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# *Global Taxonomy Initiative in Asia*

***Edited by***

***Junko Shimura***

NIES

独立行政法人 国立環境研究所
NATIONAL INSTITUTE FOR ENVIRONMENTAL STUDIES

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## *Report and Proceedings of 1st GTI Regional Workshop in Asia Putrajaya, Malaysia, September 2002*

***Edited by Junko Shimura***

NATIONAL INSTITUTE FOR ENVIRONMENTAL STUDIES

独立行政法人　国立環境研究所

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# *Preface*

The proceedings here are the result of the first "Global Taxonomy Initiative Regional Workshop in Asia" held at Putrajaya, Malaysia on September 10-17, 2002. It was the first regional workshop after Global Taxonomy Initiative "Programme of Work" was approved at the $6^{th}$ Conference of the Parties of Convention on Biological Diversity. Countries, economies and NGOs who are studying biodiversity in Asia shared the opportunity to identify regional gaps in taxonomy and discussed partnership to overcome the identified taxonomic impediments and work for conservation of biodiversity in the region. This book provides executive summary of the workshop, the result of taxonomic needs assessment in Asia and research articles submitted from the poster presentators. This book may help understand the status of taxonomy in the region and find good research partners to study biodiversity from the participants.

I thank those scientists participated from Asia and other parts of the world, Governmental officials of Malaysia, Australia, New Zealand and Japan, Species 2000 Asia Oceania partners, BioNET INTERNATIONAL, GBIF, Swedish Scientific Council for Biodiversity for various aspects of support. I especially thank to Mr Ian Cresswell, Mrs Karen Wilson, Dr Christopher Lyal and Dr Junko Shimura for their effort to coordinate the meeting and reporting the result in tidy form.

Makoto M. Watanabe
Director, Environmental Biology
National Institute for Environmental Studies, Japan
GTI focal point of Japan

January, 2003

# Contents

**Chapter 2: Existing research activities in taxonomic groups**



**Chapter 3: Development and sharing of taxonomic information**

## Errata

## Foreword by the Honorable Minister of Science, Technology and the Environment Malaysia

First and foremost, I would like to thank the organizers of the Global Taxonomy Initiative Regional Workshop in Asia for giving me the opportunity to say a few words in this program book. On behalf of the Government of Malaysia I wish to welcome all the distinguished participants to our country and the meeting in Putrajaya.

The need for taxonomists is becoming more crucial particlarly in assessing the biological resources in the country. Megadiverse countries in particular have yet to discover and classify their biological resources due to lack of taxonomists and expertise in the field. There is therefore an urgent need to enhance capacity in the field of taxonomy especially in developing countries and this workshop could mark the beginning of such effort.

The meeting will address various issues pertaining to the Global Taxonomy Initiative in the region and will propose a plan of action to further enhance cooperation and networking among taxonomists in the region. I urge all the participants to take this opportunity to actively participate in the discussions that will take place during the meeting.

I also wish to congratulate the various parties involved in organising the meeting particularly the Government of Japan, Secretariat Convention on Biological Diversity, NIES and the local organising committee for making all the arrangements to make this meeting a success.

Finally, I wish all of you a successful meeting and hope that your stay in Malaysia will be an enjoyable one.

Thank you.

DATO' SERI LAW HIENG DING
Minister of Science, Technology and the Environment, Malaysia

# Convention on Biological Diversity

# Secretariat

Ref.; SCBD/STTM/JM/CL/va/

19 August 2002

To: The organisers and participants of the Asian Regional Workshop on the Global Taxonomy Initiative(GTI)

I am very pleased to endorse and support the activities of the First Global Taxonomy Initiative Regional Workshop in Asia.

As you know, the Conference of the Parties to the Convention on Biological Diversity identified the need for Regional Workshops on the GTI in its decision V/9 and reiterated it earlier this year in The Hague in decision VI/8. At that time all participants were pleased to hear the announcement from Malaysia that an Asian meeting would take place this year.

There are a number of activities which have been identified as appropriate and important at the regional level for the implementation of the GTI, including regional assessments of taxonomic needs in the implementation of the Convention on Bilogical Diversity, the developments of regional priorities for action, and the support and development of regional and subregional taxonomic networks. It is gratifying to hear that you will be examining these needs and developing the regional understanding of the GTI.

I wish you the greatest success in the Workshop, and look forward to receiving a report on its progress and results.

Sincerely yours

H. Zedan

Hamdallah Zedan
Executive Secretary

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*Te Papa Atawhai*

3 September 2002

Prof A H Zakri
Chair
First GTI Regional Workshop in Asia

Dear Prof Zakri

As New Zealand's GTI Focal Point I would like to convey my strong support for the Asian regional workshop. Although I am regretfully unable to attend, due to other work commitments, I know that my New Zealand colleagues will be able to ably represent NZ, and I look forward to receiving their feedback.

We are all very aware of the importance of the GTI in providing a way to overcome the taxonomic impediment to good biodiversity management. Regional approaches to taxonomy (based on biogeographic regions rather than simply political boundaries) are particularly important, given the shared biodiversity at a regional level, and the impossibility of every country holding full taxonomic capacity across all species groups. This workshop provides a valuable opportunity to identify logical regional groupings, for example large marine ecosystems. The Asian workshop is therefore a very exciting development, providing a strongly participatory process for developing a regional strategy. I would very much like to congratulate you and the organising team for taking this critical step towards implementation of the GTI in Asia. COP decisions on the GTI are useful, but in the end it is initiatives such as this which will make the difference on the ground.

So my congratulations to your team, to Malaysia as the host country, and to Japan for the funding support they have provided. I wish you all the best for the workshop, and for the future implementation of the GTI in Asia.

With warm regards

Paula Warren
GTI Focal Point for New Zealand

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---

Prof A. H. Zakri
Chair of the 1st GTI regional workshop in Asia
Director
The United Nations University
Institute of Advanced Studies

Dear Professor Zakri,

On behalf of Environment Australia I am very pleased to convey our endorsement and support for the First Global Taxonomy Initiative Regional Workshop in Asia, to be held in Malaysia from 10th to 13th September 2002.

Australia has played an important role in developing the Global Taxonomy Initiative (GTI) under the Convention on Biological Diversity (CBD) and so it is pleasing to see this workshop will take another step in its implementation through the development of regional taxonomic priorities, as agreed in decisions V/9 and VI/8 of the Conference of Parties to the CBD. I commend your team for organising this regional workshop, and I would like to thank in particular the host country, Malaysia, for its support in ensuring this workshop will be a great success. I would also like to thank the Government of Japan for its generous funding to enable so many participants to attend.

Finally I would like to call on all participants to work hard to develop a regional strategy for the GTI underpinned by useful projects, and to then take these back to the country in which they work and to drive their development not only with the broader scientific community but also with all government bodies implementing the Convention of Biological Diversity. I wish you well in your endeavours.

Yours sincerely,

Peter Cochrane
Director National Parks

27 August 2002

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Prof A. H. Zakri
Chair of the 1st GTI regional workshop in Asia
Director
The United Nations University
Institute of Advanced Studies

Dear Prof. Zakri,

I am very pleased to endorse and support the First Global Taxonomy Initiative Regional Workshop in Asia.

It is with great pleasure that the National Institute for Environmental Studies of Japan shares the role for organizing this regional workshop with the host country, Malaysia, and Australia with the distinguished partner organizations and the countries in the region.

I wish you the greatest success in the Workshop and look forward to tangible outcomes and activities in taxonomy that will help support sustainable development in the region. I also would like to express my appreciation to the scientists in the region who are taking part and to urge them to use this opportunity to promote the necessary linkages between all countries in the region to ensure we build adequate capacity in taxonomy to play the essential role in implementing the Convention on Biological Diversity.

Sincerely yours,

Kazuhiro Tabe

Kazuhiro Tabe
Director
Planning Division
Nature Conservation Bureau
Ministry of the Environment
1-2-2 Kasumigaseki, Chiyoda-ku, Tokyo 100-8975,
Japan

# Introduction to the Global Taxonomy Initiative

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In the early years of the Convention on Biological Diversity (CBD) the signatory Parties (which include almost all of the countries participating at this meeting) realised that there were difficulties related to taxonomy which were limiting its successful implementation. These difficulties, termed the taxonomic impediment, are caused by an insufficient number of taxonomists, difficulty of accessing taxonomic information, and constraints on taxonomic institutions. The Global Taxonomy Initiative (GTI) was developed as a cross-cutting issue of the CBD in order to deal with this problem. As a component of the CBD it is a part of a non-binding international agreement. The GTI has provided a number of documents, agreed to by the Parties to the Convention, exploring the issues of the taxonomic impediment and identifying actions to combat it. These documents are in the form of decisions of the Conference of the Parties to the CBD, and can be found on the CBDs web site (http://www.biodiv.org/decisions). The particular decisions that relate to the GTI are III.10, IV/1.D, V/9 and VI/8. The last of these is the GTI Programme of Work agreed to by Parties at their meeting in April this year.

In the decisions the Parties to the CBD identified a number of necessary actions. These included, on a country basis, the identification of a National GTI Focal Point (an institution or individual responsible for transmitting information about GTI-related activities) and a national taxonomic needs assessment of taxonomic needs for meeting obligations under the CBD and implementing it most effectively. Such needs assessments are important at the country level and also regionally and globally; one of the functions of this meeting is to outline a regional taxonomic needs assessment. Having identified needs, effective responses are vital in order to make progress. These responses will include capacity building - training, development of jobs for the trained personnel, establishing methods of information provision and exchange, and infrastructural development. This will be directed at removal of the taxonomic impediment, and will be needed, as appropriate, both in developing countries and their partners in industrialised nations. A key element of the Programme of Work is the recognition that some issues are more appropriately addressed on a regional basis, both for reasons of scientific efficiency and to ease the financial burden on individual countries; the support and development of regional taxonomic networks is seen as a priority. Similarly, there are issues, such as developing a taxonomic information system, that are effectively global in nature, and will be resolved through global partnerships and capacity building. As capacity develops, so must the real work of addressing the taxonomic problems be undertaken. This work will require an increased integration between taxonomists and those working in environmental resource management and conservation areas.

The activities identified in the programme of work and allied decisions (e.g. see VI/5 on the International Pollinators Initiative and VI/9 on the Global Strategy for Plant Conservation) will require resources. The Global Environment Facility (GEF) is the Financial Mechanism of the CBD and some resources may be available from them, given the appropriate project proposals, but they cannot provide all of the funding necessary. Many industrialised countries have bilateral aid schemes which are appropriate, which may involve development of partnerships with the institutions in the donor country.

The GTI has developed as a complex and comprehensive political agreement on what should be done to remove the taxonomic impediment. However, it can only come to fruition is the taxonomic community decide to make it work.

# REPORT

## 1st GTI Regional Workshop in Asia

*September 10-17, 2002*

# Building Capacity: From Bangladesh to Bali and Beyond

## Report of First Global Taxonomy Initiative Workshop in Asia

## Putrajaya, Malaysia, September 2002

## Executive Summary

Asia is a region of extraordinary biological richness and diversity, and includes megadiverse countries such as Indonesia, which has within its national boundaries some 17% of the world's species. The countries of the region have all signed and ratified the Convention on Biological Diversity, and recognise the importance of conservation, sustainable use and equitable access to the genetic benefits of their biodiversity. Through the Convention process, and at various Conferences of the Parties and meetings of the SBSTTA[1] representatives of these countries have identified, among other issues, the 'taxonomic impediment' – the shortage of taxonomic information, expertise and resources that hinder implementation of the CBD. As a result they have been active in setting up the Global Taxonomy Initiative as part of the Convention, in order to address this issue. The workshop reported on in this document was an opportunity for taxonomists and other biodiversity specialists in the region to identify particular issues of the region that should be addressed under the aegis of the GTI, and to plan ways of carrying out the necessary work.

There was a strong call for more interaction with CBD processes, and for CBD Focal Points to respond to COP decisions V/9 and VI/8 and ensure the appointment of GTI Focal Points where this had not already taken place, and for those Focal Points to be closely and proactively involved with implementation of the GTI Programme of Work.

There have been several attempts to assess the taxonomic needs of the region, including a major initiative in and around this workshop. Within many individual countries taxonomic needs in terms of the Convention are still to be assessed, in response to COP decisions V/9 and VI/8, although preliminary reports were presented to the workshop. The results of the regional and national efforts prepared for the workshop, although still requiring more input for a variety of user group at national and regional levels, indicate major problems in meeting the needs that have and will be identified under the CBD.

No single country has the expertise or funding to fully document all its biodiversity, although as a basis for management and to ensure adequate access to genetic resources and protection of rights at national and sub-national levels (CBD Art. 15) such knowledge is vital. There is a need to document biodiversity across the region immediately, and particularly in a number of ecosystem types that are under massive threat from a variety of anthropogenic causes. Taxonomy, in the context of the GTI,

[1] Subsidiary Body on Scientific, Technical and Technological Advice.

is also fundamental to work on other CBD issues including invasive alien species, indicators of biodiversity, and bio-safety.

There is an inadequate pool of taxonomic experts and support staff, with dwindling prospects for the replacement of an aging personnel. Inadequate staffing levels were cited as one of the four major stumbling blocks for implementation of the GTI by 89% of respondents to a region-wide questionnaire. There is a clear need to address the demography of taxonomic expertise and provide employment prospects and training for younger staff. Meeting these training needs must in part be carried through to universities, where new courses and encouragement for students to take taxonomy options are needed. Other training options must also be investigated across the region.

Another issue regarding staffing is the inadequacy of coverage of taxonomic groups within the region. Comparison of distribution of expertise with that of collections, and with the numbers of species in the different types of animals and plants covered, shows strongly that there are too few taxonomists to cover adequately the 'lower' organisms, particularly invertebrates, non-vascular plants, and micro-organisms.

Building partnerships within the region will be fundamental for a major increase in our taxonomic capacity, as noted in COP decision VI/8. Regional cooperation will provide a cost-effective solution for all countries involved, not only in increasing our knowledge base but also in maintaining the wealth of data and collections we have already amassed. Some models of regional activities are available, for example ASEANET (a technical cooperation network for taxonomy covering all organisms), ANeT (a network covering just one group of organisms, ants), and Species 2000 Asia Oceania (a collaborative group creating databases of the region's animals, plants and micro-organisms). EASIANET is another network covering all organisms that has recently been established on the basis of implementing the GTI. While some new facilities will need to be created, the various existing initiatives can be built upon to deliver information to their members, as well as research products. Such information will include, for example, regional directories of taxonomists, collections, type photographs, training courses, species and specimen databases, and research and collecting permit requirements. Greater involvement in these networks will be facilitated by improved communication, which itself is dependant on improving access to communication media, particularly the internet. Such networks require sustained financial support if they are to function for the region.

There is also a regional need for the maintenance of living cultures of micro-organisms. This is expensive and there is a strong need for funding; one solution is to support a single main regional culture collection for microbes and micro-fungi, with special collections maintained in each country that needs them.

There is a clear need across the region for improved facilities, both in terms of buildings and institutions and for specialised equipment, particularly in information technology, including fast internet connectivity. The need is also for sustainability, since a number of institutes have aging equipment that cannot be used.

While some problems will take decades and be costly to address, there are many ways in which our regional capacity can be significantly improved at minimal cost. For instance, the primary published information describing Asia's native species, and the type specimens of those species, are currently difficult to access, and this is a major hindrance to delivering taxonomic information as required. Through global collaboration with Northern Institutions, where much of the information is contained, it will be possible to provide electronic access for Asian scientists to work on current problems.

Many of the needs for CBD implementation that should be addressed with the support of taxonomists in the region will involve cross-border collaboration and multinational research efforts. Cooperation at governmental levels is required to ensure appropriate memoranda of understanding to facilitate this process, building on the mechanisms for the GTI outlined in the Bonn Guidelines on Access and Benefit Sharing (COP decision VI/24). New and innovative ways to expedite the collection and exchange of specimens between scientists working in this region will provide one small step in breaking down barriers that at present hinder the conservation, sustainable use and equitable access to the genetic benefits of biodiversity.

Funding levels for taxonomy in support of the CBD need to be increased greatly, and 95% of respondents to the questionnaire indicated that this was a major hindrance. Improved funding will enable the issues of high running costs and inadequate infrastructure, including poor access to means of electronic communication to be addressed, as well as facilitate appropriate research and biodiversity documentation.

Good agreement exists in the scientific community on what research priorities should be, and these are set out in the report as a preliminary Global Taxonomy Initiative programme of work for Asia. Developing and implementing this programme will require the involvement of both taxonomic and environmental management communities, and increased links to government and convention processes.

# 1. The Global Taxonomy Initiative and regional workshops

The Convention on Biological Diversity (CBD) was established in 1992 with the objectives of conservation, sustainable use, and the fair and equitable sharing of benefits arising from utilisation of the genetic resources of biodiversity. To achieve these objectives, and in particular addressing topical regional issues such as invasive species, biodiversity indicators and bio-safety, there is an unequivocal need for taxonomic information. This need has been recognised since the first meeting of the CBD's Subsidiary Body on Scientific, Technical and Technology Advice (SBSTTA) in Paris in September 1995, and has led to the adoption of the Global Taxonomy Initiative (GTI) as part of the Convention.

The GTI has been the subject of several 'decisions' of the Conference of the Parties (COP) to the CBD: III/10, IV/1.D, V/9 and VI/8 (from the third, fourth, fifth and sixth meetings of the COP respectively). The text of these can be found at http://www.biodiv.org/decisions. At its sixth meeting, the COP endorsed a programme of work for the GTI[2] and emphasized the need to coordinate its implementation with existing national, regional, sub-regional and global initiatives, partnerships and institutions. Parties and other governments were urged to promote and/or carry out the programme of work, designate national focal points for the GTI, provide updated information about legal requirements for exchange of biological specimens, and about current legislation and rules for access and benefit-sharing in terms of the needs for the GTI, and to initiate (where this has not been done) the setting-up of national and regional networks to aid the Parties in their taxonomic needs in implementing the CBD.

Many issues are best addressed on a regional rather than national level, since species and ecosystems often extend across national boundaries, and cooperation regionally will best suit the identification and resolution of issues that can only be solved by concerted effort. Resources may be optimised on a regional or subregional basis, to avoid unnecessary duplication and operate in the most cost-effective and scientifically efficient manner. Understanding this the Parties to the Convention called for regional meetings to identify and prioritise taxonomic needs in terms of the implementation of the Convention, and to suggest activities necessary to meet them, noting the importance of building on institutions and initiatives already in place. This report presents the findings of a meeting held in Putrajaya, Malaysia,

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[2] see http://www.biodiv.org/decisions/default.asp?lg=0&dec=VI/8 or pages 113-142 of the PDF file at http://www.biodiv.org/doc/decisions/cop-06-dec-en.pdf

10-13 September 2002, which was the third in a series of workshops on the GTI (the first held in Central America[3], the second in Africa[4]), and the first to be held in Asia.

## 2. Workshop composition and programme

The representation of 128 participants from 22 countries and economies (Appendix 7), included taxonomists across all taxonomic disciplines, representatives of taxonomic and other networks, policy makers, government officials, and bioinformatics specialists from a wide range of disciplines. This enabled discussion of broad issues facing the region in relation to describing and documenting its biodiversity, as a prerequisite to sensible management for sustainable use, conservation and equitable access to the benefits arising from the utilisation of the genetic resources of biodiversity.

The workshop provided a strong basis for developing a true picture of the current taxonomic capacity in Asia, and for formulating the most urgent priorities to address these issues. Unfortunately some countries could not be represented, including Cambodia, Laos, Myanmar, North Korea, Pakistan, Papua New Guinea and Sri Lanka. However, input has been sought from these countries via a mailed questionnaire on resources and impediments.

The workshop opened with a day of plenary presentations (see Appendix 5 for programme details), including brief statements on the current status of taxonomic study in each area. These statements complemented a questionnaire-based survey carried out before the workshop (Appendix 6), and the combined assessment is presented in Appendix 1.

This report provides a synthesis of the results of the assessment and the outputs from a series of working groups held throughout the workshop to discuss different aspects of the taxonomic situation in Asia, and a set of proposals to meet the needs identified.

## 3. Findings of the Workshop

The findings summarised below are expressed, where action is needed, as a preliminary GTI programme of work for the Asian Region (Appendix 3). In general it was felt that Asia currently does not have the capacity to understand and manage its biodiversity. For the past two centuries, taxonomic description of Asian taxa has most actively occurred outside the region. The past 50 years has seen many of Asian countries develop rapidly in an economic sense, but a concurrent development in independent scientific capacity to describe and document this region's natural resources has not always occurred. The region suffers from very poor coverage of scientific expertise in many taxonomic groups, especially lower organisms. Consequently the knowledge base for many groups is currently well below the level necessary for sound decision-making for conservation or sustainable use.

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[3] Herrera, A. (ed.), 2001, *Development of Taxonomic capacity in Central America. Global Taxonomic Initiative, Convention on Biological Diversity*. 57pp. Instituto Nacional de Biodiversidad, Costa Rica.
[4] Klopper, R.R., Smith, G.F. Chikuni, A.C. (eds), 2001, The Global Taxonomy Initiative: documenting the biodiversity of Africa. Proceedings of a workshop held at the Kirstenbosch National Botanical Garden, Cape Town, South Africa (27 February-1 March 2001). *Strelitzia* 12: xiii + 202pp.

## 3.1 The GTI in Asia

The workshop was one of the first opportunities available for many Asian taxonomists to gain first hand information on the GTI and the CBD. The taxonomic community in the region, and biodiversity scientists in general, have had relatively little direct exposure to the Convention and to the GTI in particular. That the opportunity provided by the workshop was needed was shown both by the manner in which the verbal reports were compiled, and the answers to the questionnaire. In the returned questionnaires, for example, more than one in four respondents felt unsure of what taxonomic resources were required to meet CBD implementation. There appears to be a poor recognition at institutional/organisational level of the relevance of taxonomy for implementation of CBD, and in general understanding of CBD activities and issues, and the focus of the GTI, are not as wide as will be needed. For the GTI to be successful it is essential for much greater depth to be achieved in promoting the link between biodiversity policy and science in all countries and economies. Significant outreach activities are required to address this issue. Importantly, the recently established LOOP of BioNET-INTERNATIONAL, EASIANET, was predicated on the implementation of the GTI programme of work, and this has also been a strong driver in the activities of the longer-established ASEANET.

One measure that countries could adopt immediately to address the situation is increasing the support and use of 'focal points' to proactively work with and disseminate information to the scientific community. All parties to the CBD have agreed to establish GTI focal points, yet few countries in Asia have so far designated them. How each focal point functions at a national level will best be developed through consultation between government officials and the broader taxonomic and environmental management communities, and for the focal points to provide a useful service to both the taxonomic fraternity and the broader community it will be necessary to provide this role with appropriate resources. Each focal point needs to be monitored to ensure they are targeting the correct audience. National taxonomic and natural history societies are willing to be more actively involved in the GTI but currently lack the mechanisms for engaging practically with the Convention, and the development of strong working relationships with GTI focal points will significantly improve the implementation of the GTI Programme of Work throughout the region. Notably, National GTI Focal Points from several Countries were actively involved in preparing the workshop and ensuring its success[5].

The results of the questionnaire and the national reports showed, irrespective of the level of understanding of the Convention process, that within the region taxonomic resources are not currently adequate to provide sufficiently detailed knowledge on the components of biodiversity and for the implementation of the Convention on Biological Diversity.

The meeting highlighted the fact that Asia is blessed with great biodiversity riches, yet our science base is one of the poorest in the world, and our biota is inadequately known and covered by current research. A massive resurgence in regional taxonomic effort that focuses on documenting this region's diverse environmental zones is needed if we are to cope with the ever increasing demands on the environment here. However, taxonomy suffers from a poor image in Asia compared to other disciplines such as biotechnology. This is coupled with an apparent reluctance of funding bodies to fund taxonomic projects, despite the fundamental role of these in understanding biodiversity.

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[5] Australia, Germany, Indonesia, Japan, Malaysia, Netherlands, Thailand

## 3.2 Responding to user needs in CBD 'thematic areas' and 'cross-cutting issues'

Within specific sectoral areas (such as invasive species and agriculture), detailed taxonomic information will always be required for effective management. Linked to these specific needs there are opportunities for collaboration nationally, regionally and globally between taxonomists and the relevant sectoral interests – the users of the taxonomic products. The CBD has established a range of 'thematic areas' and 'cross-cutting issues', many of which require taxonomic support for adequate implementation. In particular, the workshop recommended that taxonomists take a greater role in dealing with the cross-cutting issue of *invasive alien species*, which are an established problem in the area. There is now a growing appreciation of this issue, which has been largely overlooked by both governments and taxonomists alike. Coordination of effort across political boundaries is a promising approach to dealing with this global, multidisciplinary problem.

The workshop agreed that within the thematic areas of the CBD the necessary focus for increased taxonomic effort should be on ecosystems that have higher levels of endemism and are most threatened within the region. These include terrestrial limestone communities, caves, swamps, island and marine ecosystems, lakes and rivers. Many other systems also need urgent attention if we are to manage our biological resources optimally.

Similarly, greater action by taxonomists is needed on recognition and identification of *endangered species* and those of *potential economic use* (significant trade and quarantine species), plus their relatives.

The needs highlighted are reflected in the draft programme of work for the GTI in Asia developed through the workshop (Appendix 3).

As one measure that would assist in responding to needs in this context, the workshop recommended the formation of an international (regional) committee, including representatives of the extant networks, and national GTI or CBD focal points, to organize training, establish standards for data collection, and coordinate training workshops for sectoral issues, starting with quarantine and agriculture. Regional collaboration is needed to ensure adequate specimens/cultures are available for easy identification and for further taxonomic research in these groups. Regional trade agreements provide a significant opportunity to mobilise taxonomic effort to proactively build capacity to meet the increasing need for scientifically credible baseline information on the status of species.

## 3.3 Collaboration and networking among taxonomists

There are a number of examples of regional cooperation and projects in the region, many of these being very active and contributing towards regional needs (e.g. ASEANET; and see Appendix 2). However, there are areas where networking of taxonomists and other biodiversity scientists could still be improved, with many of the current interactions based on previous colonial ties. All participants agreed that strengthening the networks within the region would create huge benefits at little cost, providing enhanced opportunities for exchange of information and ideas. At the same time, links need to be maintained with taxonomists outside the region to ensure adequate coverage of all taxa.

Communication and collaboration among taxonomists in the region needs to improve. This includes greater outreach to voluntary and retired taxonomists who also have a huge contribution to make. Existing networks and initiatives (Appendix 2) are important, although these may be hampered by funding restrictions and under-used. Personal communication between individuals is important, but poor electronic access hinders even this in many cases.

Simple measures to support better exchange of information can be achieved relatively easily. The workshop recommended as high priorities:

- Establishment of a regional directory of taxonomic institutions, experts and fields of expertise to encourage collaboration across the region.
- Establishment of a regional society of systematic biologists, which would link to appropriate national societies (such as the Biodiversity Research Group of Bangladesh) to provide a broader coalition of scientists to help promote the role of biodiversity science in the region, as well as to improve contact between scientists.
- More stable funding for established networks such as ASEANET, EASIANET, PACINET and Species 2000 Asia Oceania.

There are a number of existing initiatives, such as ASEANET, EASIANET, Species 2000 Asia Oceania, that could be further involved in delivering regional directories of taxonomists, collections, type photographs, training courses, species and specimen databases, and research and collecting permit requirements, and already provide examples of how this can be done. The delegates agreed that at least one Website[6] could usefully be set up to provide on-line links, although it was strongly noted that other means of communication are needed as well.

Support has been forthcoming from governments to establish Technical Cooperation Networks (BioNET-INTERNATIONAL LOOPs) in East and Southeast Asia and the South Pacific (and is underway in South Asia). However, the financial and political commitments needed to continue effective coordination and programme development of such networks has been lacking. In addition, some networks have been established by individual researchers (e.g. ANeT[7]) with little support from or involvement with government processes. With even marginally increased support and encouragement from governments the existing scientific research community will be able to operate more effectively and target their work at the needs highlighted by the GTI.

## 3.4 Imbalances in numbers of collections, experts and species

Whilst there are a fair number of collections within the region, these cannot be used without sufficient research and support staff, and taxonomists are hampered in their work without ready access to reference collections. The results of the regional survey undertaken prior to the workshop (Appendix 1) shows both an absolute and a relative numerical inadequacy in the pool of taxonomic experts and support staff; these both being major obstacles to meeting the increasing demands for comprehensive and up to date information. Across all institutions staffing is inadequate, in terms of total numbers of full-time taxonomists and support staff, age structure, and spread of expertise across the taxonomic spectrum.

In general, the Asian region suffers from very poor coverage of scientific expertise in many taxonomic groups, especially lower organisms. The regional knowledge base for many groups is currently well below the level necessary for sound decision-making in terms of implementation of the Convention on Biological Diversity. To understand clearly the nature of the problem of addressing the paucity of taxonomic data available for Asian species it is not only necessary to look at the overall number of experts in the region, but also the current lack of experts in many groups. A simple analysis of the number of taxonomists compared to the number of known species in each major group of organisms (see back cover) shows the highly skewed focus of research currently. However the problem is much worse, even within the groups that would appear "well-represented", such as vascular flora, there is a lack of trained scientists to complete the current taxonomic effort required to document our

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6 http://www.gti.nies.go.jp is now being used

7 Asian Network for Ants

biodiversity within a reasonable time to meet the needs of the CBD. Furthermore if we consider the number of as yet to be described species the problem is even further exacerbated.

There is a severe deficit of taxonomists for protozoa, micro-fungi, micro-algae and bacteria/archaea. Similarly, there are too few experts studying invertebrates in the region. Appendix 1 provides a more detailed analysis of the 2002 survey of taxonomic capacity in Asia. Increasing research on the lower taxa, particularly micro-organisms, will substantially increase taxonomic knowledge of known organisms, and should raise the rate of description of new species. Importantly it is the role of lower organisms in many ecosystem processes that is poorly understood, and better comprehension of the species is the first step in increasing our understanding of their ecology, and therefore of enabling appropriate management in the context of the CBD.

## 3.5 Maintaining the succession of knowledge and skills base

The results of the questionnaire demonstrate clearly an aging taxonomic workforce in Asia. However, in order to maintain an optimal understanding of the species present both at national and regional scales, continuation of specialised knowledge of specific techniques, morphology and species characteristics is required. Much of this knowledge is not available in published form, but is most effectively passed on from one individual expert to another, together with the materials kept at the specimen/culture collections. To ensure this handing-on of knowledge, institutions holding collections need to employ a mixture of older and younger taxonomists. This step will require an appropriate level of funding to increase the number of taxonomic positions and ensure a steady stream of younger taxonomists entering the profession.

In addition, encouragement of younger people to take up taxonomy as a career is needed to address these shortages. Despite being at the core of understanding and managing biodiversity, taxonomy suffers from a poor image, and a new campaign is needed to counter this and to boost university teaching of the discipline, which has been in decline for some time.

Better education in taxonomy and biodiversity is important to improve public awareness of biodiversity issues and increase the number of young taxonomists. Ideally this should start at secondary school level; however currently this happens in slightly less than a third of the secondary schools in the region. A higher level of education in taxonomy is necessary to understand and improve knowledge of Asian biodiversity. More graduate and post-graduate training in taxonomy is needed within the region, and better training opportunities are needed to encourage young students. Other possibilities already being employed at some levels include PhD and MSc courses in other countries and in-house short courses on particular topics. Regional scientists should continue to be involved in collaborative projects with specialists from elsewhere to build on and develop expertise. Regional cooperation has already been initiated at an institutional level in Asia where in-country conditions are not adequate, especially in microbiology, but overall, there is a paucity of courses in the region dealing with taxonomy.

In addition to training of students who will form the next generation of specialists, training is also needed to extend the skills of existing taxonomic staff. Training of parataxonomists is also important.

## 3.6 Taxonomic infrastructure and equipment

The need for significant improvements in physical conditions for collections was seen as an urgent need throughout the region. Provision is needed for caring for 'orphan' collections in all countries. Some centres could act as regional repositories for particular groups. For selected small to medium collections, the establishment of improved collection conditions (simple and cheap methods for improving collection security) could proceed with minimal funding and could then be used as pilot for others.

Basic infrastructure for specimen collection and study, including collecting and drying equipment and facilities, compound microscopes, specimen cabinets, freezers and refrigerators, is available at most institutions but needs upgrading in many cases. Availability of equipment and facilities for relatively advanced technology in taxonomy is variable, as is funding for training technicians and for operational costs.

Tissue culture facilities, cryo-preservation facilities, and molecular equipment for taxonomy are inadequate in many institutions. The expense of obtaining and maintaining this equipment is another factor limiting the regional capacity to study lower organisms and micro-organisms, compared to the larger and better-known animals and plants. This more restricted infrastructure for microbial cultures is probably a major reason that the graduate and post graduate level of education in microbiology is largely provided at foreign institutes, where resources are better. This further compounds the inadequate number of taxonomists in microbiology in Asia as many scientists then stay abroad in order to work in their field of expertise.

Increasing the infrastructure for microbial culture collections is needed. Regional cooperation for supporting proxy preservation of cultured strains and safe deposit of important strains at the established facilities in the region within the lawful mechanism of access and benefit-sharing between the collaborating countries is also important until an adequate infrastructure can be built up throughout the region.

The ever-increasing cost of library books and journals is of concern generally since taxonomy relies so heavily on publications both old and new. In one country, no foreign journals have been bought since 1990. Providing electronic, on-line access to taxonomic information and resources currently not available in Asia is more cost-effective than collecting such rarely available and very expensive books and journals to build up a library at each collection. However, there is a major issue in the availability of adequate computer equipment and internet access.

Computers and Internet connections are available at most of the surveyed institutions, but often not to an adequate level. Connection to the Internet is of course highly important for email and access to the rapidly accumulating taxonomic information on the Internet. However, it is also vital for creating local taxonomic electronic resources. Taxonomists need to build up regional datasets to fill the knowledge gap: to digitize data from each collection to manage the specimens/cultures; to make their own data available to colleagues at remote institutes; and, more importantly, to participate in global data projects for broader aspects of science relevant to understanding biodiversity and supporting conservation.

A general need expressed in the region is for upgrading and extending both facilities and equipment since these are generally aging or outgrown. Resources are very limited in some cases, with some countries mentioning the lack of funds for such items as laboratory or computer equipment.

## 3.7 Location of and access to reference specimens

Many scientists at the meeting expressed concern over the continuing restricted access to scientific material (collections and literature) held elsewhere in the world, particularly in developed countries. The issue is particularly acute with respect to type specimens. Because many types of Asian species are held in collections outside the country of origin, and often outside the region itself, Asian researchers cannot always examine them. To compound the problem, the collection where the specimen is kept may not be known. Even when the repository has been located, researchers often need to travel overseas in order to make comparative studies; this cost can be significant, and is known to prevent some studies of Asian biodiversity from taking place. Improving access (particularly electronically) to such taxonomic material is a priority. Some institutions are moving quickly to provide access and repatriate data, but there is no coordinated approach and few resources to make it happen, with current efforts undertaken on a case by case basis.

There is a clear need for collections to be databased at a variety of levels: particular collections held; overall coverage; species held; and specimen data. These databases, once compiled, should be made available in electronic and other suitable formats. The need is not only for collections held outside the region, but also for those within the region, both because some collections within the region hold material from other Asian countries, and this will be a step to providing a regional facility. When data sharing of this nature takes place, whether through the web or by direct provision from collections, knowledge of the quality of the data is vitally important to users. The level of quality of identifications (including for example the name and date of the identifier, and history of name changes in the database, and whether changes were based on expert re-identification of the specimens concerned or whether it was a change based on a review of name changes in the literature) is essential. Equally important is knowledge of the quality of the locality data, which ideally should be geo-referenced. It is also important to know whether the database is based on individual specimens collected and preserved or whether it is based on field survey data without voucher specimens.

Collections that hold type specimens are urged to provide high-resolution images of type specimens, ideally through the Internet and also on CD-ROM. This is already happening in some cases, but needs to be rapidly expanded to meet increasing need. However, although electronic dissemination of images and other information is important, effective and efficient delivery of taxonomic information is hampered by poor access in Asia to electronic communication, information-gathering and dissemination, now taken for granted in much of the developed world. Not only is the technical infrastructure inadequate, much of the physical infrastructure is in decline in the region (including aging buildings and equipment).

Provision by northern institutions of duplicate specimens to the country of origin and to other countries where the organism occurs should be promoted, with the commitment by countries of origin to adequately curate specimens to agreed international standards. However, projects to preserve reference specimens/cultures in Asia will only be effective if the basis of the collections concerned is as comprehensive a set as possible of reliably-identified specimens to serve as vouchers. In the absence of this pre-existing resource there will need to be an increased collaboration of taxonomists regionally and globally to develop it.

For micro-organisms, a living culture is able to be duplicated at any collection if appropriate media and conditions can be maintained. This allows the preservation of duplicates in different collections and it makes access to types easier as long as strains are distributed widely between collaborators. However, to keep the characteristics of the strains, a good cryo-preservation facility is necessary.

## 3.8 Agreements on research access and benefit-sharing

Agreements are needed on access to data and information, specimen collection and deposition, intellectual property rights, and benefit-sharing at government level as well as at institutional level. This could be either as a blanket agreement (a memorandum of understanding – MOU) at the national level covering all scientific projects, or on a project-by-project basis at institutional level. In all cases MOUs should ideally be developed in the spirit of collaboration. Separate MOUs would be needed for bio-prospecting and commercialisation. The workshop recommended that institutions in each country be designated to handle MOUs.

The location where specimens are to be deposited should be specified in an MOU. This will depend on the type of specimen: plant, animal or microbe. It may be useful to designate an institution as a national repository for each group of organisms in each country, as called for in CBD COP decision V/9. Generally holotypes and single specimens collected during the course of a study should be deposited in the country of origin. Paratypes and isotypes should be deposited in more than one location if possible. In any case, free access should be guaranteed to types and microbial type strains for all taxonomists. Specimens in some countries are sent elsewhere for identification and there is free exchange of duplicates – this practice should be encouraged to make use of the world's limited pool of taxonomic experts.

The current permit system for collection of biological data is cumbersome and sometimes a major barrier to scientific study. It needs to be simplified in order to facilitate implementation of the GTI. The meeting strongly supported the designation of a 'competent national authority' in each country and economy, which would provide a streamlined approach to obtaining permission for taxonomic research (see Convention on Biological Diversity (A&BS) Bonn guidelines 11L, 34, 36F, 42E and 63B on collection and use of specimens for taxonomy)[8].

## 3.9 Disseminating the results of taxonomic research

The needs of users of taxonomic products must be more clearly ascertained and documented, which in turn will generate appropriate innovative uses for collections and their data.

More publications are needed at all levels of knowledge to make the results of taxonomic research widely available to all users: from specialist taxonomic publications to local field guides, CD-ROMs, general information on-line, etc. These should cover marine as well as terrestrial ecosystems.

## 3.10 Publicising the role of taxonomy

The public image of taxonomy is extremely important. The fact that taxonomy underpins many aspects of biological sciences (including those important to implementation of the Convention on Biological Diversity, and such issues as biotechnology) is not always appreciated. There is an urgent need to reach out to decision-makers and prospective students alike. Taxonomists need to be more interactive with these groups and with the media to reach the general public to ensure support for this basic activity.

All taxonomists should take a more active public relations role as individuals, and make themselves known to people who need taxonomic expertise (and who have funding to support our activities). For example, the delegates at the regional workshop of Global Invasive Species Programme (GISP) held in Bangkok in 2002 included very few of those present at the Asian GTI workshop, and participants should make contact with these participants to discuss possible collaboration on invasive species.

## 3.11 Funding

Across all aspects of the taxonomic impediment in Asia the lack of sufficient funding was identified as a major constraint, and in particular it was highlighted that there is currently insufficient funding for

[8] http://www.biodiv.org/decisions - see decision VI/24

people, infrastructure and projects. There is apparently some reluctance among funding bodies to fund taxonomic projects, especially dealing with lower organisms.

Some users are charged (cost recovery) for access to collections e.g. research workers with big grants and industry, but much of the funding to support collections ultimately has to come from governments.

## 3.12 Major taxonomic needs in Asia: conclusion

The survey results summarised in Appendix 1 clearly showed four major stumbling blocks for taxonomy in the region:

- Lack of research funds (95%)
- Inadequate staffing levels (89%)
- High running costs (84%) and
- Difficulty of access to taxonomic literature/libraries (80%).

In addition, continuing maintenance and upgrading of equipment and facilities are needed. Each taxonomist's effort devoted to understanding biodiversity has been significant, but taxonomists require regular published output to be eligible for research grants/funds and thereby to make more effective use of the available infrastructure and to increase the availability of equipment in laboratories. Employment of qualified staff from younger age groups requires improved education systems that cover taxonomy from primary to graduate and post-graduate level and adequate employment opportunities in both in-country and regional research institutions. This will facilitate filling the gaps in taxonomic knowledge over the broad spectrum of biodiversity. Internet technology is one partial solution to the problem of access to taxonomic information, including image data of type specimens kept in remote institutions and access to literature/libraries elsewhere. While in total the problem is large, each component can be addressed but will truly require regional cooperation with a long term vision to ensure the region is equipped to meet the needs of biodiversity conservation into the future.

# List of Appendices

Appendix 1. Survey of current regional capacity and gaps

Appendix 2. Existing networks and Initiatives in the Asian region relevant to the GTI

Appendix 3. Implementation of the Global Taxonomy Initiative Programme of Work in Asia

Appendix 4. Posters presented at the Workshop

Appendix 5. The Programme of the 1st GTI Workshop in Asia

Appendix 6. Questionnaire sent to Asian taxonomists and institutions in 2002

Appendix 7. Participants in the 1st Asian GTI Workshop

Appendix 8. Sponsors, report editors and contact details

# Appendix 1. Survey of current regional capacity and gaps[9]

The Conference of the Parties to the CBD has requested all Parties to work together to ascertain regional taxonomic capacity. To facilitate an understanding for the Asian region a survey of taxonomic resources and needs was carried out in 2002 by the National Institute for Environmental Studies, Japan. A questionnaire on taxonomic needs and capacity (Appendix 6) was sent to major taxonomic institutes, GTI focal points and CBD focal points in the region prior to the 1st GTI Asian Regional Workshop. By the end of July 2002, 69 organisations from 17 countries and economies in the region[10] had completed the questionnaire, and an interim analysis of these responses was presented at the workshop to facilitate discussion. This result is not a compilation of national or country-wide assessments but is a compilation of the answers from the Asian institutes and organisations that responded to the questionnaire. Details of the responding institutions, organizations and initiatives, and if the individual experts and the organisms studied by them, will be provided on the World Wide Web server for the GTI in Asia (http://www-gti.nies.go.jp) after agreement is obtained from individual respondents.

The survey continued until December 1st, 2002 to increase the coverage of organisations in the region (these extended results will be published elsewhere). The results will be updated on the GTI in Asia website.

To supplement the questionnaire representatives of 14 countries and economies[11] presented brief verbal reports during on the workshop on the status of their taxonomic infrastructure and staffing. No set format was required and these reports varied widely in content and style, and consequently, no tabulation was possible. Elements of these reports are included in the information given below, by topic, and discussed in Section 3 in the main body of the report.

## Status of taxonomic resources in Asia in terms of CBD implementation

Ninety-seven percent of the respondents to the questionnaire believed that taxonomy was "not adequately addressed" in their country. However, to the question 'Is your staff adequate to address CBD issues?' 70% answered 'No', and 28% answered 'Not sure'. The verbal reports generally dealt similarly with basic taxonomic capacity as opposed to capacity specifically in terms of CBD implementation. Much of the analysis below therefore reflects taxonomic capacity as a general resource, although given that such capacity is a vital basis for GTI and other CBD implementation, the results can and must be taken as indicative of the region's ability to respond Section 3 in the main body of the report.

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[9] Acknowledgements – Data were analysed and put into report format by Dr Junko Shimura. She thanks Ms Manami Matoba and Mr Yoshihiro Sato for their work on digitising information and the compilation process. She also thanks Mr Ian Cresswell, Mrs Karen Wilson and Dr Christopher Lyal for correction of English language and important suggestions through the discussion on GTI.

[10] Responding organisations are distributed as follows: Brunei (1), China (2), Hong Kong (1), Indonesia (9), Japan (7), Malaysia (2), Mongolia (2), Myanmar (1), Pakistan (6), the Philippines (4), Singapore (1), Sri Lanka (2), Taiwan (2), Thailand (25), Vietnam (3). The number in parentheses indicates the number of organisations that had replied to the questionnaire *by the end of July 2002.*

[11] Bangladesh (Badrul Amin Bhuiya); China (Hui Xiao); Hong Kong (Kevin Hyde); India (Haque M.A.); Indonesia (Dedy Darnaedi); Japan (Makoto M. Watanabe); Malaysia (Mashhor Mansor); Mongolia (Tsetseg Baljinova); Philippines (Domingo Madulid); Singapore (Ruth Kiew); Republic of Korea (In Kyu Lee); Taiwan (Kwang-Tsao Shao); Thailand (Wichien Yongmanitchai); Vietnam (Nguyen Xuan Hong).

## Communication and networking

Better regional communication and networking are needed to make best use of the taxonomic resources available (see below). Often poor communication was reported between Asian countries; this may have come about at least partially because traditionally regional communication has been based on strong links between individual Asian countries and institutions in industrialised countries with strong historical colonial links.

Research results and general biodiversity information, the products of the taxonomic process, need to be communicated more widely. Projects have started in some countries to do this electronically, notably for specimen data or images. However, this is still of limited use to many people in the region, as illustrated by a recent Biodiversity Asia Network survey of participants in a workshop. This survey found that none of the taxonomists surveyed, belonging to seven countries of the Southeast Asian region, had heard of international initiatives such as the Species Plantarum Project, GTI, Species 2000, or the Taxonomic Impediment or the Darwin Declaration. In addition, only 9% of these taxonomists had access to the Internet although 80% had access to email. Two countries pointed out that they have few computers and could not afford Internet access. Political restriction of access may also be a problem in other cases. This indicates that, prior to more widespread availability of the Internet, other means of communication need to be used in the short term while seeking to improve electronic, on-line communication and access to information and in the Asian region.

A benefit of greater national and regional collaboration will be the better taxonomic coverage of the spectrum of organisms, since no single institute or country or economy can cover this fully by itself. Producing regional directories of biological collections, taxonomists and current projects will be a first step. Promoting professional societies (Appendix 2), and informal networks of specialists in a particular group of organisms, will also help. Regional groups such as, ASEANET, ANeT and SEABCIN are tackling some of these issues. Within countries other initiatives have been set up within the region to address communication needs. The Biodiversity Research Group for Bangladesh was established recently to promote discussion and contacts; it already has 200 members and is starting a checklist of species in the country. In China there are a range of on-line products, e.g. a list of Chinese taxonomists and their areas of expertise, Fauna of China, and specimen information (including types), and the government has funded hard-copy publication of the Fauna of China, the Flora of China, the Cryptogamae of China and other taxonomic works. In Malaysia the first National Expert Meeting and workshop on Malaysian Taxonomy Initiative was held in September 2002 to assess taxonomic needs and identify strategies to enhance taxonomy in the country. It was organised jointly by MOSTE, UKM, UMS and ASEANET. Despite these initiatives more widespread involvement is needed, involving among others the more recently developed networks such as EASIANET and a planned BioNET-INTERNATIONAL network for South Asia (SACNET).

## Collections, experts and species numbers

Institutions holding the major taxonomic collections of their respective countries comprised 60% of those responding to the questionnaire.

Figure 1 illustrates the numbers of specimen/culture collections in Asia for each major group of organisms. One hundred and forty (140) collections of animal and plant specimens and microbial cultures were identified through the questionnaire (note that some of the 69 respondent organisations hold collections of more than one group of organisms, and that these are counted as separate collections). In some countries, a range of small to large biological collection facilities (herbaria, zoological collections and culture collections) exist but in many countries no single major national collection exists with a strong emphasis on collection storage and research with a larger, full-time taxonomic staff to maintain and conduct research on the collections. Thailand, for example, has 55 institutes housing small to large biological collections, amounting to about 5 million specimens in total, but there is no National Natural History Museum. Malaysia and the Republic of Korea also lack such national institutes.

The highest number of collections identified from the questionnaire exists for invertebrate animal specimens (41), followed by vertebrate animals (20), vascular plants (23) and non-vascular plants (12). Although 'fungi/yeast' (20) may include macro-fungi, there appear to be about 40 collections for microscopic organisms in the region. The survey therefore demonstrates that collections do exist in Asia for all groups of organisms. However, the survey does not provide details on the relative size or status of the collection. It is anticipated that while collections exist for lower organisms this will contain a much lower proportion of species compared to the overall number of species predicted for that group in the Region.

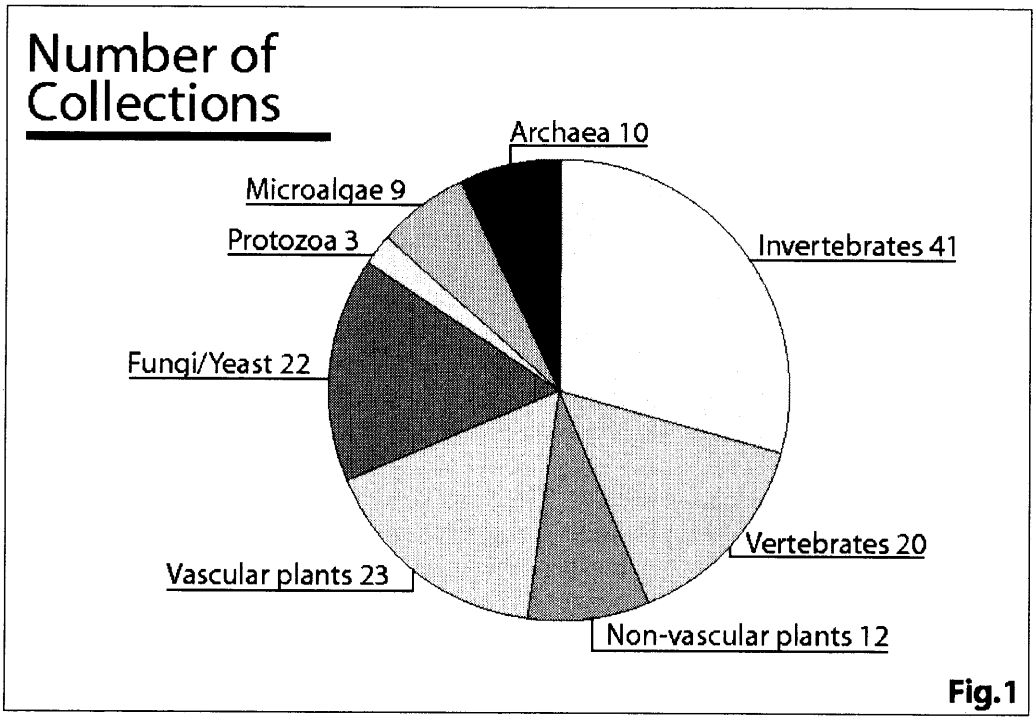


**Fig. 1. The number of collections for different groups of organisms in Asia as reported in the 2002 survey.**

The survey reports on the number of collections that exist for each group of organisms. Note that an organisation may hold collections of more than one group of organisms.

All countries reported a problem with taxonomic staffing, judging it inadequate in total number, or uneven in age distribution, or uneven in distribution of researchers across the spectrum of organisms. In Japan, for example, there are only two experts on Protozoa but 268 studying arthropods and 61 studying vertebrates. There is also an imbalance in distribution of staff amongst biological collections, with, for example, 35% of herbaria in Japan having no active taxonomist working on the specimens and 39% having only one or two taxonomists – and without any support staff. Most other countries reported a great shortage of full-time taxonomists and/or of support staff.

From the questionnaire results it can be seen that the highest number of experts work on invertebrate animals (Fig. 2). Rather fewer experts study vascular plants and vertebrate animals. Almost half of the experts are zoologists, while botanists working on vascular and non-vascular plants number slightly less. There is an average of 2–4 experts working at each animal and plant collection, although relatively fewer in non-vascular plant collections than those of other types. Relatively few experts work on micro-organisms, although collections of micro-organisms do exist in the region. The average number of experts at each micro-organism collection was 0 (for protozoa) to 1 in round numbers (fungi/yeast, micro-algae, bacteria/archaea). The low number of experts for micro-organisms is a barrier to increasing coverage of all species.

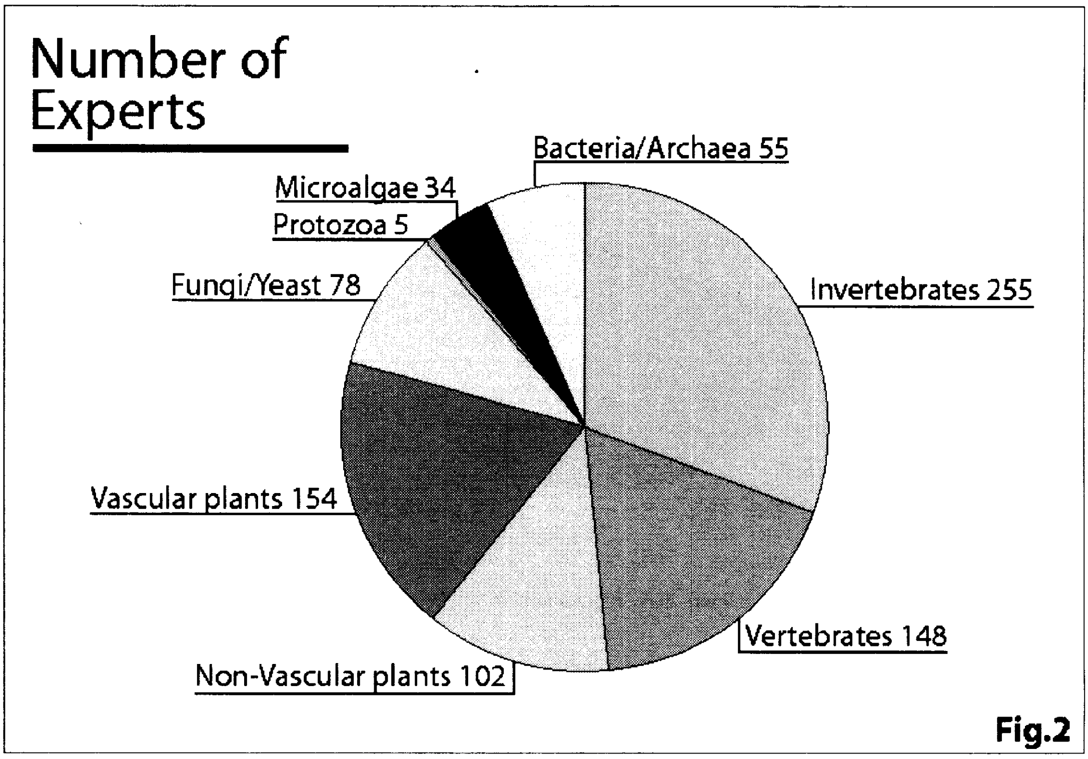


**Fig. 2 The number of experts (not all full-time) working on different groups of organisms in Asia, as reported in the 2002 survey.**

When the number of experts in the region is compared to the number of known species in each major group of organisms (Fig. 3), it is clear that some groups of organisms are significantly under-resourced in terms of active taxonomic work. A further analysis of the estimated number of species (compared to the known number of species) would show that the current number of experts (Fig. 2) is completely inadequate compared to the huge numbers of unknown organisms in the lesser-known groups of microorganisms, invertebrates and fungi.

It is important to note that while some 148 taxonomists study vertebrates, 154 vascular plants and 102 non-vascular plants, these are not considered adequate to provide adequate taxonomic information on the estimated number of species in these groups (both named and as yet undescribed) in the Region. There is a much more severe deficit of taxonomists for protozoa, micro-fungi, micro-algae and bacteria/archaea. Similarly, the number of experts on invertebrate animals is not in reasonable balance with the immense number of species in the region.

An important step to rectify the situation was taken in Indonesia with the recent GEF–World Bank project on biodiversity resources, supported by funding from other countries, which resulted in 19 new staff in the botanical and zoological institutes at Bogor with higher degrees, and one parataxonomist. Aspects of this project should be taken as a model for future biodiversity projects in Asia.

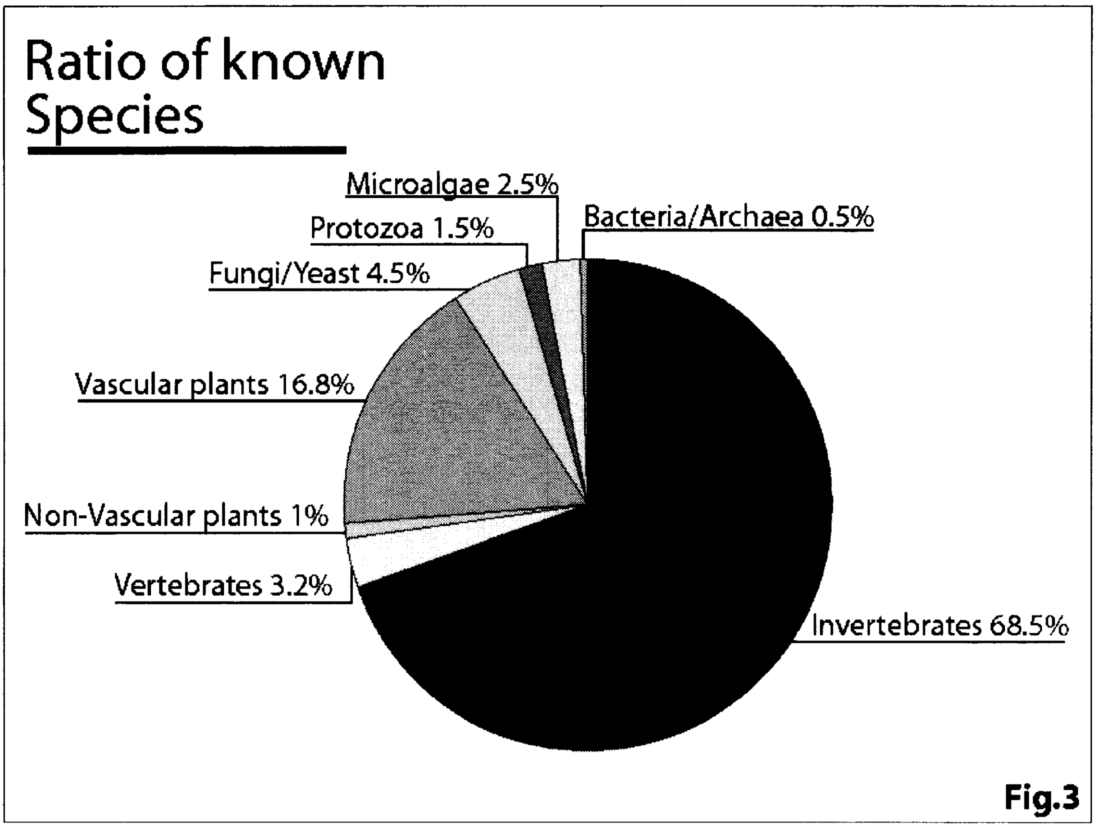


**Fig. 3. The ratio of the number of known species in each major group of organisms.**

The ratio of known global species is used because there is no estimate of species numbers in Asia; These numbers are taken from 'Implementing the GTI: Recommendations from DIVERSITAS Core Programme Element 3, including an assessment of present knowledge of key species groups' (UNEP/CBD/SBSTTA/4/INF6).

## Maintaining the succession of knowledge and skills base

Three linked issues are dealt with in this section: the demography of existing staff (also touched on in the previous section), the transfer of skills from those staff to their replacements, and the training of those replacements outside of an 'apprenticeship' system.

More than 60% of experts from responding institutions are over 40 years old (Fig. 4). This pattern is also observed when the data are examined by country or by group of organisms. The increasing average age of taxonomists was pointed out at the second meeting of SBSTTA[12], and is still true in Asia in 2002. At the 1st GTI Workshop in Asia no single country reported that an active program or policy had been implemented to address the issue that within 10-15 years the region will lose a massive amount of its scientific expertise as taxonomists retire. The current recruitment levels will not provide an adequate taxonomic base for sound decision-making into the future.

[12] UNEP/CBD/SBSTTA/2/5.

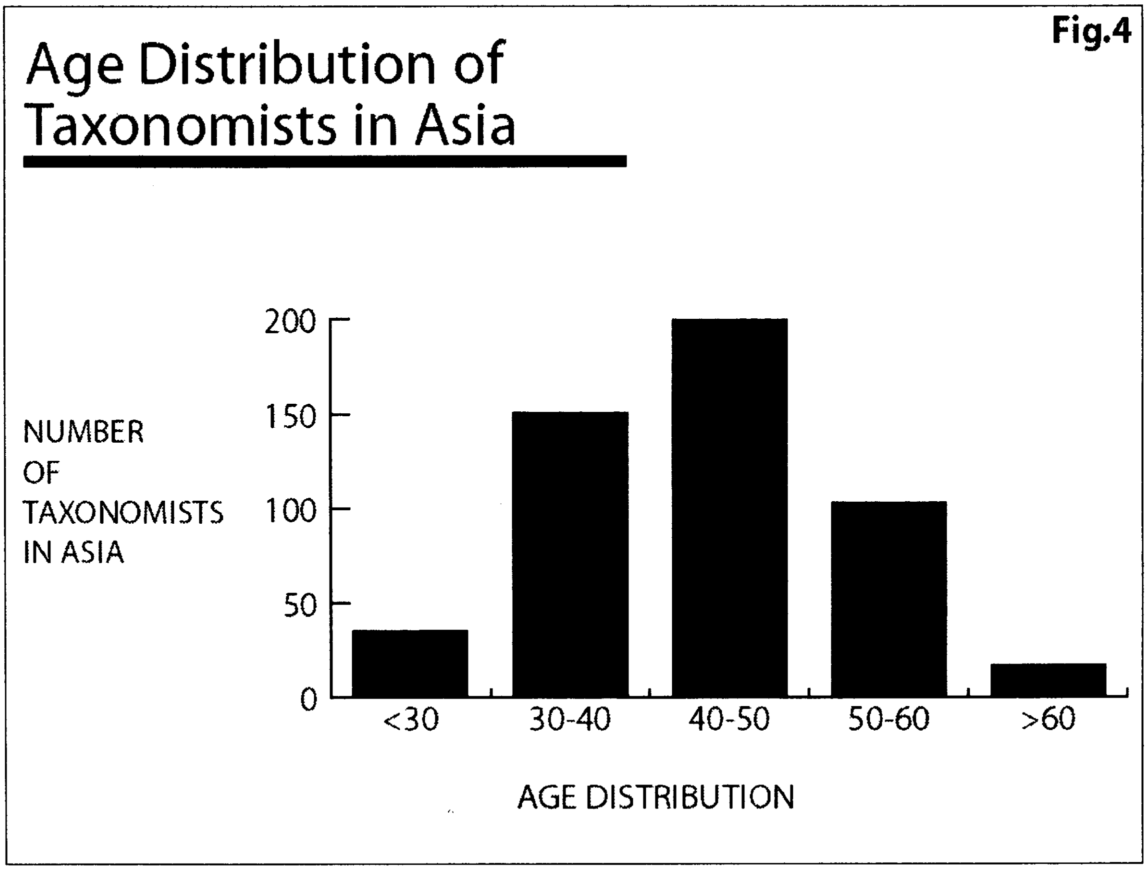


**Fig. 4. Age distribution of experts at Asian taxonomic collections.**
(The total number of experts reported in the 2002 survey was 831)

To increase the number of young taxonomists, better education is important. This survey indicates that taxonomy is taught in only 30% of secondary schools and is generally regarded as a subject for university/college-level education. Graduate and post-graduate training in taxonomy is provided by institutes outside their country according to 15% of respondents; most of these courses focussing on lower organisms (invertebrates, non-vascular plants and micro-organisms). Some of these courses are in other Asian countries, whilst others are out of the region. Within the region several initiatives were mentioned: the University of Hong Kong is training higher degree students from across the region in mycology, within Indonesia a 6–8 week Regional Training Course on Plant Taxonomy is run at Bogor every 2–3 years, and in the Republic of Korea universities are starting PhD programs covering taxonomy.

## Infrastructure

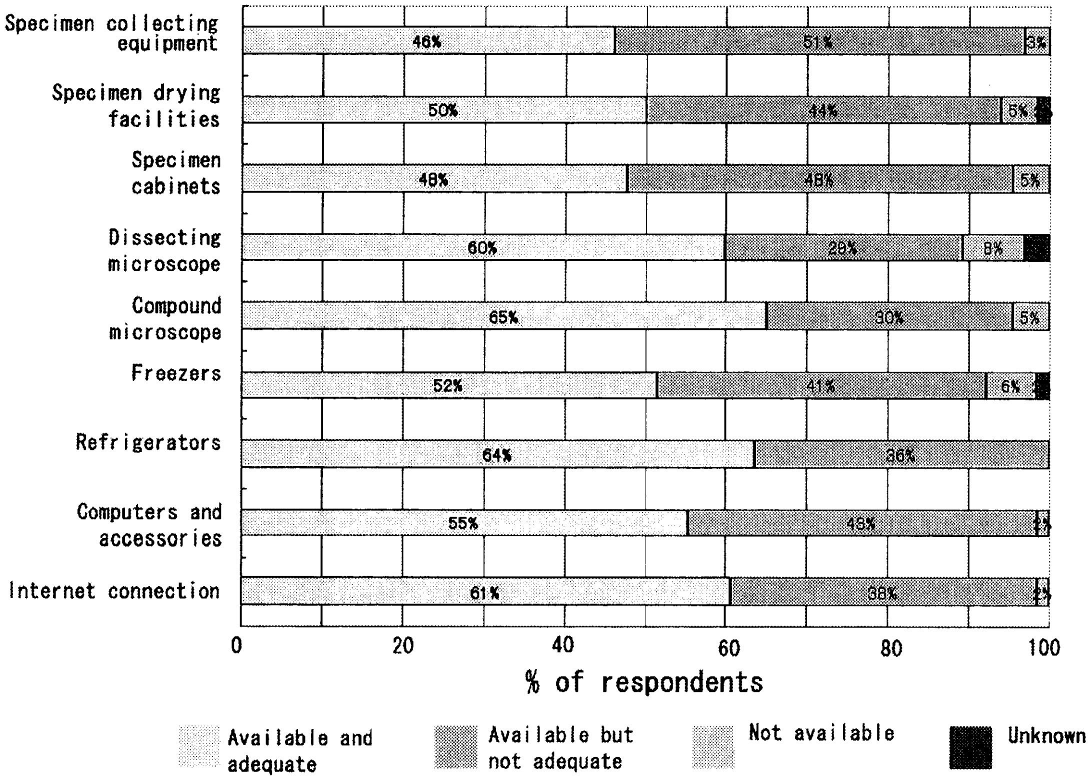


**Fig. 5. Availability of basic equipment and facilities for taxonomic studies.**

Facilities vary from minimal to good for a variety of historic and economic reasons. The survey sought information on the availability and adequacy in Asia of the major types of equipment required for all facets of taxonomy. Figure 5 provides a synthesis of the results (the total number of respondents varied from 64 to 66 depending on the particular item).

Basic infrastructure for specimen collection, including collecting and drying equipment and facilities, compound microscopes, specimen cabinets, freezers and refrigerators, appears to be available at almost all of the responding institutions, although 30–50% of the respondents stated that such equipment is available but not adequate.

Computers and Internet connections are available at 98% of the respondent institutions, although availability is sometimes not adequate (43% for computers and accessories, 38% for internet connection). In those institutions with inadequate connection, it is likely that the physical connection is possible but cannot be used by taxonomists due to lack of funding to pay access fees. In some cases, email access is available but browsing websites is not allowed due to limited access to a wide area network.

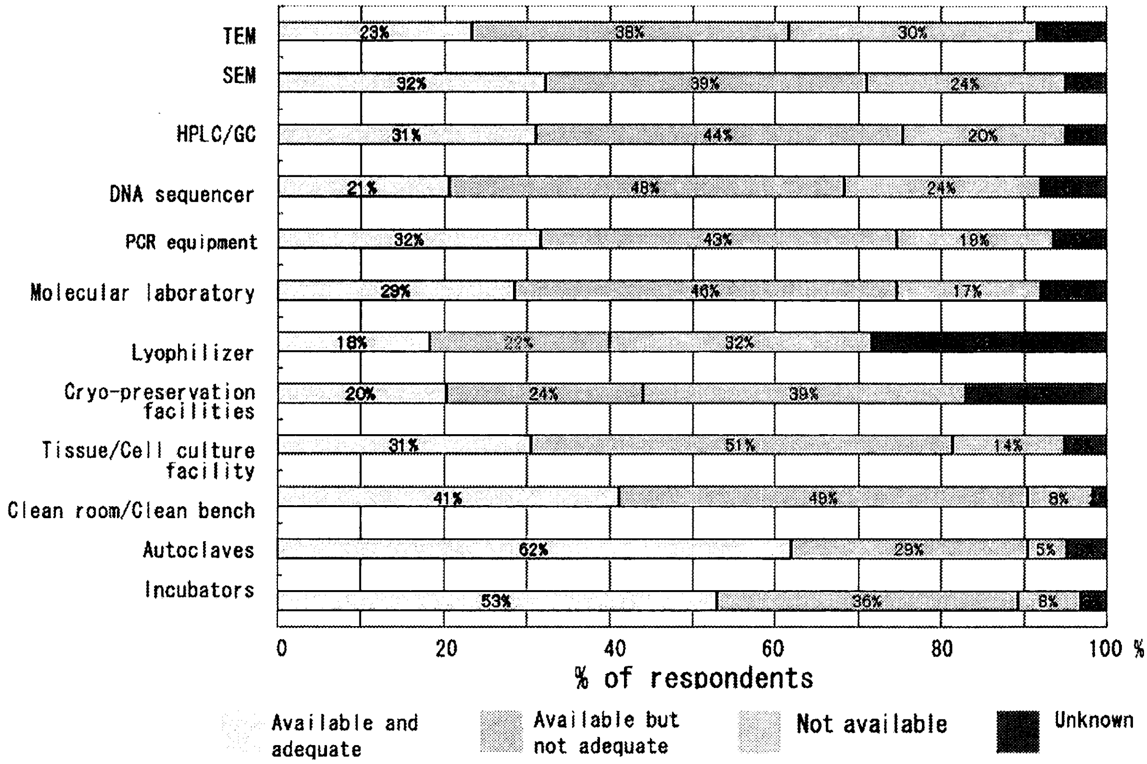


**Fig. 6. Availability of equipment and facilities for advanced technology in taxonomy.**

The availability of each kind of equipment indicated on the vertical axis is shown in the explanatory note at the bottom. The total number of respondents varies from 60 to 66 depending on the individual item. The figures on the bars indicate the % of respondents for each item.

Availability of equipment and facilities for relatively advanced technology in taxonomy is variable (Fig. 6), as is training for technicians. Scanning electron microscopes are available at 70% of these Asian institutions, and more than half of these also have a transmission electron microscope available. However, the collection-holding institutions that have electron microscopes stated that the TEM (39%) and SEM (36%) are not adequately used. It is understood that ongoing funding is not sufficient for the operational costs for electron microscopy and its accessories in many places, so that while the original purchase of the equipment has been made possible the lack of ongoing funding to operate it means that is stays out of the reach of many scientists, particularly younger scientists.

Tissue culture facilities, cryo-preservation facilities, and molecular equipment for taxonomy are not adequate at 30–60% of institutions. As described in the previous sections and as indicated by this inadequacy of equipment, the regional capacity to study micro-organisms is limited compared to the animals and plants.

Several examples of governments responding to these needs were presented to the meeting. The Government of China has put major funding into new facilities for some of its biological collections. In India the government has started a program to improve taxonomic knowledge of neglected groups, and to help in this process has set up four coordinating centres, each with 4-6 collaborators. In Singapore the government has updated the Raffles Museum facilities and is currently building a new herbarium in the Botanic Gardens, whilst in the Republic of Korea the government has recently opened the Biodiversity Centre to promote taxonomic study.

## Location of and access to specimens

Forty-five percent of responding institutions that held major taxonomic collections in their countries did not have their specimen/culture information is not in database form. Among the organizations with information already in electronic form, 66% of them do not have that information accessible on the World Wide Web.

Type specimens/cultures of all groups need to be accessible for taxonomic studies. However, respondents stated that many type specimens/cultures collected from their own countries are kept outside the country, particularly in the case of animals and plants.

Within the region there have been a number of recent initiatives to make collection data available. For example, Indonesia, Malaysia, Philippines, Singapore and Thailand are collaborating with the National Herbarium, Leiden, and the Department of Botany, Oxford University, on common access to herbarium specimen databases (SEABCIN project). In the Philippines the National Herbarium has started an on-line database of its specimens, while in Singapore the Botanic Gardens is putting images of the type specimens in its herbarium on-line. In Taiwan the government is funding TaiBNET, which has databased information on 30 000 species in the past year. Indonesia plans to release their collection management and mapping programs to other countries in the region at the end of this year. As soon as possible thereafter, a training course for taxonomists in this region to learn to how to use these programs would be of significant value.

Table 1 provides information on collection databasing by country, collated at the workshop.

| Country/Economy | National collections | Data shared electronically between collections |
|---|---|---|
| Bangladesh | yes | |
| China | yes | Yes |
| Hong Kong | in some groups | |
| India | yes | |
| Indonesia | yes | Yes |
| Japan | yes | in progress in some groups |
| Malaysia | no | strong individual collections; data sharing started |
| Mongolia | yes | other individual collections |
| Philippines | yes | just started |
| Singapore | yes | |
| Taiwan | yes | Started on metadata using Species 2000 name database |
| Thailand | in some groups | started in some groups |
| Vietnam | yes | in some groups |

**Table 1. Electronic databasing of national collections.** Data from questionnaire responses.

## Analytical and other software

The workshop examined the use of free software to increase effectiveness through utilizing broader data pools from collection databases. It focused on mapping software, and then expanded to other software as well as human resource networks to facilitate sharing of collection databases. Table 2 provides information on map and gazetteer availability by country, collated at the workshop. Countries are omitted from the table if no information was available at the workshop.

| Country/Area | Maps | Gazetteers |
|---|---|---|
| China | Yes | Yes |
| Hong Kong | Yes | Yes |
| India | yes [purchase] | Yes |
| Indonesia | Yes | yes but not comprehensive |
| Japan | yes [purchase] | Yes |
| Korea | Yes | ? |
| Malaysia | yes [purchase, expensive] | Yes but not recent |
| Philippines | Yes | Yes but not comprehensive |
| Singapore | Yes | Yes |
| Taiwan | Yes | Yes |
| Thailand | yes [purchase] | Yes but not recent |

**Table 2. Maps and gazetteers by country.** Data provided by participants.

*Mapping Software*

A demonstration of UOMAP, a free software program in preparation, was given by Dr. Takeshi Sagara (The University of Tokyo) who is developing the program. The demonstration involved the freshwater collection database of the National Science Museum, Tokyo. When the program is completed, some time in the second half of 2003, it will be available for use by researchers with collection databases and matching gazetteers.

Botanists in India are developing BIOCAP, a landscape-level mapping program. Indonesian scientists are developing INSTANTMAP for use with data from individual specimens, or field surveys, which is available from the Indonesian Biodiversity Information website. Many other mapping programs are being developed in other regions of the world including CAMRIS (USA).

In the future, for regional studies, mapping programs will need to be integrated, or raw data from shared databases utilized. An additional problem is that historical data sometimes needs to be mapped at a different scale from modern data, due to the inaccuracy of old data.

*Other Software*

Within the region, Microsoft Access software is being utilized in India to develop an interactive and user-friendly key for the identification of 50 species of mangroves. The next stage will include a key for up to 650 species. A mapping system of thematic layers (species diversity, richness, etc) is also being developed in India to determine high priority conservation areas. An identification program for 3900 bony fish species is being developed in the National Science Museum, Japan, and will be available on web around the end of 2002.

# Appendix 2. Existing networks, initiatives and key partnerships in the Asian region relevant to the GTI[13]

## Global networks and initiatives

| Name | Acronym | URL |
|---|---|---|
| Asia and Pacific Plant Protection Commission | APPPC | http://www.eppo.org/WORLDWIDE/RPPOs/apppc.html |
| Biological Collection Access Service for Europe | BioCASE | http://www.biocase.org/ |
| BioNET-INTERNATIONAL: the Global Network for Taxonomy | | http://www.bionet-intl.org |
| Botanic Gardens Conservation International | BGCI | http://www.bgci.org.uk/ |
| Clearing House Mechanism of the CBD | CHM | http://www.biodiv.org/chm/default.aspx |
| Convention on Biological Diversity | CBD | http://www.biodiv.org |
| DIVERSITAS | | http://www.icsu.org/diversitas/ |
| Expert Center for Taxonomic Identification | ETI | http://www.eti.uva.nl/ |
| FishBase | | http://www.fishbase.org |
| Global Biodiversity Information Facility | GBIF | http://www.gbif.org |
| Global Invasive Species Programme | GISP | http://jasper.stanford.edu/gisp/home.htm |
| International Association of Botanical Gardens | IABG | http://www.rbgkew.org.uk/bgci/iabg.htm |
| International Biodiversity Observation Year | IBOY | http://www.nrel.colostate.edu/IBOY |
| International Organization for Plant Information | IOPI | http://www.iopi.org |
| International Plant Protection Convention | IPPC | http://www.ippc.int/IPP/En/default.htm |
| International Pollinators Initiative | IPI | http//:www.biodiv.org/decisions – see decision VI/5 on Agricultural Biological Diversity |
| International Working Group on Taxonomic Databases | TDWG | http://www.tdwg.org/ |
| International Union for the Conservation of Nature | IUCN | www.iucn.org/themes/SSC/whats_new.htm |
| Microbial Resource Centre | MIRCEN | http://www.unesco.org/science/life/mircen_network.html |
| Millennium Ecosystem Assessment | MEA | http://www.millenniumassessment.org/en/ |
| Ocean Biogeographic Information System | OBIS | http://www.marine.rutgers.edu/obis |
| The Species Analyst | | http://tsadev.speciesanalyst.net/ |
| Species 2000 | | http://www.sp2000.org |

[13] The lists presented here are not exhaustive, but was derived from the knowledge of the workshop participants; other initiatives and institutions are encouraged to communicate with J. Shimura at junko@nies.go.jp to ensure their addition to the list available to the region.

| Name | Acronym | URL |
|---|---|---|
| UNESCO'S Man and the Biosphere Programme | UNESCO-MAB | http://www.unesco.org/mab/ |

## Regional networks and initiatives

| Name | Acronym | URL |
|---|---|---|
| Asian network for ants | ANeT | www.geocities.com/anet_diwpa/ |
| ASEAN Regional Center for Biodiversity Conservation | ARCBC | www.arcbc.org.ph |
| ASEAN Taxonomic Network (LOOP of BioNET-INTERNATIONAL comprising 10 ASEAN countries, with E. Timor to come) | ASEANET | www.mardi.my/aseanet |
| Asian Network of Microbial Resources | ANMR | |
| Biodiversity Information Sharing Service | BISS | http://arcbc.org.ph/new.biss.htm |
| Australian DIWPA | | http://ecology.kyoto-u.ac.jp/~gaku |
| Crustacea Net – (Web-based system of interactive keys and information about world Crustacea – coordinated by Australian DIWPA (cv)) | | http://www.crustacea.net |
| Department of Agriculture, Fisheries and Forestry, Australia | AFFA | http://www.affa.gov.au/index.cfm |
| DIVERSITAS in the Western Pacific | DIWPA | http://diwpa.ecology.kyoto-u.ac.jp/index.html |
| East Asian Taxonomic Network (Loop of BioNET-INTERNATIONAL comprising China, Japan, Mongolia, N and S Korea) | EASIANET | http://easianet.ecoport.org |
| East Asian Network for Taxonomy and Biodiversity Coordinated from S Korea | EANeTBC | |
| Expert Center for Taxonomic Identification | ETI | www.eti.uva.nl/database/WTD.html |
| International Association of Botanical Gardens Asia Division | IABG | www.rbgkew.org.uk/bgci/iabg.htm |
| IUCN/SSC Specialist Groups (e.g. South Asian Invertebrates, Invasive Species) | | www.iucn.org/themes/ssc/whats-new.htm |

| Name | Acronym | URL |
|---|---|---|
| Microbial Resource Centre (Bangkok) | MIRCEN | http://wdcm.nig.ac.jp/CCINFO/CCINFO.xml?383 |
| MykoWeb — linkages to other mycological sites – does not cover this region very well | | http://www.mykoweb.org |
| National Geography of Inshore Areas | NaGISA | yshira@seto.kyoto-u.ac.jp or kawai@kobe-u.ac.jp |
| Pacific Basin Information Forum (just starting) | | http://www.pbin.nbii.gov |
| Pacific Northwest Information Node | | http://www.pnwin.nbii.gov |
| Pacific Taxonomic Network (Loop of BioNET INTERNATIONAL) | PACINET | |
| Plant Resources of South East Asia | PROSEA | http://www.prosea.nl/ |
| South Asian Taxonomic network (LOOP of BioNET-INTERNATIONAL under development) | SACNET | |
| SE Asian Botanical Collections Information Network | SEABCIN | http://storage.plants.ox.ac.uk/brahms/projects/seabcin.html |
| SE Asian Biodiversity Information Network | SEABIN | |
| Species 2000 Asia Oceania | | www-sp2000ao.nies.go.jp |
| Website of SE Asian Biodiversity | | sea.nus.edu.sg/organisations/museums/index.ht |

## Projects with regional or international input

| Name | URL |
|---|---|
| Flora of China | http://www.flora.huh.harvard.edu/china/ |
| Flora Malesiana | http://ww.nhncml.leidenuniv.nl/pubs/index.htm#fmal |
| Flora of Ceylon | http://www.infolanka.com/flora/ |
| Flora of Taiwan | http://www.pnh.com.ph/ |
| Flora of Philippines | |
| Flora of Thailand | http://www.forest.go.th/Botany/Flora/Treated_flora.htm |
| Pacific–Asia Biodiversity Transect (PABITRA ) (parallel to DIWPA – IBOY project) | http://www.botany.hawaii.edu/pabitra |
| JSPS Biodiversity studies in coastal waters of E and SE Asia (Japanese Society for the Promotion of Science) | |
| GTI pilot project in Asia (Global Environmental Research Fund, Ministry of Environment, Japan) | http://www-gti.nies.go.jp |

## National networks, bodies and reference centres

| Country / Economy | Institute | Acronym | URL |
|---|---|---|---|
| Bangladesh | Biodiversity Research Group of Bangladesh | BRGB | |
| Bangladesh | Culture collection at Institute of Food and Nutrition, University of Dhaka | | |
| Bangladesh | Herbarium | BNH | |
| Bangladesh | Herbarium | BRRI | |
| Bangladesh | Herbarium | BARI | |
| Bangladesh | ICDDRB, Dhaka, (Culture collection) | ICDDRB | |
| Bangladesh | National Botanical Garden, Dhaka | | |
| Bangladesh | National Herbarium | | |
| Bangladesh | National Museum | | |
| China | Chinese Biodiversity Information System | CBIS | |
| China | Department of Ecology and Biodiversity, University of Hong Kong | | |
| China | Institute of Zoology, Chinese Academy of Sciences, Beijing | | |
| Indonesia | Herbarium Bogoriense | | |
| Indonesia | Indonesia National Biodiversity Information Network | NBIN | |
| Indonesia | Museum Zoologicum Bogoriense | | |
| Japan | Biodiversity Center of Japan | | http://www.biodic.go.jp/index_e.htm |
| Japan | National Institute for Environmental Studies | | http://www-gti.nies.go.jp |
| Malaysia | Ministry of Science, Technology and the Environment | MOSTE | http://www.moste.gov.my |
| Malaysia | National Oceanography Directorate | NOD | http://www.moste.gov.my/kstas/nod/default.htm |
| Malaysia | Quarantine Center, Ministry of Agriculture | | |
| Taiwan | Taiwan Biodiversity Information Facility (includes databases to local experts; species checklist; organism database; literature database) | TaiBIF | http://gbif.sinica.edu.tw |

| Country / Economy | Institute | Acronym | URL |
|---|---|---|---|
| Thailand | National Biological Control Research Center | | |

## Useful on-line databases etc

| Name / contents | Comments | URL |
|---|---|---|
| GTI National Focal Points | | http://www.biodiv.org/world/parties.asp |
| CBD National Focal Points | | http://www.biodiv.org/world/parties.asp |
| CBD SBSTTA Focal Points | | http://www.biodiv.org/world/parties.asp |
| Chinese Institute of Zoology | Databases included: Taxonomic codes to the Chinese fauna; Species inventory database of Chinese animals; Endangered and protected species database of Chinese animals; Chinese biodiversity references; Experts; Medicinal animals in China; Chinese biodiversity database index; Fauna Sinica; Zoological journals published in China | http://www.ioz.ac.cn |
| Institute of Crop Germplasm Resources, China | | http://icgr.caas.net.cn |
| | | http://sdinfo.forestry.ac.cn |
| | | http://sdinfo.coi.gov.cn |
| Institute of Mycology, CAS | | http://www.im.ac.cn |
| | | http://www.biodiv.org.cn |

## Systematic Societies in Asia

| Country/ Economy | Societies | Comments |
|---|---|---|
| Bangladesh | yes | Biodiversity Research Group of Bangladesh (BRGB) |
| Bhutan | not known | |
| Cambodia | not known | |
| China | yes | taxonomists listed on Web |
| East Timor | not known | |
| Hong Kong | no | |
| India | yes | informal, just started |
| Indonesia | yes | some taxonomists listed on Web |

| Country/ Economy | Societies | Comments |
|---|---|---|
| Japan | yes | Union of Japanese Societies for Systematic Biology just established; some taxonomists listed on Web<br>Union of Japanese Societies for Natural History also covers the societies for taxonomy |
| Laos | not known | |
| Malaysia | yes | just started |
| Mongolia | not known | |
| Myanmar | not known | |
| North Korea | not known | |
| Pakistan | not known | |
| Papua New Guinea | not known | |
| Philippines | yes | Association of Systematic Biologists of the Philippines established in 1982 |
| Singapore | not known | |
| Republic of Korea | yes | |
| Sri Lanka | not known | |
| Taiwan | Yes | taxonomists listed on Web |
| Thailand | no (needed) | some taxonomists listed on Web |
| Vietnam | No | |

# Appendix 3. Implementation of the Global Taxonomy Programme of Work in Asia

This preliminary Programme of Work to implement the GTI in the Asian region was developed by the workshop. It is presented under the headings used in the Programme of Work of the GTI as adopted by the CBD COP[14]. Where possible the core needs, in so far as they are known, are briefly discussed, some national and regional actions proposed, key partnerships identified, and both short-term and long-term activities given. Very little detail is given in Operational Objectives 4 and 5, since much of the identification of issues there must come from people working in the conservation, sustainable use and access and benefit sharing areas. However, some access and benefit-sharing issues are covered, and there is a treatment of some issues concerned with Invasive Alien Species. In many cases the actors to carry out the recommendations have not been identified, and it is for the wider taxonomic community in the region to work to implement the programme. This is only a first attempt at the process of producing a Regional Programme of Work, and wider consultation including experts from other sectors may lead to its further development.

**GTI Operational Objective 1 – Assess taxonomic needs and capacities at national, regional and global levels for the implementation of the Convention.**

*Planned Activities 1 and 2: Country-based and Regional taxonomic needs assessments and identification of priorities.*

Whilst these are separate 'planned activities' in the GTI programme of work, the needs are strongly bound together in the Asian region, and to avoid duplication the two are considered together.

1. <u>Core needs</u>

In order to identify the requirements for taxonomic information, skills and infrastructure for full implementation of the CBD, a needs assessment is required. Ideally this should be undertaken both at country level and at the regional level. Such an assessment does not deal in taxonomic resources in isolation, but in terms of user needs for the implementation of the Convention.

2. <u>National and regional actions</u>

Delegates should establish with their GTI National Focal Point or CBD National Focal Point whether or not taxonomic needs assessments have been carried out. If not, steps should be taken to obtain funding for one. The national reports provided by participants at this workshop will be of great assistance in preparing final country assessments.

On the regional level, the initial survey reported here should be extended to be complete and comprehensive (although the report summary presented above already makes it clear that some initial activities are required). In compiling the regional needs assessment use should be made of the national assessments as they become available, and of the preliminary national data presented here. Two other recent reports, compiled by ASEANET and AFFA Australia should also be drawn upon: "Needs assessment in taxonomy of arthropod pests of plants in countries of South East Asia:

[14] http://www.biodiv.org/decisions (go to decision VI/8)

Biosystematics, Collection and Information Management"[15] and "Needs assessment in taxonomy and biosystematics for plant pathogenic organisms in countries of South East Asia"[16].

One of the important components of both national and regional needs assessments will be to make contact with initiatives actively dealing with biodiversity issues at these levels, both from the point of view of identifying needs to be met through development of taxonomic resources and with a view to forging partnerships to meet the needs identified.

The opportunity afforded by the needs assessments to forge contacts across sectors, and between taxonomists, other biologists, environmental managers, and Focal Points, should be built upon to encourage further collaboration and to assist the Focal Points in their task of reporting on action in their countries.

