L., Moestrup, Ø., Mozley-Standridge, S.E., Smirnov, A.Y. and Spigel, F. (2007). Diversity, Nomenclature, and Taxonomy of Protists. *Systematic Biology* 56: 684–689.

ALA—Atlas of Living Australia (2009). *Atlas of Living Australia*. Canberra. http://www.ala.org.au/ [Accessed 14 July 2009].

AmphibiaWeb (2005). *AmphibiaWeb. Information on amphibian biology and conservation*. Berkeley, California: AmphibiaWeb. http://www.amphibiaweb.org/ [Accessed 15 June 2005].

AmphibiaWeb (2009). *AmphibiaWeb. Information on amphibian biology and conservation*. Berkeley, California: AmphibiaWeb. http://www.amphibiaweb.org/ [Accessed 13 March 2009].

Amrine, J. (2005). *Synopsis of the Described Ricinulei 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—Australian National Botanic Gardens (2004). *Australian Flora and Vegetation Statistics*. http://www.anbg.gov.au/anbg/australian-flora-statistics.html [Accessed 21 August 2005].

ANBG—Australian National Botanic Gardens (2009). *Australian Plant Name Index*. Electronic version at http://www.anbg.gov.au/apni/index.html. [Accessed 10 April 2009].

Anon. (1994). *Biodiversity: the UK Action Plan*. London: Her Majesty's Stationery Office.

Austin, A.D., Yeates, D.K., Cassis, G., Fletcher, M.J., La Salle, J., Lawrence, J.F., McQuillan, P.B., Mound, L.A., Bickel, D.J., Gullan, P.J. Hales, F.F. and Taylor, G.S. (2004). Insects 'Down Under'—Diversity, endemism and evolution of the Australian insect fauna: examples from select orders. *Australian Journal of Entomology* 43: 216–234.

Australian Biological Resources Study: see ABRS.

Australian National Herbarium (ANH), Australian National Botanic Gardens (ANBG) and Australian Biological Resources Study (ABRS) (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. pp. 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.

Bamber, R.N. and Nagar, A.E. (2009). *PycnoBase: Pycnogonida World Database* http://www.marinespecies.org/pycnobase/index.php [Accessed 9 April 2009].

Beesley, P.L., Ross, G.J.B. and Glasby, C.J. (2000). Polychaetes and Allies: The Southern Synthesis. *Fauna of Australia* Vol. 4A. Melbourne: CSIRO Publishing.

Bellinger, P.F., Christiansen, K.A. and Janssens, F. (2009). *Checklist of the Collembola of the World* 1996–2009. http://www.collembola.org [Accessed 25 March 2009].

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—no longer available 2009].

BirdLife International (2008). *State of the world's birds 2004: indicators for our changing world.* Cambridge, UK: BirdLife International.

Birds Australia (2009). *Birds. Checklist.* Melbourne: Birds Australia. http://www.birdsaustralia.com.au/birds/checklist.html [Accessed on 13 March 2009].

Bisby, F.A., Roskov, Y.R., Orrell, T.M., Nicolson, D., Paglinawan, L.E., Bailly, N., Kirk, P.M., Bourgoin, T., Baillargeon, G. (eds) (2009). *Species 2000 & ITIS Catalogue of Life: 2009 Annual Checklist.* Digital resource: www.catalogueoflife.org/annual-checklist/2009/. Reading, UK: Species 2000 [Accessed 14 April 2009].

Blakemore, R.J. (2008). *Cosmopolitan Earthworms—an Eco-Taxonomic Guide to the Peregrine Species of the World* 3rd edn. Japan: VermEcology.

Bonato, L., Chagas Jnr, A., Dioguardi, R., Edgecombe, G.D., Lewis, J.F., Minelli, A., Pereira, L.A., Shelley, R.M., Uliano, M. and Zapparoli, M. (2006). *Chilobase: a web resource for Chilopoda taxonomy.* http://chilobase.bio.unipd.it/docs/chilobase.php [Accessed 25 March 2009].

Bouchet, P. (2006). The Magnitude of Marine Biodiversity. Chapter 2 in Duarte, C.M. (ed.). *The Exploration of Marine Biodiversity: scientific and technological challenges.* Bilbao: Fundación BBVA. Available online at http://www.marinebarcoding.org/userfiles/File/bouchetmagnitude.pdf [Accessed 16 March 2009].

Bramwell, D. (2002). How many plant species are there? *Plant Talk* 28: 32–34.

