

IMPLEMENTING THE GTI:

Recommendations from *DIVERSITAS* element 3, including an assessment of present knowledge of key species groups

1. The goal

The *DIVERSITAS* element on *systematic inventory - discovering and describing the world's species diversity* aims to:

- contribute to the implementation of Articles 6–8 and 10 of the Convention on Biological Diversity (CBD) (General Measures for Conservation and Sustainable Use; Identification and Monitoring; *In-situ* Conservation; Sustainable Use), and,
- particularly Article 7(a) (Identify components of biological diversity important for its conservation and sustainable use) by:
 - giving an overview of the state of our knowledge of the world's biodiversity;
 - indicating the gaps in that knowledge;
 - suggesting criteria for setting priorities to fill those gaps;
 - recommending some key actions for the removal of the taxonomic impediment.

To accomplish this task, *DIVERSITAS* established an expert panel whose work was developed through a questionnaire, consultations, and in discussions held at a workshop in Paris, France, on 20-21 February, 1999. The product of this work is part of *DIVERSITAS*' contribution to the implementation of the Convention. This contribution was foreshadowed in Decision 1 *pro parte* of COP IV, and has been further elaborated in the memorandum of understanding between *DIVERSITAS* and the CBD secretariat.

This paper builds on meetings held under the auspices of *DIVERSITAS* and others in Crete, Darwin and London during 1997 and 1998. General guidelines for taxonomic inventory at the national and regional level were also discussed at a workshop held at the American Museum of Natural History in New York, 17-19 Sept. 1998, and are also provided as an information paper to SBSTTA.

This paper contains an overview of the state of our knowledge of species-level diversity, by global and continental numbers of known species, thus indicating regional and taxonomic gaps. Criteria are suggested to set priorities for gap filling. By presenting numbers of taxonomists and collections, along with recommendations and a few examples of ongoing initiatives to build taxonomic capacities, the paper identifies the need for national capacities (collections, infrastructure and expertise) and the strengths of existing collections in fostering regional and international scientific collaboration, and in advancing the Global Taxonomy Initiative (GTI). In the reports required by the CBD, there is an advantage to including advances in the implementation of these capacities and co-operation.

DIVERSITAS recommends strongly that taxonomic/systematic questions, which are essentially global in nature, must be approached through co-operative efforts at national, regional and global levels. Internationally, sharing of information is an essential factor in overcoming the taxonomic impediment, identified in the Darwin declaration (www.anbg.gov.au/abrs/flora/webpubl/darwin.htm). Because species concepts may vary, and because removing the taxonomic impediment implies a wider understanding of the taxonomic hierarchy, this paper often uses the term *taxa*, which includes families, genera, species, sub-species, varieties, etc.

It is now apparent that the description and collation of the world's species diversity cannot be completed in a reasonably short time, without modifications to the ways species are described and recorded. Given the rapid improvements in information technology, it is perhaps time to consider the establishment of an electronic journal devoted to species descriptions, or the establishment of worldwide coordinated databanks, into which new descriptions must be logged, after publication. This database could operate in a fashion similar to the DNA and protein sequence databases already in existence. Such a system would enable faster communication (reducing synonymies) and may address the imbalance in current taxonomic efforts. The CBD covering, as it does, all levels of the biological hierarchy, is in a unique position to promote such changes.

In order to assist development of the GTI, *DIVERSITAS* recommends measures for capacity building in taxonomy/systematics.

DIVERSITAS strongly endorses the call from COP IV that '*special consideration should be given to regional perspectives and the setting up of regional centres of taxonomic expertise, as well as to the taxonomy efforts of other intergovernmental programmes, agencies and relevant institutions*'. As well as regional co-operation, better co-operation and team development between taxonomists of various disciplines, plant, animal and microbial, is recommended. In all this, the need for recasting the mechanisms and imperatives of the funding agencies are underscored.

In the following sections, we recall the reasons and needs for taxonomic work (section 2). Based on the state of knowledge, presented in section 5, and a small sample of countries' own taxonomic capacities (section 3), we suggest some criteria for setting priorities and provide specific recommendations and examples for capacity building in training, infrastructure and international collaboration (section 4).

2. Why do we need to work on taxonomy? Why is it important to distinguish species from one another?

Taxonomy and systematics are all about communication and information. To conserve, manage or use organisms, or to communicate about them, we need an unambiguous nomenclature. Good taxonomy delivers stable classification and unequivocal names, both of which facilitate communication. In turn, this makes it possible to conserve, manage or use biodiversity more effectively. While, in a sense, it is possible to fulfil partially the Articles of the CBD without any taxonomic base, it will not be possible to achieve these objectives fully, over the long term. We need a balance between the imperatives of management and use, and the need for solid, unequivocal information on global biodiversity at the species level.

While the CBD is focused on individual countries and most outcomes will be at national levels, for taxonomy the focus is wider. Most systematics issues are best dealt with on a regional or global basis, as biodiversity at the ecosystem and species levels recognizes no political boundaries. Many taxonomic groups are in urgent need of regional or even global overviews, to deal with superfluous names, and re-evaluate the taxonomy of the whole group. Significant economies of scale and effort can be achieved by adopting a regional approach, rather than a national, single-country one, to inventorying or solving taxonomic problems of particular groups of organisms.

PRODUCTS AND USERS OF TAXONOMY

TAXONOMY is the science of naming organisms and classifying them in groups of similar organisms.

Main PRODUCTS of taxonomic work are:

- a) Scientific names*
- b) Accurate identifications*
- c) Understanding relationships among organisms*
- d) Knowledge of geographical distribution of species*
- e) Knowledge of natural history*
- f) Collections for comparisons*
- g) Basic data for monitoring of biodiversity and environmental quality.*

Who are the USERS of the work produced by taxonomy?

- **Private sector:** *food industry, forestry industry, pharmaceutical industry, medicine, veterinary industry, fisheries, private gardens, materials' protection, ecotourism, etc.*
- **Governmental services:** *customs, police, national and international regulations for food security, quarantine, wildlife trade, human health, trade, etc.*
- **International agencies responsible for the administration of health, food, trade and conservation agreements:** *CITES, CMS, WTO, WHO, FAO, IPPO.*
- **General public,** *including media, for educational and leisure purposes.*

Some REASONS to use taxonomic work are:

- *The need for unambiguous identification of harmful and beneficial organisms*
- *Investigations of new crops, use as bio-indicators, and management of natural resources in agriculture, forestry, fisheries, water supply industry, and horticulture*
- *Correlation with geological history and uses such as petroleum and mineral extraction, through use of micro organisms*
- *Health care: disease causing' organisms*
- *Pharmaceutical and biotechnology industries: identification of possible beneficial organisms for discovery and management of biological resources on an international scale.*

Systematics is the study of the diversity of organisms, of the historical (evolutionary) and genetic relationships among organisms, and of their similarities and differences. As taxonomy and systematics are strongly related in terms of attaining the knowledge of the diversity of life, we use these terms indiscriminately in this document

3. A note on selected national taxonomic capacities

Curatorial capacities and biological reference collections are the base for taxonomic work. Assessing their current taxonomic capacities, some countries have become aware of these needs and are taking initiatives that could serve as examples for the implementation of the Global Taxonomy Initiative.

In SOUTHERN AFRICA, ten countries (Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Zambia, Zimbabwe) have defined their needs for herbaria curatorial capacities. A five-year project (SABONET), funded by GEF is currently under way to increase curatorial capacities from 216 to 425 people, including scientific and physical curation plus data basing personnel.