3. Key partnerships

National Focal Points for the GTI, CBD, GEF, UNEP and UNDP; government Departments charged with implementing the CBD; regional and sub-regional taxonomic networks, including ASEANET and EASIANET; national, regional and global bodies concerned with aspects of convention implementation. (see Appendix 2)

4. Short-term activities

a) The questionnaire on taxonomic capacities and needs circulated prior to the workshop to be extended and analysed. Delegates were requested to return extra questionnaires to Dr Shimura (by 1st December 2002) for analysis and presentation to SBSTTA 8 in March 2003.
b) The results of the questionnaire at the time of the workshop to be put on the workshop web site. Given that some taxonomists lack internet access, copies should be sent to all delegates here to distribute in their own areas. This element was to be completed within 6 months of the workshop.
c) A directory of the major national and international initiatives and organisations dealing with biodiversity in the region to be assembled, building on the data presented here in Appendix 2. The information to be collected will include institutional names (and acronyms), institutional remit, and contact details.
d) Delegates to contact their national CBD / GTI Focal Points and discuss the GTI and the need for taxonomic needs assessments.
e) In the design of the assessments, very particular note should be made of the users of collections. Their needs have to be ascertained, and new innovative uses for collections and their data identified if necessary to meet them.

*Planned Activity 4: Public Awareness and Education*

1. Core needs

The public image of taxonomy is extremely important. The fact that taxonomy underpins the conservation, sustainable use and IPR issues of biodiversity, as well as other areas of research such as biotechnology, is not widely appreciated. In contrast, taxonomy has a relatively poor image in the area when compared to these other activities, despite its important role in those subjects. There is an

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[15] I.D. Naumann & M.Md. Jusoh, 2002, produced by ASEANET and Agriculture, Fisheries and Forestry – Australia (AFFA).
[16] Graeme Evans, Keng Yeang Lum & Leanne Murdoch, 2002, produced by ASEANET and Agriculture, Fisheries and Forestry – Australia (AFFA).

urgent need for taxonomists to interact more with a wide range of stakeholders, including government, decision-makers, environmental managers, conservationists, students and educational establishments, the general public and the media to ensure understanding and support for taxonomy as a basic activity. The Global Taxonomy Initiative itself is generally poorly understood, and its significance in terms of action under the CBD needs to be explained to the appropriate sectors, including other CBD-related initiatives. This latter issue is also addressed below under Planned Activities 5 and 6.

2. National and regional actions

Most of the activities listed below need to be undertaken by individual taxonomists or taxonomic and related institutions. Some activities are appropriate to be undertaken at the national or regional level by, *inter alia*, GTI National Focal Points and regional networks and initiatives.

3. Key partnerships

GTI National Focal Points, Regional networks, EASIANET, ASEANET, ANeT, UNESCO, GISP and other regional networks and initiatives.

4. Short-term activities

Contact to be made by participants with delegates to the regional workshop of Global Invasive Species Programme (GISP) held recently in Bangkok to discuss joint issues, significance of taxonomic expertise and information and possible collaborative projects (q.v.).

The long-term strategies laid out below in all cases do not need a lead time to implement, and delegates from the workshop, and other taxonomists, should take the initiative to make the appropriate contacts and highlight the significance of taxonomy to implementation of the CBD, the rationale for the GTI, and the issues for the region arising because of the taxonomic impediment.

5. Long-term strategies

a) Value of taxonomy to other biologists, conservationists etc
   - All taxonomists within the region, or working with the biota of the region, must take a more active and sustained PR role as individuals, and make themselves known to people and other biodiversity-based projects who need, whether knowingly or unknowingly, access to taxonomic expertise (including those who have funding to support taxonomic activities).
   - Taxonomists should take steps to develop appropriate contacts and target their work to ensure they are involved in the project design stage of other biodiversity projects, and not just brought in during subsequent phases to identify specimens.
   - Community awareness / education packages on taxonomy should be developed and disseminated.
b) Disseminating information about the Global Taxonomy Initiative.
   - Delegates at this workshop will know more about GTI than anyone else in each country/economy, so need to be active in local CBD implementation to make each government's job easier. They should immediately contact appropriate government officers in their countries, and workers in appropriate sectors.
   - Information should be placed on relevant Web pages explaining the importance and attractions of taxonomy. Delegates both individually and through their home institutions and society memberships etc. could create and maintain these.
   - Employ a communicator for ca.2 years to package the GTI message on taxonomy in a reader-suited language. The body to carry this out has not been identified.
   - Brochures and posters on the GTI programme of work to be made available to a wider audience, especially in zoos and botanic gardens. The GTI Programme Officer of the SCBD

to make literature available on request; GTI Focal Points to be contacted by delegates to supply SCBD with needs.

c) Publicising the taxonomic impediment as it applies to Asia
   - Publicise the point that taxonomists are aging and few of the younger generation are going into the field of taxonomy, so that action can be taken locally to provide career opportunities to young taxonomists. This can be undertaken by delegates at workshop and taxonomic institutes.
   - Relay the message regarding the taxonomic impediment to the National Academy of Sciences of each country, and to scientific societies, so that they lobby relevant decision-makers. This to be the initial responsibility of delegates at workshop and taxonomic institutes.
   - Funding on the longer term may be available from UNESCO and environment-friendly businesses.

**GTI Operational objective 2 – Provide focus to help build and maintain the systems and infrastructure needed to obtain, collate and curate the biological specimens that are the basis for taxonomic knowledge.**

*Planned activities 5 and 6. Global and regional capacity-building to support access to and generation of taxonomic resources, and strengthening of existing networks for regional cooperation in taxonomy.*

Capacity building needs identified by the workshop were, in many cases, appropriately dealt with through existing networks on a regional or sub-regional basis. The two planned activities of the GTI programme of work are most appropriately covered together. There are numerous examples of regional cooperation and of regional projects in Asia, many of which are very active and contributing towards regional needs. These range from regional networks (e.g. for sharing data, or for providing funds for small projects) to projects documenting the diversity of flora and fauna on a regional basis. In some of these projects, the collaborations are conducted through country-to-country initiatives. One key point is that personal contacts between researchers are important and often much collaboration can be achieved through such contacts.

1. <u>Core needs</u>

For convenience, the many needs identified by the workshop, and through the country reports are summarised below under the headings 'Collections and collection management', 'Communication', 'Human resources', 'Funding', 'Identifications and names', 'Information', 'Infrastructure', 'Long-term sustainability' and 'Technology transfer'. In general, interactions between institutions and countries across the region, especially in terms of joint research and collecting, and exchange of specimens, need to be simplified.

*<u>Collections and collection management</u>*

Taxonomic work in support of the CBD cannot continue and be developed without the taxonomists having access to functioning collections, these being an essential tool to support activities. The following needs were identified:

a) National reference centres within each of the countries in the Region (as noted in CBD COP decision V/9 paragraph 2c).
b) Local taxonomic centres, at least initially.
c) Maintenance of microbial cultures (like other collections) is expensive and there is a strong need for funding to maintain such facilities. One possibility is to develop a regional culture collection (e.g. in Japan, and/or MIRCEN in Thailand, in the case of microbiology). Regional repositories or reference centres may also be appropriate for some other taxa.

d) Increased support for conservation of specimens, (noted particularly with respect of herbarium collections and marine collections), the issues being collection housing (cabinets etc) and chemical treatments;
e) Provision for dealing with 'orphan' collections (i.e. those without associated specialists or specialist knowledge) in all countries.
f) Increased space to store adequate material ('virtual' museums may sometimes be an appropriate solution).
g) Increased core funding for curatorial staff, to ensure the maintenance and development of the collections.
h) Increased availability of collection management handbooks.
i) Demonstration to funders that there is a value for comprehensive collections to enable and support work focussed on priority areas (see also education and awareness-raising).
j) A DNA directory for microbes.

*Communication*

a) Many taxonomists in the region are unaware of international activities such as BioNET INTERNATIONAL and DIWPA. There is generally poor communication between CBD COP and CBD SBSTTA delegates and scientists concerning CBD/GTI issues involving the taxonomic community. The taxonomic community itself needs to be made more aware of issues identified in the Convention process. Because of these communication difficulties individuals and institutions are missing possibilities of participating in projects, opportunities of funding, and informing their national representatives of convention-related taxonomic needs. Similarly, the same national representatives are hindered in their work of gathering information within their countries, and ensuring they are as effective as possible in ensuring CBD implementation.

b) There is a need to improve communication between taxonomists in the region; there is limited use of existing networks – personal communication is important. There is also poor electronic access for communication and information-gathering and dissemination.

c) To facilitate communication, and support strengthening of links and network development, information on the existing expertise, institutions, collections and courses available within the region, or relevant to the region, is required.

*Funding information and needs*

Funding is in general is inadequate to support long-term salaried scientists, technicians, and materials. This was noted as especially so in Malaysia, Indonesia, and Philippines for microbial taxonomy. In Thailand the need for competent taxonomists and database people was recognised. It was noted that the existence of the CBD process helps in the justification for funding for appropriate projects and capacity. However, there is still reluctance among some funding bodies to fund any taxonomic projects, especially in micro-organisms.

An issue raised was the ability to apply for funding and knowledge of the donors and their requirements. In general, individual scientists apply for funding, and their parent institutes seem not to have individuals trained or with the responsibility of preparing proposals and with appropriate knowledge of donors. Some institutions do, however, employ consultant to write proposals.

*Human resources*

a) The demography of staff is inappropriate to the growing needs for taxonomic expertise, with an aging population of taxonomists and too few younger researchers, technicians and curators.
b) There is inadequate staffing, in terms of total numbers of full-time taxonomists and support staff.
c) The knowledge base in the region is patchy, notably including a poor coverage of many taxonomic groups, especially lower organisms such as lichens, fungi, protozoa, microalgae, and bacteria.
d) There is a requirement to address declining interest on conventional (morphological) taxonomy against molecular taxonomy, whilst ensuring that molecular techniques and expertise is available.

e) Career and job opportunities in taxonomy are insufficient to meet the needs of the CBD, and should be expanded.
f) Often Asian taxonomists do not publish enough due to lack of training or confidence in their work.
g) Training is needed to enhance skills of existing staff.
h) Insufficient numbers of young students are taking up taxonomy.
i) There is a shortage of teachers of specialist taxonomy.
j) Regional training courses are needed (e.g., the courses organised by Bogor), as well as others (e.g. national, institutional, university-based, out of country etc). Recipients of such training should include young taxonomists and parataxonomists, and coverage will include collection management techniques and use of selected databases (e.g. BRAHMS), perhaps with standardisation of the software at the regional level.

*Identification and names*

Whilst there is a clear intention and need to develop capacity within the region, there will always be a need to obtain identifications of organisms outside countries and the region. This will be both in terms of meeting problems as they arise, and also developing the reference capacity of collections held within the region. Issues raised in connection with this were:

a) Restricted access to collections held outside the countries of origin, and a concomitant need for repatriation of data, including data associated with type specimens;
b) Simplified access to type material, including through images made available on the web;
c) Free access to types and type strains (microbiology) for all taxonomists;
d) Provision of authoritatively identified specimens, with up to date nomenclature;
e) Prepared but unsorted specimens need to be identified (a partial possible solution was identified with the suggestion of taking digital images and sending them to specialists);
f) Development of protocols for the treatment of raw samples of groups not under study in mass collection projects. Issues include:
    - Legal restrictions preventing specimens to be sent to other countries without permission;
    - Expense of sending specimens abroad;
    - Balancing the costs of storage of material against other collection needs;
    - Dislike of discarding collected material among collection managers and researchers a.

    Some possible solutions were suggested, and concomitant requirements:
    - Information from other countries on what might be exchanged with whom – 'market research' is needed;
    - 'Advertising' holdings to encourage visitors to work on material, with a need to database mass unsorted collections;
    - Global database of specialists. This is being developed in the region by ASEANET, EASIANET and Japan. Globally the ETI list of taxonomists is intended to meet this need, although notably no non-European members of the working group had registered themselves on this database. Internet access was identified as an issue in this regard.
g) Permission to collect specimens in some countries, leading to problems in research. (see further under 'Access and benefit-sharing' below)
h) Cost of obtaining identifications from some institutions.
i) More publications at all levels of knowledge: from specialist taxonomic publications to field guides, CD-ROMs, general information on-line, etc. Publications should cover marine areas as well as terrestrial.

*Information requirements*

Many libraries within the region are insufficient; there is a restricted access to taxonomic literature, both old and recent. There is consequently a need for more literature, including in digitised format. The hight cost of journals is a limiting factor, and the poor availability of computers and internet access in some areas also hinders access to digitised data.

*Infrastructure*

a) Overall the infrastructure is inadequate (including aging buildings and equipment).
b) There are inadequate facilities in most cases for collection storage and taxonomic research.
c) In many cases access to computers and the internet is inadequate.

*Long-term sustainability*

a) There is a need for sustainability of taxonomic institutions (cf COP IV/1.D, para 11.a)
b) There is also a need for long-term planning e.g. predicting storage needs arising from increasing collection size. For example, Bogor has a long-term programme; CAS have long-term funding for training. Some other institutes do not have long-term planning.

*Technology transfer*

a) Equipment for special fields, for example molecular studies, is needed, especially to allow microbiologists to gain the data locally needed for them to publish species descriptions in international journals.
b) More IT support and internet access is needed across the region.

2. National and regional actions

Taxonomists are encouraged to participate in projects locally and regionally. One mechanism to ensure this is to provide appropriate funding, training and career-path development. Graduate and postgraduate students should be more involved in taxonomic research, noting that this is usually contingent on professorial grants, although perhaps industry scholarships are possible.

3. Key partnerships

BioNET-INTERNATIONAL; ASEANET; EASIANET; SACNET; Species 2000 Asia Oceania; the ASEAN Regional Center for Biodiversity Conservation (ARCBC); the South-East Asian Biodiversity Information Network (SEABIN); convention mechanisms (e.g. CITES); existing scientific societies, systematic associations, and organizations such as World Federation of Culture Collections.

4. Short-term activities

An international (regional) committee should be formed, including national GTI or CBD focal points, to organize training, establish standards for data collection, and coordinate training workshops for sectoral issues, starting with quarantine and agriculture. Regional collaboration is needed to ensure adequate specimens/cultures are available for easy identification and for further taxonomic research in these groups.

*Collections and Collection management*

a) Improve physical conditions for collections. For selected small to medium collections, establish improved collection conditions (simple and cheap methods for improving collection security) and use as pilot for others.
b) In discussions with government departments raise collection-related obligations under the CBD as stated in COP decisions.
c) List regional collection resources on the Web, using existing Websites, e.g. Bishop Museum in Hawaii. The following to be created, among others:
    - directories of relevant types and type photographs, species and specimen databases;
    - Collections at oversight level (i.e. by higher taxonomic grouping);
    - collections held in detail [for some ASEAN countries and Leiden (plants), this is being done under SE Asian Botanical Collections Information Network];
    - URLs of available country maps (with scale) and gazetteers in region (1:100,000 appropriate for regional studies). (N.B. Indonesia plans to release their collection management and mapping programs to other countries in the region at the end of this year.

As soon as possible thereafter, a training course for taxonomists in this region to learn to how to use these programs would be of significant value.)

d) Improve arrangements for specimen transfer and living culture transfer and make information available. Establish loans policy and system.

e) Develop parataxonomists to increase collections.

*Communication and networking*

a) A regional society of systematic biologists should be set up, with an Asian–Pacific coverage and national representatives. Its roles will include linking national societies (e.g. the Biodiversity Research Group of Bangladesh, the Association of Systematic Biologists of the Philippines, national mycological societies etc.). Associations of Biologists in the Pacific region could be approached with a view to an alliance. Key personnel to set this in motion have not yet been identified.

b) Links within and between regional networks and other initiatives and their coordinators should be strengthened, and their national and regional coordinators are urged to take steps to ensure this happens.

c) National societies should become more actively involved in GTI, etc. Such societies should contact the National GTI or CBD focal points of each country to make them aware of their existence and potential involvement, and to offer partnership in implementation of the GTI. Delegates at the workshop should contact presidents/chairs of their societies, urging them to make contact with GTI / CBD national focal points.

d) Directories for the region covering a number of aspects of work should be produced and made available. The data will be made available via a web site (although other means of communication are needed as well), initially using the GTI server at NIES. Although some of these data can be collected and made available in the short term, the project will require funding (est. 3 million yen p.a.) if it includes on-line forms for adding entries to directories (for setting up forms and maintaining them), and for maintenance. In addition to the Japanese web site, other initiatives and individuals offered their assistance, as indicated below. Directories will include:

- Software for taxonomic projects, especially free programs for species and specimen databases, mapping, identification keys. Indonesia plans to release their collection management and mapping programs to other countries in the region at the end of this year. As soon as possible thereafter, a training course for taxonomists in this region to learn to how to use these programs would be of significant value.
- Centres of expertise in the region, including information on the institution, address, email address and areas of expertise. A directory was planned to be completed in three months, and hosted by ASEANET. The project was to be coordinated by Dr L. Cardenas with the GTI national Focal Points, and the ASEANET National Coordinator for Thailand.
- Major national and international initiatives and organisations dealing with biodiversity in the region (see Appendix 2).
- Taxonomists, following the format of the World Taxonomists Database (www.eti.uva.nl), which includes name, institution address, email address, specific fields or major taxa of interest. Participants at the workshop were asked to send particulars within three days of returning home. ASEANET offered to put information on its Webpage within three weeks, with the aim of producing a comprehensive list in two months. Other main actors will include EASIANET, SACNET, the Japanese national GTI Focal Point and Species 2000 Asia Oceania. Coordinators responsible for the various taxonomic groups were identified: Plants – Dr Ruth Kiew of Botany Asia Network; Fungi – Dr Kevin Hyde; Vertebrates – Dr Keiichi Matsuura; Invertebrates – Dr Jambari; Insects – Dr Christoph Haeuser; Bacteria – Dr Junko Shimura; Micro-algae – Dr Phang.
- Courses or attachment/fellowships offered within the region by centres of expertise, etc. The information needed includes: courses offered, web page, description, fee, length of course, date of offering, language used, qualifications required by participants. Data were required in three months, with the prime actors being NIES, ASEANET and EASIANET.

- Web list of available country maps (with scale) and gazetteers in region (1:100,000 appropriate for regional studies).
- List of identification guides.
- National workshops/training courses in collection database management (particularly important where no national systematic societies are present).

e) E-mail listservers to facilitate contact between specialists with the same field of interest should be set up, either by specialist networks and research partnerships, via existing networks, or by individual specialists. GTI regional workshop participants and specialists of nemerteans are listed on the listserv of Species 2000 Asia Oceania. The address is gtiao@sp2000ao.nies.go.jp and nemertes@sp2000ao.nies.go.jp, respectively. To subscribe to them contact junko@nies.go.jp.

f) Network of microbial culture collections and living collections.
Bacteria, fungi, micro-organisms, germplasm, micro-algae and macro-algae all require similar storage. A network should be developed of people who are currently working in isolation: value-adding, help each other build capacity, develop a directory, help to identify and fill gaps, standardize diagnostic techniques, emphasis on biodiversity. At present there are different objectives in different organizations, some have industrial applications. In the UK, such a network was formed, which led to a benefit in marketing and efficiencies of scale.

*Identification resources*

a) Compile a list of identification guides available on Web.
b) Diagnostic Networks – based on tools being used to identify taxa, should be investigated.
c) Regional cooperation to name particular groups/identify unsorted collections.
d) Develop global networks for taxa needed to make contacts and aid identification.

*Human resources: training*

a) Regional and national workshops/training programs in, e.g., taxonomy of certain groups, database management, collection management (particularly important where no national systematic societies are present).
b) A directory of courses or attachment/fellowships offered within the region by centres of expertise, etc. would be of value in identifying training opportunities.
c) Universities should be encouraged to enhance taxonomic training.

5. Long-term strategies

a) Institutions to develop long-term strategies, including
   - a marketing strategy, promoting the understanding of the importance of taxonomy, using the example of Bogor, and the 1995 UNEP document 'Global Biodiversity Assessment';
   - a business plan, identifying how they can make an income from collections, e.g. private sector funding; taxonomic ecotourism (e.g. guide books for tourists; brochure for national parks).
b) Community participation should be encouraged.
c) Stakeholder meetings should be held to identify user needs and how to meet them (as in the recent SABONET meeting)
d) Establishment of a research associate system for institutions and networks.
e) Develop a Microbial Culture Collection Network, noting that microbial taxonomy is of relevance to all thematic areas and cross-cutting issues of the CBD. Indications of the regional capacity pertaining to human resources and infrastructure are given elsewhere in the report.
   - Coordination mechanism – Build on the experience of the past five years of the Asian Network on Microbial Research. Japanese funding for this has concluded but the network is still virtual; its activities involved specimens and bioinformation.
   - Important to show the benefits (e.g. multiple uses) of long-term collections. Note the relative values of ex-situ collections rather than in situ conservation and the necessity to maintain culture to enable correct identification of material collected from the natural environment in the future.

- Participation – Build on the track record of the ANMR. Involve the National Biological Resources Center as a possible leader. MIRCEN could act as a regional centre but needs additional support.
- Funding. Possibly, *Inter alia* GEF. Need to specify the benefits to business of being involved in funding.
- Timing. Resurrection of the ANMR should be achievable quite quickly, given that it is virtual, but must conform to the Japanese fiscal year in terms of crafting a proposal. Plan to have meetings with all stakeholders, including scientists and industry.

**Operational Objective 3 – Facilitate an improved and effective infrastructure/system for access to taxonomic information; with priority on ensuring that countries of origin gain access to information concerning elements of their biodiversity**

*Planned Activity 7. Develop a coordinated global taxonomy information system*

1. Core needs

Mechanisms need to be developed to share information at the local level, and make data from the major herbaria or museums more easily available. Such information includes literature, species information, specimen data and checklists for taxa. The latter information will assist in the preparation of national and regional checklists. Where possible material in non-English literature needs to be translated to English. Issues of maintaining data in perpetuity, and of data-sharing (noting the need to maintain ownership or IPR) need to be addressed. There are issues of standards for data exchange /sharing. These are being addressed by various groups, e.g. the taxonomic data working group (TDWG), and regional involvement in these needs to be at an appropriate level.

Although much of the discussion below is centred on electronic resources, printed resources are also important. Needs regarding conventionally published information have been mentioned above.

2. National and regional actions

Software will soon make it easy to link individual institutes' databases, obviating the need to centralise data. In this context interoperability of different database systems is important for sharing data. The issues is being addressed by various IT research groups, e.g. Species 2000, Species 2000 Asia Oceania, The Species Analyst, EU projects (W. Berendsohn et al.), and links between institutes and networks in the regions and these initiatives should be developed and maintained.

3. Key partnerships

Species 2000, Species 2000 Asia Oceania, The Species Analyst, BioCASE, GBIF, TDWG. FishBase (www.fishbase.org), SEABCIN.

4. Short-term activities

a) Existing databases of specimen data and checklists for taxa should all be made accessible on-line.
b) A list of local and regional databases on websites should be compiled and made accessible on-line (with a hard copy list in the near future).
c) Data-sharing and the use of the Web are important for future communication in Asia. Initiatives, institutes and researchers should make contact with appropriate data-sharing initiatives and seek to participate in their activities (e.g. GBIF, OBIS, Species 2000 and Species 2000 Asia Oceania, FishBase, SEABCIN). GBIF could facilitate such participation by:
   - providing arguments for national benefits, especially to governments, noting the immediate benefits for scientific community, that obligations for sharing data are free of risk (the provider retains control), and giving examples for overall benefits at national level (e.g. Mexico and CONABIO)

- clarifying the required establishment of Participant 'Nodes' in GBIF (one node as a minimum requirement, with no implication for centralisation at national (or regional) level)
- supplying a 'toolkit' to interested local institutions / individuals in non-participating countries.
- Participation in forthcoming "Joint International Forum on Biodiversity Information: Building Capacity in Asia and Oceania" in Tsukuba, Japan (October 2003). This will be held in conjunction with GBIF (http://www-gti.nies.go.jp/forum2003/).

5. Long-term strategies

a) A project to compile and coordinate a database of type specimen information for local taxa to be set up, possibly in association with GBIF.
b) A project to compile regional inventories (checklists, floras and faunas) to be set up.
c) Initiatives and institutes in the region should work with GBIF work programs in the following areas:
    a. Electronic Catalogue of Names of Known Organisms [ECAT]
        - Start to interlink large regional databases
        - Accommodate and retrieve local/regional checklists
        - Host orphan (local) databases
    b. Digitisation of Natural History Collection Data [DIGIT]
        - Provide access to type specimen information, esp. for local fauna/flora
        - Incorporate and remain compatible with existing db solutions (e.g., BRAHMS http://storage.plants.ox.ac.uk/brahms/, 'Platypus' http://www.ea.gov.au/biodiversity/abrs/abif/platypus/ and 'Specify')
    c. Data Access and Database Interoperability [DADI]
        - Provide open source software and (free) IT support
        - Develop/distribute tools to facilitate routine taxonomic work (compilation of checklists and catalogues, interactive identification guides, etc) eg TaxoNote
    d. Outreach and Capacity Building [OCB]
        - Facilitate Internet access
        - Allow access and develop applications in many different languages
        - Conduct local training courses
    e. Digital biodiversity literature resources
        - Provide access to old and rare taxonomic references, acting as broker for problems with copyright, IPR, legal issues.

**GTI Operational Objective 4 – Within the major thematic work programmes of the Convention include key taxonomic objectives to generate information needed for decision-making in conservation and sustainable use of biological diversity and its components**

Taxonomy is essential for the study, conservation and sustainable use of biodiversity, and for ensuring equitable access to the benefits of its genetic resources. The projects suggested below would include extensive collecting to build up correctly identified collections, checklists, keys, etc., particularly for poorly known taxa or ecosystems. For prioritising these, the group gave weight to projects that considered common and urgent concerns with social impact.

Asian ecosystems include many special communities with high levels of endemism. Among the terrestrial systems on this class, and which are most threatened, are those associated with limestone, caves, mountains, swamps, forest canopy and tree holes and phytotomata. Vegetation on ultramafic or on soils of high metal content is important, as are island ecosystems. Inland water and marine and coastal systems important to prioritise are mentioned below under the appropriate planned activities.

In the long term need ecosystem-based taxonomy projects such as limestone ecosystems, freshwater ecosystems, coastal zone ecosystems and agriculture-based ecosystems.

*Planned Activity 8. Forest biological diversity*

No specific needs were identified by the workshop under this activity, although the immense significance of the forest ecosystem within the region was emphasised. Note was taken of the importance of canopy biodiversity and the fauna and flora of tree holes.

*Planned Activity 9. Marine & coastal biological diversity*

1. Core needs

Ecosystems within this planned activity that were noted as important in terms of endemicity and threat status were small (marine) islands, deepsea vents, sea mounts and the interstitial environment.

2. Key partnerships

Within the region several projects involving Japan are under way, including a GTI Pilot Project. The Ocean Biogeographic Information System is active in the region. Other relevant projects being undertaken at present include:

- A study of a small Indonesian island (DIWPA, Kyoto University)
- Investigation of impacts on small-island biodiversity resources (USM; National Oceanography Directorate, MOSTE)
- Birds and plants on Philippine islands
- Meiofauna in seagrass beds (Thailand)
- Island-biogeography study of mosses (University of Singapore).

3. Short-term activities

Participation in forthcoming JSPS Langkawi Meeting of five countries, coordinated through the Ocean Research Institute of Tokyo University. This is a 10-year project, using an existing network of marine biologists.

5. Long-term strategies

A collaborative project on tropical small island biodiversity should be developed on a regional basis, possibly under the leadership of Indonesia as an archipelagic country.

- Rationale – small tropical islands have a range of major ecological habitats (e.g. coastal forest, mangrove, coral-reef) and are susceptible to human perturbation, including introduction of alien species. Such islands generally have high endemicity, and require taxonomic examination to provide the tools for adequate management.
- A strategy for longer-term activities has to be developed. New collecting of some taxa (e.g., birds, fish, vascular plants) may not be necessary, especially if good image libraries are built up, otherwise voucher specimens will be needed to ensure taxonomic reliability, as well as subsequent verifiability and repeatability. For new collections, the costs of labour-intensive collecting, preserving, labelling, and databasing need to be accommodated in the project.
- A coordination mechanism is required to link existing activities.
- Participants – Ecologists, taxonomists, national and regional museums and herbaria. Possible funding agencies include UNESCO Island Ecology Program, DIWPA, ISME (mangrove ecology), and International Coral Reef Institute (ICRI), etc.

*Planned Activity 10. Dry and sub-humid land biodiversity*

No priorities were identified by the meeting in this area of activities under the CBD.

*Planned Activity 11. Inland waters biodiversity*

1. Core needs

There is an urgent need to have detailed biological inventories of fresh water ecosystems in the region, since they are of vital importance as water sources and are being rapidly degraded. The region includes riparian systems, lakes and rivers and estuaries with high levels of endemism. No actions were identified in this aspect of work, but it was noted that key partnerships should be developed with RAMSAR and the Peat Swamp Project. The Penang Declaration was noted as pertinent to this topic.

*Planned Activity 12. Agricultural biodiversity*

Taxonomy is of particular importance in identification and building up reference collections for agricultural pests and diseases and in terms of biotechnology resources.

*Planned Activity 13. Mountain biodiversity*

Although the biodiversity of mountain ecosystems was identified by the workshop as being particularly important in terms of convention implementation, no particular activities or needs were identified in this area.

**GTI Operational Objective 5 – Within the work on cross-cutting issues of the Convention include key taxonomic objectives to generate information needed for decision-making in conservation and sustainable use of biological diversity and its components.**

*Planned Activity 14. Access and benefit-sharing*

1. Core needs

The issues for countries in the region regarding access and benefit-sharing matters discussed by the workshop come under two headings:

a) Issues arising from national legislation covering transboundary research and transfer of specimens between countries;
b) Issues pertaining to identification of taxa to protect stakeholders' rights to the benefits of genetic resources within the region.

Most of the discussion centred on the first issue. Addressing the second issue will involve considerable joint work across the region to clarify species identities and their distributions. The text below is focussed on transboundary issues and specimen transfer.

Species and ecosystems do not adhere to national boundaries, and therefore to be effective and avoid costly duplication much research activity must be carried out across borders. Concomitant with the partnerships established to carry out such research, specimens may be transferred between partner countries for the purposes of taxonomic study to underpin implementation of the CBD. Action is needed on the issues of gaining permission for research, collecting and loans.

2. National and regional actions and recommendations

Networks, partnerships and joint projects within the region should be backed by Memoranda of Understanding (MOUs) between the partners drawn up before joint work commences. The coverage of these should include, as appropriate:

- Agreement at government and science institutional levels, either as a blanket agreement at the national level covering any project, or at an institutional level on a project by project basis. Regulations must be in the spirit of collaboration.
- Designation of institutions to handle the MOU in each country;

- Clarity on the distinctions between bioprospecting and commercialisation on one hand and taxonomic research in support of CBD implementation on the other, to ensure prior informed consent by stakeholders;
- Issues regarding benefit sharing (including data and information, specimens, profit, Intellectual Property Rights). Prior informed consent should be sought as to any subsequent use of specimens collected under the auspices of the MOU, as recommended in the Bonn guidelines[17].
- Deposition of specimens collected. For example,
    - o Holotypes and single specimens collected during the course of a study might be deposited in the country of origin. Other specimens might be divided equally between the participants, except DNA specimens (where limited facilities are available). Where the specimens are deposited will depend on the type of specimen - plant, animal or microbe.
    - o Paratypes and isotypes should be deposited in more than one location if possible, for security in case of loss.
    - o Information and publication should be shared between the collaborating institutions.

Issues concerning permission to collect and conduct research need to be streamlined to facilitate implementation of the Global Taxonomy Initiative.

- The permit system is a sometimes a barrier and should be simplified for scientific work in support of implementing the Convention.
- A streamlined approach to obtaining permission for taxonomic research under the GTI is required. 'Competent national authorities' should have information on what permits are needed and where to get them. The 'Bonn guidelines' on Access and Benefit Sharing (paras11L, 34, 36F, 42E and 63B) give some guidance for collection and use of specimens for taxonomy, and can be consulted.
- Dialogue between taxonomists and policy-makers on the issue of permits for collecting, research, import and export should take place.

3. Short-term activities

- Collective lobbying by taxonomists to help persuade governments to develop regulations for access and benefit sharing issues that encompass the specific needs of the GTI, and do not hinder the implementation of this aspect of the CBD.
- Delegates to contact their CBD National focal point and ask for action on the notification on Access and Benefit-sharing issued by the Executive Secretary on 23 July 2001.
- Delegates to share information on permit requirements in their countries and disseminate through ASEANET, EASEINET and other regional networks.
- Delegates should refer to the Bonn guidelines_to understand their implications for taxonomic research in the region. Delegates should also refer to the information document on Access and benefit-sharing and the GTI that went to the working group that developed the Bonn Guidelines (see page 13-29 of the PDF file at http://www.biodiv.org/doc/meetings/cop/cop-06/official/cop-06-06-en.pdf).

*Planned Activity 15. Invasive Alien Species*

1. Introduction

Invasive alien species are an established problem in the area, and one that has been largely overlooked by government and taxonomists. There is a growing appreciation of the invasive species issue, which has been the subject of intense global discussion and study over the past decade. Coordination of effort across political boundaries is a promising approach to dealing with this global, multidisciplinary problem.

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17 http://www.biodiv.org/decisions (see decision VI/24)

2. Main issues

- People want lists, i.e. to be told what species to look out for, rather than to create their own lists from risk assessments; solution is possibly to pool efforts into a regional pest risk analysis.
- The baseline biodiversity data of the region is either inside the heads of experts, in collections, or in widely scattered scientific literature and not standardized or shared.
- To identify invasive alien species, a list of unwanted species is needed to guide the development of identification tools – different sorts of tools are required, depending upon the expertise of the user.
- Projects that are needed for combating invasive alien species include holding workshops to train the trainers, creating species lists and identification tools, etc.

3. Synopsis of current capacity and gaps

- Gaps exist in expertise in invertebrates and micro-organisms; flora seems "do-able".
- Policy concerns e.g. that governments promote the planting of non-natives

4. Baseline needs for maintaining and developing institutional, infrastructural and other resources

- Internet access and information sources (URLs)
- Computer hardware and technological know-how
- Hard copy compendia
- CD ROMs such as CABI compendia
- Species lists from neighbours and from own country
- Identification tools, including simplified ones for non-taxonomists
- Mechanism for telling people what is available
- At least one taxonomist in the region for each key group
- Linkages between taxonomists, specialists, and quarantine officials
- Capacity to do surveys for invasive species
- Secure reference collection, including representatives of key species

5. Regional actions

- Development of an international (regional) committee (including national focal points) to organize training, establish standards for data collection, and coordinate training workshops
  - An initial workshop for the committee might include:
    - Define policy needs
    - Examine technical capacity
    - Determine priority ecosystems and species of concern
    - Identify baseline information, pathways, vectors
    - Identify highest priority sites for survey
    - Best way of organizing information/reporting/IPPC obligations
    - Determining who should coordinate, post-workshop
- Regional coordination established through a designated national focal point, the GTI focal point or alternate.
- Scientific and cost benefits of regional activities and centres should be demonstrated:
  - By utilizing existing models of cost benefit developed outside the region.
  - Perform local biodiversity studies, including baseline studies before species arrival and contrast with invaded systems
  - Promote and publicise such studies and showcase examples.

6. Key partnerships

- Invasive species detection initiatives or surveys for invasives
  - Ecologists, parataxonomists, volunteers, NGO's, the general public, farmers, transporters, foreign horticulturalists, naturalist guides, schools

- Agencies responsible are not fully developed in many countries; this was mentioned as a possible resource that should be compiled. The growing LOOP network is a good place to start.
- Organizations, national examples:
    - National Biological Control Research Center (Thailand)
    - Quarantine Center, Ministry of Agriculture (Malaysia)
    - Organizations, regional examples:
        - AFFA
        - MAF
    - Organizations, international example:
        - Global Invasive Species Programme (GISP)
- Neighbouring developed countries and those with trade/traffic links
- Policy makers and regulators

7. Short term activities, including possible pilot projects with quick returns ('Low hanging fruit')

- Participants at the workshop should make contact with local delegates to the regional workshop of Global Invasive Species Programme (GISP) held recently in Bangkok to discuss needs and possible collaboration on invasive species.
- The development of a 'flying squad' to produce regional cooperation for survey of IAS should be considered.
- Development of a database for regional use which covers problem species, with details of how to identify them.
- Set up training workshops to determine what are the key invasive species in each country. Include an expert from each group of organisms having invasive species. The emphasis should probably be on incipient invasives, rather than established pests.
- Establish a network of focal points (GTI or designated alternate) to accumulate the following standardized catalogues of information:
    - Experts
    - Datasets
    - Organizations
    - Projects
    - Species lists
- Build up participation in (free) listservers e.g. aliens-L, pestnet, etc.

8. Measurements of success

- Presence and rate of flow of information.
- Compiled lists.
- Successful containment of IAS.

9. Long-term goals/projects

- Establishment of a new regional institute for invasive species control; including taxonomist/biocontrol collaboration.
- Long term monitoring plots.

**Table 1 FIT OF PROPOSALS WITH THE OPERATIONAL OBJECTIVES OF THE GTI PROGRAMME OF WORK**

| Operational Objective | Matching proposal on alien invasive species |
|---|---|
| *1*: Assess taxonomic needs and capacities at national, regional and global levels for the implementation of the Convention. | *Activities will identify needs and existing capacity to develop:*<br>**Early warning system*<br>**Diagnostic tools, for all life stages*<br>**Information; filling the gaps, e.g. degree of infestation*<br>**Training new taxonomists in particular areas that have invasives; train specialists for particular taxa*<br>**And highlight places where closer ties are required between ecologists and taxonomists for complete coverage of the problem* |
| *2*: Provide focus to help build and maintain the human resources, systems and infrastructure needed to obtain, collate and curate the biological specimens that are the basis for taxonomic knowledge. | **Activities have goals to designate specific reference centres for invasives*<br>**Specific natural history centre for training and display of specimens*<br>**"Focus" is also upon an issue of emergency economic importance.*<br>**If the project is regional or national, a designated centre is necessary*<br>**Each country should have its own specialist who is connected to a network of specialists* |
| *3*: Facilitate an improved and effective infrastructure/system for access to taxonomic information; with priority on ensuring that countries of origin gain access to information concerning elements of their biodiversity. | **Creates a distributed database with information that is presented in a standardized format* |
| *4*: Within the major thematic work programmes of the Convention include key taxonomic objectives to generate information needed for decision-making in conservation and sustainable use of biological diversity and its components. | *For thematic work programmes, see below* |
| *5*: Within the work on cross-cutting issues of the Convention, include key taxonomic objectives to generate information needed for decision-making in conservation and sustainable use of biological diversity and its components. | *For cross-cutting issues, see below* |
| **Thematic Area / Cross-cutting Issue** | **Matching proposal** |
| P.A. 8: Forest biological Diversity | *Invasives impact on forest biodiversity, e.g. weeds at ecotones, pathogens or insects in native plantations.* |
| P.A. 9 Marine & coastal biological diversity | *Ballast water*<br>*Hull fauna*<br>*Tools* |
| P.A. 10. Dry & sub-humid lands biodiversity | *Also susceptible to invasive plants, e.g., grasses,* Mimosa pigra *(Thailand, Vietnam); invasives can alter fire regimes, etc.* |

| | |
|---|---|
| P.A. 11. Inland waters biodiversity | *Invasives examples:*<br>*Melaleuca<br>**Molluscs*<br>**Bangladesh:* Tilapia *(African fish), catfish from Thailand*<br>*Invasives can adversely affect fresh water biodiversity (especially native fish & invertebrates) directly or directly by altering hydrology, etc.* |
| P.A. 12. Agricultural biological diversity | *Monocultures and chemical use makes the system susceptible to invasion. Invasion by new species can necessitate renewed or increased use of chemicals, which disrupts programmes that conserve natural enemies and implement IPM.* |
| P.A. 13. Mountain biological diversity | *These systems are also susceptible to invasion, for example by* Lantana. |
| P.A. 14. Access & benefit-sharing | *Not applicable* |
| P.A. 15. Invasive alien species | *That's what we're all about* |
| P.A. 16. Article 8(j) | *(Indigenous knowledge) Indigenous peoples often have a good historical perspective about what is native, what is not*<br>*Some invasives can have a significant impact on indigenous peoples but not the mainstream of society* |
| P.A. 17. Ecosystem approach | *Species competition. Taxonomists will be needed to assist ecologists do their work on ecosystem parameters.*<br>*Use the integrity of the whole ecosystem to study the effects of invasives* |
| P.A. 18. Protected areas | *May be somewhat less vulnerable if they consist of healthy ecosystems*<br>*Taxonomists should work with protected areas managers to detect and control invasives*<br>*Visitors may be vectors of invasives* |

*Planned Activity 16. Support in implementation of Article 8(j) (traditional knowledge)*

This topic was not discussed at this workshop. It needs a separate workshop to bring together a different group of workers.

*Planned Activity 17. Ecosystem approach*

The requirements of the Ecosystem approach to Convention activities were not discussed in depth at the workshop.

*Planned Activity 18. Protected areas*

This aspect of work under the Convention was not specifically discussed at the workshop.

# Appendix 4. Posters presented at the Workshop

| Poster title | Presenter | Country/ Economy |
|---|---|---|
| India Coordinated Project on Taxonomy Capacity Building (AICOPTAX) | M.A.Haque | India |
| Conservation status of the Agaricales, Boletales, Cantharellales, Lycoperdales, Phallales and Russulales of South Australia | J.A.Simpson & C.A. Grgurinovic | Australia |
| A Web-based biodiversity GIS using a robust geo-coding algorithm | Takeshi Sagara, Keiichi Matsuura & Junko Shimura | Japan |
| All India Coordinated Research Project on Indian Orchids | C. Sathish Kumar | India |
| An illustrated catalogue of Pakistani opisthobranchs (Cephalaspidea, Anaspidea and Notaspidea) | Itrat Zehra | Pakistan |
| Australian Plant Pest Database | Ian David Naumann, Lumb & Pheloung | Australia |
| Biodiversity inventorying Beijing: Actuality and problems | Xianming Gao | China |
| Biodiversity of bacteria isolated from various environments of Karach: Water, air and soil | Nuzhat Ahmed | Pakistan |
| Biodiversity of Pakistan: Status and issues | S. Azhar Hasan | Pakistan |
| Building Taxonomic Capacity in Bangladesh | Badrul Amin Bhuiya | Bangladesh |
| Computer aided identification for capacity building. An application on trees of Western Ghats (India) | B.R.Ramesh & Grard Pierre | India |
| Developing the German GTI: Ongoing activities in taxonomy and bioinformatics | Klaus Riede & Christoph Haeuser | Germany |
| Diversity of glue-green algae and green algae in the deciduous dipterocarp forest at Huai Kha Khang wildlife sanctuary | Duenrut Chonudomkul, Wichien Yongmanitchai & Chantana Sookpreedee | Thailand |
| Documenting biodiversity minus the most diverse group?: The status, problems and prospects of insect taxonomy and taxonomists in the Philippines | Ireneo L. Lit, Jr. | Philippines |
| DWNP Scientific Zoological Reference Centre | Sahir Othman, Noor Alif Wira Osman & Lim Boo Liat | Malaysia |
| Establish biodiversity information network in Taiwan | Kwang-Tsao Shao, W.J.Wu, C.I.Peng, S.H.Wu, P.F.Lee, S.Lin & Y.L.Yu | Taiwan |
| Flora of Japan database, and needs for regional flora check list | Motomi Ito | Japan |
| Freshwater fish introduction in Pakistan: Facts and figures at the beginning of the 21st century | Shahid Mahboob & Mohammad Hassan | Pakistan |
| Fruit flies: species of economic plant in upper part of northern Thailand | Paitoon Lekeawasdl | Thailand |
| Identification of Threatened Species from Regional Faunas; Examples from Australian Marine Fishes | John R. Paxton | Australia |

| **Poster title** | **Presenter** | **Country/ Economy** |
|---|---|---|
| Identification of yeasts isolated from Gunung Halimun National Park | Atit Kanti, Heddy Julistiono & I Made Sudiana | Indonesia |
| Implementation Method for Data Exchange of Biological Diversity Information Databases | Akira Sato, Hirosh Kajihara, Takeshi Sagara, Satoshi Ono & Junko Shimura | Japan |
| Identification of yeasts isolated from Indonesian fermented foods | Atit Kanti, Susono Saono & Kazuo Komagata | Indonesia |
| Integration of the Global Environmental Facilities (GEF) and other collaboration projects into Indonesia Biodiversity conservation programme: Lessons learnt from Indonesia | Arie Budiman | Indonesia |
| Japanese Nemertean Specimen Database | Hiroshi Kajihara, Junko Shimura, Fumie Kasai & Makoto M.Watanabe | Japan |
| Landscape, Vegetation and Floristic Notes of Nusakambangan Island, Cilacap-Indonesia | Tukirin Partomihardjo | Indonesia |
| Macrofungal Diversity: The poor state of knowledge in Malaysia | Su See Lee & Yu Shyun Chang | Malaysia |
| Marine taxonomic research activities in Thailand | Somchai Bussarawit | Thailand |
| Meristic Character Database of Fishes: A case study of identification tool | Keiichi Matsuura | Japan |
| Microalgal diversity in Asia: The collaborative research between Japan and Thailand/Indonesia for capacity building of microalgal taxonomy. | Fumie Kasai, Masanobu Kawachi, Wichien Yongmanitchai, Sulastri, Mayumi Erata, Junko Shimura & Makoto M. Watanabe | Japan |
| Mycology in Asia, the past, the present and future needs | K.D.Hyde | Hong Kong |
| Natural history of land pulmonate snail collection and species diversity in Thailand: A case study for taxonomy research in developing countries | Somsak Panha | Thailand |
| New record of aphids (Homoptera: Aphididae) in northern Thailand | Warunee Sirikajornjaru, Valuli Rojanavongse & Suchart Upatham | Thailand |
| No Title | Ayilliath Kuttiyeri Pradeep | India |
| No Title | Da-Wei Huang | China |
| No Title | R. Hendrian, M.Sc. | Indonesia |
| No Title | Siti Nuramaliati Prijono | Indonesia |
| No Title | Soenartono Adisoemarto | Indonesia |
| Nomencurator: A nomenclatural history model to handle multiple taxonomic views | Nozomi Ytow, David R. Morse & David McL. Roberts | Japan, UK |
| Pacific basin information node, United states geological survey | Mark Fornwall | USA |
| Palms and palm hotspots in the Philippines | Edwino S. Fernando | Philippines |
| Parasites of citrus leaf miner, *Phyllocnistis citrella* (Stainton) (Lepidoptera: Phyllocnistidae) in Thailand | Kosol Charernsom | Thailand |
| Philippine species of *Illeis mulsant* (Coleoptera: Coccinellidae: Coccinellinae: Phylloborini) | Jessamyn D. Recuenco-Adorada | Philippines |

| **Poster title** | **Presenter** | **Country/ Economy** |
|---|---|---|
| Physiological characters and phylogenetic position of yeasts isolated from fermented blaglutinous rice, black 'oncom' and cassava 'tape' based on 18S rDNA sequences | Rostiati N.R. Napitupulu, N. Nikoh & T.Fukatsu | Indonesia |
| Present state and future trends in taxonomy research in Mongolia | Tsetseg B., Namkhaidorj B. & Galbaatar T. | Mongolia |
| Revitalisation of Taxonomy-A Business Plan in 21st Century | A.K.Sarbhoy | India |
| Species Differentiation of an Alcohol-Resistant *Monascus* sp. MM by Morpho-physiological Characterization | Nandang Suharna & Heddy Julistiono | Indonesia |
| Stinky Bacteria from World Largest Corpse Flower *Amorphophalus titanium* Becc | Novik Nurhidayat & Sri Hartin Rahadju | Indonesia |
| Taxonomic Activities in Brunei Darussalam | Jomari Bin Haji Ahmad | Brunei Darussalam |
| Taxonomic Condition in Myanmar | Phyu Phyu Lwin | Myanmar |
| Taxonomic information on the biodiversity in Vietnam | Bui Dinh Chung | Vietnam |
| Taxonomic needs assessment in Thailand | Banpot Napompeth & Chalinee Kongsawat | Thailand |
| Taxonomic studies of crustacea in Pakistan | Quddusi B. Kazmi | Pakistan |
| Taxonomic Studies of Oribatid Mites (Acari: Oribatida) of Mongolia | Badamdorj Bayartogtokh | Mongolia |
| Taxonomic studies on Malaysian Chrysomelidae (Insecta: Coleoptera) | Mohamed S. Mohamedsaid | Malaysia |
| Taxonomy of procaryotes in water ecosystems of East Asia | Namsaraev Bair, Kozyreva Ludmila, Dagurova Olga & Namsaraev Zorigto | Russia |
| The activities of Botanical Survey of India | M.Sanjappa | India |
| The current status and future plants of plant taxonomic research in the Philippines and the role of GTI in its implementation | Domingo A. Madulid | Philippines |
| The dung beetle fauna (Coleoptera, Scarabaeidae) of Thailand | Yupa Hanboonsong | Thailand |
| The implementation of database applying Nomencurator schema and the development of the user interface for it | Satoshi Ono, Ryo Fujimoto, Takehisa Okada, Hiroshi Kajihara, Akira Sato, Nozomi Ytow & Junko Shimura | Japan |
| The inventory of freshwater fishes in Indonesia: A race with the time | Renny Kurnia Hadiaty | Indonesia |
| The status of insect pests, diseases and herbarium collection at NIPP, Vietnam | Nguyen Van Tuat | Vietnam |
| The status of insect pests, diseases and herbarium collection at NIPP, Vietnam | Quach Thi Ngo | Vietnam |
| The status of orchid taxonomy in the Philippines | Esperanza Marbel G. Agoo | Philippines |
| The Status of Plant diversity and Taxonomic Research in Bangladesh | M.Matiur Rahman | Bangladesh |
| University of Malaya Algae Culture Collection (UMACC) | Siew-Moi Phang & Wan-Loy Chu | Malaysia |

| Poster title | Presenter | Country/ Economy |
|---|---|---|
| Utilization of Field Survey Database Software for flora and fauna data management from Nusakambangan Island, Central Java, Indonesia | Roemantyo & B. Hartoko | Indonesia |
| Vascular ground flora in a dipterocarp-oak forest in northern Thailand | Wangworn Sankamethawee, J.F.Maxwell & Vilaiwan Anusarnsunthorn | Thailand |
| Yeasts Diversity of Gunung Halimun National Park (The Last Sub mountain forest in Java) | Atit Kanti, Heddy Julistiono & I Made Sudiana | Indonesia |
| ??????? | Jade Donavanik | Thailand |

# Appendix 5. The Programme of the 1st GTI Workshop in Asia

| 1st GTI Regional Workshop in Asia Programme | | |
|---|---|---|
| Putrajaya Marriot Hotel, September 10-17, 2002 | | |
| | **Monday 9 September** | |
| | Participants arrive | |
| 14:00-18:00 | Steering Committee+LOC +session chairs +GTI Programme Officer Meeting: closed | |
| 18:00-20:00 | Registration and Informal Gathering of Participants | |
| | | |
| **DAY 1** | **Tuesday 10 September** | |
| 8:30 | Registration and coffee | |
| 8:50 | Opening Ceremony | |
| | Welcome Address by Prof. Dato' Dr. Abdul Latiff Mohamad, Chairman of the LOC | |
| | Welcome Remarks by Dr. Christopher H.C. Lyal, the acting GTI Programme Officer from the Secretariat of Convention on Biological Diversity | |
| | Welcome Remarks by Mr. Mitsuo Usuki, the Representative from the Ministry of Environment, Japan | |
| | Opening Address by Y.B. Dato' Seri Law Hieng Ding, Minister of Science, Technology and the Environment, Malaysia | |
| | | |
| 10:00 | Tea/Coffee/Press conference | |
| 10:30 | Session 1 - Setting the Scene | Chair: Ian Cresswell (ABRS, Australia) |
| 10:30 | Group discussion on GTI programme of work from the country perspective | Country representatives |
| 11:00 | Regional activities and GTI: <ASEANET> | Soetikno (ASEANET) |
| 11:15 | <EASIANET> | Hui Xiao (EASIANET, China) |

| | | |
|---|---|---|
| 11:30 | <Species 2000 Asia Oceania> | Makoto M.Watanabe (NIES, Japan) |
| 11:45 | Outcome of 3GTW (3rd Global Taxonomy Workshop) - Asian region perspective | Nick King (BioNET INTERNATIONAL) |
| 12:00-14:00 | Lunch/Poster session/Demos | |
| | Session 2 - Taxonomy in the Asian Region, in a Global Context | Chair: Christopher Lyal (Secretariat of CBD) |
| 14:00 | Taxonomic capacity for agricultural protection - IPPC and GTI | Christine Reed (Ministry of Agriculture and Forestry, New Zealand) |
| 14:20 | Invasive species and GTI | Annie Simpson (NBII, USA) |
| 14:40 | Financial support for GTI activities | David Duthie (GEF) |
| 15:00 | GTI operational objective 3: Access to taxonomic information and the possible role of GBIF | Christoph Haeuser (Chair of GBIF Governing Board) |
| 15:20 | Tea/Coffee | |
| | Session 3 - How do we reach regionally agreed taxonomic priorities? | Chair: Jameson Seyani (Commonwealth Science Council, UK) |
| 15:40 | Existing taxonomic capacity in Asia (Questionnaire results from Asia) | Junko Shimura (NIES, Japan) |
| 16:10 | Country report on taxonomic needs | Country representatives |
| 17:30 | Discussion on the format of workshop and establishing composition of break-away groups | Ian Cresswell (ABRS, Australia) |
| 17:50 | Close of Session 3 | |
| 18:00 | Cocktail Party hosted by Ministry of Science, Technology and the Environment, Malaysia | |
| 20:00 | Session chairs, working group chairs and rapporteurs meeting; other participants free | |

| | | | |
|---|---|---|---|
| **DAY2** | **Wednesday 11 September** | | |
| 8:30 | Coffee/Tea | | |
| | Session 4 - Learning from the Past: What do we need to do to quickly increase capacity? | | |
| | **Working Group 1** | **Working Group 2** | **Working Group 3** |
| 8:50 | Chair: Saw Leng Guan (FRIM, Malaysia)<br>Rapporteur: Haque M.A. (India) | Chairs: Ji Li-Qiang (Academy of Science, China),<br>Christoph Haeuser (GBIF)<br>Rapporteurs: Dennis Gordon (NIWA, New Zealand),<br>Christopher Lyal (CBD) | Chair: Ian Naumann (AFFA, Australia)<br>Rapporteur: Annie Simpson (NBII, USA) |
| | Regional cooperation in identifying gaps in current taxonomic coverage | Collections, curation and maintenance of specimens: Lessons learnt from GEF project in Indonesia | Regional approach to combating invasive species: What is the role of GTI |
| 10:30 | Tea/Coffee/Poster session/demos | | |
| 10:50 | Prioritisation of needs to cover gaps | Prioritisation of needs of collections | Prioritisation of projects for capacity development for managing invasive species |
| 12:30-14:00 | Lunch / preparation of report for the afternoon session | | |

| | | | |
|---|---|---|---|
| 14:00 | Session chairs report for Day 2 | | |
| 16:00 | Tea/Coffee/Poster session/demos | | |
| 16:30 | Meeting close to allow drafting group to write up | | |
| 16:30 | Drafting group to write outcomes | Drafting group to write outcomes | Drafting group to write outcomes |
| | Close of session | | |
| **DAY 3** | **Thursday 12 September** | | |
| 8:30 | Coffee and informal gathering of participants | | |
| | Session 5: Sharing data: How do we increase our effectiveness by utilising broader data pool? | | |
| 8:50 | **Working Group 4** | **Working Group 5** | **Working Group 6** |
| | Chair: Maryati Mohamed (Univ. Malaysia), Junko Shimura (NIES, Japan) Rapporteur: Christine Reed (Ministry of Agriculture and Forestry, New Zealand) | Chairs: Keiichi Matsuura (National Science Museum, Japan), Somchai Bussarwit (Phuket Marine Biological Center,Thailand) Rapporteur: John Paxton (Australian Museum, Australia) | Chair: Christoph Haeuser (GBIF) Rapporteur: David Roberts (Natural History Museum of London, UK) |
| | Access and benefit sharing: issues of specimen transfer across national boundaries. | Utilizing free taxonomic and GIS software: Outputs from Fish pilot project | GBIF: What do we hope from GBIF and how we can contribute for global data pool? |
| 10:15 | Tea/Coffee/Poster session/demos | | |
| 10:45 | Session 5 continues | | |
| 12:30-14:00 | Lunch | | |
| 14:00-20:00 | **Study tours:** Course A: Forest Research Institute Malaysia; Course B: Department of Wild Life and National Parks. Both courses will stop at KLCC (twin towers in Kuala Lumpur) after the tour | | |
| 14:00 | Session chairs and drafting group gather | | |
| 16:00 | Tea/Coffee for drafting group | | |
| 20:00 | Free Evening | | |
| **DAY4** | **Friday 13 September** | | |
| 8:30 | Tea/Coffee | | |
| | Session 6: Agreeing on regional priorities for the GTI | | Chair: Makoto M. Watanabe (NIES, Japan) Rapporteur: Nick King (BioNET INTERNATIONAL) |
| 8:50 | Session chairs' report from Day 3 | | |
| 10:20 | Tea/Coffee/Poster session/demos | | |
| 10:50 | Open discussion of top priorities identified - reaching consensus | | |
| 12:30 | Lunch/posters/demos | | |

| | | | |
|---|---|---|---|
| | Session 7: Finalisation of projects to meet the priorities identified | | |
| 14:00 | **Working Group 7** | **Working Group 8** | **Working Group 9** |
| | Chair: Ruth Kiew (Singapore)<br>Rapporteur: Lourdes Cardenas (Philippines) | Chairs: K.Y. Lum,<br>S. Soetikno (ASEANET)<br>Rapporteur: Penny Berents (Australian Museum) | Chair: Christopher Lyal (SCBD)<br>Rapporteur: Karen L. Wilson (RBG Sydney, Australia) |
| | Regional cooperation to fill in the gaps of taxonomic knowledge | Regional cooperation to build capacity on specimens/culture collection | Coordination of existing networkings and initiatives for GTI |
| 16:00 | Tea/Coffee | | |
| 16:30 | Session 8: Closing session - Report on proposed projects and general summary | | Chair: A. H. Zakri (UNUIAS) |
| 17:30 | Closing Ceremony and presentation of the best poster awards | | |
| | | | |
| 19:30 | Final report compilation by steering committee and local secretariat (closed) | | |
| | | | |
| **Side events** | **Saturday 14 September** | | |
| 9:00-12:00 | "Open-ended Species 2000 Asia Oceania Forum" – Species 2000 AO working group | | |
| 12:00-14:00 | Lunch | | |
| 14:00-17:00 | EASIANET Loop Cordinating Committee Meeting | | |
| Evening | "MEXT advisory committee meeting" closed meeting | | |
| | | | |
| **Side events** | **15-16th September "Computer training course and demos"** | | |
| | *Natural History Collection data input tool<br>*Catalog of Life CD-ROM 2002<br>*What is Nomencurator? | | |
| **Side events** | **15-16th September "Field trips in Malaysia"** | | |
| | Course A: Kuala Selangor + Fireflies | | |
| | Course B: Pasoh Reserve + Malacca | | |

# 1$^{st}$ GTI Regional Workshop in Asia

# Guidelines for discussion at working groups and side events

## GENERAL NOTES FOR PARTICIPANTS

1. Be aware of the GTI programme of work and of its goals. It was attached to the invitation letter to attend this workshop and it also is bound in the programme in your conference bag. Please read it thoroughly one more time before you come to the session.
2. Actively participate in all sessions and side events, and be prepared to share your views. Be prepared to commit yourself to collaborate regionally and to share the task in order to build up taxonomic capacity in all Asian countries.
3. Avoid lengthy presentations of your work or organization at the working group sessions. The forum for such presentations is the poster session.
4. Please listen carefully to speakers who are not using English as their working language. Diverse local English accents and expressions are a part of Asian culture and deserve respect.
5. Be clear in your proposals; this is an opportunity for you to send your voice to the Secretariat of Convention on Biological Diversity and to build up a strategic and achievable work plan with your global partners.
6. Volunteer to join the drafting group whether or not you are a native-English speaker, in order to produce a regionally appropriate report.

## CHAIRS AND RAPPORTEURS

Strict time management of sessions is important, especially for the plenary session. Make sure that key discussion points raised at the plenary session are taken into the working sessions.

At the beginning of each working group session, the Chair or a participant picked by the Chair should present one or two relevant topics. Chairs and rapporteurs are expected to make contact with active participants as workshop facilitators to lead the discussion prior to coming to the workshop.

## ISSUES TO BE COVERED

**<DAY 1 September 11, 2002>**

***Session 1: Setting the scene.***
What is the goal of the GTI?
What is expected of taxonomists involved in GTI work?
Who are the actors who should be involved in the GTI in the region?
What mechanisms are available and what needs to be built for the GTI?
Why should we initiate a pilot project?

***Session 2: Taxonomy in the Asian Region, in a Global context.***
What is expected globally from taxonomy in terms of the Convention on Biological Diversity?
What is the global contribution from Asia?

***Session 3: How do we reach regionally agreed taxonomic priorities?***
What are the regional taxonomic needs?
What is the regional taxonomic capacity?
How are taxonomic resources and capacity distributed in the region?
How can GTI projects be financed?

**<DAY 2 September 11, 2002>**

***Session 4: Learning from the Past: What do we need to do to increase capacity quickly.***

*WG1: Regional cooperation in identifying gaps in current taxonomic coverage*
Which taxa are inadequately known and covered?
Which environmental zones are inadequately known and covered?
What projects are needed to cover the gaps identified?

*WG2: Collections, curation and maintenance of specimens: Lessons learnt from the GEF project in Indonesia*
What mechanisms are needed to develop and carry out pilot projects in the region?
How do we develop projects regionally?
How do we encourage taxonomists to participate in projects locally and regionally?

*WG3: Regional approach to combating invasive alien species: What is the role of the GTI?*

How do we know the baseline biodiversity in the region?
What is needed to identify invasive alien species?
What projects are needed for combating invasive species?
What partnerships are needed within and outside the region for dealing with invasive alien species problems?

**<DAY 3 September 12, 2002>**

***Session 5: Sharing data: How do we increase our effectiveness by creating and utilizing a broader data pool?***

*WG4: Access and benefit sharing: issues of specimen transfer across national boundaries*
Lessons and issues arising from the Japanese GTI pilot project.
What access and benefit sharing regulations exist in the region and what is their impact on collaborative taxonomic studies?
How can the GTI contribute to access and benefit sharing issues?

*WG5: Utilising free taxonomic and GIS software: outputs from the Japanese fish pilot project.*
What public domain software is available?
What is needed?
What strategies are needed to mobilise and obtain more?
Why is geographic information important for the GTI?
How can taxonomists contribute to biogeography?
What tools are needed for the GTI pilot project?

*WG6: GBIF: What do we hope from GBIF and how can we contribute to the development of the global data?*
Why is global data sharing important?
What can GBIF do for taxonomy in the region?
What can taxonomists do for GBIF regionally?
What is needed for taxonomists to contribute to GBIF?

**<DAY 4 September 13, 2002>**

***Session 6: Agreeing on regional priorities for the GTI.***

What priorities are identified in the region?
What measures are needed to establish appropriate pilot projects?

***Session 7: Finalisation of projects to meet the priorities identified***

*WG7: Regional cooperation to fill in the gaps of taxonomic knowledge*
Who are the actors needed to address the gaps?
How can the collaboration between the different actors be developed and maintained in the short and long terms?

*WG8: Regional Cooperation to build capacity of specimen and culture collections.*
Who are the actors involved in ensuring the maintenance and accessibility of existing collections?
Who are the actors involved in building additional collections and developing extant ones?
What resources are needed?
How can the collaboration between the different actors be developed and maintained in the short and long terms?

*WG9: Coordination of existing networks and initiatives in implementing the GTI*
What are the relevant existing networks, initiatives and partnerships?
What capabilities and partnerships need to be developed?
What coordination mechanisms would be effective and acceptable?

# Appendix 6. Questionnaire sent to Asian taxonomists and institutions in 2002

3 June, 2002

Dear Colleague

## GTI QUESTIONNAIRE ON TAXONOMY IN EAST ASIA

There is an urgent need for capacity-building and infrastructure renewal if taxonomy is to keep up with the demand for up-to-date information on species. The Convention on Biological Diversity (CBD) has recognised this taxonomic impediment and has formulated the concept of a Global Taxonomy Initiative (GTI) to promote a concerted effort between international funding agencies, national and sub-national governments, and non-governmental bodies. The aim of the GTI is to enable the provision of appropriate taxonomic information and capacity to underpin decision-making in conservation of biological diversity, sustainable use of its components and equitable sharing of the benefits derived from the utilisation of genetic resources. This will be achieved by addressing (a) the lack of taxonomic information on the identity of components of biological diversity in many parts of the world, and (b) the need to build capacity for taxonomic activity in all regions, but especially developing countries, including reference materials, databases, and taxonomic expertise relevant to the objectives of the CBD. The GTI covers the taxonomic information required to support the implementation of the Convention at all three levels of biodiversity (genetic, species and ecosystem), and is concerned with all organisms.

The accompanying questionnaire aims to determine the taxonomic expertise in Asia and to examine the needs of Asian taxonomic institutions in terms of the GTI. Up-to-date information is urgently required. The needs assessment is very much in line with the recommendations made by the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) to the Conference of Parties of the CBD — *'each country should conduct a taxonomic needs study'*. We would greatly value your support in making the needs assessment as comprehensive as possible. Completed questionnaires should provide excellent baseline information to support funding applications from Asian systematists to international donor agencies. Please bear in mind that the GTI is there to serve all the components of biodiversity (animals, plants, micro-organisms etc). It would therefore be useful if you could liaise with colleagues from other disciplines in your country in completing the questionnaire.

Please return the completed questionnaire not later than **30 June 2002** to **Dr Junko Shimura, National Institute for Environmental Studies, 16-2 Onogawa, Tsukuba, Ibaraki 305-8506, Japan.** Through completing this questionnaire you will be benefiting not only your own institution, but also those of the region as a whole. Thanking you in anticipation for your co-operation.

Yours sincerely

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The United Nations University, Institute of Advanced Studies
Malaysia
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**Prof Abdul Latiff**
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**Prof Makoto M. Watanabe**
GTI Focal Point of Japan
Director: Environmental Biology
National Institute for Environmental Studies
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# GLOBAL TAXONOMY INITIATIVE
# INFORMATION FOR ASIA

**TITLE:____ SURNAME: ________________ FORENAMES: ________________**

**POSITION (e.g. Curator of the herbarium): ______________________________**

**POSTAL ADDRESS:**

______________________________
______________________________
______________________________
______________________________

**ZIP CODE: ________________**
**COUNTRY: ________________**

**PHYSICAL ADDRESS:**

______________________________
______________________________
______________________________
______________________________
______________________________

**E-MAIL ADDRESS: ______________**

**INTERNATIONAL TEL. NO.:______________________________**
**INTERNATIONAL FAX NO.: ______________________________**

---

## A. NEEDS ASSESSMENT

1. Has a taxonomic needs assessment been completed for your country?

| Yes | No | Not sure |
|---|---|---|

2. If yes, for which groups (tick the appropriate box or indicate x if you overwrite on electronic file)

| ANIMALS | | PLANTS | | MICROORGANISMS | | | |
|---|---|---|---|---|---|---|---|
| Invertebrate | Vertebrate | Non-vascular | Vascular | Fungi/ Yeast | Protozoa | Microalgae | Bacteria Archaea |
| | | | | | | | |

3. If a Needs Assessment has been prepared, where can it be found?

## B. COLLECTIONS

4. Is your collection a major collection of your country?

| Yes | No | Not sure |
|---|---|---|

5. If yes, is it:

| | | |
|---|---|---|
| 1. actively curated (e.g. updating of names) | Yes | No |
| 2. protected against "decay"? | Yes | No |
| 3. adequately staffed? | Yes | No |
| 4. electronically databased? | Yes | No |
| 5. made accessible on Web? | Yes | No |

6. if yes on 5. indicate URL: http://

6. What organisms are in your collection (tick the appropriate boxes)?

| ANIMALS | | PLANTS | | MICROORGANISMS | | | |
|---|---|---|---|---|---|---|---|
| Invertebrate | Vertebrate | Non-vascular | Vascular | Fungi/ Yeast | Protozoa | Microalgae | Bacteria Archaea |
| | | | | | | | |

7. Where are the major biological collections in your country kept? (List up to five major institutions)

| TYPE OF INSTITUTION | NAME, ADDRESS, FAX & E-MAIL (if available) |
|---|---|
| Herbaria | |
| Botanical gardens | |
| Museums | |
| Zoos | |
| Culture Collections | |
| Others | |

## C. PROJECTS

8. Which **MAJOR** taxonomic projects have been/are/will be conducted in your country (*ca.* 1995- 2004)? Tick the appropriate boxes

| ANIMALS | | PLANTS | | MICROORGANISMS | | | |
|---|---|---|---|---|---|---|---|
| Invertebrate | Vertebrate | Non-vascular | Vascular | Fungi/ Yeast | Protozoa | Microalgae | Bacteria Archaea |
| | | | | | | | |

## D. COLLABORATION

9. Give the names of up to three institutions with which you collaborate.

| | | NAME OF INSTITUTIONS |
|---|---|---|
| ANIMALS | Invertebrate | |
| | | |
| | | |
| | Vertebrate | |
| | | |
| | | |
| PLANTS | Non-vascular | |
| | | |
| | | |
| | Vascular | |
| | | |
| | | |
| MICRO-ORGANISMS | Fungi/yeast | |
| | | |
| | | |
| | Protozoa | |
| | | |
| | | |
| | Microalage | |
| | | |
| | | |
| | Bacteria Archaea | |
| | | |
| | | |

10. Do taxonomic networks exist in your region?
If yes, list up to two networks.

| | | | | NAME OF NETWORK |
|---|---|---|---|---|
| ANIMALS | Invertebrate | Yes | No | |
| | Vertebrate | Yes | No | |
| PLANTS | Non-vascular | Yes | No | |
| | Vascular | Yes | No | |
| MICROORGANISMS | | Yes | No | |

## E. STAFFING

11. Approximately how many taxonomists/systematists currently practise in your institute?
(Indicate the number in appropriate boxes)

| ANIMALS | | PLANTS | | MICROORGANISMS | | | |
|---|---|---|---|---|---|---|---|
| Invertebrate | Vertebrate | Non-vascular | Vascular | Fungi/ Yeast | Protozoa | Microalgae | Bacteria Archaea |
| | | | | | | | |

12. In your opinion, are these numbers sufficient to address CBD issues?

| Yes | No | Not sure |
|---|---|---|

13. Please, fill in the details of each individual taxonomist/systematist at your institute?
For Taxonomic specialty, pick one of the numbers from the list below and indicate in the box.
Specify the taxa in free text if needed. (see the example in the first row)

1. Invertebrate
2. Vertebrate
3. Non-vascular plants
4. Vascular plants
5. Fungi/Yeast
6. Protozoa
7. Microalgae
8. Bacteria/Archaea

| Family name | Fore name | Taxonomic specialty | | e-mail address | Age (tick appropriate box) | | | | | Data can be open to the Web site? | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Smith | John | 4 | Fabaceae | grl@x.yy.ac.jp | <30 | 31-40 ✓ | 41-50 | 51-60 | 60< | Yes ✓ | No |
| | | | | | <30 | 31-40 | 41-50 | 51-60 | 60< | Yes | No |
| | | | | | <30 | 31-40 | 41-50 | 51-60 | 60< | Yes | No |
| | | | | | <30 | 31-40 | 41-50 | 51-60 | 60< | Yes | No |
| | | | | | <30 | 31-40 | 41-50 | 51-60 | 60< | Yes | No |
| | | | | | <30 | 31-40 | 41-50 | 51-60 | 60< | Yes | No |
| | | | | | <30 | 31-40 | 41-50 | 51-60 | 60< | Yes | No |
| | | | | | <30 | 31-40 | 41-50 | 51-60 | 60< | Yes | No |
| | | | | | <30 | 31-40 | 41-50 | 51-60 | 60 < | Yes | No |
| | | | | | <30 | 31-40 | 41-50 | 51-60 | 60 < | Yes | No |
| | | | | | <30 | 31-40 | 41-50 | 51-60 | 60 < | Yes | No |
| | | | | | <30 | 31-40 | 41-50 | 51-60 | 60 < | Yes | No |
| | | | | | <30 | 31-40 | 41-50 | 51-60 | 60 < | Yes | No |
| | | | | | <30 | 31-40 | 41-50 | 51-60 | 60 < | Yes | No |
| | | | | | <30 | 31-40 | 41-50 | 51-60 | 60 < | Yes | No |
| | | | | | <30 | 31-40 | 41-50 | 51-60 | 60 < | Yes | No |
| | | | | | <30 | 31-40 | 41-50 | 51-60 | 60 < | Yes | No |
| | | | | | <30 | 31-40 | 41-50 | 51-60 | 60 < | Yes | No |

## F. TEACHING OF TAXONOMY

14. Is taxonomy in your country taught in:

| | | |
|---|---|---|
| 1. secondary schools? | Yes | No |
| 2. universities and colleges? | Yes | No |

15. How often is the curriculum revised?

| | | | |
|---|---|---|---|
| Never | Every five years | Every ten years | Other |

16. If taxonomy is not taught at universities, where are the taxonomists trained?

| | | NAME OF INSTITUTION |
|---|---|---|
| ANIMALS | Invertebrate | |
| | Vertebrate | |
| PLANTS | Non-vascular | |
| | Vascular | |
| MICROORGANISMS | | |

## G. INFRASTRUCTURE

17. Are the following pieces of taxonomic equipment available in your country?

| EQUIPMENT | AVAILABLE & ADEQUATE | AVAILABLE BUT NOT ADEQUATE | NOT AVAILABLE | UNKNOWN |
|---|---|---|---|---|
| Dissecting microscope | | | | |
| Compound microscope | | | | |
| SEM | | | | |
| TEM | | | | |
| Computers & accessories | | | | |
| Internet connection | | | | |
| Specimen cabinets | | | | |
| Refrigerators | | | | |
| Freezers | | | | |
| Incubators | | | | |
| Autoclaves | | | | |
| Specimen drying facilities | | | | |
| Specimen collecting equipment | | | | |
| Clean room / Clean bench | | | | |
| Tissue/Cell Culture facilities | | | | |
| Cryo-preservation facilities | | | | |
| Lyophilizer | | | | |
| Molecular laboratory | | | | |
| PCR machine | | | | |
| DNA sequencer | | | | |
| HPLC / GC | | | | |
| Others (specify) | | | | |

## H. INVENTORIES / FLORAS

18. Have inventories of the following organisms been done in your country?

| | | | | | | |
|---|---|---|---|---|---|---|
| ANIMALS | Invertebrates | Yes | No | Vertebrates | Yes | No |
| PLANTS | Non-vascular | Yes | No | Vascular | Yes | No |

| | | |
|---|---|---|
| FUNGI & YEAST | Yes | No |
| PROTOZOA | Yes | No |
| MICROALGAE | Yes | No |
| BACTERIA & ARCHAEA | Yes | No |

19. Are taxonomists in your country involved in preparing of the floras and fauna inventories? | Yes | No |

20. If not, give general reasons why

______________________________________________

______________________________________________

______________________________________________

## I. TAXA

21. Have any groups been listed for priority research or study? | Yes | No | Not sure |

22. If yes, which groups or taxa? (List up to five)

22.1 on a national level? ______________________________

______________________________

22.2 on a regional scale? ______________________________

______________________________

23. If not, for which taxa should funding projects be developed as a matter of priority? (List up to five)

______________________________________________

______________________________________________

______________________________________________

______________________________________________

______________________________________________

## J. TAXONOMIC INFORMATION

24. Is documented taxonomic information available and accessible? | Yes | No | Not sure |

25. If yes, is it available/accessible in your country as | hard copy | databases | CD ROM |

26. Are by-products from taxonomic studies available in your country? | Yes | No | Not sure |

(tick the appropriate box)

| RED DATA LISTS | ENDEMICS | ALIEN INVASIVES | ECONOMICALLY IMPORTANT ORGANISMS |
|---|---|---|---|
| | | | |

27. Are specimens from your country, including Types, held at foreign institutions?

| | | SPECIMENS /CULTURES | | | TYPES | | |
|---|---|---|---|---|---|---|---|
| ANIMALS | Invertebrate | Yes | No | Not sure | Yes | No | Not sure |
| | Vertebrate | Yes | No | Not sure | Yes | No | Not sure |
| PLANTS | Non-vascular | Yes | No | Not sure | Yes | No | Not sure |
| | Vascular | Yes | No | Not sure | Yes | No | Not sure |
| MICRO-ORGANISMS | Fungi/Yeast | Yes | No | Not sure | Yes | No | Not sure |
| | Protozoa | Yes | No | Not sure | Yes | No | Not sure |
| | Microalgae | Yes | No | Not sure | Yes | No | Not sure |
| | Bacteria/Archaea | Yes | No | Not sure | Yes | No | Not sure |

28. If yes, does your country have easy access to these specimens/cultures? | Yes | No |

## K. STUMBLING BLOCKS

29. What are the major stumbling blocks preventing progress in the taxonomic effort?

| | | |
|---|---|---|
| • Lack of staff | Yes | No |
| • Lack of physical infrastructure (e.g. bricks & mortar) | Yes | No |
| • Lack of scientific and collecting equipment (e.g. microscopes; vehicle) | Yes | No |
| • Lack of electronic equipment (e.g. computer, scanner, GPS) | Yes | No |
| • Lack of project-related research funding | Yes | No |
| • Lack of institutional running costs (e.g. preservatives, mounting materials) | Yes | No |
| • Lack of basic taxonomic literature and library facilities | Yes | No |

30. In your opinion, is taxonomy adequately addressed in your country? | Yes | No |

—oooOOOooo—

Please return the completed questionnaire page 2- 9, not later than 30 June 2002 to **Dr Junko Shimura**

**National Institute for Environmental Studies**
**16-2 Onogawa, Tsukuba, Ibaraki 305-8506 Japan**
**or e-mail to junko@nies.go.jp**
**or fax to Dr Junko Shimura, Fax nr +81-298-50-2778**

# Appendix 7. Participants in the 1st GTI Workshop in Asia

| | |
|---|---|
| **Australia** | |
| Penny Berents | Australian Museum |
| Ian Cresswell | Australian Biological Resources Study, Environment Australia |
| Ian D. Naumann | Agriculture, Fisheries and Forestry Australia |
| John Paxton | Australian Museum |
| Karen L. Wilson | Royal Botanic Gardens Sydney |
| **Bangladesh** | |
| Badrul Amin Bhuiya | University of Chittagong (Interim SACNET Coordinator) |
| **Canada** | |
| Christopher H.C. Lyal | Secretariat of the Convention on Biological Diversity |
| **China** | |
| Li-Qiang Ji | Chinese Academia Sinica (CBIS) |
| Hui Xiao | Chinese Academia Sinica |
| **Germany** | |
| Christoph L. Haeuser | Global Biodivesity Information Facility (GBIF) |
| **Hong Kong** | |
| Kevin D. Hyde | The University of Hong Kong |
| **India** | |
| Haque M.A. | Ministry of Environment India |
| B. R. Ramesh | French Institute of Pondicherry |
| **Indonesia** | |
| Arie Budiman | Indonesian Institute of Sciences (LIPI) |
| Dedy Darnaedi | LIPI |
| Roemantyo | LIPI |
| Setijati Sastrapradja | Indoensian Biodiversity Foundation |
| Tukirin Partomiharjo | LIPI |
| **Japan** | |
| Ryo Fujimoto | Lance Co Ltd |
| Hiromitsu Hagiwara | Department of Botany, National Science Museum |
| Motomi Ito | University of Tokyo |
| Hiroshi Kajihara | National Institute for Environmental Studies (NIES) |
| Fumie Kasai | NIES |
| Masanobu Kawachi | NIES |
| Hiroshi Kawai | Kobe University |
| Keiichi Matsuura | National Science Museum |
| Akira Nakagiri | National Institutes of Technology and Evaluation |
| Tohru Nakashizuka | DIVERSITAS in the Western Pacific and Asia (DIWPA) |

| | |
|---|---|
| Takehisa Okada | Lance Co Ltd |
| Satoshi Ono | Lance Co Ltd |
| Takeshi Sagara | University of Tokyo |
| Akira Sato | University of Tsukuba |
| Junko Shimura | NIES/GTI Japan |
| Minoru Soeya | Ministry of the Environment |
| Hiroshi Tobe | Kyoto University |
| Mitsuo Usuki | UNU/IAS |
| Makoto M. Watanabe | NIES/GTI Japan |
| Seiki Yamane | University of Kagoshima |

**Japan/Malaysia**

| | |
|---|---|
| A. H. Zakri | UNU/IAS |

**Kenya**

| | |
|---|---|
| David Duthie | UNEP/GEF |

**Korea**

| | |
|---|---|
| In Kyu Lee | Seoul National University, Biodiversity Center |

**Malaysia**

| | |
|---|---|
| Aslitawaty Abu Bakar | Universiti Putra Malaysia (UPM) |
| Bastiah Ahmad Lembaja | RRIM – Rubber Research Institute Malaysia |
| Yu Shyun Chang | Forest Research Institute Malaysia (FRIM) |
| Beng-Jin Chee | FRIM |
| Lucy Chong | Forest Dept. Sarawak |
| Richard Chung | FRIM |
| Bakhtiar Effendi Yahya | Institute for Tropical Biology & Conservation, Universiti Malaysia Sabah (UMS) |
| Eng Goh Siok | MOSTE |
| Rusea Go | UPM |
| Mohd. Fairus Jalil | Institute for Tropical Biology & Conservation,UMS |
| Claysius Konggoi | UPM |
| Takahisa Kusano | BBEC Programme, ITBC, UMS |
| Abdul Latiff Mohamad | Universiti Kebangsaan Malaysia |
| Lim Boo Liat | Jabatan Perhilitan |
| Lum Keng Yeang | Malaysian Agriculture R&D Institute (MARDI) |
| Maryati Mohamed | University of Malaysia Sabah |
| Mohamed Mohamedsaid | Pusat Sistematik Serangga, Universiti Kebangsaan Malaysia (Sabah) |
| Normaya Nordin | FRIM |
| Joan Pereira | Forest Research Centre, Sabah Forest Department |
| Phang Siew Moi | Institute of Biological Sciences, University of Malaya |
| Adib A. Rahman | MOSTE |
| Phoon Sook Ngoh | UPM |
| Mariam Abdullah | UPM Undergraduate |
| Abdul Rahim Ismail | UPM |
| Amir Feisal Merican | Institut Sains Biologi, University of Malaya |
| Cheksum Tawan | UNIMAS |
| Hasdi Hassan | Jabatan Perhilitan |
| Hjh Rosmah Hj Jafar | Pusat Penyelidikan Pertanian |
| Idris Abd. Ghani | UKM |
| Salma Idris | MARDI |

| | |
|---|---|
| Idris Zulkifli | MOSTE |
| Ismail Ahmad | UKM |
| Jalil Md. Som | Jabatan Perhutanan Semenanjang Malaysia |
| Jambari Haji Ali | UPM |
| Siti Aisah Alias | UM |
| Mamat Jusoh | ASEANET/MARDI |
| Mashhor Mansor | USM |
| Md. Salleh Sazlina | USM |
| Meriam Mohd Yusof | Malaysian Cocoa Board |
| Mohd. Nor Burhanuddin | MOSTE |
| Mohd Rosli Abdullah | MOSTE |
| Noraini Azhar | MOSTE |
| Norman Hj Kamarudin | Malaysian Palm Oil Board |
| Petra Gin Sulai | Jabatan Perhilitan |
| Rahman Khairul Adib Abd | MOSTE |
| Rita Manurung | Jabatan Perhilitan |
| Runi Sylvester Pungga | Forest Research Centre, Sarawak Forest Dept |
| Yen-Yen Sam | FRIM |
| Saw Leng Guan | FRIM |
| Wuu-Kuang Soh | FRIM |
| Soetikno S. Sastroutomo | ASEANET, MARDI |
| Monica Suleiman | Institute for Tropical Biology & Conservation, UMS |
| Siti Ranlah Ahmad Ar | Malaysian Palm Oil Board |
| Tosiah Sadi | MARDI |
| Umi Kalsom Yusof | UPM |
| Joanes Unggang | UPM |
| Wong Khoon Meng | Rimba Ilmu University of Malaya |
| Catherine Yule | Monash University Malaysia |

**Mongolia**

| | |
|---|---|
| Tsetseg Baljinova | Division of Microbiology, Institute of Biology, Mongolian Academy of Sciences |

**Netherlands**

| | |
|---|---|
| Pieter Baas | National Herbarium of the Netherlands |

**New Zealand**

| | |
|---|---|
| Christine Reed | National Advisor - Indigenous Flora and Fauna |
| Dennis Gordon | National Institute of Water and Atmospheric Research |

**Philippines**

| | |
|---|---|
| Lourdes Cardenas | Museum of Natural History |
| Domingo Madulid | Philippine National Herbarium, National Museum |
| Esperanza Maribel Guiao Agoo | De La Salle University |

**Singapore**

| | |
|---|---|
| Ruth Kiew | Herbarium and Library, Singapore Botanic Gardens |

**Taiwan**

| | |
|---|---|
| Chang-Hung Chou | National Pingtung University |
| Keng-Hsien Lin | Institute of Zoology, Academia Sinica |
| Yung-Chang Lin | Institute of Zoology, Academia Sinica |
| Kwang-Tsao Shao | Academia Sinica |

| | |
|---|---|
| Yuan-Lung Yu | Institute of Zoology, Academia Sinica |

**Thailand**

| | |
|---|---|
| Chalinee Kongsawat | Thailand's ASEANET National Coordinator |
| Somchai Bussarwit | Phuket Marine Biological Center |
| Wichien Yongmanitchai | Kasetsert University |
| Wangworn Sankamethawee | CMU Herbarium, Department of Biology, Chiang Mai University |
| Vullapa Arunpairojana | Microbiological Resource Centre (MIRCEN), Thailand Institute of Scientific and Technological Research (TISTR) |

**UK**

| | |
|---|---|
| Nick King | BioNET INTERNATIONAL |
| David McL. Roberts | Natural History Museum, London |
| Jameson H. Seyani | Commonwealth Science Council |

**U.S.A.**

| | |
|---|---|
| Annie Simpson | National Biological Information Infrastructure, US Geological Survey |
| Guanghua Zhu | Missouri Botanical Garden (Flora of China) |

**Vietnam**

| | |
|---|---|
| Hong Nguyen Xuan | National Institute for Plant Protection |
| Hoa Thi Tran | Institute of Agricultural Genetics, Section for Biodiversity & Biosafety |
| Tien Hiep Nguyen | Vietnam National Centre for Natural Science and Technology |

# Appendix 8. Sponsors, report editors and contact details

**Major sponsor of the workshop**
National Institute for Environmental Studies, Japan. The workshop was supported by the Special Coordination Fund for Promoting Science and Technology of the Ministry of Education, Culture, Sports, Science and Technology (MEXT) Japan, and the Global Environmental Research Fund of Ministry of Environment, Japan.

**Other sponsors of the workshop**
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Ian Cresswell, ABRS, Australia
Dennis Gordon, NIWA, New Zealand
Sophia Hirakuri, UNU, Japan
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Keiichi Matsuura, Natnl Sci. Museum, Japan
Tatsuo Sasaoka, Biodiversity Center Japan, Japan
Karen Wilson, RBG Sydney, Australia
Minoru Soeya, Ministry of Environment, Japan
Junko Shimura, NIES, Japan

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Maryati Mohamed, Universiti Malaysia Sabah
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# PROCEEDINGS

## 1st GTI Regional Workshop in Asia

*September 10-17, 2002*

# PROCEEDINGS

## Chapter 1:
## Taxonomy and biodiversity conservation in the countries, economies and regions

# DWNP Scientific Zoological Reference Centre

Sahir Othman, Noor Alif Wira Osman and Lim Boo Liat
*Department of Wildlife and National Parks Peninsular of Malaysia (DWNP)*

The Department of Wildlife and National Parks (DWNP) is the custodian of wildlife in the country covering all vertebrate wildlife species with special emphasis on the protection, management and conservation of endangered large mammals, such as the large cat species, elephant, rhinoceros, banteng, tapir, gaur and serow. At the start of the new millennium, management emphasis has been widened still further to include all biological species, the ecological interaction between them and the environment on which they depend-biodiversity. These would include conservation education, research and most importantly managed eco-tourism. With these responsibility, the DWNP recognises that there is critical need to:

a. Perpetuate the general public's faith in government agencies such as the DWNP, that have been assigned responsibility for the conservation of wildlife.
b. Ensure our ability as a nation to manage and develop our resources in a sustainable and equitable way.