Brusca, R.C. and Brusca, G.J. (2003). *Invertebrates.* 2nd edn. Sunderland MA: Sinauer Assoc.

Büchen-Osmond, C. (1988). *Viruses of Plants in Australia.* http://www.ncbi.nlm.nih.gov/ICTVdb/Aussi/ausiname.htm [Accessed 29 June 2005].

Buck, W.R., Goffinet, B., Engel, J.J., Konrat, M. von and Pickering, J. (2009). *Discover Life: Marchantiophyta.* http://www.discoverlife.org/mp20o?search=Marchantiophyta [Accessed 21 May 2009].

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. (2008). *A comprehensive list of extant Hemichordata with links to images*. Updated Nov. 2008. https://www.webdepot.umontreal.ca/Usagers/cameroc/MonDepotPublic/Cameron/Species.html [Accessed 16 March 2009].

CBD—Convention on Biological Diversity (2009a). *Global Taxonomy Initiative*. http://www.cbd.int/gti/ [Accessed 6 July 2009].

CBD—Convention on Biological Diversity (2009b). *Plant Conservation Report, A review of progress in implementing the Global Strategy for Plant Conservation*. Montreal, Canada: Convention on Biological Diversity Secretariat. http://www.cbd.int/doc/meetings/cop/cop-09/information/cop-09-inf-25-en.pdf [Accessed 10 May 2009].

CHAFC—Council of Heads of Australian Faunal Collections (2007). *Online Zoological Collections of Australian Museums (OZCAM)*. http://www.ozcam.gov.au/about.php [Accessed 5 July 2009].

CHAH—Council of Heads of Australasian Herbaria (2009a). *Australian Plant Census (APC)*. http://www.chah.gov.au/chah/apc/index.html [Accessed 15 April 2009].

CHAH—Council of Heads of Australasian Herbaria (2009b). *Australia's Virtual Herbarium (AVH)*. http://www.chah.gov.au/avh/ [Accessed 4 July 2009].

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 online searchable database http://www.cpbr.gov.au/apni/index.html [Accessed 6 July 2009].

Chapman, A.D. (2006). *Numbers of Living Species in Australia and the World*. 61pp. Canberra: Australian Biological Resources Study. ISBN (printed): 978 0 642 56849 6l ISBN (online): 978 0 642 56850 2. http://www.environment.gov.au/biodiversity/abrs/publications/other/species-numbers/2006/index.html.

Christidis, L. and Boles, W.E. (2008). *Systematics and Taxonomy of Australian Birds*. Melbourne: CSIRO Publishing.

Coddington, J.A. and Levi, H.W. (1991). Systematics and evolution of spiders (Araneae). *Annual Review of Ecology and Systematics* 22: 565–592.

Connor, S. (2009). *The Independent:* 23 May 2009. http://www.independent.co.uk/news/science/a-seahorse-the-size-of-a-pea-and-the-other-bizarre-species-new-to-science-1689776.html [Accessed 27 May 2009].

Convention on Biological Diversity: see CBD.

Cowan, R.A. (2006). *Australian Marine Algal Name Index*. Australian Biological Resources Study, Canberra, and Murdoch University, Perth. (Accessed July 2009].

Corliss, J.O. (2000). Biodiversity, Classification, and Numbers of Species of Protists. pp. 130–155 in Raven, P.H. and Williams, T. (eds). *Nature and Human Society: The Quest for a Sustainable World*. Washington, DC: National Academy Press.

Crandall-Stotler, B. (2008). *Bryophytes*. http://bryophytes.plant.siu.edu/bryojustified.html [Accessed 9 Jun. 2009].

Crosby, M. *et al.* (1999). *A Checklist of Mosses*. Missouri Botanical Garden. http://www.mobot.org/MOBOT/tropicos/most/checklist.shtml [Accessed 15 May 2009].

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].

Day, S.A., Wickham, R.P., Entwisle, T.J. and Tyler, P.A. (1995). *Bibliographic Checklist of Non-Marine Algae in Australia. Flora of Australia Supplementary Series*. No. 4. Canberra: Australian Biological Resources Study.

Deacon, J. (2005). *Fungal Biology*. Blackwell Publishing. Focal Topic: *The Biology of Lichens* available at http://www.biology.ed.ac.uk/research/groups/jdeacon/FungalBiology/lichen.htm [Accessed 4 July 2009.]

Deacon, J. (n.dat.). The Microbial World: Lichens. http://www.biology.ed.ac.uk/research/groups/jdeacon/microbes/lichen.htm [Accessed 4 July 2009].