The UNITED KINGDOM holds some of the largest and more valuable collections in the world. Over 104 millions of specimens are kept in 22 collections, the largest being the Natural History Museum in London (60 million specimens) and the Royal Botanic Gardens, Kew (7 million) of which many are types from which species were described. These institutions collaborate closely in research and the development of taxonomic capacities in other countries and are studying ways to repatriate information to countries of origin.

MEXICO has assessed its national taxonomic capacities on zoological, botanical and microbiological collections, by federal states. As a fundamental step to improve its capacities, CONABIO has databased its collections, repatriated data on collections around the world and is training taxonomists to manage information. Furthermore, CONABIO has produced Biotica, a commercial package to database specimen' collections and related information.

KOREA has recently conducted an assessment on biological collections and taxonomic experts, determining the need and urgency for data basing its collections, establishment of a National Museum of Natural History and adequate training for human capacities, for properly implementing the CBD in the country.

The NETHERLANDS has recently made available international access to its botanical type specimen collections, by posting high-resolution images of these types on the Internet.

	nr of coll. staff	zoological collections	botanical collections	types	data based	
(million of specimens)						
UK	22	74.7	17.7	1.300.000		598
FRANCE	3	41.5	16.6	~ 650.000		125
INDONESIA		~0.5	~1.0			47
KOREA	8	4.1	0.50	2.222	24%	--- ²
MEXICO	8 ¹	3.0	7.3		90%	--- ²
NETHERLANDS	6	20.0	6.0	ca.300.000	19%	50

Staff: number of curators with taxonomic capacities

Numbers of collections are those with more than 100,000 specimens, or (¹) more than 85% of all collections

Types (holotypes + paratypes) excluding fossils

(²) the total number of taxonomic expertise not differentiated for Korea and Mexico is 207 and 961, respectively.

4. Addressing the needs: suggested actions

Given the present state of knowledge presented in section 6, and the different strategies undertaken by several nations signatories of the CBD;

Taking into account previous declarations concerning the taxonomic impediment and the Global Taxonomy Initiative as a way to shorten those needs,

The *DIVERSITAS* expert panel on taxonomy fully endorses the initiatives suggested in the report from the London meeting in September 1998, provided as an Information Document for SBSTTA IV.

Furthermore, it recommends the following strategies for national efforts:

1. Establish criteria and principles to guide the priority-setting processes for identifying actions to implement taxonomy-related initiatives, especially at regional and global levels.
2. Provide some suggestions and examples for capacity building in infrastructure, training in taxonomy, and international collaboration, consortia and co-operation.
3. Include actions for increasing national taxonomic capacities and establish mechanisms for international co-operation in this field; those should be included in national reports and in national biodiversity strategies.

4.1. Criteria for a priority approach

National priorities for biodiversity are a matter for signatory nations of the Convention on Biological Diversity and will be addressed independently, by each nation, within that framework. Despite those national prerogatives, taxonomic work, especially above the species level, requires global or continental efforts and therefore extensive cooperation, for its advance. The information presented in this report, globally and by regions, suggests an urgent need for action to cope with those taxonomic imperatives, which are essential to the effective implementation of the CBD.

Therefore, *DIVERSITAS* recommends a "priority approach" from the taxonomic perspective, following some common *criteria* that could be applied at national as well as regional or global levels.

The criteria for defining priorities, as discussed at the Paris meeting, are as follows:

4.1.1. TAXA of economic value. Because of interactions at both community and ecosystem levels, we recognize that all species have economic value and, in some way, influence human welfare. We are more concerned here, however, with species that have direct and immediate effects on human health, food supplies (including agricultural crops and fisheries), timber, biotechnology, and similar benefits (degraders of xenobiotics, remediation technologies). We include here species that have positive effects (e.g., pollinators, seed dispersers, scavengers) and negative effects (e.g., disease vectors, crop pests, pathogens, foreign species that threaten indigenous biodiversity).

4.1.2. TAXA that characterise ecosystems. Such species may define the structure of an ecosystem, the types of uses for which it is appropriate, or function within an ecosystem. For example, from the plant world, many of the Rubiaceae occur as shrubs or small trees in the wet-dry tropical regions of the world, the families Ericaceae and Epacridaceae characterise shrub lands or heath lands in both hemispheres, the Laminariales are important structural determinants of temperate near-shore marine ecosystems. From an animal perspective, corals and sponges are key marine organisms, and many invertebrates have important recycling roles in terrestrial and aquatic ecosystems. Extreme environments are often characterised by exclusive presence of pro- and eukaryote microorganisms.

Of particular concern here are marine and fresh water ecosystems (surface and subsurface waters equally), because they are poorly known and of extreme importance as fish habitats and as sources of water and food for human consumption. It is critical that we are able to characterise their structure and function and to identify indicator species that signal health or specific problems. Other ecosystems requiring attention are mountain areas, arid and semi-arid regions where organisms may have ephemeral lives associated with changes in moisture balance, and lowland tropical forest, where habitat change is high.

With a complete understanding of the component species of each ecosystem and interspecies interactions, identifying areas for appropriate land uses, and developing methods for the restoration of degraded sites will be greatly accelerated.

4.1.3. TAXA living in threatened areas: This category includes:

- a) heavily exploited species, such as marine fish, that are poorly known taxonomically;
- b) species that form the biota of rapidly deteriorating or disappearing habitats or ecosystems;
- c) species threatened with extinction; and
- d) narrow endemics and species with very limited distribution.

4.1.4. TAXA that are Indicator species or species groups. Species or species groups that are highly sensitive to changes in both biotic and abiotic conditions in the environment, at local, regional, and global scales and that are useful in monitoring such change.

In providing these criteria, and by indicating the existing gaps in our knowledge of biodiversity, *DIVERSITAS* suggests the tools necessary to develop regional or global priorities. Taxonomic priorities can be taxa that are poorly studied and are important, according to the criteria suggested; or they may be bio geographical, in the case of ecosystems in which most taxonomic groups are little known, or geographical in the sense that most developing countries are taxonomically less well studied. An assessment of national taxonomic priorities must precede the regional priority-setting process; that exercise will guide the identification of common criteria and priorities for regional co-operation.

THE FORGOTTEN PRIORITY: THE MARINE REALM

Some 15% of all species described so far are marine, 80% of which belong to Phyla restricted to the seas. A high proportion of the marine micro fauna such as molluscs, crustaceans, polychaeta worms and multicellular algae are already known, but the current knowledge of nematodes and protists is much less complete. The biomass of small deep-sea organisms such as the meiofauna (mainly nematodes) probably equals or exceeds the biomass of larger organisms; but data on comparative species richness are lacking.

Marine research lags behind continental research because sampling and observing require the use of ships and equipment that are expensive to own and maintain. On the other hand, most marine ecosystems are essential for the economy of many islands and archipelagos, as well as countries relying heavily on biotic resources from the seas. Exploration of deep-sea systems and other marine ecosystems in international waters deserves special consideration, and the CBD is urged to deal with this, within the UNCLOS framework, to achieve progress.

4.2. Suggestions for capacity building

To develop further the Global Taxonomy Initiative, *DIVERSITAS* sees capacity-building measures in systematics as essential.