The DWNP since 1987 has started a research laboratory for the study of small vertebrate fauna in Peninsular Malaysia with the objective of establishing a scientific vertebrate species reference collection with the aims of:

1. Training of young morphological taxonomist (systematics) the latter are fast becoming endangered species.
2. Reference collection of type specimens on vertebrate fauna of the country.
3. An zoological education centre for students from schools, graduate students from universities and general public where they can view and be aware of the rich fauna biodiversity resources of the country.
4. A teaching vertebrate zoology museum for university graduates and post-graduates for their research and dissertation courses.
5. Training of the States DWNP personnel throughout Peninsular Malaysia to undertake zoological studies of small vertebrate fauna in each of the states.
6. Facilitate scientists and post-graduates from Europe, USA, India, Thailand, Vietnam and China such as a reference prelude to their studies on small vertebrate fauna in Southeast Asia.

The Research Laboratory established in 1987 was fast running out of storage space for the scientific reference collections made. A proper museum building with adequate facilities for the storage and maintenance of the collection was inevitable, and with full support from the government, the museum building was established in the Sixth Malaysian Plan (1991-1995). Table 1 shows the total number of dry and wet specimens and species for each of vertebrate taxa so far deposited in the museum. In addition the invertebrate collection comprising more than 200 species mainly moths, butterflies, beetles etc. are also curated.

**Table 1. Comparison on the Percentage of vertebrate species in Museum collection against total of species in Peninsular Malaysia**

| No. | Taxa | No. of specimens | No. of species collection | No. species in P. Malaysia | Percentage (%) against total sp. in P. Malaysia |
|---|---|---|---|---|---|
| 1. | Fish | 100 | 46 | 350 | 13.1 |
| 2. | Amphibians (Frog, toads caecilian) | 1300 | 74 | 97 | 76.3 |
| 3. | Reptiles (Lizards, Geckos and Crocodiles) | 135 | 62 | 105 | 59.0 |
| | Snakes | 345 | 84 | 150 | 56.0 |
| | Turtles | 15 | 9 | 29 | 31.0 |
| 4. | Birds | 500 | 110 | 638 | 17.2 |
| 5. | Volant mammals (Bats) | 2840 | 84 | 107 | 78.5 |
| 6. | Non Volant mammals (Rodents and small carnivores) | 655 | 67 | 110 | 60.9 |
| | | 5990 | 536 | 1606 | 33.4 |

The zoological reference collections in the museum are also made available to scientists, graduates and post-graduates from universities from abroad and at home. To date a total of 71 people comprising of 48 scientists and 23 graduates and post-graduates used the reference collections in the museum for their studies and towards their degree dissertation. (Table 2).

**Table 2. Students, graduates and post-graduates from overseas and local Universities**

| No. | Institutions | Year | Scientist | Graduate and Post-Graduate | Remarks |
|---|---|---|---|---|---|
| 1. | UKM (University Kebangsaan Malaysia) | 1998-2002 | - | 7 | B.Sc and M.Sc dissertations |
| 2. | UPM (University Putra Malaysia) | 1999-2001 | 3 | - | Examination of museum reference materials |
| 3. | USM (University Sains Malaysia) | 1999-2002 | 2 | - | Examination of museum reference materials |
| 4. | UNIMAS (University Malaysia Sarawak) | 1999-2002 | 4 | - | Examination of museum reference materials |
| 5. | UNIMAS (University Malaysia Sarawak) | 2000 | - | 1 | Examination of museum reference materials |
| 6. | UMS (University Malaysia Sabah) | 1999-2001 | 3 | - | Examination of museum reference materials |
| 7. | UMS (Universiti Malaysia Sabah) | 2000 | - | 2 | B.Sc dissertations |
| 8. | KUSTEM Terengganu | 2000-2001 | - | 2 | B.Sc dissertations |
| 9. | UM (Universiti Malaya, K.Lumpur) | 1998-1999 | - | 2 | Examined museum reference materials |

| | | | | | |
|---|---|---|---|---|---|
| 10. | Chulalongkorn University, Thailand | 2000 | - | 2 | Examined museum reference materials |
| 11. | UiTM (University Teknologi Mara) | 2000-2001 | - | 3 | Examined museum reference materials |
| 12. | University of Madras, India | 1999 | 2 | - | Examined museum reference materials |
| 13. | University of Pondicherry, India | 1999 | 2 | - | Examined museum reference materials |
| 14. | University of Wales, Britain | 1998-1999 | 2 | - | Examined museum reference materials |
| 15. | University of Wales, Britain | 1998-1999 | - | 1 | Ph.D dissertation |
| 16. | Boston University, Boston, USA | 1998-2000 | 3 | - | Examined museum reference materials |
| 17. | University of La Selle, Carlifornia, USA | 1998-2002 | 4 | - | Examined museum reference materials |
| 18. | University of Tokyo, Japan | 1998-2002 | 4 | - | Examined museum reference materials |
| 19. | University of Aberdeen, Scotland, Britain | 1997-2000 | 4 | - | Examined museum reference materials |
| 20. | University of Copenhagen, Denmark | 1998-2001 | - | 2 | M.Sc dissertation |
| 21. | Miyazaki Medical Collage, Japan | 2001 | 1 | - | Examined museum reference materials |
| 22. | Nagoya University, Japan | 2002 | 1 | - | Examined museum reference materials |
| 23. | NIES (National Institute for Experiment studies) | 1997-2001 | 3 | - | Examined museum reference materials |
| 24. | Singapore National Museum | 1999-2002 | 3 | 2 | Examined museum reference materials |
| 25. | British Natural History Museum, London | 1998 | 1 | - | Examined museum reference materials |
| 26. | American Natural History Museum, New York | 1998 | 1 | - | Examined museum reference materials |
| 27. | Natural Museum, Washington D.C USA | 1998 | 2 | - | Examined museum reference materials |
| 28. | Chicago Natural History Museum, Chicago USA | 1999-2001 | 2 | - | Examined museum reference materials |
| 29. | Natural History Museum, Australia | 1999 | 1 | - | Examined museum reference materials |
| | | | 48 | 23 | |

The museum also cater for school children and the publics where lectures are given on the faunal biodiversity and its conservational value. Foreign dignitaries, such as conservationist, scientists and important government officers also visited the museum where they were briefed on the functions of the museum and its reference collection. During the period from 1997-2002, a total of 658 visitors visited the museum (table 3).

**Table 3. Visitors to the Museum**

| No. | Visitors to the Museum | Year | School Children | Public Visitors | Foreign Visitors | Total |
|---|---|---|---|---|---|---|
| 1. | Student from primary and secondary schools | 1997-2002 | 468 | - | - | 468 |
| 2. | Public organisations | 1997-2002 | - | 125 | - | 125 |
| 3. | Foreign visitors from Asia, Southeast Asia, Europe and America | 1997-2002 | - | - | 65 | 65 |
| | | | 468 | 125 | 65 | 658 |

Presently no national repository exists in the country in as far as a scientific reference collection is concerned. There are small collections of such material that are scattered in different institutions and universities for teaching purposes only. The Museum Negara in Kuala Lumpur, as part of its functions, is to be a repository for natural history reference collection, but since its establishment in the 70s it has been primarily a display museum.

The DWNP's zoological reference museum, though young, is highly active as an "Education Centre of Natural History". Its principal role is to serve as readily accessible depository and source of reference for all vertebrate animal species (fish, bird, mammals and amphibian and reptiles) that can be further extended to include other important invertebrate species as well. Based on the popular visits illustrated in table 2 and 3, the present museum should be established as a centralized national history collections which could then be the "National Scientific Zoological Reference Centre" of Peninsula Malaysia.

# All India Coordinated Project on Capacity Building in Taxonomy (AICOPTAX) – An Overview

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## Abstract

**Sound taxonomic knowledge base is pre-requisite for sustainable use of biological resources. At this juncture, when the need for a taxonomic stocktaking of the earth's bio-diversity has become important, the taxonomic expertise is declining globally. Studies indicate urgent need to encourage excellence and motivate experts to work in hitherto neglected groups of organisms, e.g. microbes, lower groups of plants, animals etc. A comparison of number of species described and estimated in India in major taxonomic groups and the number of available taxonomists in the country indicate that the expertise is inadequate. Also, the taxonomic expertise is not evenly distributed for different groups. In fungi and bacteria, number of estimated species are about 85,000 and 3,29,000 respectively. Taxonomic experts available in India in these areas are only 15 and 20 respectively. On the other hand, the estimated number of species in angiosperms are only 20,000. Experts available in India in angiosperms are 130.**

**In this background, the Ministry of Environment and Forests, Government of India set up a Technical Group to develop an All India Coordinated Project on Capacity Building in Taxonomy (AICOPTAX) and after inter-ministerial consultations, the project was launched in 1999-2000. The project envisaged establishment of centres for research in identified priority gap areas (e.g. viruses, bacteria, microlepidoptera, etc.) for taxonomy, education and training and also strengthening of existing organizations. So far, 12 centres for research, each with 4 to 6 collaborating units, and two centres for training have been established. Financial assistance is provided to these centres for undertaking taxonomic activities. Each research centre is engaged in training about 10 research scholars. In addition, the training centres are imparting training in Bio-systematics using latest technologies. Presently, the project is for a period of five years. Its future continuation will be decided after taking into account the achievements and future requirements.**

***Key words : Taxonomy, Biodiversity, AICOPTAX, Capacity Building***

## Introduction

Taxonomy is the science of identification, classification and naming of organisms. Taxonomic work involves study of morphological characteristics and phylogenetic relationships of organisms. Knowledge of taxonomy is essential for applied biological sciences including medicine, agriculture, forestry and fisheries. Also, a sound taxonomic knowledge base is a prerequisite for environmental assessment, ecological research, effective conservation, management and sustainable use of biological resources etc. At this crucial juncture, when the need for a taxonomic stocktaking of the earth's biodiversity is becoming increasingly important and urgent, it is being realized that the taxonomic expertise is aging and declining in number in India as well as globally. This decline of taxonomic expertise is likely to create problems in assessment and conservation of biodiversity. It needs to be addressed urgently. Current requirements of taxonomic work and available expertise and studies indicate an urgent need to encourage excellence and motivate experts to do work in hitherto neglected groups of organisms e.g. microbes, lower groups of plants, animals etc. The challenge is quite serious because while on the one hand the existing expertise is aging and retiring, on the other not many young scholars are opting for studies in taxonomy. This is true for India and it is likely that the same situation exists in other countries.

## Indian Scenario

In Indian context, this aspect attains greater importance on account of the fact that India is one of the 12 mega biodiversity nations of the world. So far about 47,000 species of flowering and non-flowering plants have been identified in the country. This makes about 12% of the recorded world's flora. Group-wise details have been given in Table 1.

**Table 1.**

**Comparative statement of recorded number of plant species in India and the world**

| Taxa | Species | | Percentage of India to the World |
|---|---|---|---|
| | India | World | |
| Bacteria | 850 | 4,000 | 21.25 |
| Viruses | Unknown | 4,000 | - |
| Algae | 6,500 | 40,000 | 16.25 |
| Fungi | 14,500 | 72,000 | 20.14 |
| Lichens | 2,000 | 17,000 | 11.80 |
| Bryophyta | 2,850 | 16,000 | 17.80 |
| Pteridophyta | 1,100 | 13,000 | 8.46 |
| Gymnosperms | 64 | 750 | 8.53 |
| Angiosperms | 17,500 | 2,50,000 | 7.0 |

As far as faunal diversity is concerned, about 89,500 animal species have been recorded in India. This works out to about 7.28% of the total faunal diversity present on the earth. A comparative statement providing details about the number of animal species belonging to different groups so far recorded on the earth and in India is given in Table-2. The guess estimates for these organisms for India is much higher. For example, guess estimate for bacteria for India is about 85,000 species, for fungi it is about 3,29,000 species, for insects it is more than 5.0 lakh species and for Molluscs it is about 14,500 species and so on. These figures clearly indicate that the achievements so far made in India with respect to identification and description of floral and faunal diversity are far from satisfactory. Another factor which is evident in Indian context is that the taxonomic expertise is not evenly distributed for various groups of organisms. Certain groups have very low or almost nil expertise. For example, in case of Fungi and Bacteria, the taxonomic experts available are only 15 and 20 respectively. On the other hand, the number of species of angiosperms estimated to be present in the country is only about 20,000. The number of experts in this field is 130.

**Table 2.**

| Comparative statement of recorded number of animal species in India and the world | | | |
|---|---|---|---|
| **Taxa** | **Species** | | **Percentage of India to the World** |
| | **India** | **World** | |
| Protista | 2,577 | 31,259 | 8.24 |
| Mollusca | 5,070 | 66,535 | 7.62 |
| Arthropoda (Insecta, crustacea etc) | 68,389 | 9,87,949 | 6.90 |
| Other invertebrates | 8,329 | 87,121 | 9.56 |
| Protochordata | 119 | 2,106 | 5.65 |
| Pisces | 2,546 | 21,723 | 11.72 |
| Amphibia | 209 | 5,150 | 4.06 |
| Reptilia | 456 | 5,817 | 7.84 |
| Aves | 1,232 | 9,026 | 13.66 |
| Mammalia | 390 | 4,629 | 8.42 |

## Initiative from Ministry of Environment and Forests, Government of India

Taking into account, the uncomfortable situation in the country with respect to taxonomic studies and expertise, the Government of India organized a two day Workshop in February, 1997. Top taxonomic experts of the country were invited to attend the workshop. During the workshop critical gap areas where taxonomic expertise in the country was fast dwindling or had almost vanished were identified. The workshop then recommended that the Government should take immediate measures to develop taxonomic expertise in the country. An All India Coordinated Project on Capacity Building in Taxonomy (AICOPTAX) was suggested. The Ministry of Environment and Forests then set up a technical group to develop the project. The technical group held discussions with various agencies including other Ministries and Departments of the Government and developed a full-fledged project. In due course, the project was approved for implementation.

## All India Coordinated Project on Capacity Building in Taxonomy (AICOPTAX)

The AICOPTAX project suggested establishment of centres for research in identified priority gap areas such as viruses, bacteria, fungi, microlepidoptera, helminthes etc. to carry on taxonomic research and education and training programmes. Also, provisions were made for fellowships, scholarships, chairs, career awards etc. Simultaneously, provisions were made for strengthening Botanical Survey of India and Zoological Survey of India, the two premier survey organizations in the country responsible for survey of plant and animal wealth of the country. The AICOPTAX project was launched in 2000. It has been continuing for the last about 3 years. So far twelve subjects for taxonomic research and two centres of training have been identified. These subjects are

- Animal Viruses
- Bacteria and Archaea
- Bamboos and Grasses

- Diptera
- Fungi
- Lichens and Bryophytes
- Mollusca
- Microlepidoptera
- Helminthes and Nematodes
- Orchids
- Palms
- Peridophytes and Gymnosperms
- Training in Plant Biosystematics
- Training in Animal Biosystematics

For each subject an experienced expert in taxonomy has been identified to act as Coordinator. He/she heads the Coordinating Unit for the subject. For each subject there are four to six Collaborating Units across the country headed by one Collaborator each. The Coordinating units and the Collaborating Units together undertake various activities such as

- Survey, collection, identification and preservation
- Maintain collections and taxonomic databanks
- Develop identification manuals
- Train college teachers and students and local communities in para taxonomy
- Training of two research scholars at each unit

Financial assistance for running the AICOPTAX is provided by the Ministry of Environment and Forests, Government of India directly to the Coordinating units and Collaborating units. Initially, the project was planned for five years. Its continuation will be decided after the evaluation of the achievements made during this period.

## Achievements so far

Since the implementation of the AICOPTAX in the country substantial achievements have been gained especially, with respect to the taxonomy of the organisms belonging to the groups which are included in the project. Some of the achievements are being listed below:-

### Animal Viruses

Various units working on animal viruses are studying different groups of viruses. One group is working on viruses of Blue tongue disease of sheep. Another group is working on pox viruses of animals, especially sheep and goats. The third group is working on non-polio enteroviruses. Non-polio enteroviruses were selected by this group taking into account that they cause acute flaccid paralysis in children and so far they have not been investigated properly in India. The lab has collected 58 specimens including 46 clinical and 12 environmental samples for non-polio enteroviruses. Out of the 58 samples, 34 were found positive for NPEV isolation. Serotyping for these viruses has been completed. The fourth unit has chosen to work on viruses affecting the nervous system of humans. The collaborating unit is working on bacteriophages of salmonella and study of the viruses in immuno compromised humans.

## Bacteria and Archaea

The coordinating unit on Bacteria and Archaea has developed a working manual for microbial taxonomy. This document which provides details regarding isolation and characterization of rhizobia based on various tools is attempted for early researchers, postgraduate students and others faced with the daunting task to assigning the taxonomic and phylogenetic relationships. The information compiled is based on actual experience of laboratory techniques. The gene pool used for the purpose is neither large enough nor representative of the existing seven genera but it is hoped that for those handicapped by way of information search and methodologies, this compendium will prove helpful. This unit has also developed a summer training module for functional and molecular characterization of plant rhizospheric bacteria. The unit has a total of 3000 bacterial isolates which have been preserved as glycerol stocks for identification which is in progress.

One of the collaborating units working on 10 thermophilic isolates obtained from soil, sediments and water samples from hot springs have recorded the presence of *Bacillus stearothermophilus* (6 isolates) *B.coagulans* (3 isolates) and *B.alvei* (1 isolate). Study of Methanogenic bacteria obtained from a lake has resulted in isolation of two acetate utilizing methanogens from the sediment samples. Both the isolates were found growing optimally at 35 $^{o}$ C. One of the isolates is being studied further as it grows well in alkaline conditions. The optimum growth at pH 9 was not known for *Methanosarcina*. Another collaborating unit working on Bacteria and Archaea has collected large number of samples of soil, water and rocks, leaf, skin of animals and human beings etc. from different places in arid Rajasthan. The study has resulted in 37 isolates of micrococci. These bacteria are being characterized on the basis of 64 attributes. Twenty five out of 35 isolates have already been characterized.

A third collaborating unit working on soil bacteria has come across 230 isolates from 22 soil samples collected from various localities. 184 have been found to belong to the genus *Bacillus*. Various isolates of *Bacillus* were observed to secrete amylolytic, celluloytic, lipolytic, xylanolytic, pectinolytic and chitinolytic enzymes. Three isolates were found to produce extracellular antimicrobial compounds. One isolate exhibited inhibitory activity against *Bacillus* spp and *Micrococcus* sp. and fungi such as *Aspergillus niger*, *Neuropora* sp. and *Thermomucor* spp. 34 *Bacillus* isolates were observed to produce extracellular pectinolytic enzymes and 26 *Bacillus* isolates exhibited clear zones of chitin hydrolysis on solid medium containing chitin. Also, it was observed that majority of *Actinomycete* isolates (88%) secreted xylanolytic enzymes.

## Bamboos and Grasses

One of the collaborating units on Bamboos and Grasses has re-discovered the endemic species *Eriochrysis rangacharii* C.E.C. Fisch. This species was not spotted during the last about 100 years and it was included in the Red Data Book of Indian plants. During the study this species has been found growing in the Nilgiri hills of South India. Similarly, one species of *Eragrostis* has been found to be quite distinct from other allied species. This species is being examined to ascertain if it is a new species. One of the *Panicum* species collected in a naturalized condition appears to be *Panicum plenum* Hitchc.& Chase, a North American species. These specimens are being studied to confirm the exact identity. One of the collaborating units is engaged in collection of detailed taxonomic information on bamboo rich Eastern India. The purpose is to prepare a detailed account of the bamboos found in the region including North Eastern part of the country as the bamboos play very import role in the economy of the area. Similarly, another collaborating unit is engaged in detailed survey of bamboos found in the southern part of the country. This group has discovered an interesting species of *Dendrocalamus* from the state of Maharashtra. It may turn out to be a new species. One of the Collaborating Units working in Maharashtra found some grass specimens which do not match with any Indian grass species. Efforts are being made to identify these. Also, a new species of *Themeda* i.e., T.*pseudotremula* has been communicated to Kew Bulletin. Still another unit has collected *Davidsea attenuata* from the state of Kerala. This bamboo was so far known from Sri Lanka only. Also, two species of *Ochlandra* have been collected from Kerala state. It is expected that these may be new to science.

## Fungi

One of the collaborating units has made extensive survey of various locations in Central India for fungi infecting common weeds. More than 550 fungal isolates were recovered from 300 different samples of 30 weeds. It included 24 highly pathogenic fungi. The unit has also undertaken extensive seedling and whole plant bioassays with respect to the fungal isolates to determine their herbicidal potential. The purpose is to explore the possibilities of use of fungi to control weeds. Another collaborating unit working on keratinophilic fungi has isolated various specimens from different habitats supposed to be rich in keratinous substrates. During the study several species have been recorded which are new to India and also certain species have been recorded which are new to keratinophilic flora. One collaborating unit on fungi is concentrating on entomogenous fungi. They have recorded large number of entomogenous fungi from the forests and several other localities of Western Ghats of southern India. Also, efforts are being made to isolate and document litter inhabiting hyphomycetous fungi from the forests of Western Ghats. So far 175 entomogenous fungi have been recorded in pure culture and a total of 161 litter inhabiting fungi have been recorded from the area. The collaborating unit on fungi has concentrated itself on higher Basidomycetes of southern India. So far they have collected more than 400 specimens from different areas. Presently identification of the collected material is in progress. Preliminary observations have indicated that white spored taxa showed higher diversity than the dark spored taxa. Genus *Russula* showed wide range of distribution in certain forest areas of South India. Earlier, this unit collected 176 fungal species. Altogether, 20 species of *Aspergillus* were isolated from soil. *Penicillinum rubrum* and *P. frequentens* were also isolated from soil. 120 fungi belonging to hyphomycetes and fungi imperfecti were also collected.

## Lichens and Bryophytes

About 200 follicolous lichen specimens have been studied and identified into 32 species. 250 specimens of *Cladonia* have been studied and identified into 39 species. These specimens were collected from the North Eastern part of the country. From the Northern part of the country 400 specimens have been collected and these have been identified to be belonging to 38 genera and 99 species. The flora is dominated by foliose lichens (48 species) followed by crustose and fruticose lichens (46 and 4 respectively). During the study it was found that most of corticolous lichens are epiphytic on *Pinus, Quercus* and some broad leaf trees. During the study, *Hyperphyscia isidiata* (Moberg) was recorded first time in the country. Another collaborating unit working on lichens in the North East India collected 250 specimens. A total of 38 species were identified. Eight are new records for India. Similarly, three folicolous species were found which were new for the country. Another collaborating unit working in the Nilgiri Hills reported the presence of *Exormotheca ceylonensis* Meijer, earlier reported from Nilgiri way back in 1964 by Udar and Chandra and was never collected again since then. It has become rather rare and is present very scantily in Nilgiri. It has been now recorded from two localities. *Palgiochasma appendiculatum* Lehm.et Lindenb known from Kodaikanal now shows its occurrence in Nilgiri hills also. *Taxilejeunea eckloniana* Lindenb, one of the two species of *Taxilejeunea* (Spruce) Schiffin. emend Schuster known from India has been collected from a different region. *Diplophyllum nanum* (Dum.) Herz, a representative of family Scapaniaceae earlier known only from Eastern Himalayas in India is reported for the first time not only from Nilgiri hills but also from South India. A different collaborating unit has been successful in collecting over 1500 specimens of various groups of lichens from different localities in the Western Ghats. During the study an interesting and rare lichen genus *Sclerophyton* which was not reported from India earlier was found growing in the Western Ghats of Maharashtra State. The new species has been described as *Sclerophyton indicum.*

## Mollusca

Coordinating and collaborating units on Mollusca have concentrated on the Southern part of the country. 37 species of gastropods have been collected from the South East coast of India. Coordinating unit is preparing a check-list of 258 land snails of Western Ghat.

## Microlepidoptera

Various collaborating units and the coordinating unit have made collections from different areas of the country. One of the collaborating units has prepared permanent slides for 210 species. 148 species have been identified up to the family level while 47 species have been identified up to genus level. Another collaborating unit has collected 3103 individuals and these have been classified into respective families. A third collaborating unit has surveyed 15 localities in the Central part of the country. It has collected more than 3200 specimens. A study of their distribution have shown variations in different areas. Another collaborating unit working in the North East part of the country has collected more than 3300 specimens and these have been classified upto family level for ten families. Coordinating unit for Microlepidoptera has collected more than 1200 specimens from Northern part of the country and classified them to the family level. In case of Microlepidoptera certain difficulties are being encountered in proper identification on account of lack of reference material. We are looking at possible ways to solve this problem.

## Helminthes and Nematodes

The coordinating unit on Helminthes and Nematodes is concentrating on entomophilic nematodes and soil nematodes. During the course of study various genera of entomohilic nematodes belonging to 4 families of the super family Thelastomatoidea were collected from invertebrate hosts while working on the soil nematodes. In all, 73 genera have been identified of which 20 belong to Rhabditida, 13 belong to Diplogastrida, 14 to Dorylaimida, 10 to Mononchida, 3 to Aphelenchida, 5 to Tylenchida, 4 to Enoplida, 2 to Monhysterida and 1 each to Araeolaimida and Chromadorida. One of the collaborating units on Helminthes is working on helminth parasite diversity in the North Eastern part of India. Among the siluroid fishes (*Clarias* and *Heteropneustes* spp), monozoic cestodes of the Order Caryophyllidea emerged as the predominant parasitic form. All other fish host types revealed the occurrence of digenetic trematodes and enteric nematodes. However, the prevalence and intensity of the helminth infection in these fishes was, in general, quite low. Mithuns (*Bos frontalis frontalis*) in Arunachal Pradesh and also in Bhutan were found to harbour nematodes as the predominant helminth species. In freshly slaughtered mithuns three types of nematodes were found, of which *Strongyloides* sp. was present in large numbers (150-200). Another collaborating unit working on the plant parasitic nematodes in the state of Manipur has identified 114 nematodes. They belong to 24 different genera, 11 subfamilies, 8 families, 2 superfamilies – Tylechoidea and Criconematoidea and suborder – Tylenchina.

Another collaborating unit working on Helminthes found as fish parasites in different habitats has come across several cases which may be considered new to the project of Helminthology. Three of these belong to trematodes and 6 to nematodes groups. Seasonal dependence on the existence of certain parasites have already been recorded. Parasitic infection was found to be maximum during autumn season 75% , moderate in summer 47% and minimum in winter season 18% signifying that moderate temperature favours the parasites to survive while low and high temperatures are not suitable for the existence of the parasites.

## Palms

In case of Palms, several survey trips have been conducted in the North Eastern part of India and also in the Southern part of the country. The material collected during these surveys are being identified. Also, a nursery has been created through collection of seeds from the field. The nursery includes rare species *Calamus inermis*. The nursery also contains seedlings of rare rattan cane from Meghayala *Calamus khasianus*.

## Pteridophytes and Gymnosperms

*Ephedra gerardiana* was collected from wild localities in the state of Uttranchal. It was found to be occurring naturally in the area. A source book has been created through compilation of available information about pteridophytes in the state of Kerala. Earlier, the information was spread over in various publications. The data base contains information on 331 species belonging to 32 families and 32 genera, including 42 fern-allies. Also, it has been documented that 35 species are very rare, 112 species are rare and 102 species are common in the area. The rare filmy fern *Crepidomanes christii* which was earlier known to be growing at only one place in Kerala state has been recorded from a sacred grove in another area. Similarly, *Bolbitis crispatula* which was earlier known from the northern part of India was collected from the state of Kerala (South India). Thus, the present collection became a new record for the South Indian Flora. In another study, a new record of *Lygodium altum* (Clarke) v.A.v.R from Orissa state was recorded. Earlier, it was not recorded to be growing there. During the study on pteridophytes a large number of fern species from the state of Andhra Pradesh and Tamil Nadu in India have been recorded. These are being identified.

## Training in Bio-systematics

The two centres on training have conducted various programmes. One programme was on preservation and identification of zoological specimens. Another programme was organized on wildlife DNA extraction and finger printing. The programme was aimed at imparting latest knowledge on the application of DNA technology in conservation genetics, DNA marker studies on some endangered species etc.

The Centre related to plant bio-systematics has conducted several training programmes related to :

(a) refinement of boundaries and delimitation of taxa,
(b) delineation of gene pools,
(c) assessment of genetic diversity,
(d) bio-prospecting,
(e) GIS based diversity assessment,
(f) role of reproductive biology in speciation,
(g) taxonomic database management and information retrieval etc.

Scientists, teachers, researchers and others working in the area of plant and animal taxonomy have participated in these programmes.

## Conclusion

The AICOPTAX is under implementation for about last two and half years and the achievements made so far are substantial. It has provided opportunity for scientists and workers to engage themselves in areas which were so far generally neglected. Large number of new species, new records and new habitats have been recorded for various groups. Considering the success of the project, recently two new subjects i.e. Diptera and Orchids were added. Studies related to these subjects have started only now. This is the reason why we are not reporting findings for these two subjects, presently.

The launching of AICOPTAX in the country and its successful implementation has made it clear that taxonomy as a subject is welcome to the scientists, teachers, researchers and students. If they are provided adequate financial and other facilities, they can achieve the desired goal in the field of taxonomy. It will be of great help in the assessment, evaluation and conservation of biodiversity.

# Utilization of Indonesia Biodiversity Information System (IBIS) for Biodiversity Data Management in Indonesia. Case study: Flora from Nusakambangan Island, Central Java, Indonesia

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## Abstract

**Since the year 2000, some of the biodiversity data collected from Nusakambangan Island has been computerized manage using Indonesia Biodiversity Information System (IBIS) software. By this software data can be organized well and classified easily. Users can retrieves their data that has been entered to the system using searching application. By the special criteria that can be chosen by users through lookup list, data output/results can be exported to text or spreadsheets format for further analyses.**

**This paper will discuss about the procedures how to use this software for extracted and compiled biodiversity data from Nusakambangan for further spatial and non-spatial analyses. By this method, important information can be created and produced as a basic data for landscape and biodiversity management especially in Nusakambangan Island.**

***Key Words: Nusakambangan, biodiversity, management, spatial analyses, software***

## Introduction

Indonesia Biodiversity Information System (IBIS) is developed by Research Centre for Biology - LIPI for biodiversity data management maintained in this institute. There are three divisions under this Centre Research, that is Botany Division for herbarium specimen, Zoological Division for zoological museum collection and Microbiological Division for microbe living collection. This institute using IBIS must maintain about 2 million herbarium specimen, 1.7 million zoological museum specimens and 20,000 strain of microbe living collection.

Collecting biodiversity data has been conducted since 19 century. This activities was started when Herbarium Bogoriense was established in 1841 and later in the year of 1894 followed by establishing of Museum Zoological Bogoriense.

As a database application, IBIS has several modules developed in this structure. Every module has linked to each other in order to optimizing data flow when the system is running (Roemantyo, et al, 2002). The module is comprises specimen data (herbarium, zoological museum and microbe living collection), maps data, field survey data and bibliography. Through the inbound linked keys inside the modules, data in every module can be searched and displayed together on the map view. Query data results can be exported to the text files or spreadsheets for further analyses.

This paper will discuss about biodiversity data management using IBIS with special reference to flora data collected from Nusakambangan Island, Central Java, Indonesia. Nuskambangan is a small island located in southwest part of Central Java (7°42'52" S - 7°44'50'S and 108°44'04'E - 108°47'05E), about 36 km long and 6 - 8 km width. This island mainly covered by lowland rain forest vegetation, but in many places has been cut and replaces it by rubber or coconut plantation.

## Flora data in IBIS

More than 1,000 records of biodiversity data have been entered to IBIS. Old biodiversity data mainly originated from specimen modules collected before 1940 when Dutch government still occupy this country. New data was recorded to Field Survey Database modules base on field survey and observation activities since the year 2000. Between 1940 - 1999 not so many researchers visiting for research and observation in the island. This is because Indonesia Government classifies Nusakambangan as a prison island; therefore not so many people can get permission to come to this island. High security level was practiced for every visitor who wants to visit to this island.

Biodiversity data was extracted and compiled by IBIS searching application. The data output (results) is used for further analyses. Data were collected during field survey activity in the year 2000 - 2002 (Partomihardjo, et al, 2001). Coordinate data were collected using GPS reading on every vegetation community and species composition. Base on the data coordinate and other notes recorded in every row of data, spatial analyses were carried out using Erdas Imagine software for geocode correction position. After that all data from IBIS was overlaid on the map reference 1: 25,000 (Bakosurtanal, 2000) using Arc View in order to get information from base map (map reference).

Existing data collected from the field were compared to the information found in the map reference. If there are any difference data between map reference and field data survey, new polygon must be created directly as new map file. Beside that land use and land system thematic map were used in this analyzes for the changes of area status identification. New land use and vegetation map will be created base on new data survey conducted in Nusakambangan. In this analyses land system thematic maps is use to classify recurring type of land. About 128 land system was recognized found in Indonesia (RePPProT, 1989).

## Result and Discussion

Around 655 species of flora belong to 92 families and 262 genera were recorded originated to Nusakambangan Island. It can be noted that some species was important because of their economic status or locally classified as endangered species. The list below explained some examples about the species.

1. Tress *Buchanania arborescens, Palaquium obovatum, Hopea sangal, Gonystylus macrophyllus, Shorea javanica, Shoutenisa ovata, Chydenanthus exelsus, Dipterocarpus littoralis, Parkia roxburghii.*
2. Scrub/Small size tress/Climber *Raufolfia serpentina, Tabernaemontana pauciflora,* rattan species (*Calamus ciliaris, C. flabillatus, C. javensis, C. unifarius, Plectocomia elongata*), *Raflesia patma.*
3. Herb *Amorphophallus campanulatus, A. descus-silvae.*
4. Rare plant species *Gonystylus macrophyllus, Shorea javanica, Shoutenisa ovata, Chydenanthus exelsus, Dipterocarpus littoralis, Pisonia grandis, Raflesia patma, A. descus-silvae.*

Spatial analyses to the species distribution, habitat and their community, indicated that at least 10 habitat types were identified, that can be briefly state as cave, alluvium rock type, limestone, sandstone, intertidal mudflats, wetlands, lake, coastal, rivers, mangrove. Some habitat has been disturbed due to the uncontrolled human activities, such as mining, illegal cutting for making paddy field, developing plantation and fish pound area, etc.

In general vegetation communities can be identify as follow: forest, grassland, old and secondary forest (see Fig.1). Forest vegetation in this island is comprises of mangrove community, coast forest community (sandy beach and rocky slope beach), lowland rain forest community (hilly limestone lowland rain forest and disturb lowland forest).

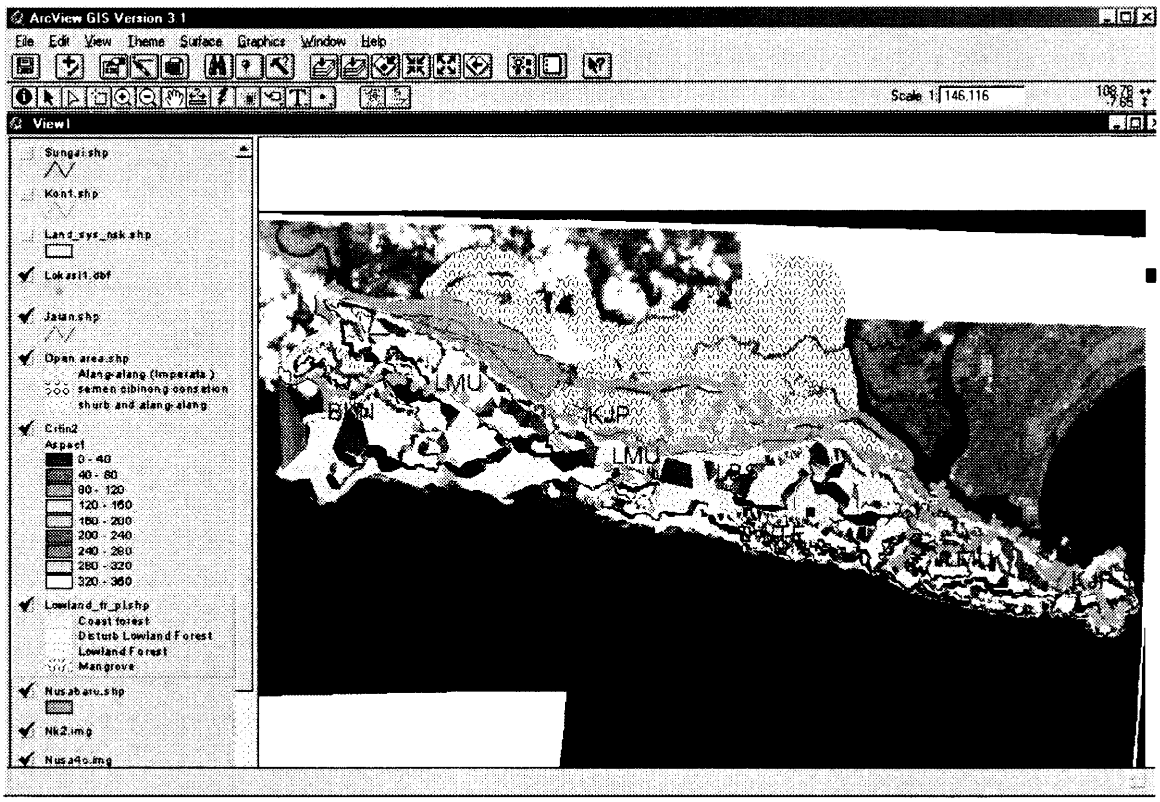


**Fig. 1 Points of observation, species distribution and vegetation type in usakambangan**

In the open area it can be identify that grassland vegetation type was occupy wide area in this island. There are 2 communities found in grassland vegetation type, that is *Imperata* and *Saccharum* communities. *Imperata* communities was more common than *Saccharum* communities.

Old secondary forest occupies wide area of this island, that mainly located in west part of this island and some were located in abandoned rubber plantation. Old secondary forest was originated from lowland rain forest. Due to the scarcity of commercial timber for house construction and furniture sources in mainland Java, illegal felling and encroachment are very common in this area.

Young secondary forest is mainly develop from abandoned ladang/garden near by resettlements that built by illegal visitor or abandoned prison building. This area is not so wide, and mainly located a long the northwest coast of this island.

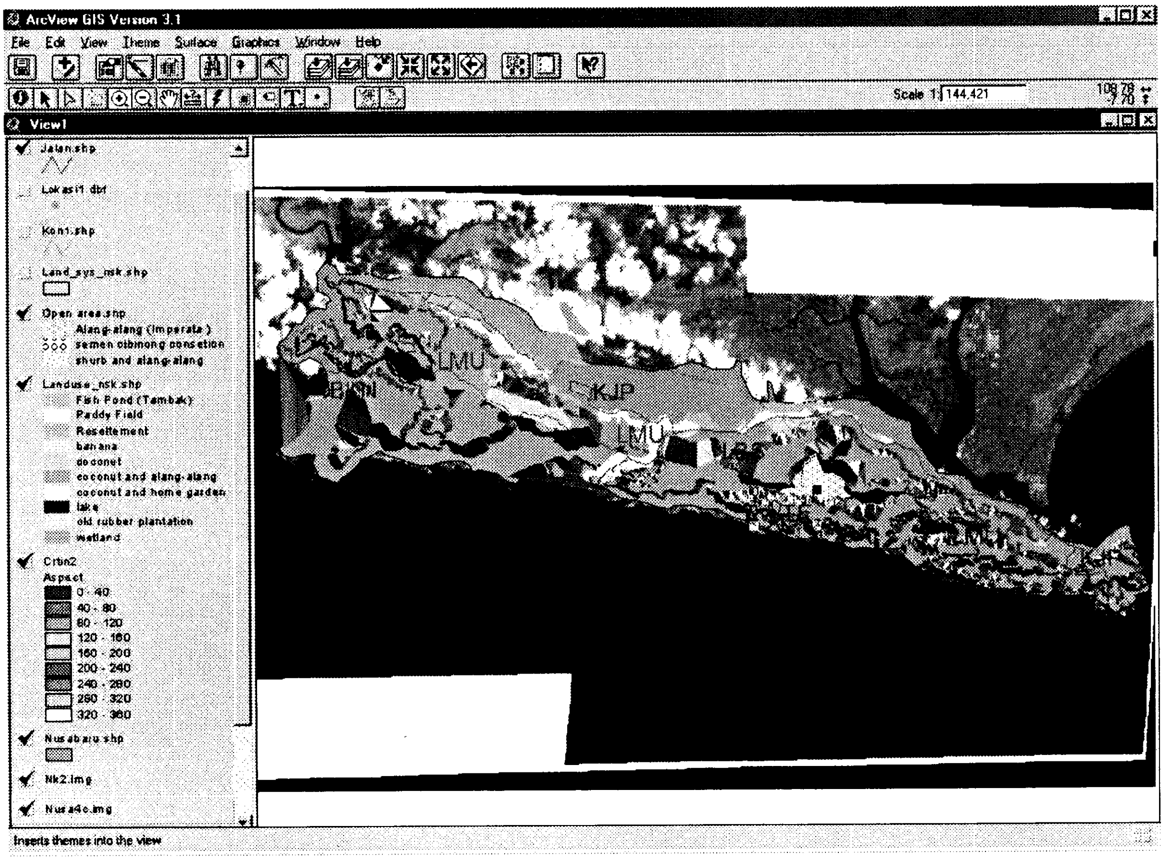


**Fig. 2 Land use map of Nusakambangan**

Base on the detail locality data, about 6 land used type were recognized found in this island, that is: fish ponds, paddy fields, coconut plantations, rubber plantations, banana plantations and resettlements. Compare to the earlier land used map edition (RePPProt 1989) there are any significant changes on land used especially on increasing the area use for fishpond, banana plantation and paddy field.

Analyses to the vegetation type map overlaid by land system map (RePPProt, 1989) showed that there are 6 land systems found in this area (see Fig. 3). Those are:

1. BKN (BAKUNAN) Sedimentary lithology, alluvium rocktype, with minor river floodplains within hill land type.
2. LMU (LEMIRU) Lithology sedimentary, limestone, marl rock type, calcareous. Land type tilted plateau with conical karst hillrock in dry area.
3. KJP (KAJAPAH) Lithology sedimentary, alluvium or recent marine rock types. Land type inter tidal mudflats
4. SAR (SUNGAI AUR) Lithology sedimentary, tuffite, sandstone, fine grain tephra. Hillrocky plain on tuffaceous sediments
5. LBS (LUBUKSIKAPING) Lithology mixed, alluvium rocktype. Gently sloping non volcanic alluvial land types
6. WTE (WATAMPONE) Lithology sedimentary, tuffite fines grained tephra, sandstone, and mudstone. Undulating, tuffaceous sedimentary plain.

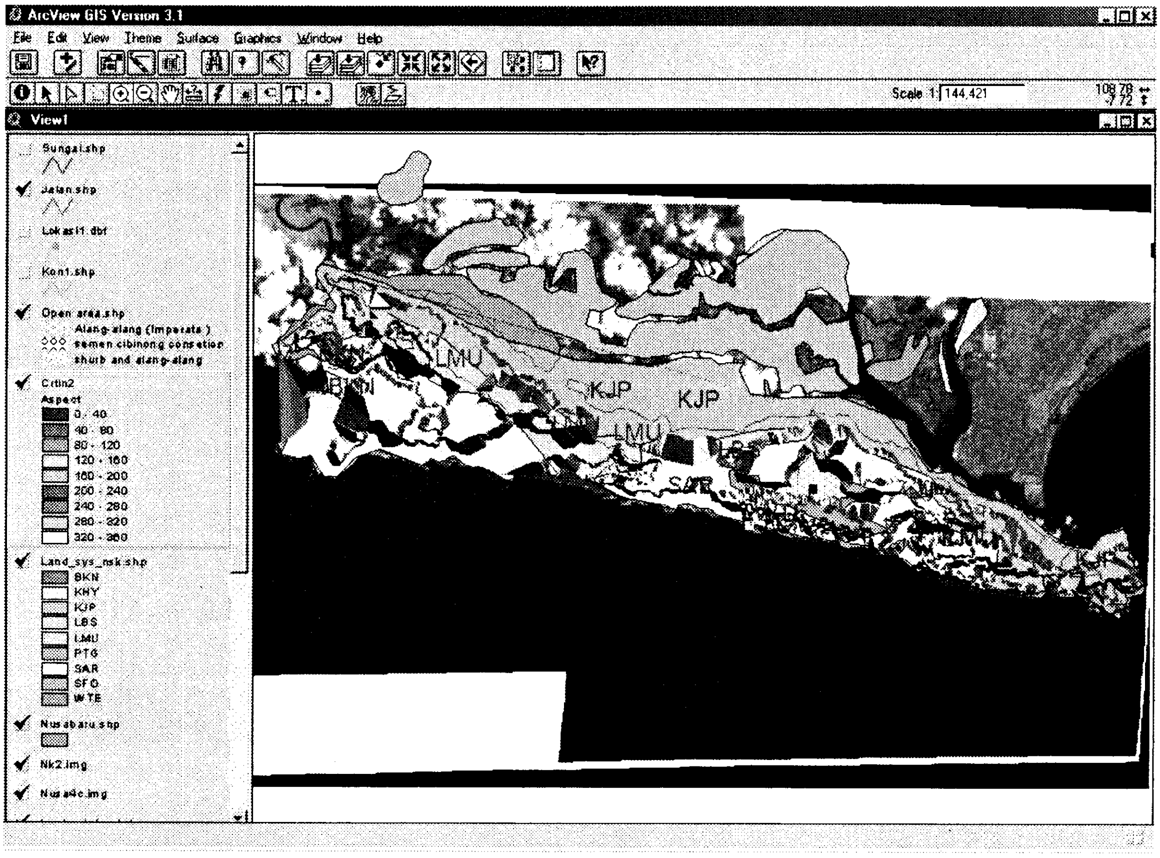


**Fig. 3 Land system overlaid on vegetation map**

Compare to the other small island in Indonesia, Nusakambangan can be classified as a rich area due to the variability of landscape, vegetation and habitat type (Partomihardjo et all, 2002). It was meant that this area is probably also rich with biodiversity.

Base on land system, detail classification for forest community can be identified more detail (see Fig.3). Using information were taken from land system map, mangrove community can be detail grouped in to the tidal, brackish water on muddy coast, undulating tuffaceous sedimentary plain. Lowland rain forest is occurred on limestone area with calcareous and conical hillrock land type. Beside that this communities occurred also in alluvium rocktype and alluvium sandstone.

## Conclusion and Suggestion

About 655 species of flora belong to 92 families and 262 genera were recorded in digitize format data on IBIS, originated to Nusakambangan Island. Biodiversity collection and valuation of the natural resources in this island should be conducted as soon as possible, because of habitat erosion is very fast. As a last resort of lowland rain forest found in Java that rich with habitat type diversity, species diversity and specific vegetation communities occurred on limestone, alluvium rocktype and sandstone, Nusakambangan island should be manage carefully.

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# Biological Diversity of Small Islands: Case Study on Landscape, Vegetation and Florictic Notes of Nusakambangan Island, Cilacap – Indonesia

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## Abstract

**Nusa Kambangan and its surrounding small islands have many interesting and unique aspects in their landscape, vegetation and floristic notes, and worthy of special protection. There is a number of quite large caves on the island with considerable biological and ecological significant as well as touristric features such as Portugees fort, lighthouse and beautiful beaches.**

**The island supports beach vegetation includes mangrove, sand beach and coastal mixed forest on steep slopes. Inland vegetation consists of forest on hilly limestone areas, lowland mixed Dipterocarp, old secondary forests, scrub area and abandoned *Imperata* grassland, as well as coconut and rubber plantation. The most interest feature is the presence of the giant trees *Dipterocarpus littoralis*, which is known from Nusa Kambangan only. Now days this endemic species is under very threatened condition by illegal felling. The rare species recorded on this island are *Amorphophalus descus-silvae, Cydenanthus excelsus, Nephelium juglandifolium, Raflesia patma* and *Raufolfia serpentina*. The abundance species in the disturbed forest areas include *Arenga obtusifolia* and clumps of bamboos.**

***Key words: Nusa Kambangan Island, unique, landscape, vegetation, floristic notes and endemic.***

## Introduction

Indonesia is well known as a large equatorial archipelagic nation with high biological diversity. The country comprises approximately 17.000 islands which are consists of large (five), medium and small islands. More than 70% of the Indonesian archipelago was categorized as small islands. Some authors defined that the smallest island is a land area that regard to sustain in fresh water supply, the critical size for a supply to be maintained being about 10 ha (Huggett 1995, Whittaker 1998).

Nusa Kambangan is a unique small island of Indonesia due to its biological and ecological aspects. The island supports on of the largest expanses lowland Dipterocarp rain forest in Java, therefore no wonder if this island gives some impression of original Javan forest (Whitten *et al.*, 1997). The most interest feature from the taxonomical point of view is the presence of an endemic giant timber tree *Dipterocarpus littorelis* (Ashton 1982). However, the population of the species known from Nusakambangan only, now days is under serious threatened by illegal cutting. There are also some rare species present on the island such as *Amorphalus decus-silvae, Gonystylus macrophyllus, Chydenanthus excelsus, Hopea sangat, Rafflesia patma,* and *Shorea javanica.*

A number of quite large caves on the island with considerable biological and ecological significant for being protected (Ko, 1983c, Soeyanto1989, Whitten *et al.*1997). There are four gazetted reserves i.e. a tiny offshore island protecting "Wijaya Kusuma" plants, an over grown Portugize fort called Karang Bolong covering 0,3 ha, about 200 ha of the forested eastern tip and about 700 ha on the southwest corner of the island.

The management authority conducted by the Prison Services of the Department of Justice and Human Right. This is because of the four high security prisons located on this island. Consequently, access to the island for public is very carefully controlled. How-ever, in practical there are many illegal visitors with various purposes easily landed on many different places without known by the security patrol. Now days Nusa Kambangan increasing crowded and most of the forest cover have been disturbed.

## Study Sites and Methods

### Geology and Topography

The geological structure of Nusa Kambangan is complex. At least seven land systems were recognized in the small island, while only 128 were recorded from Java-Bali (Whitten *et al.*, 1999). Land system known as combination of rock types, hydro-climate, landforms, soils and organisms and the link between them. The landforms are varied, alluvial plains and hilly areas are moderately to strong dissected by a fine pattern of stream. The elevation range from 0 – 200 m above sea level with the highest point on the eastern part of the island about 190 m.

Based on physiographic regions, Nusa Kambangan is part of D1 Pangandaran Dissected Pleatau, where the southern Mountains of West Java begin. Together with Segara Anakan and the valley of Citanduy, belonging already to the Bandung-depression Zone of West Java (van Bemmelen, 1949).

### Location

Nusa Kambangan is a small island located on the most western part of south coast of Central Java. The island with 36 km long and 3 – 9 km wide lies longitudinally to Java just across the mouth of Citanduy. Geographycally this island extended from 7° 40' 30'' – 7° 46' 30'' South Longitude and 108°03' 30'' – 108° 45' 00'' East latitude. Based on the administration system, Nusa Kambangan belongs to Sub-District South of Cilacap and parts of Tambakreja village. The island become very important due to its position as a bumper of Cilacap city and its natural port as well as the largest mangrove area in Java i,e Segara Anakan, from the direct influence of Indian Ocean.

### Methods

Flora data records were obtained from various expeditions to the islands since 1919 – 1936 and 2000 – 2002. Floristic studies and herbarium collections have been done in 2000 – 2002 field surveys. Herbarium specimens were collected from each different species. The specimens were processed and deposited in Herbarium Bogoriense, Bogor for identification purposes. Vegetation communities and its species composition were identified directly during field surveys and than transferred into IBIS for further analysis. Sampling plots of 20 X 50m for ecological study was taken within each vegetation community. The diameter at breast height and total high of each trees within sampling plots were recorded. The GPS readings are also taken in each sampling plot.

## Results and Discussions

### Vegetation

There is still no detailed survey of the vegetation of the Nusa Kambangan, although botanical collection was carried out since 1797 (van Steenis 1950). Base map 1 : 25.000 scale (Bakosurtanal,1999)indicated that six vegetation types can be identified on the island. In general the vegetation type of Nusa Kambangan can be classified into eight different types.

Whitten *et al.* (1997) reported that vegetation of Nusa Kambangan is still remarkable. In general the main natural vegetation communities of the island according to site condition can be briefly stated as follows: mangroves (1), coastal mixed forest on sandy beach (2), coastal vegetation on rockface beach (3), lowland (dipterocarp) rain forest (4), forest on limes tone ridges (5), old secondary (6), young secondary (7) and imperata grassland (8).

**Mangrove.** Most of the mangrove communities occur in tidal and brackish waters, where the mangroves are associated with muddy coasts (Whitten *et al.* 1997). The only well developed mangroves is around the river estuaries face to Segara Anakan, where mangrove community can develop up to a kilometre from sea shore. The mangrove communities attached to Nusa Kambangan developed along the northern coast faced to Java. Smaller areas occur in the south end of Bantarpanjang coast in the mouth of Kalijati. Mangrove communities also developed inland along the river of Salak Jero. Very thin mangrove developed in the mouth of rivers at southern coast.

**Sandy beach.** The sandy beach area with good representation of the beach flora was extensively found on Bantarpanjang coast. The typical sand shore elements consist of trees component e.g.*Barringtonia asiatica, Calophyllum inophylum, Erythrina orientalis, Hernandia peltata, Hibiscus tiliaceus, Pongamia pinnata* and *Terminalia catappa*. The other elements that common as under storey included *Diospyros maritima, Pandanus tectorius, Cycas rumphii, Desmodium gangeticum* and *Scaevola taccada.* In open areas of disturbed canopy *Ischaemum muticum* and *Wedelia biflora* developed abundantly as ground cover. In some parts *Ipomea pes-caprae* associated with *Ischaemum muticum* and *Cyperus pedunculatus* found immediately behind the reach of the highest tides. The small sandy beaches also found in southern coast of the island such as at Kalikencana, Salak Bokong, Gareman, Permisan, and Karangbandung beaches. Magnificent long stretched of the natural beach vegetation like on this island cannot be seen along the coast of Java.

**Rocky shore.** Most of the southern coast of Nusa Kambangan consists of rocky shore interrupted by narrow sandy beach around the mouth of rivers. These shores are buffeted by very strong waves and produced steep rock beaches. There is almost no vegetation on steep face of rocky beaches. The scrub community developed on the ridges consists of mixed inland typical species such as: *Arytiera littoralis, Diospyros maritime, Planchonela duclitan* and *P. obovata.* The vegetation of gently slope areas dominated by *Terminalia catappa* and *Syzygium speudoformosum.* Due to the strong influences of salt spray, only *Pandanus tectorius* can survive as a main under storey layer on this community.

**Lowland forests.** There are two types of lowland rain forests are recognized on the island: lowland forest on limestone and on sedimentary lythology-alluvium rocktype complexes. There are some other minor lowland forest types associated with the differentiation of rock type and soils.

**Forest on limestone.** Most of the forest on limestone has lost by many different agents such as illegal shifting cultivations, rubber plantations and limestone mining for Portland cement industry. The remaining forest on limestone is mostly on the ridge of hilly area and above large caves. The species composition of this forest is relatively rich. Within 0.2 ha single plot located on the ridge of limestone area, 73 species of trees ($\geq$ 10 dbh) belonging to 60 genera and 30 families were recorded. This number will be higher if shrub and herbs layer taken into account (Partomihardjo & Prawiroatmodjo 2001). Little is known about the composition of limestone forests. Chin (1977 in Whitten *et al.* 1997) list 1.216 species of angiosperm were recorded from limestone hill in Malaya. It was mentioned that 261 (21.4%) are endemic to the peninsula, 335 species are characteristic of limestone and 254 (20.8%) confined to it. Anderson (1995 in Whitten *et al.* 1997) estimated that there are over 600 species on the limestone hill of Sarawak. Limestone forest of Nusa Kambangan appear floristically also different from other lowland (dipterocarp) forest.

**Lowland forest on alluvium rocky complexes.** Similarly to Java, most of the lowland forests have seriously disturbed for along time ago. Un-disturbed forests usually remain on steep slopes and remote areas. The forest consist of many species of large trees such as *Alstonia scholaris, Artocarpus elastica, Bischofia javanica, Dipterocarpus littoralis, Dracontomelon dao* and many species of figs (*Ficus* spp.), There is variety of lowland (dipterocarp) forest on alluvium rocky complexes, but mostly are dominated by abundant palm trees of Arenga obtufifolia or dense of rattans scrub. This palm forests are secondary growth and have an overstorey of trees but sparse. Hommel (1987) reported that palm tree of *Arenga obtusifolia* also very abundant and dominated the understorey layer of Ujung Kulon lowland forests.

**Old secondary forest.** This vegetation community covered large areas mainly consists of abandoned rubber plantation and heavy disturbed natural forests. This forest consists of scrubs and trees species e.g.: *Canarium denticulatum, C.hirsutum, Macaranga tanarius, Dysoxyllum gaudichaudianum, Syzygium spp., Garcinia spp* and *Hevea brasiliensis.*

**Young secondary forest.** The vegetation community developed on abandoned "ladang" and bananas plantations. The secondary vegetations dominated by *Chromolaena odorata, Clibadium surinamense* and *Lantana camara.* Trees found in the succession such as *Dillenia exelsa, Kleinhovia hospita, Omalantus populneus* and *Villebrunea rubescens.*

**Imperata-grassland.** Most of the grassland communities developed on critical land after long period of "ladang" activities. The vegetation dominated by single species of Imperata cylindrical. Other associated species included *Chromolaena odorata, Lantana camara* and *Mimosa.invisa.*

**Flora**

In the 2000 survey, 547 species were recorded from the island, including 3 Pterydophytes, 3 Gymnosperms, 91 Monocotyledonae and 468 Dicotyledonae. Of the 547 species recorded on this period, about 430 were native of Nusa Kambangan (Partomihardjo *et al.* 2001). A total of 150 species have been recorded in 2001 survey that concentrated on hilly limestone areas. Of the 150 species, 85 have not been recorded on previous survey. Of the 45 species records from the herbarium specimen data based, 8 species have not been re-found. Based on the data up to 2001 survey, total number of vascular plant records from Nusa Kambangan is approximately 655 species (Table 1). This species records will surely increase when the exploration extend to the wider areas.

**Table 1. Number of plant species recorded on Nusa Kambangan from 2000-2001 surveys compared to Java flora.**

| Islands | Area (km2) | Pterydo-phytes | Gymno-sperm | Monoco-tyledon | Dycoty-ledon. | Total |
|---|---|---|---|---|---|---|
| Java | 126.366 | 519 | 29 | 1924 | 4062 | 6.539 |
| Nusa Kambangan | 30 | 11 | 3 | 99 | 542 | 655 |

From the botanical point of view, Java and its surrounding small islands is the best known in Southeast Asia (Ashton, 1989 in Whitten *et al.* 1997). The total number of plant species recorded on Java including weeds and cultivated species is over 6500 species. From this total, more than 4500 species are native to Java. Backer & Bakhuizen van den Brink (1965), mentioned that the total plant species has surely increased to the increases alien plants, whilst native species must gradually decreasing due to the natural forest disturbances. Native plants will be occurred on a relict natural forest such as on Nusa Kambangan. Further more, native plants may become an endemic species of a relic natural forest due to the main natural habitat loses. It is note worthy that Nusa Kambangan will be a suitable site for biological studies.

## Conservation and Sustainable Management Perspectives

Regarding the conservation and sustainable management perspectives in Nusa Kambangan, several important aspects need special discussion. These include types of vegetation community and noteworthy species as well as the utilization, potential and disturbance.

**Unique vegetation communities.** The most interesting vegetation community on the island is the forest communities developed on the limestone ridges. In particular this forest consists of association among beach component such as *Buchanania arborescens, Palaquium obovatum* and inland typical component including *Hopea sangal, Gonystylus macrophyllus, Shorea javanica* and *Shoutenia ovata.* They construct such unique physiognomy that surely this forest type must rank as one of Java's most unusual natural communities. In some parts this typical forest well developed above the caves, and usually dominated by figs trees.

The lowland rain forests develop on alluvium-rocky known as the most diverse among the others. The conservation of the remaining mixed lowland dipterocarp forest with only few individuals of *Dipterocarpus* trees left is urgently needed.

In addition to these, it may also be emphasized that the coastal mixed forest is very well developed both on the flat sandy beach and steep slopes of various rock types. Therefore, it is remarkable to mention that Nusa Kambangan has some special and un-usual vegetation communities found in Java.

**Rare and endemic species.** Endemic and rare species contribute the significance of Nusa Kambangan gazetted as a conservation area. The presence of *Dipterocarp littoralis, Chydenanthus excelsus, Gonystyllus macrophyllus, Nephelium juglandifolium, Rafflesia patma* and other rare and interesting species, gives impression this island is small but special.

**Potential plants.** Although in local scale, the utilization of trees as a timber resources was very significant, may be due to the scarcity of commercial timber species in main land of Java. Illegal felling and encroachment are very common almost on the whole island. Timber for local consumption included *Alstonia scholaris, Anthocephalus sinensis, Pterospermum javanicum, Pterospermum divercifolium, Calophyllum soulatri, Canarium denticulatum, Sterculia foetida Vitex pubescens.*and *Dipterocarpus littoralis.* Besides timber as mentioned above, there are some potential forest products such as many species of rattans, medicinal plants occurred on this island.

Wild fruit tree species include *Stelechocarpus burachol* (burahol), *Pometia pinnata* (kraminan) and *Garcinia dulcis* (mundu). The wild population of burahol and mundu on this island represent natural population, which is important for material breeding and wild animals feeding.

**Disturbances to the forest communities.** At first illegal human settlement on Nusa Kambangan mainly provided by Banana Plantation Project as temporary workers (Pemda Dati II Cilacap, 2001). However, the project was no longer exist, and the people continues to stay illegally on the island as farmers. They clear the forest for cultivated crops such as rice, cassava and maize. They also cutting trees for timber and constructing their houses. There is no doubt that increasing human activities on this island disturbed the natural vegetation. Due to the forest clearances on the upper part of this island, now it is difficult to get fresh water during dry season.

Reforestration is needed to expand the returnable of Nusa Kambangan forest function. Replanting on the abandoned "ladang" and restoration of the disturbed forest by using local species are strongly suggested. Moreover, seedlings plantation can be used for increasing species richness instead of collecting of seedling from the natural forest.

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# Integration of the Global Environmental Facilities (GEF) and Other Collaboration Projects into Indonesia Biodiversity Conservation Programme: Lesson Learnt from Indonesia

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## Background

Collections of Indonesian flora, fauna and microbe are mainly deposited in Herbarium Bogoriense (HB), Museum Zoologicum Bogoriense (MZB) and Microbial Collection (MC) of Research Centre for Biology of the Indonesian Institute of Sciencies. HB and MZB have served as Museum since the 19th century, while MC is still being established.

The Muiseum was established by Dr. JC. Koningsberger in 1894, a zoologist who was actively involved in research of plant pest and diseases. The Museum has been progressively developed since then and nowadays has a modern buidling sited within the complex of Natural Sciences of LIPI at Cibinong. The museum hosted 2.250.000 specimens of 120.000 species and is the largest zoological museum in South East Asia. Of these collections, 10% were databased and access to the type specimens were available from the internet. There are 25 taxonomists work at the museum, 14 are specialised in invertebrate and 11 are vertebrate specialist.

Microbial collection of RCB hosted 1240 microbial culture, including 300 yeast, 440 bacteria, 500 lower fungi. This division has eight taxonomists, each half specialised in fungi/yeast and bacteria. None of the microbial collections were databased since the database system is still being established.

Herbarium Bogoriense is one of the popular herbaria in the world, which was founded in 1841 during Dutch colonial times. It has been the research centre for the local and international research. There are approximately 2.000.000 specimens were kept in the herbarium and around 10% of these were databased. Most of the plants were originally collected from Islands of Indonesia, and other regions in Malesia. The specimens comprise dried fruits, seeds, ferns, moss, fungi and proof specimens of ecological researhes. There are 23 taxonomists work at the herbarium, 20 are specialised in vascular and non vascular plant, and 3 focus in fungi.

## Current Collaboration Projects

Considering this vast collections kept in the two large museums and only limited resources available, it is essentially important to seek for other source of external funds mainly for the maintenance of the infrastucture and development of human resources. Hence, several collaborations were established to fullfil the demands. This include the assignation of the Memorandum of the Director (MOD) signed on 1994 for GEF fund. Another agreement was develop in accordance with the Global Partnership Plan of Action of 1992 in which the Government of Japan and the USA announce a common intention to strenghten cooperation in the field of environmental conservation. More over, several international projects collaborated with the centre has also been estabished, including Japan Society for the Promotion of Science (JSPS), National Institute of Environmental Science of the Government of Japan (NIES), DIVERSITAS of Pacific and Asia (DIWPA), Asean Regional Centre for Biodiversity Conservation (ARCBC), UNESCO, South East Asia herbaria-NHN, SEABCIN, and Asian Development Bank (ADB). The scheme, outputs and outcomes of these collaboration projects were described as follows:

### 1. Global Environment Facility-Biodiversity Collection Project (GEF-BCP)

The GEF was established in November 1994 as a collaborative venture of two main Implementing Agencies, the World Bank and UNDP. Indonesia has been part of GEF project since 1995 whose aimed was to strengthen the institutional capacity of centre, to support systematic biological collections, as basic reference tools for biodiversity inventory and monitoring. These will be achived through an integration of collections management (including research, products and services); human resources development, enhancing national and international cooperation, and electronic data management tools (Table 1).

**Table 1. Summary of activities and Project output**

| Activities | Project Output |
|---|---|
| Human Resource Development:<br><br>❑ Degree Program<br><br>❑ Overseas Work Study / Overseas Training<br><br>❑ Internship | <br><br>19 completed their degrees, 6 with Ph.D and 13 with M.Sc. (11 recruits)<br><br>27 completed overseas work studies for coordinators and collection managers<br><br>28 interns from universities and research institution visit and received some trainings on the curation and management at the herbarium or museum for the period of three to six month. |
| Building Improvement | Building improvement for herbarium such as developing: pressing area, electric oven, corrugated allumunium, ware house+AC, pigeon holes; new mounting room, dbase room. Increased electric power; AC for laboratory and type room in 1st floor, and 3rd floor for dbase |
| Storage Improvement | Herbarium: 1068 cabinets for vascular plant; 35 for cryptogam<br>Museum: 565 cabinet for mammal and bird; 4 compactus (2 from Government of Indonesia - GOI), 570 insect cabinet (GOI), MZB designed cabinet applied patent |
| Collection Management | Herbarium: 210,000 specimens; 25,000 types+20,000 new specimens remounted; 500,000 genus cover+1.5 M species folder changed; 7335 vascular+non vascular fungi rebottled.<br>Museum: all specimens stabilize, moved to the new building, and reorganized; new specimens integrated; Taxonomic organiszation: mammals (95%), bird, herp, fish, mollusc, and insect (60%) |

| | |
|---|---|
| Equipment | 5 long arm, 2 dissecting, and 11 high powered microscope and other field equipment |
| Computers/LAN | 2 servers, 7 clients, 1 printer + 1 scanner for herbarium, and 1 server, 2 computers (other all computer and LAN provided by JICA-BCP in a new building). |
| Databasing | Establishment of a fully functional software for collection management: Indonesian Biodiversity Information System (IBIS) in herbarium, 240,000 entries (priority taxa 105,000 entries); 142,000 entries for museum,and trained IT staff. |
| Validation | Bamboo 457 entries ;Arecaceae 556 entries; sheet labels; protocol for botany validation for herbarium; and 22,000 entries validated (include non priority taxa)check list of types; taxonomic list; guide line for validation for museum specimens. |
| References | 100 books bought for herbarium, and 30 titles (1 set) of Zoological record for the museum. |
| Publications | ❑ 14 field guide books published: 9 titles originaly written by Indonesian Scientist and 5 have been translated from English to Bahasa Indonesia<br>❑ those field guides sale in low price<br>❑ 1 brochure and 2 manuals |
| Others | ❑ Short visit to 4 staff USA (4), 3 staff Australia (3) , 3 staff Germany/ Netherland (3), and 24 local staffs trained on IT<br>❑ Financial and Institutional Sustainability Study: 2 reports (1 report + annex)<br>❑ Competitive Research Grant: 22 grants (13 GEF, 9 GOI)<br>❑ Health and Safety Improvement Action Plan |

## 2. Japan International Cooperation Agency Biodiversity Conservation Project (JICA-BCP)

The JICA-BCP has started in 1$^{st}$ July 1995, as a joint project among the Forest Protection and Nature Conservation bureau of the Ministry of Forestry (PHKA-MoF), the Research Centre for Biology of the Indonesian Institute of Science (RCB-LIPI), and the Japan International Cooperation Agency (JICA).

The first phase of BCP has started in July 1995 for three fiscal years. The project has now in its second phase that has started since July 1998 for five fiscal years. The JICA-BCP consisted of two schemes, Grant Aid and Technical Cooperation. Grant Aid was developed to support building and equipment facilities both for specimen collection storages and research laboratory activities. A new modern building, 8200 m2, has been built for Zoological Museum. Two third of this area was provided for the zoological collections. Another 11,000 m2 building is still in the early stage of planning for the new herbarium and microbiology collection.

The overall goal of the project is to support the achievement of the Biodiversity Action Plan for Indonesia (BAPI). In addition, the project was also aimed to strengthen the institutional capacity for biodiversity conservation in both the PHKA-MoF (which role as the management authority for protected areas) and RCB-LIPI (as the scientific authorithy), which comprised three main components: Information Processing and Network, Research and Survey; National Park Planning and Management. The first component includes development of a database software for biodiversity information, namely Field Survey Database that has been released mid of this year. The second and third component involving the establishement of appropriate researched-based national park conservation and management of Gunung Halimun National Park for an in-situ conservation model.

### 3. DIVERSITAS in Western Pacific and Asia (DIWPA)

DIWPA was proposed a program called IBOY (International Biodiversity Observation Year) by the late Prof. Tamiji Inoue in 1997 to increase research collaboration in the western Pacific and Asian region. The idea was to establish a latitudinal biodiversity inventory across the Asian region that would act as the baseline for future long-term monitoring of biodiversity across DIWPA countries. Indonesia has been involved within this project since 2001 and has established three core research sites located at Gunung Halimun National Park, Tangkuban Perahu (both in Java) and Bukit Suharto (East Kalimantan). This collaboration project will terminate in 2005.

### 4. UNESCO

UNESCO helps to start the regular regional plant taxonomy training course. It started in 1985 up to know. The course was designed to provide a taxonomic background using traditional and modern approaches. It covered various subject on plant taxonomy such as Collecting and exploration techniques including fieldwork in the protected area, Theory & practise in nomenclature, Theory and practice in key construction & identification, Planning and execution of a revision, monograph and floristic account, Floristic studies of selected groups, Cytology & molecular systematics, Database on biodiversity, The use of microcomputer in taxonomic research. The summary of the training can be seen in the table below.

**Table 2. Date, Instructers, Participants and sponsors for the regional taxonomy training course**

| No. | Date | Tutors | Participants | Sponsors |
|---|---|---|---|---|
| I | Sept. 1985 4 weeks | Herbarium Bogoriense & Rijksherbarium | Indonesia (14) | Rijksherbarium & GOI |
| II | Oct-Nov 1987 4 weeks | Herbarium Bogoriense & Rijksherbarium | Malaysia (2); Philippines (1); Thailand (3); Indone-sia (7) | UNESCO, GOI, Rijksherbarium |
| III | Sept-Oct 1992 5 weeks | Herbarium Bogoriense, Rijksherbarium & Univ. Calcutta | PNG (3); Philippines (2); Thailand (2), Vietnam (1); Indonesia (1) | UNESCO, GOI, Rijksherbarium |
| IV | Nov-Dec 1994 5 weeks | Herbarium Bogoriense, Univ. Calcutta, Rijksherbarium, UNESCO-ROTSEA | Malaysia (1); Philippines (1); Thailand (2), Vietnam (2), Indonesia (1) | UNESCO, GOI, MacArthur Foundation, Rijksherbarium |
| V | Nov-Dec 1996 5 weeks | Herbarium Bogoriense, Rijksherbarium, MacArthur Foundation, UNESCO – ROTSEA | Thailand (2), Vietnam (2), Malaysia (1), Philippines (1), Indonesia (8) | UNESCO, GOI, MacArthur Foundation, Rijksherbarium |

| | | | | |
|---|---|---|---|---|
| VI | Jul-Aug 2002-09-06<br>6 weeks | Herbarium Bogoriense, Nat. Herbarium Netherland, Univ. Kyoto, Univ. Philippines (UPLB), Singapore Botanic Garden, FRIM | Brunai Darussalam (2), Myanmar (2), Indonesia (4), Lao PDR (3), Malaysia (2), Philippines (2), Singapore (2), Thailand (2), Vietnam (2), Cambodia (2) | UNESCO, GOI, ARCBC, Univ. Kyoto |

## 5. ASEAN Regional Centre for Biodiversity Conservation (ARCBC)

Another collaboration scheme has assigned with ARCBC. By design, ARCBC shall strengthen the conservation of biodiversity in the ASEAN region by establishing a network of focal agencies called NBRUs (National Biodiversity Reference Units) in each participating country, linked through the project. In Indonesia, appart from co-sponsoring the last regional taxonomy training course in 2002, they also co-sponsored workshops in Indonesia such as "ASEAN Regional Workshop on Standardization of Biodiversity Reporting and Information-Sharing", and another workshop on "Indonesian Training Needs Assessment of Institutions and Human Resources Involved in Biodiversity Conservation".

The invertebrate training course that was held in July-August 2002 sponsored by ARCBC and GOI. There were 17 participants from nine SE Asia countries, e.i. Brunei (2); Indonesia (4); Lao PDR (1); Philippines (2); Thailand (2); Vietnam (2); Cambodia (2); and Malaysia (2). The tutors come from Museum Zoologicum Bogoriense (MZB), Reference Collection Museum, University of Singapore, Natural History Museum, London, Natural National Museum, Leiden, and National Histories Museum, Paris. It covered subject on evolutionary biology & evidence of evolution, speciation & zoogeography, clasification system, process of morhology character in systematic study, numerical taxonomy, phylogeny systematic, database and computer analysis of cladistic, scientific writting and publication, and practical subjects such as collection management, collecting methods, sorting-mounting-labelling, and practical identification for certain taxa.

## 6. Asian Development Bank (ADB)

ADB agree to help the Government of Indonesia of setting network for biodiversity information. The idea of setting this network, National Biodiversity Information Network (NBIN), was started in 1994. The objectives of the NBIN is to establish a practical and sustainable computerized information network for providing high quality biodiversity data and information that encourages and promotes the sustainable use of Indonesian natural resources.

NBIN is initiated by RCB to link the existing organisational databases, programmes, initiatives, in a comprehensive nationwide system for sharing, upgrading, intregrating , using and communicating information about biological diversity. Its aim was to establish a practical and sustaible computerised information network to provide high quality biodiversity data and information that encourages and promotes the sustainable use of Indonesian natural resources.

This project runs in collaboration with 28 national institutes including univesities and governmental research institutions. RCB acts as an implementing agency, thus plays an active roles in ecouraging other organisations to join with the project.

### 7. South East Asia Biodiversity Collection Information Network (SEABCIN)

SEABCIN was implemented in 2001 with the MoU of seven major herbaria in SE Asia and NHN. The project was designed for 3.5 years and aimed to establish the network of biodiversity collections among these seven herbaria, to improve hebarium curation and management, and to provide access to global users to the information of biodiversity within the South East Asian countries through the website.

### 8. Japan Society for the Promotion of Science (JSPS)

The main activities of the collaboration between RCB and JSPS are focused on the research and the developing of the human resource. The five research subjects which are encountered in this collaboration are Ecology, Agriculture, Limnology, Technology, and Social. The main research location is Central Kalimantan. The periode of collaboration is 1997-2006.

### 9. National Insitute for Environmental Studies (NIES)

NIES is a research institutions under the Ministry of Environment, Japan. It collaboration with RCBwhich began in 2000 and will terminate in 2003 is aimed to the study of change of biodiversity composition on post forest fire. The studiy is mostly done in West Kalimantan.

## Lesson Learnt from The Regional and International Collaboration Projects

Started from the GEF-BCP project followed by JICA-BCP and other projects, a common ground of the project objectives can be defined: i.e. 1) promote collaboration research of biodiversity, 2) develope joint project at the multi level, 3) establish biodiversity networks and network of databases, 4) conduct training courses pertinent for biodiversity, 5) provide scientific bases for developing common policies for biodiversity management and conservation, and 6) encourage interchange of information among scientist.

Although all the projects described were implemented in national scale, the result of the project is supported the biodiversity studies and conservations in the regional scale. Several essensial lessons are revealed from those collaboration projects. These lessons are:

- **Recognition of the demand for biodiversity information services and product.**

Systematic biology (i.e., the classification of living organisms) provides the scientific theory, principles, and process to inventory, monitor, and catalogue biodiversity information. Systematic collections (i.e., reference collections of plant and animal specimens that are preserved in chemicals or pressed and dried, DNA material and sequencing result collections) and their associated data provide basic reference tools for acquiring , managing, accessing, and disseminating this scientific information on biodiversity. Biodiversity information services and products are required in natural resources management, identification of plants and animals with economic potential, conservation, spatial planning, natural resource valuation, environmental impact assessment, etc.

The projects have opened a recognition nationaly, regionaly and internationaly about the importance of the biodiversity information. This recognition reflected by the less practical concern institution to the biodiversity. They shows their concern to taxonomy and conservation by:

1. The acceptance of the project NBIN by the GOI. This project proposed based on the systematic collections as the asset of the RCB. The GOI then agreed for the loan funding from ADB for the implementation of NBIN.
2. The Japan International Cooperation Agency (JICA) which formely concentrate on the development of the public facilities, agreed to support the facilities building for the rehousing zoology collections in Cibinong. JICA has recognised the importance of the collections globaly. There is a possibility continue their support in rehousing herbarium and microbial collections into a new building in the coming years.
3. The World Bank agreed to support the promotion of the conservation through the religion in Indonesia.

- **The importance of establishing research network at regional level.**

Improving systematic information through better reference collections and through better access to the associated data is therefore an integral component of the global and regional biodiversity strategy. Since this systematic information is widely spread and need to be regularly update, it is necessary to connect and gather it into one accessible frame. Fact shows that updating systematic informations is uneffective when it done by a single institution. The problem is due to the lack of expertise about some of the taxa and/or its associated information.

By making systematic information available in the web, the updating procces becomes faster and feedback respond come from the expert worlwide. Simultaneously, RCB has also invited several regional and international experts to work in Indonesia. Together with RCB staffs, These experts have conducted research and updated all associated informations on the priority taxa. In other word, a potential stimulus to the development of research projects was the establishment or strengthening of collaborative links between individuals working on the same or similar problems whether they be in RCB or other organization in Indonesia, or overseas.

- **The importance of the design strategy for establishing regional projects involving collaboration with external organisations.**

1. <u>User demand priority</u>

Design strategy should be developed based on the user demand priorities. In order to determine this user need, RCB has gathered many information from the potential stakeholders of the project services and products. There were many common features about user needs, such that they fall basically into three major groups:

- products that enable organism to be identified and located;
- data sets that can be sufficiently well analyzed and presented in appropriate formats, to enable decision makers to utilize the information, for example, for land management and conservation;
- information associated with species on, for example, conservation status, biochemical attributes or associated parasites.

Those features have now been adopted in all RCB project designs.

2. <u>External organisation partnership</u>

Wide scale collaboration project attract more support from the potential donors, because it shows that the project is seriously design. Nearly all of the project with external organisation as a partner or as counterpart are subjected to receive funding from donor. This partner involves since the begining of the designing process of the project. For instance:

- GEF-Biodiversity Collection Project was designed together with Harvard University
- JICA-Biodiversity Conservation Project was designed in collaboration with Ministry of Environment, Japan, and Japan Wildlife Research Center (JWRC)

Learned from user demand priority and the external organisation partnership, an example of a small project as initiated regional project for Asia and Pacific is proposed. This initiative project entitle 'Small Islands Biological Diversity' (see annex) is choosen due to the fact that most of the countries in Asia comprise of many small islands which considered as the most fragile environment affected by the development and it is also considered as the unique habitat from the point of evolutionary taxonomy.

- **The project sustainability**

The projects include financial, staffing, training, technical assistance, and physical investments designed to support long-term institutional transformation, therefore it is very important to develop a financing strategy to address financial sustainability after the project period.

At national scale, the financing strategy of the GEF-BCP project and the rest of the projects enable RCB to obtain the long-term increases in the institutional budget to cover the incremental operating costs resulting from the projects, and continuity development of biodiversity information. The annual review of the work plan facilitates any necessary adjustment in the staffing plan and the Goverment's contribution.

Furthermore, the physical investments provide supplies and equipment necessary for the efficient long-term scientific studies, scientific management of the national biogical collections, and long-term scientific studies on biodiversity conservation. These physical investment improved working conditions, which are essential to staff motivation.

In regional scale, the projects contributes updated biological information and references for the long-term biodiversity conservation in the region. These projects also establish an intensive regional collaboration among of scientist and institution. However, financial contribution for the further studies and the development of the database networking can not be provided since the end of the project. Thus, a trust fund or a financing venture or a regional funding agency beside GEF is really important to be determined.

# Present State and Future Trends in Taxonomy Research in Mongolia

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## Introduction

Mongolia is situated in the heart of Asia between the Russian Federation and the Chinese People's Republic. There are many different unique ecosystems in Mongolia, which are the essential components of Asian continental ecosystems. Among them the mountainous, steppe and desert ecosystems inhabited with many endemic species are prevailed.

In 1993 the Government of Mongolia ratified the Convention on Biodiversity and, by the present, Mongolia is a signatory to the nine globally important documents relevant to sustainable use of biodiversity and implementing 18 international projects of which 5 projects are GEF-sponsored ones. At the moment Mongolia is in a preparation stage for ratification of the Cartagena Protocol on Biosafety to the CBD. All of these documents have found their reflection in Mongolia's policy for sustainable development. However, importance of taxonomy for implementation of national and international agreements and plans on biodiversity use and conservation has not been emphasized in any documents or projects.

Nevertheless, understanding on necessity of upgraded and strengthened taxonomy for fulfillment of its "obligations under various international environmental agreements" to which Mongolia is a signatory, in particular to the Convention on Biological Diversity, has existed. Based on this and to overcome its "taxonomic impediment" Mongolia joined the initiative of the BioNet-International and participated in the Formulation Workshop of the Easianet LOOP held last year in Beijing. Furthermore, the GTI Programme of Work approved by the 6$^{th}$ COP, Hague (April 2002), has arisen a great expectation in the country that it will give significant impacts on capacity building in taxonomy, especially in developing countries and in countries with economies in transition.

In this report data on present state in taxonomy, maintenance and preservation of specimens, taxonomy and access to genetic resources for bioprospecting, future trends, needs and constraints for implementation of the GTI Programme of Work in Mongolia will be presented. Some measures for the development of regional cooperation will be suggested.

## Present State in Taxonomy

During the last 70 years Mongolian taxonomists together with foreign scientists, especially Russian scientists, have carried out comprehensive exploration of Mongolia's flora and fauna. As a result, the majority of species of flora and fauna inhabiting various ecosystems of Mongolia has been described. Below we give a brief description on numbers of species of fauna, flora and microflora.

**Fauna.** In Mongolia there are 138 species and 40 subspecies of mammals belonging to 74 genera, 23 families and 8 orders. Birds constitute a significant part of biological resources and account to be 457 species of 200 genera, 60 families and 19 orders. They make up 5.1% of birds registered worldwide. Among 75 species of fish registered in Mongolia there are 3 species endemic to Central Asia. Reptiles and amphibians found in Mongolia are not rich in species. They have 28 species and 64.2% of them have been described for the Great Gobi desert. Arthropods are the most numerous faunas in Mongolia. For instance, more than 500 species of 5 orders of *Arachnidae* have already been discovered.

**Insects.** Active participation of scientists from different countries has allowed carrying out the comprehensive studies on insects. As a result, at present 12500 species of 28 orders of insects have been identified for Mongolia of which 2000 species described as the new species not just for Mongolia but for the world. The most numerous taxa are the following: order *Coleoptera* with 2520 species of 63 families, order *Diptera* with 2372 species of 74 families, order *Lepidoptera* with 1210 species of 39 families, and order *Hymenoptera* with 1050 species of 34 families. Among insects found in Mongolia 300 species are the forest pests.

**Flora.** Mongolian flora is considered to be as a comparatively well studied one. At present it accounts to be 2823 species belonging to 570 families of 130 classes of vascular plants, more than 1300 species of algae, 432 species of mosses, 930 species of lichens and 870 species of fungi (mushrooms). Among them there are hundreds of rare species and species that are endemic to Mongolia and Central Asia.

**Microorganisms.** At present according to the data available, around 580 species of microorganisms belonging to 82 genera have been described as dwelling in the Mongolian natural environments and as parasitic mycoflora.

Results of study on Mongolian biodiversity have been published in more than 4000 papers and books. Nevertheless, in spite of long-term investigation of Mongolia's flora and fauna, all species of them have not been discovered yet and their complete inventory is far from being finished. Much is done but much is going to be done.

**Red Book of Mongolia.** During the last fifty years human activities and natural disasters have caused significant loss of biodiversity. To reflect these negative changes in animal and plant resources and numbers of species and to improve their conservation the Red Book of Mongolia was amended and republished in 1997. This edition contains 103 animal species of which 30 (21.7%) species of mammals, 30 (6.68%) species of birds, 6 (8.57%) species of fish, 4 species of amphibians, 4 species of reptiles (30%), 1 species of agnathans, 2 species of crustaceans and 19 (0.15%) species of insects. As for plants, 100 (4.16%) species of vascular plants, 4 species of mosses, 6 species of algae, 12 species of lichens, 6 species of fungi - in total 128 species of plants have been included in the Red Book of Mongolia.

**Collections and herbariums.** Among research institutes of Mongolia most experienced and active taxonomic studies have been carried out at the Institutes of Biology and Botany of Mongolian Academy of Sciences. At present the Institute of Biology maintains and preserves in their collections data and samples of 5000 mammals, 10000 birds, 2000 fish and 100000 specimens of 7000 species of insects collected from different ecosystems of the country. Catalogue of insects consists of 8600 cards with information on the areas of their distribution.

As for microorganisms, the main part of them are maintained in three culture collections settled down at the Mongolian National University, the Centre for Food Research and the Institute of Biology, the Mongolian Academy of Sciences. The latter one is the largest among them. It maintains about 900 identified and non-identified microbial strains including bacteria, yeasts and micro-algae. But, due to the lack of appropriate equipment and chemicals, taxonomic identification and proper preservation of strains cannot be carried out on the modern level. A lot of strains are discarded and lost every year. Among them there are many strains with industrially important properties. So, if the strain lost is industrially important or extinct one, the loss, undoubtedly, is much more and irreplaceable. The same situation is observed in every culture collection in Mongolia.

The herbarium of the Institute of Botany contains more than 100 thousand plants including 80 thousand of vascular plants, 20 thousand of mosses, 10 thousand of lichens and about 6 thousand of algae and fungi. The above collections include rare specimens of animals and plants of Central Asia and Mongolia and many holotypes and paratypes of insects. But, due to inadequate preservation conditions, absence of premises equipped with appropriate storage facilities and chemicals required most of them in an endangered state.

## Taxonomy, Bioprospecting and Access to Genetic Resources

As it is underlined in the GTI Programme of Work: "The more each country can develop its capacity to properly inventory, collect, classify, and then commercialize its biological resources, the greater will be the return of benefits to that country. These four elements (inventory, collection, classification, commercialization) can be seen as a hierarchy of increasing capacity". So, biodiversity prospecting defined "as the search for wild species, genes and their products with actual or potential use to humans" has close relation to taxonomy. Furthermore, proper taxonomic identification is significant for patent application. It also facilitates the targeted screening for needed genes and chemical products.

At present, biodiversity prospecting is more practiced in regions rich in biodiversity that is correct. However, for example, there have been no evidence so far that the majority of microorganisms used in biotechnology industries have their origin from the tropical rain forests or marine waters which are considered to be the most rich in biodiversity regions on our planet.

Meanwhile, the strain of *Thermus aquaticus* recovered from the extreme environment such as a hot spring in Yellowstone National Park has revolutionized molecular biology studies. Its enzyme DNA polymerase called now *Taq* polymerase, was found to be heat stable and helped to automate the polymerase chain reaction (PCR). This reaction is used to reproduce even a small segment of DNA a million- or billion-fold. Now PCR are used in study of human genome, diagnosis of genetic diseases, molecular evolution studies in systematics and forensics. This example is a good illustration of that the regions with extreme environments and comparatively poor in biodiversity also deserve thorough exploration.

Mongolia is a country with exceedingly variable climatic conditions, which give rise to many unique ecosystems and biota. For example, one quarter of Mongolia's ecosystems consists of deserts, and the country has numerous hot springs, a large area of permafrost, and many saline lakes. For this reason, there is a great probability that new microbial species, having unique properties or producing diverse compounds, will be discovered here. The more so, as several microbial strains to be used in production of valuable compounds and microbial biomass have already been found here. In addition to this, study on actinomycetes isolated from different soils of Mongolia's main three natural zones (desert, steppe and forest-steppe) revealed that most of them were able to produce antibiotics, amino acids and proteolytic enzymes. Moreover, a strain producing a novel antibiotic of the aureolic acid group was isolated from desert soil. Strains that can be used for production of bacterial insecticides, fertizers and microbial single cell protein, for degradation of pollutants and mineral leaching were isolated as well. Several strains of *Basillus thuringiensis* were isolated from the caterpillars of Siberian bombyx.