DEH—Department of the Environment and Heritage (2001). *Australia State of the Environment Report*. Melbourne: CSIRO and Canberra: Department of the Environment and Heritage. http://www.environment.gov.au/soe/2001/index.html [Accessed 4 July 2009].

DEH—Department of the Environment and Heritage (2007). *State of Environment Report. Indicator BD-01 The number of fauna and flora species described in Australia compared with previous years and estimated total number of species. http://www.environment.gov.au/soe/2006/publications/drs/indicator/92/index.html* [Accessed 2 April 2009].

DEWHA—Department of the Environment, Water, Heritage and the Arts (2009a). *EPBC Act List of Threatened Fauna*. http://www.environment.gov.au/cgi-bin/sprat/public/publicthreatenedlist.pl?wanted=fauna [Accessed 12 March 2009].

DEWHA—Department of the Environment, Water, Heritage and the Arts (2009b). *EPBC Act List of Threatened Flora*. http://www.environment.gov.au/cgi-bin/sprat/public/publicthreatenedlist.pl?wanted=flora [Accessed on 19 May 2009].

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. Gland, Switzerland and Cambridge, UK: IUCN.

Eades, D.C. and Otte, D. (2009). *Orthoptera Species File Online*. Version 2.0/3.5. http://Orthoptera.SpeciesFile.org [Accessed 18 March 2009].

Earle, C.J. (ed.) (2009). *The Gymnosperm Database*. http://www.conifers.org/index.html [Accessed 15 April 2009].

Entwisle, T.J. and Huisman, J. (1998). Algal Systematics in Australia. *Australian Systematic Botany* 11: 203–214.

Eschmeyer, W.N. and Fricke, R. (eds) (2009). *Catalog of Fishes*. Online version dated 13 Mar. 2009 http://research.calacademy.org/research/ichthyology/catalog/fishcatmain.asp [Accessed 7 June 2009].

Eschmeyer, W.N. and Frong, J.D. (2009). *Species of Fishes by family/subfamily*. Online version dated 13 Mar. 2009 http://research.calacademy.org/research/ichthyology/catalog/SpeciesByFamily.asp [Accessed 7 June 2009].

Euzéby, J.P. (2004). *BIOS—Bacteriology Insight Orienting System*. http://www-sp2000ao.nies.go.jp/english/bios/ [Accessed 28 June 2005].

Euzéby, J.P. (2009). *LPSN: List of Prokaryotic names with Standing in Nomenclature*. http://www.bacterio.cict.fr/index.htm [Accessed on 20 April 2009].

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].

FishBase (2009). *FishBase. A Global Information System on Fishes*. http://www.fishbase.org/home.htm [Accessed 12 March 2009].

Follo, J. and Fautin, D. (2001). 'Echinoidea' (Online), *Animal Diversity Web*. http://animaldiversity.ummz.umich.edu/site/accounts/information/Echinoidea.html [Accessed 15 March 2009].

Fontaneto, D., De Smet, W.H. and Ricci, C. (2006). Rotifers in saltwater environments, re-evaluation of an inconspicuous taxon. *J. Mar. Biol. Ass. U.K.* 86: 623–656.

Fontaneto, D., Segers, H. and Melone, G. (2008). Marine rotifers from the Northern Adriatic Sea, with description of *Lecane insulaconae* sp. nov. (Rotifera: Monogononta: Lecanidae). *J. Mar. Biol. Ass. U.K.* 88: 253–258.

Fox, R. (2006). *Invertebrate Anatomy OnLine. Thelyphonus. Whip Scorpion*. http://webs.lander.edu/rsfox/invertebrates/thelyphonus.html [Accessed 27 March 2009].

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. New York: American Museum of Natural History [Accessed 15 June 2005].

Gaston, K.J. and Blackburn, T.M. (1997). How many birds are there? *Biodiversity and Conservation* 6: 615–625.

GBIF—Global Biodiversity Information Facility (2009a). *ECAT. Electronic Catalogue of Names of Known Organisms*. http://www.gbif.org/prog/ecat [Accessed 6 July 2009].

GBIF—Global Biodiversity Information Facility (2009b). *Global Biodiversity Information Facility Data Portal*. http://www.gbif.org/ [Accessed 17 July 2009].

Geoffroy, J.-J. (2001). *Diplopoda // Chilopoda // Pauropoda // Symphya // & also Onychophoras*. Centre International de Myriapodologie. http://www.mnhn.fr/assoc/myriapoda/ [Accessed 20 June 2005].