Our recommendations address the main problem on taxonomic work: training, infrastructure and international collaboration. Although presented separately, they should be seen as an essential integrated framework for taxonomic work.

a) Training

To increase national capacities on taxonomy *DIVERSITAS* recommends national governments to:

1. **Improve national training programmes at all levels:** curators/taxonomists at MSc and PhD level in national curricula, across all groups of organisms, as well as museum technicians, collection assistants and Para taxonomists. Longer-term training is especially important: MSc, PhD and postdoctoral levels, at least initially, may have to take place in countries with well-developed university programs in systematics; such training should be supported by fellowships over 2 years and opportunities for personnel exchange. Individuals trained must be guaranteed a job during and after training. Training programmes may be shared at regional levels.

Some examples of successful training projects:

CONABIO is training dozens of students and professional taxonomists from Costa Rica and other Latin American personnel in data basing taxonomic information through its database model called BIOTICA, which is now being commercialised.

SABONET in Southern Africa - a set-term project, funded by GEF, to develop capacity at national herbaria in Southern Africa. This is now instrumental in fostering regional co-operation as well.

SAFRINET in the same region – is an ongoing programme (part of Bionet International) to improve capacity in systematics of agriculturally important organisms.

EU programme on Large Scale Facilities and Taxonomy and Mobility in Research.

The Herbarium Techniques Course at the Royal Botanic Gardens, Kew is run every two years and trains technicians in the permanent preservation and management of collections, as well as how to extract, make use of, and make widely available the data held therein. Eight courses have been run at Kew as well as single courses in Malaysia, Brazil, China and Russia, while people trained at this course have held regional training courses on the same subject in East Africa.

The Visiting Scientist Program and the Research Training program, at the National Museum of Natural History, Smithsonian Institution, Washington DC, USA are two initiatives, for scientists and for students respectively, aiming to provide opportunities for collaborative research and training, using the facilities and interacting with researchers from the NMNH.

Capacity building projects in the Netherlands include a MSc programme on Biodiversity and natural products at Leiden University and the National Graduate School 'Biodiversity' - a combination of taxonomy and bio pharmacy, specially targeted to students from developing countries. There are possibilities to move on to PhD programmes.

Missouri Botanical Garden has a training programme for students coming from developing countries (e.g. Peru, Madagascar, Colombia, China) in taxonomy, molecular systematics, databases, etc.

2. **Establish chairs in taxonomy/systematics** in the National University system, perhaps under a joint system of sponsorship through UNESCO and UNEP.

3. **Encourage north-south and south-south co-operation** in exchange programmes for MSc and PhD, and collection management training programmes; grants for visiting scientists, grants for sabbaticals etc. to promote taxonomic research and information distribution.

Recommendation: prioritise all aspects of taxonomic activity, including the management of collections, and methods of information distribution within taxonomic training. *DIVERSITAS* recommends that the GEF be encouraged to support training fellowships or specially targeted training programs in taxonomy (perhaps by establishing a dedicated fund).

Product: trained taxonomists, leading to improved taxonomy, which will give nations the capability to inventory, identify, conserve and use their biodiversity. The outcome will be a reversal of the trend of the greying of the taxonomic community noted by many authors for several parts of the world in the last decade and contribute to initiatives such as the electronic catalogue Life on Earth, pursued by the Species 2000 project (www.sp2000.org).

b) Infrastructure

In building a suitable infrastructure for taxonomic biodiversity research and information transfer, *DIVERSITAS* recommends the following priorities:

1. First priority should be given to **data basing existing information** from biological specimens held within and outside the country, following the example of the successful and now fully operational CONABIO model in Mexico.

As regards human infrastructure, **assessing existing taxonomic expertise** on species that occur in the country - specialists within the country as well as those in other parts of the world.

It is suggested the CBD might wish to request the GEF to develop mechanisms to fund proposals of this nature.

2. The establishment of **national collections** is an important step in setting capacities for taxonomy, especially in developing countries. These places are the residence for collections from the field and the expertise of trained taxonomists. National collections are important for activities related to nature conservation, wildlife management, environmental impact assessment, taxonomic training, etc.

Physical infrastructure (buildings, libraries, collections furniture such as shelves, etc.) should be considered an urgent need in developing countries. Minimum standards for long term specimen storage and other collection facilities should be established by the scientific community, and libraries to support taxonomic research should be assessed and improved when required.

Capacity building in developing countries should be focussed on both **taxonomic expertise** and **information technology skills** required to utilize effectively the benefits of electronic databases. Attention should be given to the physical resources needed, e.g. hardware and software.

3. From the national databases of existing collections, the use of GIS will collect and connect information that will make obvious **gaps** in taxa and ecosystem biodiversity knowledge; these should be addressed by focused field exploration, collection building and taxonomic research.
4. Parties are encouraged to set these priorities in the framework of **regional networks**, in view of the transnational nature of geographic patterns/distribution of species diversity.
5. Parties holding major global biodiversity collections are invited to support this process by:
 - a. assisting in data basing specimens from the countries concerned
 - b. giving access, as much as possible, to their collections by providing information and digital images of their specimens on the Worldwide Web
 - c. providing training and guidelines for collections management and for data basing collections

Projects: all recommended actions are projects on a national or regional scale.

Outputs from these activities would be:

- National and regional databases of specimens, species, GIS and ecological data - directly operational for conservation and suitable management policies
- Guidelines to building and maintenance of collections
- National/regional registers of taxonomists and specimen data on the Worldwide Web,

while the **outcome** will be a much stronger and more accessible basis for biodiversity knowledge and management.

Overview treatments

Overview treatments of group of organisms are vital for advancing taxonomic work worldwide. Species descriptions on their own are not very useful, if they cannot be bundled and synthesized in floras/faunas; for most organisms there is a lack of synthetic and readily available inventories. Such inventories should enable identification of species - which is several steps further than a basic list of species; and even such basic lists are lacking for many groups. An example of a worldwide basic list is the Plant Names Project (<http://pnp.huh.harvard.edu/>), which is a cooperative project between the herbaria of Kew, Harvard and Canberra. For insects, there is a recent checklist of over 90,000 North American valid species, and a similar list for Africa is being prepared by ICIPE. Much of such information is already present in a variety of formats, and bringing such information together in an accessible format would be of great benefit to everyone.

From workable checklists and other sources of known species, country lists can be built up and linked with bibliographic information, images of types and representative specimens - such information would be of great value to institutes at a national level, as it would enable them to perform species identifications or construct species identification manuals. The Worldwide Web can be a very useful tool in the distribution of such information.

c) International collaboration, consortia & cooperation

A large part of current taxonomic capacities is in developed countries and their large institutions. *DIVERSITAS* therefore recognizes that, in order to overcome the taxonomic impediment in a significant manner, there is a need for a cohesive strategy for capacity building in taxonomy, which would best be achieved through a three-tiered approach consisting of within country, regional/sub-regional, and global perspectives.

At the same time, it is difficult to get international projects funded. *DIVERSITAS* calls for a new way to apply for GEF/UNEP/UNDP/World Bank funding for partnerships to deliver the Global Taxonomy Initiative. Under these new arrangements, support would be provided for consortia to be established that include one or more target countries that wish to increase their taxonomic capability, together with one or more global taxonomic institutions in the developed world. Once formed, such consortia would be funded to work together to begin collaboration on pilot projects, and to develop funding proposals for larger projects. It is envisaged that the funding for such projects would be provided through the developing country partners. As an example, the UK Government's Darwin Initiative has included a number of projects that demonstrate what can be achieved through such partnerships. It is also envisaged that given budgetary and time constraints for capacity-building, regional consortia could target the formation of collaborative human capacities on different groups, thus covering a higher diversity of taxa, rather than each country repeating expertise on the same few groups.