As for plants, there are 845 species of medicinal plants, 68 species of soil-binding plants and 120 species of important food plants in Mongolia. Over 100 species of medicinal plants are used for production of 200 medicines. As a result of study of 50 different species of plants carried out at the Institute of Chemistry and Chemical Technology, MAS, about 500 individual compounds have been isolated of which 119 were novel compounds. Interestingly, these novel compounds (alkaloids, coumarins, flavonoids and terpenoids) were in more oxidized forms compared to those isolated from plants grown in other geographical regions of the world. Based on these novel compounds 3 medical preparations were developed. There are also many species of animals that used in Mongolian, Chinese and Tibetan traditional medicine. Consequently, biodiversity prospecting in this region can be promising and "then be used to attract the necessary investment in the full range of commercial uses of components of that biological diversity".

## Future Trends, Needs and Constraints

As it was mentioned above, the main part of Mongolian flora and fauna were taxonomically studied. Major difficulties have been encountered during study and inventory of organisms on micro level. Lack of modern taxonomic facilities and absence of sound and reliable identification keys, especially in regard to microorganisms, have caused it. So, the future taxonomic studies in Mongolia should be concentrated on:

- microorganisms,
- lower plants
- and invertebrates.

In this case assistance, financial and training, derived from the international, regional cooperations and research grants for scientists can play a crucial role for the development of taxonomy in Mongolia and other developing countries. The GTI should unite and coordinate efforts for inventory of weakly studied organisms through building capacities and, thus, promote implementation of its PoW aimed at supply decision-makers with comprehensive information. Based on these information it is expected that more reasonable policy on conservation of biological diversity, sustainable use of its components and equitable sharing of the benefits derived from the utilization of genetic resources will be developed worldwide.

**Human and research laboratories' capacities.** As it is known, since 1980 when the Approved List of Bacteria was adopted, the microbial taxonomy has greatly been changed in the past twenty years. Particularly important advances were derived from use of chemical, numerical and molecular taxonomic methods. Unfortunately, due to the lack of appropriate facilities and information, almost of them have not been available so far for the Mongolian taxonomists. Moreover, nowadays methods for identification of microbial species are becoming more and more sophisticated. They need in rather expensive equipment and chemicals that are not available to taxonomists in developing countries. However, the microbial resources and diversity are richer in these countries and they are not sufficiently studied or sometimes hardly ever touched. It seems that the problem of study of microbial diversity and their conversation in developing countries, such as Mongolia, are straightly connected with financial support for building up of appropriate laboratory facilities and training the personnel. However, as it can be seen from the Mongolian experience, developing countries and countries with economies in transition cannot provide sufficient finance to raise and upgrade taxonomic capacities. For example, since 1990, due to the transition period to a free-market economy and difficult economic situation, the Government of Mongolia has not been able to provide sufficient financial support to research institutions in carrying out the taxonomic studies on required modern level. Hence, laboratory facilities and level of taxonomists and technicians dealing with identification of living organisms, maintenance and preservation of collections and herbariums are in inadequate condition. They need in sufficient upgrading and renovation.

This situation prevents significantly from fulfilling of obligations taken under the Convention on Biological Diversity and other international environmental agreements. It also causes difficulties in use of biological resources for sustainable development, identification pests in agriculture and forestry, patent applications and for bio-monitoring.

As for a level of taxonomic studies, they are mostly based on anatomy and morphology. There are no facilities and sophisticated techniques for carrying out studies on cell, tissue and molecular levels. For instance, there is no electron microscope in any research institutes of the Mongolian Academy of Sciences. Also there is no a taxonomic laboratory equipped adequately for making taxonomic study on molecular level. It makes impossible publications of results of taxonomic studies in internationally recognized scientific journals causing isolation of Mongolian taxonomists from other world. Besides, there is shortage of high-qualified taxonomists who can carry out modern taxonomic studies. About 60 researchers are engaged in taxonomic studies of different groups of organisms in research institutions and universities in Mongolia. But the middle age of them is around 40. All of them need in training in modern techniques of taxonomy.

**Information facilities.** Few institutions in Mongolia equipped adequately to make databases. It is caused by lack of computers and program packages, specialists in bio-informatics and their weak knowledge of English. As it was mentioned above, huge information on species, their habitats and properties has already been collected. But, due to the lack of computers and programs they are maintained on cards.

In spite of wide spread of INTERNET service in Mongolia, research institutes of the Mongolian Academy of Sciences have no money to pay for this service and have no sufficient number of computers to use INTERNET information. Furthermore, they have not received any foreign scientific journals since 1990. Regarding expertise, almost all of them based on classic old methods. Due to shortage of financial support, there is no possibility to send specialists to international training courses and invite experienced foreign taxonomists to make expertise or send specimens for chemical and molecular analyses to laboratories of developed countries.

Therefore, recognizing that development of taxonomic capacities on regional level will facilitate development of this science in every regional country and collaboration on databases will make available more comprehensive data to all countries we would like to suggest discussing the following measures for regional cooperation:

- To strengthen the laboratory facilities of culture collections and herbariums.
- To train taxonomists in the field of modern taxonomy, preservation and maintenance of specimens.
- To set up a regional database of organisms known for every country and country-based databases on economically important species and their properties.
- To identify countries and institutions which can give expertise on definite groups of organisms, training and provide taxonomic identification for organisms whose taxonomy is not sufficiently developed.
- To identify countries and institutions where researchers of developing countries can make molecular biology study of their specimens or send samples for such analyses free of charge.
- To develop standardized reliable and simple keys for identification.
- To decide on providing type strains free of charge.
- To decide at what extent the "Bonn guidelines on access to genetic resources and

fair and equitable sharing of the benefits arising out of their utilization" can be used for capacity building in taxonomy.

- To create fund to support endangered collections and herbariums.
- To create fund for support taxonomic research in developing countries.

## Conclusion

As it can be seen from the above, there is an urgent need for regional cooperation to solve the problems of inadequate taxonomic services. Moreover, there is a great expectation in Mongolia that the GTI-PoW and activities of BioNet-International would assist significantly to capacity building in taxonomy of every country of the region. Implementation of the GTI-PoW means that Mongolian taxonomists will be able to carry out their research on modern level and through this meet their international obligations. Furthermore, it will help to improve expertise for patent application, upgrade works for identification of pests, invasive alien species and bio-monitoring and widen application of bio-resources for sustainable development of the country. It also will facilitate the creation of adequate conditions for preservation and maintenance of biological specimens that represent unique biological diversity of Mongolia. Establishment of the cooperation will also enable Mongolian taxonomists to share experiences and receive the information needed through INTERNET. Comprehensive inventory of living organisms to be made and their databases to be created will, as it is underlined in the GTI-PoW, "show clearly how the development of basic taxonomic capacity leads to an improved knowledge base and understanding of the biological resources held by the country, which can then be used to attract the necessary investment in the full range of commercial uses of components of that biological diversity". Finally, it means that every country will be able not just develop an appropriate policy for conservation and sustainable use of its biodiversity, but also implement it into the real life. Through this countries will have more opportunities to increase the input of biodiversity into improving the welfare of people without depletion of their biological resources. We hope that it will be so.

# Taxonomic Condition in Myanmar

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## Abstract

**In Myanmar, the biosystematics activities are not yet been improved. Taking awareness of the importance of biosystematics activities in Myanmar is carrying out the related activities with the limited resources of technicians and facilities. We hope that it can improved by providing the training upgrading the facilities, networking and collaborative research with relevant institutions. Anyhow, Myanmar has the better potential to take part in the network of biosystematics' if it is strengthened the work towards a direction to having a coordinating national programme in the country.**

***Keywords : Biosystematics conditions of NACI and NIs.***

## Introduction

Myanmar is lying between 5° 58′ and 28° 38′ N latitude and between 92° 9′ and 101° 10′ E longitude. Myanmar share its border with China, Laos, Thailand, India and Bangladesh. Myanmar lies in the tropical monsoon zone with the exception of the temperate northern most parts of the country. Myanmar has different biodiversity and also rich in biological resources. It has different kinds of beneficial organisms, arthropods, animals since it possess both tropical and temperate climate.

## Collaboration and Cooperation between NACI and NIs

In Myanmar, the biosystematics activities are not yet been improved due to country's national coordinating institutes and national institutes can be worked out under limited situation. Myanma Agriculture Service acts as the National Coordinating Institution (NACI) and its representative, head of plant protection division, was appointed as the National coordinator. The national institutes (NIs) of Myanmar are Yezin Agriculture University (YAU), Plant Protection Division (PPD) and Central Agriculture Research Institute (CARI). The number of experts and staffs members trained in biosystematics among the NIs are significantly different from one department to another. Most of the qualified personnel are involved in the field of extension services for crop production. The number of qualified staffs with their respective field of specialization are mentioned following table.

**Table 1.**

| Sr. No. | NIs | Expertise in taxonomic group | Nos of trained personnel |
|---|---|---|---|
| 1 | Plant Protection Division | Insects | 6 |
| 2 | Plant Protection Division | Microbes (Fungus, Bact. & Nematodes) | 6 |
| 3 | Yezin Agriculture Universities | Insects | 12 |

| | | | |
|---|---|---|---|
| 4 | Yezin Agriculture Universities | Microbes (Fungus, Bact. & Nematodes) | 12 |
| 5 | Central Agriculture Institute | Insects | 3 |
| 6 | Central Agriculture Institute | Microbes (Fungus, Bact. & Nematodes) | 2 |

Note * There are no virologists (in service) in Myanmar.

## Some Activities of NIs

Under Plant Protection Division, there are Entomology section, plant pathology section, biocontrol section. These sections work on the determination of seasonal patterns of pests and natural enemies. The systematic study of the pests and natural enemies of each section is essential. Plant Quarantine section (one section of PPD) inspects the plant and plant products of export and import from abroad by using taxonomic keys. The collection of particular parasites and predators are rared in laboratory of biocontrol section. There has been planned to conduct research work on new parasites of some insect pests. For the time being, eight orders, ninety-six families and two hundred and twenty two arthropod insects species has been identified in plant protection division.

There are one National Museum and one Zoological Garden in Myanmar. These are under controlled by the department of forest. Taking awareness of the importance of biosystematics activities are carrying out as the related activities with the limited resources of technicians and facilities. All NIs have their own collections. Identification services are also rare due to very few numbers of taxonomists in this country. Fundamental course work concerning with taxonomic was taught in Yezin Agriculture University. Actually, biosystematics is carried out only by the local Myanmar scientists due to lack of cooperation with international institutes. The number of insects and other specimens sent for identification are very rare. At present, the collected specimens in hand are not enough for long term identification as a reference material for our museum to study. The following taxa should be funded by projects for development as a matter of priority. These taxa are Coleoptera: Chrysomelidae; Lepidoptera: Pyralidae, Noctuidae; Diptera: Tephriididae; Hemiptera: Pentatomidae. Myanmar needs long-term training in biosystematics as well as the other facilities (such as small instruments, computer and biosystematics related software) to establish all biological specimens in the country.

Very little work of NIs activities in the field of biosystematics of insects, nematodes and microorganisms has been done. Therefore reports, proceedings and journals, related to taxonomy or biosystematics of arthropods, nematodes or microorganisms are not available at this moment.

## Conclusion

Myanmar has better potential to take part in the network of biosystematics if it is strengthened the biosystematics work towards a direction to have a coordinating national programme in the country. In this regards, priorities should be given on the development of the human resources; facilities concerned with the development of information and communication; rehabilitation of resources and development of the application of new technologies relating to the biosystematics field concentrating on insects, nematodes and microorganisms.

# Biodiversity of Pakistan: Status and Issues

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## Abstract

**Pakistan is one of the most fortunate countries in the world in terms of its biological diversity. It represents parts of at least three distinct biogeographical regions, namely Palaearctic, Ethiopian and Oriental. There are practically all types of habitats represented, including dry cold, tropical, subtropical, plains, deserts, estuaries and marine etc. Correspondingly a variety of plants and animals are present in these areas. As can be expected from world wide statistics, hardly 10-15% of the biodiversity has yet been known in this country. There are relatively very few organizations which are involved in the collation, collection, preservation, identification and carrying out research on the biodiversity of this country.**

**During last few decades Pakistan has undergone quick ecological changes due to heavy biotic pressure, unsustainable use of biological resources, urbanization, deforestation and industrialization etc. These have resulted in the loss of suitable habitats and consequently extinction of several valuable species. The current losses of biodiversity have been resulted due to direct as well as indirect causes.**

**Many environmental and social problems face us in the new century. Building a just, stable, harmonious world for ourselves and our children should be the central organizing principle for civilization. How we might do this is the overarching question for every one of us. Sustainable development is a way of meeting the needs of the present without destroying resources that future generations will need. It promises a new era of economic growth and an assurance that the poor get their fair share of the benefits of that growth.**

***Key Words: Pakistan, Biodiversity, Fauna and Flora, Taxonomic issues***

## Introduction

For the survival of human race on this planet, conservation and sustainable development of biological resources is a high priority area the world over. The Earth's stock of animal species represents some of the most valuable natural resources with which we can confront the unknown challenges of the future. We are coming to learn that birds and reptiles, insects and sea slugs, fishes and mammals hold all goodies in store for us if we only can ensure their survival. For sustainable development, we must know the species present in an ecosystem, their interdependence and how they react to disturbances. A complete knowledge of biodiversity is not only essential for its own sake, as a great natural resource, but is also important in the betterment of our crops and animal farming and for proper management of our environment and of ourselves.

It has been estimated that there are 5-30 million species of plants and animals in the world In spite of hundreds of years of efforts, it is estimated that out of these about 1.4 million species have so far been known (UNEP 1995). This means that there are still literally millions of species of plants and animals which are yet to be discovered. With the enormous amount of benefits obtained from the known species of plants and animals, it is easy to surmise that knowledge about more species will be of tremendous utilization for mankind.

Pakistan which lies at the western end of the Indian subcontinent and has a total area of 804,152 sq. km. includes some of the world's highest cold areas and hottest areas, and many intermediate stages and so it has equivalent of many of the world's most important climatic and vegetative zones or biomes. We see the Arctic zone mirrored in areas of permanent snow and ice fields which occur above 17,000 ft. in the Himalayas. Below this there are alpine meadows and scrub where fauna is equivalent to the tundra biome. Further down are the dry coniferous forests where fauna can be compared with boreal forest biome.

With the few hundred miles of its territory, Pakistan represents parts of at least three biogeographical regions of the world and thus its biodiversity is composed of a blend of Palaearctic and Indomalayan elements, with some groups also containing forms from the Ethiopian region. Indomalayan forms are found in the east of the country, in the Indus Basin, and Palaearctic forms in the mountains of the north and west. The Palaearctic species contain a mixture of those common to a large part of Eurasia, along with those with affinities to the Middle East, West Asia (Afghanistan and Iran), Central Asia, and Tibet.

There are practically all types of habitats represented, including dry cold tropical, subtropical, plains, deserts, estuaries and marine etc. High altitudes in the Northern Areas have created niches suitable to hundreds of species of gorgeous birds, mammals, reptiles and insects. Fish fauna of the country is no inferior. The fascinating life of migratory fish, Hilsa, is a boon to fish industry as well as challenge to students of experimental biology for its physiological peculiarities. Blind Dolphin of Indus Delta is representative of a rare mammalian group.

## Status of Biodiversity of Pakistan

Species richness is only one measure of biological diversity but the use of this parameter to assess biodiversity is limited by the fact that many species, particularly insects, fungi and micro-organisms, remain to be identified. Little work has yet been done to evaluate other measures of biodiversity in Pakistan, including *taxonomic* and *functional* diversity, and the amount of genetic variability within species and their sub-divided populations.

Because Pakistan is largely bounded by man-made borders and does not comprise an isolated entity in biogeographic terms, relatively few species are found only in Pakistan. Thus, Pakistan has relatively low national rates of endemism for some species (about 7% for flowering plants and reptiles, and 3% for mammals; Table 1) but higher for fresh-water fish (15%). However, the proportion of 'restricted range' species occurring in Pakistan is much higher, and for many of these species, Pakistan contains the bulk of the global population.

Mammals

Up to 174 mammal species (including yet to be published information from PMNH) have been reported to occur in Pakistan (Table 1). There are at least three endemic species and a number of endemic and near-endemic subspecies. Species belonging to the Palaearctic realm occur largely in the Himalayan and Balochistan uplands; those belonging to the Indo-Malayan realm occur primarily in the Indus plains including the Thar desert and Himalayan foothills. In addition, species with affinities to the Ethiopian region occur in the dry southwest and along the Makran coast and Thar desert of Pakistan (Roberts 1997).

Birds

At least 668 species of birds have been recorded in Pakistan (Table 1), of which 375 are recorded as breeding (Roberts 1991). A high percentage of Pakistan's bird fauna is migratory, with a huge invasion of Palaearctic winter visitors (over 30% of recorded species). One third of Pakistan's bird species have Indo-Malayan affinities, and the remaining Palaearctic; of the latter, about one third are more specifically Sino-Himalayan in distribution. The Suleiman Range, Hindu Kush, and Himalaya in NWFP and Azad Kashmir comprise part of the Western Himalayan Endemic Bird Area; this is a global centre of bird endemism with 10 restricted range species in Pakistan. The Indus valley wetlands constitute a secondary area of endemism, with one restricted range species.

Reptiles and amphibians

Over 177 species of reptiles are known in Pakistan, (Chelonia 14, Crocodilia 1, Sauria 90, Serpentes 65). Of these, 13 species are believed to be endemic (Table 1). As with other groups, these are a blend of Palaearctic, Indo-Malayan and Ethiopian forms. One genus, the monospecific *Teratolepsis,* is endemic, while another, *Eristicophis,* is near-endemic. The Chagai Desert is of particular interest for reptiles, with six species endemic to Pakistan and a further six species found only here and in bordering parts of Iran. Important populations of marine turtles nest on Pakistan's southern beaches. As Pakistan is a predominantly arid and semi-arid country, it is not surprising that only 22 species of amphibians have been recorded, of which 9 are endemic.

Fish

Pakistan has 198 freshwater fish species, including introduced species. This fish fauna is predominantly south Asian, with some west Asian and high Asian elements. There are 29 endemic species. Also noteworthy are the 9 species of snow trout (sub-family Schizothoracinae) which occur in rivers of the northern mountains. Species richness is highest in the Indus river plains, the Kirthar Range and the Himalayan foothills, while the river systems of north-east Balochistan have the highest levels of endemism. Almost 800 species of fish have been recorded in Pakistan's coastal waters; however, no analysis of their population status and distributional range is available.

Invertebrates

There is rich invertebrate life from alpine to marine environment. Unfortunately only a tiny proportion of the fauna (10-15%), as can be expected from world wide statistics, hardly has yet been known in Pakistan. However, some taxa are better known than others, especially for marine invertebrates (Table 1). Among the best known are also the Lepidoptera (butterflies), and at least two books on the butterflies of Pakistan have been published. The total number of butterfly species probably exceeds 400, with high rates of endemism in the Satyrids, Lycaenids and Pierids (PMNH data). Butterflies of high altitudes are largely either endemic or are derived from boreal fauna from the west. In the northern mountains alone, 80 species with many endemics, have been recorded (Hasan 1997).

So far, more than 5000 species of insects have been identified in Pakistan including 1000 species of Heteroptera, 400 species of Lepidoptera, 110 species of Diptera, 49 species of Isoptera, 109 species of Polychaetes, over 700 marine molluscs, 100 species of land snails, and 355 species of nematodes.

Plants

Pakistan has 18 different types of ecological zones with a variety of habitat types like the coastal mangrove forests, the desert subtropical foothills dry and moist temperate areas, the alpine pastures etc. Owing to peculiar variable climatic topographic and physiographic conditions, Pakistan harbors a great diversity of flora. More than 6000 species of flowering plants, gymnosperms and ferns are reported so far from our region with about 4000 fungal species and about 1000 algae. Data about liverworts, mosses and lichens is unknown. Plant life unfortunately, is being lost due to human activities like overpopulation, urbanization, housing, roads, industrialization and tourist development, deforestation and overgrazing.

Medicinal plants have a rich resource base, which is spread over a wide range of ecological zones of Pakistan. About 2000 medicinal plants species (including higher and lower plants) are known from Pakistan. Over the years our medicinal plants are being utilized unsustainably by locals. In some areas the forest department auctions the collections of limited quantity of herbs to the highest bidder, with the result that the medicinal plants are collected indiscriminately (mostly rooted out) leaving little room for their regeneration. Similarly biochemists/pharmacologists/ pharmaceutical companies use tones of medicinal plants to get a few grams of alkaloids. This has resulted in the depletion of medicinal plants in those areas where they used to be abundant. The examples of *Dioscorea, Podophyllum, Paeonia, Digitalis Colchicum* and *Saussurea* may be cited in this connection. Infact, there is no clearly definable medicinal plant sector formulating policies that regulate the trade practices, the promotion of innovative conservation measures and the sustainable utilization of medicinal plants.

**Table 1.**

| GROUP | Number of reported species | Endemics | Threatened |
|---|---|---|---|
| Mammals | 174[1] | 6[2] | 20[3] |
| Birds | 668[4] | ? | 25[3] |
| Reptiles | 177[1] | 13[5] | 6[6] |
| Amphibians | 22[7] | 9[8] | 1[7] |
| Fish (freshwater) | 198[1] | 29[1] | 1[6] |
| Fish (marine) | 788[9] | - | 5[9] |
| Echinoderms | 25[10] | - | 2[10] |
| Molluscs (Marine) | 769[11] | - | 8[11] |
| Crustaceans (Marine) | 287[12] | - | 6[12] |
| Annelids (Marine) | 101[13] | - | 1[13] |
| Insects | >5000[1] | - | - |
| Angiosperms | 5700[14] | 380[15] | ? |
| Gymnosperms | 21[14] | - | ? |
| Pteridophytes | 189[16] | - | ? |
| Algae | 775[17] | 20[17] | ? |
| Fungi | >4500[18] | 2[18] | ? |

## Depletion of Species, Populations and Wild Genetic Diversity

Extinct species

As an example of species loss, at least four mammal species are known to have disappeared from Pakistan within the last 400 years: Tiger *(Panthera tigris);* Swamp Deer *(Cervus duvauceli)*; Lion *(Panthera leo);* and Indian One-horned Rhinoceros *(Rhinoceros unicornis*). A further two species have probably gone extinct in recent decades: Asiatic Cheetah *(Acinonyx jubatus venaticus);* and Hangul *(Cervus elaphus hanglu*). The Blackbuck *(Antelope cervicapra)* has been listed as locally extinct but has now been bred in captivity while the Asiatic Wild Ass (*Equus hemionus*) is believed to be threatened with extinction in Pakistan (Ahmad 1997).

Internationally threatened species

The latest 'IUCN Red List of Threatened Animals' (IUCN 1996) lists 37 species and 14 sub-species of internationally threatened or near-threatened mammals as occurring in Pakistan. Of these, two are critically endangered, nine endangered, 11 vulnerable, 24 near-threatened, five data deficient and one conservation dependent. The critically endangered mammals are Balochistan Black Bear *(Ursus thibetanus gedrosianus)* and Chiltan Goat *(Capra aegagrus chiltanensis).* Other endangered mammals include Snow Leopard *(Uncia uncia),* Indus River Dolphin *(Platanista minor),* Markhor *(Capra falconeri),* Urial *(Ovis vignei),* and Woolly Flying Squirrel *(Eupetaurus cinereus).*

Internationally threatened bird species occurring in Pakistan include 25 internationally threatened (one critically endangered, two endangered, 22 vulnerable) and 17 internationally near-threatened bird species (IUCN 1996). The critically endangered bird is the Lesser Florican *(Eupodotis indica),* while the Siberian Crane *(Grus leucogeranus)* and Great Indian Bustard *(Ardeotis nigriceps)* are listed as endangered.

Ten internationally threatened reptiles occur in Pakistan (three endangered, three vulnerable, three near-threatened and one data deficient), but there are no internationally threatened amphibians.

Species of National Concern

Lists of internationally threatened species show only the tip of the iceberg. While there is little data available to demonstrate the decline of species' populations in Pakistan, the accelerating loss and fragmentation of natural habitats clearly implies such declines. Habitat fragmentation isolates populations of a species, exposing the species to a higher rate of loss of genetic diversity and a higher risk of extinction. While a few preliminary attempts have been made to draw up national lists of threatened species, including a list of some 500 species of plant species believed to be nationally rare or threatened (Davis *et al.* 1986), no comprehensive and systematic list of species of national concern has been compiled for Pakistan. Such a list would include: species which are nationally rare and declining; those which are nationally rare, not declining, but otherwise at risk (e.g. from population fluctuations, natural catastrophes, persecution, etc.); those which are highly localised in distribution; and those which are still widespread and common but are suffering significant decline.

## Capacity Building Issues

Our present knowledge of this economically important natural resource of the country is inadequate and fragmentary. As can be expected from worldwide statistics hardly 10-15% of the biodiversity has yet been known in Pakistan. The species that have high biological value and are potential candidates for conservation on account of their degree of endemism, rareness or risk of extinction are not yet clearly known.

Although Pakistan has some excellent taxonomists in some organizations involved in research of different biodiversity groups, yet their number are insufficient to address the task at hand and the efforts are quite in isolation. Hence there is strong need to develop close linkage and coordination among researchers, institutions both governmental and non-governmental and the donor agencies.

There are relatively very few organizations which are involved in the collation, collection, preservation, identification and carrying out research on the biodiversity of this country. One very important organization, which is playing a major role in the fields of Taxonomic Research and Public Education about natural wealth of our country is the Pakistan Museum of Natural History (PMNH). Till now more than 250,000 natural history specimens, in the form of plants, animals, minerals, rocks and fossils have been collected, curated and studied. About 300 research papers have been published by PMNH scientists in scientific journals, both national and international. PMNH also enjoys close research interaction with many institutions of the world including those from USA, Japan, England, Germany, Hungary, China and Italy etc. As a part of this international liaison, three international Symposia were held by PMNH and published a book "Biodiversity of Pakistan". Recently, The Museum has been designated as the National Focal point of Biodiversity and signed an MOU with Global Biodiversity Information Facility (GBIF). For automation and networking at PMNH, a project entitled " Biodiversity of Pakistan: Databases and Global networking: is being implemented.

Pakistan needs access to taxonomic skills and resources to be able to recognize and know the organisms that constitute and threaten their biodiversity. Since all human life depends on the sustainable management of biodiversity; taxonomy is therefore key to supporting national programmes for sustainable agricultural development, and conservation and sustainable use of the environment.

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# The Current Status of Plant Taxonomic Research in the Philippines

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## Abstract

**The last decade saw a marked revival of interest in plant taxonomic research in the Philippines but much is still desired in terms of capacity building, manpower development, funding, networking, and publication of taxonomic research. Some of the most important developments in plant taxonomy in the country focused on two aspects: botanical exploration, taxonomic publications and manuscript preparation for the Flora of the Philippines. However, the momentum for plant exploration and collection slowed down in the past years due to dwindling funds. It is hoped that the adoption of the GTI by the COP to the CBD will bring about a considerable boost in the development of plant taxonomic research in the Philippines.**

***Key Words: plant taxonomy, Flora of the Philippines, GTI***

## Introduction

The history of plant taxonomic research in the Philippines expand to more than a hundred years and dates back to the coming of Spaniards in the $18^{th}$ century (Merrill, 1903, 1923-26; Madulid, 1985, Vera Santos, 1984). In those early times botanical study was confined to documentation of economic and medicinal plants and little of the natural flora found in the then abundant primary forests throughout the country. The most important taxonomic publication published during the $18^{th}$ century was that of Fr. Manuel Blanco who published his classic work Flora de Filipinas first in 1837 and later in 1845). A grand 8 folio $3^{rd}$ edition of this book was published posthumously by the Agustinian friars in 1877 (Merrill, 1923-26).

In 1903 Elmer Merrill came to the Philippines and started a botanical career that expands to more than twenty years. Through his dedication, hard work and perseverance and Merrill built the then famous Bureau of Science herbarium and library. Starting from a modest nucleus of a few hundred plants collected in the grounds of the bureau of Science, he continued botanizing in other parts of Manila and adjacent provinces until the collection reached to about 1 million specimens with thousands of type specimens most of which were from his descriptions of new species. Not only did Merrill build the famous herbarium, he also organized a huge botanical library comparable to that of other famous botanical institutions in Southeast Asia. When Merrill returned to the United States in 1924 he left behind a prestiguous and world reknowned botanical institution. However, tragedy struck the institution when the Bureau of Science building where it was housed was totally burnt in 1945 during the Second World War.

The task of rehabilitating the herbarium fell on the shoulders of Dr. Eduardo Quisumbing, first Director of the National Museum. Disregarding the unsettled peace and order situation prevailing in many places after the war Dr. Quisumbing immediately launched an extensive plant collection campaign in the country to rebuild the botanical institution. Despite low budget for botanical collection and few personnel of the her barium Dr. Quisumbing managed to gradually increase the collection to a few thousands during the first year of collection until it reached to more than 77,000 in the early 1950s (Quisumbing, 1957). Carrying on with this activity the staff of the herbarium botanized numerous other places and to date the PNH has now accumulated more than 180,000 mounted specimens and more than 20,000 more unmounted specimens waiting for processing.

The details of the botanical work carried out by the Botany Staff of the National Museum from 1940 to 1953 and from 1953 to 1980 are documented in the reports of Quisumbing (1957) and by Madulid and Gutierrez (1981) respectively. These reports show that many important botanical sites were botanically explored at one time or another but other sites have not been botanized to this time and needs to be explored. An index to botanical collecting density in the country (Madulid,1987) showed that the most thoroughly botanized localities are Luzon, particularly Laguna and Palawan followed by Samar, Bicol Provinces, Benguet, Batanes, NE Mindanao, Mt. Apo, Sibuyan Island and Sierra Madre.

## Present Status of the Philippine National Herbarium

The PNH is the largest and oldest botanical institution and a center of systematic research in the country. The herbarium staff curate various plant groups from algae, fungi, hepatics, mosses, ferns and fern allies, gymnosperms and angiosperms. Included in the herbarium are some important collections of Elmer, Merrill, Quisumbing, Mendoza, Conklin, Vera Santos, Reynoso, Madulid, etc. The herbarium is particularly rich in plant groups such as dipterocarps, grasses, palms, orchids, ferns, etc. There are several hundred type specimens and more than 1,000 photographs of Philippine types taken from foreign herbaria. The botanical library is enriched by the purchase of 3 private botanical libraries of Gagnepain, Rehder and Beccari through the efforts of Dr. Eduardo Quisumbing former Director of the National Museum in the 1950's.

At present there are 13 permanent positions in the plantilla of the Botany Division, composed of 1 chief, 1 Asst. Chief, 1 Senior Researcher, 3 Researcher II, 2 Researcher I, 2 Illustrators, 1 Sr. Technician, 1 Technician, 1 Clerk. 3 Senior Staff of Division (i.e. Chief, Asst. Chief, Sr. Researcher) are actually performing the work as Scientists in the Scientific Career Service to allow them to do full time research and development work.. Aside from the permanent staff of the Division there are 6 contractual staff hired in research projects funded from local or foreign grants.

## Other Herbaria in the Philippines

There are several other active herbaria in the country and these may be grouped into 5 geographical areas: 1. Northern Luzon; 2. Metro Manila; 3 Southern Luzon; 4. Visayas; and 5. Mindanao (Madulid 1985 ). Estimate of the total number of specimens extant in 15 herbaria in the Philippines reveal that there about 400,000 specimens available for research throughout the country as of today. Six of these herbaria belong to government research institutions and government colleges and universities, while the others belong to private academic institutions. Not all of them are listed in the *Index Herbariorum*. The second largest herbarium in the country is the Museum of Natural History at the University of the Philippines, Los Banos, Laguna. Two satellite herbaria are also found in this campus, i.e. the one at the College of Forestry and the one at the Forest Products Research and Development Institute. A specialized herbarium on rice species and varieties in the Philippines and from around the world is found at the International Rice Research Institute, Los Banos, Laguna.

## Constraints and Problems

While there are signs of revival in interest in plant taxonomy and systematics in the Philippines, nevertheless its fast development is hindered by inherent constraints and problems. One main problem is lack of financial support from the government and private sectors to finance taxonomic research. The National Museum, which is the government center for basic plant studies, hardly has a budget for research, travel, equipment and logistic support. The Department of Environment and Natural Resources, Department of Science and Technology, Department of Education and Culture, etc. are also short of funds for basic discipline such as taxonomy. Most other herbaria, especially those run by universities, receive mere token of their school budget to maintain the herbarium and more so, to undertake taxonomic research. Oftentimes, researchers have to depend on local or foreign research grants but these are very limited and difficult to find.

Aside from lack of funds for taxonomic research we are also confronted with manpower problem. At present there are very few professional taxonomists in the Philippines. They can be divided into two groups" full time taxonomists and part-time taxonomists. The Philippine National Museum is lucky in having a strong complement of 8 plant taxonomists of which 5 have PhD degrees, two Ph.D. candidates and one M.S. candidate. Unlike in the National Museum, the taxonomists in other agencies of the government and in the academe are not full time involved in taxonomic research. About 15 of them have PhD degrees especializing in various plant groups from higher to lower plants, while others have M.S. degrees and B.S. degrees. There are around 40 plant taxonomists in the Philippines and obviously this is not enough, considering that they have to work on the more than 15,000 species of plants of the Philippines. In contrast, the United Kingdom has more than 1,000 plant taxonomists many of them holding PhD or M.Sc. degrees.

Inadequate systematic collections also hinder progress in taxonomic research in the country. As stated earlier the old Bureau of Science herbarium, which held more than 1 million collections in the 1940's was totally razed to the ground during the Second World War and present efforts to rehabilitate the institution only succeeded in bringing the collection to just one fifth of its former number so far. The Philippine Plant Inventory Project funded by the US National Science Foundation and the National Museum from 1990-1995 generated more than 17,000 specimens mostly in 10 duplicates (Madulid and Sohmer, 1997) and is, so far, the most productive botanical expeditions carried out in recent times. Yet many more areas have not been botanically explored to date and for sure new records or new species of plants are there to be discovered.

Poor herbarium facilities as well as inadequate taxonomic references are other serious problems. The PNH collections is presently housed in a cramped and limited space in the former Senate building in Manila. Obviously, it badly needs more space to accomodate the increasing herbarium collections and the backlog specimens presently stored in carton boxes. The herbarium cases are mostly made of wood and are now about 50 years old or older that it needs to be replaced by new, steel cabinets that are fire proof and insect proof. The present room also needs air conditioning, periodic fumigation and disinfestation against insects, molds, etc. High humidity in the room also makes the specimens prone to mold attack.

Its botanical library is presently located in separate rooms far from the herbarium and is so limited in space that the references could not be made accessible to researchers, visiting scientists and students. Many important taxonomic references such as Floras, monographs and revisions of families as well as important journals pertaining to Malesian plants are also wanting. However, the PNH has a complete set of the Flora Malesiana revision of families, and Blumea series in its library. The PNH also badly needs equipment such as stereo microscopes, light microscopes, computers, xerox machines, printers, etc. The condition of the herbarium at the Museum of Natural History, UPLB is better in terms of more adequate space and better research facilities but it also needs refurbishing and other equipment. The UST herbarium in Manila, on the other hand, has been recently transferred to the new

Research Center building with ample space for the herbarium, library, research facilities and office for its staff. But for many other herbaria in the country the condition and facilities are far from adequate and satisfactory.

Lack of coordination among practicing systematists in the Philippines is also a problem. Oftentimes local plant taxonomists are so engrossed in their own work that they forget to coordinate or communicate their research activities with their colleagues in the profession. This brings about incohesiveness and scattered efforts. The Association of Systematic Biologists of the Philippines was once an active organization that effectively promotes closer relation among the members but it has become inactive in the past 5 years now. It is hoped that the ASBP will be revived soon so that there will be better and closer interaction among taxonomists in the country.

## Conclusion

Despite the current world attention and interest in biodiversity conservation and sustainable development brought about by the UN Convention on Biodiversity plant taxonomic research still lags behind in the Philippines. For sure the situation in the Philippines is also the same, to a greater or lesser degree, for other countries in the Southeast Asian Region. The recent adoption of the Global Taxonomy Initiative of the Conference of Parties to the CBD marks a milestone for taxonomy in the world and hopefully this will be earnestly followed and adhered to by member countries to the convention. Each country has a stake and an important role to play in the GTI and only a concerted effort of all stakeholders will bring about a brighter future for taxonomy. This is a challenge that everyone must respond to.

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# Toward A Coordinated Biodiversity Information Network in Taiwan

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## Abstract

**"Taiwan Biodiversity Information Network" (TaiBNET) (http://taibnet.sinica.edu.tw) was recently established abreast of the movement of GTI, Species 2000 and GBIF to enhance the taxonomic capacity building in Taiwan and taxonomic information exchange and cooperation with other countries. So far, two databases are established, namely, "Taiwan taxonomists database", which comprises a list of some 250 taxonomists in Taiwan and their e-mail addresses, affiliations and the taxa they expertized. Another database is a "Catalog of lifesin Taiwan", i.e., indexing all known species on this island. Currently in the pioneer phase, this species checklist includes species names, author names, year of original description, their classification system, Chinese names, the most reliable citation of its occurrence in Taiwan, and the data providers. Species names in the checklist can be hyperlinked to other global databases for additional information. In the 1st year project, more than 30,000 native species have been collected and posted on the web. Our database can be accessed via TaiBIF (Taiwan Biodiversity Information Facility), at http://gbif.sinica.edu.tw, the national node of GBIF in Taiwan.**

***Key words : Biodiversity, TaiBNET, TaiBIF, GBIF, Taiwan, taxonomy, species checklist***

## Introduction

Biodiversity, the basis of sustainable development of human being, is one of the most important global issues in the 21st Century. Last century witnessed the drastic deterioration of biodiversity throughout much of the world. Thus, after the Earth Summit in 1992, 180 countries signed the "Convention of Biological Diversity (CBD) and actively promoted biodiversity conservation and sustainable utilization of biological resources. Item 17 of CBD requested the information exchange and item 46 of Action Plan asked all governments to establish their own regional information center, clearing house mechanism and network. All biodiversity information should be collected, sorted, reorganized and digitized in each country. Sharing information with other countries via national node to promote research, education, conservation and utilization of biodiversity is urgent. The Global Biodiversity Information Facility (GBIF) was founded in March 2001 to promote this work. Taiwan has joined the GBIF family as an associate member since 2001. Application for a voting membership was just filed and pending for approval.

Taiwan is endowed with rich biological resources with a high ratio of endemism (ca. 25%). To manage and utilize these resources properly, we need to establish basic data of biodiversity, promote digital archive projects, integrate various databases, make them readily available on the web, and establish a national biodiversity network. These tasks are frequently requested by ongoing international cooperative projects or contemporary organizations, such as DIVERSITAS, GTI, IBOY, Species 2000 and Asian Oceania project associated with it, Taxonomic Network in Asia and GBIF. In other words, biodiversity data from Taiwan is essential to mapping global biodiversity. Making our data available will benefit the nature conservation both locally and globally.

**Infrastructure of Biodiversity Information Network in Taiwan**

"Taiwan Biodiversity Information Network" (TaiBNET) http://taibnet.sinica.edu.tw (Fig. 1.) was established in line with the movement of GTI (Global Taxonomy Initiative), Species 2000 and GBIF to exchange the taxonomic capacity building and promote biodiversity education, research and conservation in Taiwan. According to the policy and strategy of GBIF, catalog of life and the digitization of museum collections are the priority projects to be established. In Taiwan, therefore, the catalog of indigenous species in Taiwan and a list of local taxonomists has been established via a TaiBNET project sponsored by National Science Council (NSC) since September 2001. The digitization of museum collections, also sponsored by NSC, is one of the major themes of the National Digital Archives Project (NDAP), which started in January, 2002.

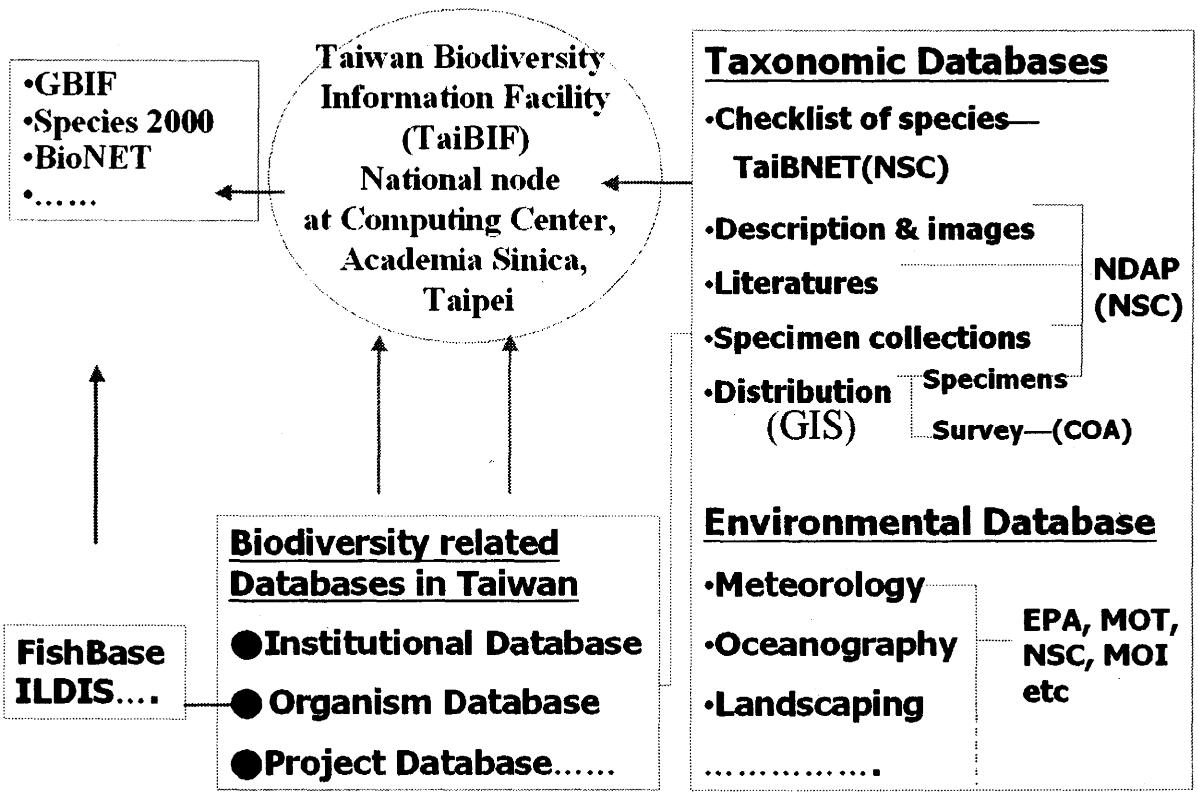


**Fig. 1 Infrastructure of biodiversity information network and related databases in Taiwan.**

The national node of GBIF (Global Biodiversity Information Facility) in Taiwan is called "TaiBIF". The website has been established at Academia Sinica (http://gbif.sinica.edu.tw). Both Institute of Zoology and Computing Center of Academia Sinica are in charge of the maintenance and data updating. Through this node, the background of participating GBIF, related documents, news, upcoming conferences, name list of Taiwanese taxonomists, catalog of life in Taiwan, specimen database, biodiversity related organization, team research projects, independent biological databases, natural heritage, and local publications, etc. can be accessed.

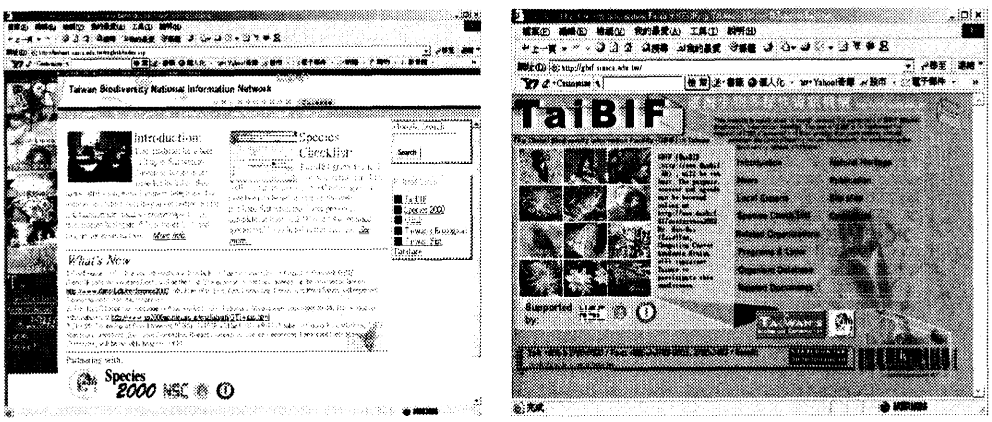


**Fig. 2 Homepages of Taiwan Biodiversity Information Network (TaiBNET) and Taiwan Biodiversity Information Facility (TaiBIF).**

## Taiwan Taxonomists Database and Species Checklist of Taiwan

Thus far, two databases have been established in TaiBNET project, namely "Taiwan taxonomists database" and the "Catalog of life in Taiwan." "Taiwan taxonomists database" comprises a mailing list of taxonomists in Taiwan and their e-mail addresses, affiliations and the taxa they specialize. To date, 250 taxonomists, including entomologists (101), marine biologists (67), botanists (37) and fungal taxonomists (30), terrestrial zoologists (15). English version of the name list was made available to facilitate foreign visitors to the website. "Catalog of life in Taiwan" indexes all known species in Taiwan. The checklist contains species name (with name of family and order to which it belong), Chinese name (when available), author and year of original description of that species, endemism (or not), as well as the most important citation of the species' distribution in Taiwan. Each species in the name list can also be hyperlinked to global databases such as species 2000 or ITIS, which contain additional information of the species concerned. So far, more than 30,000 native species have been collected and made available on the web. It is hoped that at the completion of the 3-year project, at least 80-90% of all known organisms in Taiwan will be listed..

All of these information were collected and integrated first by 8 project co-investigators: K. T. Shao (project coordinator; marine organisms), W. J. Wu, S. F. Shiao (insects), C. I. Peng (plants), S. H. Wu (fungi), P. F. Lee (other terrestrial animals), S. Lin and H. W. Yen (technical support). Most academic societies in Taiwan, such as The Societies of Entomology, Ichthyology, Malacology, Phycology, Fungus and Coral Reefs of Taiwan have endorsed and assisted in providing data and establishing this network. The data gathered from all local taxonomists were compiled and integrated into one website programmed by Y. L. Yu. The metadata of all taxonomic information across different organism groups has been just completed by the metadata team of Computing Center, Academia Sinica under the support of NADP.

## The Relationship between Taiwan Biodiversity Database and the TaiBNET with the Global Biodiversity Databases or Networks

Establish the biodiversity databases and national biodiversity information exchange center (CHM) has been considered as an important task in the *Biodiversity Promoting Action Plan* of Executive Yuan, which was activated in August 2001. Both National Science Council (NSC) and Council of Agriculture (COA) are responsible for promoting this task under the assistance and coordination of Academia Sinica. The CHM or node (TaiBIF) has been established recently at the Computing Center, Academia Sinica. In TaiBIF, national node of Taiwan, users can enquire and browse local organism databases, related government institutions, NGOs, National Parks or natural heritages, on-going team research projects, publications and related links, etc. The species checklist is established by TaiBNET project, while the museum collections and relevant information are furnished by NDAP (Fig. 3). Directly through national website of TaiBIF or indirectly through regional network of Asia or Asian Oceania, interchange of biodiversity information of Taiwan with other countries will become possible. An alternative way to exchange local information with global data is to formulate a collaborative relationship between local databases and relevant global databases. For example, the Fish database of Taiwan is intimately related to FishBase that is created by ICLARM. Through global databases and global biodiversity networks such as Species 2000 or BioNET-International, most of the updated data in Taiwan can be accessed through GBIF. Via this approach, we achieve our goal of working locally and sharing information globally. In addition to fishes, species of fungi, plants, insects, vertebrates and invertebrates known in Taiwan will also be made available on the web. Further information on each species probably can be obtained by hyperlinking to 18 global databases, such as BIOS, ITIS, CephBase, ILDIS, IOPI, MOST, Seaweeds 2000, Species Fungorum, URMO, etc. The connections among these databases and/or websites are shown in Fig. 3.

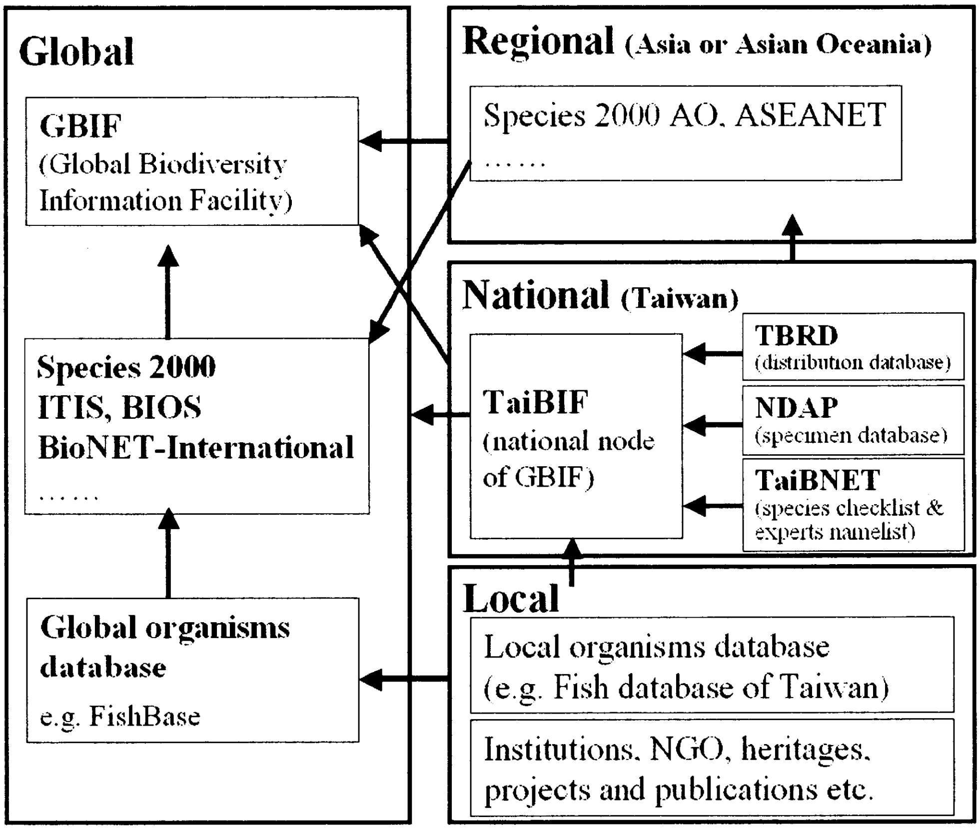


**Fig. 3 Relationships and cooperation between regional and global databases.**

## Future Perspectives

1. List of taxonomists in Taiwan

In addition to information on 250 taxonomists already compiled, we will collect such information from all of Taiwanese ecologists or applied scientists in agriculture, forestry and animal husbandry in the future.

2. Species checklist of Taiwan

Raven (1992) estimated that approximately 150,000 species may occur in Taiwan. For the first time, the TaiBNET project is making a coordinated effort to seek for collaboration from all Taiwanese taxonomists to contribute most updated and authorized checklist of the taxa that they specialize in. In the first phase of the first three years, our goal is to provide the most complete checklist, probably up to 50,000 species including microorganisms accessible on the internet. In additional to the species name, Chinese name, author(s) and year of original description, and the citation that validated the occurrence of the species concerned in Taiwan in the first phase, we hope to continue this project to include images of the specimens, video footages, biological data of morphology, ecology and behavior, synonyms, where the specimens are deposited, utilization as well as their local and worldwide distribution data (GIS-based).

We hope that our experience in database building is useful for other countries to develop fish databases or databases of other organisms. Global biodiversity conservation and sustainable biological resources utilization will only be achieved when all of us share complete and up-to-date biodiversity information with each other.

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# Taxonomic Needs Assessment in Thailand

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## Abstract

**Taxonomy of animals, plants and microorganisms in Thailand has long been inadequately supported in almost all aspects in all government agencies dealing partially or substantially with taxonomy of both basic and applied nature. With the advent of the Convention on Biological Diversity in 1992, taxonomy has been identified as an impediment to the implementation of the Convention worldwide. Typical of any developing countries, Thailand and her neighbors in Southeast Asia have suffered and fallen behind in capacity-building in taxonomy both in terms of human resources and accompanied infrastructure development in almost all classes of organisms which are the main composition of their biological resources. Under the ASEANET/BioNet-INTERNATIONAL, efforts are being made to help assist capacity-building in the Southeast Asian Region and interest in taxonomy is being revived. The Needs Assessment in Taxonomy and Biosystematics for Plant Pathogenic Organisms, and Arthropods in ASEAN countries have been conducted in October 2001 and May 2002. A Thai scholar who received training in "Taxonomy of Parasitic Hymenoptera" at the British Museum (Natural History) in the UK under the ASEANET sponsorship has consequently conducted a similar training course in Thailand on a regular basis at the National Biological Control Research Center, Kasetsart University at Kamphaeng Saen Campus. At the National level and as a voluntary commitment under the Convention, the Office of Environmental Policy and Planning (OEPP), Thailand CBD and GTI National Focal Point, has conducted "A National Taxonomic Needs Assessment" in 2000-2001 in collaboration with the ASEAN Regional Center for Biodiversity Conservation (ARCBC) as well as organized workshops to identify the needs. The outcome of which could be used to help plan appropriate capacity-building needs and requirements in the overall improvement of taxonomic work and research in Thailand.**

***Keywords: Taxonomy, needs assessment, Thailand***

## Introduction

Biosystematic studies and investigations are considered very basic and fundamental in biological science worldwide. In most developing countries where applied science ranks highly on the priority list, biosystematics is obscure and could hardly find its niche in any national development program. It remains an "individual" or "personal" interest and enthusiasm of biological scientists. Most taxonomic work in Thailand in the past and even up till now have been mainly carried out by foreign taxonomists with or without national counterparts. As a result, most "types" and specimens were deposited and curated in natural history collections and museums outside of the country rendering them inaccessible to the local workers to peruse further taxonomic studies (Napompeth, 1999).

With few exceptions and wherever available, collections of a number of taxonomic groups are widely scattered and kept by individuals as personalized collections or deposited in the departments concerned in various universities, government departments and research institutes, with or without proper curation and maintenance. Since these collections are more or less specialized in their nature, there have been no serious attempts up till now to keep or coordinate them under an acceptable national authority such as a natural history museum or a national biosystematics center. Taxonomists themselves are also in no better position than their respective collections. No directory of various taxonomic expertise and competence is available in the country. As a result, taxonomic specialists and their fields of specialization remain "undescribed" and "unknown" to biosystematics enthusiasts.

Since the Earth Summit in Rio de Janeiro, Brazil in 1992, followed by the ratification of the Convention on Biological Diversity, and a global concern on the conservation and sustainable use of biodiversity and its impacts, biosystematics has become a key issue and once more recognized as an important tool, basic and fundamental to sustainable agricultural development and the likes. The lack or inadequacy of competence and expertise in biosystematics, which is characteristic of and intrinsic to developing countries, will certainly hamper any future development anticipated from our precious biodiversity resources and reserves.

The worldwide support to taxonomy prior to the Rio Summit in 1992 was so negligible not only in developed countries but was more so in developing countries and countries with economies in transition. The Global Taxonomy Initiative (GTI) under the Convention on Biological Diversity (CBD) will certainly help revitalize taxonomy if it could be widely and consistently implemented. It will also be of a benefit to strengthening biosystematics in developing countries especially in terms of capacity-building, technology transfer as benefit-sharing.

The objective of this paper is to provide a general overview of biosystematics and its shortfalls in Thailand. No attempt will be made on an exhaustive review of literature or facilities. It is meant to expose the biosystematics situation as to how important it will be in terms of biodiversity resources and reserves and, at the same time, how negligible and overlooked it has been in the country and its needs for future development.

## Biosystematic Resources in Thailand

There is currently no disignated national biosystematic center or natural history museum in Thailand. The National Science Museum decreed in 1995 under the Ministry of Science, Technology and Environment (MOSTE) as part of the so-called Technopolis in a satellite town of Bangkok in Klong Luang, Pathum Thani, is apparently meant and designated for exhibitions rather than collections as far as the fauna and flora of the country are concerned. The MIRCEN Bangkok, under Thailand Institute of Scientific and Technological Research (TISTR) is well known and well networked for its collections of microorganisms. The Marine Aquarium of Burapha University at Bang Saen, Chon Buri, is one of the country's attractions for visitors to this beach resort. A freshwater aquarium has been long maintained for public display at the Department of Fisheries located on the Bangkhen campus of Kasetsart University in Bangkok.

The so-called "Godfrey Collection" of insect fauna of Thailand, started by expatriate collectors in collaboration with Thai counterpart collectors and taxonomists dating back to the early 1900s, is now housed, curated, updated and maintained at the Division of Entomology and Zoology, Department of Agriculture in Bangkok. This insect collection is considered the largest in Thailand. At present, over 7,400 insect species in 304 families, 170 mite species in

23 families, and 80 spider species in 16 families have been identified and curated at this collection. A similar insect collection is housed at the Department of Entomology, Faculty of Agriculture, Kasetsart University. It was started in the early 1960s with assistance from the University of Hawaii under the Kasetsart University/University of Hawaii (KU/UH) Project. Smaller insect collections are also found at various universities and some private collections in the country.

The National Biological Control Research Center (NBCRC) started a small reference collection of insect natural enemies specializing on parasites and predators of biological control importance in the late 1970s. It is called "Natural Enemies Reference Depository – NERD" and is located at NBCRC headquarters located at Kasetsart University in Bangkok and NBCRC Central Regional Center at the Kamphaeng Saen campus of Kasetsart University in Nakhon Pathom.

Some herbaria can also be found in the country in the Royal Forest Department, Department of Agriculture, Chiang Mai University and other academic institutions.

Needless to say, there is lack of a practical mechanism in the country to coordinate and collaborate the function and services of these available collections in order to make the best use of these limited resources.

There is a limited number of taxonomists in different taxonomic groups in Thailand. Most of them have been well trained for identification of organisms of their respective specialized areas. Descriptions of new species by Thai taxonomists are very few or, whenever there is any, would be mainly done in collaboration with foreign specialists. Also, relatively few "types" of the described species, animals or plants, are deposited in the collections in Thailand.

Identification services are also limited and are mainly done by comparison with identified specimens. Under most situations, the specimens are sent out to overseas museums or authorities for identification and in some cases are at a cost. At times, the specimens borrowed or sent for identification "disappear" together with the foreign experts. The Department of Agriuculture and Kasesart University provide identification services for insects, both general and those of economic importance. NBCRC at Kasetsart University provides identification services for insect parasites and predators for biological control workers within Thailand and occasionally for researchers from neighboring countries in Southeast Asia.

As far as biosystematic studies in Thailand are concerned, the country is in desperate need for all forms of support: physical in terms of basic infrastructure and physical facilities; personnel in terms of experts, consultants, specialists as well as technicians; and technical as well as technological in terms of database, reference materials, pertinent literature, electronic supporting services, etc. And, as a member of the Southeast Asian Region, a technical cooperation network in the region is necessary for future upgrading and collaboration work in biosystematics.

## Thailand and ASEANET

As far as Thailand is concerned, the country status on taxonomy has a relatively slow pace of development and has remained behind neighboring countries in the Southeast Asian Region. The lack of long-term and sustainable coordination and cooperation is characteristic among various institutes in the country and the so-called national institutes (NIs) under ASEANET are no exception either. As earlier stated, there exists an urgent need in the country to upgrade and strengthen biosystematics with a strong and long-term a national program to help serve as a focal point with a clearing house mechanism for future coordination and implementation of the development, (Napompeth, 2000).

Following the ASEANET Formulation Meeting in Kuala Lumpur in August 1996, the National Biological control Research Center (NBCRC) on behalf of Kasetsart University was designated and authorized as the National Coordinating Institute (NACI) by the Office of Environmental Policy and Planning (OEPP), Ministry of Science, Technology and Environment (MOSTE). The subsequently identified and designated National Institutes (NIs) are:

1. Kasetsart University, Bangkok (KU) with NBCRC as NACI
2. National Science Museum, Pathum Thain (NSM)
3. Chulalongkorn University, Bangkok (CU)
4. Mahidol University, Bangkok (MU)
5. Chiang Mai University, Chiang Mai (CMU)
6. Khon Kaen University, Khon Kaen (KKU)
7. Prince of Songkla University, Hat Yai, Songkhla (PSU)
8. Burapha University, Chon Buri (BU)
9. Department of Agriculture, Ministry of Agriculture and Cooperatives (MOAC) (DOA)
10. Royal Forest Department, MOAC (RFD)
11. Department of Fisheries, MOAC (DOF)
12. Thailand Institute of Scientific and Technological Research, MOSTE (TISTR)

A questionnaire prepared by the Network Coordinating Institute (NECI) was sent out to NIs and other institutes and individuals to collect information from the NIs working on biosystematics especially insects, nematodes and microorganisms on their manpower resources, number of collection and records, information available, and their needs in these areas to strengthen the institute. Other than the NIs the questionnaire was also sent to other agencies such as Mae Jo University, Mae Jo, Chaingmai (MJU); Naresuan University, Phitsanulok (NU); Thammasat University, Rangsit Campus, Pathum Thani (TU); Silpakorn University, Kakhon Pathom (SU); Ubon Ratchathani University, Ubon Ratchathani (URU); Maha Sarakham University, Maka Sarakham (MSU); and key well known biosystematicists in the country. The questionnaires were sent out in September 1999.

Altogether 49 questionnaires were sent out to 14 universities, 4 government departments, 2 research institutes, 12 individual biosystematicists and 17 NBCRC collaboratings agencies. Of these, only 7 responses were received. One each from NBCRC Central Regional Center, Kasetsart University at Kamphaeng Saen, Kakhon Pathom; Chiang Mai University, Chiang Mai; Burapha University, Chon Buri; and Chulalongkorn University promised to send it after the completion of the database renovation (but not received up till now). Two responses were received from Prince of Songkla University, one each from Hat Yai Campus in Songkhla and Pattani Campus, Pattani.

In these questionnaires it is noted that the responses were all from academic institutes, none was from government agencies nor individuals. The four key institutions of insect biosystematics, namely, Kasetsart University, Department of Agriculture, Royal Forest Department, and the National Science Museum did not respond at all in spite of repeated request and reminders. It is also noted that among those responses some indicated needs for the rehabilitation of the facility such as Chiang Mai University (US$ 52,000), Prince of Songkla University (US$ 37,000 for Hat Yai Campus and US$ 32,500 for Pattani Campus), and Burapha University (US$ 25,000), totaling US$ 146,500 excluding additional cost for human resource development training needs and references of various forms, conventional as well as electronic.

## ASEANET Activities in Thailand

A survey of information and communication technology in ASEANET questionnaire prepared by NECI in order to gather information and data on the status of Information and Communication Technology (ICTs) within the National Coordinating Institutes (NACIs) was again sent to all NIs and other agencies and individuals involved earlier in April 2000. This has become a great attempt for there was no single response!!!!

Again in June 2000, NECI prepared another questionnaire for the compilation of ASEANET taxonomic expertise. The questionnaire was sent to the same target groups at 49 destinations. The response received so far were from NBCRC, Kasetsart University on parasitic Hymenoptera; Khon Kaen University, Khon Kaen on Scarabaeninae (dung beetles); and the Thailand Institute of Scientific and Technological Research (TISTR), Bangkok on algae and cyanobacteria, fungi and gliding bacteria (both fruiting and non-fruiting).

Department of Agriculture, MOAC which houses the country's largest insect collection with an insect museum of about 500,000 specimens, and 8,071 species of which were identified never respond to any questionnaire or request. Similarly, Kasetsart University with its insect museum containing over 200,000 speciemens with the number of species identified not known also never respond to any questionnaire.

From August to September 2000, and attachment program arranged by ASEANET and BioNET-INTERNATIONAL enabled a Thai entomologist of NBCRC Central Regional Center at Kasetsart University at Kamphaeng Saen, Nakhon Pathom to undergo a training program on the Taxonomy of Parasitic Hymenoptera at the British Museum (Natural History) in London, UK. THAIBUG, a list of parasitic Hymenoptera of Thailand was one of the outcome of this training program. Since then two regular training courses have been conducted for local entomologists. In addition, a list of reference specimens of natural enemies at the Natural Enemies Reference Depository (NCRD) of the NBCRC Headquarters at Kasetsart University in Bangkok was also preliminarily completed.

## Thailand, ASEANET and AFFA

The Needs Assessment in Taxonomy and Biosystematics for Plant Pathogenic Organisms in ASEAN Countries including Thailand was undertaken by ASEANET in collaboration with Department of Agriculture, Fisheries and Forestry – Australia (AFFA) in October 2001 (Evans *et.al.*, 2002). A similar survey was also undertaken in May 2002 (Naumann, 2002). Both the surveys will eventually reveal the real and practical needs in the taxonomy and systematics of plant pathogens and arthropods of quarantine importance in Thailand and the ASEAN countries.

## Thailand and GTI

During June 2002 prior to the 3rd Global Taxonomy Workshop organized by BioNET-INTERNATIONAL in Pretoria, South Africa from July 8-12, 2002, ASEANET collaborated with GTI Asia by urging each ASEANET country to respond to a GTI Questionnaire on Taxonomy in East Asia - Global Taxonomy Initiative Information for Asia. This is a questionnaire prepared by Japanese GTI focal point and sent in late June 2002 with a deadline of submission on June 30, 2002. In Thailand the questionnaire was sent to 42 individuals, agencies and universities. In spite of the short notice a total of 23 questionnaires were returned from 14 agencies.

## Thailand and GISP

Taxonomy is also crucial in the timely and proper identification of invasive alien species (IAS). Taxonomy as an impediment in the Global Invasive Species Programme (GISP) and close collaboration with Bio-Net INTERNATIONAL were referred to quite often in the Regional Workshop on the Prevention and Management of Invasive Alien Species: Forging Cooperation Throughout South and Southeast Asia. The workshop was organized by the US Government, GISP and co-hosted by OEPP and Thailand Biodiversity Center (TBC) from August 14-16, 2002 in Bangkok with over 60 participants and observers from 19 countries.

## Thailand and ASEAN Regional Center for Bidiversity Conservation (ARCBC)

In September 2000 the Office of Environmental Policy and Planning (OEPP), the CBD and GTI National Focal Point for Thailand, organized a consultation meeting on the training needs in biodiversity and management of protected areas. Participating in the meeting were experts and representatives of the government and private sector. Outstanding among all other training needs was the training needs in biosystematics emphasizing the building-up of para-taxonomists. Another seminar organized by OEPP in October 2000 was also on the training needs in the conservation of biodiversity and the management of protected areas in Thailand. Again in this seminar, the training needs in biosystematics was identified and details given. The needs range from taxonomy of various microorganisms at the molecular level to the taxonomy of higher plants, insects, fishes and other animals.

Both the seminars which were organized by OEPP were partially supported by the ASEAN Regional Center for Biodiversity Conservation (ARCBC).

## Current Status on Taxonomic Institutions

The current status of taxonomic institutes in Thailand as an outcome of the task carried out by the Office of Environmental Policy and Planning (OEPP) serving both as CBD and GTI national focal point of Thailand was summarized and presented as a report to the CBD Secretariat in 2002 (Sirikul Bunpapong and Anchira Maneevong, *pers. comm.*; Kongsawat, 2002).

A questionnaire was sent out to NIs and other agencies which are involved in taxonomic works. These agencies include the Royal Forest Department (RFD), Department of Fisheries (DOF), Department of Livestock Development (DOLD), Department of Agriculture (DOA), Department of Agricultural Extension (DOAE), universities under the Ministry of University Affairs and other relevant agencies. The questionnaires were sent out in July 2001. Sixty-seven questionnaires were returned to OEPP. Preliminary analysis of the information received provides the results shown as follow:

- **Types of institutions:** Most of the 64 institutions who returned the questionnaire are not directly responsible for taxonomic collection but required to collect specimens for their own need. Up to 86% of institutions have undertaken some forms of specimen collection, however there are few funding institutions in comparison to those involved in taxonomic works.
- **Types of collections in relevant institutions:** The returned questionnaire revealed that 55 institutions had been assigned to collect taxonomic specimens. These institutions include 7 herbariums, 2 botanical gardens, 13 zoological museums (and aquariums), 6 germplasm collection centers, 1 gene bank, 8 agencies where collection

are carried out by individual researchers and 18 institutions where there are more than one types of collection.

- **Number and condition of specimens:** Of the total 55 specimen-collecting institutions identified, specimens in more than 80% of institutions were reported to be in good condition and can be used for reference. Five institutions were found to collect more than 100,000 specimens. These institutions are National Inland Fisheries Institute and Marine Biological and Fishery Research Institute of DOF, Entomology and Zoology Division of DOA, Department of Entomology, Faculty of Agriculture, and Faculty of Forestry, Kasetsart University.
- **Status of taxonomists:** The survey found that of 277 taxonomists, 75 are with institutions directly responsible for specimen collection, 187 are employed in institutions with other responsibilities but required specimen collection, 8 are with institutions responsible for taxonomy related tasks but do not carry out any specimen collection and 7 work for institutions with other responsibilities. When classified according to the group of organisms they are responsible, 82 work on botany, 70 on invertebrates, 47 on vertebrates, 51 on microorganisms, 10 on planktons, 9 on algae, 6 on parasites and 2 on protozoa. Those responsible on animal and plant groups are accounted for over 70 % due largely to diversity of known species, followed by microorganisms, plankton and algae, respectively. Very few taxonomists were found to work on true parasites and protozoa.

## National Needs and Requirements

- **Needs for additional taxonomists:** Forty-two institutions expressed their need for additional 190 taxonomists in total, 93 from institutions directly responsible for specimen collection, 74 from institutions with other responsibilities but required specimen collections, 6 from institutions responsible for taxonomy-related tasks but do not carry out any specimen collection and 17 from institutions with other responsibilities. When classified on the basis of specialization, the required taxonomists include 79 plant specialists, 44 invertebrate specialists, 37 vertebrate specialists, 25 specialists in microorganism, 2 plankton specialists, 2 parasite specialists and one algae specialist. The needs are often based on the lack of particular specialists in the institutions, transfer or retirement of existing taxonomists, overwhelming amount of specimens yet to be classified or the desire to enhance effectiveness and capability.
- **Need for para-taxonomists:** In total, 40 institutions expressed their need for additional 432 para-taxonomists. Para-taxonomists are mainly required for providing assistance to existing taxonomists such as in the survey and specimen collection, specimen maintenance, systematic storage and management of data as well as reducing workload of the taxonomists in researching and teaching and allowing more productive work on taxonomy.
- **Needs for collection facilities:** From 55 institutions where specimen collections have been conducted, 31 (56.36%) indicated their needs for rooms/buildings to accommodate better arrangement of present and future collection, enabling more sustainable use and to enable better access to interested individuals for study and other reference works.
- **Needs of taxonomic laboratories:** Twenty-nine institutions (57.73%) from 55 specimens-collection institutions, stated their need for additional laboratories in order

to separate specimen classification and analysis from other research activities, enabling greater efficiency and teaching of visiting classes.

- **Equipment/instrument for collecting specimens:** Over 50% of 55 specimens-collecting institutions confirmed their demands for additional equipment for collecting specimens or replacing the existing ones with more appropriate tools. The equipment required varied according to the organisms being studies. In general, these include nets, scuba diving gears, forceps, preservation liquid, liquid nitrogen, specimen jars, ovens, cabinets, etc.
- **Equipment/instrument needs for specimen classification:** From the above mentioned 55 institutions, 32 (58.20%) specified their needs for additional equipment for classifying specimens. Most of them demanded microscopes with varied specification, depending on the types of studies and size of concerned specimens, including stereo microscope, compound microscope, camera lucida, PCR machine, DNA sequencing, electrophoresis equipment, etc.
- **Equipment/instrument needs for data collection:** Thirty-four institutions from 55 specimens-collecting institutions (61.82%) stated their needs for computers to be used for data collection tasks, in order to facilitate searching and retrieval for analysis and other uses.
- **Needs for vehicles:** Approximately half of 55 specimens-collection institutions expressed their needs for vehicles (car and boats) to facilitate specimen collection expedition.
- **Needs for funding for taxonomic work:** From all respondents, 29 institutions stated their needs for additional funding for taxonomic works, ranging from Baht 100,000 to 1,000,000 annually (US$ 1.00 = Baht 42.00)
- **Other needs:** Other needs of respondents are relatively similar, such as additional budget, promotion of taxonomic works, textbooks and other taxonomic reference materials, annual training, provision of opportunities and support of new generation of taxonomists. Meeting these needs, however, depends on cooperation between taxonomists and reasonable support from government and funding assistance agencies.

## Conclusion

In Thailand, biosystematics is considered a basic science and only a handful of biological systematicists are actively involved. Collections of various taxonomic groups are also widely scattered in various institutions, public and private, as there is no biosystematics center nor natural history museum in the country which serves as a clearing house. Characteristic of most of these collections are substandard physical and technical facilities, poor curation and maintenance, shortage of well-trained taxonomists and curators, inadequate support, and lack of recognition and appreciation by policy makers. There exists an urgent need in the country to upgrade and strengthen biosystematics with a strong and long-term national program to help serve as a focal point for future coordination and development. Linkages and networking of biosystematic collections within the country and outside in the region for necessary and relevant collaboration could be one of the mechanisms to help strengthen and sustain biosystematic studies in Thailand and the region as a whole. With worldwide concern on biological diversity, the importance of biosystematics has become so obvious and there exists an immediate need to help develop and strengthen biosystematics investigations within each respective country in a particular geographical region, especially Southeast Asia which is one of the important centers of biological diversity and centers of origin for several plant and animal species.

A nice phrase such as "conservation and sustainable use of biodiversity" will not be substantially realized with the lack of adequate biosystematic efforts and continuing support provided to biosystematicists. Similar constrains and limitations are also applicable to any future attempt dealing with the inventory and monitoring of national biodiversity resources and reserves. With negligible expertise and competence available in Thailand, any national plan or program on the conservation and sustainable use of biodiversity together with the necessary inventory and monitoring will be merely a matter of speculation, not knowing definitely how and when such attempts can be accomplished.

Biosystematic work in Thailand had a very weak start right from the beginning. Most taxonomic work on Thai fauna and flora, in the past and till now, have been in the hands of foreign collectors and taxonomists working within and outside of the country. With no due recognition to local taxonomists, no matter how scarce they may be, biosystematics work in the country is dwindling due to lack of support, research grants and interest of various funding agencies. There exists an overdue and urgent need to provide reasonable and adequate support to strengthen biosystematics work toward a direction to establish a coordinating national program in the country. It will be through this mechanism that such a national establishment can serve as a national contact or focal point in terms of linkages or networking with other institutions dealing with biosystematics within and outside of the country in the region. The ultimate goal should be the support, promotion and strengthening of biosystematics in the country as well as in the region in a cooperative and collaborative manner.

Thailand needs and requires long-term training needs in biosystematics as well as the rehabilitation of the antiquated facilities to curate all biological specimens in the country. This needs and requirements is equally shared by other member countries of the ASEANET.

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# Species 2000: New Zealand —
# Benefits, Lessons, and Intended Outcomes

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## Abstract

***Species 2000: New Zealand* is a three-stage activity with multiple goals. The three stages are: 1) a millennial symposium reviewing the entire New Zealand biota (completed); 2) published volume(s) of kingdom/phylum-by-phylum reviews of all taxa, with end-chapter checklists of all known species; 3) electronic checklists of species, with synonyms, available on the worldwide web. The goals of the New Zealand activity include: 1) consciousness-raising among New Zealand taxonomists about Species 2000 and global species databases (GSDs); 2) consciousness-raising among New Zealand government departments and ministries about the crucial role of biosystematics in biosecurity, human and animal health, sustainable ecosystem management, resource identification and use, and conservation; 3) promotion of the concept of a 50-year National Biosystematics Strategy, to be aligned with the New Zealand Biodiversity Strategy launched in March 2000; and 4) New Zealand contributions to GSDs that conform to the core data standards of Species 2000. Lessons learned from the activity so far include: 1) the value of using the media to promote one's aims; 2) the need for detailed long-term planning and commitment; 3) how RSDs may contribute to GSDs.**

***Key Words : Species 2000, New Zealand, Millennial symposium, Inventory of biota, Global Species Databases, Regional Species Databases, National biosystematics strategy***

## Introduction

It has been recognised for many years that the diversity of species on Earth exceeds current taxonomic capacity to inventory it. Estimates of the number of species still vary widely, especially for prokaryotic organisms. Recent analyses of known and estimated global species diversity (Hawksworth and Kalin-Arroyo, 1995; Stork, 1999) estimate that only around 1.75 million species have been described out of perhaps 12.5 million to 13.6 million species total. Also, at the present rate of global new-species description per year (~13,000), it will take most of the present new millennium to complete the task of formal description. This is not only discouraging but alarming, especially in the face of increasing extinctions of species in most environments. Further, the ~1.75 million species already described are not even fully cataloged. The laudable aim of Species 2000 is to correct that situation by creating a linked cumulative register of Global Species Databases (GSDs), and some progress has been made toward that end.

A parallel activity that is being carried out in some parts of the world is Regional Species Databases (RSDs). State-by-state biological surveys are being undertaken in the USA and species inventories have been completed for some states, including Hawaii and Illinois (Eldredge & Miller, 1994). A similar survey was made in Bermuda (Sterrer, 1998). A major benefit of GSDs is that a corrected global list of species in a single taxon excludes synonyms, whereas regional lists may not only reflect regional uses of particular binomials but overlap from region to region. RSDs may be very useful in specific regions, however, by providing a baseline biodiversity inventory for a variety of purposes. Gordon (this volume) lists a number of potential benefits of regional or national inventories. They constitute a point-in-time stocktaking against which future gains and losses of species may be measured, especially if the biodiversity data are accompanied by ancillary data on distribution and abundance. The question arises, however: How useful are RSDs in contributing to the overall aims of Species 2000? This question is addressed here by considering the current *Species 2000: New Zealand* activity. We also look at the prospective outcomes and lessons learned from carrying out an all-biota review and inventory.

## Goals and Steps in Achieving a Regional Biodiversity Inventory — New Zealand as an Example

Achieving a complete species inventory for New Zealand (Gordon, this volume) is challenging for many reasons. While the land area of New Zealand (268,200 km$^2$) is not huge, it nevertheless exceeds that of the United Kingdom, or Honshu + Shikoku, and the 200 nautical mile Exclusive Economic Zone (EEZ) is the fifth largest in the world at almost 4.2 million km$^2$, spanning 30 degrees of latitude from the subtropics to the subantarctic. The resource base, by contrast, is relatively small since the population is only 3.8 million, but there has been a long history of collecting fauna and flora from the time of the first expeditions and, during the past 150 years, taxonomic research has resulted in a reasonable knowledge of the biota. Even so, it is becoming clear that it will take from 100 to 400 more years to complete the task of recognising and naming all species, at the present rate. The *Species 2000: New Zealand* activity was initiated, therefore, to review the nation's biological diversity by compiling a list of all known living and fossil species, current to 31 December 1999. Although this activity may be seen as national, it is also simultaneously regional in that both the terrestrial and marine biota are so distinctive as to represent a separate biogeographic region or realm (Sherman et al., 1990; Olson and Dinerstein, 1998; Myers et al., 2000).

It was intended that this exercise would also provide an opportunity to raise awareness among New Zealand taxonomists about Species 2000 and GSDs. Some taxonomists are already contributing to Species 2000 through ILDIS and FishBase but many were not aware of the aims and progress of Species 2000. A complementary goal was to raise awareness of New Zealand's biodiversity, and the crucial role of taxonomic research, among government agencies.

Planning for the New Zealand activity began in September 1997, about two-and-a half years before the 2000 meeting, when I suggested an all-biota review in an application for continued funding for NIWA's research programme in marine taxonomy. New Zealand's Foundation for Research, Science & Technology accepted the idea but provided no supplementary funding to assist in bringing it about. Promotion of the activity nevertheless began in April 1998 when four-colour flyers were distributed to the systematics community in New Zealand and selected specialists overseas, with accompanying information explaining its purpose and an invitation to participate. The national review and inventory were also explained in workshop presentations in 1998 and 1999 to scientists at Landcare Research (responsible for most of New Zealand's research on the systematics of terrestrial arthropods, nematodes, fungi, bryophytes, vascular plants, and bacteria) and to an annual meeting of SYSTANZ (Systematics Association of New Zealand), respectively. By the end of 1999, after two extensive mail-outs and numerous e-mail messages and telephone calls, more than 140 New Zealanders (including many retired from formal employment but still active in research – one a nonagenarian) and about 24 overseas taxonomists had agreed to contribute.

The review activity would take place in three phases. Phase 1 would be a symposium, phase 2 the publication of the symposium volume, and phase 3 the publishing of species lists on the worldwide web. The symposium, planned as a millennial-year activity, was held at the Museum of New Zealand (Te Papa Tongarewa) in Wellington, 1–5 February 2000. A deliberate strategy of the symposium was not only to review species diversity but also to explain the benefits and applications of biodiversity knowledge. The SYSTANZ executive agreed to fund media promotion for the symposium. A media-liaison person was hired to write promotional material and to inform contacts in radio, television, and print media about the all-biota review, which was billed as the first of its kind in the world at the national level.

Keynote speakers were lined up to address symposium delegates, including the chair of Species 2000, Professor Frank Bisby, Reading University, U.K., and Dr David Given, Manager of the International Centre for Nature Conservation, Lincoln University, New Zealand. A personal invitation was sent to the Minister of the Environment in the new Labour government, the Hon. Marian Hobbs, to officially open the symposium, and Dr Morgan Williams, Parliamentary Commissioner for the Environment, agreed to speak at the symposium banquet.

**Box 1. Pre-symposium Media Release (9 January 2000):**
***Species 2000* — A Checklist of New Zealand's Rich Tapestry of Life**
**(by media-liaison person Redmer Yska, from notes supplied by the convener).**

The marathon challenge of listing every known local species of animal and plant will be the main focus of *Species 2000: New Zealand*, a landmark millennial symposium to be held in Te Papa from February 1 to 5. The nationwide biological census and knowledge review — the first of its kind in the world — will cover all; living and fossil, native and introduced species and subspecies found in New Zealand's seas, fresh waters, and land at the end of December 1999. Biologists estimate that New Zealand may have 80,000 species of native animals, fungi, and plants. About half of these have been described and named to date. The main groups are the insects and fungi, each with a possible 20,000 species. Of our known species, about 1000 are considered threatened, especially birds.

The Wellington meeting will identify what is unique and special to New Zealand, focussing on the practical uses and benefits of knowing all forms of life. The rich and largely unknown marine life found within our vast 200 nautical mile Exclusive Economic Zone will receive particular attention. Work on the local checklist has been proceeding during 1999, with the help of more than 160 contributors (including 24 overseas). Following the symposium, a wide range of species checklists and other information will be published in book form and progressively on the internet. The fresh data will be used by local Crown Research Institutes and Te Papa and will feed into similar databases around the world.

*Species 2000: New Zealand* is linked to Species 2000 International, a global programme with the ambitious aim of indexing the world's known species as a practical tool for counting and measuring biological life worldwide. Programme coordinator Dr Frank Bisby of Reading University in the United Kingdom is a keynote speaker at the symposium. "The timing is practical, with the end of a century a useful time marker for a baseline review. The symposium will result in an authoritative checklist of species names for nearly all taxonomic groups current to 31st December 1999", explained organiser Dr Dennis Gordon from the National Institute of Water and Atmospheric Research. "Worldwide, approximately 1.75 million species of life have so far been described. Realistic estimates of the likely number of global species, however, range up to 14 million. This means that more than 85 percent of species on Earth remain unrecognised. Most are tiny animals, fungi, and microorganisms yet to be described. "Forest plants and even marine animals are included in this number, which means that new flowers, materials, medicines, and marine natural products are still undiscovered", said Dr Gordon. "Meanwhile we know that some 4,000 species are becoming extinct each year in tropical forests alone, and trawl-fishing activities on the world's continental shelves are having serious impacts on populations of marine life. Our knowledge of New Zealand's biological diversity is relatively good compared to the global situation. We probably know about 50 percent of our species. The symposium will give a much clearer picture of our knowledge — and our ignorance — than ever before. Above all, *Species 2000: New Zealand* will be a celebration of our biodiversity as a special heritage to be respected and treasured by all New Zealanders."

Media statements were released three weeks before the symposium (Box 1) and on the morning of the first day, resulting in several newspaper articles. Early on the first day there was a television interview with the convener, D. Gordon, on the 'Breakfast' programme of TV1, and prime-time evening television highlighted the all-biota review, accompanied by interviews with the convener and Professor Bisby. Radio New Zealand conducted interviews with the convener, Professor Bisby, and several symposium speakers, and these and aired over the next several days on 'Morning Report', 'Checkpoint', and 'Eureka', the latter a weekly science programme. Conference registration reached 141 and, in addition to the keynote speeches, 75 other presentations were made during the five days of the symposium.

**Box 2. End-symposium Media Release (6 February 2000): Biodiversity Strategy Must Address Task of Listing Species (by media-liaison person Redmer Yska, from notes supplied by the convener).**

New Zealand has a vast reservoir of undiscovered and unrecorded species. But unless a new generation of local taxonomists is trained to start cataloguing these biological riches, this vital work will fall even further behind. This was the main message emerging from Species 2000: New Zealand, a five-day symposium at Te Papa that concluded yesterday. The national biological census covered all living and fossil, native and introduced species and subspecies found in New Zealand's seas, fresh waters and land at the end of December 1999.

Organiser Dr Dennis Gordon, from the National Institute of Water and Atmospheric Research, said delegates were unanimous that the Government's Biodiversity Strategy must address the need to document New Zealand's biota. "It is vital that as Government moves to implement New Zealand's biodiversity strategy, it comprehensively addresses the issues raised at Species 2000: New Zealand. The door is now open. "In her opening address to our symposium, Environment minister Marian Hobbs announced the imminent approval of New Zealand's first biodiversity strategy. We welcome this warmly. We also welcome her acknowledgement of the need for funding to address the critical shortfalls. Such shortfalls exist not only in the area of information, but also in the capacity to build and sustain our efforts. "They have an indispensible role to play in helping to 'turn the tide' on the decline of New Zealand's biodiversity."

Dr Gordon said special challenges existed for marine biodiversity inventory. He pointed to the fact that just one macroalgal specialist was working in the country, with none for marine fungi. Yet New Zealand's Exclusive Economic Zone is 15 times the size of the land area, and the fourth or fifth biggest in the world. As a priority, the Biodiversity Strategy recognises the need for a strong information, research, and capacity base. Within this, there could be no more critical element of the framework than a catalogue of the very diversity of life forms on which biodiversity is based. Dr Gordon said New Zealand could not afford to approach the catalogue of life in the ad hoc way it has done so to date. "At the present rate, it would take two centuries to document all of New Zealand's [remaining] biota. Let's shorten that. "An entirely workable but visionary approach is open to us. A 50-year strategy, in five ten-year steps, would offer New Zealand the opportunity to look systematically at its present knowledge gaps. We need to take a measured approach towards prioritising this issue and recuiting and training the people to fill the gaps. "This massive task needs to be carried out before it grows too big. Our known biota is fast reaching a size where it is becoming incomprehensible. Many species groups are not catalogued and the literature is often scattered."

Dr Gordon cited biosecurity, human and [animal] health, sustainable ecosystem management, and conservation as other clear reasons why the issue needed to be urgently addressed. Resource identification and use also stood to provide New Zealand with an immense range of benefits. "We sometimes forget that a comprehensive catalogue of biodiversity is also a matter of naked human self-interest. We simply don't know enough about the potential sources out there of food, medicines, and biochemicals. It could come from fungi, bacteria, or marine life. ... We know so little about the fantastic creatures we share the Earth with. We don't know how many there are, or what kinds of things they have to offer. It is like a library of unread books and we haven't even finished the first chapter. And the great tragedy — especially for our children and grandchildren — is that we are losing the species around us before we can even turn the next page."

The timing of the symposium was doubly fortuitous, coinciding with concurrent discussions about the Global Taxonomy Initiative at the SBSTTA 5 meeting in Montréal and the forthcoming launch of the New Zealand Biodiversity Strategy, both of which were mentioned in the Minister's opening speech, which was covered in the print media. The symposium closed with a final press release (Box 2) calling for a 50-year National Biosystematics Strategy (cf. Wilson, 1985) for New Zealand and this was reported in newspaper articles as well as on the daily internet science news service of the Royal Society of New Zealand. It is estimated that completion of an inventory of undescribed marine species will take at least another century (Gordon, 2000) and, for terrestrial arthropods, two centuries or more, at the present rate of description. A biosystematics strategy is crucially needed to shorten that time time-frame.