Geoffroy, J.-J. and Ruhberg, H. (2006). *World Checklist of the Onychophora*. http://www.mnhn.fr/assoc/myriapoda/ONYLIST.HTM [Accessed 30 March 2009].

Global Biodiversity Information Facility: see GBIF.

Govaerts, R. (2002). How many species of seed plants are there? *Taxon* 50: 1085–1090.

Grimaldi, D. and Engel, M.S. (2005). *Evolution of the Insects*. Cambridge Evolution Series 1. Cambridge, UK: Cambridge University Press.

Groombridge, B. and Jenkins, M.D. (2002). *World Atlas of Biodiversity*. Prepared by the UNEP World Conservation Monitoring Centre. Berkeley, USA: University of California Press.

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].

Guiry, M.D. and Guiry, G.M. (2009). *AlgaeBase*. World-wide electronic publication, National University of Ireland, Galway. http://www.algaebase.org [Accessed on 15 July 2009].

Hallan, J. (2003). *Biology Catalog: Synopsis of the Described Taxa of the World*. Austin, Texas: Texas A&M University. http://insects.tamu.edu/research/collection/hallan/0SYNOPT1.htm [Accessed 19 March 2009].

Halliday, R.B., O'0, 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? *The Journal of Arachnology* 30: 357–372.

Harvey, M.S. (2003). *Catalogue of the Smaller Arachnid Orders of the World—Amblypygi, Uropygi, Schizomida, Palpigradi, Ricinulei and Solifugae*. Collingwood, Vic. CSIRO Publishing.

Harvey, M.S. (2007). The smaller arachnid orders: diversity, descriptions and distributions from Linnaeus to the present (1758 to 2007). *Zootaxa* 1668: 363–380 (2007).

Harvey, M.S. (2009). Pseudoscorpions of the World, version 1.2. Western Australian Museum, Perth. http://www.museum.wa.gov.au/arachnids/pseudoscorpions/

Hassler, M. and Swale, B. (2001). *Checklist of World Ferns*. CD-ROM.

Hassler, M. and Swale, B. (2002). *Checklist of the Ferns and Fern Allies*. http://homepages.caverock.net.nz/~bj/fern/ [Accessed 27 June 2005].

Hassler, M. and Schmitt, B. (2009). *Checklist of Ferns and Lycophytes of the World*. http://www.rz.uni-karlsruhe.de/~db111/flora/ferns/index.php [Accessed 26 May 2009].

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 Society* Vol. 145. Rozelle, 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*, 6th edn Dubuque, Iowa, USA: Wm.C.Brown Publishers.

Hickman, C.P., Roberts, L.S., Larson, A. and l'Anson, H. (2004). *Integrated Principles of Zoology*. 12th edn Boston, MA: McGraw Hill. 872 pp.

Hill, K. (1998a). Pinophyta. *Flora of Australia* 48: 545–596. Melbourne: ABRS/CSIRO Australia.

Hill, K. (1998b). Cycadophyta. *Flora of Australia* 48: 597–661. Melbourne: ABRS/CSIRO Australia.

Hill, K. and Stevenson, D.W. (2004). World List of Cycads. Sydney: Royal Botanic Gardens. http://plantnet.rbgsyd.nsw.gov.au/PlantNet/cycad/wlist.html [Accessed 15 May 2009].

Hnatiuk, R. (1990). *Census of Australian Vascular Plants, Australian Flora and Fauna Series* No. 11. Canberra: Australian Government Publishing Service. 650 pp.

Hodda, M. (2000). *Nematodes of the Murray-Darling river system and coastal freshwaters of southeastern Australia* http://www.ento.csiro.au/science/nematode.html [Accessed 7 April 2009].

Hoek, C. van den, Mann, D.G. and Jahns, M.M. (eds) (1995). *Algae. An Introduction to Phycology*. Cambridge, UK: Cambridge University Press.

Hoese, D.F., Bray, D.J., Paxton, J.R. and Allen, J.R. (2005). *Australian Faunal Directory: Superclass Pisces*. Canberra: ABRS. http://www.environment.gov.au/biodiversity/abrs/online-resources/fauna/afd/taxa/Pisces. [Accessed 13 March 2009].

Hoese, D.F., Bray, D.J., Allen, G.R., Paxton, J.R., Wells, A. and Beesley, P.L. (2006). *Zoological Catalogue of Australia* Volume 35, Parts 1–3. Melbourne/Canberra, Australia: CSIRO Publishing and ABRS.