The **strategic** goal is to mobilize information; for too many groups there is a lack of synthetic and readily available inventories of existing taxonomic knowledge for most organisms. On the **operational** level, *DIVERSITAS* recommends that GEF makes easier the funding of collaborative projects for capacity building by providing 'seed money' to prepare project proposals (e.g. within training funds). Workers in taxonomy in developing countries need to get in touch with those

from developed countries, and currently there is no help to do that. The mechanism could be to empower developing countries to purchase services from developed country institutes (a single country would probably need to consult/employ services from several institutes), while training its own taxonomists.

Additionally, *DIVERSITAS* suggests that a 'data mobilization' fund is established, to which developing countries can apply for resources to get taxonomic information mobilized from around the world.

Projects:

As a *series of bilateral projects* *DIVERSITAS* recommends what has been called data repatriation but is more properly information sharing or mobilization: the making available of specimen data to the country of origin. Such a project would be organized in three steps:

1. creating the information resource, by databasing the specimens or collections (selected, like types or on a geographical basis) as well as literature (like **protologues**, often in old and rare publications) in large-scale institutions in the developed country;
2. building the Information Technology infrastructure in the developing country, if necessary; including access to the Worldwide Web; and, if necessary, training people to use such systems.
3. maintaining long-term relationships and institutional contacts, e.g. by establishing liaison officers (along the model of Indian and Australian liaison officers at the Royal Botanic Gardens, Kew) either on a permanent or on a medium term basis; such liaison officers would respond to requests for missing data, especially literature.

Nepal and the British Museum partnership

Botanists and government officials in Nepal, hampered by the lack of locally available information about the plants of Nepal approached the Natural History Museum in London for help. The Museum submitted a successful proposal to the UK Government's Darwin Initiative for a project designed to strengthen the taxonomic capability of Nepal. Most of the personnel involved are from Nepal and, working together with colleagues at the three major British herbaria, (Natural History Museum, Royal Botanic Gardens, Kew and Royal Botanic Garden, Edinburgh) they have created an illustrated database of the key plant specimens held in these institutions. At the end of the project, in late 1999, computer systems will have been established at key institutions in Nepal and at a total cost of around £150,000, the taxonomic impediment of inaccessible information on the plants of Nepal will have been removed forever. The information will also be made available on the Worldwide Web. Beyond this project, the collaborating partners, together with botanists at the University of Tokyo, now intend to continue working together to produce the first Flora of Nepal.

As a *series of multilateral projects*, *DIVERSITAS* recommends projects building on, or modelled on successful regional flora and fauna consortia (e.g. Flora Mesoamericana; Flora Malesiana; Flora of China; Fauna Malesiana; Fishbase) involving many local scientists and large institutes from several countries. These are scientific programs with well-defined objectives. *DIVERSITAS* calls for new projects along similar lines in other groups, using these models.

Products: manageable information, and the capacity to manage it and create new information from it (e.g. through GIS, field guides, DELTA keys, checklists of local names/uses, country Red Data lists) which would include the identification of gaps in knowledge and needs.

Species-based and specimen-based information is becoming increasingly available via the Worldwide Web. Species 2000 is a co-operative global initiative seeking to provide common access point for users of such databases. This taxonomic information will constitute the backbone of the OECD's Global Biodiversity Information Facility (GBIF).

d) Reporting on taxonomy-related capacity building

It is suggested that to implement fully the Global Taxonomy Initiative at the national level, a mechanism could be to develop a Taxonomic Action Plan, which could be separate from, or included in its national strategy for biodiversity. In focussing on taxonomy, each country should first undertake an assessment of its national capacities, including available human resources, collections and their housing, and knowledge gaps.

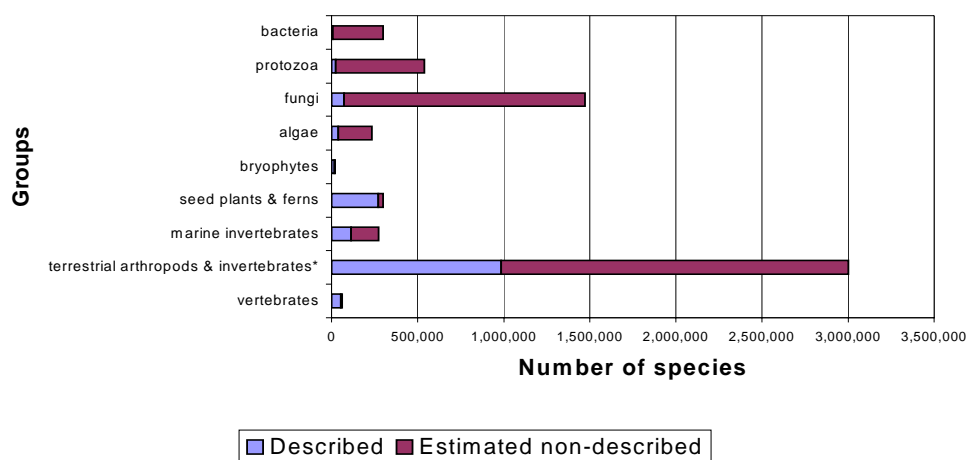
The involvement in co-operative regional networks and other transnational initiatives, as well as progress in determining priorities for systematic work in relation to the recommended criteria and the annual budget for taxonomic work, could provide sound information to evaluate the implementation of a GTI.

5. The state of knowledge *what we (do not) know*

This section attempts to present the State of Knowledge of various groups as we know, though it should be noted that the data used in it is very conservative. As a practical example of the taxonomic impediment, blanks in this part prove the difficulties in assembling these data in as meaningful a form as is desirable – thus, illustrating the scale of the problem. However, because of the nature of this section, we will keep working on improving and gathering available information; we welcome any contribution.

A note on numbers

Several sources for data at global level are available – the Global Biodiversity Assessment (UNEP), Global Biodiversity Status of the Earth’s Living Resources (WCMC), etc. However, these data are often at variance and the constant factor is level of uncertainty. It should be a goal of the CBD, to at least provide some certainty in the magnitude of estimates of species numbers, within a short time frame. The tables and figures below represent the experts “best-guess” approach to the major organism groups (in the following figure the data for viruses are lacking - see below – but number may possibly be as high as all the other numbers combined).



Information was assembled to provide an overview of the state of knowledge on species diversity, using the following major groupings:

1. *Viruses and bacteria*
2. *Protozoa*: Amoebae, Flagellates, Ciliates, Sporozoans, Heterotrophic unicellular organisms
3. *Fungi*: including slime-moulds, oomycetes, lichen-forming fungi and yeasts
4. *Algae*: including macro and micro algae
5. *Bryophytes*: mosses, liverworts, hornworts
6. *Seed plants & ferns*
7. *Invertebrates (freshwater & terrestrial)*: arthropods (insects, arachnids, crustaceans), nematodes, annelids, molluscs, sponges, corals, and all multicellular heterotrophs.
8. *Invertebrates (marine)* : including also corals, sponges, and all multicellular heterotrophs
9. *Vertebrates (and other chordata)*

The Tables presented have a number of **conventions**:

Reference collections: large zoological and herbarium collections (not the number of specimens!)