## Outcomes and Lessons

Undertaking a national all-biota review and inventory is challenging at any time, but especially so when there is no funding and all contributors must donate their time and effort to compile species lists, write chapters, and travel to a symposium. Further, although the Convention on Biological Diversity has significantly raised awareness of biodiversity internationally and in New Zealand, there has not yet been a concomitant increase in taxonomists in most countries. Encouragingly, the Conference of the Parties to the Convention suggested, at their 2000 meeting (COP-5, Nairobi, May 2000), actions to advance implementation of the Global Taxonomy Initiative that may result in capacity-building in the years ahead [http://www.biodiv.org/Decisions/COP5/html].

In New Zealand, as in many countries, inventories of selected taxa had already been compiled or were underway, but not for whole phyla, and not integrating all native, adventive, and fossil species. It was found that the lead time of more than two years for the New Zealand symposium was necessary in order to complete species checklists on time, frequently involving first-time collaboration between neontologists and paleontologists. An additional challenge was to make a generalist symposium appeal to both specialist taxonomists [do coleopterists wish to hear reviews from algologists, for example?] and the public (e.g., government ministries and media representatives). Hence it was necessary, and fruitful as it turned out, to ask reviewers to also address applications of the knowledge of their specialist taxa.

Was the *Species 2000: New Zealand* activity able to influence the formulation of the New Zealand Biodiversity Strategy? A draft version of the strategy was released for public evaluation and discussion in February 1999. New Zealand taxonomists immediately noted the lack of explicit recommendations concerning taxonomic research. In spite of feedback at subsequent national workshops relating to the draft strategy, and the press release on the last day of the symposium (Box 2), the final version of the strategy published by the New Zealand Department of Conservation and Ministry for the Environment (2000) still lacked recommendations for a strategic programme of systematics research. The New Zealand taxonomic community is continuing to lobby for a National Biosystematics Strategy.

Following his return to the United Kingdom after the symposium, Professor Bisby reviewed how the New Zealand national/regional activity may be perceived to relate to Species 2000, commenting (Bisby, pers. comm. 2000): "The speakers covered what were remarkably exciting developments over all groups of the New Zealand biota, and [the] immediate goal is to bring together contributions into a hardcopy published New Zealand checklist. ... But what also emerged from the meeting was:

- The logic of capturing these lists in one or more ongoing New Zealand species checklist databases of which several components already exist;
- That several of the contributors ... would be interested to develop GSD checklist databases for either substantial or small groups for which they do not already exist. Where the groups were small, the GSDs could be aggregated into a single multispecies database, as we are already seeing in the CABI Species Fungorum datasets;
- That several of the New Zealand specialists are involved in existing GSD networks participating in Species 2000, including ILDIS and FishBase;
- And that several of the existing New Zealand databases would be interested to connect to Species 2000 links in the same way as ... BIOTA-SP.

It is clear from the New Zealand activity that initiating RSDs should facilitate direct and indirect contributions to GSDs. This should especially be the case for any country or region which, like New Zealand, has a relatively high proportion of endemic species in the biota (Myers et al., 2000). It is likely that the volume resulting from the New Zealand symposium will published in 2004, accompanied by media publicity. Following the launch of the hardcopy volume(s), checklists can be prepared for availability on the internet and, after the addition of synonyms, for incorporation into Species 2000 GSDs.

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# Biosystematics: Capability and Needs Assessment for New Zealand – 2001/02*

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## Introduction

The national capability in biosystematics was last surveyed in 1995/96 (Penman 1996) which established a baseline from which to monitor changes, especially in the Crown Research Institute and University sectors. The 1995/96 survey was conducted in an environment where some signals were given of growth in funding for biosystematics that would arrest the previous decades-long reduction in effort. Despite some funding increases early in the period, subsequent increases did not eventuate as the Foundation for Research, Science and Technology changed both processes and priorities.

Given the changes to investment processes and the growing awareness of key issues such as biosecurity and biodiversity loss, it is timely to review the current capability 5 years on from the original survey. The 2001 survey widened its coverage to the Ministry of Agriculture and Fisheries and to the Museum sector. This latter sector did report results in the 1995/96 survey but they were prepared by the sector itself rather than using common questionnaires. Hence later comparisons of changes within the Museum sector may not be valid.

## Process

A questionnaire similar to that used in 1995./6 was sent to all Crown Research Institutes and Universities. As indicated, the Museums and MAF were also sent the same questionnaire. Comments on directions, barriers etc. and probable staff changes were also sought. Unlike the 1995/96 survey, data on the systematics capability associated with paleontology was sought in the current survey.

Surveys were returned from:

***Crown Research Institutes:***

- AgResearch
- HortResearch
- Landcare Research
- Geological and Nuclear Sciences
- NIWA

***Universities:***

- Victoria
- Canterbury
- Lincoln
- Auckland
- Otago

* This paper was received not as for submission of paper, however, editor concerned that it was important to include herein as information of New Zealand. Format was slightly adjusted for this book without changing the contents.

*Museums:* Otago
Canterbury
Te Papa
Auckland

*Ministry of Agriculture and Forestry:* National Plant Pest Reference laboratory

## Results

### *Capability in Key Groups:*

Table 1 summarises the current capability (2001) measured as Full Time Equivalents (FTEs) against target groups of organisms.

**Table 1. Biosystematics capability in target groups (full time equivalents) within the Crown Research Institutes, Museum and University Sectors**

| Group | Crown Research Institutes | Universities | Museums | MAF | Total |
|---|---|---|---|---|---|
| Terrestrial organisms | 20.15 | 19.55 | 25.05 | | 64.75 |
| Marine organisms | 11.62 | 13.33 | 10.2 | | 35.15 |
| Freshwater organisms | 3.4 | 6.31 | - | | 9.71 |
| Bioprocess organisms | 4.85 | 7 | - | | 11.85 |
| Food spoilage organisms | 0.15 | - | - | | 0.15 |
| Plant pests | 4.65 | 0.1 | 1.9 | 24.5 | 31.15 |
| Animal pests | 0.2 | 5 | - | | 5.2 |
| Other | 0.15 | 8 | - | | 8.15 |
| **TOTAL:** | **45.17** | **59.29** | **37.15** | **24.5** | **166.11** |

Comparisons with the 1995/96 survey must be handled with care as some additional providers were included in this survey and the Museum sector used a different survey in 1995/96. For example, the Museum sector in 1995/96 claimed 27 FTEs working on biosystematics of target groups, while in 2000 the level was 37.15 FTE. It seems unlikely that the capability has grown by 37.6% over 5 years. Also comparisons within the CRIs need to recognise that paleontology was not surveyed in 1995/96. By removing the biosystematics FTE reported by the Institute of Geological and Nuclear Sciences (IGNS) we can make a more meaningful comparison of trends over the past 5 years. Table 2 compares CRI and University data in 1995/96 and 2000/01 with IGNS FTE removed.

**Table 2. Comparisons of biosystematics capability (FTE) in the CRI and University sectors in 1995/96 and 2001/02 (excluding paleontology (IGNS)**

| Group | Crown Research Institutes | | Universities | |
|---|---|---|---|---|
| | **1995/96** | **2001/02** | **1995/96** | **2001/02** |
| Terrestrial organisms | 24.4 | 19.5 | 25.04 | 19.55 |
| Marine organisms | } 8.82 | 10.12 | } 7.4 | 13.33 |
| Freshwater organisms | | 3.4 | | 6.31 |
| Bioprocess organisms | 5.32 | 4.85 | 5.4 | 7.0 |
| Food spoilage organisms | 4.0 | 0.15 | - | - |
| Plant pests | } 20.15 | 4.65 | } 1.81 | 0.1 |
| Animal pests | | 0.2 | | 5.0 |
| Other | 0.75 | 0.15 | 2.6 | 8.0 |
| **TOTAL:** | **63.44** | **42.92** | **42.25** | **59.3** |

The key changes over 5 years are in the following

- Terrestrial organisms (non plant or animal pests) : an effective decline of 21% (10.4 FTE) of scientist engaged in biosystematics research, with the decline in CRIs being 20% and in universities 22%.

- Marine and freshwater organisms : a > double increase of FTE (15.44 FTE) with the increase for CRIs being 6.2 FTE and universities 12.24 FTE. This probably reflects new marine and freshwater biosystematics' programme funding in 1998/99.

- Bioprocess organisms (organisms used in food processing, waste disposal etc); a 9.5% (1.13 FTE) increase in effort. This increase was in universities with CRI input declining by 0.47 FTE.

- Food spoilage organisms: No respondents claimed ongoing capability in the biosystematics of food spoilage organisms while 4.15 FTE were reported in 1995/96. Some of this expertise may have been reported under the 'Other' category of Table 2 which increased from 0.9 FTE in 1995/96 to 10.6 FTE in 2001/02.

- Plant and animal pests: Capability to undertake taxonomic studies and identify pests has declined markedly. In 1995/96 22 FTE were directed to this area while in 2001/02 only 10 FTE provide this capability. MAF has significant capability (24.5 FTE) but since MAF was not part of the 1995/96 survey, any declines or increases in their capability were not captured. Their focus is on providing identification services rather than biosystematics research.

The overall shifts of capability in the CRIs and universities were a decline of 32.3% (20.5 FTE) and an increase of 40% (17 FTE) respectively. With Massey University not reporting in the 2001/02 survey, we can expect the university capability increase to be even higher.

## Biosystematics Skills

Modern biosystematics requires access to a much wider range of skills than in the past. As we move beyond traditional documentation and description (referred to here as

'Taxonomy'), biosystematists are increasingly accessing molecular biology and information technology. Also the growing requirement to make information more accessible requires more emphasis on databases and information products.

An assessment of the current distribution of skills applicable to biosystematics is in Table 3.

**Table 3. Current assessment of skills (full time equivalents) in biosystematics within Crown Research Institutes, Museum and University Sectors**

| Group | Crown Research Institutes | Universities | Museums | MAF | Total |
|---|---|---|---|---|---|
| Taxonomy | 10.97 | 2.865 | 13.14 | | 26.975 |
| Molecular analysis | 4.41 | 3.21 | 0.05 | | 7.67 |
| Phylogenetics | 2.43 | 4.1 | 0.24 | | 6.77 |
| Databases/bioinformatics | 2.43 | 1.1 | 6.2 | 2 | 11.73 |
| Collections management | 3.4 | 1.185 | 13.45 | | 18.035 |
| Information products | 4.66 | 0.1 | 1.79 | | 6.55 |
| Other | 3.46 | 1.385 | 2.7 | | 7.545 |
| **TOTAL:** | **31.76** | **13.945** | **37.57** | **2** | **85.275** |

Skills in skill mix over 5 years can be compared by reference to the CRI and university reports for 1995/96 and 2001/02 (Table 4). The greater number of FTE claiming skills in 2001/02 of relevance to biosystematics than staff working on particular groups reflects people with skills that could be applied to biosystematics , should funding be available.

**Table 4. Changes in biosystematics skills in the CRI and university sectors between 1995/96 and 2001/02 (excluding paleontology (IGNS)**

| Group | Crown Research Institutes | | Universities | |
|---|---|---|---|---|
| | **1995/96** | **2001/02** | **1995/96** | **2001/02** |
| Taxonomy | 27.78 | 10.28 | 14.81 | 2.87 |
| Molecular analysis | 6.62 | 4.41 | 18.0 | 3.21 |
| Phylogenetics | 3.44 | 2.31 | 6.49 | 6.2 |
| Databases/bioinformatics | 6.51 | 1.99 | 0.5 | 1.15 |
| Collections management | 16.74 | 2.99 | 2.15 | 1.19 |
| Information products | 2.35 | 4.44 | 0.3 | 0.1 |
| Other | - | 3.46 | - | 1.39 |
| **TOTAL:** | **63.44** | **29.88** | **42.25** | **13.95** |

Major shifts in skill mix include:

- ***Taxonomy***: The major decline of reported effort aimed at the documentation and description of our biota is of concern (a decline of 28.75 FTE from 1995/96 to 2001/02) giving a skill base in 2001/02 of only one-third that of 1995/96.

- ***Molecular biology:*** Despite burgeoning growth in molecular biology in research institutes and universities, such skills directed towards biosystematics have declined by one-third in CRIs and by over 80% in universities. The university figures would be expected to higher with return from Massey University.
- ***Databases/bioinformatics:*** The convergence of IT with biosystematics promises much but this is not reflected in the current commitment of staff. There is a small increase in

universities while in CRIs commitments have declined by over 60%. Some of this may have been balanced by the increase in effort of over 2 FTE directed towards information products (which may include database access).

- ***Collections management:*** There is a large drop of expertise dedicated to collections management over the 5 years. Excluding Museums, there were 18.9 FTE dedicated to collections in 1995/96. By 2001/02 this had fallen to 4.2 FTE, a decline of 78%. CRIs showed the major decline with FTE reducing from 16.74 to 2.99 (an 82% decline). While a direct comparison with Museums is not possible, it appears that Museum FTEs dedicated to Collections, Databases and Information Products have remained largely static (19.7 FTE in 1995/96 and 21.4 FTE in 2001/02).

## Developing Capability

If capability and skill expansion is required to rebuild biosystematics in New Zealand, we need to develop new staff from within universities. Currently (2001/02) there are 45 PhD candidates claiming biosystematics as their primary research discipline. Of these, 24 are working on biosystematics of terrestrial organisms and 18 are studying marine organisms. Of these students approximately 5.5 claim taxonomy as their primary focus, 10 claim molecular analysis and 6.5 claim phylogenetics. There is virtually no effort in developing skills in bioinformatics, collections management or information products. A Massey University response would increase these numbers.

## Future Needs

Despite the reported declines in biosystematics over the last 5 years, all sectors indicate an increasing need for biosystematists over the next 8 years. In the 1995/96 survey, CRIs and universities were asked to project needs beyond 2000 (to 2005). Both sectors projected a need for 14 FTE. Table 5 reports on projections to 2010 across all sectors.

**Table 5. Future requirements for biosystematists over the next 8 years within Crown Research Institutes, Museum and University Sectors**

| Group | Crown Research Institutes | | Universities | | Museums | | MAF | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | 2001-5 | 2005-10 | 2001-5 | 2005-10 | 2001-5 | 2005-10 | 2001-5 | 2005-10 | |
| Terrestrial biota | 3.5 | 7.5 | 14.5 | 14 | 5 | 4 | - | - | 48.5 |
| Marine biota | 6 | 8 | 4 | 4 | 2 | 4 | - | - | 28 |
| Freshwater biota | 1 | - | - | - | - | - | - | - | 1 |
| Bioprocess organisms | 1 | 1.5 | - | - | - | - | - | - | 2.5 |
| Food spoilage organisms | 0.5 | - | - | - | - | - | - | - | 0.5 |
| Plant pests | 0.5 | 0.5 | - | - | - | - | 8 | 6 | 15 |
| Animal pests | 0.05 | 0.05 | - | - | - | - | - | - | 0.1 |
| Other | 0.5 | - | 1 | - | 1 | - | - | - | 2.5 |
| **TOTAL:** | **13.05** | **17.55** | **19.5** | **18** | **8** | **8** | **8** | **6** | **98.1** |

Of interest is the growing demand within universities (perhaps as they rebuild lost staffing capacity) and the requirement from MAF for people trained in pest identification. Given that students currently enrolled in PhD programmes will complete by 2005, the 45 students could largely fill expected demand (48.5 FTE). However, this is predicated on them all completing their studies, not going overseas and funding being available to employ them.

## Conclusions

Sequential studies on capability and needs within science disciplines are uncommon. Many efforts at lobbying for new resources for particular disciplines are based on anecdotal and case study evidence. This paper, in contrast, compares a 1995/96 survey on biosystematics with results from a similar survey in 2001/02. We now have a quantitative basis on which to assess changes in capability and future needs.

If biosystematics is a key foundation to the emerging biological economy (biotechnology, bioactives etc.), managing risks to the economy and the environment (biosecurity), and supporting conservation and sustainable use (biodiversity), then this survey suggests that the widespread decline in biosystematics capability, especially within the CRIs, places much of the above at risk.

Apart from a small increase in funding to biosystematics following the 1995/96 survey (largely in marine and freshwater areas), real funding has declined, especially in the CRI sector, at a rate of 4-5% per annum (personnel and other cost increases) with no change in actual investment. If this continues, the nation faces real risks from not having skills to provide definitive identification and document the vast amount of our flora and fauna so far unnamed or undescribed. We cannot rely on others to do this for us and the Global Taxonomy Initiative a key part of the Convention for Biological Diversity, will put an international focus on our efforts to manage our biodiversity.

This paper now provides the basis to formulate an investment plan that gives long-term real support to this key discipline that underpins much of our future.

## References

Penman (1996)

# A Letter from Bhutan*

Karma C. Nyedrup
*National Environment Commission, Post Box 466, Thimphu, Bhutan*

Bhutan has not done any taxonomic needs assessment to date. However, Bhutan has completed construction of a herbarium. We have managed to collect about 14, 000 samples of vascular plants and the information is documented. These collections are curated and protected against decay. Bhutan is in the process of putting the collected data in the electronic form and putting them on the web soon. In conjunction to this, Bhutan has also completed the development of infrastructure for Botanic Gardens. It is very much in an infant stage in terms of fulfilling one of its objectives to make it a showcase for Bhutan's floral diversity due to lack of technical capabilities and financial resources.

Further, three volumes on Flora of Bhutan have been completed and it is expected to cover at least 70 percent of vascular plants. Bhutan is yet to do studies and inventory on vertebrate, vertebrate (animals), non-vascular (plants), and on microorganisms.

Bhutan does not have any zoos or zoological parks. Bhutan planned to initiate with the development of a zoological park but to begin with, Bhutan wanted to develop a master plan. Nevertheless, due to financial constraints this initiative could not be undertaken. Bhutan has many threatened and endemic fauna, which needs to be inventoried and conservation measures adopted through establishment of zoological park on a priority basis.

Bhutan has also initiated a project on domestic agro biodiversity with the inventory of the horticultural crops through donor assistance. Ultimately, these information and collections are expected to be preserved in a National Gene Bank which is construction and will be completed this year in October. A breed survey is also underway and its documentation is almost complete.

Bhutan does not teach taxonomy as a subject in schools nor Bhutan has schools specialized in this field. Some basic biology is taught in schools. If Bhutanese need to be trained in this field, they are sent outside Bhutan. To date, Bhutan has only one taxonomist who is professionally trained. There are few staffs who are taxonomists by experience. The main pressing needs in Bhutan are, capacity building and financial assistance.

Some of the institutions involved in this issue are Dr. Ugen Tshewang, Director, National Biodiversity Centre, Post Box 875, Babesa, Thimphu, Bhutan.

Should you need further clarification, please contact me.

* Letter was received not as submission for paper, however, editor concerned that the content was important to include herein as information of Bhutan.

# PROCEEDINGS

## Chapter 2:
## Existing research activities in taxonomic groups

# Biodiversity of Bacterial Flora from Coastal Areas of Pakistan: Sind and Baluchistan

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## Abstract

**Coastal areas of Pakistan offer a rich repository of marine organisms while microbial flora in these marine environment forms an integral part of this unique ecosystem. Marine bacteria especially those in the Arabian Sea live in an extremely competitive environment. Since bacteria have been reported to have novel and unique genes and bacteria from the Arabian Sea have not been studied before with emphasis on genetic diversity, samples from Karachi and Baluchistan coast were collected from a variety of sources such as surface water, deep-sea water, sediments, sea animals and plants. The samples were analyzed both qualitatively & quantitatively for the presence of bacteria. A total of 193 bacterial strains were isolated, purified and preserved. Biodiversity was studied among free and attached bacteria with respect to heavy metals resistance and antibiotics resistance. Some of the strains were screened for the production of secondary metabolites. These compounds have been checked for biological activities and were found to have the potential for commercial exploitation. The bacterial strains were identified by API-20E kits and the identifications of few of them were also confirmed by 16S rRNA gene sequencing.**

***Key Words: Karachi coast, bacterial diversity, genetic markers, 16S rRNA gene sequence***

## Introduction

Arabian Sea is the northwestern part of the Indian Ocean covering a total area of about 1,491,000 square miles (3,862,000 square km) while Pakistan lies to the north of Arabian sea and has a coast line of 527 nautical miles (nm) starting from the border of Rann of Kutch to border of Iran, presenting coastal area of Sind and Baluchistan (Fig. 1). Microbial flora in these marine environments forms an integral part of this unique ecosystem, but marine bacteria of this region have remained unexplored. Besides the lack of knowledge concerning marine bacteria (Colwell, 1997), an understanding of marine microbial biodiversity is of utmost importance for a variety of reasons. It is well known that bacteria play an integral role in the cycling of carbon, nitrogen, sulfur and phosphate. As such, it is important to determine the types of bacteria present in these particular ecosystems, the role they play in the functioning of that system, and to gauge the effects that anthropogenic forces (particularly pollution) are exerting on the diversity of marine microorganisms. Indeed, it has already been shown that sewage sludge dumping off the coast had an impact on the microbial ecology at that site (Hill *et al.,* 1993).

For the characterization of organisms, molecular biology has opened up a number of new approaches to study biodiversity at the molecular level. Historically, microbial taxonomy had been conducted using a variety of physical and biochemical tests that allow the grouping of microbial isolates into genera and species. Bacterial diversity can be accurately determined using molecular taxonomic tools such as polymerase chain reaction (PCR) amplification and sequencing of 16S ribosomal RNA genes, hybridization of DNA probes specific to genes coding for particular enzymes to either DNA (potential function) or messenger RNA (expressed function). Resistance patterns of culturable bacteria to heavy metal contaminants also gave the bacterial diversity, present in contaminated sites of costal areas (Jamil, *et al.* 2000). The link between biotechnology and biodiversity is another key reason for cataloguing and conserving marine microbial biodiversity. The marine environment has proved to be a valuable source of diversified bioactive compounds with antibacterial, antiviral, and anticancer properties (Colwell and Hill, 1992). Both free-living bacteria and bacteria that are symbionts of marine invertebrates are likely to have diversified characters and potentials of useful bioactive compounds.

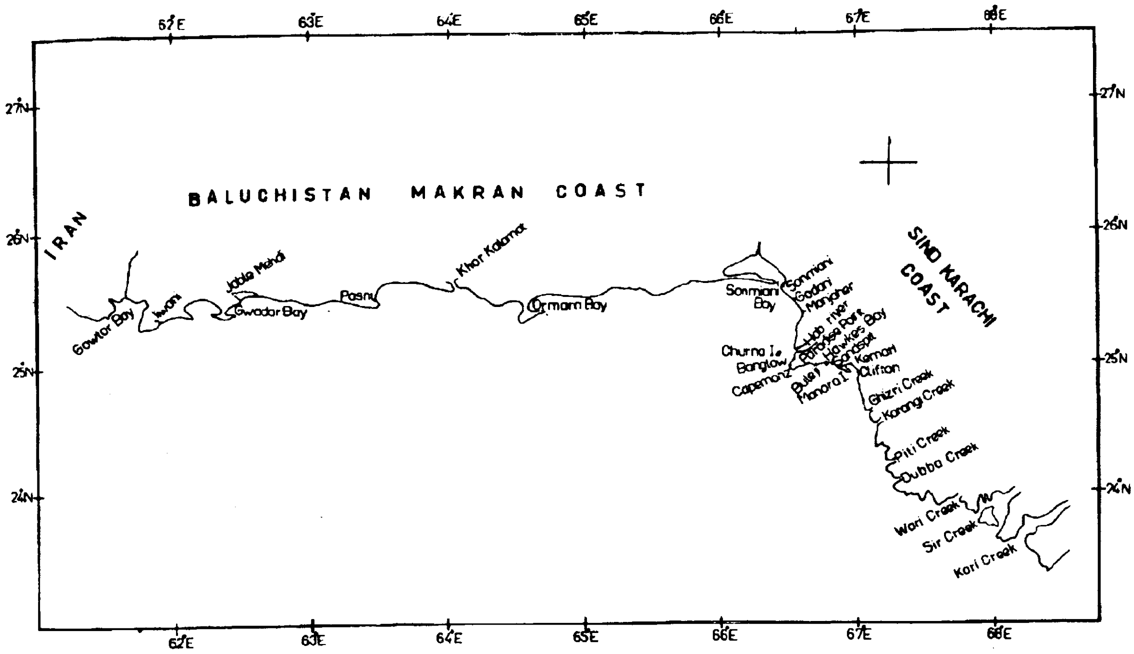



**Fig. 1 Coastal area of Pakistan**

The objective of this study was to investigate biodiversity of culturable bacteria of coastal areas (Makran and Karachi) and air (Karachi) with special reference to resistance markers and production of compounds.

## Materials and Methods

### Sampling sites, sample collection, isolation and purification

Along the coastal area of Pakistan samples were collected from different sites. These sites were Sand's Pit (around 25.20°N 66.8°E), Clifton (around 24.71°N 67.17°E), Layari River outfall (around 47.21°N 67.10°E), Manora (around 24.87°N 66.81°E), Cape Monze (Ras Muari) (around 24.5°N, 66.4°E), Gadani (around 25.5°N, 66.7°E) (Fig. 1). Culturable bacterial strains were purified and preserved as described previously (Ahmed *et al*, 2000a, Ahmed *et al*, 2000b). Purified strains were encoded as CMG (Centre for Molecular Genetics) culture stock serial numbers.

### Bacterial Identification by API-20E (Enteric Identification System)

A plastic strip holding twenty mini-test tubes was inoculated with a saline suspension of a pure culture (as per manufacture's directions). These strips were incubated in a chamber for 18-24 hours at 37°C, the color reactions were read (some with the aid of added reagents), and the reactions were converted to a seven-digit code. The codes were compared with the manufacturer's database.

## 16S ribosomal RNA gene analysis

The strains were also identified by using 16S ribosomal RNA gene sequence homology. Genomic DNA was obtained from bacteria grown overnight at 30°C in 5 ml of Luria-Bertani medium. Genomic DNA was isolated by PureGene DNA Isolation kit (Gentra Systems, USA). PCR amplification was performed with a Hybaid Omn-E thermalcycler. The PCR mixture consisted of 1.0 μl of the genomic DNA template; 20 pmol of each primer 16S3' –CCCGGGAACGTATTCACCG- and 16S5'-GCYTAAYACATGCAAGTCGA- (Cameron, 2002), 5μl of 10X $(NH_4)_2SO_4$ PCR buffer (160 mM $(NH_4)_2SO_4$, 670 mM Tris-Cl (pH 8.8 at 25°C), 0.1% Tween-20); 200 μM dNTPs; 4 mM $MgCl_2$ and 1 U of Bio*Taq* DNA polymerase (Bioline, UK) in a final volume of 50μl. Thermal cycling was undertaken by initially denaturing the DNA at 96°C for 5min followed by 14 cycles of 94°C for 1 min, 62°C for 30 sec and 72°C for 1 min, annealing temperature was lowered 1°C from 62°C to 56°C, then 16 cycles at 55°C, last elongation step was 5 min at 72°C. Colony PCR was performed for CMG458, CMG462, CMG463, CMG154 and CMG156 with cell-lysis at 96°C for 5min followed by 39 cycles of 96°C for 1 min, 57°C for 1 min and 72°C for 90 sec; followed by final extension step at 72°C for 10 min. CMG154 was subject to analysis by using primers pA and p530r as described by Beswick *et al.* (1999) while primers 16SI (-GCAGGCCTAACACATGCAAG-) (forward) and 16SII (-TTCTTTTGCAACCCACTCCC-) (reverse) (gifts from Ashraf Essa) were used for the identification of CMG156. A portion of the reaction mixtures was used to visualize PCR products on agarose gel. PCR product in the remainder of the reaction mixture was purified using QIAquick PCR purification kit (Qiagen, UK) and sequenced by respective primers (i.e., pA and p530r for CMG154; 16SI and 16SII for CMG156; 16S5' for rest of the strains) on the ABI PRISM 377 and Applied Biosystem 3700 Automated DNA Sequencers. Sequence data obtained were analyzed by using BLAST algorithm (http://www.ncbi.nlm.nih.gov/blast/Blast.cgi).

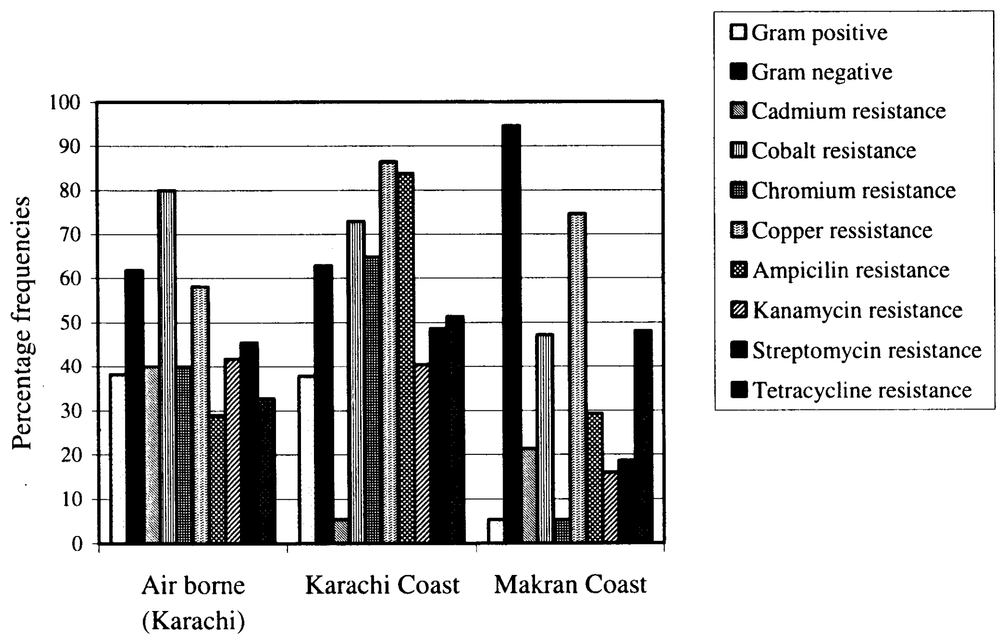



**Fig. 2 Chracterization of bacteria from three different environments**

### Genetic diversity for antibiotic resistance

In order to study the genetic diversity for the resistance pattern to antibiotics like ampicillin (Am), kanamycin (Km), streptomycin (Sm), and tetracycline (Tc) were tested on 2216E (0.1 g yeast extract, 0.5 g peptone, 0.01 g $FePO_4$ g in 100 ml seawater, 1.5% agar, pH=7) as described by Jamil, *et al.* (2000) for marine bacteria while for air borne bacteria resistance patterns were studied as described by Ahmed *et al.*, 2000**b**.

### Genetic diversity for heavy metal resistance

Genetic markers were studied for the resistance to heavy metals resistance. Maximum tolerable concentration to five heavy metals i.e. $CuSO_4$, $CdCl_2$, $CoCl_2$, $NiCl_2$ and $CrO_3$ were determined on artificial sea water as described by Jamil, *et al.* 2000 (23.5 g NaCl, 5 g $MgCl_2$, 1.1 g $CaCl_2$, 0.66 g KCl, 26 mg $H_3BO_3$, 24 mg $SrCl_2$, in 1 L. of distilled water, supplemented with 2 g tryptone and 2 g glucose (after autoclave), pH=7.0) supplemented with various concentrations (0.5, 1, 2.3 mM) of heavy metals.

**Table 1. Same origin but different resistance patterns (Karachi Coast)**

| | | | Genotype | |
|---|---|---|---|---|
| **CMG code** | **Strain** | **Origin** | **Antibiotic Resistance** | **Heavy metal Resistance** |
| CMG602 | *Bacillus cereus* | Clifton | $Am^+$, $Km^-$, $Sm^+$, $Tc^-$ | $Cd^-$, $Co^+$, $Cr^+$, $Cu^-$ |
| CMG619 | *Bacillus subtilis* | Clifton | $Am^-$, $Km^+$, $Sm^-$, $Tc^+$ | $Cd^-$, $Co^+$, $Cr^+$, $Cu^+$ |
| CMG604 | *E. coli* | Clifton | $Am^+$, $Km^+$, $Sm^+$, $Tc^+$ | $Cd^-$, $Co^+$, $Cr^-$, $Cu^+$ |
| CMG609 | *E. coli* | Clifton | $Am^+$, $Km^-$, $Sm^-$, $Tc^+$ | $Cd^-$, $Co^+$, $Cr^-$, $Cu^+$ |
| CMG610 | *E. coli* | Clifton | $Am^-$, $Km^-$, $Sm^+$, $Tc^+$ | $Cd^-$, $Co^+$, $Cr^+$, $Cu^+$ |
| CMG611 | *E. coli* | Clifton | $Am^+$, $Km^-$, $Sm^-$, $Tc^+$ | $Cd^-$, $Co^+$, $Cr^+$, $Cu^+$ |
| CMG612 | *E. coli* | Clifton | $Am^+$, $Km^+$, $Sm^-$, $Tc^+$ | $Cd^-$, $Co^+$, $Cr^+$, $Cu^+$ |
| CMG603 | *Bacillus subtilis* | Manora | $Am^+$, $Km^-$, $Sm^-$, $Tc^-$ | $Cd^-$, $Co^+$, $Cr^+$, $Cu^-$ |
| CMG629 | *Bacillus polymxa* | Manora | $Am^+$, $Km^-$, $Sm^+$, $Tc^-$ | $Cd^-$, $Co^+$, $Cr^+$, $Cu^-$ |
| CMG630 | *Bacillus polymxa* | Manora | $Am^+$, $Km^-$, $Sm^+$, $Tc^-$ | $Cd^+$, $Co^+$, $Cr^-$, $Cu^-$ |
| CMG621 | *Bacillus subtilis* | Sands Pit | $Am^+$, $Km^+$, $Sm^+$, $Tc^+$ | $Cd^-$, $Co^+$, $Cr^-$, $Cu^+$ |
| CMG622 | *Bacillus subtilis* | Sands Pit | $Am^+$, $Km^+$, $Sm^+$, $Tc^-$ | $Cd^-$, $Co^+$ $Cr^-$, $Cu^+$ |
| CMG625 | *Ps. pseudomallei* | Sands Pit | $Am^+$, $Km^-$, $Sm^+$, $Tc^+$ | $Cd^-$, $Co^+$, $Cr^-$, $Cu^+$ |
| CMG633 | *Pseudomonas* | Gadani | $Am^-$, $Km^+$, $Sm^+$, $Tc^-$ | $Cd^-$, $Co^+$, $Cr^+$, $Cu^+$ |
| CMG635 | *Pseudomonas* | Gadani | $Am^+$, $Km^+$, $Sm^-$, $Tc^-$ | $Cd^-$, $Co^+$, $Cr^-$, $Cu^+$ |

## Results and Discussion

This study was carried out to have an idea of the bacterial diversity among coastal areas of Pakistan at three levels; the ecosystem level, the species and the genes. Samples were collected from Karachi and Makran coastal areas. These samples were analyzed quantitatively and qualitatively for the presence of bacteria (Jamil *et al.* 2000). They were classified into free and attached bacteria according to their origin. Those bacteria which were attached to any surface (living or nonliving) are referred as attached bacteria while those, which were free in water, are referred to as free living bacteria. Both Gram positive and Gram negative bacteria were found in marine environment as had been already reported by Wood (1975) (Fig. 2). A total of 193 marine bacterial strains were isolated and purified using different media. Their morphological characters and Gram's reactions were studied, 121 were found to be Gram negative (88 attached and 33 free) and 72 were Gram positive (17 attached and 55 free). Among the isolates of bacterial strains from Karachi coastal areas Gram positive were 62%, while they were 80% from Makran coast (Fig. 2). This could be due to the constant discharge of industrial and domestic wastewater into Karachi coast where as Makran coast is comparatively less polluted, as it is not near industrial area. The pollutants in the Karachi coast must have resulted in disappearance of Gram positive bacteria. The results of Makran coast correspond to those of Zobell (1972) who suggested that 80% of the marine bacteria were Gram negative. Purified strains were identified by API 20E identification kit and 16S rRNA. Analysis of 16S rRNA gene sequences is a well-established and sensitive tool for identification and phylogenetic analysis of bacteria. The 16S rRNA is considered to be conserved for particular bacterial strains (Beswick *et al.* 1999). Regions of the 16S rRNA gene that are conserved in a wide range of bacterial genera were selected as target for PCR amplification and the primers used were broad range in nature which amplify nearly most of the bacterial 16S rRNA gene, genomic DNA was used to amplify 16S rRNA gene because 16S rDNA offers a more robust target than the RNA. PCR products were approximately 1.5 Kb in size, which contained conserved and hypervariable regions. To amplify the 16S rRNA gene from all the diverse strains "Touch down" PCR was performed to circumvent spurious priming during the 16S rRNA gene amplification which results in the amplification of non-specific DNA). A total of 14 16S rRNA gene sequences were determined in this study from different environmental conditions, all these organisms were found to have more than >87% homology to the GenBank data (homologous GenBank accession nos. in Fig. 5). PCR amplified product for 16S rRNA from strains like CMG607w and CMG634 when sequenced with 16S 5' primer gave results different from API 20E identification kit. Among coastal regions (Karachi & Makran) most frequently present genus was *Pseudomonas* (Fig. 6) while *Bacillus* species was not found among the coastal region of Makran and same happened with *Vibrio* species, which were not found in Karachi coast. Multiple metal and antibiotic resistances were observed among the bacterial strains from Karachi coast (Table 1). The high incidences of tolerance to metal salt indicated the level of heavy metal pollution in the air and coastal areas of Karachi (Fig. 1). Multiple metal and multiple antibiotic resistance patterns created diversity within a species (Table1). This was clearly observed with *E. coli* strains which were isolated from Clifton, all five strains showed different resistance patterns, no two stains had same resistance pattern to metal and antibiotics (Table 1). This high resistance perhaps was due to the direct discharge of untreated industrial effluent, smoke and domestic wastewater from Karachi city to coastal regions. The high resistance pattern of antibiotic and heavy metals has indicated the high level of pollution in Karachi coast and this is due to rapid industrial expansion. These toxic and harmful wastes are discharged through Layari River in the western backwaters of Manora Channel into Karachi harbor and subsequently, into the sea, polluting the coastal environment (Khan and Saleem 1988). In untreated wastes of industries heavy metals are present in significantly high amounts (Ahmed and Raihan, 1997). The high amounts of $Hg^{2+}$, $Cu^{2+}$, $Cr^{6+}$, $Co^{2+}$, $Cd^{2+}$ and $Ni^{2+}$ are very toxic to biological systems. It is a known fact that resistant bacteria are isolated from polluted and highly contaminated sites (Cooksey, 1993). Antibiotic and metal resistance among bacterial population is wide spread. Resistance to penicillins often results from the release of extracellular penicillinases in mixed cultures with ampicillin-sensitive strains. The high incidences of tolerance to metal salt indicated the level of heavy metal pollution in the air and coastal areas of Karachi. This is perhaps due to the direct discharge of untreated industrial and domestic wastewater from Karachi city to coastal regions. As bacteria exist widely in marine ecosystem and are affected by pollutants, but bacteria have remarkable ability to adjust in the environment and survive under adverse conditions. Numerical taxonomy was analyzed among the first ten bacterial strains of Karachi coast (Jamil, *et al* 2000).

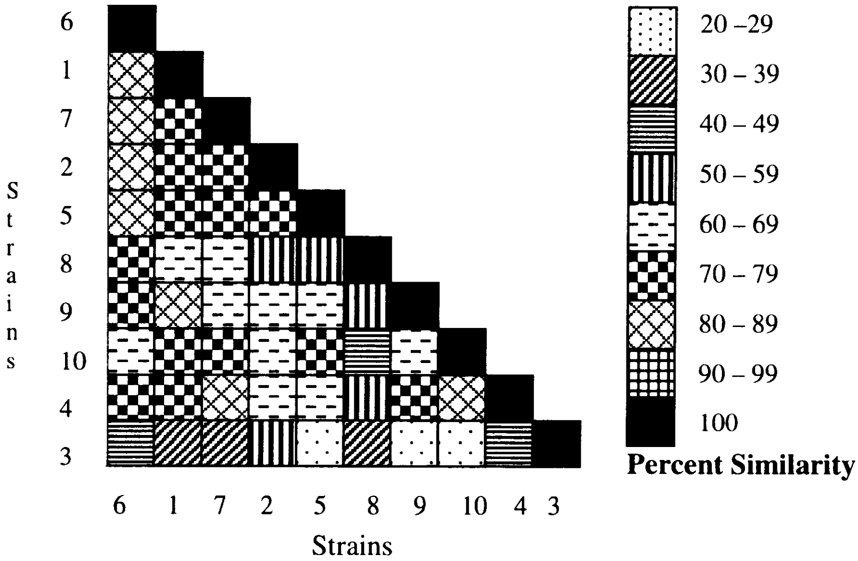
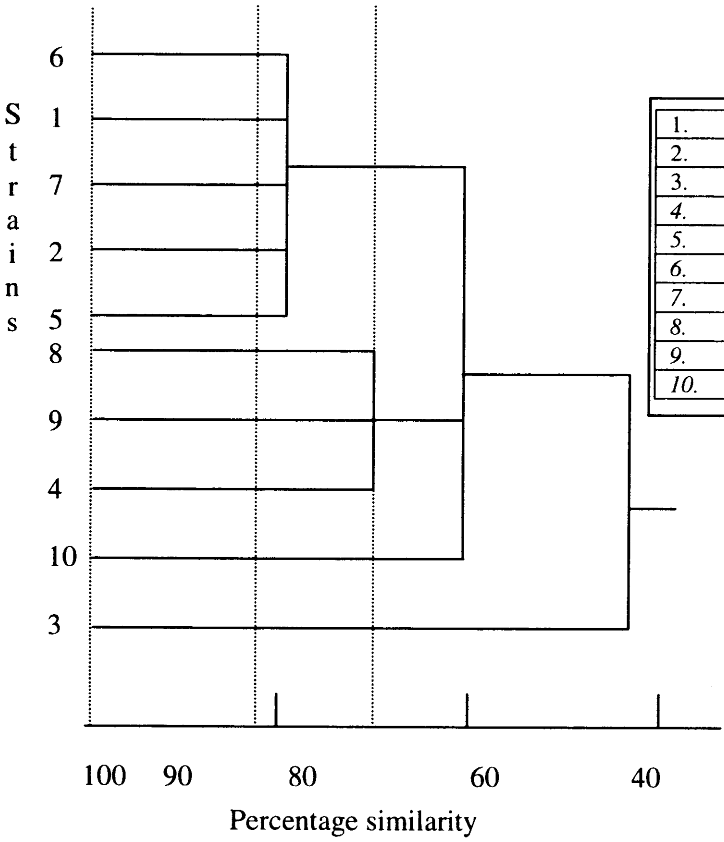



**Fig. 3 Similarity matrix ($S_J$) for a collection of 10 bacterial strains (Jamil *et al.* 2000), designated as 1 to 10. The strains have been so ordered as to bring into juxtaposition strains that most closely resemble one another in overall phenotype (Sneath, 1972).**




**Strains**

| | |
|---|---|
| 1. | *Enterobacter aerogenes* (CMG 601) |
| 2. | *Klebsiella oxytoca* (CMG 602) |
| 3. | *Bacillus subtilis* (CMG 603) |
| 4. | *E. coli* (CMG 604) |
| 5. | *Serratia liquefaciens* (CMG 605) |
| 6. | *E. colil* (CMG 606) |
| 7. | *Edwardsiella hoshiae* (CMG 607) |
| 8. | *Aeromona salmonicida* (CMG 608) |
| 9. | *E. coli* (CMG 609) |
| 10. | *E. coli* (CMG 610) |

**Fig. 4 A dendrogram showing similarity relationships among the 10 bacterial strains, using the data from Fig. 3. The two dotted vertical lines indicate possible similarity levels at which successive ranks in the taxonomic hierarchy might be established.**

Numerical taxonomy was analyzed with underlying assumption in which each phenotypic and genotypic character provided equal weighting, this analysis allowed us to express numerically, the taxonomic distances, between organisms, in terms of the number of characters they share, relative to the total number of characters examined (Sneath, 1972). Character like resistance to antibiotics and heavy metals, each resistance numbered as a single character Gram reaction, sampling sites and attachment style represent other characters, all the analyzed character were genotypic in nature except the sampling site (habitat). Similarity coefficient ($S_J$) matrices for the first ten strains were analyzed and tried to arrange them in juxtaposition (Fig. 3) and a dendrogram was drawn (Fig. 4) on the basis of similarity coefficient, interesting results were obtained that strains CMG601, CMG602, CMG605, CMG606, and CMG607 showed 80% similarity to each other with respect to the tested characters, while CMG603 (Gram positive *Bacillus*) showed 40% similarity to the other strains and all the tested strains shared <40% similarity. Strains CMG604, CMG609 and CMG610 were identified as *E. coli* by API 20E identification kit, these shared at least 70% similarity to each other, which showed that resistance and habitat differences were the major reasons to create diversity among the bacterial strains of same and different species (Table 1).

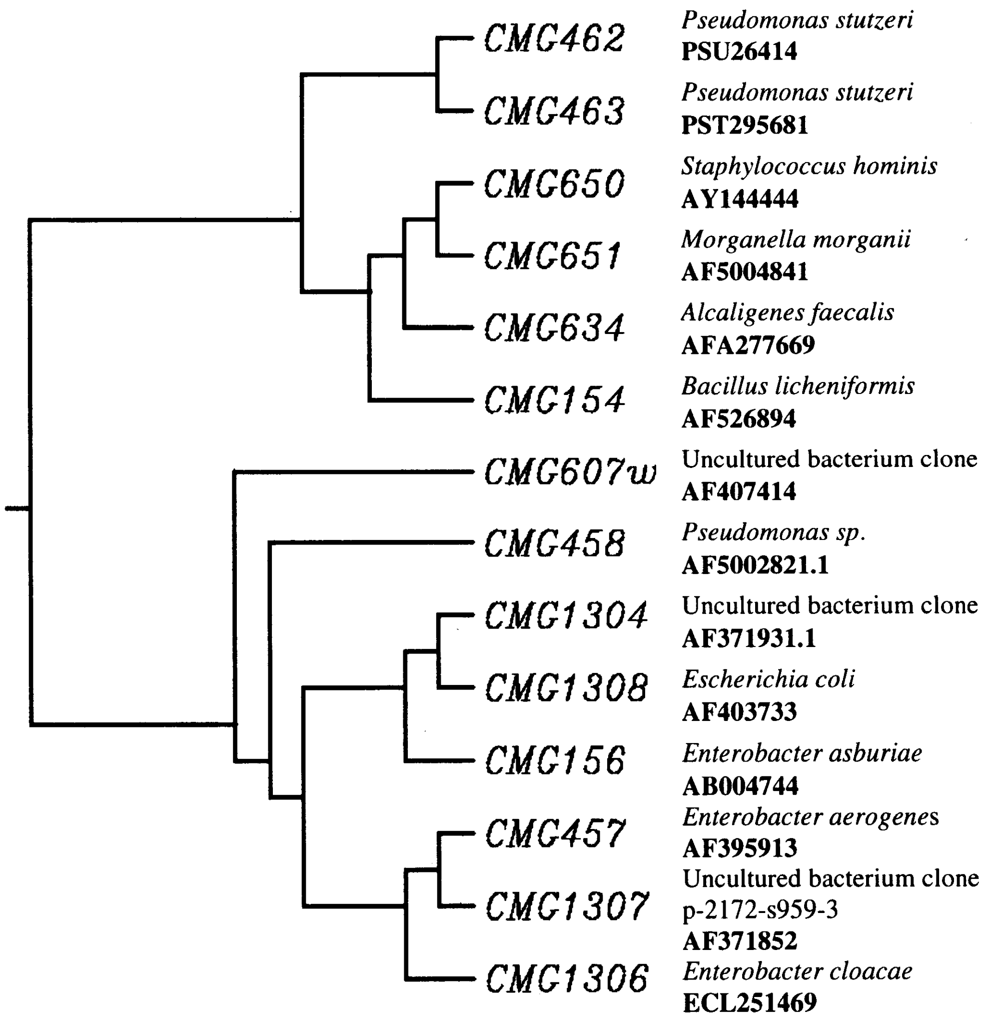



**Fig. 5 Phylogenetic dendrogram based on 16S rRNA gene sequencing. Names of cultivated organisms are shown in italic. Homologous GenBank accession numbers are listed in bold typeface.**

**Fig. 6 Percentage frequency of different genra found among the bacterial flora of Pakistan coastal regions**

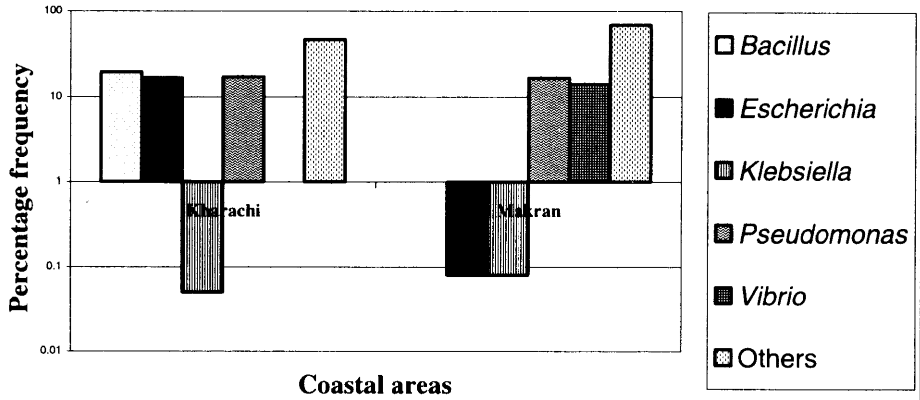



**Table 2. Production of biologically and commercially important compounds from marine isolates**

| Strain code | Identified (Method) | Compound produced |
|---|---|---|
| CMG 602 | *Klebsiella oxytoca* (API 20E kit) | Antibacterial |
| CMG 607W | Homologous to Uncultured bacterium (AF407414) | *mcl*-PHA |
| CMG 610 | *E. coli* (API 20E kit) | Antibacterial |
| CMG 612 | *E. coli* (API 20E kit) | *scl*-PHA |
| CMG 617 | *Staphylococcus saprophyticus* (Biochemical analysis) | SMHS1/2,Fatty acids |
| CMG 628 | *Staphylococcus aureus* (Biochemical analysis) | Heavy metal binding |
| CMG 633 | *Pseudomonas aeruginosa* (API 20E kit) | Antibacterial activity |
| CMG 634 | *Alcaligenes faecalis* | Glycoprotein |
| CMG 635 | *Pseudomonas aeruginosa* (API 20E kit) | Metal solubilizer, Antibacterial, Bioabsorbent |
| CMG 636 | *Bacillus subtilis* (Biochemical analysis) | Antibacterial |
| CMG 1306 | *Enterobacter cloacae* (16S rRNA gene sequencing) | Metal solubilizer, Antibacterial |
| CMG 1307 | Uncultured bacterium (p-2172-s959-3) (16S rRNA gene sequencing) | Metal solubilizer |
| CMG 1309 | Unidentified | Metal solubilizer |

Any type of stress like industrial waste and domestic waste may change the pattern of numerical taxonomy. As the Karachi air and coastal environment receive pollution from industries in form of mixed waste and smoke which provide stress to the environmental bacteria for their survival by making them resistant. It was observed when comparison analysis was conducted between bacterial strains isolated from the three different ecosystems (Makran coastal area, Karachi coastal area and air samples from different sites of Karachi), (Fig. 2) high percentages of resistance to almost all tested antibiotics and heavy metals were observed among the bacterial strains of Karachi (air and sea water), while Makran coastal area are not yet industrialized, due to this resistance frequencies were low as compared to Karachi.

Attached bacteria like CMG607w, 610,612, 617, 628, 633, 634, 635, 636, and 1307, were analysed for secondary metabolite production and diversified activity was found (Table 2). Bacteria attached to surface in aquatic environments are more active than free-living bacteria (Colwell, 1996). Differences in the activity of attached and free-living bacteria may be due to different conditions at the solid/liquid interface, as compared to bulk liquid. For example, charge on the substratum can affect the concentration of ions or charged molecules at the solid surface, thereby influencing pH (Hattori and Hattori, 1963) and substrate concentration (Hack and McFeters, 1982). Nutrients, exoenzyme metabolites or inhibitors may also be concentrated at solid/liquid interface by entrapment in exopolymers (Geesey, 1982) or by adsorption.

None of the biological typing methods offer an ideal approach for the subdivision of microbial species. The importance and applicability of each of the method may vary from one species to another, and also according to the precise geographical locations. For many species, combined use of the different methods may offer the best approach to analyze biodiversity at different levels.

This is the first report of study of bacterial diversity in the two coastal areas of Pakistan. This shall provide the basis of cataloguing bacterial strains, which are being constantly disappearing because of the pollution. This has been clearly indicated by the presence of Gram-positive bacteria in Karachi coast. There is a need to conserve the diversity among bacterial strains otherwise novel strains may disappeared.

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# Taxonomy of Prokaryots in Water Ecosystems of East Asia

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## Abstract

**The taxonomic description of dominanting prokaryotes was carried out in water ecosystems of East Asia (shallow-water hot vents, hot springs, soda lakes and Lake Baikal).**

**The main producents of organic matter in shallow-water hot vents of the Matupy Harbor of New Britain Islands (Papua New Guinea) and shallow-water of Kurile Islands are photoeubacteria *Thiocystis violacea, Rhodobacter* sp., *Thiocapsa roseopersicina, Prostecochloris aestuarii,* diatomes *Nitzshia* sp. and *Naicula* sp., sulfur bacteria *Thiothrix* sp. and *Thiodendron* sp. Cyanobacteria, purple photosynthetic bacteria and sulfur bacteria takes part in production of organic matter in hot springs of Kurile Islands and Baikal Region.**

**In dependence on the physicochemical conditions and dominating groups of microorganisms the main types of microbial communities were marked out in hot and mineral springs of Baikal Region. The main species in sulfuric mats are *Thiotrix* and *Thiobacillus*, purple mats – *Thiocapsa* and *Chromatium*, green mats – *Chloroflexus*, and cyanobacterial mats - *Oscillatoria* and *Phormidium*. In a brick-red layers of mats the iron–oxidizing bacteria from g. *Siderocapsa* and *Leptothrix* are observed.**

**The alkaliphilic cyanobacteria and anoxygenic photosynthetic bacteria were found in soda lakes, widely distributed in Baikal region. Cyanobacteria from g. *Spirulina, Phormidium, Microcoleus, Oscillatoria* and other were found in this soda lakes. The representatives of anoxyphotobacteria were found in all lakes almost. Purple bacteria g. *Ectothiorhodospira, Chromatium, Thiocapsa, Rhodobacter, Oscillochloris, Thiocystis, Amoebacter, Thiospirillum* were found among them. Green sulfur bacteria *Chlorobium* were found only two lakes. The growth of spore-forming *Helicobacteria* was obtained from dry samples of mats and bottom sediments.**

**The specific microbial communities, formed by *Thioploca* sp., were found in Frolikha Bay of Baikal. Cellulose-decomposing, methanogenic and sulfidogenic microbial communities are spread in bottom sediments of the lake. The species from g. *Sporocytofaga, Cellvibrio, Polyangum, Clostridium, Desulfotomaculum, Desulfobacterium, Methanobacterium* and other were discovered in these communities.**

***Key Words: prokaryots, phototrophic bacteria, alcaliphilic bacteria, microbial communities, shallow-water hot vents, hot springs, soda lakes, Lake Baikal.***

## Introduction

The different unique water ecosystems, such as shallow-water hydroterms of the western part of the Pacific Ocean, Kuriles Islands and Lake Baikal, hot and mineral springs of Baikal Region, soda-salt lakes of Transbaikal Region, are found on the territory of East Asia. The microorganisms are the most important component of its biota, participating in the cycles of the biogenic elements.

The investigations of taxonomy composition and studying of the role of microorganisms in the synthesis and destruction of organic matter of this ecosystems were carried out in 1990-2001.

## Materials and Methods

The microbiologycal investigation were carried out:
- in the shallow-water hydrotherms of the Pacific Ocean located near Papua New Guinea, New Britain Island (Matupy Harbor - at a depth from 0,1m to 27 m, and t = 90-70°C), and Kurile Island (Yankich Island, Kraternaya Bignt - at a depth 0,2-0,1m, t = 90-55°C);
- in the gasohydrothermal vents of Lake Baikal (Frolikha Bay of North Baikal at a depth of 420-430 m, t = 3,4-3,6°C);
- in the nitrogen-containing high-temperature springs (higher than 50°C), located in the northern part of Baikal region - Alla, Garga, Uro, Bolsherechensky (Yurkov, Gorlenko, 1992), Zmeinyi (temperature are up to 79°C, and pH values are 8,0 - 10,2);
- in the carbonaceous low-temperature (not more than 38°C) mineral springs, located in the East Sayan region - Zhoigon and Khoito-Gol;
- in 17 soda lakes of Transbaikal region, situated in Selenga's Daurya and Onon-Borzya basin. There are carbonate, sodium–sulfate and sulfate–chloride types of lakes. The pH values are 8,8 –10,1, mineralization - of 0,95 to 40 g/l. A great diversity of the physico-chemical water parameters are proposed of the development of the special microbial alkaliphilic communities. The types of lakes influence on the formation of different types of mats: from thin ephemeral films to many-layer skin–like mats, with thickness about 2-3 cm.

The diversity of the microorganisms in benthic microbial association (microbial mats) and bottom sediments was studied by different methods (Kuznetsov, Dubinina, 1989).

Microbial constituents of mats were identified by examining their morphology directly in the samples using a phase-contrast light microscope and an electron microscope.

The genotypic investigations of the pure bacterial cultures (the determination of nucleotide composition, the elevation of homology, the analyses of 16 S rRNA and PCR), were carried out by standard techniques. To examine the pigments and fat acid compositions of photobacteria and methanotrophs were used HPLC and spectrophotometric methods.

The rates of microbial processes involved in the carbon cycle (production and destruction of organic matter) were studied by the radioisotopic method (Kuznetsov and Dubinina, 1989; Namsaraev et al., 1989). The samples and sterile controls were incubated for 3-6 h at in situ temperatures and fixed by the addition of formaldehyde to a final concentration of 0,2 %.

## Results and Discussion

The physicochemical conditions influence the formation of the microbial communities in water ecosystems. Sunlight, availability of electrons donors and acceptors, aerobic and anaerobic conditions, presence of biogenic elements and labile organic matters are the determining abiotic factors.

A specific benthic microbial communities were found in the zone of hasohydrotermal vents of the western part of the Pacific Ocean and northern part of the Lake Baikal.

Bacterial, algobacterial and diatom mats developed on the bottom of the bight in the zone of hasohydrotermal vents and in areas volcanic water seeping in the marine ecosystem in the crater of the Ushishir Volcano (Kraternaya Bight, the Kuriles) (Tarasov et al., 1990). Bacterial mats were found at a depth of 0 to 5 m under stones, where sunlight does not penetrate, in zones of hydrogen-sulfide gasothermal vents with water temperatures of 12-35°C. The filamentous colourless sulfuroxidizing bacteria of the genus *Thiothrix* and *Thiobacilli* are the basis of the mats.

Algobacterial mats flourished among gasohydritermal vents and in areas of volcanic water seeping at a depth of 0.7 to 12m; the sediment surface temperature here was 10 to 34 °C.

Mats had a many-layer structure, and included microorganisms of different physiological groups (Table 1).

In algobacterial mats and in water samples, iron-oxidizing bacteria of the genus *Seliberia* were found; extremely thermophylic archaebacteria of the order *Thermoprotealis*, were obtained from samples and cultures.

**Table 1. Structure and species composition of algobacterial mats in the Kraternaya Bight**

| Mat layers | Microorganism groups | Species |
|---|---|---|
| Surface, Dense | Thiobacilli | Not identified |
| | Colourless sulfur-oxidizing bacteria | *Thiothrix* sp. |
| Intermediate, Loose | Diatoms | *Navicula* sp. |
| | | *Nitzshia* sp. |
| | | *Paralia maniliformis* |
| | | *Thalassiosira anguste lineata* |
| | Purple thiobacteria | *Thiocystis violacea* |
| | | *Thiocapsa roseopersicina* |
| | Non-sulfur purple bacteria | *Rhodobacter* sp. |
| Lower | Green sulfur-oxidizing bacteria | *Prosthecochloris aestuarii* |
| | Sulfate-reducing bacteria | Not identified |
| | Anaerobic saprophytes | Not identified |
| | Methane-producing bacteria | Not identified |

In shallow-water hydrotherms of Matupy Harbor a wide range of physiologycal diversity of microbial population were observed at temperature 55°C (Namsaraev et al., 1994 ). Low-temperature vents of the tidal zone are inhabited by various rods and cocci. High-temperature vents are inhabited by organotrophic archaea and eubacteria. By their morphology and phisiology, the observed archaea are similar to *Thermococcus* sp. The eubacteria are close to the genera *Thermotoga* and *Thermosypho*.

The specific microbial communities were found in Frolikha Bay of North Baikal at a depth of 420-430m (Kuznetsov et al, 1991). There were whitish microbial mats, where the principal mat-forming species was the colonial filamentous colorless sulfur bacterium *Thioploca* (Namsaraev et al., 1994). By their morphology, the Baikal forms of *Thioploca* were thus similar to the species *T. schmidlei*. This community developed due to unusual ecological conditions of this region of Lake Baikal. The arrival of appreciable amounts of allochthonous and autochthonous organic matter and inflow of ground waters whose composition is different from that of the Baikal water favor the activity of different groups of bacteria in mats and sediments. Organic mater is produced by autotrophic and heterotrophic bacteria. *Thioploca* participates in the carbon and sulfur cycles. The bulk of organic matter of mats and sediments is consumed for the production of $CH_4$, which is actively utilized by methane-oxidizing bacteria.

The cellulose-degrading microbial communities are widely distributed in bottom sediments of Lake Baikal. These communities participate in decomposition of cellulose-containing organic matter and consist of different microbial groups. The dominating genera and species are *Sporocytophaga, Cellvibrio, Polyangum, Clostridium, Desulfotomaculum, Desulfobacterium, Methanobacterium* and other.

The specific alkaliphilic microbial communities, participating in cycle of biogenic elements in alkaliphilic conditions, are developed in extremal conditions of soda lakes. High solar insolation, unlimited entrance of carbonates and the availability of phosphates are favorable for the development of phototrophic communities in warm season (Namsaraev et al., 1998). The thin microbial mats (1-3 mm) are found in the coastal parts of the lakes and lagoons, where the mat-forming species were cyanobacteria *Synechococcus* sp. and *Microcoleus* sp. Anoxygenic photosynthetic bacteria (purple sulfur, purple nonsulfur and green filamentous bacteria) form the colored layers. More luxuriant formations of microbial mats are observed in the lakes with mineralization higher 7 g/l and pH higher 9. A thick (2-3 cm) mat with dominating cyanobacteria *Microcoleus* sp. and *Phormidium molle*, was found to cover the whole bottom of the carbonate – chloride lake Hilganta at pH 9,5 and mineralization 40 g/l. Cyanobacteria *Aphonothece salina* and purple sulfur and unsulfur bacteria were presented in this mat. *Oscillatoria limosa, O. terebriformis, Phormidium molle, Spirulina major, Synechocystis minuscula* were identified in hydrocarbonate – sulfate – chloride – sodium lake Verkhnee Beloe at pH 10,1 and mineralization 7,5 g/l.

The anoxygenic purple sulfur bacteria of families *Ectothiorhodospiraceae* and *Chromatiaceae* are the dominating group in all studied lakes at pH 9,5. Family *Ectothiorhodospiraceae* was represented by genus *Ectothiorhodospira*. Spiral-like bacteria with intracellular sulfur described as a new representatives of the family were found in the soda lakes Ilim Torom, Maly Hysataya, Verhnee and Maloe Beloe. Dominating representatives of family *Chromatiaceae* were represented by morphotypes *Allochromatium - Thiocapsa*. A small cocci were described as a new genus and species *Thioalkalicoccus limneticus gen.nov., sp.nov.* The purple filamentous bacteria of the morphotype *Rhodobacter-Rhodovulum* were found in all studied lakes. The green filamentous bacteria *Oscillochloris* sp. were present in majority of the lakes. The bacteria of genus *Ectothiorodospira* dominated at pH 10, 2 and at a wide range of mineralization. The sporeforming rods and spiral heliobacteria were found in samples of the lakes Barun-Torey and Ostoze at pH 10,2. They belonged to two new species of a new genus *Heliorestis* gen. nov.: *Hrs. daurensis sp. nov.* and *Hrs. baculata sp. nov. Heleorestis daurensis* possess morphology, unknown to anoxygenic photosynthetic bacteria before, being a tightly twisted spiral.

The aerobic anoxygenic photosynthetic bacterium containing the bacteriochlorophill *a* was found in the middle-mineralized lake Gorbunka at pH 9,5. This bacterium was described as a new genus and a new species *Rhoseonatronobacter thiooxidans* gen. nov., sp. nov.

The different species of the aerobic and anaerobic eubacteria take an active part in destruction of organic matter in the mats, water and bottom sediments of the soda lakes (Gorlenko et al., 1999; Namsaraev et al., 1999). Among them are representatives of genera *Bacillus, Clostridium* (*Clostridium lituseburense* and *C. purinolyticum*), a new genus *Thioalcalomicrobium* sp., a new species of the genus *Methylomicrobium - Methylomicrobium buryatense* sp.nov. (Kaluzhnaya et al., 2001)

Alkaliphilic microbial communities of soda lakes have shown to be composed of major trophic groups of the phylogenetic tree of the prokaryotes (Zavarzin et al., 1999).

In dependence on the physicochemical conditions of environment and first of all, the temperature and the concentration of chemical elements, the different types of microbial communities were observed in hot and mineral springs of Baikal region and East Sayan region (Table 2) .

The development of microbial mats, consisting of oxygenic and anoxygenic photosynthetic bacteria was noticed at the places of coming-outs and mineral water outpouring. Aerobic and anaerobic geterothrophic bacteria dominate at 71-79$^{o}$ C. Green filamentous bacteria *Chloroflexus aurantiacus* were observed at temperature 50-60$^{o}$ C and lower and at presence of hydrogen sulfide. Cyanobacterial mats developed at a wide range temperature on sunlight.

In thermalic alkalic springs the main species in sulphur mats are *Thiothrix* and *Thiobacillus*, in purple mats – *Thiocapsa* and *Chromatium*, in green mats – *Chloroflexus*, and in cyanobacterial mats - *Oscillatoria* and other. The aerobic heterothrophic bacteria *Meiothermus ruber* were found in samples of Alla; sulfate-reducing bacteria *Desulfovibrio* sp. was identified in hydroterms Garga, Alla.

**Table 2. Dominating species and types of microbial communities in hot springs of Baikal region and East Sayani region.**

| Microbial mat | Temperature,°C | pH | Dominating species |
|---|---|---|---|
| Sulfur-1 | 30-71 | 8,7-9,3 | *Thiothrix, Thiobacillus,* |
| Purple | 22-53 | 8,8-9,3 | *Thiocapsa roseopersicina, Chromatium venosum, Rhodopseudomonas palustris, Chlorobium* sp. |
| Green | 22-50 | 8,0-9,3 | *Chloroflexus aurantiacus* |
| Cyanobacterial | 20-54 | 8,9-9,8 | *Oscillatoria, Synechocystis, Phormidium* sp., *Phormidium tenue, Synechococcus* |
| Sulfur-1 | 20-36 | 7,8 | *Thioploca, Thiothrix, Thiobacillus* |

In mineral springs of East Sayan – Khoyto –Gol and Zhoygon, where the temperature of water is 20°C and more, the development of photo- and chemotrophic microorganisms, forming a wide field of the microbial mats, were observed (Barkhutova et al, 2000). In upper dark- green colour photic layers of mats develop cyanobacteria - *Oscillatoria, Fischerella, Phormidium.* Thin threads of *Phormidium laminosum* give the base of studied Zhoygon mats.

A green layers of mats were formed by *Chloroflexus* sp. and other green photosynthetics belonging to the order *Chlorobiales*. A purple mats were formed sulphur and unsulphur purple bacteria from order *Rhodospirillales*, families *Chromatiaceae* and *Rhodospirillacae*.

In sulphide spring Khoyto-Gol the sulphur bacterial mat was formed by *Thiothrix* and *Beggiatoa* species.

The investigation showed that microbial communities of studied ecosystems represent great biodiversity and may play an important role in global processes of carbon and sulfur, that confirmed by quantitative estimation of geochemical activity of microorganisms.

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# Microalgal Diversity in Asia: Collaborative Research between Japan, Thailand and Indonesia for Capacity Building in Microalgal Taxonomy

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## Abstract

**A recent estimation puts the number of algal species at more than 10 million, which is two orders of magnitude higher than the number of species so far described. However, this may be plausible, because algae are an evolutionarily diverse group of organisms, and distributed in so many different terrestrial and aquatic environments as important primary producers. Moreover, certain algae have been used as biological resources. The taxonomy of some groups of algae, especially microalgae, however, is now being reconsidered in light of new analyses of biochemical and molecular data in addition to traditional morphological data. Progress in this reconsideration is urgently needed to clarify microalgal diversity. Here we demonstrate a plan of collaborative research between Thailand, Indonesia and Japan for capacity building in microalgal taxonomy as a part of the pilot project "Global taxonomy initiative for conservation of biodiversity in Asia and Oceania." We also aim to expand the capacity of culture collections, because culture strains and their information are necessary for precise identification of microalgae using biochemical and molecular techniques as well as detailed morphological observation by SEM and TEM.**

***Key Words: Biodiversity, GTI, microalgae***

## Introduction

The number of algal species may be more than 10 million (Norton *et al.* 1996). This number is two orders of magnitude higher than the number of species described so far (John and Maggs 1997). However, this may be plausible because algae are an assemblage of evolutionarily diverse organisms. This diversity came about by endosymbiosis leading to chloroplasts with various origins. Algae participate in terrestrial and aquatic ecosystems mainly as primary producers, whereas certain members of dinoflagellates, chrysophytes, and haptophytes play the role of consumers by phagotrophy. Mixotrophy seems to be rather usual in algae (Graham 2000); this means that algae are functionally diverse as well. Moreover, certain algae have been utilized as biological resources, producing useful substances such as polysaccharides, oils, carotenoids, and polyunsaturated fatty acids.

The taxonomy of some groups of algae, especially microalgae is now being reconsidered in light of newly added data on biochemical and molecular characters in addition to the traditional morphological criteria. Progress in this reconsideration is urgently needed to clarify microalgal diversity. This fact clearly distinguishes the status of microbial taxonomy from taxonomy of macroscopic organisms. Furthermore, it is difficult to access taxonomic information in terms of literature and reference strains (including type and authentic strains), especially in Asian countries.

Here we demonstrate a plan of collaborative research between Thailand, Indonesia, and Japan for capacity building in microalgal taxonomy as a part of the pilot project "Global taxonomy initiative for conservation of biodiversity in Asia and Oceania" funded by the Japanese government.

## Identification of Microalgae

Precise identification of algal species is essential to know their biological diversity, as well as for various other purposes such as biotechnology, ecology, and biogeochemistry. In contrast to the situation for higher plants and animals, the identification and classification of algae, especially microalgae, are generally familiar only to biologists who are specialists in algal taxonomy. The foremost reason for this is the microscopic size of the microalgae. Identification of microalgae requires at least a light microscope, and frequently requires scanning and transmission electron microscopes.

For some kinds of algae with rigid cell coverings, scanning electron microscopy is the most effective technique for identification at species level (Fig. 1). Cell coverings distinguish a large number of species among the coccolithophorids and diatoms as well as certain species of chrysophytes, dinoflagelltes, and euglenoids. Ultrastructure of flagellar apparatus and chloroplast structure sometimes become critical characters to identify microalgae at higher taxonomic levels.

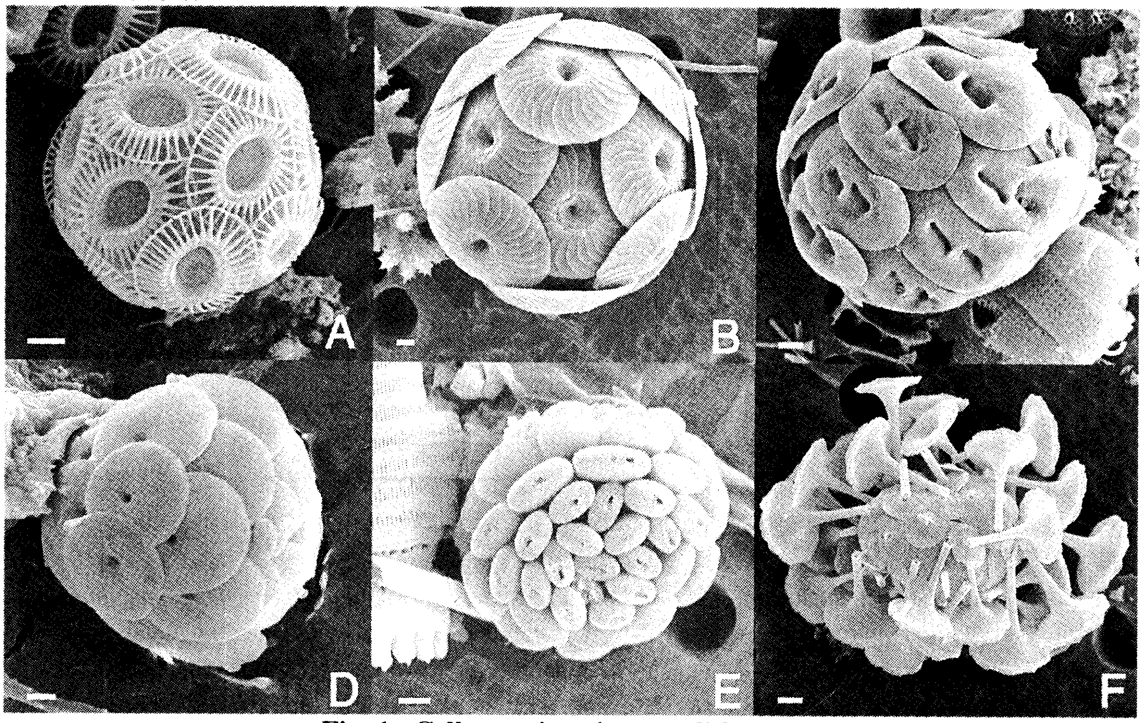


**Fig. 1 Cell coverings in coccolithophorids.**
**A: *Emiliania huxleyi*, B: *Calcidiscus leptoporus*, C: *Helicosphaera carteri*, D: *Oolithotus fragilis*, E: *Algirosphaera oryza*, F: *Discosphaera tubifera*. Scale bar = 1 μm.**

Algal taxonomy has traditionally depended primarily on morphology. However, advances of molecular techniques in taxonomy have revealed the frequent occurrence of parallel evolution of very similar body types, such as a coccoid form, uniseriate filaments, and various types of colonial forms in widely scattered phylogenetic groups. This has complicated the identification of certain groups of microalgae even for taxonomists proficient in the use of morphological data; for example, the taxonomic position of coccoid green algae has been revised in recent years by analyzing 18S rDNA sequences (Friedl 1997).

## Importance of Culture Strains for Microalgal Taxonomy

In a number of cases, algae must be cultured to elicit expression of a particular critical taxonomic character, e.g., zoospores. Life cycle analysis is also necessary to determine, e.g., how autospores are generated. For analyses of the above-mentioned ultrastructure and genetic characters as well, culture strains are necessary. Especially in cyanobacteria, polyphasic taxonomy that includes morphology, biochemistry, and genetics is necessary (Castenholz 2001).

Culture strains and their genetic information should be deposited in appropriate culture collections and databases, respectively, when a new species is established. Culture collections should accumulate those authorized strains for further studies as reference strains for biodiversity study, surveys for useful substances, and other purposes.

## Culture Collection Activities

The culture collection work at the Microbial Culture Collection, the National Institute for Environmental Studies, Japan (NIES-Collection) is shown as a typical case. The NIES-Collection has more than 1000 strains of microalgae that cover almost all classes. The main activities of the collection are acceptance of strains for deposit, and their preservation and distribution (Fig. 2). Deposited strains of eukaryotic algae should be clonal and unicellular, whereas cyanobacteria strains should be pure (clonal and without any other organisms).

At the NIES-Collection, most strains are maintained by serial subculture (Fig. 3). The strains are transferred to new media every 2 weeks to 4 months, and preserved at 5-25 °C. The culture conditions and culture media are different depending on strain. Cryopreservation is also used extensively (Fig. 4), because subculturing takes much space and manpower and it sometimes causes changes in morphology, physiology, or genetic characteristics of strains. In 2002, 170 strains of cyanobacteria are preserved in liquid nitrogen.

Observation of the cell states, including morphology, behavior, growth, freedom from bacterial contamination and DNA sequencing for taxonomic confirmation, are routinely conducted (Fig. 5). The catalog of strains is available both from the homepage (http://www.nies.go.jp/biology/mcc/home.htm) and as a publication.

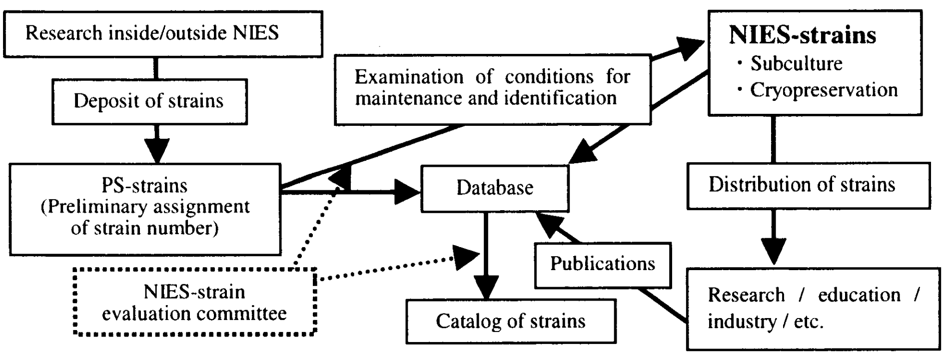


**Fig. 2 The process from deposit of strains, through establishment of NIES strains, to distribution of strains.**

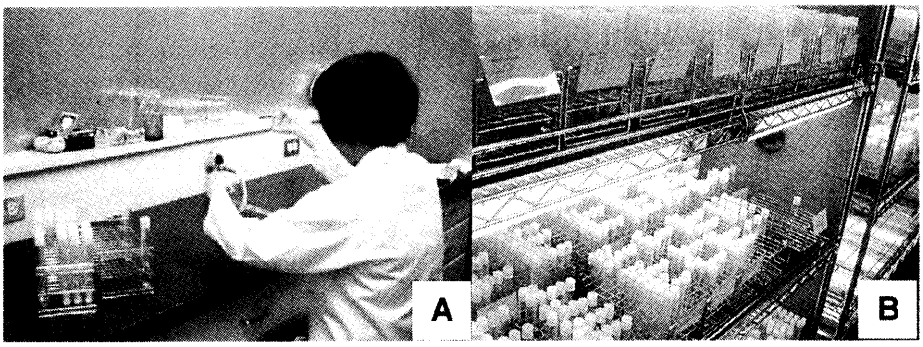


**Fig. 3 Subculture. A. Transfer of strains in a clean room. B. Strains in a temperature-controlled culture room.**

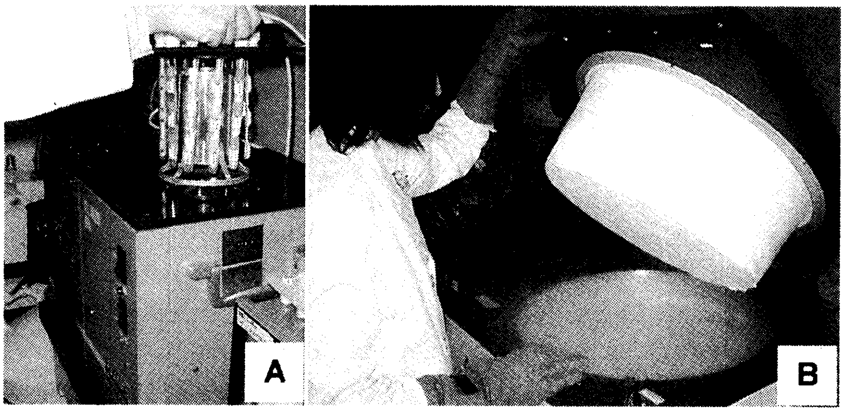


**Fig. 4 Cryopreservation. A. Program freezer. B. Liquid nitrogen tank.**

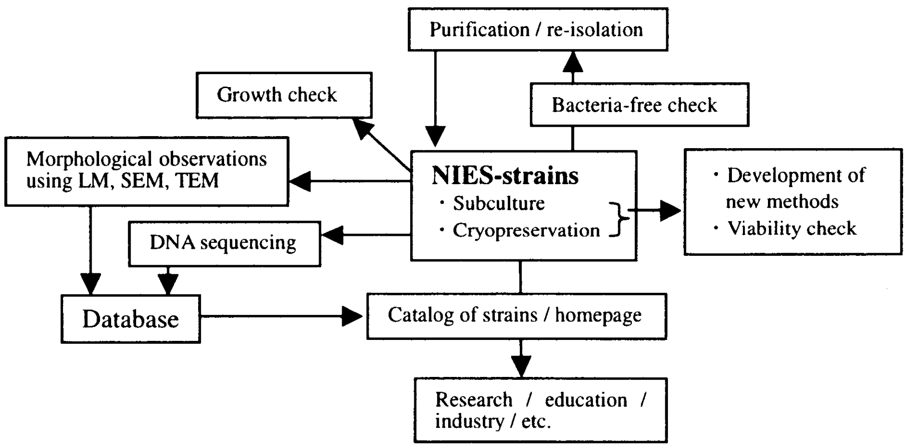


**Fig. 5 Other routine work at the culture collection.**
**LM: Light microscope**

## A Tentative Plan of Collaborative Research between Thailand and Japan

As a sub-project of the pilot project "Global taxonomy initiative for conservation of biodiversity in Asia and Oceania," we will carry out "Taxonomic studies of microalgae in freshwater wetland and coastal region of Indonesia and Thailand. Here we demonstrate a tentative plan of collaborative research between Thailand and Japan.

In Thailand, the project for capacity building will be conducted by supplementing the existing checklist, published (Lewmanomont *et al.* 1995) through the Office of Environmental Policy and Planning, the Thai focal point for the Convention on Biological Diversity, with new taxonomic data and by providing new techniques. This checklist describes 132 genera (333 species) of marine algae and 161 genera (1001 species) of freshwater algae. However, this list covers only 4 divisions among the generally accepted 10 divisions. Thus, we specially focus on taxonomy of several taxa that are not covered by the checklist. These taxa often have extremely small and/or fragile cells and seem to have been overlooked by light microscopy studies and by traditional sampling and fixation.

The taxonomic research is to be collaboratively conducted between Kasetsart University, Thailand, and NIES, Japan. Objectives of this research are 1) to transfer the techniques for isolation, culture, and identification of algal strains to scientists in Kasetsart University; 2) to step up the algal culture collections and corresponding databases to facilitate data access for reference cultures, taxonomic literature, images, etc.; and 3) to catalog algal strains isolated from research sites. Study sites were chosen in southern Thailand, including inland wetlands, mangroves, and a coastal area of Phuket Island, Lake Songkhla and wetlands in its vicinity, and coastal areas near Songkhla. These sites include various freshwater and marine environments, and a wide taxonomic range of microalgae is expected.

Taxonomic studies will be conducted by two different methods, one based on culture strains (Fig. 6) and the other based on specimens fixed in the field (Fig. 7), according to previously described characteristics for identification.

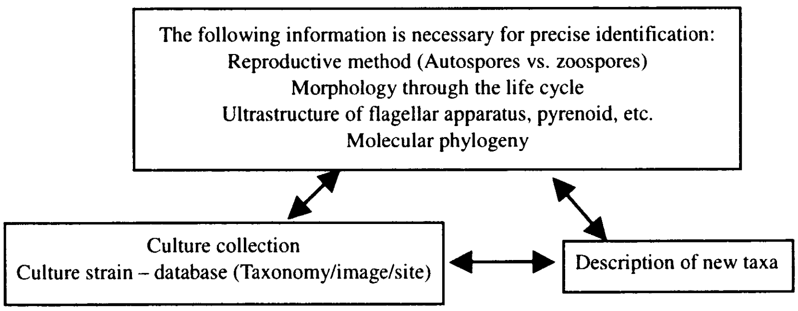


**Fig. 6 Taxonomic studies of microalgae based on culture strains.**

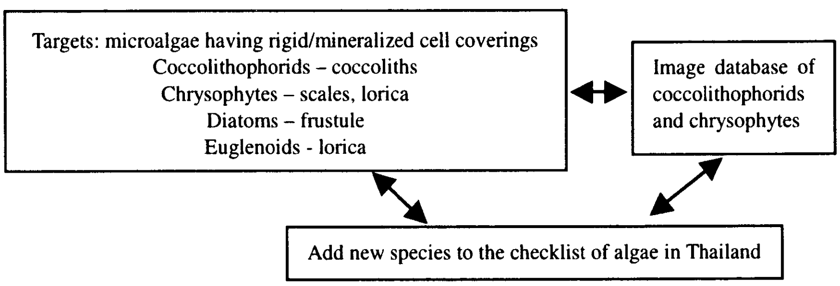


**Fig. 7 Taxonomic studies of microalgae based on specimens fixed in the field.**

We will also expand the capacity of culture collections in this project for the reasons described previously.

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# University of Malaya Algae Culture Collection (UMACC)

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## Abstract

**The University of Malaya Algae Culture Collection (UMACC) is the only culture collection of microalgae in Malaysia, consisting of more than 150 microalgal isolates. It serves as a national collection of microalgae and supplies selected cultures to both the research community and the industry. The collection consists of unialgal cultures, of which many are axenic, representing strains from Cyanophyceae, Chlorophyceae, Prasinophyceae, Euglenophyceae, Haptophyceae and Bacillariophyceae. Many are indigenous strains, isolated from diverse aquatic habitats of Malaysia, ranging from freshwater lakes, wastewater ponds, mangrove swamps, coastal waters to estuaries. There are also several strains of aerial microalgae isolated from wall scrapings (e.g. *Chlorococcum*). Many of the microalgae in the UMACC have been used in various studies conducted by the Algal Biotechnology Group of the University of Malaya, and these include the following : (i) screening of the microalgae for high-value chemicals such as polyunsaturated fatty acids, carotenoids and phycobiliproteins, (ii) use of the microalgae for treatment of agro-industrial wastewaters such as rubber and palm oil mill effluents, and sago factory wastewater, (iii) use of the microalgae as biomonitors for heavy metal pollution and nitrogen enrichment in freshwater ecosystems, (iv) use of the microalgae as mosquito larvicidal agents, (v) use of the microalgae as animal feed. The UMACC has expanded with the recent addition of 15 isolates of Antarctic microalgae. The microalgae were isolated from snow, seawater and soil samples, and water from waste treatment pond collected around Casey Station, Antarctica during the expedition there last year. Characterisation of the morphology and growth of the Antarctic microalgae is in progress. This first Malaysian collection of Antarctic microalgae is useful for our studies on the physiological adaptation of such microalgae under extreme conditions, especially in comparison to tropical species, in attempts to understand impacts such as global warming and increased UV radiation. The UMACC is important for the development of research in algal biotechnology in Malaysia. Our future research trends are directed towards genomic studies, which include research on phylogenetics, microarray analysis and genetic transformation. The rich microalgal biodiversity in Malaysia highlights the need to conserve this important microbial resource.**

***Key Words : microalgae, culture collection, algal biotechnology, Antarctic microalgae***

## Introduction

The University of Malaya Algae Culture Collection (UMACC) was established in 1987 following the interest in developing algal biotechnology in Malaysia. Earlier phycological research interests focused mainly on ecological surveys and description of microalgal flora in lakes and rivers (e.g. Prowse and Ratnapathy, 1970; Ratnasabapathy and Kumano, 1974). In addition, a monograph on the marine diatoms of Malaysia and Singapore was published (Wah *et al.*, 1993). The Algal Biotechnology Group from the University of Malaya, led by the first author, started the research on applied phycology. Two of the major areas of interest were the screening of indigenous microalgae of Malaysia for fine chemicals, and the use of microalgae to treat agro-industrial wastewater. Unialgal cultures are important for such studies, and this led to the need to isolate microalgae from local habitats. The earlier collection consisted of mainly microalgae isolated from lakes and wastewater treatment ponds. As the research interests expanded to cover marine microalgae, marine diatoms were added into the collection.

Algal biotechnology has been receiving increasing interest, and has been regarded as a priority area of research under the Ministry of Science, Technology and the Environment, Malaysia. The UMACC serves an important facility that supplies algal cultures to both the research community and industry. A Catalogue of Strains for the UMACC was published in 1999, giving the list of strains and culture techniques (Phang and Chu, 1999).