Hoffman, R.L. (1980). *Classification of the Diplopoda:* Geneva: Muséum d'Histoire Naturelle.

Hoffman, 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.

Hopkin, S.P. (1997). *Biology of the Springtails (Insecta: Collembola)*. Oxford, UK: Oxford University Press.

Hugot, J.P., Baujard, P. and Morand, S. (2001). Biodiversity in helminths and nematodes as a field of study: an overview. *Nematology* 3: 199–208.

Hutchings, P.A. and Fauchald, K. (2000). Class Polychaeta: Definition and general description. pp. 1–3 in Beesley, P.L., Ross, G.J.B. and Glasby, C.J. (eds). *Polychaetes and Allies: the Southern Synthesis.* Melbourne: CSIRO Publishing.

Hyde, K.D., Gareth-Jones, E.B., Leaño, E., Ponting, A.D. and Vrijmoed, L.L.P. (1998). Role of fungi in marine ecosystems. *Biodiversity and Conservation* 7: 1147–1161.

ICTV—International Committee on Taxonomy of Viruses (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].

ICTV—International Committee on Taxonomy of Viruses (2008). *Virus Taxonomy 2008.* http://www.ictvonline.org/virusTaxonomy.asp?version=2008 [Accessed 21 April 2009].

IPNI—International Plant Names Index (2009). *International Plant Names Index.* http://www.ipni.org/ London, UK: Royal Botanic Gardens, Kew. [Accessed 10 May 2009].

IUCN (2004). *The IUCN Red List of Threatened Species. Summary Statistics.* http://www.redlist.org/info/tables/table1.html [Accessed 15 June 2005—no longer available July 2009].

IUCN (2009a). *Mammals on the IUCN Red List—IUCN Red List Status.* http://www.iucnredlist.org/mammals/redlist_status [Accessed 10 March 2009].

IUCN (2009b). *Numbers of threatened species by major groups of organisms* (1996–2008). http://www.iucnredlist.org/documents/2008RL_stats_table_1_v1223294385.pdf [Accessed 12 March 2009].

Kathirithamby, J. (2002). *Strepsiptera. Twisted-wing parasites.* Version 24 Sept. 2002 (under construction). http://tolweb.org/Strepsiptera/ [Accessed 17 March 2009].

Kerr, A.M. (2000). *Holothuroidea. Sea cucumbers.* Version 01 December 2000. http://tolweb.org/Holothuroidea/19240/2000.12.01 in The Tree of Life Web Project. http://www.tolweb.org/Holothuroidea [Accessed 16 March 2009].

Kier, G., Kreft, H., Lee, T.M., Jetz, W., Ibisch, P.L., Nowicki, C., Mutke, J. and Barthlott, W. (2009). A global assessment of endemism and species richness across island and mainland regions. *Proceedings of the National Academy of Sciences* 106(23): 9322–9327.

Kirk, P., Cannon, P.F., Minter, D.W. and Stalpers, J.A. (2008). *Dictionary of the Fungi* 10th edn. CABI, UK.

Kirschner, J. and Kaplan, Z. (2002). Taxonomic manuscripts in relation to global red lists. *Taxon* 51(1): 155–158.

Konrat M. von, Söderström L., Hagborg, A. and Gog, L. (2009). *Early Land Plants Today (ELP)* http://www.early-land-plants-today.org/ [Accessed 21 June 2009].

Kott, P. (2005). *Catalogue of Tunicata in Australian Waters.* Canberra: ABRS. http://www.environment.gov.au/biodiversity/abrs/publications/electronic-books/tunicates.html [Accessed 13 March 2009].

Kott, P. (2006). *Australian Faunal Directory. Subphylum Tunicata.* Canberra: ABRS. http://www.environment.gov.au/biodiversity/abrs/online-resources/fauna/afd/taxa/Tunicata [Accessed 13 March 2009].

Lydeard, C., Cowie, R.H., Ponder, W.F., Bogan, A.E., Bouchet, P., Clark, S.A., Cummings, K.S., Frest, T.J., Gargominy, O., Herbert, D.G., Herschler, R., Perez, K.E., Roth, B., Seddon, M., Strong, E.E. and Thompson, F.G. (2004). The Global Decline of Nonmarine Mollusks. *Bioscience* 54(4): 321–330.

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 edn. Cambridge University Press, Cambridge.