Number of taxonomists: a rough estimate of the number of people publishing articles on a given group, and so increasing knowledge of the taxonomy of that group. These numbers are much higher than the number of paid positions for taxonomic work.

Collecting cover: a rough indication of the degree to which the species diversity of an area has been collected. The estimate is based on published data for some groups giving numbers of specimens collected per given area.

Information accessibility: a rough indication of the degree to which the species diversity of an area is accessible including in collections catalogues and published works, on electronic databases and so forth. Collecting cover and information accessibility are designed as *very poor*, *moderate to good*, *patchy* (large gaps within an area where some parts are good), or *excellent*.

Values: Where a *range* of numbers was originally indicated, we have chosen the mean; unless the range was extremely large (lower end of range an order lower than upper range) in which case we have substituted a ‘?’

Species diversity has been assessed by **continents**, as they represent main natural boundaries for regional biota (except for prokaryotes). Thus, we consider the following “regions”:

- *Africa and Madagascar*
- *North America*
- *South and Middle America*
- *Asia, including South Eastern Asia islands*
- *Europe*
- *Oceania, including Australia, New Zealand and the Pacific islands*
- *Antarctica*

MAIN GROUPS OF SPECIES	estimated total	described species	% non described	number of taxonomists
Vertebrates	< 60,000	51,937	10 %	(33%)
terrestrial arthropods & invertebrates ¹	3,000,000	985,000	55 %	+6,000
marine invertebrates	273,000	115,275	55 %	285
seed plants & ferns	300,000	270,000	10 %	<4,000
Bryophytes	21,000	17,000	20 %	< 300
Algae	235,000	40,000	83% ?	< 330
Fungi	1,470,000	72,000	95 %	500
Protozoa	538,000	23,000	95% ?	800
Bacteria	?	6,900	95% ?	40
Viruses	?	4,000	99% ?	75
TOTAL	ca. 6,000,000	1,650,111		ca.18,000

(¹) For a working figure, we have added, to the number of known insects, 120,000 described species of annelids, arachnids, crustaceans, molluscs and worms. Number of species not described, others than insects, will add up to a million.

ENDEMISM AND THE LANDSNAILS OF INDONESIA

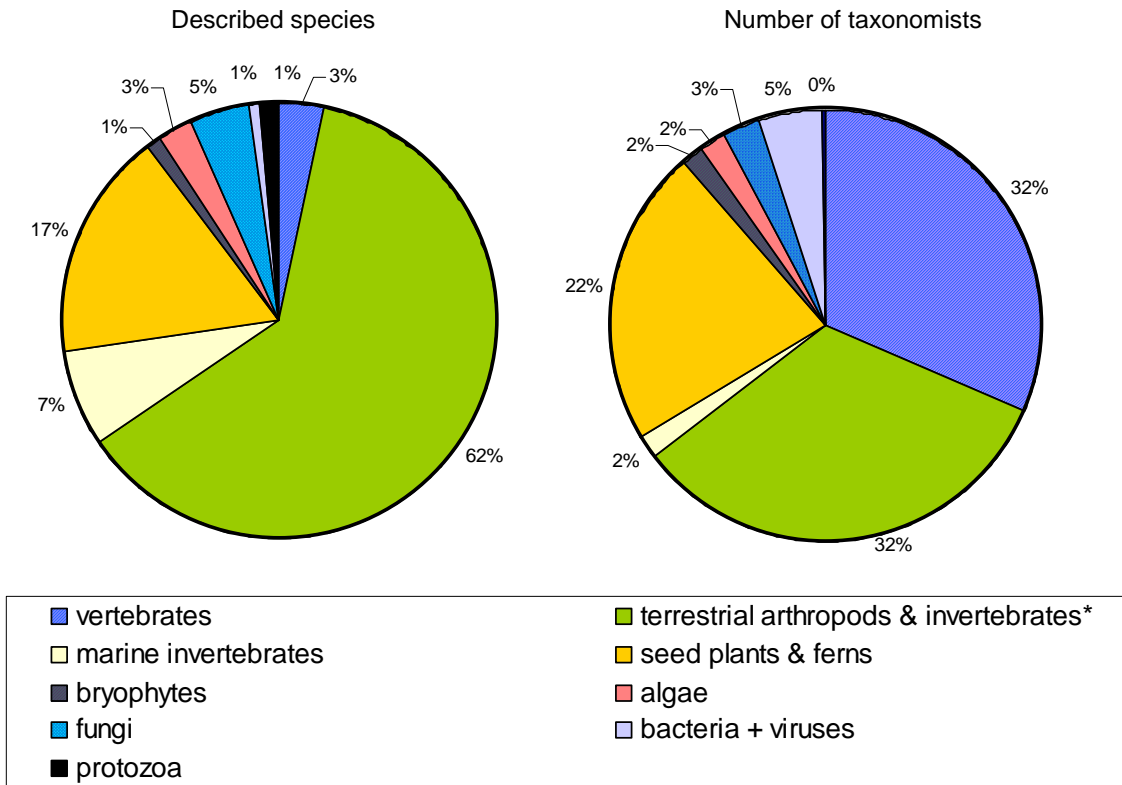
Land and freshwater molluscs exhibit a remarkable level of endemism in tropical regions, in mountain and calcareous areas, and on islands. In the Indonesian archipelago for example, 1260 of the ca. 3000 known indigenous species are single island endemics, existing nowhere else in the world. This high level of endemism is associated with generally low tolerance to ecological change: of the 641 animal species of which the recent extinction in the wild is documented by the IUCN, 236 species (37%) are land and freshwater molluscs, that is more than birds, mammals and reptiles altogether.

Owing to the preservation of their shells after death, much extinction of molluscs has been and can be documented. Most probably, many more species crucial to local ecosystem functioning, belonging as well to molluscs as well as to more discrete soil, litter and freshwater taxa, have a similarly low ability, if any, to recover once locally eliminated. Doubtlessly, many such animal species did and will become extinct before identification. Land and freshwater molluscs can be used as indicators of environmental changes involving similarly behaving taxa: freshwater molluscs have been one of the three indicator taxa retained by the WCMC in its report on freshwater biodiversity hotspots to COP.

Presently, less than 100 taxonomic experts in this group cover the 30,000 living species in the world, which in turn might represent as little as half the total of all living species. Less than 150 species are described every year, and less than 10% of these occur in the neotropical and paleotropical regions, where biodiversity appears richest – and habitat change is greatest.

A note on taxonomists

Globally, the number of species described, per major group of organisms and the number of taxonomists working on them, are rather unbalanced. Here are the figures:



1. BACTERIA AND VIRUSES

	strains in collection s	estimated total species	% unknown	collecting cover	information accessibility	number of reference collections	number of taxonomists
Asia	(48,706)				good	147	
Europe	(166,357)				very good	139	
Africa	(3,682)				good	12	
America:N	(65,477)				very good	70	
America:S&M	(5,774)				good	54	
Oceania	(43,257)					60	
Antarctica							
GLOBAL	(333,253)		>95%			482	700

NOTE: under 'species described' we indicate the number of strains in reference collections according to WFCC directory, instead of number of species as no numbers are available per regions. However, we estimated a total of 6,900 species formally described (see table with global numbers).