The UMACC consists of more than 150 strains, representing the classes Cyanophyceae, Chlorophyceae, Prasinophyceae, Euglenophyceae, Haptophyceae and Bacillariophyceae. The cultures were isolated from diverse habitats in Malaysia, ranging from freshwater lakes, wastewater ponds, mangrove swamps, coastal waters to estuaries. There are several aerial microalgae isolated from wall and boat scrapings (e,g, *Chlorococcum* and marine diatoms), which were used in the studies to develop anti-fouling paints. Some cultures deposited in the UMACC are from other culture collections, including CCAP, CCMP, CSIRO and NIES. Recently, 15 isolates of Antarctic microalgae have been added into the Collection, following our recent expedition with the Australians to Casey Station in Antarctica.

The UMACC microalgae have many potential applications as indicated by the findings from the various studies conducted. The research include the following:

1. screening of the microalgae for high-value chemicals such as polyunsaturated fatty acids, carotenoids and phycobiliproteins.
2. use of the microalgae to treat agro-industrial wastewaters such as rubber and palm oil mill effluents, and sago factory wastewater.
3. use of the microalgae in toxicity testing, as biomonitors for heavy metal pollution and nitrogen enrichment in freshwater ecosystems, and in removal of heavy metals.
4. use of the microalgae as mosquito larvicidal agents.
5. use of the microalgae as animal feed.

## Screening of Potential Microalgae for Production of Fine Chemicals

Sixteen microalgal isolates from the UMACC were screened for high-value chemicals such as polyunsaturated fatty acids (PUFA), carotenoids and phycobiliproteins (Chu, 1996). The chlorophyte *Ankistrodemsus convolutus* UMACC 101 contains appreciable amounts of lutein and may be a potential poultry feed (Chu *et al.* 1995a). Factors such as carbon source and light-dark cycle can affect the growth and pigmentation of this alga (Chu *et al.* 1995b). The diatom *Nitzschia inconspicua* UMACC 111 produces appreciable amounts of eicosapentaenoic (EPA) and arachidonic acid; yield of EPA increases in cultures aerated with 5% $CO_2$ (Chu *et al.* 1996). The marine cyanophyte *Oscillatoria* UMACC 216 is a potential producer of phycoerythrin (Chu *et al.* 2001).

## Use of the Microalgae to Treat Agro-industrial Wastewater

*Chlorella vulgaris* UMACC 001 and *Spirulina platensis* UMACC 161 are two microalgae from the Collection that have the potential to treat wastewater. *Chlorella vulgaris* UMACC 001 grows well in high rate algal ponds (HRAP) treating rubber effluent, with high biomass production and percentage removal of Chemical Oxygen Demand (COD), $NH_4$ and $PO_4$ (Phang *et al.*, 2001). Further increase of biomass production can be achieved with the addition of molasses in the rubber effluent. *Spirulina platensis* UMACC 161 has been successfully grown in HRAP treating digested sago starch wastewater, with high biomass production and good treatment efficiency (Phang *et al.*, 2000). The algal biomass can be used as high quality animal feed.

## Use of the Microalgae in Toxicity Testing, Biomonitoring and Heavy Metal Removal

Several microalgae from the UMACC have potential applications in toxicity testing for heavy metals and in biomonitoring of heavy metal pollution and nitrogen enrichment. For example, *Ankistrodesmus convolutus* UMACC 101 is a good species for toxicity testing against heavy metals such as Cd, Co, Cr, Cu, Fe, Mn and Zn (Samina Hussein, 1999). The marine microalgae *Chaetoceros calcitrans* UMACC 147, *Isochrysis galbana* UMACC 141, *Tetraselmis tetrahele* UMACC 144 and *Tetraselmis* UMACC 146 are suitable microalgae for use in toxicity testing against Cd, Cu, Mn and As (Melor Ismail *et al.* 2002). Four chlorophytes, namely *Chlorella vulgaris* UMACC 001, *Scenedesmus quadricauda* UMACC 039, *Scenedesmus quadricauda* UMACC 041 and *Ankistrodesmus convolutus* UMACC 101 were tested for use as bioindicator for nitrogen enrichment based on their tolerance to different levels of nitrate and ammonium (Foo *et al.*, in press). The non-living biomass of *Chlorella vulgaris* UMACC 001 can be used to remove cadmium by adsorption process (Hashim *et al.*, 1997).

## Use of the Microalgae as Mosquito Larvicidal Agents

The effect of four chlorophytes from the UMACC on the larval survival, development and adult body size of the mosquito *Aedes aegypti* were investigated (Rohani Ahmad *et al.*, 2001). Larvae of *Aedes aegypti* fed with *Chlorella vulgaris* UMACC 185, *Scenedesmus quadricauda* UMACC 220 and *Chlorococcum* UMACC 213 showed high mortality and delayed pupation and body size reduction, indicating that these cholrophytes are potential larvicidal agents.

## Use of the Microalgae as Animal Feed

There is a potential application of the UMACC microalgae as aquaculture and poultry feed. The marine microalgae *Chaetoceros calcitrans* UMACC 147, *Isochrysis galbana* UMACC 141 and *Tetraselmis tetrahele* UMACC 144 are commonly used aquaculture feed. The potential use of algal biomass generated from waste-grown algae such as *Chlorella vulgaris* UMACC 001 and *Spirulina platensis* UMACC 161 is being explored. *Chlorella vulgaris* UMACC 001 was shown to be a nutritious feed for chironomid larvae (Habib *et al.*1997).

## Antarctic Microalgae

Fifteen Antarctic microalgae were isolated from samples of seawater, inland water, snow, soil and rocks collected from Casey Station ($66^{o}$ 17' S, $110^{o}$ 29' E), Antarctica. The collection includes chlorophytes like *Desmococcus* UMACC 224, *Ulothrix* UMACC 227, *Chlorococcum* UMACC 228 and *Chlamydomonas* UMACC 229, and diatoms like *Navicula* UMACC 231 and *Pinnularia* UMACC 232 (Chu and Phang, 2001). This first Malaysian collection of Antarctic microalgae is important for our studies on their physiological adaptation under extreme conditions, especially in comparison to tropical species, with regards to impacts such as global warming and increased UV radiation.

## Conclusion

The UMACC represents a valuable microbial resource, as indicated by the potential applications of the organisms. To tap the potential of this resource, our future research trends are directed towards genomic studies, including research on phylogenetics, microarray analysis and genetic transformation. The diverse collection of indigenous mircoalgae of the UMACC also reflects the rich biodiversity of microalgal flora in Malaysia. Thus, efforts should be invested in conserving the microalgal resources in Malaysia.

## Acknowledgements

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# The Situation of the Taxonomic Studies on 'minor' Invertebrates in Asia: the Phylum Nemertea as a Test Case

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## Abstract

**Nemerteans, often referred to as ribbon worms, are soft-bodied marine invertebrates. They are usually less than 10 cm in length, but species that attain a length of 1-3 m are not uncommon, and a certain species is recorded to have a maximum body length that exceeds 30 m. As is often the case with lower invertebrates, nemertean taxonomy is confused because it has been based primarily upon literature, not upon actual comparison with type specimens. Accordingly, it is necessary to make specimen-information as widely available as possible. We have been try to create a database that stores information of Japanese nemertean specimens with recently developed tool kit, which facilitates data input for natural history collection. This paper gives a brief outline of the taxonomy of nemerteans and its species diversity in Asian region.**

***Key Words:marnie invertebrates, Nemertea, dabatase, taxonomy***

## Introduction

Nemertean worms (phylum Nemertea, Fig. 1), often called 'ribbon worms', are acoelomatic, mainly marine invertebrates. They are thought to be phylogenetically closely related to platyhelmithes (e.g., *Planaria*) and to be a sister taxon to other 'spiralians' including annelids (e.g. earthworm) and mollusks (e.g. octopus) (Fig. 2).

| | | |
|---|---|---|
| 1. Placozoa | 12.Gastrotricha | 23.Sipuncula |
| 2. Rhombozoa | 13.Kinorhyncha | 24.Pentastomida |
| 3. Orthonectida | 14.Nematoda | 25.Onychophora |
| 4. Porifera | 15.Nematomorpha | 26.Tardigrada |
| 5. Cnidaria | 16.Acanthocephala | 27.Arthropoda |
| 6. Ctenophora | 17.Priapulida | 28.Phoronida |
| 7. Platyhelminthes | 18.Loricifera | 29.Brachiopoda |
| 8. Gnathostomulida | 19.Cycliophora | 30.Bryozoa |
| 9. Nemertea | 20.Mollusca | 31.Chaetognatha |
| 10.Kamptozoa | 21.Annelida | 32.Echinodermata |
| 11.Rotifera | 22.Echiura | 33.Hemichordata |
| | | 34.Chordata |

**Fig. 1 A standard classification of the Kingdom Animalia**

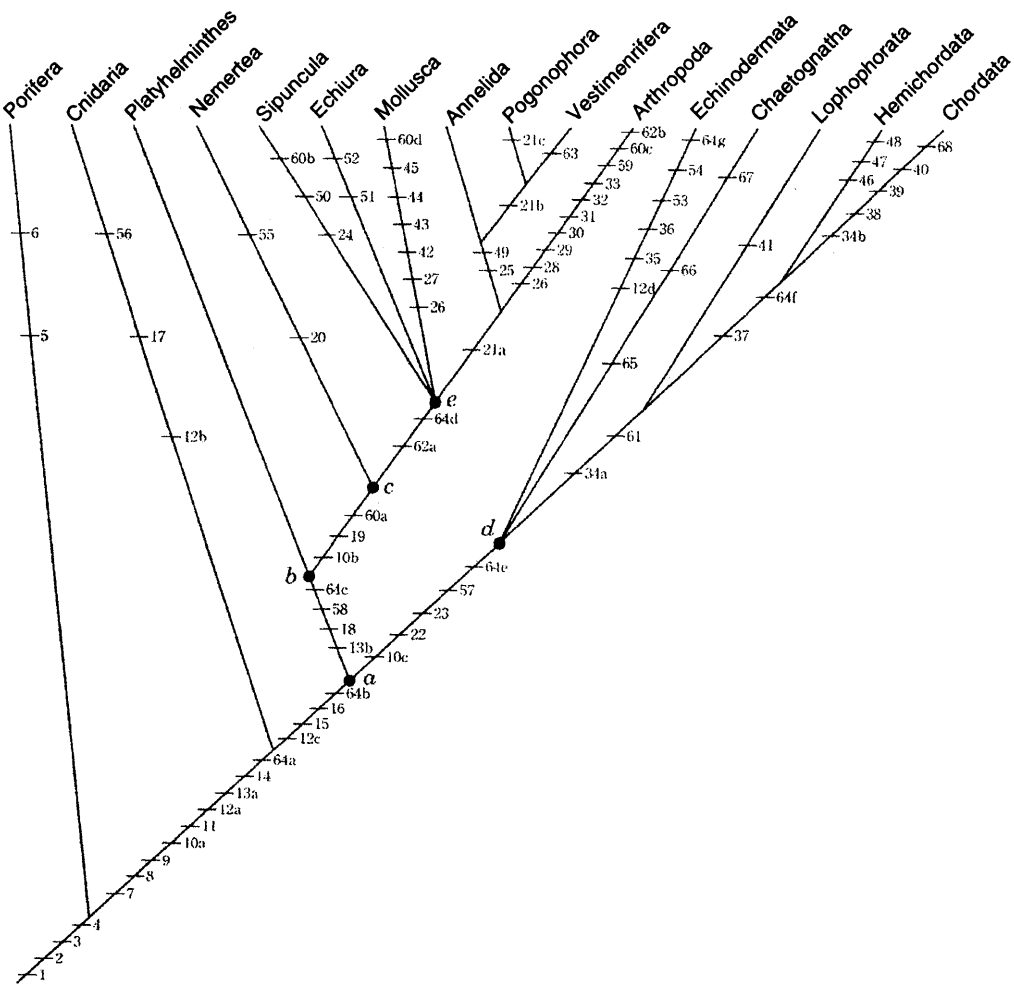



**Fig. 2 Phylogenetic relationship between major metazoan phyla inferred from morphological characters (Brusca and Brusca, 1990)**

The most striking feature of nemerteans is their eversible proboscis (Fig. 3), which is independent of their digestive canal. The proboscis is used to capture their preys; nemerteans usually feed upon small crustaceans (Fig. 4) or polychaets (Fig. 5).

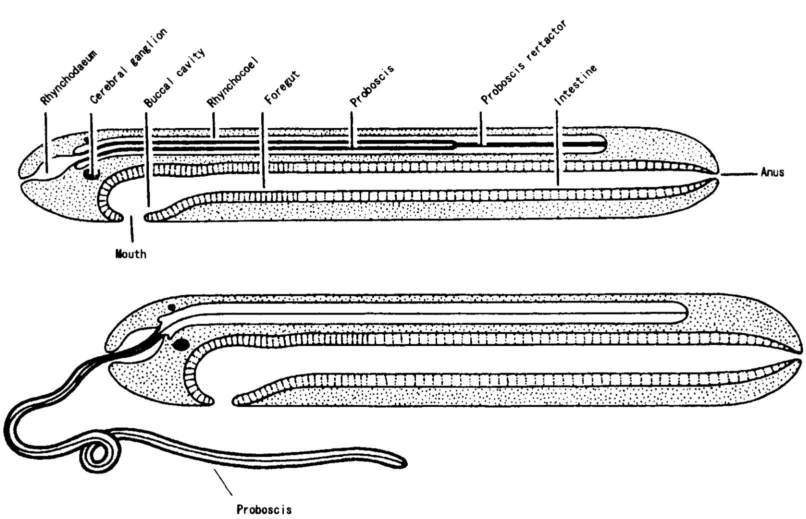



**Fig. 3 Schematic diagrams to show the body organization of nemerteans viewed laterally on sagittal section (Gibson, 1982)**

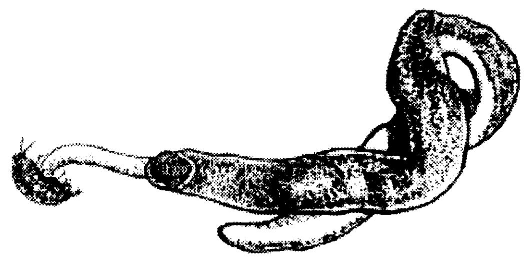


**Fig. 4 A nemertean attacking a small crustacean with its proboscis. The nemertean worm immobilizes the prey with paralytic toxin that is secreted from the proboscis before sucking out the prey's soft parts inside the exoskeleton. A certain kind of the chemical component produced by nemerteans has been proved to be a potential anti-Alzheimer's disease drug. After Kem & Soti (2001)**

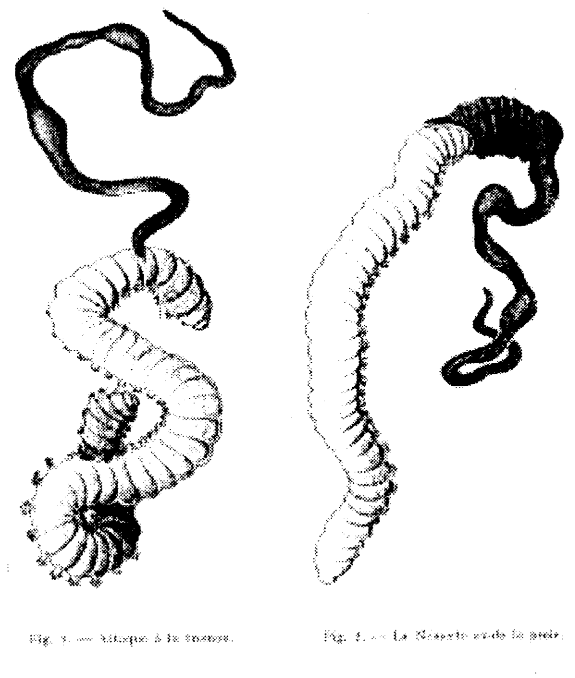


**Fig. 5 A nemertean predating a lugworm (*Nereis*) that is two or three times larger than itself (left), and then swallowing it (right). After Gontcharoff (1948)**

Nemerteans are typically slender and elongate in shape with smooth surfaces (Fig. 6). Most of the nemerteans are benthic, mainly found under stones or among algae in intertidal sandy or rocky shore, but some inhabit sublittorally from few meters to several hundred meters depth.

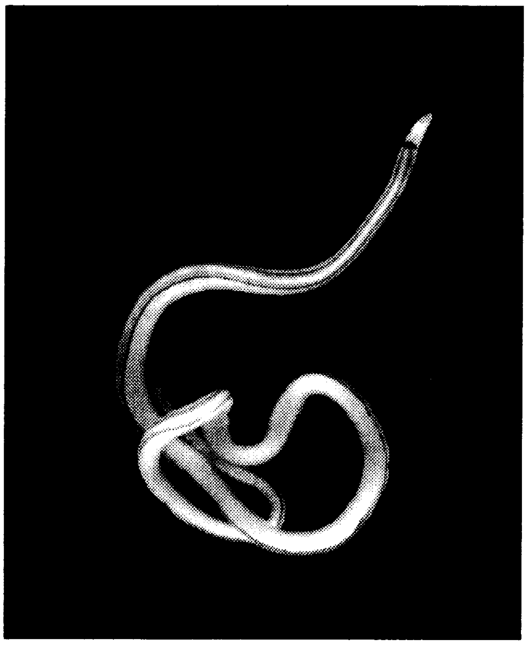


**Fig. 6 Photograph to show the general appearance of a nemertean taken in life**

## Taxonomic Practice

Because nemerteans are poor in taxonomically useful external characters, their classification is primarily based upon histological examinations of the internal morphology (Figs 7, 8), which is usually a time-consuming work. This may prevent the advancement of the taxonomic studies in this group.

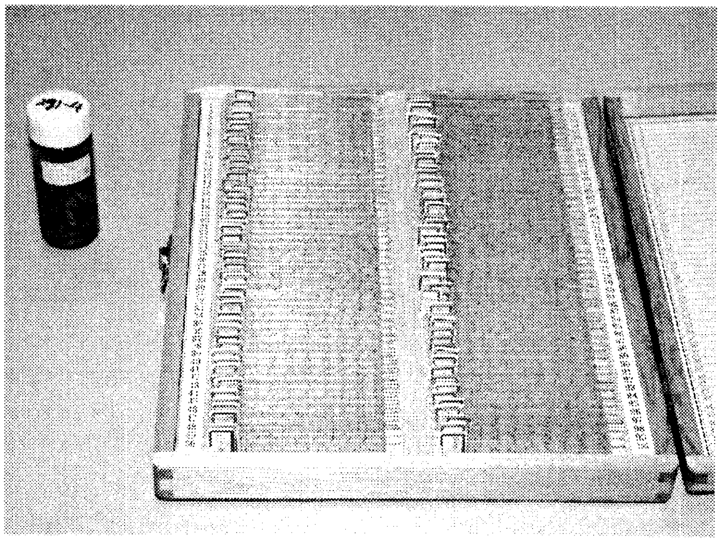


**Fig. 7 A specimen preserved in a vial and a series of transverse sections. Complete serial sections of a specimen of 5 cm may result over 100 slide glasses.**

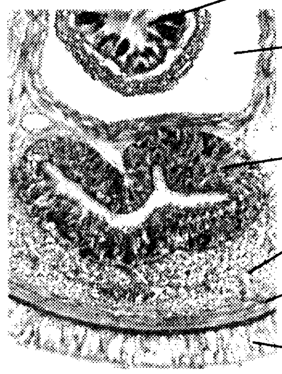



**Fig. 8 Transverse section through the stomach region of a nemertean to show the general appearance of the various body organs. Nemertean taxonomy is primarily based upon examination of its internal morphology.**

## Brief Historical Review of Taxonomic Studies of Asian Nemerteans

Quoy and Gaimard (1833) reported nemerteans from Indonesia as the first record in Asia. Following scientific expeditions during the 19th Century and the early 20th Century made by European researchers, such as the *Challenger* Expedition and the *Siboga* Expedition, yielded sporadical increases of the reported species number mainly in Maldives, Sri Lanka, Singapore and Indonesia.

The first Asian nemertean specialist was born in Japan, whose first paper was published in 1897. A total of three successors have followed him in this country; this may account for the largest number of reported species in Japan among Asian countries.

Also, the appearance of native taxonomists accounts for the remarkable increase of the number of the species reported from China since 1980's.

Unfortunately, no native researcher has grown up in Asian countries except China and Japan; in these countries the number of the reported species has reached to a plateau for a long time.

## Species Diversity in Asia

While about 1100 species have been known worldwide, the number of the Asian species so far reported is 223 (Fig. 10, Tab. 1), and this is less than a half of that of the European species. Is this proportion reasonable or not?

Singapore has the highest species density in terms of coastline length (Tab. 2). Given the species diversity commensurates with the coastline length, and the species density in Singapore is applicable in all the Asian countries, the total number of the Asian species is over 10,000, with Indonesia being the richest diversity (Fig. 11). If the endemic species ratio in each country is 20%, about 2,000 species species are still expected to live in this region, which is ten times higher than the currently known number.

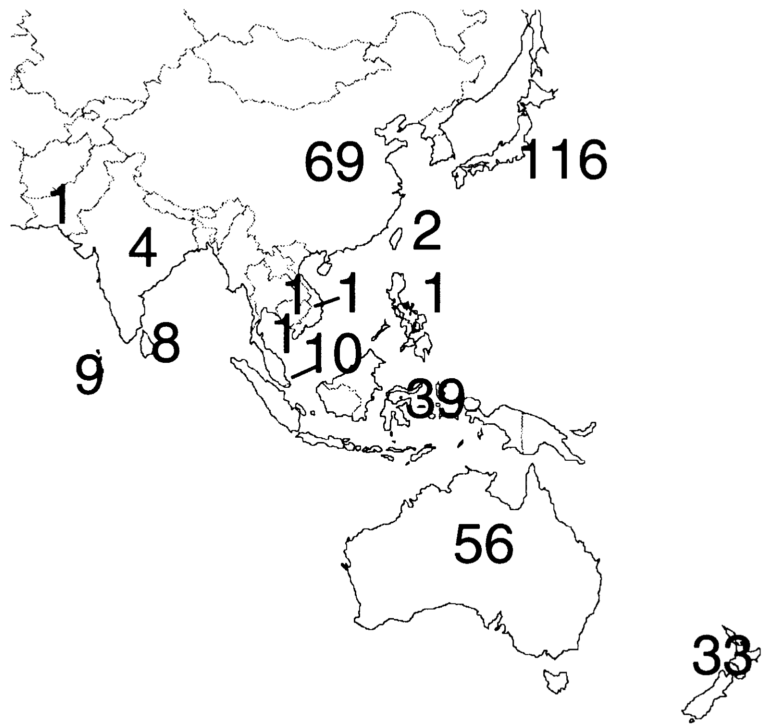



**Fig. 10 Numbers of species reported in the Asia-Oceania countries**

**Table 1 Number of species and percentages of endemism in each of the Asian countries. The numbers in the upper right portion of the table are Sorensen's Quotient of Similarity, while those in the bottom left portion are the number of the common species between two countries**

| Country | Pakistan | Maldives | India | Sri Lanka | Cambodia | Vietnam | Malaysia | Singapore | Indonesia | Philippines | Taiwan | China | Japan | Australia | New Zealand |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of species | 1 | 9 | 4 | 8 | 1 | 1 | 1 | 10 | 39 | 1 | 2 | 69 | 116 | 56 | 33 |
| Endemism (%) | 0 | 89 | 75 | 75 | 100 | 100 | 0 | 90 | 87 | 0 | 50 | 62 | 62 | 82 | 82 |
| Pakistan | — | 20 | 40 | 22.2 | 0 | 0 | 0 | 0 | 5 | 0 | 66.7 | 0 | 1.7 | 3.5 | 0 |
| Maldives | 1 | — | 15.4 | 0 | 0 | 0 | 0 | 0 | 4.2 | 0 | 18.2 | 0 | 1.6 | 3.1 | 0 |
| India | 1 | 1 | — | 0 | 0 | 0 | 0 | 0 | 4.7 | 0 | 0 | 0 | 1.7 | 0 | 0 |
| Sri Lanka | 1 | 0 | 0 | — | 0 | 0 | 0 | 0 | 4.3 | 22.2 | 0 | 0 | 1.6 | 0 | 0 |
| Cambodia | 0 | 0 | 0 | 0 | — | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Vietnam | 0 | 0 | 0 | 0 | 0 | — | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Malaysia | 0 | 0 | 0 | 0 | 0 | 0 | — | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| Singapore | 0 | 0 | 0 | 0 | 0 | 0 | 0 | — | 4.1 | 0 | 0 | 0 | 0 | 3 | 0 |
| Indonesia | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | — | 5 | 4.9 | 3.7 | 6.5 | 10.5 | 0 |
| Philippines | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | — | 0 | 0 | 1.7 | 0 | 0 |
| Taiwan | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | — | 0 | 1.7 | 3.5 | 0 |
| China | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | — | 23.8 | 6.4 | 2 |
| Japan | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 5 | 1 | 1 | 22 | — | 4.7 | 2.7 |
| Australia | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 5 | 0 | 1 | 4 | 4 | — | 2.3 |
| New Zealand | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 1 | — |

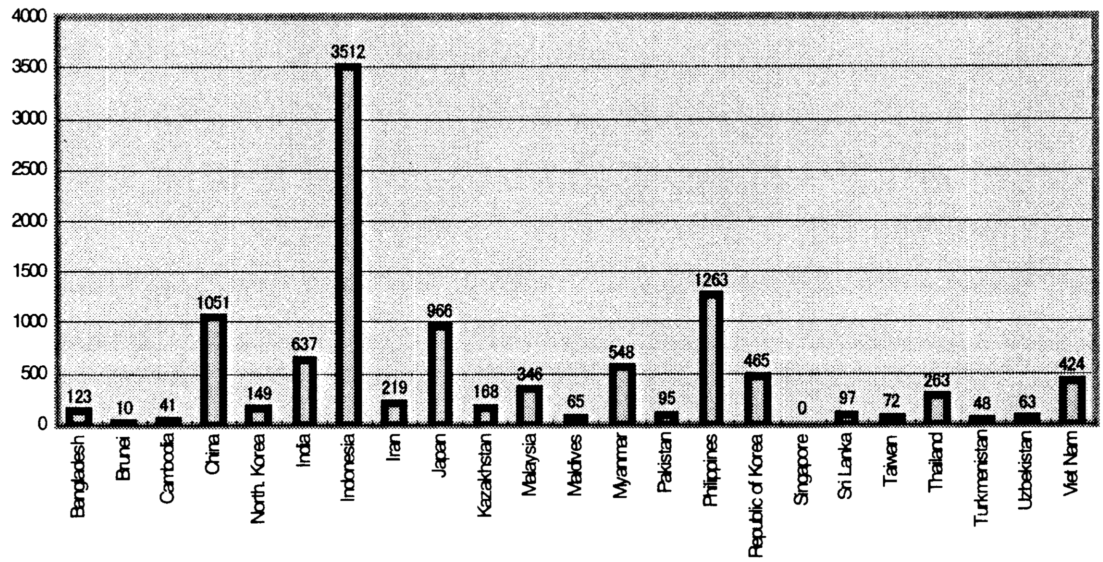



**Fig. 11 Rough estimation of the number of undiscovered species in Asian countries, given the species density in Singapore applies throughout the region.**

**Table 2 Coastline length, number of reported species, roughly estimated number of species and the number of expected species in the Asian countries**

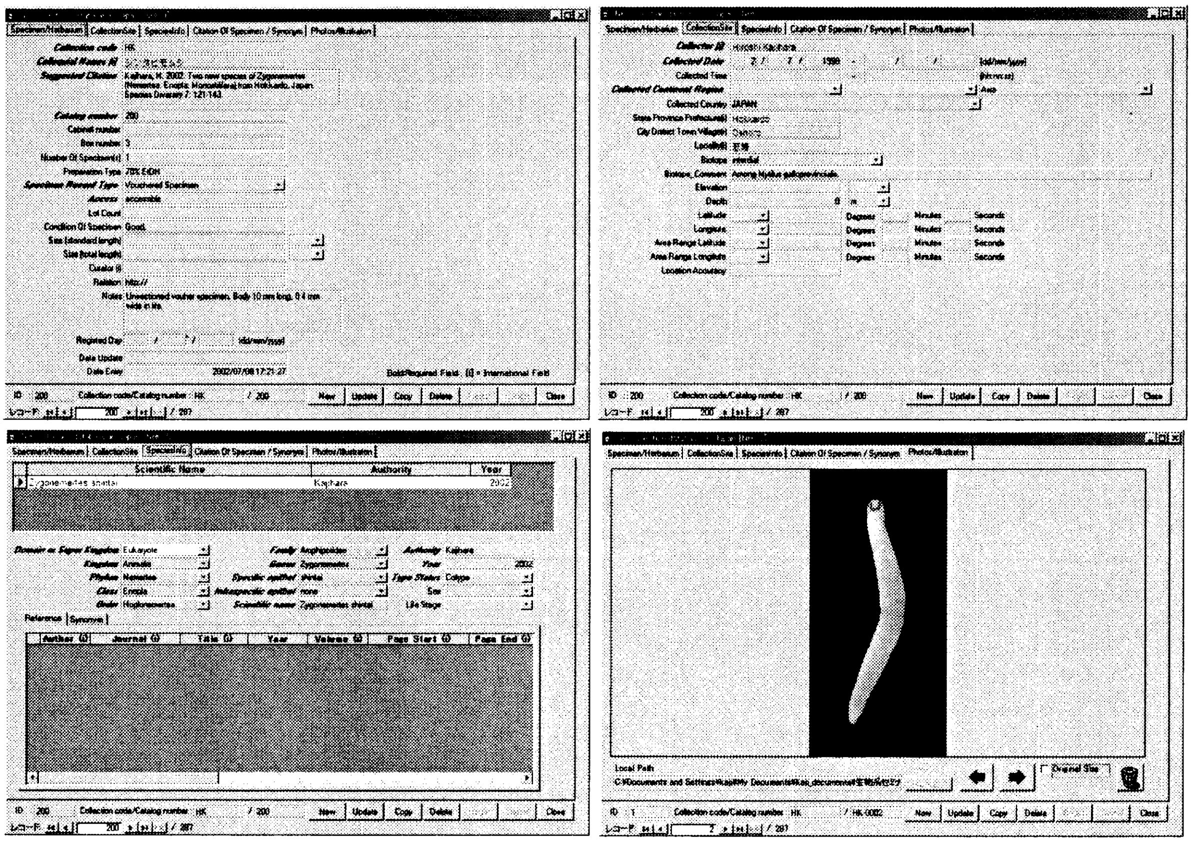
| Country | *Coastline length (km) | Number of reported species | **Expected number | Gap |
|---|---|---|---|---|
| Bangladesh | 3306 | 0 | 123 | 123 |
| Brunei | 269 | 0 | 10 | 10 |
| Cambodia | 1127 | 1 | 42 | 41 |
| China | 30017 | 69 | 1120 | 1051 |
| North. Korea | 4009 | 0 | 149 | 149 |
| India | 17181 | 4 | 641 | 637 |
| Indonesia | 95181 | 39 | 3551 | 3512 |
| Iran | 5891 | 0 | 219 | 219 |
| Japan | 29020 | 116 | 1082 | 966 |
| Kazakhstan | 4528 | 0 | 168 | 168 |
| Malaysia | 9323 | 1 | 347 | 346 |
| Maldives | 2002 | 9 | 74 | 65 |
| Myanmar | 14708 | 0 | 548 | 548 |
| Pakistan | 2599 | 1 | 96 | 95 |
| Philippines | 33900 | 1 | 1264 | 1263 |
| Republic of Korea | 12478 | 0 | 465 | 465 |
| Singapore | 268 | 10 | 10 | 0 |
| Sri Lanka | 2825 | 8 | 105 | 97 |
| Taiwan | 2007 | 2 | 74 | 72 |
| Thailand | 7066 | 0 | 263 | 263 |
| Turkmenistan | 1289 | 0 | 48 | 48 |
| Uzbekistan | 1707 | 0 | 63 | 63 |
| Viet Nam | 11409 | 1 | 425 | 424 |

*Data taken from UNEP website (http://geocompendium.grid.unep.ch/data_sets/coastal/sheets/all%20-%20coastline_length.xls)

**Expected number of species = 10/268 × Coastline length

## Japanese Nemertean Specimen Database

A Japanese nemertean specimen database is under construction (Fig. 12). Nemertean classification has rather been based upon literature information and this ahs caused a taxonomic confusion in this group. To avoid this, the information of specimens, especially types, or at least those from type localities, should be open to the furure nemertean taxonomists in Asian countries. The contents will be available via www in due course.



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# Mycology in Asia, the past, the present and future needs

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## Abstract

**After fifteen years of carrying out research in mycology in the Asia region I have come to realize the strengths and weaknesses of taxonomic research in mycology in the region. This paper will address the state of taxonomic mycology in the Asian region and provide examples of past and present work in various countries. In general terms, taxonomic mycological research has decreased dramatically throughout Asia although there are countries that have made great improvements. The present work on taxonomic mycology (based on publications in international journals) is dismal, with very few countries having any active mycologist(s). This should provide a startling wake up call to politicians if they are serious about implementing GTI. The paper will conclude with suggestions to improve the future of mycology in the East Asian regions.**

***Key Words : Bioprospecting, Fungi, IMACA, Mycological research, Taxonomy***

## Introduction

In order to fulfill their commitments to the Convention on Biological Diversity (CBD), countries of the Asian region must understand that taxonomic expertise is vital for effective implementation (http://www.biodiv.org/convention/articles.asp). The Global Taxonomy Initiative (GTI) therefore states "understanding taxonomy to be a priority in implementing CBD" (http://www.biodiv.org/programmes/cross-cutting/taxonomy/). Fungi, in particular are a group of organisms where most countries in the region lack taxonomists to carry out the roles of CBD. Previously, several Asia countries had relatively active taxonomic groups, but in recent years the number of active mycologists has dwindled because of other commitments, retirement of the mycology population without replacement and more importance being placed on other disciplines, such as biotechnology. This paper will briefly review the history of the study of fungi in the Asian region and then examine the current situation using publications in international journals. Suggestions on how improvements to mycological expertise in a country can be made are given with particular references to the successes in Thailand.

## Taxonomic mycology in Asia – the past

Before the 2nd world war, most mycology in Asia, besides Japan (e.g. K. Hara) was carried out by visiting scientists. Alternatively, collectors working in the region collected fungi and then sent material to Europe to be examined and described by eminent mycologists of the day (1900-1920). In this way material was described from Indonesia (P. Hennings, F. Höhnel, O. Penzig and P.A. Saccardo) and the Philippines (P. Sydow, H. Sydow, H. Rehm). Occasionally expatriate mycologists living in various countries made significant inputs to taxonomic mycology. In Sri Lanka (T. Petch) made substantial contribution to the study of fungi, while E.J.H. Corner made substantial contributions in Malaysia and Singapore. Studies on microfungi were less common, although several Japenese researchers made substantial contributions (e.g. I. Hino, K. Katamuto, T. Matsushima, K. Tubaki). Substantial contributions were also made in Malaysia by A. Kuthubutheen and A. Nawawi, in India by C.V. Subramanian, in Indonesia by M. Rifai and in China by S.C. Teng. Unfortunately, most of these researchers have past away, retired or moved to other non-research disciplines and they have not been replaced.

## Taxonomic mycology in Asia – the present

The only method to obtain an accurate evaluation of the status of mycological taxonomy in the region is to survey the number of publications from the region. This can be carried out relatively easily by looking in the Bibliography of Systematic Mycology (Anonymous, 1989-2001) where all accessible mycological publications in taxonomy are listed (both international and national journals). This is the most accurate way to express involvement in taxonomic mycology as it clearly shows which mycologists are active in the region. The IMACA Asian Systematic Mycologists Directory published in 1998 (Quimio, 1998) lists more than 170 systematic mycologists in the region, but this is misleading as the majority of these listed workers are either inactive, work in other fields, have retired, or are students that have moved on to do other things or have left the region. I chose the years 1989, 1994, 1999 as five yearly intervals were considered to be adequate to indicate trends in publications of active mycologists in the region. Because there is a lag time of 1-2 years in listing of all publications in the Bibliography, 1999 was the latest year that could be accessed fully. China, Hong Kong, Macau and Taiwan are treated as separate regions (and thus called countries for simplicity of communication).

In Table 1 we list the number of taxonomic mycological publications by country from the Asian region over the last three, eight and 13 years. In 1989 there were 62 publications in the Asian region with 17 active researchers. Researchers in India (7), Japan (3), and Taiwan (3) were particularly active. Of the 22 listed countries there were no publications from 16 countries and no active taxonomic mycologists in 18 countries. Therefore most countries in the region lacked active taxonomic mycologists. The situation became worse in 1994 with only 42 publications and 10 active researchers. There were no longer any active researchers in India. Japan (6), China (2) and Hong Kong (2) had the only actively publishing researchers in the region. Of the 22 listed countries there were no publications from 16 countries and no active taxonomic mycologists in 19 countries. The situation appears to have improved in 1999 with 117 publications and 32 active taxonomic mycologists. Researchers in Hong Kong (21), Japan (6) and Taiwan (6) were particularly active. Of the 22 listed countries there were no publications from 14 countries and no active taxonomic mycologists in 16 countries.

There are general trends in the results of this survey. The majority of countries (72.7-81.8%) did not publish during the years surveyed and thus had no active taxonomic mycologists. India was previously active, but with a rapid decline in both publications and active taxonomic mycologists after 1989. The results for China, Japan and Taiwan were relatively consistent, maintaining a number of publications and having between 2-6 active taxonomic mycologists. In Hong Kong there was a rapid rise in both publications and active taxonomists, mainly as a result of the Centre for Research in Fungal Diversity.

The results for China, Hong Kong and Taiwan indicate that there is a relatively healthy group of actively publishing systematic mycologists. The situation for other countries in the region is, however, depressing. If China, Hong Kong and Taiwan are excluded then the publications since 1989 have decreased and so have the numbers of active mycologists. There are, however, some improvements not shown in these results. The numbers of taxonomic mycologists in South Korea has steadily increased, although there is still a low number.

Thailand now has more than 10 active taxonomic mycologists and the numbers are increasing at a fairly rapid rate.

**Table 1. Numbers of publications in mycological taxonomy in international and national journals and number of active mycologists* in 1989, 1994 and 1999 in the Asian region.**

| Country/region | 1989 | | 1994 | | 1999 | |
|---|---|---|---|---|---|---|
| | Publications | Active mycologists | Publications | Active mycologists | Publications | Active mycologists |
| Bangledesh | - | - | - | - | - | - |
| Brunei | - | - | - | - | - | - |
| Cambodia | - | - | - | - | - | - |
| **China** | **6** | **2** | **4** | **2** | **18** | **3** |
| **Hong Kong** | **-** | **-** | **13** | **2** | **54** | **21[$]** |
| India | 30 | 7 | 4 | - | 4 | - |
| Indonesia | - | - | - | - | - | - |
| **Japan** | **15** | **3** | **17** | **6** | **22** | **6** |
| Korea | 1 | | - | - | 3 | 1 |
| Lao | - | - | - | - | - | - |
| Macau | - | - | - | - | - | - |
| Malaysia | 3 | 2 | 1 | | 2 | 1 |
| Mongolia | - | - | - | - | - | - |
| Myanmar | - | - | - | - | - | - |
| North Korea | - | - | - | - | - | - |
| Pakistan | - | - | - | - | - | - |
| Papua New Guinea | - | - | - | - | - | - |
| Philippines | 1 | - | - | - | - | - |
| Singapore | - | - | - | - | - | - |
| **Taiwan** | **6** | **3** | **3** | | **13** | **6** |
| Thailand | - | - | - | - | 1[#] | - |
| Vietnam | - | - | - | - | - | - |
| **Total** | **62** | **17** | **42** | **10** | **117** | **38** |
| **Total excluding China, Hong Kong and Taiwan** | **49** | **13** | **22** | **6** | **32** | **8** |

*Publications in journals listed in Bibliography of Systematic Mycology. Publications in taxonomy and checklists only considered (i.e. plant pathology, biology, industrial mycology excluded).

[#] This figure has increased dramatically in 2002 so that there are probably more than 20 taxonomic publications and more than 10 active researchers.

[$] Many of these are students that were undergoing PhD training in Hong Kong and have now returned to other countries (e.g. Australia, China, Philippines, New Zealand).

## Taxonomic mycology in Asia – the future

The present work on taxonomic mycology (based on publications in international journals) is disappointing, with very few countries having active mycologists at all. This should provide a startling wake up call to politicians if they are serious about implementing GTI. The problem now is that the base of taxonomic mycologists in the region is remarkably small and if we are to remedy this situation we have to do something now before all expertise is completely lost. In reality there are only a small number of Centers of Taxonomic Mycological expertise in the region. These include BIOTEC, in Bangkok, Thailand, The Department of Biology, Chiang Mai University, Thailand and The Centre for Research in

Fungal Diversity, Hong Kong and Systematic Mycology and Lichenology Laboratory, Academia Sinica in Beijing China. Unfortunately, within these Centers, only the Department of Biology, Chiang Mai University, Thailand and The Centre for Research in Fungal Diversity, The University of Hong Kong, have extremely good taxonomic library resources, which are essential for taxonomic mycological research.

The only effective way to move forward is therefore to develop these existing Centers and use them to provide higher degree training for students in the region. This is already happening to a certain extent in these existing centers. More than 40 students have been trained at the Centre for Research in Fungal Diversity, The University of Hong Kong. Many of these students are from the region and have now returned to their respective countries and have become active mycologists (e.g. L.D. Guo, Systematic Mycology and Lichenology Laboratory, Academia Sinica, Beijing, China). There are three resident taxonomic mycologists, and more than 10 Thai students undergoing training at BIOTEC, Bangkok, Thailand and eight students undergoing training at Chiang Mai University. There is a need for the Thai centers to train other nationalities and in this way it may be possible to train enough students to return to their respective countries who can then be concentrated in their own Centers. The problem however, exists as to where funds for such training can be acquired.

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# Taxonomic Capacity and the Conservation Status of Fungi in Australia

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## Abstract

**The conservation status of 443 species of Agaricales, Boletales, Cantharellales, Lycoperdales, Phallales and Russulales of South Australia is reviewed. Because of lack of data on individual taxa no species was determined to be extinct or vulnerable. Factors affecting conservation of fungi in Australia are discussed.**

***Key Words: Australia, threatened species, conservation, Holobasidiomycetidae***

## Introduction

In Australia studies of the conservation status of fungi has lagged behind that of the charismatic megabiota—the angiosperms and vertebrates. While individual mycelia may be very extensive and long-lived, formation of basidiomata is dependent upon diverse environmental factors (e.g. season, temperature, frost, moisture, humidity), nutrient reserves, presence of sexually compatible genotypes, presence of stimulatory organisms and exposure to inducing factors (e.g. fire or ammonia). The ephemeral nature of most basidiomata and their seasonality does not make them conducive to ecological studies. Dried basidiomata are somewhat unattractive and not easy to study. Thus the Australian mycoflora, even the macrofungi, is relatively poorly known.

Settlement of the island continent Australia by Europeans two centuries ago resulted in extensive land clearing in the higher rainfall areas (those receiving more than 400 mm of rain per annum) for agriculture, exotic tree plantations and pastoral enterprises. In general farmers and pastoralists cleared or altered native plant communities faster than botanists and ecologists were able to study the natural Australian flora. Cultural debates about the extent and nature of vegetation change in Australia are ongoing (Griffiths, 2002). The Australian flora is now relatively well known with modern flora treatments, detailed classifications of vegetation communities, reliable data on distributional patterns and environmental correlations, and increasing data on intraspecific genetic variation. However, it has become increasingly apparent that Australian landscapes at the time of European settlement were the consequence of more than 40 000 years of management by the aboriginal inhabitants particularly through landscape burning for game management (Dodson and Mooney, 2002).

## Materials and Methods

In 1997 a revision of the agaric, bolete and gasteromycete mycoflora of South Australia was published (Grgurinovic, 1997). The study was based in large part on collections made by J.B. Cleland, mostly between 1920 and 1940, and housed in the State Herbarium of South Australia, Adelaide (AD). All collections cited in Grgurinovic (1997) are vouchered by herbarium specimens making the records especially valuable. Subsequently Grgurinovic and Simpson (2001) compiled the available information about the biological habit and known distribution of each species. These data were then analysed to determine the conservation status of each species.

In Europe conservation status of macrofungi has been determined using the IUCN Red Data Book categories as shown in Table 1 (Arnolds and de Vries, 1993).

**Table 1. Categories of threatened macrofungi as used for IUCN Red Data Book Lists in Europe**

| Category | Attributes |
|---|---|
| 1 Extinct species | Species that have not been found for several decades in spite of intensive field work. |
| 2 Endangered species | Rare species that have strongly decreased in the 20th Century and/or occupying habitats that are endangered or declining. |
| 3 Vulnerable species | Species that are likely to become endangered in the near future if the causal agents for their decline are not reduced or removed. |
| 4 Rare species | Species with small populations or few sites that are not at present threatened, but may become at risk without adequate protection. |
| 5 Indeterminate | Care demanding species that cannot be placed in one of the above categories owing to lack of information. |

Use of these categories was considered inappropriate as no professional taxonomic mycologist working on the groups revised by Grgurinovic (1997) had worked in South Australia for more than 50 years. Furthermore in the 20th century there had been no surveys of presence of species that had been described from threatened habitats. Therefore we modified the ROTAP model used for rare and threatened plants in Australia (Briggs and Leigh, 1995). The categories adopted are listed in Table 2. Placement in the categories is qualitatively and not quantitatively determined on the basis of expert knowledge.

**Table 2. Categories for known distribution, conservation status and protected area status for macrofungi in South Australia**

| Category | Attribute |
|---|---|
| 1 | Known by one collection only |
| 2 | Known distribution an area less than 100 km diameter |
| 3 | Known from only one State or Territory in Australia |
| 4 | Known from more than one State or Territory in Australia |
| X | **Presumed extinct.** Taxon not collected or otherwise verified over the past 50 years despite searching in all known and likely habitats or the known habitat has been destroyed. |
| E | **Endangered.** Taxon is in serious risk of disappearing from the wild within 20 years if present land use and other threats continue to operate. |
| V | **Vulnerable.** Taxon not presently endangered but at risk of disappearing from the wild within 50 years through continued habitat depletion or changes in land use or land management. |
| R | **Rare.** Taxon that appears to be rare in Australia but that does not have an identifiable threat at present. |
| K | **Poorly known.** Taxon that is suspected to belong to one of the above categories but accurate field distribution data is lacking at present. |
| N | **Not endangered.** Taxon not under threat. |
| C | **Reserved**. Taxon has at least one population within a national park or other proclaimed conservation reserve in South Australia. |
| [C] | **Reserved**. Taxon has at least one population within a national park, or other proclaimed conservation reserve in another Australian State or Territory. |

## Results

The conservation status of 443 species of Holobasidiomycetidae known from the State of South Australia in southern Australia has been evaluated. The World Conservation Union Red List criteria endorsed in 1994 were found to be inappropriate as the decision rules are based on quantitative threshholds of population size, distributional ranges, rates of decline and extinction risk. For most of the past 60 years there has been no taxonomic mycologist working on the Agaricales, Boletales, Cantharellales, Lycoperdales, Phallales or Russulales of South Australia. Therefore no quantitative data were available. The modified ROTAP system outlined in Table 2 largely overcomes these difficulties. The conservation status of a species is indicated by a combination of a number and one or more letters.

Ecological attributes of the taxa studied are shown in Table 3. Cantharellaceae have not been included in Table 3; the three species recorded from South Australia are known only from the holotype and are presumed to be ectomycorrhizal. The great majority of the fungi in this study come from areas now with cleared or modified native vegetation. Ectomycorrhizal fungi comprise 35% of the mycoflora studied and were the predominant ecological group. Soil saprotrophs, 31% of the taxa, were the second largest group. Fifty-six taxa (13%) have been introduced from overseas. Of these 19 taxa are ectomycorrhizal with exotic trees. Introduced species were most common amongst the coprophilous fungi.

**Table 3. Ecological attributes of Agaricales, Boletales, Lycoperdales, Phallales and Russulales of South Australia**

| Attribute | Agaricales | Boletales | Lycoper-dales | Phallales | Russul-ales | Total |
|---|---|---|---|---|---|---|
| No. of species | 309 | 35 | 54 | 21 | 21 | 440 |
| Introduced species | 44 | 11 | 0 | 0 | 1 | 56 |
| Coprophilous species | 20 | 0 | 0 | 0 | 0 | 20 |
| Introduced coprophilous species | 13 | 0 | 0 | 0 | 0 | 13 |
| Ectomycorrhizal species | 94 | 33 | 3 | 2 | 21 | 153 |
| Introduced ectomycorrhizal species | 8 | 10 | 0 | 0 | 1 | 19 |
| Litter saprotrophs | 53 | 0 | 0 | 6 | 0 | 59 |
| Introduced litter saprotrophs | 6 | 0 | 0 | 0 | 0 | 6 |
| Soil saprotrophs | 70 | 1 | 49 | 16 | 0 | 136 |
| Introduced soil saprotrophs | 18 | 0 | 0 | 0 | 0 | 18 |
| Wood-inhabiting saprotrophs | 66 | 1 | 0 | 0 | 0 | 67 |
| Introduced wood-inhabiting saprotrophs | 3 | 1 | 0 | 0 | 0 | 4 |

Species known only from the holotype, lectotype or neotype collection comprised 22% of the taxa studied (Table 4). More than half of the taxa (57%) was described from a collection from South Australia (Table 5). Only 34% of taxa are known from conservation reserves in South Australia. A remarkable 26% of the total taxa recorded are known from one small national park of 840 ha close to Adelaide. No taxon was determined to be extinct.

**Table 4. Conservation status of ecological groups of Agaricales, Boletales, Cantharellales, Lycoperdales, Phallales and Russulales of South Australia**

| Ecological Group | Total | Species with holotype, lectotype or neotype described from a collection from South Australia | Species collected from sites presently in conservation reserves in South Australia |
|---|---|---|---|
| No. of species | 443 | 252 (57%) | 151 (34%) |
| Coprophilous species | 20 | 7 (35%) | 9 (45%) |
| Ectomycorrhizal species | 156 | 95 (61%) | 56 (36%) |
| Litter saprotrophs | 59 | 40 (68%) | 24 (41%) |
| Soil saprotrophs | 136 | 54 (40%) | 30 (22%) |
| Wood-inhabiting saprotrophs | 67 | 43 (64%) | 34 (51%) |

**Table 5. ConServation status of Agaricales, Boletales, Lycoperdales, Phallales and Russulales of South Australia.**

| Attribute | Agaricales | Boletales | Lycoperd -ales | Phallales | Russul -ales | Total |
|---|---|---|---|---|---|---|
| No. of species | 309 | 35 | 54 | 21 | 21 | 440 |
| Species with known distribution range of less than 100 km (Categories 1 and 2) | 146 | 6 | 7 | 0 | 9 | 171 |
| Rare taxa (Category R) | 113 | 1 | 4 | 0 | 5 | 125 |
| Poorly known taxa (Category K) | 104 | 12 | 32 | 4 | 11 | 164 |
| Species presently known only from holotype, lectotype or neotype | 87 | 1 | 4 | 0 | 5 | 99 |
| Species with holo-type, lectotype or neotype described from a collection from South Australia | 211 | 11 | 12 | 0 | 15 | 252 |

## Discussion

If more mycologists were to be employed to suvey the macrofungi of southern Australia is it likely they would find large numbers of new taxa? Studies in recent years of the diverse mycoflora of sequestrate ectomycorrhizal fungi suggests the answer will be in the affirmative (Bougher and Lebel, 2001). In the study by Grgurinovic and Simpson (2001) 174 of the 443 taxa studied (39.3%) were found to have a known distribution of less than 100 km. This is in agreement with other studies of the indigenous Australian mycoflora (Claridge *et al.*, 2000; Grgurinovic, 2001). In recent revisions of Agaricales in Australia at least 50% of the taxa are novel (Grgurinovic, 2001). May (2002) by contrast found only 52 of 491 holobasidiomycete macrofungi known from Western Australia (10.6%) were endemic to that State. However, if only the orders common to the studies by Grgurinovic and Simpson (2001) and May (2002) are taken into account the proportion of endemic taxa in Western Australia increases to 20.8%.

About one-third of the fungi studied by Grgurinovic and Simpson (2001) are ectomycorrhizal. An understanding of the functional ecology of these fungi requires knowledge of host range, site requirements, and size, distribution, persistence and longevity of mycelial genets in local populations (Dahlberg, 2001). It is now apparent that localised populations can be small or large, few or of high densities of small populations, and of few or many species (Sawyer et al., 1999; Anderson et al., 2001). An understanding of what taxa persist as short- or long-lived genets, and factors causing turnover and replacement are vital to conservation management. Coexistence of taxa, and of various genets of the same taxa, might be explained by the partitioning of various abiotic, temporal or biotic resources.

By and large eucalypt ectomycorrhizal fungi do not seem to be host specific (May and Simpson, 1997). Co-evolution of eucalypts, about 700 species in total, and their mycorrhizal symbionts will most likely have occurred. However, as yet there is little evidence of vicariant speciation amongst eucalypt ectomycorrhizal fungi. This might be in part because within each of the 12 genera or subgenera of eucalypts (Brooker, 2000) species are interfertile. There is significant gene flow within and between sympatric species of each subgenus.

Conservation is driven by knowledge of species distribution, decline and threat to habitat. There are too few modern taxonomic treatments of the Australian mycoflora and too few people skilled in identification to get adequate surveys of species distributions. Funding is minimal so progress relies on volunteers, often retirees. Species protection in Australia is through both State and Commonwealth legislation and is a slow and complex process. There are in Australia one Federal, six State and two Territory Governments. Lists of extinct and threatened taxa are maintained by the Federal Government and are based on advice from the scientific community. These lists guide spending on species recovery plans, constrain development, and help set agendas for survey and reserve acquisition. In 2000 about 64 vascular plant species were listed as extinct and about 1200 (7.5%) as threatened nationally. While a large number of phanerogam taxa are protected only a few fungi are. This disparity reflects the interests of the scientific community most of whom work on phanerogams or vertebrates, either as ecologists or taxonomists. Idealistically it might be expected scientists would recognise the need for greater resourcing of assessments of the conservation needs of fungi and other cryptogams but in the real world they are competing for limited resources. The consequence is that fungal conservation is by default based on the assumption that if the phanerogams and vertebrates are adequately conserved then cryptogams and invertebrates will be too. It is a major challenge for mycologists to redress this imbalance. Grgurinovic and Simpson (2001) determined 28% of the species studied as rare but, because of lack of knowledge about individual species, did not determine any species as extinct or vulnerable. In New South Wales the Hygrocybeae (Hygrophoraceae) of Lane Cove Bushland Park has been listed under both the New South Wales Threatened Species Conservation Act and the Australian Heritage Commission Act (Kearney and Kearney, 2000). In Western Australia two species of *Amanita* have conservation status (May 2002).

In much of Australia rainfall is low and erratic and soils often infertile. Fungi play an important role in maintaining these ecosystems, as pathogens, mycorrhizal symbionts and in breakdown of organic matter and nutrient cycling. The significance of robust fungal communities for maintenance of phanerogam community stability and tree and shrub fitness and vigour is often not appreciated (Brundrett and Cairney, 2002). Communities of fungi in foliage, in wood and on roots are typically species-rich. The estimated number of fungi in Australia is at least ten-fold the number of phanerogams. Yet the taxonomic and herbarium resources devoted to mycology are perhaps less than a tenth of those devoted to higher plants (Grgurinovic and Walker, 1993). More than 80% of known macrofungi of Victoria are represented in the National Herbarium of Victoria by five or fewer collections (May 2002). Fungal collections in other States, where they exist, are similarly few (Grgurinovic & Simpson, 2001; May, 2002) except for plant pathogens of agricultural crops (Grgurinovic and Walker, 1991). The status of taxonomic mycology in Australia has probably declined since the last survey in 1991 (Grgurinovic and Hyde, 1993). There will need to be substantial investment of money and other resources in the taxonomy, ecology and biogeography of the fungi, possibly diverted from studies of the charismatic biota, to provide the taxonomic and biogeographic data so badly needed.

Particular challenges are faced in identifying threatened fungus species owing to the nature of their life history, ephemeral and often cryptic basidiomata, and the diffuse and not morphologically distinctive vegetative phase immersed in a large and often heterogeneous substratum. Rarity is an important attribute of most threatened fungi possibly predisposing taxa to threats. There can be no doubt there was a considerable decrease in the range of most species of macrofungi in South Australia in the 20$^{th}$ century as a consequence of land clearing for agriculture, horticulture, plantation forestry, industry and urban development. In Australia approximately 5.7 million hectares are within areas mapped to be at risk or affected by dryland salinity. It has been estimated that by 2050 the area of regions with a high risk of dryland salinty may increase to 17 million hectares (Audit, 2001). It is likely fragmentation and genetic isolation of populations has accompanied range reduction. Lack of systematic monitoring of fungal communities and paucity of mycologists makes it impossible to determine if there has been a general decline in fungal populations or diversity within natural (even if disturbed) plant communities including conservation areas. A start has been made to develop new molecular tools to determine the diversity of the mycoflora and the impacts of phanerogam management strategies (e.g. Glen *et al.*, 2001; Chen & Cairney, 2002).

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# Macrofungal Diversity: The Poor State of Knowledge in Malaysia

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## Abstract

**Most of the world's biodiversity resides in the tropics. Malaysia being one of the megadiversity countries is species rich in most groups of organisms. However, the diversity of macrofungi or larger fungi is highly underestimated and poorly known compared to other groups. The picture of Malayan fungi given by Chipp in 1921 has been totally changed as foreseen by the studies of the late Prof. E.J.H. Corner. Corner's studies on tropical fungi particularly from Malaysia, included many genera, both saprophytes and polypores and he described many new species. His 1991 work on *Trogia* resulted in 27 new species out of the total 33 reported. Together with Bas, he described 28 new species of *Amanita* in 1962. The boletes showed an amazingly high species richness, where 114 or 79.7% of the 143 species from 11 genera reported, were new species. Since Corner, there have been very few systematic studies on fungi. Recent studies by Hattori on wood decay fungi in Pasoh Forest Reserve; Lee, Watling and Turnbull on ectomycorrhizal fungi at Pasoh, Kepong and nearby areas, all indicate high macrofungal species richness in relatively small areas. Corner opined that the Malesian region not only held the richest of angiosperm vegetation but also the richest, least known and most difficult to elucidate of the fungus biota. He believed that 70% of the fungi had yet to be discovered in Malaysia. The main difficulty faced by local mycologists is the lack of suitable keys and monographs for proper identification of tropical macrofungi. Furthermore, the lack of trained taxonomic mycologists is another obstacle in view of the many new taxa encountered. Thus, the Global Taxonomic Initiative (GTI) is a most appropriate forum to discuss and formulate means of strengthening the study of tropical mycology and fungal diversity not only in Malaysia but the rest of Asia.**

***Key Words: Macrofungal diversity, Malaysia***

## Introduction

Most of the world's biodiversity resides in the tropics. Malaysia being one of the megadiversity countries is species rich in most groups of organisms. However, the diversity of macrofungi or larger fungi is highly underestimated and poorly known compared to other groups. The picture of Malayan fungi given by Chipp in 1921 has been totally changed as foreseen by the studies of the late Prof. E.J.H. Corner. Corner opined that the Malesian region not only held the richest of angiosperm vegetation but also the richest but least known and most difficult to elucidate of the fungus biota. He believed that 70% of the fungi had yet to be discovered in Malaysia.

## Current Status of Knowledge on Macrofungi in Malaysia

Corner's studies on tropical fungi particularly from Malaysia, included many genera, both saprophytes and polypores and he described many new species. His 1991 work on *Trogia* resulted in 27 new species out of the total 33 reported (Corner 1991). Together with Bas, he described 28 new species of *Amanita* in 1962 (Corner and Bas 1962). The boletes showed an amazingly high species richness, where 114 or 79.7% of the 143 species from 11 genera reported, were new species (Corner 1972). Since Corner, there have been very few systematic studies on fungi. Recent studies by Hattori (per. comm.) on wood decay fungi in Pasoh Forest Reserve; Lee, Watling and Turnbull (2002) on ectomycorrhizal fungi at Pasoh, Kepong and nearby areas, all indicate high macrofungal species richness in relatively small areas.

Corner's studies on macrofungi in Malaysia including Singapore had resulted in numerous new taxa being described. Some of the genera showing high species richness are *Amanita*, *Amauroderma*, *Boletus*, *Cantharellus*, *Mycena*, *Polyporus*, *Tricholoma* and *Trogia* (Table 1).

Recent studies by Lee, Watling and Turnbull (2002, Table 2) showed that 65.5% of the taxa collected were unidentified or possible new species. To date, less than 10% of *Russula* collected could be identified to species level. It is highly likely that many are species new to science. Figure 1 shows some probably different taxa of red-capped *Russula*. Approximately 62% of *Amanita* collected was identified as were 64% of the boletes. In contrast, only 17% of *Lactarius* and 38% of *Cantharellus* collected could be identified. It is also interesting to note that some hypogeous fungi previously considered absent in the tropical rain forests were discovered. Some examples are shown in Figure 2. Corner's numerous keys only allow the identification of limited taxa, and very often, many could not be identified to species, suggesting that many are likely to be new species awaiting description. Keys and/or monographs are badly needed for proper species or taxa delineation in tropical fungi.

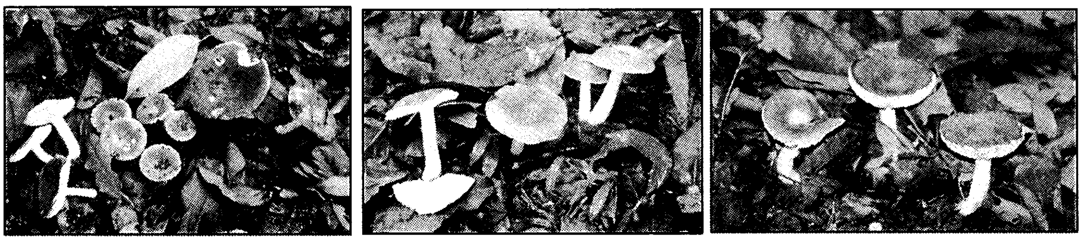
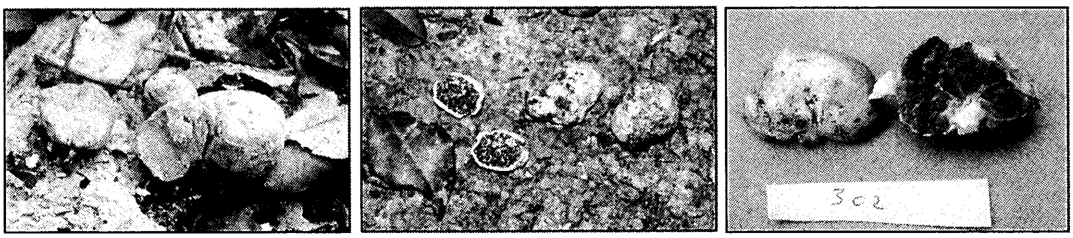


**Fig. 1 Three probably different species of red capped *Russula***



(a) (b) (c)

**Fig. 2 Some hypogeous fungi previously considered absent in the tropical rain forests. (a) *Arcangeliella* sp., (b) *Horakiella* sp. and (c) *Gautieria* sp.**

**Table 1. List of families/genera of Malaysian (including Singapore) macrofungi from selected publications**

| Family/Genus | Number of species | Number of new taxa | Reference |
|---|---|---|---|
| *Amanita* | 39 | 30 | Corner & Bas 1962 |
| *Amauroderma* | 16 | 14 | Corner 1983 |
| *Baeospora* | 2 | 2 | Corner 1981 |
| *Boletus** | 132 | 106 | Corner 1972 |
| *Bondarzewia* | 4 | 3 | Corner 1984 |
| *Buglossoporus* | 10 | 9 | Corner 1984 |
| *Cantharellula* | 1 | 1 | Corner 1981 |
| *Cantharellus* | 14 | 10 | Corner 1966 |
| *Clitocybe* | 10 | 9 | Corner 1994 |
| *Collybia* | 5 | 5 | Corner 1981 |
| *Craterellus* | 2 | 1 | Corner 1966 |
| *Echinochaete* | 7 | 6 | Corner 1984 |
| *Ganoderma* | 24 | 12 | Corner 1983 |
| *Gyroporus* | 2 | 1 | Corner 1972 |
| *Haddowia* | 2 | 1 | Corner 1983 |
| *Heimiella* | 4 | 3 | Corner 1972 |
| *Laetiporus* | 2 | 2 | Corner 1984 |
| *Lentinus* | 5 | - | Corner 1981 |
| *Lepista* | 5 | 5 | Corner 1994 |
| *Leucopaxillus* | 4 | 4 | Corner 1994 |
| *Limacella* | 2 | 2 | Corner 1981 |
| *Meripilus* | 2 | 2 | Corner 1984 |
| *Mycena* | 45 | 39 | Corner 1981 |
| *Panus* | 8 | 4 | Corner 1981 |
| *Pleurotus* | 10 | 8 | Corner 1981 |
| *Polyporus* | 26 | 16 | Corner 1984 |
| *Pulveroboletus* | 2 | 1 | Corner 1972 |
| *Strobilomyces* | 5 | 4 | Corner 1972 |
| *Termitomyces* | 6 | - | Pegler & Vanhaecke 1994 |
| *Tricholoma* | 49 | 47 | Corner 1994 |
| *Trogia* | 33 | 27 | Corner 1966 |
| **Total** | **470** | **370 (78.7%)** | |

*Inclusive of all taxa placed in Corner's subgenera of *Boletus*, *Tylopilus*, *Austroboletus*, *Boletellus*, *Leccinum*, *Pulveroboletus*, *Ixocomus* and *Xerocomus*. All these subgenera have now been promoted to genera. However, since not all of Corner's species have been re-examined for new placement, they are retained in *Boletus* for convenience.

Studies of other fungal groups such as the wood inhabiting fungi in Malaysia by Japanese mycologists also showed a similar trend of species richness with many unidentified taxa (Hattori pers. comm.). Table 3 shows the taxa collected from the Pasoh Forest Reserve, Malaysia, and studied by T. Hattori of the Forestry and Forest products Research Institute, Japan. The very high number of unidentified or new taxa of macrofungi simply implies the very high species richness of macrofungi in Malaysia.

Table 2. List of putative ectomycorrizhas collected from Pasoh Forest Reserve, Malaysia

| Family | Number of species | Number of taxa identified to known species | Number of unidentified/ new (?) taxa |
|---|---|---|---|
| Amanitaceae | 34 | 21 | 13 |
| Boletaceae | 45 | 29 | 16 |
| Cantharellaceae | 13 | 5 | 8 |
| Chamonixiaceae | 1 | 1 | - |
| Clavulinaceae | 1 | 1 | - |
| Cortinariaceae | 9 | 5 | 4 |
| Elasmomycetaceae | 1 | 1 | - |
| Entolomataceae | 13 | 7 | 6 |
| Gautieriaceae | 3 | - | 3 |
| Gomphaceae | 1 | 1 | - |
| Hydnaceae | 1 | 1 | - |
| Hymenochaetaceae | 1 | 1 | - |
| Hymenogasteraceae | 2 | 1 | 1 |
| Russulaceae | 149 | 16 | 133 |
| Pisolithaceae | 1 | 1 | - |
| Sclerodermataceae | 8 | 4 | 4 |
| Secotiaceae | 2 | - | 2 |
| Thelephoraceae | 1 | 1 | - |
| Tricholomataceae | 10 | 5 | 5 |
| **Total** | **296** | **102** | **194 (65.5%)** |

(Source: Lee, Watling and Turnbull 2002)

Table 3. List of wood inhabiting fungi found in Pasoh Forest Reserve, Malaysia

| Family | Number of species | Number of taxa identified to known species | Number of unidentified/ new (?) taxa |
|---|---|---|---|
| Auriscalpiaceae | 1 | - | 1 |
| Bankeraceae | 1 | - | 1 |
| Boliniaceae | 1 | - | 1 |
| Coniophoraceae | 3 | 2 | 1 |
| Coriolaceae | 107 | 45 | 62 |
| Diatrypaceae | 1 | - | 1 |
| Exidiaceae | 1 | - | 1 |
| Ganodermataceae | 13 | 10 | 3 |
| Grammotheleaceae | 4 | 2 | 2 |
| Heriaceae | 2 | 1 | 1 |
| Hymenochaetaceae | 44 | 25 | 19 |
| Hyphodermataceae | 3 | 1 | 2 |
| Lentinaceae | 5 | 3 | 2 |
| Meruliaceae | 5 | 3 | 2 |
| Polyporaceae | 25 | 16 | 9 |
| Schizophyllaceae | 1 | 1 | - |
| Sistotremataceae | 1 | 1 | - |
| Steccherinaceae | 4 | 3 | 1 |
| Stereaceae | 4 | 3 | 1 |
| Thelephoraceae | 3 | 1 | 2 |
| Xylariaceae | 18 | 12 | 6 |
| **Total** | **247** | **129** | **118 (47.8%)** |

(Source: Hattori pers. comm.)

## Problems and Solutions/Recommendations

### *Problems*

Malaysian mycologists face several problems and similar problems are probably experienced and shared by researchers in fungal taxonomy in this region. These problems can be summarised as follows:

- Macrofungi found in forest areas but public access to forests generally difficult
- Diminishing forest areas
- Lack of keys and monographs for tropical fungi
- Lack of trained tropical mycologists locally
- Seasonality/periodicity of fungal fruiting, short-lived and ephemeral nature of basidiomata in tropical forests, sporadic or erratic fruiting, solitary basidioma
- Mycology no longer a main subject in the local university curricula

### *Solutions/Recommendations*

Some solutions to these problems and recommendations are suggested here:

- International fora, e.g. GTI, can be used to highlight these problems
- Need to train more mycologists, e.g. through ASEANET
- Need to emphasise the importance of mycology in the local university curricula
- Need to educate and increase awareness of policy makers and general public on the roles and importance of fungi and other micro-organisms
- Networking between regional scientists, e.g. through ASEANET, UNESCO

## Acknowledgements

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# Vascular Ground Flora in a Dipterocarp-Oak Forest in Northern Thailand

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## Abstract

**A study of the vascular ground flora in a dipterocarp-oak forest was done at Mai Muang Nao Arboretum, Chiang Mai Province, Thailand. The area includes 0.8 km$^2$ of dipterocarp-oak with pine, seasonal forest on granite bedrock at 950-1125 meters elevation. There are three seasons in northern Thailand, *viz.* cool-dry (November-February), hot-dry (March-May), and rainy (June-October). The area is being destroyed by local villagers who have cut trees, burned the ground flora, and allow their cattle to graze in the forest. The fieldwork was done twice a month from March 2001 to February 2002, which included collecting specimens, as well as recording plant phenology, habitats, and abundance for each species. There are three main habitats, *viz.* open, fire-damaged, degraded area, marshy areas, and shaded areas with bamboo thickets along a seasonal stream. We found 60 families, 169 genera, and 271 species of vascular plants. The number of families of pteridophytes, monocotyledons and dicotelydons are 10, 13, and 30 respectively. The most abundant family is Compositae with 30 species, then Leguminosae, Papilionioideae with 29 species, including 10 species of *Crotalaria*- the most common genus. These two families mainly appear during October-January and finish fruiting before the dry season and forest fires which come during February-April. The twenty species of Orchidaceae, most of which have few individuals, are clearly in need of protection.**

*Key Words : Vascular plant, Ground flora, Dipterocarp-Oak forest, Phenology*

## Introduction

Deciduous dipterocarp-oak forest (Maxwell & Elliott, 2001) is named due to being dominated by Dipterocarpaceae and Fagaceae. Sometimes this forest type is called savanna (Maxwell, 1988; Stott, 1984). It is situated at elevations from *c.* 60-1800 m, with the total annual rainfall of 800-1,300 mm and 5 months with under 100 mm, and the mean annual temperature is 24-28 °C (Maxwell & Elliott, 2001). There are three seasons in northern Thailand, *viz.* cool-dry (November-February), hot-dry (March-May), and rainy (June-October).

Mai Muang Nao Arboretum was established in 1993 and is located in Baw Salee Subdistrict, Hod District, Chiang Mai Province, northern Thailand at approximately 18° 8' N latitude, 98° 23' E longitude. This has an area of *c.* 0.8 km$^2$ and is under the Forest Botany Division, Royal Forest Department. It is bounded by a seasonal stream bordering Mae Toh National Park. The vegetation is deciduous dipterocarp-oak with some remnant pine, seasonal forest at 950-1,125 m elevation on granite bedrock. There are three main habitats, *viz.* open, fire-damaged, degraded deciduous dipterocarp-oak with some pine; marshy areas; and partly shaded areas with bamboo thickets along a seasonal stream.

The most abundant deciduous tree species in the area are *Dipterocarpus obtusifolius* Teijsm. *ex* Miq. var. *obtusifolius, Shorea siamenis* Miq. var. *siamensis, S. obtusa* Wall. *ex* Bl. (Dipterocarpaceae); *Quercus kerrii* Craib var. *kerrii* (Fagaceae).

The area lacks detailed information about the flora, which appears in different seasons and in different microhabitats. It is a degraded area, but it has high diversity of stress-tolerant species, which are found in fire-damaged and marsh areas, as well as in the streambed in the dry season. The area is threatened by local villagers who cut trees, remove orchids for selling, burn the vegetation, and allow their cattle to graze in the forest.

## Methods

Fieldwork was done twice a month from March 2001 to February 2002. Specimens of the vascular ground flora, less than 1.5 m high, were collected in flowering and fruiting stages. All specimens have had their phenology, habitats, and abundances recorded in a botanical database. Extra flowering material of some families are preserved in 70% alcohol in the liquid collection. Dried specimens are kept in CMU Herbarium as voucher specimens, with distribution to BKF, L, A, CAS, and MO.

## Results and Discussion

There were 60 families, 169 genera, and 271 species of vascular plants found in the study area. The number of families of pteridophytes, monocotyledons, and dicotelydons are 10, 13, and 30, respectively. The most abundant family is Compositae with 30 species, then Leguminosae, Papilionioideae with 29 species. The most common genus is *Crotalaria* with 10 species. These two families mainly appear during October-January. The peak flowering period is in October with 82 species and lowest in March with 23 species. There are three distinct habitats, which are composed of different species.

**1. Open, fire-damaged, degraded areas** which covers more than 90 % of the study area. Abundant and common deciduous species in this habitat are: *Murdannia scapiflora* (Roxb.) Royle, *M. gigantea* (Vahl) Bruck. (Commelinaceae); *Inula nervosa* Wall. *ex* DC., *Blumea fistulosa* (Roxb.) Kurz, *Blumeopsis flava* (DC.) Gagnep. (all Compositae); *Carex continua* Cl. (Cyperaceae); *Scutellaria glandulosa* Hk. f. (Labiatae); *Crotalaria alata* D. Don, *C. ferruginea* Grah. *ex* Benth., *Desmodium motorium* (Houtt.) Merr., (Leguminosae, Papilionoideae); *Pimpinella cambodgiana* H. Boiss. (Umbelliferae); *Curcuma zedoaria* (Berg.) Rosc. (Zingiberaceae)., and *Drosera peltata* J. E. Sm. *ex* Willd. (Droseraceae). The dominant deciduous ground cover are grasses (Graminae) which covers more than 50 % of this habitat, *viz. Arundinella setosa* Trin. var. *setosa, Callipedium parviflorum* (R. Br.) Stapf, *Heteropogon contortus* (L.) P. Beauv. *ex* Roem. & Schult., *Hyparrhenia rufa* (Nees) Stapf, *Sporolobus indicus* (L.) R. Br. var. *flaccidus* (Roem. & Schult.) Veldk.

A characteristic, fire tolerant species is *Phoenix loureirii* Kunth var. *loureirii* (Palmae). Comparing distribution and vegetation types by using the CMU database shows this area having similar diptercarp-oak vegetation as in Doi Suthep-Pui National Park (Chiang Mai Province) and Doi Kuhn Tan National Park (Lampun Province). There are many species in danger of extirpation, especially deciduous terrestrial orchids (Orchidaceae) such as *Pecteilis susannae* (L.) Raf., and *Phiaus tankervilleae* (Banks *ex* L' Her.) Bl. which are threatened and down to few individuals because of habitat destruction and commercial collection.

**2. Open marsh areas** There are three perennial marshes/bogs scattered in this area and cover an area of *c.* 0.2 hectare. Some species are only found in this area include: *Drosera burmannii* Vahl (Droseraceae); *Eriocualon gracile* Mart., *E. oryzetorum* Mart. (Eriocaulaceae); *Xyris capensis* Thunb. (Xyridaceae); *Fimbristylis miliacea* (L.) Vahl, *Scirpus mucronatus* L. (Cyperaceae). The perennial species include: *Pogostemon auricularius* (L.) Hassk., *P. cruciatus* (Benth.) Kuntz *P. koehneanus* Muschl. (Labiatae); and *Viola betonaetifolia* J. E. Sm.

(Violaceae). The most common evergreen herbs are: *Impatiens chinensis* L. (Balsaminaceae), *Rotala rotundifolia* (Ham. *ex* Roth.) Koeh. (Lythraceae); *Limnophila villifera* Miq. ssp. *gracilipes* (Craib *ex* Hoss.) Yama. (Scrophulariaceae). The three annual species of Lentibulariaceae, *viz. Uticularia hirta* Klein *ex* Link, *U. minutissima* Vahl, and *U. scandens* Benj. are restricted to this habitat as well as *Burmannia coelestis* D. Don (Burmanniaceae); and includes the type locality of *Ranunculus siamensis* Tam. (Ranunculaceae).

**3. Shaded areas along a seasonal stream** forms a boundary of the study area. There are bamboo thickets scattered along the banks. The vegetation consists of many species, which are also found in the other two habitats. There are many evergreen species, which are common and only in this area, *viz. Hygrophila intermedia* Imlay, *Sericocalyx parviflora* (Wall. *ex* Nees) Brem., *Strobilanthes anfractuosus* Cl. *ex* Hoss (all Acanthaceae). Common annual species are *Canscora diffusa* (Vahl) G. Don (Gentianaceae); *Selaginella kurzii* Baker (Selaginellaceae); and *Pilea trinervia* Wight (Urticaceae). Some deciduous herbs include: *Gomphostemma strobilinum* Wall. *ex* Benth. var. *acualis* (Kurz *ex* Hk.f.) Prain (Labiatae), *Peliosanthes teta* Andr. ssp. *humilis* (Andr.) Jessop (Liliaceae). Some rare deciduous species include: *Paris polyphylla* J. E. Sm.(Liliaceae); *Geodorum recurvum* (Roxb.) Alston, *Zeuxine affinis* (Lindl.) Benth. *ex* Hk. f. (Orchidaceae); *Zingiber parishii* Hk. f., and *Globba* sp. (Zingiberaceae). There are three deciduous species restricted to this habitat which are down to a few individuals, *viz. Brachycorythis henryi* (Schltr.) Summ., *Peristylus prainii* (Hk. f.) Krzl., and *Tainia viridifusca* (Hk. f.) Benth. & Hk. f. (Orchidaceae).

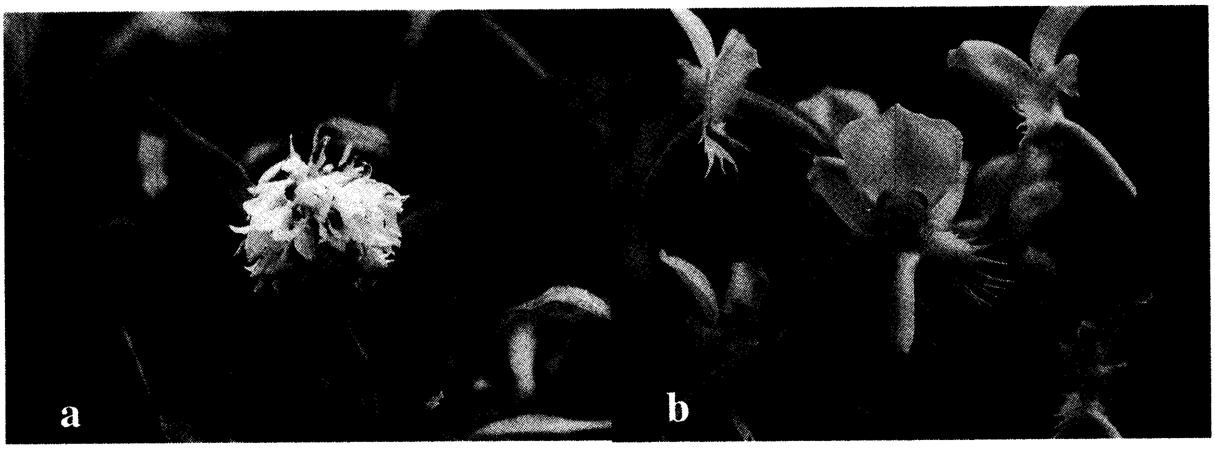

**Fig. 1 rare ground orchids : a. *Geodorum recurvum* (Roxb.) Alston; b. *Pecteilis susanae* (L.) Raf.**

## Conservation

The expansion of monocrops and pastoral agriculture around the area is the main threat to the ground flora. Although the area was established to preserve the area, habitat destruction still continues. Local villagers allow their cattle to graze, while felling trees, selling wild orchids along the highway are still going on. To effectingly conserve biodiversity in the area, strict enforcement is required against poachers.

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# The Status of Insect Pests, Disease and Herbarium Collection at NIPP, Vietnam

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## Abstract

**The National Institute for Plant Protection (NIPP) is belonging to the Ministry of Agriculture and Rural Development (MARD) Vietnam. It has one of the largest collection of insect pests, plant diseases, weeds and natural enemies in Vietnam. More than ten thousands of insect pests species are identified and over filthy specimens are kept in the collection room. It has nearly thousand species of plant diseases are storaged at NIPP, including dried reference and living reference collection of bacteria and fungi. The collection of type specimens about three thousands names. The NIPP has a strong staff members to cover all needs in different fields of research such as mycology, bacteriology, virology, nematology, insect natural enemies, parasites and predators. It ha an authorized responsibility, which is assigned by the MARD to coordinate and function of national collection. About forty senior scientist with high academic degree are good taxonomists in entomology, plant pathology, nematology, weed, insect natural enemies, predators and parasites. A necessary apparatus and equipment are available at NIPP to support identification and training. The NIPP has conducted many training courses for Vietnamese scientists, provincial technicians on diagnostic techniques for detection, characterization and identification of insect pests, plant pathogens, natural enemies, weed species, etc. A conservation techniques and herbarium processing, maintenance are also providing to various clients.**

**To improve a collection status, especially for better conservation and service several needs and suggestion are made such as revising a scientific name of some groups of collected specimens, rehabilitation of insect pests and diseases collection; cataloging all specimens by different means, and develop illustrated database with a computer assisted techniques.**

***Key Words: herbarium, Vietnam, insects, pests, plant disease***

The National Institute for Plant Protection (NIPP) is the only government institute conducting research in the field of plant protection in Vietnam. Total staff of NIPP is 152 (19 Ph.D; 1 Professor; 5 Associate Professor; 16 Ms.C; 80B.Sc and 39 Technicians). NIPP has 8 units: Biological Control; Pest Diagnosis and Seed Health; Entomology; Plant Pathology; Pesticide and Weeds; Pest Museum and Taxonomy; Experimental Station and Department of General Affair. NIPP has an authorized responsibility which is assigned by the Ministry of Agriculture and Rural Development, Vietnam, to coordinate of function as country coordinator in pest surveys, inventory, identification service, pest taxonomy and preservation of national pest collection.

## 1. Pest survey and collection

In Vietnam, NIPP coordinated and conducted 3 general pest surveys (pest inventories):

* 1967-1968: Pest survey in northern Vietnam. This survey collected 2962 insect species belonging to 194 families and 20 orders and identified 629 pathogen species causing plant diseases in Vietnam.

* 1977-1978: General survey on insect pests and plant diseases in southern Vietnam. 1113 insect species and 294 pathogen species were identified and collected.

* 1997-1998: Survey on insect pests and diseases of fruit crops in Vietnam. 428 insect and mite species and 166 plant pathogen species were identified.

Besides, NIPP scientists in collaboration with other national and international institutes conducted systematic survey on economically important pest species of major crops in Vietnam such as rice, maize, groundnut, potato, vegetables. These survey systematically provide additional disease samples and pest specimens for NIPP collection.

During the surveys attention was paid not only on pest and pathogen species but also on their natural enemies. The scientists from Biological Control Center actively participate in the surveys. These surveys provided diseases samples and pests specimens which are now maintained ( preserved) in the NIPP collection room.

Weed scientist of NIPP are also participating actively in weed survey and taxonomy in Vietnam.

## 2. Taxonomy activities

NIPP researchers working in various research areas involve in taxonomy activities. Among them, 11 mycologists, 5 bacteriologists, 2 virologist, 3 nematologists, 12 entomologists, 3 weed scientists and 4 IPM specialists are participating in pest surveys and pest identification work. They are dealing with various crops and pest groups.

**Table 1. NIPP staff participating in pest taxonomy**

| Research area | Number of specialists participating in taxonomy |
|---|---|
| Mycology | 11 |
| Bacteriology | 5 |
| Virology | 2 |
| Nematology | 3 |
| Weed science | 3 |
| Entomology | 12 |
| IPM and Biological control | 4 |
| **Total** | **40** |

## 3. Insect pests, Diseases and Herbarium collection at NIPP

### 3.1. Insect pests and their natural enemies

In the collection room at NIPP, at present there are more than 100.000 insect specimens. Among these specimens 8170 insect species have been identified with species name. More than 2000 insect species of the collection are still unidentified. The host range of many insect species is also unknown. Apart from this collection, more than 8000 specimens of 500 insect natural enemies species are also available.

Every year, new specimens and new insect species collected by NIPP and Vietnamese entomologists are added to NIPP insect collection.

### 3.2. Plant diseases

1048 dried samples of plant disease collected in Vietnam are stored in NIPP collection room. Among them 793 pathogen species have been identified. However, 22 pathogens causing plant diseases are unidentified.

Living samples of plant pathogen are also available at NIPP. 30 plant pathogens causing disease on important crops in Vietnam ( mainly bacterial and fungal pathogens) are sorted at NIPP. These samples are used in training and research work in Vietnam.

### 3.3. Weed collection

300 dried weed samples are available in NIPP weed collection. Among these samples, 82 weed species have been identified. Other 13 weed species need be identified. The weed collection of NIPP serves as references for weed taxonomy in Vietnam.

## 4. Training and information exchange in disease diagnosis and pest identification

NIPP specialists attended international training courses on disease diagnosis and pest identification on various crops organizing by CABI, IRRI, ICRISAT, ACIAR... Being an implementing organization of multilateral and bilateral project funded by international research institutions or national research institute of developed countries, NIPP has opportunities to work with qualified taxonomists. During the projects implementation, NIPP scientists can improve their skill and knowledge on pest taxonomy.

NIPP hosts and organizes many in-country training courses on disease diagnosis and pest identification for plant protection and agricultural specialists in Vietnam. Survey method, conservation techniques, herbarium processing, collection maintenance are provided by NIPP to various clients. NIPP publications on diagnostic techniques for detection, characterization and identification of insect pests, plant pathogens, natural enemies, weed species etc. are popularly used and highly appreciated by Vietnamese scientists and provincial technicians. Necessary equipment and facilities are available at NIPP to support identification work and training.

## 5. Major constraints to pest survey, taxonomy and collection maintenance in Vietnam

Major constraints to pest survey, taxonomy, collection curation and preservation in Vietnam may be summarized as following:

- Very limited fund is provided to pest survey taxonomy work and collection maintenance
- Lack of taxonomy keys and references
- Lacking qualified taxonomists, especially young taxonomists
- Poor facilities for collection storage
- Taxonomy is mainly based on traditional methods and morphological characteristics. Using of molecular techniques us still very limited.

## 6. Suggestions to improve collection status, conservation and taxonomy in Vietnam

Pest collections available at NIPP are important reference for pest identification work and training in Vietnam. To improve the status and utilization of these collections, the following needs should be considered:

- Revising scientific names of some groups of collection specimens.
- Giving scientific names to unidentified species available in the collections
- Rehabilitation of insect pests and diseases collections
- Cataloging all specimens for easier their management and utilization for reference and training
- Basing on available specimens and samples, develop illustrated database with computer assisted techniques
- Strengthening the capacity of NIPP in pest taxonomy through regional and international cooperation

# Taxonomic Studies of Oribatid Mites (Acari: Oribatida) of Mongolia

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## Abstract

**The present work deals with the results of studies on taxonomy and biodiversity of oribatid mites of Mongolia. According to the collection material from different regions of Mongolia, the oribatid mites are appeared to be very rich in species diversity. At the moment the author found 341 species of oribatids belonging to 120 genera and 52 families. Among them 214 species are recorded for the first time from Mongolia. In the course of this study, the author described 57 new species of oribatid mites from Mongolia. Distribution and diversity of oribatid mites in the soils of different natural ecosystems of Mongolia are not even. Most diverse composition of oribatid mites was found in forest, forest-steppe and steppe ecosystems, where more than 270 species were found. Relatively few species were found in semidesert and desert ecosystems, where only 68 and 24 species are recorded, respectively. Not only the species richness, but also the abundance of oribatid mites is quite different in the investigated ecosystems (average number in forest-steppe - 43200 ind/m$^2$; steppe - 18300 ind/m$^2$; semidesert - 5680 ind/m$^2$ and desert - 375 ind/m$^2$). Overall diversity of oribatid mites is strikingly higher in the central and northern regions of Mongolia, reflecting the habitat requirements of oribatid mite species, and the greater habitat diversity in the central mountains, and valley grasslands of the northeast.**

***Key Words : Acari, Oribatida, Taxonomy, Biodiversity, Mongolia***

## Introduction

Oribatid mites are one of the numerically dominant groups of free living microarthropods in soils, mosses and lichens growing on the trees and rocks, where their densities commonly reach several hundred or thousand individuals per square meter. Since the species diversity and population density of oribatid mites are very high, the role of them in the ecosystem is very significant and, together with soil microorganisms, they play an important role in decomposition of plant and animal debris accumulating on the soil surface.