Mah, C.L. (2009). *World Asteroidea database*. Available online at http://www.marinespecies.org/asteroidea [Accessed 16 March 2009].

Martin, J.W. and Davis, G.E. (2001). An Updated Classification of the Recent Crustacea. Natural History Museum of Los Angeles County. *Science Series* 39: 1–124. http://www.nhm.org/research/publications/CrustaceaClassification.pdf [Accessed 19 May 2009].

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. and Williams, T. (eds) *Nature and Human Society: The Quest for a Sustainable World*. Washington, DC: National Academy Press.

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.

McCarthy, P.M. (2006). *Checklist of Australian Liverworts and Hornworts*. Australian Biological Resources Study, Canberra. Version 6 April 2006. http://www.anbg.gov.au/abrs/liverwortlist/liverworts_intro.html [Accessed 14 April 2009].

McCarthy, P.M. (2009). *Checklist of the Lichens of Australia and its Island Territories*. Australian Biological Resources Study, Canberra. Version 23 March 2009. http://www.anbg.gov.au/abrs/lichenlist/introduction.html [Accessed 16 April 2009].

McCarthy, P.M. and Orchard, A.E. (eds) (2007). *Algae of Australia: Introduction*. Canberra: ABRS; Melbourne: CSIRO.

McCauley, D.W. (n.dat.). *Urochordata and Cephalochordata*. http://www.personal.psu.edu/users/c/l/clm278/the%20cephalocordata.html [Accessed 15 June 2005—no longer available 2009].

McNeely, J.A., Miller, K.R., Mittermeier, R. and Werner, T.B. (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.

Meeûs, T. de and Renaud, F. (2002). Parasites within the new phylogeny of eukaryotes. *Trends in Parasitology* 18(6): 247–251.

Mendes, L.F. (2002). Taxonomy of Zygentoma and Micrcoryphia: historical overview, present status and goals for the new millennium. *Proc. Xth International Colloquium on Apterygota, České Budějovice 2000: Apterygota at the Beginning of the Third Millennium*. Elsevier GmbH.

Mesibov, B. (2008). Millipedes of Australia. http://www.qvmag.tas.gov.au/zoology/millipedes/index.html [Accessed 17 March 2009].

Messing, C.G. (n.dat.). *Charles Messing's Crinoid Pages* http://www.nova.edu/ocean/messing/crinoids/index.html [Accessed 16 March 2009].

Metting, F.B. (1996). Biodiversity and application of microalgae. *Journal of Industrial Microbiology* 17: 477–489.

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, *Animal Diversity Web*. http://animaldiversity.ummz.umich.edu/site/accounts/information/Echinodermata.html. [Accessed 17 June 2005].

Myers, P. (2001a). Insecta, *Animal Diversity Web*. http://animaldiversity.ummz.umich.edu/site/accounts/information/Insecta.html [Accessed 17 June 2005].

Myers, P. (2001b). Diplopoda, *Animal Diversity Web*. http://animaldiversity.ummz.umich.edu/site/accounts/information/Diplopoda.html [Accessed 17 June 2005].

Myers, P. (2001c). Chilopoda, *Animal Diversity Web*. http://animaldiversity.ummz.umich.edu/site/accounts/information/Chilopoda.html [Accessed 17 June 2005].

Myers, P. (2001d). Crustacea, *Animal Diversity Web*. http://animaldiversity.ummz.umich.edu/site/accounts/information/Crustacea.html [Accessed 17 June 2005].

Myers, P. (2001e). Annelida, *Animal Diversity Web*. http://animaldiversity.ummz.umich.edu/site/accounts/information/Annelida.html [Accessed 23 June 2005].

Myers, P. (2001f). Nematoda, *Animal Diversity Web*. http://animaldiversity.ummz.umich.edu/site/accounts/information/Nematoda.html [Accessed 23 June 2005].

Myers, P. (2001g). Platyhelminthes, *Animal Diversity Web*. http://animaldiversity.ummz.umich.edu/site/accounts/information/Platyhelminthes.html [Accessed 23 June 2005].

Myers, P. (2001h). Porifera, *Animal Diversity Web*. http://animaldiversity.ummz.umich.edu/site/accounts/information/Porifera.html [Accessed 24 June 2005].

Myers, P. (2001i). Hirudinea, *Animal Diversity Web*. http://animaldiversity.ummz.umich.edu/site/accounts/information/Hirudinea.html [Accessed 6 April 2009].