Numbers for **viruses** are difficult to predict as ecological studies are lacking. If evolution has generated specific relationships between hosts and viruses one could postulate a scenario in which each eukaryotic species could encompass at least one prokaryotic and one virus species. In addition, each prokaryotic species could contain at least one virus species. The percentages would then be:

Eukaryotic species = 25% (? 6 million species)
 Prokaryotic species = 25% (? 6 million species)
 Virus species = 50% (? 12 million species)

Numbers of **taxonomists** are also difficult to estimate. It must be assumed that the majority of collections are run by a single scientist only, who may have dual functions, e.g. they have teaching responsibilities at universities as well as taxonomic responsibilities. Only the major "Northern-Hemisphere" collections have more than ten scientists, such as those in Japan, the USA and some European countries.

State of knowledge of major subgroups:

So far, the Northern Hemisphere has contributed 77% of microbial *ex-situ* diversity in reference collections. The proportion of strains housed in industrial, non-public collections (e.g. the pharmaceutical industry) will give a different picture, as most of the collection activities have taken place in countries of the Southern Hemisphere (e.g. Indonesia, Australia, Philippines, Africa and Southern- and Middle America). A problem is that the pharmaceutical industry often does not share data freely and that virus' collections are separated into plant and animal viruses and specialized listing of the origin of viruses are not available.

The main **gaps** are obvious lack of collections and taxonomic expertise in African and many South American countries.

Why do we need to work in the taxonomy of this group:

Bacteria have been the source for a broad spectrum of pharmaceutical, industrial, and food-related products. Exploitation of bacteria for novel products is an ongoing research topic with high priority in many countries. If scientists are now claiming that the number of cultured organisms represent only a small fraction of the actually occurring diversity, and molecular methods prove that the diversity ranges **to hitherto** completely unknown groups of bacteria, exploration of species diversity in bacteria is mandatory for the discovery of completely novel compounds, whose application will improve the living standard of mankind. Discovery and taxonomic description of novel species is a function of the development of (conceptually) new culture techniques.

Diversity of microorganisms and *ex-situ* collections:

Most prokaryotic collections are not self-supportive and do not receive government support. This results on the inability to house "diversity" as a goal, as that is not of immediate commercial interest. The long-term support of collections is in doubt; how does one assess the value of a collection?

Moreover, what would be the fate on an endangered collection? Questions asked frequently, especially by funding bodies:

- 1.- Do we need so many Culture Collections with redundant content (as compared to a global network of well identified, certified strains).
- 2.- How much "diversity" can and should be covered by collections, knowing that the majority of strains are yet uncultured.
- 3.- How much free exchange should be permitted between culture collections (see 1.) See also the responsibilities of Northern Hemisphere collections to support countries of origin of diversity.

THE SPECIES CONCEPT AND PROKARYOTIC ORGANISMS

The current biological species concept is difficult to apply to microorganisms, especially prokaryotic organisms as they do not reproduce sexually. In practice, specimens or strains are characterized by morphological, biochemical or molecular similarity.

If we base our speculation on a continuation of the present species concept, most ecologists would agree that the number of prokaryotic species equate to about 50% of all described species, excepting the viruses - and this percentage will remain the same, no matter how high the number of eukaryotic species.

The estimated numbers of prokaryotic species have increased significantly over the past 15 years: From 30,000, through 800,000 to 2,000,000 or, based on the figures in this document, as high as 6,000,000. The basis for this number is awareness that whenever we investigate an eukaryotic species, we find ribosomal sequences of prokaryotes that are so unrelated to the sequences of known prokaryotic species that we have to assume that these symbionts, parasites and saprophytes of eukaryotic species, represent novel species. Most of them can yet not be cultivated in the laboratory, so that formal descriptions of these species will be missing for a long time. Nevertheless, even among the cultivated species, the number of species is much higher than anticipated in the past, as only now, with emphasis of molecular tools, the extent of molecular diversity among phenotypically similar organisms can be appreciated.

2. PROTOZOA

	species described	estimated total species	% unknown	collecting cover	information accessibility	number of reference collections	number of taxonomists
Ciliates	8,000	22,500	66 %		patchy	2	3
Amoebae	< 3,000	10,000	66 %		poor	2	4
Flagellates	2,000	6,000	66 %		poor	2	8
Parasitic protozoa	< 10,000	500,000	98 %		patchy	4	25
GLOBAL	23,000	538,500	95 %		very poor	6	40

These data are very crude estimates and could not be grouped by continents. At present, there are less than 40 regularly publishing protozoan taxonomists worldwide, including workers on free-living and parasitic protozoa!

State of knowledge of major subgroups:

Except for Europe and Antarctica, all regions of the world are poorly explored, especially South America, Australia, India, and the Malaysian region. Information accessibility is very poor in protozoa, even a catalogue is missing; there are a few fauna compilations but no worldwide coverage. Large taxonomic programs are urgently needed, especially in threatened ecosystems.

Why do we need to work in the taxonomy of this group:

Parasitic protozoa are the cause of the most serious endemic and epidemic diseases of the world in humans and domesticated animals (i.e. malaria, sleeping disease, coccidiosis). Around 70 to 80 protozoan parasites are known from humans, but almost every well-studied metazoan species contains at least one specific protozoan parasite. Thus, the 500,000 non-described species are a conservative estimation.

Free-living protozoa significantly contribute to the energy fluxes in marine, freshwater and terrestrial ecosystems, mostly via grazing most of the bacterial production. Thus, they enhance the energy transport through the ecosystem.

3. FUNGI (including slime-moulds, oomycetes, lichen-forming fungi and yeasts)

	species described	estimated total species	% unknown	collecting cover	information accessibility	number of reference collections	number of taxonomists
Asia	20,000	600,000	> 95 %	very poor	poor	80	110
Europe	25,000	65,000	60 %	good	fair	121	210
Africa	10,000	450,000	> 95 %	poor	very poor	20	15
America:N	21,000	250,000	> 90 %	fair	fair	40	105
America: S&M	10,000	500,000	> 95 %	very poor	very poor	75	50
Oceania	6,000	250,000	> 95 %	very poor	poor	15	10
Antarctica	750	1,750	55 %	good	fair	-	-
GLOBAL	72,000	1,470,000	95 %	poor	poor	350	500

State of knowledge:

Extent of ignorance varies markedly amongst different biological and taxonomical groups. In general, slime-moulds, lichen-forming fungi, gasteromycetes and polypores are better known globally than, for example, species associated with arthropods and plants.

The known figures vary in accuracy as no comprehensive checklist exists for any continent. The estimated unknown figures are based on the numbers to be expected by extrapolation from the numbers of plants in the same geographical regions. Note has been taken of such published information as has appeared.

Reference collection totals include both key dried reference collections and collections of cultures; some smaller collections are omitted, especially in Europe and N. America.

Why do we need to work in the taxonomy of this group:

Fungi are important as sources of bioactive compounds for exploitation (e.g., penicillin); as food, both for humans and for other organisms; in that they are critical in the maintenance of ecosystems, performing key processes such as decomposition; and, in that, they are indicators of environmental health.

4. ALGAE

	species described	estimated total species	% unknown	collecting cover	information accessibility	number of reference collections	number of taxonomists
Asia	1,250	~ 2,065	50-80%	?	?	160	30
Europe	6,500	~ 8,125	20-30%?	good	fair	500	130
Africa	1,500	~ 2,475	50-80%	poor	poor	90	< 10
America:N	1,500	~ 1,875	20-30%?	fair	fair	530	70
America: S&M	3,500	~ 5,600	40-80%?	patchy	?	270	80
Oceania	3,000		50-80%	fair	fair	30	10
Antarctica	750?		20-50%				
sub-total ¹	+25,000	~ 45,000					
macro-algae	10,000	11,000	18%				
GLOBAL	<40,000	235,000	83%				< 330

(¹) Note that information by continents only refer to freshwater species, adding only 18,000; given sub-total includes other non-marine micro-algae.