Most of groups of oribatid mites are ecologically very dependent on their environment, and consequently could be used as biological indicators for the quality or health of the environment. At the starting point of such a study, we need information on each species of soil animals in various kinds of natural ecosystems and the environments under different degrees of human impacts. During the recent few decades, soil animals becoming one of the important and suitable objects of studies on biodiversity, ecology and bioindicator systems, which are continued now in many countries of the world (Al-Assiuty *et al.*, 1993; Noti *et al.*, 1996; Straalen, 1997). Therefore, the study of taxonomy, biodiversity and ecology of soil microarthropods in certain regions is of theoretical as well as practical importance.

Before discussing about the main results of the present study, I would like to refer some data concerning the previous studies of oribatid mites of Mongolia. Until the start of the author's study, the fauna of oribatid mites of Mongolia has been very poorly known.

The first collection of oribatid mites from Mongolia was made by Dr. Zoltan Kaszab, the Hungarian entomologist, when he visited there for six times (between 1963 and 1966). Mahunka (1964, 1981) and Balogh and Mahunka (1965) studied those collections and recorded 43 species for the first time in Mongolia and described 17 new species.

Later, Russian acarologist Golosova in co-authorship with other researchers (Golosova, 1983; Golosova and Ryabinin, 1984; Golosova and Karppinen, 1985) published some papers on Mongolian oribatids, describing seven new species. These are the all works, which were published before our study.

The present work is summarized the results of studies on taxonomy, biodiversity and ecology of soil oribatid mites of Mongolia. The oribatid mites are one of the numerically dominant groups of soil microarthropods in Mongolia and, therefore we drew our attention to this group of animals.

## Materials and Method

The present investigation was initiated from 1990 by the author, and the study is based on the collection materials of oribatids from different natural ecosystems of Mongolia, which were collected during last decade.

The number of collected specimens used in this study and their collection data are given in the respective taxonomic works, which published during last few years (see the "references" section). Collected animals were investigated in laboratory for sorting, preparing micropreparats using different equipments, including compound light and scanning electron microscopes. The identification of the taxonomic status of oribatid mite taxa is based on the identification keys and many other works with descriptions and redescriptions of various species of oribatid mites from all parts of the world. In both field and laboratory investigations the author used standard methods as stated by Górny and Grüm (1993) and Meyer (1995).

## Results and Discussion

According to the collection material of oribatid mites from different regions of Mongolia, the mites are appeared to be rather rich in species composition and abundance as those in the other parts of the world. On the basis of this study we found in Mongolia 341 species of orbatids belonging to 120 genera and 52 families. Among them 214 species are recorded for the first time to the fauna of Mongolia (Bayartogtokh, 1997b, c). In addition, the author described more than 50 new species of oribatid mites from Mongolia (Bayartogtokh, 1997a, 1998a, b, 1999a, b, c, 2000a, b, c, d, e, f, g, h, i, 2001a, b, c, d; Bayartogtokh and Aoki, 1997a, b, 1998a, b, c, 1999a, b). Also more than 30 little known species of oribatid mites, which recorded for the first time in the fauna of Mongolia, were redescribed (Bayartogtokh, 1999a, 2000, a, c, g, 2001a, b, d; Bayartogtokh and Aoki, 1997b, 1998a, c, 1999a, b, 2000).

The taxonomic reviews of oribatid mites of the families Tegoribatidae, Eremaeidae, and several genera, such as *Tectocepheus*, *Liebstadia*, *Eporibatula*, *Epilohmannia*, *Scheloribates* and *Punctoribates* are completed, referring to the known species in the world, and the identification keys to the species of above groups are proposed. Sixteen new combinations and six new synonyms are proposed for the species of the genera *Minguezetes*, *Minunthozetes*, *Lepidozetes*, *Liebstadia*, *Eporibatula*, *Pedrocortesella*, *Licnodamaeus* and *Eueremaeus*. The biogeographical analysis of the genera *Epidamaeus*, *Belba*, *Dyobelba*, *Eporibatula*, *Liebstadia* and families Tegoribatidae and Eremaeidae is made based on the geographic distribution of all known species of these groups.

The summarized data on species richness of oribatid mites in main natural ecosystems (vegetation zones) of Mongolia is shown in Table 1.

**Table 1. Species richness of oribatid mites in main natural ecosystems of Mongolia**

| Name of families | Number of species in different natural ecosystems | | | |
|---|---|---|---|---|
| | Forest-steppe | Steppe | Semidesert | Desert |
| Paleacaridae Granjean, 1932 | 2 | - | - | - |
| Aphelacaridae Grandjean, 1954 | 1 | - | - | - |
| Hypochthoniidae Berlese, 1910 | 2 | 1 | - | - |
| Cosmochthoniidae Grandjean, 1947 | 2 | 1 | - | - |
| Sphaerochthoniidae Grandjean, 1947 | 1 | 1 | - | - |
| Brachychthoniidae Thor, 1934 | 5 | 3 | 2 | 1 |
| Phthiracaridae Perty, 1841 | 4 | 2 | 2 | - |
| Oribotritiidae Grandjean, 1954 | 1 | 1 | - | - |
| Euphthiracaridae Jacot, 1930 | 5 | 2 | 1 | 1 |
| Perlohmanniidae Grandjean, 1954 | 1 | - | - | - |
| Epilohmanniidae | 2 | 1 | 1 | 1 |
| Nothridae Berlese, 1896 | 6 | 3 | - | - |
| Camisiidae Oudemans, 1900 | 6 | 2 | 2 | 1 |
| Trhypochthoniidae Willmann, 1931 | 6 | 3 | 1 | 1 |
| Malaconothridae Berlese, 1916 | 2 | - | - | - |
| Liodidae Grandjean, 1954 | 1 | - | - | - |
| Gymnodamaeidae Grandjean, 1954 | 2 | 1 | 1 | - |
| Pheroliodidae Paschoal, 1987 | - | 3 | 2 | - |
| Licnodamaeidae Grandjean, 1954 | 2 | 1 | 1 | - |
| Damaeidae Berlese, 1896 | 12 | 5 | 2 | 1 |
| Cepheidae Berlese, 1896 | 1 | 3 | - | - |
| Eremaeidae Sellnick, 1928 | 8 | 4 | 2 | 1 |
| Liacaridae Sellnick, 1928 | 4 | 4 | 2 | - |
| Astegistidae Balogh, 1961 | 2 | 1 | 1 | - |
| Gustaviidae Oudemans, 1900 | 1 | - | - | - |
| Peloppiidae Balogh, 1943 | 2 | - | - | - |
| Carabodidae C.L.Koch, 1837 | 2 | 2 | 2 | - |
| Tectocepheidae Grandjean, 1954 | 4 | 2 | 1 | 1 |
| Oppiidae Grandjean, 1954 | 22 | 13 | 9 | 3 |
| Quadroppiidae Balogh, 1983 | 1 | 1 | 1 | - |
| Suctobelbidae Jacot, 1938 | 3 | 3 | 2 | 1 |
| Banksinomidae Kunst, 1971 | 4 | 3 | 2 | 1 |
| Cymbaeremaeidae Sellnick, 1928 | 1 | 1 | - | - |
| Micreremidae Grandjean, 1954 | 1 | 1 | - | - |
| Passalozetidae Grandjean, 1954 | 1 | 3 | 4 | 3 |
| Scutoverticidae Grandjean, 1954 | 8 | 6 | 4 | 2 |
| Parakalummidae Grandjean, 1936 | - | 1 | - | - |
| Haplozetidae Grandjean, 1936 | 4 | 2 | 1 | - |
| Oribatulidae Thor, 1929 | 16 | 10 | 6 | 2 |
| Protoribatiidae Balogh & Balogh, 1984 | 3 | 3 | 1 | - |
| Scheloribatidae Grandjean, 1953 | 9 | 3 | 2 | 1 |
| Zetomotrichidae Grandjean, 1934 | 2 | 1 | - | - |
| Ceratozetidae Jacot, 1925 | 12 | 8 | 6 | 1 |
| Chamobatidae Grandjean, 1954 | 1 | - | - | - |

**Table 1. Species richness of oribatid mites in main natural ecosystems of Mongolia (continued)**

| Name of families | Number of species in different natural ecosystems | | | |
|---|---|---|---|---|
| | Forest-steppe | Steppe | Semidesert | Desert |
| Euzetidae Grandjean, 1954 | 1 | - | - | - |
| Mycobatidae Grandjean, 1954 | 6 | 3 | 1 | 1 |
| Oribatellidae Jacot, 1925 | 4 | 2 | 2 | - |
| Phenopelopidae Petrunkevitch, 1955 | 4 | 1 | 1 | - |
| Achipteridae Thor, 1929 | 2 | 1 | - | - |
| Tegoribatidae Grandjean, 1954 | 4 | 2 | 1 | - |
| Galumnidae Jacot, 1925 | 5 | 4 | 2 | 1 |
| Total | 201 | 118 | 68 | 24 |

As shown in above table, the distribution and diversity of oribatid mites in different natural ecosystems of Mongolia are not even, and depend greatly on the ecological characteristics of different habitats. The most diverse composition of oribatid mites was found in forest-steppe and steppe ecosystems, while relatively poor species were found in semidesert and desert ecosystems, where only less than 100 species are found totally.

Relatively few families, such as Oppiidae, Oribatulidae, Ceratozetidae, Damaeidae represented with high species diversity in most natural ecosystems. In contrast, many families as Aphelacaridae, Paleacaridae, Sphaerochthoniidae, Hypochthoniidae, Cosmochthoniidae, Oribotritiidae, Perlohmanniidae, Liodidae, Gustaviidae etc. are represented by single or two species, and they known to be distributed only in a single or two natural ecosystems.

Not only species richness, but also the abundance of oribatid mites was quite different in the investigated ecosystems (Figure 1). The average number of oribatid mites in the soils of forest-steppe is equal to 43200 ind/$m^2$, while that in the steppe ecosystem is 18300 ind/$m^2$. Two other ecosystems, which have extremely xeric characters, involved much little population density of oribatids. For instance, the average number of oribatid mites in semidesert ecosystem is equal to 5680 ind/$m^2$, while in the desert ecosystem - 375 ind/$m^2$.

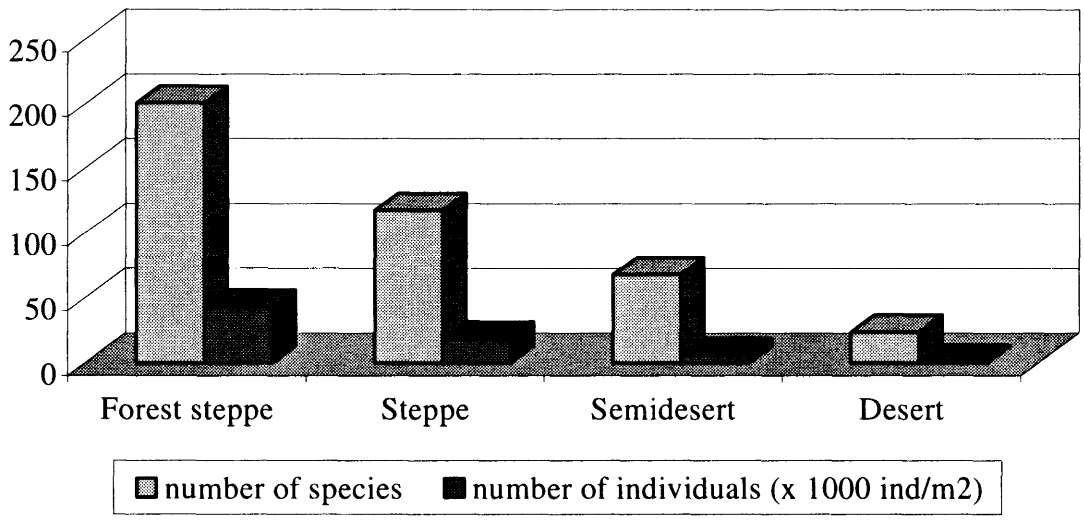


**Fig. 1. Species richness and population density of oribatid mites in main natural ecosystems of Mongolia**

It means that the diversity and distribution of oribatid mites are related to soil properties (moisture, litter, humus), which vary depending on the type of vegetation zones or ecosystems. For instance, the litter layer depth is more important in forest than in open grassland, while the moisture is more important in steppe, semidesert and desert ecosystems. Overall diversity of oribatid mites is strikingly higher in the central and northern regions of Mongolia, reflecting the habitat requirements of oribatid mite species, and the greater habitat diversity in the central mountains, and valley grasslands of the northeast.

The characters of community structure, vertical distribution in the soil layer and composition of dominant species of oribatid mites were also different in every habitat, and concrete results on these aspects will be appeared in the future research work. As the oribatid mite fauna of Mongolia is still not completely known, further studies should uncover many unknown species, as well as leading to a deeper understanding of known distributions and habitats of the previously studied species and different topics of their taxonomic and ecological characters.

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# Taxonomic Studies of Crustaceans in Pakistan

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## Abstract

**The taxonomic study of Pakistan can be divided into two phases: one pre 1947 era when subcontinent was not politically divided and in other phase after 1947 - the post independence era. In the pre-partition era most of the work was done by British workers mostly naturalists like Alcock who were working for British Army. Some locals like Kohli were also contributing. For the coastal fauna some famous Expeditions like the John Murray Expedition and IMS "Investigator" collected animals from this area now divided into Sindh and Makran coasts. These studies sketched the broad foundation of future work. The River Indus with its marvelous background and its right and left banks have been always a source of attraction to the scientists of all fields particularly the geologists, archaeologists, climatologists, biologists, ecologists and equally interested carcinologists. The Indus River passes through green valleys, barren mountains and great deserts and at the base of triangular delta it has the Arabian Sea board. Three ecozones of the Indus basins have been identified as the riverine tract, terrestrial and the littoral and mangrove forest ecozone; as a result there are amazing contrasts in biodiversity indicating amphidromic, semi-terrestrial, euryhaline and marine species.**

**The real momentum the carcinological study gained was with the establishment of the Marine Reference Collection & Resource Centre (MRC). The collections are deposited at the Zoological Survey Department repository and the MRC repository, the latter grown into a nucleus of taxonomic research activities, not only on the common intertidal, subtidal but the hidden parasitic and interstitial ones. Some other institutions of the country are also engaged in this study.**

**The present paper reviews all the previous works done on the taxonomy of Crustacea in Pakistan including the species from virtually all habitats. An inventory of the faunistic records of Pakistani crustaceans is given in tabulated form.**

**The present study revealed that many species which were reported by Henderson in 1893 and others have either disappeared or migrated from the coastal and deltaic regions. There is no information on their status. The geographical range of marine Crustacea of Pakistan clearly indicate that very few are endemic, some are cosmopolitan, others are widely spread throughout the western Indian Ocean, Red Sea, Arabian Gulf and Gulf of Aden and very few extended to Mediterranean Sea through the Suez Canal.**

**Even though we are in the information age but information on the taxonomy of crustaceans even though they have commercial value is not fully available in Pakistan in retreivable form and unfortunately we are about to loose a generation of specialists in crustacean systematics, concomitant with that loss will be at a decline in our ability to examine and respond to questions of biodiversity.**

**Key words: Pakistan, Crustacea, known marine, freshwater, terrestrial species and fossil records.**

## Introduction

The crustaceans have diversified structure but despite this diversity, passing through amphibious life style only very few terrestrial forms have evolved, of these only some isopods have become completely terrestrial. Otherwise the majority have adopted for life in water, as nekton, plankton, as associates of other invertebrates as well as on a variety of benthic substrates as slow moving bottom dewellers, interstitial inhabitants, semissesile burrowers and permanently sessile. Members of four subclasses have become parasitic.

Pakistan (Fig. 1) is situated at the northwestern end of the south Asian or Indian subcontinent. It lies approximately between 24 and 37 degrees north latitude and between 61 and 78 degrees east longitude. It is the seventh largest country in Asia, with an area of 803,940Km$^2$. There is a 1,000km long coastline along the Arabian Sea. Pakistan is largely arid and semiarid, but the wide geographical and altitudinal range from a tropical coast through sun baked deserts to highest mountains combined with the blending of elements from different biogeographical regions leading to the recognition of 15 distinct ecological zones and several subzones (Afzal *et al.*, 2001) which ensure an interesting and diverse flora and fauna reflected by plants (over 20,000 spp.), mammals (500 spp.), birds (1300 spp.) and insects (at least 20,000 spp.) (IUCN, 1991). Despite a large volume of literature dealing with Crustacea no such record has been kept by any agency for Crustacea. The documentation of faunal study is scattered and many of the earlier literature are not available. Early crustacean collecting both aquatic and terrestrial in Pakistan was undertaken by members of the British colonial forces and staff members of the Indian Museum. The post-independence survey has increased the known fauna to over 590 marine species, 117 fresh water, 4 terrestrial forms and 7 fossil records.

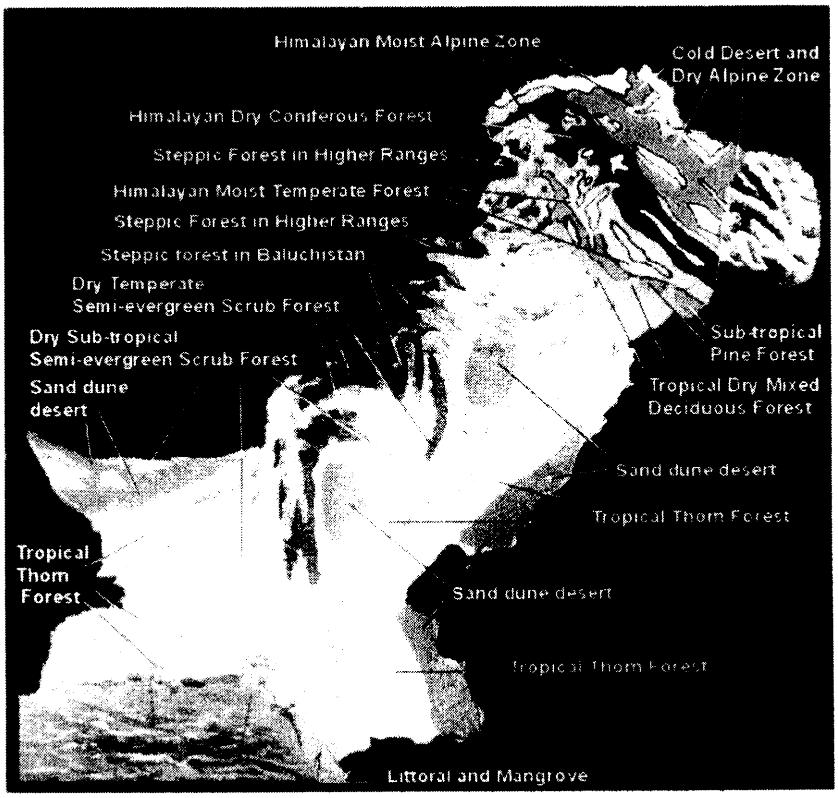


**Fig. 1. Major Ecological Zones of Pakistan.**

**Terrestrial Crustaceans:** Very few reports on the terrestrial crustaceans are available, none from inland and the presence of 3 isopods and one hermit crab from coastal areas is observed. The reasons of this may be that: (a) Majority of crustaceans have adapted to aquatic way of life, (b) a relatively high degree of difficulty in travel due to both the harsh terrain in Pakistan and its inaccessibility because of lack of facilities.

**Freshwater Crustaceans:** The fresh water crustaceans have been probed from inland lakes, rivers, ponds and reservoirs. On perusal of literature it shows that majority of species reported are planktonic and knowledge of benthic species is almost nil except one or two, e.g., *Neodiaptomus kingherensis* Baqai *et al.* which is benthic and distributed in the littoral zone of Lake Kingher. The limited space does not allow to follow the style of inventory for marine and terrestrial species. All that could be said is that notostracans (2 spp.), conchostracans (4), cladocerans (3 spp.), anostracans (6 spp.), copepods (26 spp. both free living and parasite), branchiurans (5 spp. parasite), ostracods (6 spp.), amphipods (2 spp.) and decapods (carideans 16 spp., crabs 6 spp.) have been so far reported. The works consulted on free living freshwater crustaceans show some significant contributions by: Arora, Alcock, Mahoon *et al.*, Baqai *et al.*, Ali, Chaudari *et al.*, Arshad *et al.*, Dussart *et al.*, Pretzmann, Henderson, Bindra, Laghari, Qadri, Saqib, Iqbal, Kazmi and Yaqoob while on the parasitic species are Jafri, Ahmed and Mahar.

**Marine Crustaceans:** History of carcinological studies in maritime zone also can be divided in preparation (1893-1947) and postpartition eras (1947 to-date). Though the literature is scattered, however knowledge of marine fauna from Pakistan coast has recently increased. The work gained momentum with the establishment of the Marine Reference Collection & Resource Centre in 1968 at the Karachi University. The important contributions to free living species are Alcock, Henderson, Qadri, Kohli, Hashmi, Tirmizi *et al.*, Kazmi *et. al.*, Haq *et al.*, Karim, Chopra, Ghani *et al.*, Javed *et al.*, Khan *et al.*, Ahmed *et. al.*, Bianchi, Keenan *et al.*, Holthuis and Dore *et al.* The parasitic and cryptic species have been recently taken up and some work by Kazmi *et al.*, Ghani *et al.*, and Bacescu has been published.

**Fossils Records:** Not much work on fossils is present, this area is yet to be explored thoroughly. Fossil Ostracods are reported upon by Hasnain *et al.*, Thebow, Ahmed, Brayer, Siddique, from Palaeocene and from middle and upper Eocene, few fossil Decapods are identified by Stoliczka, Glaessner, Collins & Morris.

## Material and Methods

A checklist of nominal species is prepared, following the natural system of animals (Bowman & Abele, 1982), collated from all the earlier literature available (as early as 1893) to me and supplemnted by my present unpublished studies. The inventory is being documented for Crustacea from virtually all habitats (marine, freshwater and land). The design of inventory is the species name, authors name, habitat and abundance. The incomplete identifications are avoided except at three places which represent the sole record of that taxon. Available informations on fossil record is also incorporated to reveal the beauty and order in crustacean biogeography and taxonomic capacity. Only the important works are mentioned. Works that have been suspended or whose contents are assimilated into recent studies are omitted. In the Reference part only the general references are given. The sources of information are not given at the end of paper as 'References' because of limitation of space.

## Inventory for Marine and Terrestrial Species

Phylum Crustacea Pennant, 1777
Class Branchiopoda Latreille, 1817.
Subclass Sarsostraca Tasch, 1959
Order Anostraca Sars, 1867.
Family Artemiidae Grochowski, 1896.
*Artemia karachienses* Planktonic, highly saline water. Not Common.
Class Maxillopoda Dahl, 1956
Subclass Cirripedia Burmeister, 1834
Order Thoracica Darwin, 1854.
Family Scalpellidae Pilsbry, 1916
*Lithotrya nicobarica* Reinhard, 1880. Rocks. Not Common.
Family Lepadidae Darwin, 1851
*Lepas anserifera* Linnaeus 1767. On floating objects. Common.
*Lepas anasifera* indica Annandale 1909. On floating wood. Common.
*Conchoderma virgatum* forma *hunteri* (Owen). On decapod Crustaceans. Not common.
Family Poecilasmatidae Nilsson – Cantell, 1921
*Poecilasma kaempferi dubium* (Hoek, 1907). On deep Sea Decapods. Uncommon.
*Trilasmis minuta* Gruvel, 1992. Body of Decapods. Not common.
*Octolasmis tridens* (Aurivillius, 1893). On body parts of Decapods. Moderately common.
*Octolasmis grayii* var. *pernuda* (Annandale, 1909). On Snakes. Not common.
*Octolasmis lowei* (Darwin, 1851). On gills of Decapod Crustaceans. Not Common.
*Octolasmis aymonini gerynophila* (Pilsbry ). On gills of deep sea Crustaceans. Not common.
*Octolasmis cor* Aurivillius, 1893. Gills of Decapods Crustaceans.
*Octolasmis angulata* forma *bullata* (Aurivillius, 1893). On gills of Decapods. Not common.
*Octolasmis warwickii* Gray 1825. Decapods. Not common.
Family Balanidae Leach, 1817
*Balanus amphitrite amphitrite* Darwin, 1854. Intertidal, on stones. Very common.
*Balanus reticulatus* (Utinomi, 1967). On body of Crabs. Common.
*Balanus amarylus* Darwin, 1854. Intertidal, On stones. Common.
*Balanus tintinnabulum* Linnaeus, 1758. Intertidal region, on stones, Common.
*Tetralita squamosa* Bruguicre, 1798. On gorgonids. Not common.
*Chelonibia patula* (Ranzani, 1818). On body of marine Decapods. Common.
*Chelonibia testudinaria* Linn, 1761. On body of marine turtles. Common.
*Chathamalus malayansis* Pilsbry, 1916. On rocks or stones. Not common.
Family Archeobalanidae Newman & Ross, 1976
*Conopea calceola* (Ellis, 1758). On gorgonids. Not Common.
Subclass Copepoda Milne-Edwards, 1840.
Order Calanoida Sars, 1902.
Family Augaptilidae Sars, 1905
*Augaptilus longicaudatus* (Claus, 1863). Pelagic, offshore. Not common.
*Euaugaptilus hecticus* (Giesbrecht, 1889). Palagic, offshore. Not common.
*Euaugaptilus latifrons* Sars, 1907. Pelagic, offshore. Not common.
*Euaugaptilus nodifrons* (Sars, 1905). Pelagic, offshore. Not common.
*Haloptilus longicornis* (Claus, 1863). Pelagic, offshore. Not common.
*Haloptilus paralongicirrus* Park, 1870. Pelagic, offshore. Not common.
*Pachyptilus pacificus* Johnson, 1936. Offshore, bathypelagic. Not common.
Family Heterorhabdidae Sars, 1902
*Heterostylites longicornis* (Giesbrecht, 1892). Pleagic, offshore, deep sea. Not common.
*Mesorhabdus angustus* Sars, 1907. Pelagic Offshore, deep sea. Rare.
Family Lucicutiidae Sars, 1902
*Lucicutia clausi* Giesbrecht, 1889. Bathypelagic. Not common.
*Lucicutia curta* Farran, 1905. Bathypelagic. Not common.

*Lucicutia flavicornis* (Claus, 1863). Bathypelagic, inshore shallow water. Not common.
*Lucicutia gaussae* Grice, 1963. Bathypelagic, inshore shallow water. Not common.
*Lucicutia grandis* (Giesbrecht, 1895). Bathypelagic, inshore shallow water. Not common.
*Lucicutia longicornis* (Giesbrecht, 1889). Bathypelagic, inshore shallow water. Not common.
*Lucicutia polaris* Brodsky, 1950. Bathypelagic, inshore shallow water. Not common.
Family Metridinidae Sars, 1902. emend. Dunn & Hulsemann, 1979.
*Pleuromamma indica* Wolfenden, 1905. Pelagic, Near shore. Common.
Family Phyllopodidae Brodsky, 1950.
*Phyllopus limpar* Farran, 1908. Pelagic, offshore. Not common.
Family Acartiidae Sars, 1903.
*Acartia amboinensis* Carl, 1907. Pelagic, near shore. Not common.
*Acartia pacifica* Steuter, 1923. Near shore, pelagic common.
*Acartia hamata* Mori, 1937. Offshore. Rare.
*Acartia bowmanida* Abraham, 1976. Coastal pelagic common.
*Acartia plumosa* Scott, Coastal, pelagic common.
Family Candaciidae Giesbrecht, 1892.
*Candacia turberculata* Wolfenden, 1905. Pelagic, offshore. Not common.
*Candacia curta* (Dana, 1849). Pelagic, offshore. Not common.
*Paracandacia truncata* (Dana, 1849). Pelagic, offshore. Not common.
Family Centropagidae Giesbrecht, 1892.
*Isias tropica* Sewell, 1932. Pelagic, near shore. Not common.
*Centropages dorsispinatus* Thompson & Scott, 1903. Pelagic, near shore, creeks. Common.
*Centropages furcatus* (Dana, 1849). Pelagic, offshore, shallow waters. Common.
*Centropages orsinii* Giesbrecht, 1892. Pelagic, near shore, offshore. Common.
*Centropages tenuiremis* Thompson & Scott, 1903. Pelagic, near shore, creeks. Common.
*Centropages karachiensis* Haq & Fazl-ur-Rehman, 1973. Pelagic, near shore. Common.
Family Pontellidae Dana, 1853.
*Calanopia elleptica* (Dana, 1849). Pelagic, coastal. Common.
*Calanopia minor* Scott, A. 1902. Pelagic, coastal and oceanic. Not common.
*Labidocera pectinata* Thompson & Scott, 1903. Pelagic, near shore. Common.
*Labidocera minuta* Giesbrecht, 1892. Pelagic, inshore, coastal. Common.
*Pontella andersoni* Sewell, 1912. Pelagic, near shore. Common.
*Pontella investigatoris* Sewell, 1912. Pelagic, inshore, near shore. Common.
*Pontella securifer* Brady, 1883. Pelagic, inshore, offshore. Common.
*Pontella karachiensis* Fazl-ur-Rehman, 1973. Pelagic, near shore. Common.
Family Pseudodiaptomidae Sars, 1902.
*Pseudodiaptomus serricaudatus* Scott, 1894. Pelagic, coastal, brackish. Common.
Family Temoridae Giesbrecht, 1892.
*Temora discaudata* Giesbrecht, 1889. Pelagic, near shore. Common.
*Temora turbinata* (Dana, 1849). Pelagic, near shore. Common.
*Temora dubia* Lubbock, 1856. Pelagic. Common.
*Temora stylifera* Near shore. Pelagic. Common.
*Temoropia mayumbaensis* Scott, 1894. Pelagic Offshore. Not common.
Family Tortanidae Sars, 1902.
*Tortanus forcipatus* (Giesbrecht, 1869). Pelagic, inshore, near shore. Common.
Family Calanidae Dana, 1849.
*Canthocalanus pauper* (Giesbrecht, 1888). Offshore, bathypelagic. Not common.
*Undinula vulgaris* (Dana, 1849). Pelagic, near shore, shallow water. Common.
Family Paracalanidae Giesbrecht, 1892.

*Calanocalanus pavo* (Dana, 1849). Pelagic, offshore, coastal. Not common.
*Acrocalanus longicornis* Giesbrecht, 1888. Pelagic, oceanic, surface. Common.
*Acrocalanus monachus* Giesbrecht, 1888. Pelagic, offshore. Common.
Family Clausocalanidae Giesbrecht, 1892.
*Clausocalanus minor* Sewell, 1929. Pelagic, offshore. Not common.
*Clausocalanus furcatus* Brady, 1882. Pelagic, offshore. Not common.
Family Euchaetidae Giesbrecht, 1892.
*Euchaeta concinna* Dana, 1849. Pelagic, offshore. Not common.
*Euchaeta rimana* Bradford, 1974. Pelagic, offshore. Not common.
*Euchaeta wolfendeni* Scott, 1909. Pelagic, near shore, offshore. Not common.
Family Scolecitrichidae Sars, 1902.
*Scaphocalanus magnus* (Scott, 1894). Pelagic, offshore. Not common.
*Scaphocalanus longifurca* (Giesbrecht, 1888). Bathypelagic. Not common.
*Scolecithricella ctenopus* (Giesbrecht, 1888). Pelagic, offshore. Not common.
*Scolecithricella paramarginata* Schulz, 1991. Pelagic Offshore. Not common.
*Scottocalanus sedatus* Farran, 1936. Pelagic, offshore. Common.
*Amallothrix longispina* Schulz, 1991. Bathypelagic. Common.
Family Eucalanidae Giesbrecht, 1892.
*Pareucalanus attenuatus* (Dana, 1849). Bathypelagic. Not common.
*Eucalanus crassus* Giesbrecht, 1888. Coastal, bathypelagic. Common.
*Eucalanus pileatus* Giesbrecht, 1888. Coastal, bathypelagic. Common.
*Eucalanus subcrassus* Giesbrecht, 1888. Coastal, bathypelagic. Common.
*Eucalanus subtenuis* Giesbrecht, 1988. Coastal, bathypelagic. Not common.
*Rhincalanus nasutus* Giesbrecht, 1888. Bathypelagic. Common.
*Rhincalanus cornutus* (Dana, 1849). Bathypelagic. Common.
Order Misophrioida Gurney, 1932
Family Misophriidae Brady, 1878.
*Benthomisophria palliata* Sars, 1909. Pelagic, offshore. Not common.
Order Harpacticoida Sars, 1903.
Family Cylindropsyllidae Sars, 1903.
*Arenopontia indica* Rao, 1969. Psammonic. Common.
Family Canuellidae Lang, 1948.
*Scottolana longipes* Thompson & Scott, 1903. Psammonic. Common.
Family Ectinosomatidae Sars, 1903.
*Microsetella norvegica* (Boeck, 1864). Pelagic, offshore, Common.
Family Diosaccidae Sars, 1906.
*Metamphiascopsis hirsutus* Thompson & Scott, 1903. Phytal. Common.
Family Miraciidae Dana, 1846.
*Miracia efferata* Dana, 1852. Offshore, in shore, planktonic. Common.
Family Clytemnestridae Scott, 1909.
*Clytemnestra scutellata* Dana, 1878. Offshore, inshore, sand. Common.
Order Poecilostomatoida Thorell, 1859.
Family Oncaeidae Giesbrecht, 1891.
*Oncaea media* Giesbrecht, 1892. Planktonic. Common.
Family Clausidiidae Embleton, 1901.
*Conchyliurus maximus* Reddiah, 1960. Parasitic. Not common.
Family Porcellidiidae Sars, 1904.
*Porcellidium viride* (Philippi, 1840). Phytal. Common.
Family Sapphirinide Thorell, 1859.
*Copilia mirabilis* Dana, 1852. Pelagic Inshore. Not common.
Family Caligidae Burmeister, 1835.
*Caligus punctatus* Shiino, 1955. Parasitic. Common.
*Caligus diaphanus* Nordman, 1832. Parasitic. Not common.
*Caligus robustus* Bassett. Smith, 1898. Parasitic. Not common.
*Paralebion elongatus* Wilson, 1911. Parasitic. Not common.
Family Penneliidae Burmeister, 1835.
*Lernaecnicus hemirhamphi* Kirtisinghe, 1933. Parasitic. Common.
Order Monstrilloida Sars, 1903.
Family Monstrillidae Giesbrecht, 1892.

*Cymbasoma rigidim* Thompson, 1888. Endoparasitic naupliar and planktonic adult. Not common.
*Cymbasoma williamsoni* Khan, 1976. Endoparasitic naupliar and planktonic adult. Common.
*Cymbasoma tirmiziae* Khan and Kamran, 1975. Endoparasitic naupliar and planktonic adult. Common.
Class Ostracoda Latneille 1806.
Subclass Myodocopa Sars, 1866.
Order Myodocopida Sars, 1866.
Family Cylindroleberididae Müllen, 1906.
*Asterope mariae* (Baird, 1850). Planktonic. Common.
Family Philomedidae Mullen, 1906.
*Philomedes lilljeberji* Sars, 1928. Planktonic. Common.
*Pyrocypris sinuosa* Mullen, 1900. Planktonic. Common.
Family Cypridinidae Baird, 1850.
*Cypridina megalops* Sars, 1900. Planktonic. Common.
*Gigantocypris mullerii* Skojsberf. Planktonic. Not common.
Class Malacostraca Latreille, 1806.
Subclass Phyllocarida Packard, 1879.
Order Leptostraca Claus, 1880.
Family Nebaliidae Baird,1850.
*Nebalia dahli* Kazmi & Tirmizi, 1989. Panktonic, mangrove area. Not common.
Subclass Hoplocarida Calman, 1904.
Order Stomatopoda Latreille, 1817.
Family Lysiosquillidae Giesbrecht, 1916.
*Acanthosquilla acanthocarpus* (Claus, 1871). Benthic. Not common.
*Lysiosquilla tredecimdentata* Holthuis, 1941. Benthic. Fairly common.
Family Squillidae Latreille, 1803.
*Clorida latreillei* Eydoux & Souleyet, 1842. Benthic. Common.
*Clorida microphthalma* (H. Milne-Edwards, 1837). Benthic. Fairly common.
Family Harpiosquillidae Manning, 1980.
*Harpiosquilla raphidea* (Fabricius, 1798). Benthic, offshore. Common.
*Harpiosquilla harpax* (de Haan, 1844). Epibenthic, offshore. Fairly common.
*Cloridopsis scorpio* (Latreille, 1825). Epibenthic, offshore. Not common.
*Cloridopsis immaculata* (Kemp, 1913). Benthic, offshore. Not common.
*Oratosquilla nepa* (Latreille, 1825). Epibenthic, offshore. Common.
*Oratosquilla interrupta* (Kenap, 1911). Epibenthic, offshore. Common.
*Oratosquilla hesperia* (Manning, 1968). Epibenthic, offshore. Common.
Family Gonodactylidae Giesbrecht, 1910.
*Gonodactylus botti* Manning, 1975. Intertidal, in rocks. Common.
*Gonodactylus smithii* Pocock, 1893. Intertidal, in rocks. Common.
*Gonodactylus lanchesteri* Manning, 1967. Intertidal, in rocks. Not common.
*Gonodactylus demanii* Henderson, 1893. Intertidal, in rocks. Common.
Family Protosquillidae Manning, 1980.
*Protosquilla pulchella* (Miers, 1880). Subtidal, in rocks. Not common.
*Protosquilla lenzi* (Holthuis, 1941). Subtidal, in rocks. Common.
*Mesacturoides fimbriatus* (Lenz, 1905). Subtidal, in rocks. Not. common.
Family Eurysquillidae Manning, 1977.
*Manningia amabilis* Holthuis, 1967. Benthic, offshore. Not common.
Subclass Eumalacostraca Grobben, 1892.
Order Mysidacea Boas, 1883.
Family Mysidae Dana, 1850.
*Gastrosaccus muticus* W.M. Tattersall, 1915. Bathypelagc littoral, common.
*Acanthomysis quadrispinosa* Nouvel, 1965. Nearshore. Not common.
*Acanthomysis indica* W.M. Tattersall, Bathypelagic 1992. Littoral. Not common.
*Acanthomysis pelagica* Pillai, 1957. Bathypelagic littoral. Not common.
*Indomysis anandalei* W.M. Tattersall, 1914. Backwaters. Common.
*Boreomysis verrucosa* Tattersall, 1939. Mesopelagic. Not common.
*Boreomysis sibogae* Hansen, 1910. Bathypelagic. Not common.
*Afromysis macropsis* Tattersall, 1922. Bathypelagic littoral. Common.

*Dactylamblyops murreyi* Tattersall, 1939. Mesopelagic. Not common.
*Thalassomysis sewelli* Tattersall, 1939. Mesopelagic. Not common.
*Siriella gracilis* Dana 1852. Littoral, epipelagic. Common.
*Siriella thompsonii* H.M. Edward 1837. Bathypalegic. Common.
*Siriella affinis* Hansen, 1910. Littoral, Mesopelagic. Common.
Family Lophogastridae Sars, 1870.
*Gnathophausia gigas* W. Suhm, 1873. Bathypelagic. Not common.
*Gnathophausia gracilis* W. Suhm, 1875. Bathypelagic. Not common.
*Gnathophausia zoea* W. Suhm, 1875. Pelagic, deep Sea. Not common.
*Eucopia major* Hansen, 1910. Mesopelagic. Not common.
*Eucopia australis* Dana, 1852. Bathypelagic. Not common.
*Eucopia unguiculata* W. Suhm, 1875. Mesopelagic. Not common.
Order Amphipoda Latreille, 1816.
Family Oxycephalidae Dana, 1853.
*Paraphronima gracilis* Clause, 1879. Near shore. Common.
*Rhabdosoma whiter* Bate, 1862. Planktonic, inshore. Common.
*Oxycephalus clausi* Bovallius, 1890. Planktonic. Very common.
*Tullbergella cuspidata* Bovallius, 1887. Planktonic, inshore. Common.
Family Urothoidae Bousfield, 1978.
*Urothoe spinidigitus* Walker, 1904. Fine sediment. Sometimes. Common.
Family Taltaridae. Rafinesque, 1815.
*Hyale hawaiensis* (Dana, 1853). Algal biotopes, infralittoral. Common.
*Talorchestia martensi* (Weber, 1795). On beaches, burrowing in fine sand, under sea weed.
Family Ampeliscidae Costa, 1857.
*Byblis lepta* (Giles, 1888). Muddy or detritus bottoms. Not common.
*Cheiriphotis megacheles* (Giles, 1885).
Family Corophiidae Dana, 1849.
*Corophium acherusicum* Costa, 1851. Infralittoral, among algae, tunicates, polyzoa, on installations. Common.
*Corophium acutum* Chevreux, 1908. Algal. Common.
*Photis longicaudata* (Bate & Westwood, 1862). Infralittoral, among algae. Common.
*Ericthonius brasiliensis* (Dana, 1855). Infralittoral – Circalittoral, entangled. Not common.
Family Leucothoidae Dana, 1852.
*Leucothoe furina* (Savigny, 1817). Endocommensal in ascidians. Common.
*Leucothoe spinicarpa* (Abildgaard, 1789). With ascidians and sponges, algae. Common.
Family Amphithoidae Stebbing 1899.
*Cymadusa filosa* Savigny, 1816. Phytal. Common.
Family Gammaridae Leach 1813.
*Quadrivisio bengalensis* Stebbing, 1907. Near shore. Common.
*Elasmopus japonicus* Stephensen, 1932. Infratidal. Not common.
*Elasmopus pectenicrus* (Bate, 1862). Infratidal, among algae or on shelly bottom. Common.
Family Dullchiidae Dana, 1849.
*Laetmatophilus durbanensis* Barnard, 1937. Commensal. Moderately common.
Family Lysianassidae Dana, 1849.
*Shoemakerella nasuta* (Dana, 1849). Near shore. Common.
Family Amphilochidae Boeck, 1871.
*Stenothoe gallensis* Walker, 1937. Intertidal. Common.
*Cyproidea ornata* Haswell, 1880. Phytal. Common.
Order Isopoda Latreille, 1817.
Family Paranthuridae Menzies and Glynn, 1968.
*Paranthura latipes* Barnard, 1955. Intertidal. Moderately common.
Family Anthuridae Leach, 1814.
*Caenanthura indica* Negoescu, 1980. Littoral, Common.
Family Santiidae Kussakin, 1988.
*Halacarsantia* sp. Kazmi, 2001. Phytal, Rare.

Family Joeropsidae Nordenstam 1933.
*Joeropsis karachiensis* Kazmi and Yousuf, 2002. Phytal. Not common.
Family Bopyridae Rafinesque, 1815.
*Argeopsis inhacae* Kensley, 1974. Parasitic. Very rare.
*Allathelges pakistanensis* Kazmi Markham, 1999. Parasitic. Rare.
*Parathelges neotenuicaudis* Shyamasundari *et al,* 1993. Parasitic. Rare.
*Parabopyrella indica* (Chopra, 1923). Parasitic. Common.
*Parabopyrella aff. nierstraszi* (Chopra, 1930). Parasitic. Common.
*Parabopyella saronae* (Bourdon and Bruce, 1979). Parasitic. Common.
*Probopyrus prashadi* (Chopra, 1923). Parasitic. Common.
*Parapenaeon japonicum* (Thielemann, 1910). Parasitic. Common.
*Aporobopyrina lamellata* Shiino, 1934. Parasitic. Common.
*Aporobopyrus ryukyuensis* Shiino, 1939. Parasitic. Not very common.
*Progebiophilus assisi* Kazmi and Bourdon, 1997. Parasitic. Not common.
Family Cirolanidae Dana, 1853.
*Atarbolana exoconta* Bruce and Javed, 1987. Rocky intertidal. Not common.
*Atarbolana setosa* Javed and Yasmeen, 1989. Rocky, intertidal. Not common.
*Cirolana brucei* Javed and Yasmeen, 1995. Rocky, intertidal. Not common.
*Cirolana bovina* Barnard, 1940. Rocky, intertidal. Not common.
*Cirolana manorae* Bruce and Javed, 1987. Rocky, intertidal. Not common.
*Neocirolana arabica* Javed and Yasmeen, 1990. Rocky, intertidal, Common.
Family Coralanidae Hausen, 1890.
*Argathona muraeneae* Bal and Joshi, 1959. Temporary parasitic, marine fish benthic. Common.
*Lanocira gardineri* Stebbing, 1904. Intertidal, associated with sponges, worms, ascidians. Common.
*Lanocira kroyeri* Hansen, 1890. Intertidal, Crevices. Not common.
Family Cymothoidae Dana, 1852.
*Anilocra dimediata* Bleeker, 1857. Parasitic, marine fish. Common.
*Catoessa ambassae* Schioedte and Meinert 1884. Parasitic. Common.
*Cymothoa eremita* (Brunnich, 1783). Parasitic. Common.
*Elthusa raynaudii* (H. Milne Edwards, 1840). Parasitic. Common.
*Joryma engraulidis* (Barnard, 1936). Estuarine, parasitic. Common.
*Mothocya karobran* Bruce, 1986. Parasitic. Not common.
*Nerocila barramundae* Bruce, 1987. Parasitic. Not common.
*Nerocila depressa* Milne Edwards, 1840. Parasitic. Not common.
*Nerocila kisra* Bowman and Tareen, 1983. Parasitic. Common.
*Nerocila phaiopleura* Bleeker, 1857. Parasitic. Common.
*Nerocila orbignyi* (Guerin-Meneville, 1832). Parasitic. Common.
*Nerocila serra* Schiodte and Meinert, 1881. Parasitic. Common.
*Nerocila sigani* Bowman and Tareen, 1983. Parasitic. Common.
*Norileca borealis* Javed and Yasmeen, 1999. Parasitic. Not common.
*Norileca indica* H. Milne Edwards, 1840. Parasitic. Common.
*Norileca triangulata* (Richardson, 1910). Parasitic. Not common.
*Cerceis biforamina* Javed and Yousuf, 1996. Intertidal. Common.
*Dynamenella bullejiensis* Javed and Ahmed, 1988a. Intertidal. Not common.
*Dynamenella granulata* Javed and Ahmed, 1988. Intertidal. Not common.
*Paracerceis sculpta* (Holmes, 1904). Creeks. Not common.
*Paradella dianae* (Menzies, 1962). Intertidal. Common.
*Paraimene tuberculata* Javed and Ahmed, 1988b. Intertidal. Not common.
*Sphaeromopsis minutus* Javed and Yousuf, 1995. Intertidal. Not common.
*Sphaeromopsis petita* Javed and Yousuf, 1997. Intertidal. Not common.

*Sphaeromopsis serriguberua* Holdich and Harrison, 1981. Intertidal. Not common.
*Clianella amblysina* Pilai, 1954. Intertidal. Not common.
*Cymodoce spinula* Yousuf and Javed, 2002. Intertidal. Not common.
*Paracilicaea keijii* Javed, 1990. Intertidal. Common.
*Sphaeroma terebrans* Bate, 1866. Mangrove wood. Common.
*Sphaeroma triste* Heller, 1861. Wood-boring. Not common.
*Sphaeroma walkeri* Stebbing, 1905. Mangrove wood. Common.
Family Microcerberidae Karaman, 1933.
*Coxicerberus* sp., Kazmi and Naushaba, 2001. Interstitial. Rare.
Family Ligiidae Brandt, 1883.
*Ligia exotica* Roux, 1828. Semiterestrial. Common.
Family Eubelidae Budde-Lund 1904.
*Periscyphis vittatus* Omer-Cooper, 1926. Terrestrial. Common.
Family Idoteidae Milne wards, 1840.
*Synidotea fecunda* Javed and Yasmeen, 1994. Rocky cum sandy beach. Common.
*Synidotea indiea* Javed and Yasmeen. Sand or rock. Common.
Order Tanaidacea Hansen, 1895.
Family Leptocheliidae Lang, 1973.
*Leptochelia*. Planktonic. Common.
Family Kalliapseudidae Lang, 1956.
*Pakistanapseudes leptochelatus* Bacescu, 1978. Planktonic, phytal. Common.
*Cristapseudes omercooperi* (Larward, 1954). Planktonic, phytal, Very common.
Family Pagurapseudidae Lang, 1976.
*Pagurapseudes setulosa* Kazmi and Siddiqui, 2001. Empty gastropod shells. Common.
Order Cumacea Kroyer, 1846.
Family Bodotriidae Scott, 1901.
*Cuma scorpioides* Montagu, 1804. Buried in sand. Not common.
*Cuma edwardsii* Goodsir, 1843. Benthic. Not common.
*Iphinoe dayi* Jones, 1960. Buried in sand. Common.
Family Nannastacidae Bate, 1866
*Cumella pygmaea* Sars, 1864. Buried in sand. Not common.
Family Leuconidae Sars, 1878.
*Leucon acutirostris* Sars, 1864. Planktonic. Not common.
Order Euphausiacea Dana, 1852.
Family Euphausiidae Dana, 1852.
*Nematocilis gracilis* Hansen, 1910. Planktonic. Not common.
*Stylocheiron indicus* Silas and Mathew, 1967. Planktonic. Common.
*Stylocheiron affine* Hansen, 1910. Planktonic. Not common.
*Stylocheiron suhmii* Sars, 1883. Planktonic. Not common.
*Stylocheiron carinatum* Sars, 1883. Planktonic, offshore. Not common.
*Pseudeuphausia latifrons* G.O. Sars, 1885. Planktonic, coastal. Common.
*Euphausia diomedeae* Ortman, 1894. Planktonic, oceanic. Common.
*Euphausia brevis* Hansen, 1905. Planktonic. Common.
*Euphausia sansoi* Torelli, 1934. Planktonic. Rare.
*Euphausia sibogae* Hansen, 1908. Planktonic. Common.
*Euphausia pseudogibba* Ortmann, 1893. Planktonic. Not common.
Family Bentheuphausiidae Colosi, 1917.
*Bentheuphausia amblyops* G.O. Sars, 1855. Planktonic, neritic. Common.
Order Decapoda Latreille, 1803.
Family: Penaeidae Rafinesque, 1815.
*Metapenaeopsis stridulans* (Alcock, 1905). Inshore, outer continental shelf. Common.
*Metapenaeopsis mogiensis consobrina* (Nobili, 1904). Offshore. Not common.
*Trachypenaeus curvirostris* (Stimpson 1861). Near muddy sand. Not common.
*Penaeus japonicus* Bate 1888. Near muddy sand. Not common.
*Penaeus monodon* Fabricius 1798. Near mud or sand. Common.
*Penaeus canaliculatus* Olivier Coastal areas. Not common.
*Penaeus semisulcatus* de Haan 1850. Sand or mud. Common.

*Penaeus indicus* H. Milne Edwards 1837. Estuarine mud or sand. Very common.
*Penaeus merguiensis* de Man, 1887. Shallow waters. Common.
*Penaeus penicillatus* Alcock, 1905. Along coastline. Very common.
*Penaeus latisulcatus* Kishinouye, 1900. Shallow waters sand, gravel, mud. Rare.
*Metapenaeus stebbingi* Nobili, 1904. Inshore Sea. Common.
*Metapenaeus brevicornis* (H. Milne Edwards, 1837). Marine or brackish. Not common.
*Metapenaeus monoceros* (Fabricius, 1789). Brackish waters. Common.
*Metapenaeus affinis* (H. Milne Edwards, 1837). Muddy bottoms, shallow water. Common.
*Parapenaeopsis stylifera* (H. Milne Edwards, 1837). Shallow water. Very common.
*Parapenaeopsis sculptilis* (Heler, 1862). Coarse sand, fine mud. Common.
*Parapenaeopsis hardwickii* (Miers, 1878). Shallow water. Common.
*Parapenaeopsis acclivirostris* Alcock, 1906. Shallow water. Not common.
Family Solenoceridae Wood-Mason & Alcock, 1891.
*Solenocera choprai* Nataraj, 1945. Outer continental shelf. Not common.
*Solenocera alticarinata* Kubo, 1949. Shelf area. Not common.
*Solenocera hextii* Wood Mason, 1891. Outer continental shelf. Not common.
*Solenocera crassicornis* (H. Milne Edwards, 1837). Inshore. Common on muddy bottoms.
*Solenocera pectinata* (Bate 1881). Shallow water. Not common.
Family Sicyoniidae Ortmann, 1898.
*Eusicyoia lancifer* (Oliver, 1811). Deep sea water. Not common.
Family Aristeidae Wood-Mason, 1891.
*Gennadas clavicarpus* de Man, 1907. Offshore, deep sea water. Not common.
Family Sergestidae Dana 1852.
*Lucifer penicillifer* Hansen, 1919. Planktonic. Common.
*Lucifer hanseni* Nobili, 1905. Planktonic common.
*Acetes japonicus* Kishinouye, 1905. Inshore sea, shallow waters over muddy bottoms. Not common.
*Acetes indicus* H. Milne Edwards, 1830. Inshore sea, brackish water. Common.
*Acetes erythraeus*. Inshore. Not common.
*Acetes johni* Nataraj, 1947. Inshore Sea. Not common.
Family Stenopodidae Clause, 1872.
*Microprosthema validum* Stimpson 1860. Intertidal, rocky shore. Fairly common.
Family Oplophoridae Dana, 1852.
*Acanthephyra eximia* Smith, 1884. Deep sea. Not common.
Family Pasiphaeidae Dana,1852.
*Eupasiphae gilesii* (Wood-Mason, 1892). Planktonic, offshore. Not common.
*Leptochela pugnax* de Man, 1916. Planktonic, inshore. Not common.
*Leptochela sydniensis* Dakin and Colefax, 1940.
Family Palaemonidae Rafinesque, 1815.
*Macrobrachium equidens* (Dana, 1852). Marine, brackish. Not common.
*Palaemon swelli* (Kemp, 1925). Littoral, in low salinity. Common.
*Palaemon pacificus* (Stimpson, 1860). Intertidal rockpools. Common.
*Palaemon semmelinkii* (de Man, 1881). Creeks and backwaters. Common.
*Exopalaemon styliferus* H. Milne Edwards, 1840. Marine to freshwater. Common.
*Nematopalaemon tenuipes* (Henderson, 1893). Littoral, brackish, estuarine and backwaters. Occasional.
*Periclimenes elegans* (Paulson, 1875). Subtidal. Common.
*Periclimenes seychellensis* Borradaile, 1915. Subtidal. Common.
*Periclimenes longirostris* (Borradaile, 1915). Offshore. Not common.
*Anchistus custos* (Forskal, 1775). Commensal. Common.
Family Alpheidae Rafinesque, 1815.
*Athanas dimorphus* Ortmann, 1894. Shallow water, in weeds. Common.

*Synalpheus tumidomanus* (Paulson, 1875). Intertidal rock pools. Common.
*Synalpheus thai* Banner and Banner, 1966. Subtidal. Not common.
*Salmoneus brevirostris* (Edmondson, 1930). Rocky areas, intertidal. Common.
*Autamate gardineri* Coutiere, 1902. Intertidal to shallow subtidal. Not common.
*Alpheus lobidens* de Haan, 1888. Upper tidal to midtidal. Very common.
*Alpheus splendidus* Coutiers, 1897. Intertidal. Common.
*Alpheus crassimanus* Heller, 1865. Intertidal. Common.
*Alpheus albertei* Kazmi, 1974. Intertidal rock pools. Not common.
*Alpheus pacificus* Dana, 1852. Intertidal rock pools. Common.
*Alpheus edwardsii* (Audouin, 1884). Intertidal, under rocks. Common.
*Alpheus zulfaquiri* Kazmi, 1980. Intertidal. Not common.
*Alpheus strenous* Dana, 1852. Littoral. Not common.
Family Ogyridae Hay and Shore, 1918.
*Ogyrides orientalis* (Stimpson, 1860). In sand under stone. Not common.
Family Hippolytidae Dana, 1852.
*Saron marmoratus* (Olivier, 1811). Littoral, in rockpods. Very common.
*Lysmata vittata* Stimpson, 1860. Littoral to sublittoral. Common.
*Exhippolysmata ensirostris* Kemp, 1914. Shallow water. Common.
*Hippolyte ventricosa* H. Milne Edwards, 1837. Intertidal, weeds. Common.
*Latreutes anoplonyx* Kemp, 1914. Floating weeds. Common.
*Latreutes mucronatus* (Stimpson, 1860). Associated with medusae. Not common.
Family Processidae Ortmann, 1896.
*Procèssa edulis crassipes* Nouvel and Holthuis, 1957.
Family Pandalidae Haworth, 1825.
*Heterocarpus laevigatus* Bate, 1888. Deep Sea. Not common.
Family Crangonidae Haworth, 1825.
*Pontocaris pennata* Bate, 1888. Deep Sea. Not common.
*Pontophilus parvirostris* Kemp, 1916. Rocky shore Rare.
Family Callianassidae Dana, 1852.
*Callianassa masoomi* Tirmizi, 1970. Intertidal mud, sand with loose stones. Common.
*Callianassa audax* De Man 1911. Sandy beach. Not common.
*Callianassa martensi* Miers, 1884. Sandy beach. Not common.
*Neocallichirus manningi* Kazmi and Kazmi, 1992. Sandy beach. Not common.
*Upogebia kempi* Sankolli, 1972. Loose stones, mud. Not common.
*Upogebia assisi* Barnard, 1947. Intertidal. Not common.
*Upogebia quddusiae* Tirmizi and Ghani, 1978. Sandy beach. Common.
Family Palinuridae Latreille, 1803.
*Panulirus penicillatus* (Olivier, 1791). Rock substrates. Common.
*Panulirus versicolor* (Latreille, 1804). In shallow clear, strongly flowing waters, to 15m depth. Not common.
*Panulirus homarus* (Linnaeus, 1758). Shallow waters. Not common.
*Panulirus polyphagus* (Herbst, 1793). On muddy bottom in turbid water close to river mouths 3-90m depth. Very common.
*Panulirus dasypus* (H. Milne – Edwards, 1837). In shallow waters. Common.
*Panulirus ornatus* (Fabricius, 1798). Shallow coastal waters, including river mouths. Not common.
*Puerulus angulatus* Bate 1888. Depth range from 274 to 536m, on soft mud or sand. Not common.
*Puerulus sewelli* Ramadan, 1938. Coarse sand substrate, hard mud and shells. Not common.
Family Scyllaridae Latreille, 1825.
*Thenus orientalis* (Lund, 1793). Intertidally on a sandy beach. Common.
*Scyllarides tridacnophaga* Holthuis, 1967. Benthic. Not common.
*Scyllarus martensi* Pfeffer, 1881. Soft substrate. Rare.
Infraorder Anomura H. Milne Edwards, 1832.

Family Porcellanidae Haworth, 1825
*Ancylocheles gravelei* (Sankolli, 1963). Found under stones, in small pools Rare.
*Enosteoides ornatus* (Stimpson, 1858). Found under stones. Rare on Sindh coast.
*Pachycheles natalensis* (Krauss, 1843). In crevices of rocks near low water mark. Common.
*Pachycheles tomentosus* Henderson, 1893. Found in holes and crevices of rocks near low water mark. Common.
*Petrolisthes boscii* (Audouin, 1826). Found in rocky pools under stones and in sand near low water mark. Very common.
*Petrolisthes lamarckii* (Leach, 1820). Found under large stones. Common.
*Petrolisthes leptocheles* (Heller, 1861). Found under stones. Not very common.
*Petrolisthes ornatus* Paulson, 1875. Found under stones. Not very common.
*Petrolisthes rufescens* (Heller, 1861). Found under tones. Very common.
*Pisidia dehaanii* (Krauss, 1843). Found under stones in small pools. Common.
*Pisidia delagoae* (Barnard, 1955). Found under stones in small pools. Rare.
*Pisidia gordoni* (Johnson, 1970). Sublittoral, occasionally found in littoral zone under stones. Not very common.
*Polyonyx hendersoni* Southwell, 1909. Found under stones. Not very common.
*Polyonyx loimicola* Sankolli, 1965. Found buried under mud. Rare.
*Raphidopus ciliatus* Stimpson, 1858. Muddy bottom. Rare.
Family Albuneidae Stimpson, 1858.
*Albunea steinitzi* Holthuis, 1958. Littoral sand. Not common.
Family Hippidae Latreille, 1825.
*Emerita holthuisi* Sankolli, 1965. Littoral sand. Common.
Family Coenobitidae Dana, 1851.
*Coenobita perlatus* H. Milne Edwards, 1837. Sandy shore. Not common.
*Coenobita rugosus* H. Milne Edwards, 1837. Rocky and sandy shores. Not common.
*Coenobita scaevola* (Forskål, 1775). Virtually terrestrial, more abundent above sandy shores and tidal zone. Rare on Sindh coast, but common on Makran coast.
Family Diogenidae Ortmann, 1892.
*Calcinus elegans* H. Milne-Edwards, 1837. Rocky shore. Rare.
*Calcinus latens* (Randall, 1840). Rocky shore. Rare.
*Clibanarius aequabilis* Dana 1852. Muddy and sandy shores. Not very common.
*Clibanarius arethusa* De Man, 1888. Rocky shore. Rare.
*Clibanarius clibanarius* (Herbst, 1791). Muddy and sandy beaches. Not very common.
*Clibanarius infraspinatus* Hilgendorf, 1869. Sandy beaches. Very common.
*Clibanarius padavensis* DeMan, 1888. Muddy areas, mangrove. Very common.
*Clibanarius signatus* Heller, 1861. Rocky and sandy shores. Common.
*Clibanarius striolatus* Dana, 1852. Rocky and muddy shores. Common.
*Clibanarius virescens* (Krauss, 1843). Rocky shore. Very common.
*Dardanus setifer* (H. Milne Edwards, 1836). Off shore. Not common.
*Dardanus vulnerans* (Thalwits, 1892). Off shore. Rare.
*Diogenes alias* McLaughlin and Holthuis, 2001. Off shore, muddy area. Very common.
*Diogenes avarus* Heller, 1865. Rocky shore and muddy. Common.
*Diogenes bicristimanus* Alcock, 1905. Rocky shore. Rare.
*Diogenes costatus* Henderson, 1888. Off shore. Not common.
*Diogenes custos* (Fabricius, 1798). Off shore. Very common.
*Diogenes dubius* (Herbst, 1804). Muddy shore. Very common.
*Diogenes? fasciatus*. In creek area. Common.
*Diogenes? karwarensis* Nayak and Neelkantan, 1989. In creeks. Common.
*Diogenes? klaasi* Rahayu and Forest, 1995. In creek area. Rare.
*Diogenes? manaarensis* (Henderson, 1893). Rocky cum sandy shore. Rare.

*Paguristes perspicax* Nobili, 1906. Rocky cum muddy shores. Very common.
Family Paguridae Latreille, 1802.
*Pagurus kulkarnii* Sankolli, 1962. Rocky shores. Very common.
Infra order Brachyura Latreille, 1803
Family Dromiidae de Haan, 1833
*Conchoecetes artificiosus* (Fabricius, 1798). Muddy or sandy bottom at moderate depth. Not common.
*Lauridromia dehaani* (Rathbun, 1923). nov. comb. MacLeay, 1993. Muddy or sandy mud. Common.
*Ascidiophilus caphyraeformis* (Richters, 1880). Intertidal. Not common.
*Cryptodromiopsis unidentata* (Ruppell, 1830). nov. comb MacLeay, 1993. Rocky bottom, shallow infratidal matted with sponge.
*Epigodromia ebalioides* Alcock, 1899. Deep sea. Not common.
Family Homolidae de Haan, 1839
*Homola megalops* Alcock, 1894. Deep sea. Not common.
Family Dorippidae MacLeay, 1838
*Dorippoides nudipes* Manning & Holthuis, 1986. Sandy or soft muddy bottoms common.
*Neodorippe callida* (Fabricius, 1798). Shallow water, mangrove swamps. Common.
Family Calappidae de Haan, 1833
*Calappa lophos* (Herbst, 1782). Soft sandy bottoms. Common.
*Calappa gallus* (Herbst, 1803). Not common, bottom of sand or shell.
*Matuta lunaris* (Forskal, 1775). Backwaters, sandy and muddy region, intertidal. Common.
*Matuta planipes* Fabricius, 1798. Shallow sandy beaches, intertidal. Common.
Family Leucosiidae Samouelle, 1819
*Ixa holthuisi* Tirmizi, 1970. Soft bottom. Not common.
*Arcania erinaceus* (Fabricius, 1798). Sand, mud. Not common.
*Arcania septemspinosa* (Fabricius, 1787). Muddy bottom. Common.
*Arcania undecimspinosa* de Haan, 1814. Sand or sandy mud. Not common.
*Nursia rubifera* Muller, 1886. Rocky shore. Common.
*Nursia abbreviata* Bell, 1855. Sand, gravel or shelly substratum. Not common.
*Nursia blanfordi* Alcock, 1896. Moderate depth. Not common.
*Nursia plicata* (Herbst, 1803). Sand with clay and stones. Not common.
*Pariphiculus mariannae* (Herklots, 1852). Muddy bottoms. Rare.
*Parilia alcocki* Wood-Mason, 1891. Soft muddy bottom. Common.
*Myra fugax* (Fabricius, 1798). Mud, shelly mud. Common.
*Leucosia anatum* (Herbst, 1782). Coarse sand. Common.
*Leucosia biannulata* Tyndale-Biscoe & George, 1962. Infratidal. Common.
*Leucosia sima* Alcock, 1896. Infratidal. Not common.
*Leucosia pubescens* (Miers, 1877). Infratidal. Not common.
*Pseudophilyra blanfordi* Alcock, 1896. Sandy clay. Not common.
*Philyra globulosa* A. Milne Edwards, 1837. Muddy bottom. Common.
*Philyra platycheir* de Haan, 1841. Clay gravel and sandy bottom. Not common.
*Philyra globosa* (Fabricius, 1798). Rocky bottoms. Not common.
*Philyra scabriuscula* (Fabricius, 1798). Intertidal. Common.
*Philyra verrucosa* Henderson, 1893. Sandy bottom. Mangroves.
*Philyra corallicola* Alcock, 1899. Shelly bottom. Not common.
*Philyra concinnus* Ghani & Tirmizi, 1995. Mangroves. Not common.
*Iphiculus spongiosus* Adams & White, 1848. Offshore, soft to course bottom. Not common.
*Ebalia malefactrix* Kemp, 1915. Muddy bottom, intertidal. Common.
*Ebalia sagittifera* Alcock, 1896. Soft bottom. Not common.
Family Hymenosomatidae MacLeay, 1838

*Elamena sindensis* Alcock, 1900. Underside of rocks. Common.
*Elamena cristatipes* Gravely, 1927. Underside of rocks. Not common.
Family Majidae Samoulle, 1819
*Camposcia retusa* Latreille, 1829. Rocky weedy bottom. Common.
*Macropodia* aff. *falcifera* (Stimpson, 1857). Among seaweeds. Not common.
*Macropodia formosa* (Rathbun, 1911). Among sea weeds. Not common.
*Achaeus lacertosus* Stimpson, 1857. Weedy rocky bottoms, gorgonian colonies. Common.
*Doclea gracilipes* Stimpson, 1857. Gravel and mud. Common.
*Doclea aduncus* Wagner, 1986. Benthic. Common.
*Doclea muricata* (Herbst, 1788). Benthic. Common.
*Hyastenus pleione* (Herbst, 1803). Muddy bottom. Common.
*Hyastenus planasius* (Adams & White, 1848). Muddy bottom. Not common.
*Stilbognathus curvicornis* (Herbst, 1803). Intertidal pool with weeds. Not common.
*Simocarcinus simplex* (Dana, 1852). Rocky weedy beaches. Not common.
*Acanthonyx limbatus* A. Milne Edwards, 1862. Among seaweeds. Common.
*Acanthonyx elongatus inglei* Tirmizi & Kazmi, 1988. Among seaweeds. Very common.
*Acanthonyx scutellatus* MacLeay, 1838. Among seaweeds. Not common.
*Menaethiop bicornis* Alcock, 1895. Among seaweeds. Common.
*Menaethiop nodulosa* (Nobili, 1905). Among seaweeds. Not common.
*Menaethiop gadaniensis* Kazmi & Tirmizi, 1999. Weeds, intertidal region. Not common.
*Menaethius monoceros* (Latreille, 1825). Weeds. Common.
*Thacanophrys aculeatus* (H. Milne Edwards, 1834). Rocky and weedy bottoms.
*Maja spinigera* de Haan, 1839. Muddy or pebbles. Not common.
*Maja gibba* Alcock, 1895. Muddy or muddy sandy bottom. Not common.
*Schizophrys aspera* (H. Milne Edwards, 1834). Rocky bottoms, intertidal region. Very common.
*Schizophrys pakistaniensis* Tirmizi & Kazmi, 1995. Rocky bottom, intertidal region. Common.
*Pseudomicippe griffini* Kazmi & Tirmizi, 1999. Rocky bottom, weedy. Not common.
*Cyphocarcinus sargassumi* Kazmi & Tirmizi, 1995. Seaweeds. Rare.
*Micippa thalia* (Herbst, 1803). Offshore. Common.
*Micippa platipes* Ruppell, 1830. Sublittoral. Not common.
Family Parthenopidae MacLeay, 1838
*Dentoxanthus iranicus* Stephensen, 1945. Offshore. Not common.
*Harrovia elegans* de Man, 1887. Offshore. Not common.
*Parthenope longimana* Linnaeus, 1764. Offshore. Not common.
*Parthenope quemvis* (Stebbing, 1917). Offshore. Not common.
*Parthenope pransor* (Herbst, 1796). Offshore. Common.
*Cryptopodia angulata* H. Milne Edwards & Lucas, 1841. Offshore. Common.
*Cryptopodia angulata* var. *cippifer* Alcock, 1895. Offshore. Common.
Family Portunidae Rafinesque, 1815
*Scylla serrata* (Forskal, 1775). Mangroves and creeks. Common.
*Scylla olivacea* (Herbst, 1796). Mangrove. Not common.
*Scylla tranquebarica* (Fabricius, 1798). Mangrove. Not common.
*Charybdis annulata* (Fabricius, 1798). Fishing areas. Common.
*Charybdis orientalis* Dana, 1852. Rocky and sandy shores.
*Charybdis hellerii* (A. Milne Edwards, 1867). Virtually all types of habitats. Not very common.
*Charybdis lucifera* (Fabricius, 1798). Marine, all types of habitats. Not very common.

*Charybdis variegata* (Fabricius, 1798). Common in fish landing.
*Charybdis callianassa* (Herbst, 1789). Sandy-muddy bottoms. Common.
*Charybdis hoplites* (Wood-Mason, 1877). Common in fish landings.
*Charybdis feriatus* (Linnaeus, 1758). Common in fish catches.
*Charybdis natator* (Herbst, 1794). On muddy-sandy bottoms. Common.
*Charybdis vadorum* Alcock, 1899. Subtidal. Rare.
*Charybdis smithii* (MacLeay, 1838). Subtidal. Common.
*Charybdis anisodon* (de Haan, 1850). Subtidal. Not common.
*Thalamita crenata* (Latreille, 1829). Creeks, all marine habitats. Very common.
*Thalamita prymna* (Herbst, 1803). Rocky shores. Common.
*Thalamita admete* (Herbst, 1803). Rocky shores. Not very common.
*Portunus pelagicus* (Linnaeus, 1766). Common in fish landing. Under rocks in rock pools. Very common.
*Portunus sanguinolentus* (Herbst, 1783). Under rocks and rock pools, fishing nets. Common.
*Portunus granulatus* (H. Milne Edwards, 1834). Rocky shore, sandy or shelly bottom. Not common.
*Portunus pulchricristatus* (Gordon, 1931). Sand, crevices. Not common.
*Portunus hastatoides* (Fabricius, 1798). Marine, creeks, muddy-sandy bottom. Common.
*Carcinus maenas* (Linnaeus, 1758). Floating weeds. Not common.
*Podopthalmus vigil* (Weber, 1795). Off shore waters, creeks. Not common.
Family Goneplacidae MacLeay, 1838
*Eucrate haswelli* Campbell, 1969. Off shore waters, muddy bottom. Not common.
*Eucrate sulcatifrons* (Stimpson, 1858). Offshore waters, muddy bottom. Not common.
*Eucrate crenata dentata* Stimpson. Muddy areas. Common.
*Litocheira angustifrons* Alcock, 1900. Sublittoral. Not common.
*Litocheira setosa* H. Milne Edwards, 1873. Muddy bottom. Not common.
*Typhlocarcinus nudus* Stimpson, 1858. Muddy, sandy bottom. Not common.
Family Xanthidae MacLeay, 1838
*Galene bispinosa* (Herbst, 1783). Sandy and muddy bottom in shallow water.
*Actaeodes tomentosus* (H. Milne-Edwards, 1834). Crevices of rocks, littoral zone. Not common.
*Actaea jacquelinae* Guinot, 1976. Burried understones, intertidal. Common.
*Actaea savignyi* (H. Milne Edwards, 1834). Intertidal rock pools. Not common.
*Etisus bullejiensis* Tirmizi & Ghani, 1988. Rocky shores, understones. Not common.
*Etisus laevimanus* Randall, 1840
*Euxanthus exsculptus* (Herbst, 1790). Understones, rocky shore. Common.
*Medaeops edwardsi* Guinot, 1967. Under stones on rocky shore. Not common.
*Medaeops neglectus* (Balss, 1922). Intertidal. Not common.
*Medaeops grantilosus* (Haswell, 1882). Rocky beach, below low tidal mark. Not common.
*Neoliomera intermedia* Odhner, 1925. Under stones. Not common.
*Macromedaeus quinquedentatus* (Krauss, 1843). Shallow subtidal. Common.
*Macromedaeus crassimanus* (A. Milne Edwards, 1867). Shallow sublittoral. Common.
*Leptodius exaratus* (H. Milne Edwards, 1834). Rocky shore, between high and low tidal marks. Very common.
*Demania baccalipes* (Alcock, 1898). Rocky or shelly bottom. Not common.
*Hoploxanthus cultripes* Alcock, 1898. Under rocks. Not common.
*Platypodia cristata* (A. Milne Edwards, 1865). Under rocks. Common.
*Platypodia granulosa* (Ruppell, 1830). Under rocks. Not common.
*Xanthias sinensis* (A. Milne Edwards, 1867). Under rocks. Not common.

*Atergatis roseus* (Ruppel, 1830). Littoral rocks. Common.
*Atergatis integerrimus* (Lamarck, 1801). Intertidal rocks. Common.
*Atergatis floridus* (Linnaeus, 1767). Below low tide marks. Common.
*Atergatis dilatus* de Haan, 1835. Intertidal rocks. Common.
*Zozymodes cavipes* (Dana, 1852). Intertidal. Rare.
*Lophozozymus dodone* (Herbst, 1801). Under rocks, from low tide mark towards sea. Rare.
*Cymo andreossyi* (Audouin, 1826). Coral reefs, sand. Rare.
*Chlorodiella nigra* (Forskal, 1775). Coral reefs, rocky shore. Moderately common.
Family Pilumnidae Samouelle, 1819.
*Halimede ochtodes* (Herbst, 1783). Muddy or muddy sandy bottoms. Rare.
*Heteropanope glabra* Stimpson, 1858. Mangrove swamps. Common.
*Heteropanope laevis* (Dana, 1852. Mangrove swamps. Not common.
*Heteropanope orientalis* A. Milne Edwards, 1867. Mangrove swamps. Very common.
*Pilumnopeus pereiodontus* Davie & Ghani, 1993. Under stones. Not common.
*Pilumnopeus makiana* (Rathbun, 1929). Shallow marine waters under stones. Common.
*Pilumnopeus indica* (De Man, 1887). Shallow waters, near the littoral zone.
*Heteropilumnus trichophoroides* (de Man, 1895). Intertidal. Common.
*Nanopilumnus rouxi* (Balss, 1935). Rock pools. Not common.
*Pilumnus longicornis* Hilgendorf, 1878. Shallow water, littoral zone. Very common.
*Pilumnus vespertilio* (Fabricius, 1793). Shallow water, under stones. Very common.
*Pilumnus kempi* Deb, 1987. Shallow water. Common.
*Pilumnus karachiensis* Deb, 1987. Shallow water. Not common.
*Actumnus arbutum* Alcock, 1898. Crevices of rocks, among roots of algae. Rare.
Family Oziidae Dana, 1851.
*Epixanthus frontalis* (H. Milne Edwards, 1834). Stony or pebbly beach, intertidal zone at low salinity. Common.
*Ozius rugulosus* Stimpson, 1858. Crevices of rocks in shallow water. Common.
*Lydia tenax* (Ruppel, 1830). Littoral shallow water. Not common.
*Myomenippe hardwickii* (Gray, 1831). Stony beach. Not common.
*Menippe rumphii* (Fabricius, 1798). Stony beach. Not common.
*Eriphia sebana* (Shaw & Nodder, 1803). Crevices of rocks, shallow water. Very common.
*Eriphia smithii* MacLeay, 1838. Crevices or holes in rocks, shallow marine waters. Common.
Family Trapeziidae Miers, 1886.
*Tetralia glaberrima* (Herbst, 1790). On coral branches. Rare.
*Trapezia cymodoce* (Herbst, 1799). On coral branches. Rare.
*Pseudozius caystrus* (Adams & White, 1848. Rocky beach, shallow waters. Not common.
Family Pinnotheridae de Haan, 1833.
*Asthenognathus gallardoi* Serene & Soh 1976. In burrows, intertidal sand. Not common.
*Pinnotheres placunae* Hornell & Southwell, 1909. Commensal with *Placuna placenta.* Common.
*Pinnotheres tivelae* Gordon, 1936. Commensal with *Tivela pandorsa*. Not common.
*Sindheres karachiensis* Kazmi & Manning 2002. Commensal. Rare.
*Xenophthalmus wolffi* Takeda & Miyake, 1970. Muddy sandy bottoms, near littoral deep. Rare.
Family Ocypodidae Rafinesque, 1815.
*Nasima dotilliforme* (Alcock, 1900). Sandy beaches. Common.
*Serenella indica* Alcock, 1900. Sandy beaches. Common.
*Ocypode rotundata* Miers, 1882. Sand flats. Common.

*Ocypode cordimana* Desmarest, 1825. Sandy beaches of intertidal zone. Quite common.
*Ocypode ceratophthalmus* (Pallas, 1772). Sandy beaches near high mark. Common.
*Ocypode kuhlii* de Haan, 1835. Sandy beaches. Not common.
*Uca vocans* (Linnaeus, 1758). Burrowing in muddy flats in deltaic region. Common.
*Uca dussumieri* (H. Milne Edwards, 1852). Burrowing in muddy flats of river mouth. Common.
*Uca lactea* (de Haan, 1835). Mudy flats at low tide marks. Mangroves. Common.
*Uca acutus* Stimpson, 1858. Intertidal mud flats. Not common.
*Uca sindensis* Alcock, 1900. Intertidal Mud flats. Common.
*Uca urvillei* (H. Milne Edwards, 1852). Intertidal mudflats. Common.
*Uca annulipes* (H. Milne Edwards, 1837). Intertidal mudflats. Very common.
*Macrophthalmus laevis* A. Milne Edwards, 1867. Inland channels. Not common.
*Macrophthalmus sulcatus* H. Milne Edwards, 1852. Mangrove channels. Common.
*Macrophthalmus grandidieri* A. Milne Edwards, 1867. Mangrove channels. Common.
*Macrophthalmus depressus* Rüppell, 1830. Mangrove areas. Not common.
*Macrophthalmus pacificus* Dana, 1851. Burrowing on boarder of inland channals. Common.
*Macrophthalmus crinitus* Rathbun. Mangrove. Not common.
*Macrophthalmus boscii* Audouin and Savignyi, 1826. Between pebbles in intertidal zone. Not common.
*Macrophthalmus dentipes* Lucas, 1836. Intertidal zone. Not common.
*Macrophthalmus latreillii* (Desmarest, 1822). Muddy areas. Common.
*Scopimera scabricauda* Alcock, 1900. Found in small burrows on muddy flats at low water mark. Common.
*Dotilla blanfordi* Alcock, 1900. Burrowing in muddy sandy flats in intertidal region. Common.
*Dotilla affinis* Alcock, 1900. Burrowing in sand. Common.
*Dotilla myctiroides* (H. Milne Edwards, 1852). Intertidal zone. Not common.
*Ilyoplax frater* (Kemp, 1919). Sandy flats in intertidal zone. Common.
*Ilyoplax stevensi* (Kemp, 1919). Muddy flats, inlet waters. Common.
Family Grapsidae MacLeay, 1838.
*Grapsus albolineatus* Lamarck, 1818. Rocky coast above high tide mark. Common.
*Metopograpsus thukuhar* (Owen, 1839). Among stones, low tide mark. Common.
*Metopograpsus messor* (Forskal, 1775). Among stones. Common.
*Metopograpsus latifrons* (White, 1847). On muddy flats of mangrove channels. Common.
*Ilyograpsus paludicola* (Rathbun, 1909). Mangroves. Common.
*Planes cyaneus* Dana, 1851. Pelagic, clinging to floating material. Not common.
*Plagusia tuberculata* Lamarck, 1818. Among stones of intertidal region. Common.
*Parasesarma plicatum* (Latreile, 1806). Among boulders. Very common.
*Neoepisesarma versicolor* (Tweedie, 1940). Among rocks. Very common.
*Neoepisesarma mederi* H. Milne Edwards, 1853. Muddy flats, intertidal. Very common.
*Labuanium rotundatum* (Hess, 1865). Muddy flats, along the shore. Not very common.
*Sesarma lanatum* Alcock, 1900. Rocky shore. Common.
*Nanosesarma minutum* (De Man, 1887). Crevices. Common.
*Nanosesarma pontianacenses* (de Man, 1887). Muddy mangrove flats in brackish water. Common.
*Metaplax indica* H. Milne Edwards, 1852. Sandy-muddy flats, intertidal, brackish water. Common.

*Metaplax distincta* H. Milne Edwards, 1852. Swamps, muddy flats. Common.

*Varuna litterata* (Fabricius, 1798). Brackish water, open sea, clinging to floating material. Common.

*Pseudograpsus intermedius* Chhapgar, 1955. Rocky shores at high-tide mark. Common.

*Acmaeopleura balssi* Shen, 1932. Burrowing in mud, commensal. Not common.

## Conclusion

Present study is a part of the plan to investigate the marine animal biodiversity of Pakistan so that a conservation strategy could be evolved for them. Though certain groups which are found virtually in all habitats are represented in the list, but it is noted that hardly any freshwater amphipod, virtually no freshwater isopod or mysid has been reported. No field data is available to predict the risk of extinction faced by populations and species. Some projects should be designed to assess the reliability of predicted risks of extinction (both absolute and relative), if there are any. For non-taxonomical studies precautions like not to choose the rare species are taken. Neither the taxonomy nor the taxonomist is given due importance in these studies. This may lead to total collapse of certain species.

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# The Dung Beetle Fauna (Coleoptera, Scarabaeidae) of Thailand

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## Abstract

**A list of the Scarabaeidae dung beetles collected from both cultivated and forested areas in Thailand is presented. Altogether 268 dung beetle species of 26 genera in 15 tribes are recorded. Among those 28 new species has already been described. The ecological habitat of each dung beetle species found is also recorded. The dung beetle species diversity and richness among the different locality is discussed and the monograph of dung beetle fauna in Thailand is under constructing.**

***Key Words: dung beetle, Scarabaeidae, biodiversity ,habitat***

## Introduction

Dung beetles are scavengers that feed on dung, carcasses and other decaying organic vegetation or fungi. It has been known that dung beetles particularly coprophagous beetles who bury dung as food for themselves and their off springs are one of the most beneficial insect groups in the ecosystem. Their feeding behavior has a direct impact on cleaning up the environment, improving pasture growing and nutrients recycling. As a result of intensive livestock production, pasture pollution with dung pads from domestic livestock has become an important environmental management problem. Undisturbed dung pads can smother grass beneath them, which can later kill the grass . Besides, dung patchs are usually a good protein source for breeding and habiting by parasitic nematodes and pest flies. By feeding in the dung patch and causing it to dry out, dung beetles disrupt the lifecycle of parasites hatching in the pat as well as reduce its suitability as a breeding site for pest flies (Bornemissza 1970; Fincher 1981; Dymock ,1993). In addition, dung beetles are also very important in recycling nutrients by drying out the dung and volatilisation of minerals. They also improve the soil physical condition, soil structure and water holding capacity by incorporating organic matters back into soil (Tyndale-Biscoe, 1990).

Dung beetles have also an important role in seed dispersal. They roll away animal dung containing seeds swallowed by fruit eating mammals and bury them into the soil (Garber 1986; de Figueiredo 1993). Because they are susceptible to ecosystem changes, dung beetles are used as a parameter for biodiversity studies. Disturbance of tropical forests may affect dung beetles directly by altering temperature, humidity, or soil characteristics, or indirectly by reduction in mammal fauna (Morón 1987; Klein 1989; Halffter *et al.* 1992; Estrada *et al.* 1998).

Despite their important ecological and beneficial roles, very little is known about the dung beetles of Thailand as compared to those of other regions. Worldwide there are nearly 5,000 described dung beetle species arranged in 234 genera and 10-12 tribes (Hanski and Cambefort, 1991). The dung beetle species occurring in Thailand have been recorded for over 40 years in the three classic regional faunas covering parts of Southeast Asia (Arrow, 1931; Paulian, 1945 and Balthasar, 1963, 1964). In the last decade, a survey of dung beetle fauna of the Scarabaeidae and Aphodiinae was conducted only in the North of Thailand (Masumoto, 1987, 1988, 1989a-c, 1990, 1991, 1992a,b, 1995, 1996). Since 1999 with support from the

Thailand Biodiversity and Training Programme, study of the dung beetle fauna in Thailand has been carried out and a monograph of dung beetle fauna in Thailand is under construction. This will lead to a better understanding of the dung beetle systematics of Thailand.

## Materials and Methods

Dung beetles were surveyed in various areas of natural parks, wildlife sanctuary and cultivated and forested areas throughout Thailand. Sampling was carried out in several different ways such as hand searching directly on the dung pads, light trapping and pitfall traps baited with pig dung, rotten chicken and rotten fruit. The trap was 1-litter plastic bottle which two third cut out from the neck and made as a funnel by tipping down the neck part inside the bottom part of the bottle. The baited traps were buried with the top opened part in the rim in soil. The baited traps were left up for 24 hrs then collected in separate containers and taken back to the laboratory for further study. Forest leaf litter was also collected and extracted with Berlese funnels to sample the small litter dwelling species. The beetles were cleaned up with detergent in water to remove out the dirt, then each beetle specimen was pinned, labeled and dried out in the oven at 60 °C for 24-48 hrs. The beetles were identified for specie name by comparing with the types and other materials preserved in the Natural History Museum, London, Museum National d'Histoire Naturelle, Paris, National Science Museum, Tokyo and Masumoto's insect collection in Yokohama. Others were determined from the literature.

## Results and Discussion

A total of 268 dung beetle species of the Scarabaeidae, Aphodiidae and Geotrupidae of 26 genera in 15 tribes were found in Thailand. Two hundred and forty species were sampled from this study and 28 species were recorded from the literature. Among those two hundred and forty collected species, 210 species had already been identified while thirty species were unknown and many of them are now being described as new species. The coprophagus beetles which are dung feeding species were more diverse than saprophagus or carrion feeding beetles. Of the 26 genera reported here, the genus *Onthophagus* is the most abundant and diverse species group. One hundred and twenty seven (83% of the total number of species) collected dung beetle species belonged to this genus and their distribution covered all studied vegetation habitats. It is known that the genus *Onthophagus* is the most diverse species group and there are about 300 species within this genus widely distributed in South east Asia (Hanski and Cambefort, 1991). Hanboonsong *et al.*, (1999) reported 103 species out of 154 species of dung beetles recorded were from the genus *Onthophagus* in different habitats of the northeast

Richness of dung beetle species in the forested areas is greater than in the lowland or cultivated areas. This is possibly due to an abundant supply of food from animal biomass and vegetation in the forested areas where the areas are well preserved and protected for faunal and floral habitats. The low species diversity of dung beetle in this agroecosystem may be due to the habitat disturbance by the heavy activities in the areas such as application of soil fertilizer and soil plowing. Several genera of *Caccobius, Cassolus, Panelus, Phacosoma and Sisyphus* are mainly found in the forested habitats. Since the genera *Catharsius, Onitis* and *Oniticellus* occur very commonly in the dung of domestic animals like cow and buffalo,the local people in the Northeast use these dung beetle genera as a food protein source. Particularly, *Oniticellus cinctus* (Fabricius) is the most favourite edible dung beetle species.