Ng, P.K.L., Guiot, D. and Davie, P.J.F. (2008). Systema Brachyurorum: Part 1. An Annotated Checklist of the Extant Brachyuran Crabs of the World. *The Raffles Bulletin of Zoology* 17: 1–286. http://rmbr.nus.edu.sg/rbz/biblio/s17/s17rbz.pdf [Accessed 31 March 2009].

Nielsen, E.S. and Mound, L.A. (2000). Global Diversity of Insects: The Problems of Estimating Numbers. pp. 213–222 in Raven, P.H. and Williams, T. (eds). *Nature and Human Society: The Quest for a Sustainable World*. Washington, DC: National Academy Press.

Nieuwenhuys, E. (1998). *The spider*. http://www.xs4all.nl/~harhiem/The_spider.pdf [Accessed 17 June 2005].

Nieuwenhuys, E. (2008). *The spider*. http://www.xs4all.nl/~ednieuw/Spiders/InfoNed/The_spider.html [Accessed 1 June 2009].

Nishi, A., Ishida, K. and Endoh, H. (2005). Reevaluation of the Evolutionary Position of Opalinids based on 18S rDNA and α- and β-Tubulinb Gene Phylogenies. *Journal of Molecular Evolution* 60(6): 695–705.

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.

Oberprieler, R., Marvaldi, A.E. and Anderson, R.S. (2007). Weevils, weevils, weevils everywhere. *Zootaxa* 1668: 491–520.

Pascoe, I.G. (1990). History of systematic mycology in Australia pp. 259–264 in Short, P.S. (ed.). *History of Systematic Botany in Australasia*. South Yarra, Australia: Australian Systematic Botany Society.

Paton, A.J., Brummit, N., Govaerts, R., Harman, K., Hinchcliffe, S., Allkin, B. and Lughadha, E.N. (2008). Towards Target 1 of the Global Strategy for Plant Conservation: a working list of all known plant species—progress and prospects. *Taxon* 57(2): 1–10.

Pinto-da-Rocha, R., Michado, G. and Giribert, G. (eds) (2007). *Harvestmen—The Biology of Opiliones*. Boston, MA: Harvard University Press.

Platnick, N.I. (2008). *The world spider catalog,* version 9.5. American Museum of Natural History, online at http://research.amnh.org/entomology/spiders/catalog/index.html [Accessed 25 March 2009].

Poinar Jr., G. (2008). Global diversity of hairworms (Nematomorpha: Gordiaceae) in freshwater. *Hydrobiologia* 595: 79–82. http://www.springerlink.com/content/ww12j590g701067r/fulltext.pdf [Accessed 14 April 2009].

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—no longer available July 2009].

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.

Prance, G.T. (2001). Discovering the plant world. *Taxon* 50: 345–359.

Ramel, G. (2009a). The Phylum Porifera. *Earthlife Web.* http://www.earthlife.net/inverts/porifera.html [Accessed 19 May 2009].

Ramel, G. (2009b). What is a Lichen? *Earthlife Web.* http://www.earthlife.net/lichens/lichen.html [Accessed 4 June 2009].

Ramsey, D. (2005). *Rainforest Fungi.* http://rainforest-australia.com/fungi.htm [Accessed 28 June 2005].

Raven, P.H. and Yeates, D.K. (2007). Australian biodiversity: threats for the present, opportunities for the future. *Australian Journal of Entomology* 46: 177–187.

RBG—Royal Botanic Gardens, Kew (2009). World Checklist of Selected Plant Families. http://apps.kew.org/wcsp/home.do [Accessed 6 July 2009].

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.

Rein, J.O. (2009). *The Scorpion Files.* Norwegian University of Science and Technology. http://www.ub.ntnu.no/scorpion-files/ [Accessed 25 March 2009].

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.

Ridsdill-Smith, J. (2004). Entomology and the Australian Entomological Society. *Australian Journal of Entomology* 43: 211–215.

Rossman, 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://www.ars.usda.gov/Services/docs.htm?docid=9426 [Accessed 6 July 2009].

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., Eliott, 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.environment.gov.au/soe/1996/publications/report/pubs/chap04.pdf [Accessed 6 July 2009].

Savary, W. (2006). *The Arachnid Order Solifugae.* http://www.solpugid.com/index.htm [Accessed 27 March 2009].

Schotte, M., Kensley, B.F. and Shilling, S. (2009). *World list of Marine, Freshwater and Terrestrial Crustacea Isopoda.* Washington D.C., USA: National Museum of Natural History Smithsonian Institution [Accessed 15 May 2009].