State of knowledge of major sub-groups:

Of the global total number of algae described, 8 to 10,000 are macro-algae, 90% of which live in marine or brackish-water environments and are widespread; numbers per landmass are not meaningful. Marine phytoplankton has been estimated to range between 1,500 and 2,000. The remainder species of algae are freshwater or terrestrial micro-algae (including symbiotic forms, e.g., lichen algae).

It is very difficult to estimate numbers for continental masses since micro algae remain little known and it is generally assumed that most are ubiquitous and cosmopolitan. Distribution patterns relate more to the chemistry of water bodies and temperature/light regime, with the same suite of taxa just as well present in a shallow pond in summer in temperate regions as ponds of similar water chemistry in equable tropical environments.

The richest zones for algal species are not only in the tropics: 4 out of 7 richest areas lie between 30° to 60° N or S of the equator (Atlantic Europe, Mediterranean, Japan, southern Australia) while rich tropical areas are Philippines, Caribbean and possibly the Pacific coast of Mexico. However, algae occur not only in the oceans, but also in freshwater and in microhabitats in/on soil, on rocks and the bark of trees, even in the fur of polar bears and sloths.

Reference collections (=herbaria) are the same as for seed plants, though some herbaria (e.g. Kew) have no algae; some otherwise smaller herbaria have important algal collections associated with one or more workers. There are also marine labs with important algal collections, and culture collections with micro-algae cultures.

Realistic figures for 'taxonomists' are difficult to obtain without more study, figures relate to those interested, capable and involved in alpha-level taxonomy rather than those simply interested in higher level relationships.

"Algae" is a polyphyletic grouping with at least seven different lineages included. However, it is a still useful traditional grouping for discussion and planning processes.

Gaps:

Asia: need more collecting and more comparison

Africa: more collecting needed around SW Africa

North America: need more comparison with other regions to assess synonyms

South/Middle America: ?

Oceania: need more comparison with other regions to assess synonyms

There are notable gaps in the knowledge of micro-algae in all habitats, especially diatoms in marine habitats and all micro-algae in/on soil, on tree-trunks and on rocks. Difficulties with defining species, because of different forms of life, have been partially removed with the use of electronic microscopes and molecular studies on the taxonomy of microscopic algae, but there is a vast amount of study still to be done.

Priorities:

- existing synonymies need to be reduced by comparing species from different regions; endemism needs to be assessed better.
- marine phytoplankton, at the base of marine food chains, needs to be researched
- as potential indicators of pollution, algae in freshwater and terrestrial habitats (trees, rocks, soil) need to be researched.

Why do we need to work on the taxonomy of algae:

- algae are the basic resource for several industries (food, cosmetics, medicines, etc)
- algae contribute 40 % of global photosynthesis
- marine algae are at the base of food chains in the oceans; they are possibly a global sink for CO₂ in oceans, and therefore very important in the global warming scenario
- toxic red tides and freshwater algal blooms are increasing
- algae play a very important role in building and protecting the structure of coral reefs

species	estimated	%	collecting	informatio	number of	number of
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	described	total species	unknown	cover	n accessibility	reference collections ¹	taxonomists
Asia	5000			patchy	patchy		50
Europe	1800			good	fair		120
Africa	2000			poor	poor		< 10
America: N	2000			good	good		70
America: S&M	5,000			patchy	poor		30
Oceania	1200	1350	10 %	fair	fair		6
Antarctica	80	?	?	fair	patchy		-
GLOBAL	17,000	20,000	15 %				< 300

⁽¹⁾collections (=herbaria) see flowering plants; some large herbaria (e.g. Kew) do not hold bryophytes.

State of knowledge:

In general, bryophytes need more comparison with other regions to assess synonymies. Tropical parts of Asia, Africa, South and Middle America are poorly known in large areas, and further collecting is needed; this is also true of temperate rain forest in Australia and S America.

Gaps are nearly all over the bryophyte spectrum.

Why do we need to work on taxonomy of bryophytes:

Bryophytes, especially *Sphagnum*, have a buffering water-holding capacity at the headwaters of many streams and in moist habitats such as rainforests.

6. SEED PLANTS AND FERNS

	species described	estimated total species	% unknown	collecting cover	information accessibility	number of reference collections	number of taxonomists
Asia	70,000	77,000	10 %	patchy	patchy	160	650
Europe	12,000	12,000	< 1%	good	good	500	1200
Africa	60,000	67,000	10 %	poor	poor	90	160
America:N	18,000	18,000	1%	good	good	530	920
America: S&M	85,000	100,000	15 %	patchy	poor	270	800
Oceania	17,000	21,000	20 %	fair	fair	30	100
Antarctica	2	2	0	patchy?			
GLOBAL	270,000	300,000	11 %				

State of knowledge:

Asia: poorly collected in some areas.

Europe: note that of 1200 taxonomists in Europe quite a few are working on non-European plants.

Africa: vascular plants poorly collected in some areas; bryophytes poorly known & need continent-wide comparison

Importance of plants:

- plants are the basis of all life as we know it today; they fix the sun's energy by photosynthesis (as do algae); form a carbon sink for CO₂ and clean up pollutants
- plants form the basis of all food chains
- plants provide habitats for other organisms
- plants are vital for human uses (timber for housing; fibres for clothes; fuel wood; oils; alcohol; pharmaceuticals)
- crop weeds have a negative impact

Gaps:

In our knowledge of plants occur particularly in the tropics. Overview treatments (regional or continental floras) are vital for giving identification capability as well as showing the gaps in our knowledge, but are still lacking for many mega diverse regions in the tropics. Areas with high species

endemism and with ecosystems under threat of destruction are a particular priority (e.g. Madagascar). Large plant families of economic value such as Rubiaceae, Lauraceae and Fabaceae/Leguminosae, with emphasis in the tropics, would benefit from worldwide study to assess synonyms and generic delimitation.

7. MARINE INVERTEBRATES

MARINE REGIONS	species described	estimated total species	% unknown	collecting cover	information accessibility	number of reference collections	number of taxonomists
Arctic Ocean				good	moderate	14	30
Antarctic				good	good	21	28
Atlantic –Af&Eur				good	very good	62	150
Atlantic –Amer				good	good	21	64
Pacific –Amer				inadequate	good	19	36
Pacific –As&Aus				moderate	good	34	81
Indian Ocean				inadequate	moderate	22	53
GLOBAL	115,275	273,000 (to 10,000,000)	42% (to 98%)			160	285

State of knowledge:

A particular problem with estimating marine biodiversity is that large parts of the ocean and seafloor are not in the jurisdiction of any country and away from coasts. A breakdown of numbers of species per ocean area is not yet possible as not all described invertebrate species have been fully catalogued. In general, the tropical West Pacific is the most diverse region in the world for marine species.

High-priority groups for study include: sponges, bryozoans, ascidians, cnidarians (anemones, octocorals, hydroids), nemerteans, molluscs and echinoderms -all important in biomedical research and/or sources of bioactive biochemicals.

Worms (e.g., polychaetes, nematodes, nemerteans) and small crustaceans of soft sediments -- important in faunal turnover, sediment structure, and marine food webs.