Scotland, R.W. and Wortley, A.H. (2003). How many species of seed plants are there? *Taxon* 52: 101–104.

Scott, F.J. and Marchant, H.J. (eds) (2005). *Antarctic Marine Protists*. Canberra: Australian Biological Resources Study and Australian Antarctic Division.

Segers, H. (2008). Global diversity of rotifers (Rotifera) in freshwater. *Hydrobiologia* 595: 49–59.

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, Los Baños, Philippines: Species 2000.

Sierwald, P. and Bond, J.E. (2007). Current status of the myriapod class Diplopoda (millipedes): taxonomy diversity and phylogeny. *Annual Review of Entomology* 52: 401–420.

Sjöström, A. and Gross, C.L. (2006). Life history characters and phylogeny are correlated with extinction risk in the Australian angiosperms. *Journal of Biogeography* 33: 271–290.

Smith, V. and Page, R. (1997). *Phthiraptera. Lice*. Version 07 March 1997 (under construction). http://tolweb.org/Phthiraptera/ [Accessed 18 March 2009].

Snelgrove, P.V.R., Blackburn, T.H., Hutchings, P.A.A., Alongi, D.M., Grassle, J.F., Hummel, H., King, G., Koike, I., Lambshead, P.J.D., Ramsing, N.D. and Solis-Weiss, V. (1997). The importance of marine sediment biodiversity in ecosystem processes. *Ambio* 26: 578–584.

Stöhr, S. and O'Hara, T. (2007). *World Ophiuroidea database*. Available online at http://www.marinespecies.org/ophiuroidea [Accessed 16 March 2009].

Stotler, R. and Crandall-Stotler, B. (2009). *The Genera of Liverworts*. http://bryophytes.plant.siu.edu/general.html [Accessed 12 June 2009].

Swale, B. (2000). *Checklist of World Ferns*. http://homepages.caverock.net.nz/~bj/fern1.htm [Accessed 27 June 2005].

Szeptycki, A. (2007). *Catalogue of the World Protura*. Krakow, Poland: Wydawnictwa Instytutu Systematyki I Ewolucji Zwierzat Polskiej Akademii Nauk. http://www.isez.pan.krakow.pl/journals/azc_i/pdf/50B(1)/01.pdf [Accessed 25 March 2009].

Tangley, L. (1997). How many species are there? *US News and World Report* Aug. 18, 1997. http://www.usnews.com/usnews/culture/articles/970818/archive_007681.htm [Accessed 6 July 2009].

Thompson, F.C. (2008). *The Diptera Site. The BioSystematic Database of World Diptera*. Status Report Version 10.5 released 6 May 2008. http://www.sel.barc.usda.gov/diptera/names/Status/bdwd_105.htm [Accessed 17 March 2009].

Thorne, R.F. (2002). How many species of seed plants are there? *Taxon* 51: 511.

TIGR (2009). *TIGR Reptile Database*. http://www.reptile-database.org/ [Accessed 13 March 2009].

Trueman, J.W.H. and Rowe, R.J. (2008). *Odonata. Dragonflies and damselflies*. Version 20 March 2008. http://tolweb.org/Odonata/ [Accessed 17 March 2009].

University of Auckland (2009) *Bryophytes Overview* in New Zealand Plants: Ngaa Taonga o te Ngahere http://www.sbs.auckland.ac.nz/uoa/science/about/departments/sbs/newzealandplants/ [Accessed 15 May 2009].

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. lxiv + 862 pp. Gland, Switzerland and Cambridge, UK: IUCN–The World Conservation Union.

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 onwards). *Wikipedia. The Free Encyclopedia*. http://en.wikipedia.org/wiki/Main_Page [Accessed 21 May 2009].

Williams, J. (ed.) (2001). *Extracts from State of the Environment Report 2001* (Theme Report: Biodiversity). Canberra: Department of the Environment and Heritage. http://www.environment.gov.au/soe/2001/publications/theme-reports/biodiversity/index.html [Accessed 4 July 2009].

Wilson, D.E. and Reeder, D.M. (eds) (2005). *Mammal Species of the World. A Taxonomic and Geographic Reference*. 3rd edn. Washington, DC: Smithsonian Institution Press.

Wilson, D.G.F. (2008). Global diversity of Isopod crustaceans (Crustacea; Isopoda) in freshwater. *Hydrobiologia* 595: 231–240.

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/articles/biodivsum [Accessed 6 July 2009].

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.

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