The figures in the collections and taxonomists columns refer to the estimated numbers of collections and taxonomists dealing with each ocean area. Because collections and taxonomists may cover several or all ocean areas, the actual sum of each column exceeds the estimated global total.

Gaps:

The comments in the column on collecting cover refer to macro-invertebrates. With the probable exception of the NE and NW Atlantic, the continental shelves of all oceans have been inadequately sampled for small organisms, namely those most likely involved in faunal turnover in soft sediments. For example, the numbers of non-described micromollusca are likely to exceed the described macromollusca by a factor of two. Similarly, deep-sea (including seamount and ridge-dwelling), planktobenthic, and midwater organisms have been inadequately sampled everywhere. The estimated global tally for all species is inflated by extrapolations for small worm-like organisms, especially nematodes. Overall, the S and mid-Atlantic, S, SE and mid-Pacific, and Indian Oceans have been least well sampled.

8. TERRESTRIAL ARTHROPODS & INVERTEBRATES

Data are lacking for this assemblage. This group must be one of the prime examples of a need for synthesis, but for the time being, we are only able to supply data for Insects.

Insects

INSECTS	species described	estimated total species	% unknown	collecting cover	information accessibility	number of reference collections	number of taxonomists
Asia				patchy	patchy	100+	
Europe				good	patchy	100+	
Africa	100,000	?		patchy	patchy	75+	
America:N	90,000	160,000	40 %	fair	fair		
America: S&M				patchy	patchy	170+	
Oceania	86,000++	150,000+	50 %	patchy	patchy	20	
Antarctica	136			good	good	0	
GLOBAL	865,000	2,000,000	56 %			600+	6000+

State of knowledge:

Although some people are estimating 10 million, 30 million, or even 50 million species of insects, the panel feels that the total figure for world insect species will be less than 5 million.

From a practical standpoint, it is important to realize that most of the described species *cannot* be recognized from information in the literature, and identification tools for the group as a whole are grossly inadequate. Even for species that have been adequately described, frequently only one sex is known, and the immature stages have been described for very few species.

Species diversity by region:

Modern checklists for all insects exist only for North America, and a similar product is in production for Africa (ICIPE, about 25% completed). From a taxonomic standpoint, the only large insect order that has been catalogued worldwide is the Diptera. Recent summaries of knowledge (only rarely including checklists) are available for very few regions or countries.

Taxonomic and geographic priorities:

South America is probably the most diverse and poorly known region, but there are major problems in other regions, including Australia. Although Europe is relatively well known, the literature is in chaos (too many intellectual and language traditions that have not consulted amongst themselves); a similar complexity of literature that has not been synthesized exists in Africa and is starting to emerge in Asia.

Gaps in taxonomic knowledge: entomology lacks the tools that synthesize what is already known about the systematics of many other taxa, especially vertebrates and vascular plants, so it is hard to know where to start. A world checklist (or catalogue) of described species, with links to the key literature, is a vital need. Recent projects in North America (completed) and Africa (25% complete) show that this is logistically possible.

Collections resources: entomological collections range from small reference collections at many agriculture universities and research stations to worldwide collections of 30 million specimens.

Why we need to work in the taxonomy of this group:

About one third of the world's food production relies directly or indirectly on insect pollinators. Insects also include major pests of agriculture and human health. An estimated \$20 billion is spent worldwide every year for pesticides; yet, insect parasites and predators provide an estimated 5-10 times this value in pest control. Also, the International Plant Protection Convention includes survey and reporting requirements for "plant pests" that parallel those of the CBD in many ways.

9. VERTEBRATES

	species described	estimated total species	% unknown	collecting cover	information accessibility	number of reference collections	number of taxonomists
Asia					poor (pp.)	30	
Europe	988		< 1%		good	152	
Africa	6,533	7,675			poor	23	
America:N					good	32	
America:S&M					moderate	23	
Oceania					moderate	7	
Antarctica						-	
GLOBAL	51,937		10%			267	

Europe collectively holds the world's largest assemblage of vertebrate collections (although similar numbers of specimens are available in North America) and many European systematists work largely on taxa from outside Europe. The collections include Palearctic taxa as well as significant holding of materials from other continents, including Asia, Africa and the Neotropics. Large collections from the Neotropics and Africa are also maintained in North America. Large collections of Asian vertebrates are in Europe's major museums.

Detailed lists exist for classes, for which the global numbers are

	TOTAL	AFRICA	SC AMER	N AMER	ASIA	OCEANIA	EU
birds	9,672	1500	3,750	660	2,800	1,850	515
freshwater fish	8,411	1800					
amphibians	5,125	788	2465	241	844	402	78
reptiles	7,855	1400					123
mammals	4,629	1045					281

Marine fish are excluded because no available data and no defined boundaries in the seas.

State of knowledge of major subgroups:

Vertebrates are perhaps the best known, taxonomically, of all groups of organisms. However, new taxa continue to be discovered, during surveys and inventories of previously poorly known or inaccessible geographic areas and as the result of taxonomic revisions, which, based primarily on molecular data, reveal the presence of sibling and other hidden species. Nevertheless, coverage within the group is uneven. Birds and mammals are probably the best known.

Groups that require additional sampling and taxonomic work include: bats, small, secretive nocturnal rodents, especially tropical, arboreal taxa; amphibians occupying tropical habitats; reptiles such as snakes, which probably include the highest percentage of non-described forms, especially tropical arboreal taxa. Finally, marine and freshwater fish, although an important human resource, are surely the least known group of vertebrates taxonomically.

Gaps:

Asia: Annamite Mountain forests are priority.

Africa: fish of Congo R. need surveying; poorly surveyed continental biomes are: moist southern Miombo; moist tropical forest; arid SW; Ethiopia.

America: Caribbean reef fish require considerable work. In Central & S America: freshwater fish, amphibians, and reptiles (especially snakes) need more work.

Oceania: has very high endemism (raised by marsupials) and avifauna. Small mammals require inventory and herpetofauna is only partially understood.

Marine fish (including chondrichthyans) require considerable inventory; for example, many new species of sharks continue to be discovered from the coasts and continental shelf off southern Africa.

Perhaps the best way forward is for countries with existing expertise in marine fish (as well as other taxa) to collaborate on a global inventory of marine landscapes. Although this might begin with fish, it should concentrate on other groups (especially molluscs, annelids, corals, crustaceans, etc).

Why do we need to work in the taxonomy of this group:

Fish, the less well-known group of vertebrates, constitute the primary source of protein for much of the World's population; populations of many fish species are being over-harvested and threatened with extinction. In order to manage harvested species properly, and identify additional species that may serve as food sources, the taxonomy of this group must be well known.

Amphibians, because they respire in large part through their skin and because a majority of species have aquatic larvae, are excellent indicators of environmental conditions (particularly the presence of pollutants) in both aquatic and terrestrial habitats. Global declines in frog populations in past years signalled a potential environmental disaster, and led to the identification of multiple environmental problems. If we are to use frog species as indicators of the presence of specific substances, as well as identify the geographic areas in which a species might be useful, correct frog taxonomy must be available to serve as a basis for proper identification.

Justifications for continued study of the taxonomy of other vertebrate groups (e.g., birds and mammals that form a basis for ecotourism, birds that serve as disease vectors and reservoirs of human parasites) could also be provided, but these taxa do not seem to be priority groups at present.

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Expert Panel Workshop
DIVERSITAS/Systematics Agenda 2000
ICSU, Paris, France, February 20-21, 1999

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