In conclusion, the knowledge of dung beetle taxonomy in Thailand was previously scattered between various foreign museums and was difficult to access by local scientists. This study presents the partially dung beetle diversity in Thailand and xxx dung beetle species specimens were kept in this country museums. It is excepted that in the future we will build up and get a better understanding of the dung beetle systematics in Thailand.

**Table 1. Dung beetles from Thailand**

| Species | Food sources | Habitat |
|---|---|---|
| **I) FAMILY SCARABAEIDAE** | | |
| **Subfamily Scarabaeinae** | | |
| **Tribe Gymnopleurini** | | |
| *Gymnopleurus (Garreta) gilleti* Garreta,1914 | cow, pig, light trap | cultivated area |
| *G. (Paragymnopleurus)melanarius* Harold,1867 | cow, pig, light trap | cultivated area |
| *G. sinuatus* (Olivier,1789) | barking deer, pig | forested area |
| **Tribe Sisyphini** | | |
| *Sisyphus denticrus* Fairmaire,1889 | pig | forested area |
| *S. laoticus* Arrow, 1927 | pig | forested & cultivated areas |
| *S. longipes* (Olivier, 1789) | pig, monkey | forested area |
| *S. maniti* Masumoto, 1988 | pig, monkey | forested area |
| *S. neglectus* Gory, 1883 | pig | forested area |
| *S. thoracicus chaiyaphumensis* Han&Masu, 2000 | pig, monkey | forested area |
| *S. thoracicus thoracicus* Sharp,1875 | pig, monkey | forested area |
| *S. (Neosisyphus) bowringii* White,1884 | pig | forested area |
| **Tribe Canthonini** | | |
| *Cassolus nudus* Sharp, 1875 | gaur, mushroom | forested area |
| *C. pongchaii* Masumoto, 1989 | unknown | forested area |
| *Panelus tonkinensis* Paulian, 1939 | wild cat | forested area |
| *Phacosoma obscurum* Boucomont, 1920 | pig | forested area |
| *P. ochii* Han&Masu, 2001 | pig | forested area |
| *P. thai* Paulian, 1939 | unknown | forested area |
| *P. thailandicum* Masumoto, 1989 | wild cat, jackal | forested area |
| **Tribe Allocelini** | | |
| *Ponerotrogus kawadai* (Masumoto,1995) | unknown | unknown |
| **Subfamily Coprinae** | | |
| **Tribe Dichotomini (ex-Pinotini)** | | |
| *Parachorius lannathai* Han&Masu, 2001 | unknown | forested area |
| *Onchothecus ateuchoides* Boucomont,1912 | unknown | forested area |
| *O. corniclypeus* Chang,1980 | unknown | forested area |
| **Tribe Coprini** | | |
| *Synapsis birmanicus* Gillet, 1907 | pig | forested area |
| *S. boonlongi* Han&Masu, 1999 | pig | forested area |
| *S. dickinsoni* Han&Masu,1999 | pig | forested area |
| *S. kiuchii* Han&Masu,1999 | pig | forested area |
| *S. ochii* Masumoto,1996 | pig | forested area |
| *S. tridens* Sharp,1881 | unknown | forested area |
| *Heliocopris dominus* Bates,1868 | elephant | forested area |

**Table1 (Continued)**

| Species | Food sources | Habitat |
|---|---|---|
| *H. bucephalus* (Fabricius, 1775) | buffalo,gaur,banteng | forested & cultivated areas |
| *Catharsius birmanensis* Lansberge, 1874 | buffalo,cow, elephant,pig | cultivated area |
| *C. molossus* (Linne,1758) | buffalo, elephant | forested& cultivated areas |
| *Copris (Microcopris) propinquus* Felsche, 1910 | buffalo | cultivated area |
| *Copris (Microcopris) reflexus* (Fabricius, 1787) | cow,buffalo,pig,gaur, elephant,light trap | cultivated& forested areas |
| *C. (Microcopris) vitalisi* (Gillet, 1921) | elephant,gaur,banteng | forested area |
| *C. (Paracopris) cariniceps* Felsche, 1910 | elephant, pig | forested areas |
| *C. (Paracopris) furciceps* Felsche,1910 | elephant | forested area |
| *C.(Paracopris) punctulatus* Wiedemann,1832 | elephant, cow | forested& cultivated areas |
| *C. angusticornis* Arrow,1933 | elephant | forested area |
| *C. carinicus* Gillet, 1910 | gaur | forested area |
| *C. confucius* Harold, 1877 | pig | forested area |
| *C. corpulentus* Gillet,1910 | elephant, gaur | forested area |
| *C. iris* Sharp, 1875 | buffalo, elephant | forested& cultivated areas |
| *C. kiuchii* Masumoto,1989 | pig | forested area |
| *C. laevigatus* Gillet | cow,samber deer,elephant pig, light trap | forested& cultivated areas |
| *C. nevinsoni* Waterhouse | buffalo,cow,pig,light trap | cultivated area |
| *C. magicus* Harold, 1881 | unknown | unknown |
| *C. obenbergeri* Balthasar,1933 | unknown | unknown |
| *C. punctatus* Gillet,1910 | elephant, cow | forested& cultivated areas |
| *C. repertus* Walker,1858 | pig | forested area |
| *C. sinicus* Hope, 1842 | buffalo,cow | cultivated area |
| **Tribe Onitini** | | |
| *Onitis bordati* Cambefort,1989 | elephant | forested area |
| *O. subopacus* Arrow,1913 | bangteng, cow | forested& cultivated areas |
| *O. feae* Felsche, 1907 | cow,buffalo | forested& cultivated areas |
| *O. kiuchii* Masumoto,1907 | human | forested area |
| *O. excavatus* Arrow, 1933 | elephant, gaur | forested area |
| *O. corydon* Boisduval, 1835 | cow, buffalo | cultivated area |
| **Tribe Oniticellini** | | |
| *Drepanocerus arrowi* Balthasar,1932 | pig | forested area |
| *D. falsus* (Sharp,1875) | pig | forested area |
| *D. runicus* Arrow,1909 | pig | forested area |
| *D. sinicus* Harold,1868 | pig | forested area |
| *D. striatulus* Paulian,1945 | pig, cow | forested& cultivated areas |
| *Oniticellu cinctus* (Fabricius,1775) | bangteng,elephant | forested area |
| *O. tessellatus* Harold,1879 | elephant | forested area |

**Table1 (Continued)**

| Species | Food sources | Habitat |
|---|---|---|
| *Euoniticellus camebforti* Masumoto,1987 | pig, human | forested area |
| *Liatongus(Paraliatongus) rhadamistus* (Fabricius, 1775) | cow,buffalo,pig | cultivated area |
| *L. affinis* (Arrow,1908) | elephant,gaur,deer | forested area |
| *L. gagatinus* (Hope, 1831) | elephant,gaur | forested area |
| *L. phanaeoides* (Westwood,1840) | pig | forested area |
| *L. tridentatus* (Boucomont,1919) | elephant,gaur | forested area |
| *L. venator* (Fabricius, 1801) | cow | cultivated area |
| *L. vertagus* (Fabricius, 1798) | gaur,pig | forested area |
| *L. capricornis* Arrow, 1931 | pig | forested area |
| **Tribe Onthophagini** | | |
| *Caccobius (Caccophilus) diminutivus* (Walker, 1858) | pig | forested area |
| *C. (Caccophilus) tortus* Sharp, 1875 | pig | forested area |
| *C.(Caccophilus) unicornis* (Fabricius, 1798) | monkey,bird,pig,cow | forested area |
| *C. (Cleptocaccobius)simplex* (Boucomont, 1923) | pig, gaur,mushroom | forested area |
| *C. bidentatus* Boucomont, 1923 | pig | forested area |
| *C. masumotoi* Cambefort, 1990 | elephant | forested area |
| *Onthophagus (Colobonthophagus) tragus* (Fabricius, 1792) | buffalo,banteng,gaur pig,light trap | cultivated area |
| *O. (Gibbonthophagus) balthasari*Vsetecka, 1939 | elephant,wild cat,pig | forested area |
| *O. (Gibbonthophagus) penmani* Ma,Ochii&Ha 2002 | pig | forested area |
| *O. (Gibbonthophagus) sunantaae* Masumoto, 1989 | pig | forested area |
| *O.(Indachorius) arai* Masumoto,1989 | pig | forested area |
| *O.(Indachorius) doisuthepensis* Masumoto, 1989 | pig | forested& cultivated areas |
| *O. (Indachorius) lannamiibun* Ma,Ochii&Ha 2002 | pig | forested area |
| *O. (Indachorius) maesaensis* Ma,Ochii&Ha 2002 | pig | forested area |
| *O. (Indachorius) mongkhoni* Ma,Ha&Ochii 2002 | pig | forested & cultivated areas |
| *O.(Indachorius) nongkaiensis* Ma,Ochii&Ha 2002 | pig | forested area |
| *O.(Indachorius) scotti* Ma,Ochii&Ha 2002 | pig,human | forested area |
| *O.(Indachorius) phetchabunensis* Ma,Ochii&Ha 2002 | pig | forested area |
| *O.(Indachorius) tongbantumi* Ma,Ochii&Ha 2002 | human, pig | forested area |
| *O.(Micronthophagus) gigantivigilans* Ma,Ha&Ochii 2002 | pig | forested area |
| *O.(Matashia) anguliceps* Boucomont, 1914 | elephant, pig | forested area |

**Table1 (Continued)**

| Species | Food sources | Habitat |
|---|---|---|
| *O. (Matashia)avocetta* Arrow,1933 | elephant,pig | forested area |
| *O. (Matashia)bonasus*(Fabricius,1775) | banteng,cow | forested area |
| *O. bonorae* Zunino, 1976 | pig, rotten fruit | forested area |
| *O. (Matashia)manupurensis* Arrow,1933 | pig | forested area |
| *O. (Paraphanaeomorphus) argyropygus* Gillet, 1927 | pig | forested area |
| *O. (Paraphanaeomorphus) jeannelianus* Paulian, 1945 | elephant, pig | forested area |
| *O. (Paraphanaeomorphus) phanaeiformis* Boucomont, 1914 | pig, carcasses | forested area |
| *O. (Paraphanaeomorphus) punneeae* Masumoto, 1989 | pig, carcasses | forested area |
| *O. (Parascatonomus) anceyi* Boucomont, 1921 | pig,banteng,carcasses | forested area |
| *O.(Parascatonomus) damaki* Ma,Ha&Ochii 2002 | pig | forested area |
| *O.(Parascatonomus) piyawati* Ma,Ochii&Ha 2002 | pig | forested area |
| *O.(Parascatonomus) quaestus* Sharp, 1875 | pig | forested area |
| *O.(Parascatonomus) tricornis* (Wiedemann, 1823) | cow,pig,carcasses | forested&cultivated areas |
| *O.(Parascatonomus) yukae* Ma,Ochii&Ha 2002 | pig,carcasses | forested area |
| *O.(Phanaeomorphus) zetteli* Ma,Ochii&Ha 2002 | pig | forested area |
| *O.(Proagoderus) mouhoti* Harold, 1875 | cow,buffalo | forested&cultivated areas |
| *O.(Pseudonthophagus) gosoli* Masumoto, 1989 | elephant | forested area |
| *O.(Pseudonthophagus) penicillatus* Harold, 1879 | pig,carcasses | forested area |
| *O.(Serrophorus) atroplitus* d' Orbigny, 1902 | pig | forested&cultivated areas |
| *O.(Serrophorus) rectecornutus* Lansberge, 1883 | pig,cow,banteng | forested&cultivated areas |
| *O.(Serrophorus) sagittarius* (Fabricius, 1775) | cow, buffalo light trap | cultivated area |
| *O.(Serrophorus) seniculus* (Fabricius, 1781) | cow,pig,banteng light trap | forested&cultivated areas |
| *O.aeropictus* Boucomont, 1914 | pig | forested&cultivated areas |
| *O. aloysiellus* Zunino, 1977 | pig | forested area |
| *O. anguicornis* Boucomont, 1914 | pig,elephant,carcasses | forested area |
| *O. apilularis* Masumoto, 1995 | pig | forested area |
| *O. bokiaunsis* Masumoto, 1996 | pig | forested area |
| *O. bonorae* Zunino, 1976 | elephant | forested area |
| *O. brutus* Arrow, 1931 | pig,elephant,mushroom | forested area |

**Table1 (Continued)**

| Species | Food sources | Habitat |
|---|---|---|
| *O. chaiyaphumensis* Ma,Ochii&Ha 2002 | pig | forested area |
| *O. coracinus* Boucomont, 1914 | pig,elephant | forested area |
| *O. crassicollis* Boucomont, 1913 | pig,cow,elephant,monkey | forested&cultivated areas |
| *O. dapcauensis*Boucomont, 1921 | cow,pig | forested&cultivated areas |
| *O. deemaak*Masumoto, 1989 | pig | forested area |
| *O. deflexicollis* Lansberge, 1883 | pig | forested area |
| *O. doiinthanonensis* Masumoto, 1989 | pig,monkey | forested area |
| *O. doipuiensis* Masumoto, 1989 | pig | forested area |
| *O. doitungensis* Ma,Ochii&Ha 2002 | pig | forested area |
| *O. duporti* Boucomont, 1914 | elephant,monkey,pig | forested area |
| *O. embersoni* Ma,Ha&Ochii 2002 | pig | forested area |
| *O. falsivigilans* Masumoto, 1995 | pig | forested area |
| *O. funebris* Boucomont, 1919 | pig, carcasses | forested&cultivated areas |
| *O. gracilipes*Boucomont, 1914 | pig,elephant | forested area |
| *O. grandivigilans* Masumoto, 1995 | pig | forested area |
| *O. hastifer* Lansberge, 1885 | pig,cow,gaur,light trap | forested&cultivated areas |
| *O. hystrix* Boucomont, 1914 | pig | forested area |
| *O. jacobeus* Boucomont, 1924 | pig, cow | forested&cultivated areas |
| *O. kanyaayonus* Masumoto, 1992 | pig | forested area |
| *O. khonmiinitno*i Masumoto, 1990 | pig | forested area |
| *O. kiuchii* Masumoto, 1989 | pig,mushroom | forested&cultivated areas |
| *O. krakadaakhomus* Masumoto, 1992 | pig | forested area |
| *O. laevis* Harold, 1880 | pig,elephant | forested area |
| *O. lakyim* Masumoto, 1990 | pig | forested area |
| *O. lindaae* Masumoto, 1989 | wild cat,monkey,pig | forested area |
| *O. luridipennis* Boheman, 1858 | cow,deer,porcupine,pig | forested area |
| *O. mairuu* Masumoto, 1989 | pig | forested area |
| *O. maleengnaafon* Masumoto, 1990 | pig | forested area |
| *O. maleengnoi* Masumoto, 1990 | pig | forested area |
| *O. maniti* Masumoto, 1989 | pig | forested area |
| *O. masumotoi* Ochi, 1985 | unknown | forested area |
| *O. naaroon* Masumoto, 1990 | pig | forested area |
| *O. namnaoensis* Ma,Ochii&Ha 2002 | pig | forested area |
| *O. naviculifer* Boucomont, 1919 | unknown | forested area |
| *O. ochii* Masumoto, 1989 | pig | forested area |
| *O. orientalis* Harold, 1868 | cow,buffalo,monkey | forested area |
| *O. pacificus* Lansberge, 1885 | pig,banteng | forested area |
| *O. papulatus* Boucomont, 1914 | cow,pig,light trap | cultivated area |
| *O. phraoensis* Masumoto, 1990 | pig | forested area |
| *O. phrutsaphaakhomus*Masumoto,1992 | pig, rotten banana | forested |
| *O. proletarius*Harold, 1875 | pig | forested&cultivated areas |
| *O. pseudohystrix* Masumoto, 1995 | pig | forested area |
| *O. ratchasimaensis* Ma,Ha&Ochii 2002 | pig | forested area |
| *O. rudis* Sharp, 1877 | pig | forested area |
| *O. rugolosus* Harold,1866 | pig,banteng | forested area |
| *O. sakaeratensis* Ma,Ha&Ochii 2002 | pig | forested area |

**Table1 (Continued)**

| Species | Food sources | Habitat |
|---|---|---|
| *O. sarawakus* Harold, 1877 | pig | forested&cultivated areas |
| *O. singhaakhomus* Masumoto, 1992 | pig, elephant | forested area |
| *O. taayai* Masumoto, 1995 | unknown | forested area |
| *O. taurinus* White, 1844 | elephant,wild cat,pig | forested area |
| *O. thanwaakhonmus* Masumoto, 1989 | pig | forested area |
| *O. tholaayi* Masumoto, 1990 | pig | forested area |
| *O. tragoides*Boucomont, 1914 | cow,mushroom | forested&cultivated areas |
| *O. trituber* Wiedemann, 1823 | monkey,pig,buffalo | forested&cultivated areas |
| *O. tumami* Ma,Ochii&Ha 2002 | pig | forested area |
| *O. vaulongeri* Boucomont, 1923 | pig | forested area |
| *O. wangnamkhieoensis* Ma,Ha&Ochii 2002 | pig | forested area |
| *O. yamaokai* Ma,Ochii&Ha 2002 | pig | forested area |
| *Onthophagus* 30 *spp.*indet | cow,jackal,pig | forested area |
| **FAMILY APHODIIDAE** | | |
| **Tribe Aphodiini** | | |
| *Ataenius ambaritae* Stebnicka, 1988 | unknown | forested area |
| *Aphodius (Acrossus)tiabi* Masumoto, 1988 | pig | forested area |
| *A.(Alocoderus)luangensis* Emberson & Stebnicka, 2001 | elephant, pig | forested area |
| *A. (Aganocrossus)urostigma* Harold,1862 | pig | forested area |
| *A.(Balthasarianus)ruupbai* Masumoto,1991 | pig | forested area |
| *A. (Balthasarianus)yaaunitnoi* Masumoto,1991 | pig | forested area |
| *A.(Calamosternus)sublimbatus* Motschulsky, 1860 | pig | forested area |
| *A.(Emadiellus)rufopustulatus* Wiedemann, 1823 | pig | forested area |
| *A.(Labarrus)insularis* Petrovitz, 1961 | cow | forested area |
| *A.(Labarrus)lividus* Olivier, 1798 | pig | forested area |
| *A. (Loboparius)chaiyaphumi* Emberson&Stebnicka,2001 | pig | forested area |
| *A.(Loboparius)immarginatus* A.Schmidt,1907 | pig | forested area |
| *A.(Loboparius)joanae* Dellacasa,1983 | pig | forested area |
| *A (Loboparius)mirificus* Balthasar,1933 | unknown | forested area |
| *A.(Loboparius)punctatissimus* Boucomont, 1921 | pig | forested area |
| *A.(Megatelus) bostrichoides* Harold,1860 | pig | forested area |
| *A.(Megatelus) brahminus* Harold,1879 | pig | forested area |
| *A.(Mesontoplatys)sunantae* Stebnicka,1981 | pig | forested area |
| *A.(Nialus)hoabinhensis*Balthasar, 1946 | pig | forested area |
| *A.(Paulianellus)maderi* Balthasar,1938 | pig | forested area |
| *A.(Pharadidactylia) shantungensis* Balthasar,1941 | pig | forested area |
| *A.(Pharaphodius)attritus* Balthasar,1933 | pig | forested area |
| *A.(Pharaphodius)birmanicus* Petrovitz, 1965 | pig | forested area |
| *A.(Pharaphodius) costatulus*A.Schmidt,1908 | pig | forested area |

**Table1 (Continued)**

| Species | Food sources | Habitat |
|---|---|---|
| *A.(Pharaphodius)crenatus* Harold,1862 | pig | forested area |
| *A.(Pharaphodius)elongatulus* (Fabricius,1801) | pig | forested area |
| *A.(Pharaphodius) marginellus*(Fabricius,1781) | pig | forested area |
| *A.(Pharaphodius) orientalis* Harold,1862 | pig | forested area |
| *A.(Pharaphodius) priscus* Motschulsky,1858 | pig | forested area |
| *A.(Pharaphodius) putearius* Reitter,1895 | pig | forested area |
| *A.(Plagiogonus)khaoensis* Stebnicka,1988 | unknown | forested area |
| *A.(Plagiogonus) okumurai* Masumoto, 1992 | pig,human | forested area |
| *A.(Plagiogonus) palea* Balthasar,1967 | pig | forested area |
| *A.(Platyderides) doiangkhangensis* Masumoto,1991 | pig | forested area |
| *A.(Pleuraphodius)lewisi* Waterhouse, 1875 | pig | forested area |
| *A.(Siamaphodius) naafon* Masumoto, 1991 | pig,human | forested area |
| *A.(Teuchestes)analis* (Fabricius, 1787) | pig | forested area |
| *A.(Trichaphodius)assamensis* Petrovitz, 1976 | pig | forested area |
| *A.(Trichaphodius)commatoides* Balthasar, 1961 | pig | forested area |
| *A.(Trichaphodius)fukiensis* Balthasar, 1952 | pig | forested area |
| *A.(Trichaphodius)lomsakensis* Stebnicka, 1992 | pig | forested area |
| *A.(Trichaphodius)miksici* Balthasar, 1960 | pig | forested area |
| *A.(Trichaphodius)nigrovirgatus* A. Schmidt, 1911 | pig | forested area |
| *A.(Trichaphodius)rangoonensis* Petrovitz, 1970 | pig | forested area |
| *A.(Trichaphodius)reichei* Harold, 1859 | pig | forested area |
| *A.(Trichaphodius)segmentaroides* A. Schmidt,1909 | pig | forested area |
| *A.(Trichaphodius)khoensis* Stebnicka, 1981 | pig | forested area |
| *Oxyomus thailandicus* Masumoto, 1991 | pig,human | forested area |
| *O. kiuchii* Masumoto, 1991 | pig, human | forested area |
| *Renaudius thailandicus* Masumoto, 1991 | pig,human | forested area |
| **Tribe Euparia** | | |
| *Saprosites sp* | unknown | unknown |
| **Tribe Psammobius** | | |
| *Rhyssemus birmensis* Clouet, 1901 | unknown | unknown |
| *R. sindicus* Pittino, 1984 | unknown | unknown |
| **Tribe Thinorycterini** | | |
| **Tribe Rhyparini** | | |
| *Sybacodes liliae* Dellacasa, 1878 | pig | forested area |
| *S. lutulentus* Fairmaire,1896 | elephant, pig | forested area |
| *S. simplicicollis aureopilosus* Schimidt, 1922 | no need, elephant | forested area |
| **Tribe Corythoderini** | | |
| **FAMILY GEOTRUPIDAE** | | |
| *Enoplotrupes variicolor* Fairmaire, 1886 | human | forested area |

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# Identification of Threatened Species from Regional Faunas: Examples from Australian Marine Fishes

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## Abstract

**More than 4200 fish species are known from the nine million plus square kilometres of Australian marine waters. While threatened Australian freshwater fishes have been of concern since the early 1980s, focus on threatened marine fishes began in the mid-1990s. An overview of threatened Australian marine fishes was published in 2002, with details provided for 115 reviewed species. Of these, 17 species are considered threatened (3 critically endangered, 6 endangered, 8 vulnerable) and an additional 16 conservation dependent and 14 near threatened. A total 53 species are defined as data deficient. The vast majority of fishes in the three threatened categories are sharks and rays. The primary threats to Australian marine fishes are overfishing and habitat degradation. Research on data deficient nominated species is required. The establishment of even a small list of officially threatened species focuses the attention of both environmental scientists and fisheries authorities, due to the requirement of recovery plans.**

***Key words: Threatened marine species, Australian marine fishes***

## Introduction

The identification of threatened species is particularly challenging in the marine environment, where data are usually incomplete and evidence for decline is often meagre. An overview of threatened Australian marine fishes has recently been published (Pogonoski *et al.*, 2002). Although only 115 species (of a total of 4200+ species) were analysed in detail, the methods of choosing those species and the resulting categories and taxonomic groupings within those categories may be of interest to others in the Western Pacific region.

Australia's marine habitat exclusive of territorial islands (Norfolk, Macquarie, etc.) extends from 10° to 47° South and exceeds nine million square kilometres. The current estimate of Australian fish species (excluding those of territorial islands) is 4400+, up from 2450 in 1964 (Paxton *et al.*, 1989; Hoese *et al.*, in press). The vast majority of these species are marine, with only some 200 freshwater fish species.

The first national attempt to identify threatened fish species was a 1985 workshop of the Australian Society for Fish Biology (ASFB) that resulted in a published list of 15 threatened species and 44 other species of lower risk (Harris, 1987). Only one marine species was on the original list in a threatened category. Similarly the 1994 IUCN Red List of Threatened Species included only three Australian marine fish species (all sharks) and some 70 species of freshwater fishes, a surprising ratio given the small total number of freshwater species. In Australia distributions and abundances of freshwater fishes are better known than those of many marine fishes. As well, freshwaters are usually of smaller volume and hence more susceptible to degradation than marine habitats. Also many freshwater species have smaller distributions than marine species.

More emphasis has been given to threatened marine species in the last decade. A three-year study supported by Environment Australia to provide a first national overview of threatened and potentially threatened marine and estuarine fishes commenced in 1999. Additional aims included identification of critical habitats for the threatened species, identification of threatening processes in the marine environment, and recommendation of conservation priorities.

## Materials and Methods

With limited time and resources, the greatest problem was to identify from more than 4200 marine fishes a provisional list of species of some conservation concern for analysis. Initially all species on various government lists of threatened species and protected species, as well as those Australian marine species in the IUCN Red List, were included. Additional species were nominated by individual Australian ichthyologists. Commercial species with significant recent declines were also included. Finally selected taxonomic groups previously identified with conservation problems were added. These included the Australian endemic handfish family Brachionichthyidae (Bruce *et al.*, 1998), the seahorse and pipefish family Syngnathidae (Vincent, 1996), larger groupers and wrasses of the families Serranidae and Labridae (Sadovy, 1997), and many sharks and rays (Camhi *et al.,* 1997). A total of 115 species were chosen for analysis.

For these species, all available data on distribution, biology, threats, and evidence of decline were obtained from published literature, museum records, unpublished data, and individual scientists. Analyses of conservation status utilised IUCN Red List categories, but criteria were often more subjective than the official Red List criteria due to data deficiency. A specialist workshop with some 40 participants was held in conjunction with the 1999 Australian Society for Fish Biology Annual Conference. Each species was discussed, some in considerable detail, as the list was refined and decisions made about the various categories. In the year following the workshop, 100s of subsequent emails were exchanged with specialists in Australia and overseas as final decisions were made about all species analysed. Final text editing was completed in the third year.

## Results

Of the 115 marine and estuarine species analysed in detail, 17 are considered formally threatened (3 critically endangered, 6 endangered, 8 vulnerable), 30 at lower risk (16 conservation dependent, 14 near threatened), 53 as data deficient and 15 of least concern. Not enough information on the distribution, biology, threats and level of decline of the 53 data deficient species in Australia is available to determine the category in which they should be placed. However, some may well be threatened and all are deserving of further study.

Sharks and rays make up 21 of the 47 threatened and lower risk Australian marine species and are also the largest threatened marine group around the world (Table 1). A number of features are common to many different threatened marine fish groups: 1) low fecundity often coupled with slow growth and late maturity; 2) target species of commercial/ recreational fishers or taken as bycatch; 3) mass spawning activities or highly territorial; 4) small distribution.

**Table 1. Threatened and Lower Risk Australian Marine Fishes**

| IUCN Categories | Critically Endangered | Endangered | Vulnerable | Conservation Dependent | Near Threatened |
|---|---|---|---|---|---|
| Number of Species | 3 | 6 | 8 | 16 | 14 |
| Sharks | 1 | 3 | 3 | 3 | 3 |
| Rays | 1 | 3 | 2 | | 2 |
| Handfishes | 1 | | 2 | | |
| Toadfish | | | | | 1 |
| Roughy | | | | 1 | |
| Seahorses & Pipefishes | | | | 3 | 4 |
| Groupers | | | 1 | 3 | |
| Prettyfins | | | | 1 | |
| Nibbler | | | | | 1 |
| Wrasses | | | | 4 | 1 |
| Angelfish | | | | | 1 |
| Gemfish | | | | 1 | |
| Tuna | | | | | 1 |

Threats to Australian marine fishes include overfishing, habitat degradation from urban development and related activities, trawling, dredging, water pollution, and to a lesser extent exotic species introductions.

The 115 species of Australian marine fishes reviewed in Pogonoski *et al.* (2002) represent less than 3% of the total Australian marine fish fauna and only slightly more than half of this small total had decisions made about conservation categories. Nevertheless, the establishment of even a small list of officially threatened species focuses the attention of conservation biologists, environmental scientists, and fisheries authorities, due to the requirement of recovery plans.

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# Documenting Biodiversity Minus the Most Diverse Group?: The Status, Problems and Prospects of Arthropod Taxonomy and Taxonomists in the Philippines

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## Abstract

**Insects are the most diverse of all groups, constituting 75% of the animal kingdom and around 50% of all life forms yet most biodiversity studies and documentation projects including environmental impact assessments focus mainly on vertebrates and plants but tend to ignore arthropods. All of those projects have been or are led or coordinated by non-entomologists. Whereas this seems to be a current worldwide scenario, the picture of neglect appears clearer in the Philippines. As of 2001, the number of described Philippine insects has reached more than 20,000, a figure much larger than the known Philippine flowering plants and vertebrate wildlife combined. There are at present 18 Filipino arthropod taxonomists including three acarologists and a husband-and-wife team of araneologists. The number also includes three retired professors and one who is presently mostly busy with academic administration. Most are also teaching taxonomy and other biology/entomology courses most of the time. They focus mainly on the Hymenoptera, Hemiptera (Auchenorrhyncha, Sternorrhyncha and Heteroptera), Odonata, some Coleoptera (Coccinellidae, Chrysomelidae), some Lepidoptera (Rhopalocera), Phasmatodea, Strepsiptera as well as the Acari and Araneae. They depend mainly on locally available collections, the largest (around 200,000 pinned, liquid-preserved and slide-mounted specimens combined) being housed in the Entomology Section of the Museum of Natural History, University of the Philippines Los Baños. Despite the odds and administrative neglect including lack of funds and space, inadequate facilities (microscopes and other equipment), inaccessible types, reference specimens and taxonomic literature, Filipino insect taxonomists have managed to give whatever share they can within their limited resources to systematics and published significant contributions. Economic conditions prevailing in the country make hopes for systematics dim but there is some light, however, in the few students that have become interested in this field of study and in the increasing realization of its importance in pest management, environmental management and conservation biology.**

***Key Words: Philippines, insect taxonomy, taxonomists, terrestrial arthropod biodiversity***

## Introduction

Insects are the most diverse of all groups of organisms. They constitute 75% of all animals and around 50% of all life forms (Gullan and Cranston, 2001). Add to these figures the number of other arthropods, most notably the mites and spiders, and the proportion easily shoots up to more than 80%. In the Philippines alone, the number of known land vertebrates (1,093 species) and plants (7,620 species) combined fare poorly compared to the known terrestrial arthropods (22,635 species) (Baltazar, 2001; Gapud *et al.*, 2001). As of 2001, the number of described Philippine insects has reached 20,940 species (Table 1), broken down into the Neuropteroid orders (35.7%), Panorpoids (29.3%), Hymenoptera (14.3%), Hemipteroids (14.2%), Orthopteroids (4.8%), Palaeopterans (1.5%) and the Entognatha-Apterygota (0.2%). Specifically, the top most diverse (speciose) orders are the Coleoptera (beetles), Hymenoptera (ants, bees and wasps), Lepidoptera (butterflies, moths and skippers),

**Table 1. Species inventory of Philippine insects. (after Gapud *et al.*, 2001).**

| Order | Families | Genera | Species | Endemics | %Endemism |
|---|---|---|---|---|---|
| Diplura | 1 | 1 | 1 | 1 | 100.00 |
| Collembola | 6 | 28 | 44 | 20 | 45.45 |
| Archaeognatha | 1 | 2 | 2 | 0 | 0.00 |
| Thysanura | 2 | 6 | 6 | 1 | 16.70 |
| Ephemeroptera | 7 | 15 | 23 | 13 | 56.50 |
| Odonata | 15 | 87 | 291 | 198 | 68.00 |
| Blattodea | 14 | 43 | 99 | 54 | 54.50 |
| Isoptera | 3 | 17 | 54 | 44 | 81.50 |
| Mantodea | 5 | 19 | 42 | 26 | 61.90 |
| Zoraptera | 1 | 1 | 1 | 1 | 100.00 |
| Dermaptera | 8 | 39 | 127 | 73 | 57.50 |
| Plecoptera | 3 | 5 | 14 | 13 | 92.90 |
| Orthoptera | 12 | 195 | 451 | 341 | 75.60 |
| Phasmatodea | 5 | 50 | 207 | 179 | 86.50 |
| Embioptera | 1 | 1 | 2 | 1 | 50.00 |
| Psocoptera | 16 | 31 | 84 | 58 | 69.00 |
| Phthiraptera | 11 | 62 | 136 | 50 | 36.80 |
| Thysanoptera | 2 | 89 | 187 | 73 | 39.00 |
| **Hemiptera** | **77** | **1,000** | **2,566** | **1,557** | **60.10** |
| **Coleoptera** | **87** | **1,567** | **7,375** | **5,840** | **79.20** |
| Strepsiptera | 5 | 11 | 23 | 21 | 91.30 |
| Neuroptera | 8 | 41 | 88 | 59 | 67.00 |
| Siphonaptera | 5 | 17 | 24 | 12 | 50.00 |
| **Diptera** | **78** | **747** | **2,884** | **1,639** | **56.80** |
| Trichoptera | 16 | 55 | 319 | 306 | 95.90 |
| **Lepidoptera** | **52** | **1,185** | **2,901** | **1,808** | **62.30** |
| **Hymenoptera** | **58** | **871** | **2,989** | **2,237** | **71.50** |
| TOTAL | 499 | 6,185 | 20,940 | 14,625 | 69.80 |

Diptera (true flies, gnats, mosquitoes and midges) and Hemiptera (true bugs, aphids, mealybugs, scale insects, lac insects, jumping plant lice, whiteflies, cicadas, treehoppers, leafhoppers and planthoppers). This immense diversity of Philippine insect life is further made significant by the fact that almost 70% of Philippine insects are endemic and most are narrowly distributed in particular islands, mountains or habitats.

Unlike plants and the larger animals, however, the diversity of insects is not well appreciated. Most biodiversity research, conservation, environmental monitoring and documentation projects that have been conducted focus mainly on vertebrates and plants. It is rare, if ever, for data on this group to be gathered or sought and included even in routine environmental impact assessments. There is obviously a virtual neglect for terrestrial arthropod biodiversity and there are several reasons that can be cited (Gullan and Cranston, 2000). First, the concept of "flagship" species in conservation movements is rooted into the desire of conservationists to elicit public reaction, often times stirring emotions and egos, to a conservation issue. Such an issue could be loss of a particular habitat or dwindling species population. More often than not, these flagship species are predominantly furry animals such as pandas or koalas, or birds - often the colorfully plumed or billed types like the toucans, hornbills, macaws or great flyers or raptors like the Philippine or other eagles. Except for a few butterflies, insects often lack the necessary charisma in the public perception. This is aggravated by the negative image of insects or "bugs" as creepy crawlers, biters, filth-dwellers, annoying pests and its consequent probably widespread entomophobia.

Second, insects are generally difficult to sample in a comparable manner within and between sites. Abundance and diversity fluctuate on a relatively short time scale, in response to factors that are often, little, if at all, understood. In contrast, vegetation often shows less temporal variation; and with knowledge of mammal seasonality and of the migration habits of birds, the seasonal variations of vertebrate populations can be taken into account.

Third, arthropods are often more difficult to identify accurately, as a result of the numbers of taxa and deficiencies in taxonomic knowledge of the majority of groups. Whereas competent wildlife biologists or field botanists might expect to identify to species level, respectively, all vertebrate wildlife and plants of geographically restricted areas (with little reservation, I suppose, for tropical rainforests), no entomologist would dare to do so.

The first difficulty mentioned can be countered through more vigilant public awareness campaigns and the second one can be answered by improvement and further refinements of recently developed and enumerated sampling techniques (Biological Survey of Canada, 1994; Nakashizuka and Stork, 2002). However, the third is an impediment that although may be viewed as partly inherent in arthropod systematics certainly and urgently needs our attention and coordinated efforts. In this light, this paper aims to briefly assess the status, and problems and prospects of arthropod taxonomy as well as the taxonomists themselves under Third World conditions as in the Philippines.

## The Status and Problems of Arthropod Taxonomy in the Philippines

The status of insect taxonomy in the Philippines has been reviewed a number of times, the first one by Baltazar (1970), which was updated by Reyes (1980). Gapud (1980, 1984, 1990) also discussed this subject matter as a review of the discipline by itself as well as part of basic entomological research. Corpuz-Raros (1989) also effectively reviewed the status of Philippine insect taxonomy in her assessment of biosystematic resources and services in the Oriental Region. It is my view that the status and problems of arthropod taxonomy or systematics in the Philippines can not be taken separately and independent of those of the systematists or taxonomists themselves. Hence, the present paper treats them interdependently.

It is indeed sad to note that the problems enumerated by them have essentially remained unchanged despite technological advances in this age of computers and information technology and in an era supposedly endowed with environmental awareness and concern for biological diversity and its conservation. The issues that have been raised by systematists and taxonomists decades ago have supposedly been answered with solutions including provisions of funds and research grants. Unfortunately, when the "biodiversity" bandwagon and catchword came running, the systematists - the scientists who study the diversity of organisms - in general, i.e. including insect taxonomists, were left out. Everybody has become a biodiversity expert overnight and everyone has funds for biodiversity research projects except the systematists, who, most of the time have to spend personal funds from their already meager family budgets, for research supplies, sending/ requesting reprints or sending/receiving e-mail messages to/from colleagues in an internet shop. All others are involved in world taxonomic efforts and are able to attend biodiversity conferences including those of the **Global Taxonomy Initiative** (GTI) except the taxonomists themselves. The justification that GTI embraces both the taxonomy information producers and the users does not by itself justify or at least satisfactorily explain why all but one among attendees from the Philippines are not taxonomists!

The 14 active members among the present corps of systematists and taxonomists (Table 2) in the Philippines, age-wise, are around 35% retired or approaching retirement age.

**Table 2. List of living Filipino arthropod taxonomists/systematists and other specialists.**

| Name/Degree | Institution | Group of Expertise | Main Job | Involvement* | Age Group |
|---|---|---|---|---|---|
| Ballentes, Myrna G., Ph.D. | CMU | COL: Chrysomelidae: Hispinae | Associate Professor | Inactive | 44 |
| Baltazar, Clare R., Ph.D. | UPLB, NAST | HYM: Parasitica | Retired Professor | Active | 75 |
| Barrion, Adelina A., Ph.D. | UPLB | ARANEAE | Professor of Genetics | **Less Active | 51 |
| Barrion, Alberto T., Ph.D. | formerly IRRI | ARANEAE; STREPSIPTERA | Retired Scientist | Very Active | 51 |
| Barroga, Grace F., Ph.D. | UPLB | COL: Chrysomelidae: Galerucinae | Assistant Professor | Active | 32 |
| Cagampang-Ramos, Adela | Private | DIP: Culicidae | Private Consultant | Inactive | ? |
| Calilung, Venus J., Ph.D. | UPLB, NRCP | HEM: Aphidoidea | Retired Professor | Active | 69 |
| Corpuz-Raros, Leonila A., Ph.D. | UPLB | ACA: (plant, soil/litter & predatory mites) | Professor | Very Active | 61 |
| De Leon-Facundo, Josephine B., B.Sc. | UPLB | ACA: Ascidae | Contract Research Associate | Active | 29 |
| Eusebio, Orlando L., A.B. | UPLB | PHASMATODEA | Artist Illustrator | Active | 38 |
| Gapud, Victor P., Ph.D. | UPLB | HEM: Pentatomoidea & Aquatic; ODO; COL: Coccinellidae | Professor | Very Active | 59 |
| Lit, Ireneo L., Jr., Ph.D. | UPLB | HEM: Coccoidea; HYM: Formicidae | Extension Specialist | Very Active | 42 |
| Magpayo, Fe R., M.Sc. | ADDU | DIP: Muscoidea | Assistant Professor? | Inactive | ? |
| Navasero, Mario V., M.Sc. | UPLB | HEM: Psylloidea | Researcher | Active | 44 |
| Nuyda, Justin, B.F.A. | Private | LEP: Rhopalocera | Artist/Painter | Active | 58 |
| Recuenco-Adorada, Jessamyn D., M.Sc. | UPLB | COL: Coccinellidae | Extension Specialist | Active | 37 |
| Reyes, Cecilia P., Ph.D. | EAC | THYSANOPTERA | Professor | ***Less Active | 46 |
| Reyes, Stephen G., Ph.D. | UPLB | HYM: Sphecoidea, Apoidea, Vespoidea | Associate Professor | Very Active | 45 |
| Rimando, Leo C., M.Sc. | UPLB | ACA: Tetranychoidea and Raphignathoidea | Retired Professor | Active | 69 |
| Ruiz-Fiegalan, Elaida H., Ph.D. | CLSU | DIP: Drosophilidae | Assistant Professor | Inactive | 35 |

**Legend:** ADDU - Ateneo de Davao University, Davao City; CLSU - Central Luzon State University, Muñoz, Nueva Ecija; CMU - Central Mindanao University, Musuan, Bukidnon; EAC - Emilio Aguinaldo College, Manila; IRRI - International Rice Research Institute (Arthropods Collection), Los Baños, Laguna; NAST - National Academy of Science and Technology; NRCP - National Research Council of the Philippines; UPLB - University of the Philippines Los Baños, College, Laguna; ACA - Acari; COL - Coleoptera; DIP - Diptera; HEM - Hemiptera; HYM - Hymenoptera; LEP - Lepidoptera; ODO - Odonata; PHA - Phasmatodea; *To be classified as active, a specialist must have published at least one taxonomic paper within the last five years and is presently conducting a taxonomic research on his group of interest; **Actively publishing but mainly in insect and spider genetics, less in systematics; ***presently busy with academic administration and teaching, less in systematics.

Despite the active status of the three retired professors of systematic entomology, age- and retirement-related factors and limitations already affect their activities. On the other hand, the younger ones (45 years and below) are either still busy with pursuing higher degrees, finding their respective niches in the scientific community or looking for the elusive funding for basic entomological research. In general, Filipino arthropod systematists, unlike some of their counterparts in museums overseas, can only do systematics on the side or part-time and attend to teaching and extension work or more applied research activities most of the time. Jobs that enable arthropod systematists to embark on studies of their groups of expertise are limited and around a dozen have been forced to shift to other disciplines and abandon systematics altogether because of lack of appropriate or more decently paying positions for systematists (Table 3). Calora (1981), quoting Gapud (1980), estimated that it takes 10 years to produce one insect taxonomist. The length of time as well as the personal and public (taxpayers') investments of encouraging students and patiently training them in such a highly specialized field as systematics virtually go to waste if and when appropriate jobs are nowhere in sight after getting an advanced degree.

On the other hand, those who land jobs directly or indirectly related to systematics have to contend with the economic pressures of underemployment or have to "let both ends meet", so to speak. The economic conditions prevailing in the country make hopes dim and the problems of systematics as a science will probably stay on for at least another decade. On top of these, the systematist/taxonomist contends with counter-productive socio-political factors that are either inherent or acquired in the Philippine cultural environment. It is little wonder then that in the present setup even in institutions originally organized by systematists such as the UPLB Museum of Natural History, the systematists themselves are presently left out under the leadership of non-systematists and have not been appointed curators of their respective groups. Lest I be accused of washing dirty linen in a scientific forum, mention of the present political situation in a respected regional seat of arthropod systematics is deemed necessary as it aggravates the already mounting problems of conducting systematics research on Philippine biota. Furthermore, the present situation also reflects the lack of appreciation for systematics as a science and as a profession, and the widespread ignorance of the importance of systematics research and the information it generates in agriculture, forestry, medicine, conservation and other disciplines. Ironically, despite the rigorous training and qualifications required and the quality outputs expected of a systematist/taxonomist, some personalities claim or pretend to be so. And although academically their background and outputs fall short of the minimum required or expected, they have managed to get administrative posts and/or corner funds for research and/or foreign travel intended for systematics research or improvement and maintenance of systematic collections.

In terms of systematic collections of insects, mites and other arthropods, the largest in the Philippines at a composite number of 200,000 is that of the UPLB Museum of Natural History (UPLB MNH) (Table 4). This is the total of pinned, liquid-preserved and slide-mounted specimens deposited therein. The number and state of maintenance of collections in the other institutions listed in Table 4 are mostly unknown but judging from the problems prevailing in the Entomology Section of the UPLB MNH, there is probably also an urgent need to save them from neglect and arrest their continuous degradation.

Collections are the very life-blood of the scientific existence of systematists. Aside from the difficulty of lack of access to types deposited in foreign museums and/or material determined by more senior experts in their respective groups, access to local collections is also limited by the present political situations mentioned above. More urgently needed, however, are funds for additional space, human resources, appropriate storage and research facilities (including compound and dissecting microscopes), temperature and humidity

**Table 3. List of persons trained in systematics but shifted to other disciplines for employment and other reasons.**

| Name | Degree | Group of Study | Present Job | Age Group |
|---|---|---|---|---|
| Alba, Melanie C. | Ph.D. | HYM: Trichogrammatidae | Entomologist, Sugar Regulatory Commission | 50s? |
| Balatibat, Juancho B. | M.Sc. | HEM: Diaspididae: Diaspidini | Assistant Professor, Zoology and Wildlife, UPLB CFNR | 44 |
| Basio, Ruben G. | Ph.D. | DIP: Culicidae | Information not available | 50s? |
| Braza, Ricardo D. | B.Sc. | HEM: Psyllidae | Entomologist, Paper Industries Corporation of the Philippines | 48 |
| Calilung-Efondulan, Ma. Vibien J. | M.Sc. | HYM: Formicidae | Pest Control Manager, Wyeth Philippines | 42 |
| Calora, Feliciano B. | Ph.D. | LEP: Noctuidae | Retired Director, Cyanamid Agricultural Research Foundation, Inc. | 70 |
| Gapasin, Dely P. | Ph.D. | DIP: Sphaeroceridae | Executive for an international agriculture agency | 60? |
| Oquias-Singson, Evelyn A. | Ph.D. | HYM: Encyrtidae | Assistant Professor, Plant Protection, Cavite State University | 40s |
| Rueda, Leopoldo M. | Ph.D. | DIP: Calliphoridae | U.S.A.: Information not available | Late 40s |
| Salviejo-Raros, Perlita B. | B.Sc. | ACARI: Tydeidae | Information not available | 50s |
| Velasquez, Felipe J. | B.Sc. | HEM: Diaspididae: Aspidiotini | Entomologist, Dole Philippines | 53 |
| Zipagan, Mateo B. | M.Sc. | Ectoparasitic Insects-PHTHIRAPTERA; DIP: Bat flies | Field Operations Manager, Philippine Coconut Authority | 38 |

control, build up of database for collections, routine collection management activities and build up of companion library of reprints and other systematics references. In addition, the international community of scientists should help counter the distorted and myopic view that museums of natural history or biological museums are mainly for display and storage of specimens and a venue for income generation. Administrators should be made to appreciate that museums of natural history are, first and foremost, centers of biodiversity and systematics research. Biodiversity extension work through displays and exhibits are important in promoting public appreciation for our natural heritage, biological diversity, endangered species, conservation and sustainable environmental management. Generation of additional income through entrance fees and sales in order to augment the meager financial resources allocated from government funds are also good as long as the rates are not prohibitive. However, either or both of them should not take over research as the major or only function of natural history or biodiversity museums, because information dissemination can only go as far as data generated by systematics research will permit and provide.

## Prospects and Hopes

The Philippines sits on an archipelago that is included among the world's centers of megadiversity as well as one regarded as a biodiversity hotspot (Heaney, 2002; Ong *et al.*, 2002). Despite the alarming rate of habitat destruction and other detrimental factors, our case

**Table 4. Philippine collections of arthropods (expanded from the list of Baltazar, 2001).**

| Name / Institution Address | Strengths/ Specialty | Remarks/ Status |
|---|---|---|
| University of the Philippines Los Baños Museum of Natural History (UPLB MNH) Entomology Section, College, Laguna | ca. 200,000 holdings including types; fauna of Mt. Makiling and entire Philippines | Largest collection of arthropods in the Philippines |
| Philippine National Museum (PNM) Zoology Division, Entomology Section, Manila | No data available | Maintenance status uncertain |
| Bureau of Plant Industry (BPI) Research Division, Entomology Section, San Andres, Manila | Important vouchers of crop pests and natural enemies before 1980 | Maintenance status uncertain |
| IRRI Arthropods Collection (IRRI) Taxonomy Laboratory, Entomology and Plant Pathology Division, International Rice Research Institute, Los Baños, Laguna | Spiders, Riceland arthropods | Well-maintained until 2002 |
| Julian N. Jumalon Butterfly Collection Cebu City | Philippine Butterflies; some types | Private |
| Justin Nuyda Butterfly Collection, Parañaque City | Philippine Butterflies; some types | Private |
| Leyte State University (LSU, formerly ViSCA) Biological Museum, Department of Plant Protection, LSU, Baybay, Leyte | Fauna of Mt. Pangasugan, Leyte Island | Information not available |
| Central Mindanao University (CMU) Department of Entomology Insect Collection Musuan, Bukidnon | Fauna of Bukidnon including Mt. Kitanglad | Information not available |
| University of San Carlos (USC) Museum Department of Biology, Cebu City | Fauna of Cebu and other Visayan islands | Information not available |
| Philippine Rice Research Institute (PhilRice) Crop Protection Division Insect Collection Muñoz, Nueva Ecija | Riceland arthropods | Relatively new |
| University of the Philippines Manila College of Public Health Department of Parasitology, Manila | Medically important arthropods | Information not available |

for Philippine biodiversity conservation is not a lost one and hopes remain alive. In the same manner, despite the difficult status and seemingly insurmountable problems, systematics in the Philippines, including that of arthropods, is not entirely hopeless. The inclusion of arthropods as well as solicited contributions of the Arthropod Working Group (Gapud *et al.*, 2001; Gapud, 2002) in the setting of biodiversity conservation and research priorities spells realization of the importance and significant part of arthropods in a megadiverse region like the Philippines. On hindsight, there will always be a need for insect and other arthropod species to be identified. Examples are for agriculture and forestry (insect pests, biocontrol agents, pollinators), medical and veterinary science (ectoparasites, vectors), industry including biotechnology (sources of natural products and test organisms), environmental management and conservation biology (e.g. diet components especially of insectivores) and other fields. The continuing attractiveness of systematics among students, albeit few, also spells hope that the discipline and the so-called "tribe of systematists" will survive (Table 5). It is also important to note that, despite the odds, the bibliography of recent publications of Filipinos in systematics currently being prepared include important and commendable contributions to the taxonomy of Philippine insects, mites and spiders.

**Table 5. List of UPLB students in arthropod systematics.**

| Name | Degree Pursued | Group of Study | Main Job | Financial Support | Age Group |
|---|---|---|---|---|---|
| Atilano-Yap, Sheryl M. | M.Sc. | COL: Curculionidae: *Metapocyrtus* | Contractual Research Associate | None | 25 |
| Barrion, Aimee Lynn A. | M.Sc. | LEP: Geometridae | Part-time Research Associate | Personal | 24 |
| De Leon-Facundo, Josephine B.* | M.Sc. | ACARI: Ascidae: *Asca* | Contractual Research Associate | Personal | 29 |
| Recuenco-Adorada, Jessamyn D.* | Ph.D. | COL: Coccinellidae | UPLB Employee (Permanent) | Personal + UPLB Tuition | 37 |

**Legend:** *Also listed in Table 2; COL - Coleoptera; LEP - Lepidoptera

There should, however, be some steps taken by Filipino systematists themselves. The group should get organized and let themselves be heard. This should be an organization that will serve as their united voice and speak out for issues confronting systematics, systematic collections and the systematists themselves. The defunct Association of Systematic Biologists of the Philippines where the systematists had eventually become a minority had not only ceased to exist but also failed its purpose. A new one will probably serve Filipino systematists better.

Systematists should also altogether explore all possibilities including, if need be, lobbying for legislative support from government. The congressional support for instance, for the recently approved Wildlife Protection Act, should be viewed as a good example, granting there is accompanying budget allocation. The strategic actions recommended for biodiversity conservation priorities, especially the harmonization of research with conservation needs should also serve as guides in writing proposals and seeking financial support. The local administration, the international community of taxonomists and the donor community should also be enlightened about how to make their support, investments and contributions go to where they should go, and where maximum benefits and outputs for science and nature will be realized.

More importantly, the younger systematists should take up the torch that their more senior colleagues have continued to keep alive and continue on the race for systematics. To resolutely advance their ideals and remain steadfast in their profession will keep systematics and our common hopes for a better and biodiverse world alive.

## Acknowledgement

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# PROCEEDINGS

## Chapter 3:
## Development and sharing of taxonomic information

# The Australian Plant Pest Database

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## Abstract

**The APPD is a national, web-interfaced tool linking databases associated with plant pest reference collections in Australia. Users will be able to search the virtual plant pest reference collection of half a million insect, mite, nematode, fungi, bacterial and viral records located in over 17 separate Australian collections, using distributed database technology developed by CSIRO.**

**Queries return information that includes pest taxonomy, common name and distribution, plant host taxonomy and common name, life stage, collection dates and accession numbers. From the heterogenous collection databases, the information is amalgamated and reported to the user in a dynamic and uniform format. The APPD is similar to other biological collection portals and eventually may be associated with the Global Biodiversity Information Facility. Access to the APPD currently is restricted to Australian Government Plant Health Scientists and collection curators.**

**The APPD will support plant health scientists to make emergency management decisions in the event of incursions by plant pests or diseases, market access bids; and the justification of quarantine measures to exclude potentially harmful, exotic organisms. The system will deliver information efficiently to participating agencies for such purposes as data capture, updating taxa names and in collection management. This enables curators and researchers to focus resources on skill-demanding activities including diagnostics and the assessment of equivocal records.**

**The APPD was developed in response to the identified need of a national plant health database, by the 1996 Review of Australian Quarantine (Nairn 1996) and a plant health stakeholders workshop in 1999. APPD software development and assistance with electronic datacapture is funded by a 2000-2001 Commonwealth Budget Initiative, and managed by the Department of Agriculture, Fisheries & Forestry – Australia (AFFA) and Plant Health Australia. Unique among cross-institutional partnerships, the APPD brings together Commonwealth, State and Territory agencies, universities and industry to enrich Australian collections and protect plant health.**

***Key Words:*** ***biological database, pest records, APPD, plant health network, taxonomic tools***

## Introduction

There are more than 20 million insect, nematode, fungi, bacteria and virus records in major collections in Australia. About 5% of which are plant pests in accordance with the International Plant Protection Convention definition (IPPC 2002).

Specimen information, such as host plant, locality, date of collection and the voucher specimen location, can be of great importance to plant health scientists and curators and may ultimately justify major, quarantine-related, trade decisions. However, because much of this information is scattered widely across Australia, it can be difficult to collate.

With the decline in resources for taxonomic research and collection management, curators have found it increasingly difficult to respond to requests for pest record data. However, a recent revolution in bio-informatics has given taxonomists a powerful new tool (Sugden & Pennisi 2000).

Computer technology and internet advancements have facilitated easy storage and rapid retrieval of data from many heterogeneous databases and across great distances. Through the network portal, the retrieved information can then be presented to the user in a single, homogenous summary report. Multi-dimensional queries (for example combining a scientific name, locality, and/or host) are also possible across diverse data sources. This is difficult or impossible using traditional methods, such as the scanning of collection labels or accession books.

The Australian Plant Pest Database (APPD) is one of a growing number of such portals, which in the future will collectively provide a worldview of specimen databases. It is anticipated that the Global Biodiversity Information Facility (GBIF) will facilitate interoperability of specimen databases and other datasets, such as those containing names of organisms (e.g. Species 2000 and various regional initiatives; GBIF website, 2002) or molecular data (e.g. Genbank). Fig. 1 illustrates the possible hierarchy of the Australian node of GBIF, which is likely to include:

- APPD;
- Australian Virtual Herbarium (AVH);
- Australian Plant Disease Database (APDD; or formerly, National Collection of Fungi, NCOF);
- On-line Zoological Collections in Australian Museums (OZCAM); and
- Australian Biological Information Facility (ABIF; Fig. 1) (Names lists).

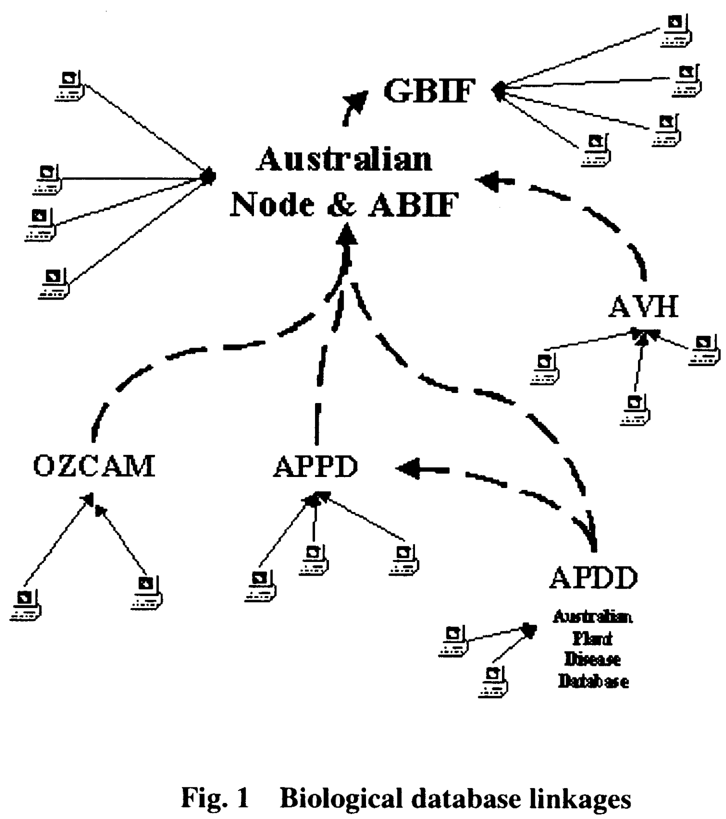


**Fig. 1 Biological database linkages**

Federal funding made available through Plant Health Australia and the in-kind contributions by the data providers supports the APPD.

## Aims & Objectives

The Australian Plant Pest Database will be a useful resource for agricultural and forest health scientists, policy makers, quarantine agencies, taxonomists and curators. It can provide detailed and verifiable information to:

- assist pest risk assessment (PRA);
- underpin statements on Australia's plant health status;
- enable rapid decision making during pest and disease emergencies (e.g. during a suspected incursion by an exotic organism);
- develop new strategies for pest management; and
- support research taxonomists, diagnosticians and curators.

The APPD development group is a unique, cross-institutional partnership. It links curators, taxonomists, software developers, plant health specialists, policy makers and peak industry bodies to create a network that is more potent than the sum of its parts.

## Methodology

The APPD began with a series of reviews during the mid 1990's and workshops (1999, 2001), involving State and Commonwealth (=Federal) Governments, collection curators and plant health scientists. This process defined the aims and objectives of the system and secured broad support, especially from data custodians.

Essential elements in the successful development of the APPD have been:

- innovative but proven internet software;
- early agreement on data standards and priorities for data capture;
- on-going guidance from a Steering Committee representing data providers, users and information technology specialists;
- coordination and management by the Office of the Chief Plant Protection Officer;
- federal funding made available through Plant Health Australia; and
- substantial in-kind contributions from data providers.

### 1. Network Architecture Development

Network architecture software was developed by CSIRO Mathematical and Information Sciences (CMIS), Canberra (CMIS 2002). The key components of the architecture include a central "broker" and a collection of individual "gateways", each tailored to the structure of local collection databases that include BioLink (using MS SQL Server), Texpress, Oracle and MS Access. Gateways are specific to each local database system and schema.

APPD user queries are distributed by the broker to the gateways. From there they are translated to a form meaningful to the local database and results returned to the broker in a standard, xml format. The broker combines the results into an html-formatted table with a downloadable distribution map, and returns these to the user (Fig. 2).

Deployment of gateway software can be varied to suit the individual needs of the IT network managers. Options include placement of gateway outside firewall with a copy of local database or deployment within firewall. It is also possible to vary the way the gateway interrogates the local database.

Access to the APPD is currently limited to data providers and plant health agencies. At present approximately 170 individuals have usernames and passwords, and it is anticipated that access will increase as more data providers join network, and confidence in the quality of the data grows.

Data providers retain ownership of their own data and responsibility for maintenance of local databases. The APPD Rules of Operation specifies the terms under which data are shared and addresses matters such as intellectual property rights.

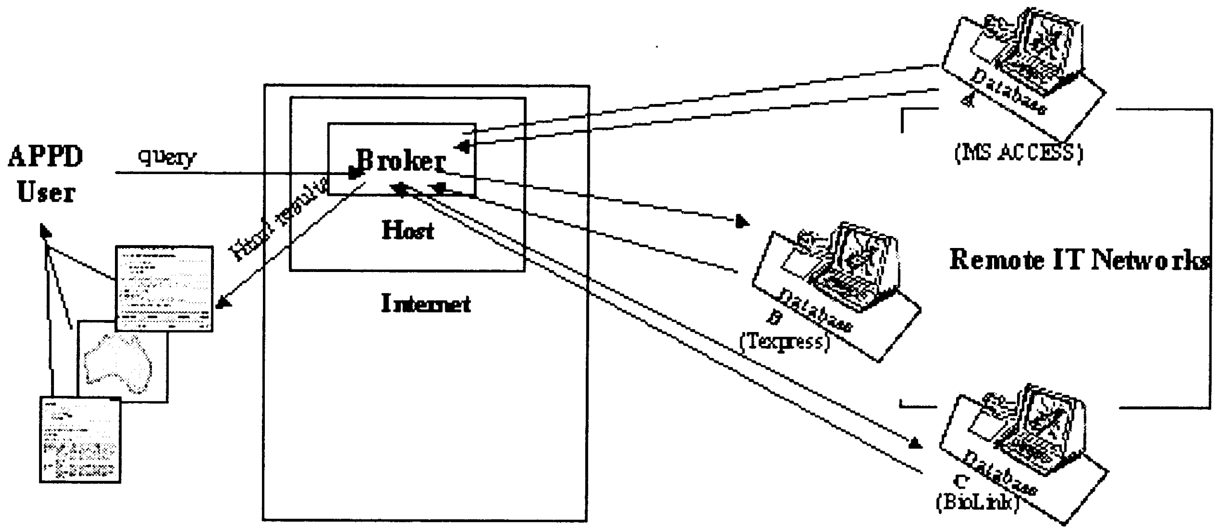


**Fig. 2 Network architecture of APPD**

## 2. Data Standards and Capture

Physical (i.e.vouchered) specimens exist for all records in the APPD. Data fields include scientific and common names; habitat; locality; latitude, longitude; host plant association; date of collection; collector; repository. The geographical scope of records is for those specimens collected in Australia (quarantine interception records excluded).

The taxonomic scope of the APPD covers pest arthropods, nematodes, fungi, bacteria and viruses (Table 1). For ongoing data capture, high priority arthropod and nematode groups (containing major pest species) were identified and funding assistance given to data providers to facilitate digitising of label data for these groups. Funding was also provided to enhance or validate pre-existing digital records. Records of taxa other than those in priority groups are also accessible via the APPD.

The APPD has also co-funded (with Rural Industries Research and Development Corporation) a study to determine how records of plant viruses can be incorporated into the APPD. The management of plant virus records from Australia are not associated with voucher specimens and would be excluded from the national information system according to current protocols used for fungal, nematode and arthropod pest records.

Environment Australia's (EA) Australian Biological Information Facility (ABIF) website has been adopted as the reference site for valid names. Joint projects have been developed with EA to address critical gaps in the ABIF website (ABRS 2002).

**Table 1. Plant pest priority taxa**

| Phylum | Class | Order | Family |
|---|---|---|---|
| Nematoda | | | Longidoridae, Trichodoridae, Rhabditida, Tylenchid families |
| Arthropoda | Arachnida | Acarina (suborder) | Tetranychidae, Eriophyidae, Tenipalpidae, Penthaleidae |
| | Insecta | Isoptera | Mastrotermitidae, Kalotermitidae, Termopsidae, Rhinotermitidae, Termitidae |
| | | Orthoptera | Acrididae, Gryllidae, Gryllotalpidae, Tettigoniidae |
| | | Thysanoptera | Thripidae, Aeolothripidae |
| | | Hemiptera | Coccoidea, Aleyrodidae, Aphidoidae, Psylloidea, Cicadellidae |
| | | Diptera | Tephritidae |
| | | Coleoptera | Cerambycidae, Curculionidae (selected subgroups), Scarabaeidae, Tenebrionidae, Chrysomelidae, Bostrichidae |
| | | Lepidoptera | Gelechiidae, Pyralidae, Noctuidae, Tortricidae |

## Timetable

50,000 records were entered into the APPD by datacapture agencies between January and June 2002. Currently the total of searchable records (at September 2002) including records from the Australian Plant Disease Database is around 500, 000, from 12 collections.

By December 2002, databases will be online from the following agencies: Victorian Department of Natural Resources & Environment, Queensland Department of Primary Industries, New South Wales Agriculture, State Forests of New South Wales, Department of Primary Industries, Water & Environment, Forestry Tasmania, South Australian Research & Development Institute/Adelaide University, Department of Agriculture Western Australia, Bureau of Sugar Experiment Stations, the University of Queensland and the Australian Plant Disease Database. Other collections will be included into the APPD at a later date, or under the OZCAM initiative.

By 2004, around 20 collections will be online with around 1 million searchable records. Fig. 3 illustrates the predicted proportional priority group composition of the APPD (excluding those records residing in the Australian Plant Disease Database).

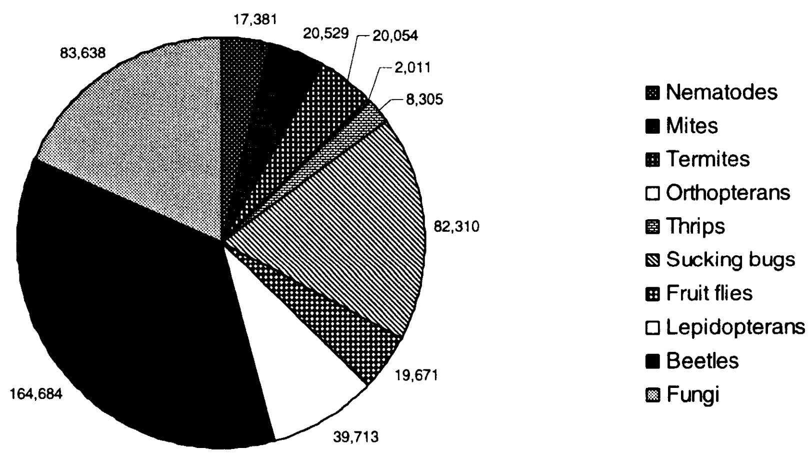


**Fig. 3 Estimated proportions of priority taxa in APPD by 2004 (excluding APDD records).**

## User feedback

Initial user survey results have been encouraging, with users finding the database highly useful to their field of expertise, easy to operate and performed the desired queries. Users were able to connect readily to the database, and queries were returned within a short period of time (Fig. 4).

The APPD has been used for the following:

- confirming plant pest and disease detections;
- establishing species host ranges;
- determining pest and disease quarantine status;
- quarantine, Import Risk Analysis and pest management;
- generation of pest distribution maps; and
- determining pest and disease ranges.

Comments from users (State and Commonwealth Governments and research organisations) have allowed CMIS to fine-tune the APPD website and software functions to users needs.

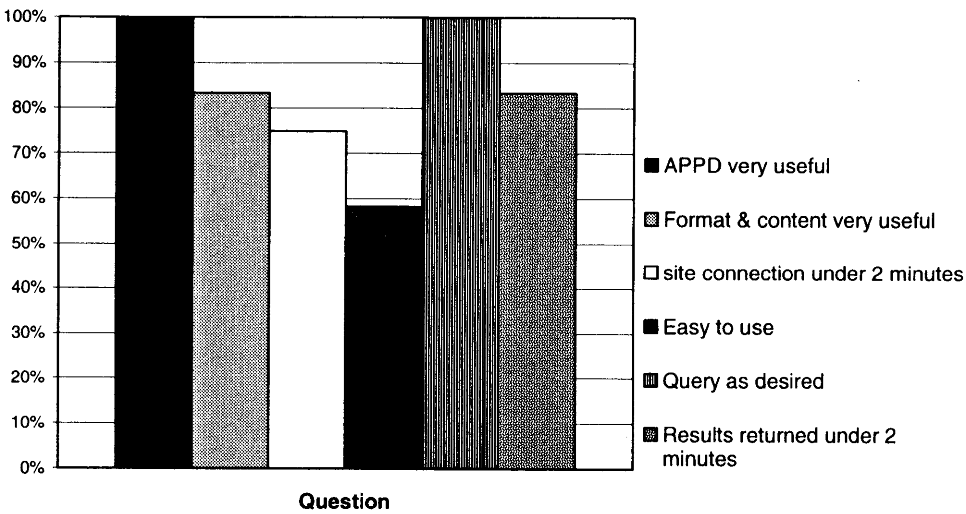


**Fig. 4 Respondent results from initial APPD useability survey**

## Case Study 1: Scientific Knowledge Base

Fruit flies (Tephritidae: Diptera) are notorious pests throughout the world, also known for the difficulties in taxonomic identification. Much identification has been based on close links between sub-families and geographic location, with response to pheromones providing taxonomic resolution at a lower level. Records consolidated by the APPD give an across-the-board picture of present fly classification and enable quick retrieval of important information about plant hosts, geographic range and response to chemical lures. Since the APPD provides collection accession numbers, specimens can easily be re-examined.

Fruit fly diagnostics is important in the international arena, and the presence of data in the APPD complements other work performed in Australia and by Australians overseas, including the identification and taxa resolution of south east Asian groups and the Australian

Biological Information Facility fruit fly checklist, supported by Environment Australian and the APPD.

### Case Study 2: Exotic Threat Preparedness & Response

Every year Australian agencies compile fact sheets on exotic pests that would pose serious risks to Australian plant industries upon importation (AFFA website 2002). The Australian Plant Pest Database is a tool for Import Risk Assessments, by indicating which exotic pests have not been reported in Australia.

The APPD may also be used to develop responses to suspected invasions of exotic pests. For example, in 2002, a new record of an apple disease *Alternaria mali* was notified to the Office of the Chief Plant Protection Officer. New taxonomic information had indicated that the disease might have been recorded as *A. alternata* and *Alternaria sp.* Scientists from the OCPPO searched the APPD fungal and host records, analysed symptom information and were able to determine that *A. mali* was already established in Australia. The Plant Health Committee (the key national decision making body), then agreed not to proceed with further emergency response.

### Case Study 3: Pest Biology

*Helicoverpa armigera* and the related *H. punctigera* are two of Australia's worst insect pests, due to their wide host range of economically important plants. In Australia, the species are estimated at causing $A200 million in annual damage and control costs in cotton alone (Wilson 1982; Twine 1989).

A search of the APPD reveals, for example:

- whether there are any regional differences in seasonality or host preference (as has been discussed for heliothines elsewhere, leading to different economic impacts);
- which alternate host plants might serve as "refugia" in managing resistance to transgenic cotton;and
- Fig. 5 demonstrates some of the return result options available through querying the APPD.

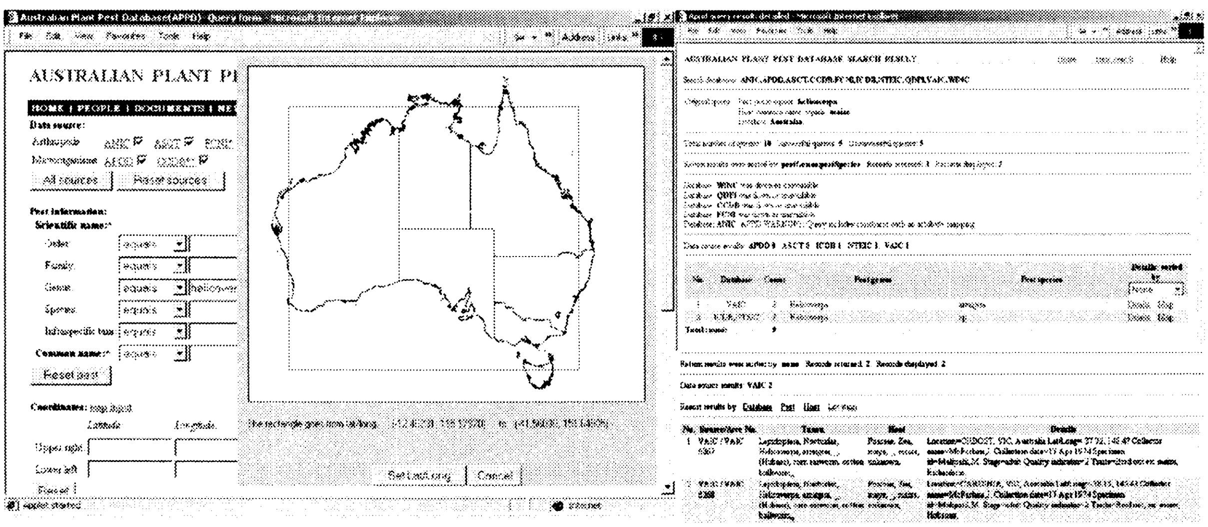


**Fig. 5 Examples of data output through (multidimensional) querying of the APPD.**

## Case Study 4: Pathogen host range

The Department of Agriculture Fisheries and Forestry - Australia (AFFA) uses APPD data to support pest risk assessments on commodities that other countries want to export to Australia. AFFA also makes extensive use of the APPD to underpin its negotiations with other countries when Australian industries are seeking access to new markets. This use is illustrated here by a map showing the citrus production areas in Australia overlaid by records of detections of *Guignardia citricarpa* (black spot) on citrus fruit (Fig. 6). The absence of records of the pathogen in inland production areas supports claims that citrus in these areas are free from the disease. Records built up over time provide confidence in the claim for area freedom.

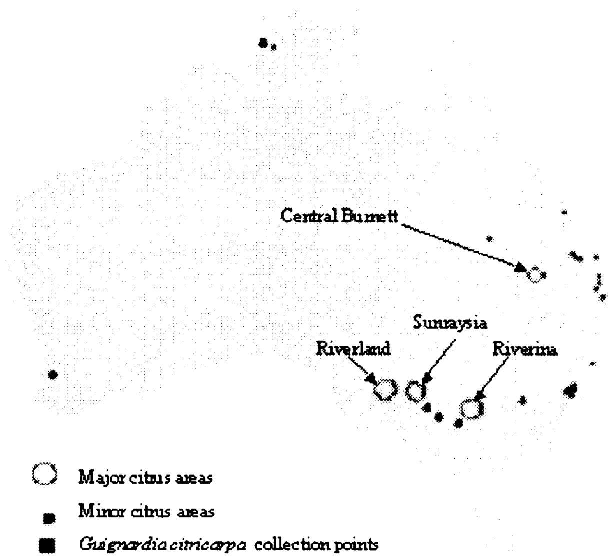


**Fig. 6 Comparison of citrus growing areas against collection records of the citrus disease, *Guignardia citricarpa.***

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# A Web-based Biodiversity GIS Using a Robust Geo-coding Algorithm

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## Abstract

**For conservation of ecosystem and sustainable use of biological resources, development of a specimen database is quite important. In order to know distributions of species, it is necessary to create a visual distribution map from place descriptions included in specimen data (a habitat, extraction ground, etc.) Therefore, creation method of the place name dictionary (i.e. gazetteer) for analyzing ambiguous place descriptions and robust geo-coding technique using the gazetteer are proposed. We also implemented a Web based map browser for the specimen database.**

***Key Words : Gazetteer, GIS, Geocoding, Web browser***

## Introduction

In these 20 years, industrial development are rapidly proceeded in developing countries. For shortage of money and technologies, precious natural eco-systems in these regions are disappearing without sufficient biological survey. This is the reason that completing "species database" is a urgent problem. Especially, specimens which belong to national or local museums are quite valuable to understand their ecological systems.

Besides, there are no global standard ways to describe specimen information; in other word, specimen databases are heterogeneous collections. Some items in one collection are not found in another, thus exchanging information beyond both country and biological group is often difficult. However, there are some common information such as scientific name, sampling date and location. We focused on the locality information to create distribution map of specimens, in order to understand species habitat intuitively and to analyze by GIS with other environmental information like climate and soil.

The major problem to create distribution maps is the location descriptions are very vaguely in fact. Thus, distribution maps had to be created by manually, and cost started too much. To resolve this problem, we developed a geo-coding algorithm utilizing gazetteers highly, which is enough robust that can convert vague place descriptions into geographic coordinate values such as longitude and latitude. In the developed system based on this algorithm, it succeeded in converting nearly 90% records and in creating a sufficiently practical distribution map from the fresh water fish specimen database which contains 28,423 records possessed by the National Science Museum of Japan.

## Creating Gazetteer

In order to perform highly precise conversion from the ambiguous name of place descriptions, a notable gazetteer with the abundant amount of information is needed. In the case of the fish specimen database, there are many examples which described the place in the set of a river name and a city name. Thus, we proposed a simple algorithm to create a gazetteer which will contain central points of river segments. This is necessary because, for example, the name of a place "Tokyo, Meguro-ku, Kitazawa-gawa" will be converted to the

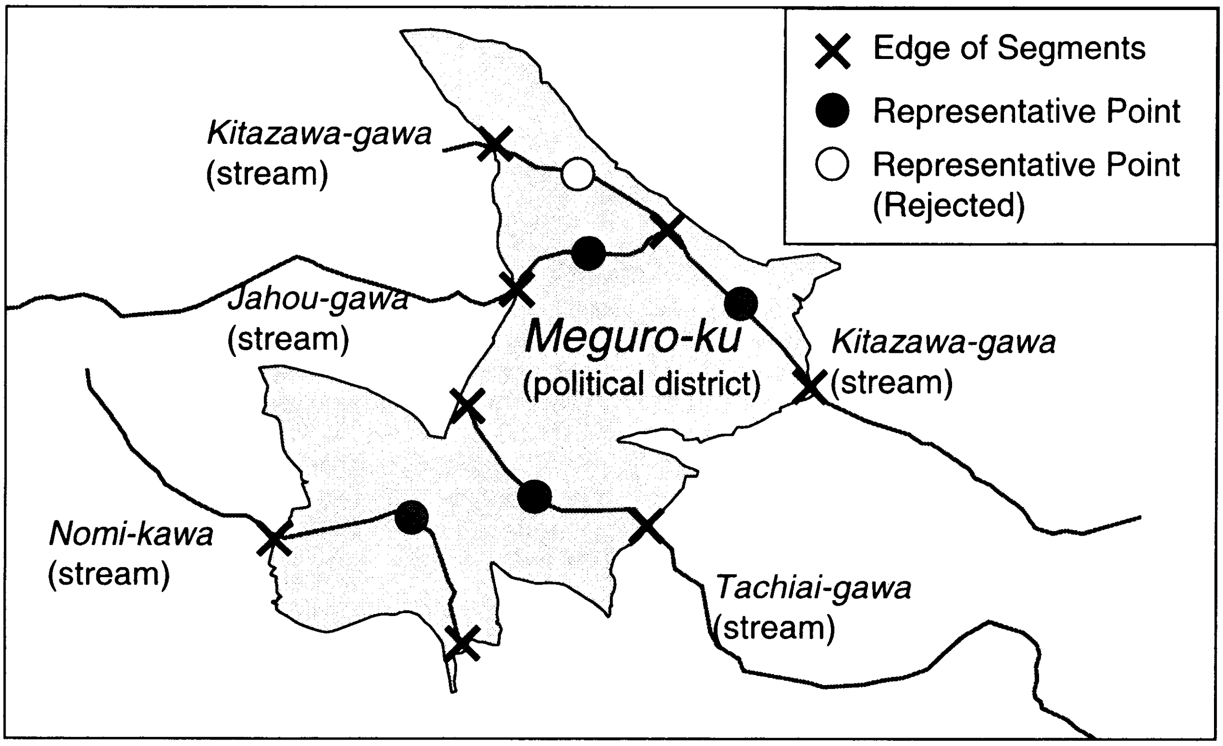


**Fig.1 Representative Points Created from Water System Network**

center point of Meguro-ku, not to on the Arakawa-River if the gazetteer doesn't contain river information. (Tokyo is a name of prefectures; Meguro-ku is a hierarchical administrative areas in Tokyo, Kitazawa-gawa is a name of a stream.) Fig.1 shows 5 representative points created from 4 streams and 1 political district, including 1 rejected representative point. Each point's coordinate values with their names are registered to the gazetteer. The algorithm to calculate these points are implemented as below.

**Algorithm 1, Creating Gazetteer**

1. Dissolve every water system line elements, such as rivers and streams, into line segments by cutting them at each confluence. In fig.1, Kitazawa-gawa is cut by Jahou-gawa, and 5 line segments (western part of Kiatazawa-gawa, eastern part of Kiatazawa-gawa, Jahou-gawa, Nomi-kawa and Tachiai-gawa) are obtained as result.

2. Cut every line segments by polygons which define political regions. Fig. 1 shows a political district (a ward) Meguro-ku in Tokyo city. Every line segments are cut by this polygon, at cross marks.

3. Calculate center point of each line segments. These points will represent stream in the area. For example, most left point in fig.1 represents Nomi-kawa in Meguro-ku district. Thus, specimens whose label says they were picked at Nomi-kawa in Meguro-ku, will be located at this point by geo-coding process.

4. Remove duplicities. There may be some points which represent the same stream and area. In fig.1, there are 2 points represent Kitazawa-gawa in Meguro-ku. In this case, the point which was created from the longest line segment will be selected.

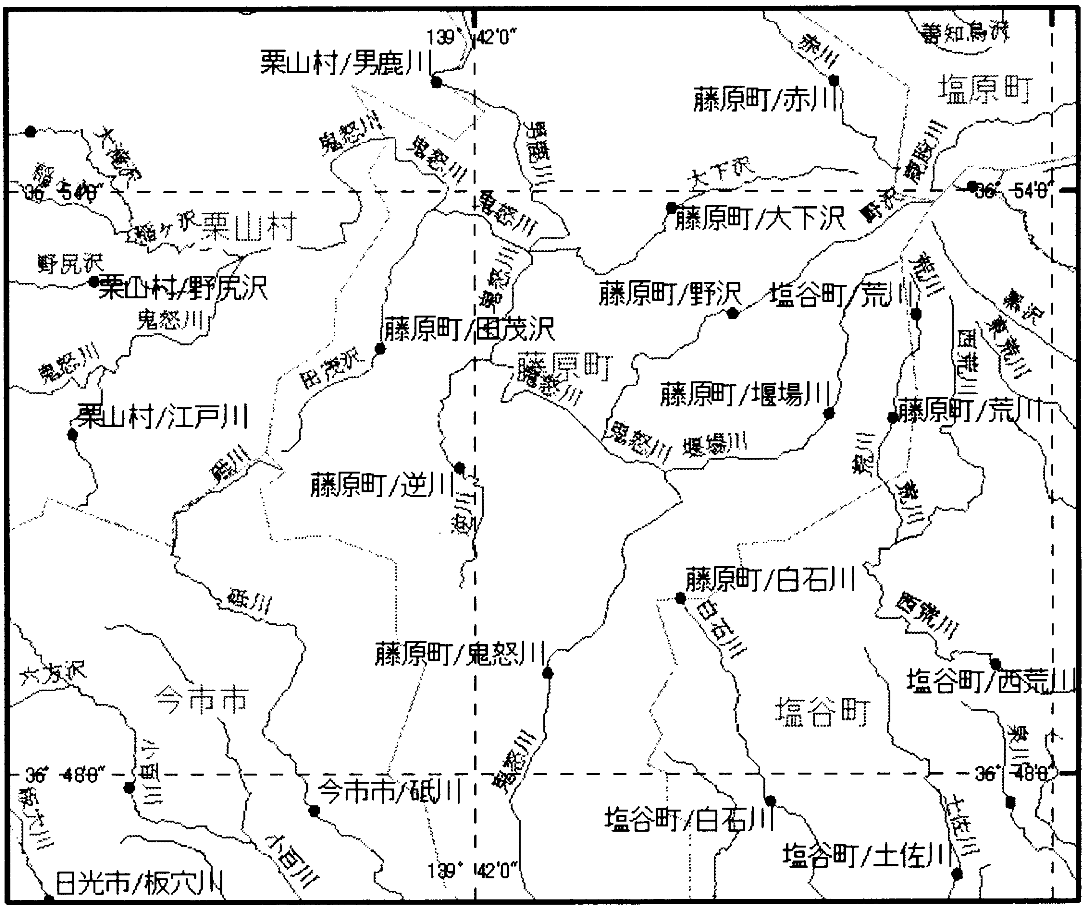


**Fig. 2 Distribution of Representative Points around Kinugawa in Fujiwara-tyo**

5. Repeat step 1 to 4 for every line elements and polygons.

Fig.2 shows representative points distribution around Kinu-gawa river flowing in Fujiware-tyo area, created by the proposed algorithm. This figure indicates each stream has its representative point at adequate location.

After adding place names of public facilities and famous location names of Japan which was created by the Geographical Survey Institute, the proposed algorithm generates a gazetteer with more than 500,000 records.

## Robust Geo-coding Method

Name of a places will sometimes be written in order of "a *river name,* a *city name*", and sometimes in order of "a *city name*, a *river name*." Additionally, various pause characters, such as commas, colons, and blanks, are used between the each words. To convert all these descriptions effectively, we adopted the following algorithm. In the following explanation, "direct geo-coding" means normal geo-coding method which simply compare location name and character strings in gazetteer.

### Algorithm 2, Robust Geo-coding

1. Divide the name of a place description into a set of words.

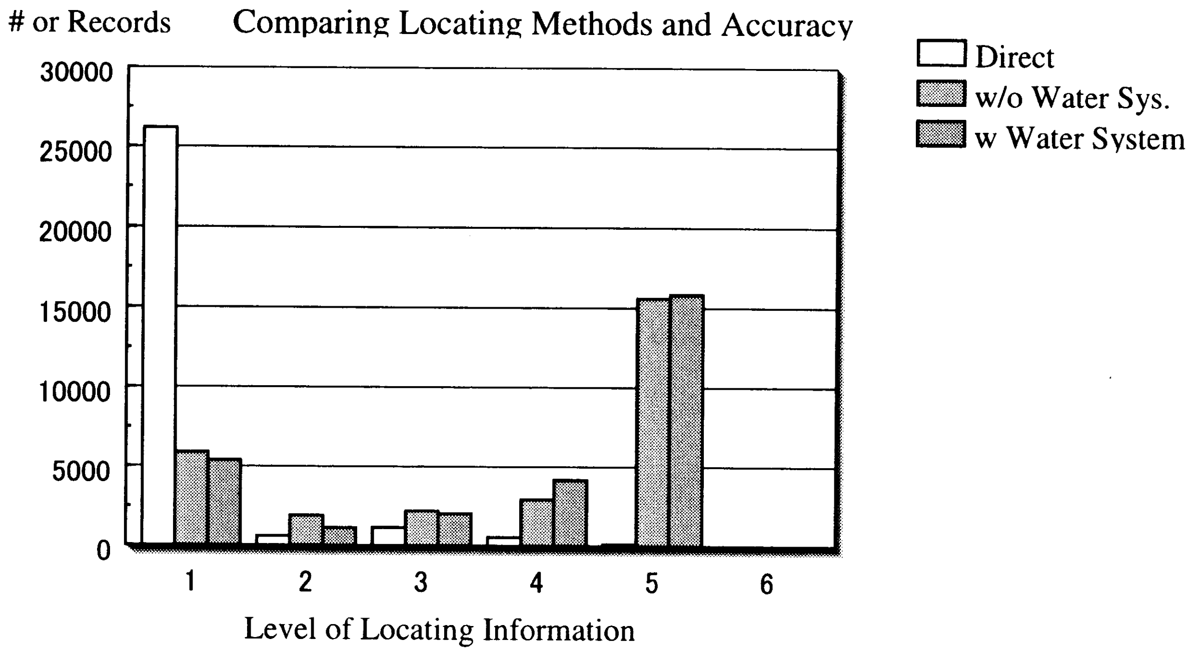


**Fig. 3 Comparing Geo-coding Methods**

2. For every possible combination of words, apply direct geo-coding method for conversion. Some combination will make high score when the order of words is same as address description in the gazetteer, besides others will make very low score.

3. Pick up the combination which make highest score. It can be converted most accurate by the gazetteer.

Using this algorithm, accuracy improved remarkably than the direct geo-coding method. In our experiments using the specimen database, more than 30% of records are located more accurate. This algorithm is not only effective to utilize of the existing database, but also as an input support tool at the time of creating a new database.

Fig. 3 shows the experimental results comparing direct geo-coding method ("Direct"), proposed geo-coding method using gazetteer without representative points created from water system network ("w/o Water Sys."), and proposed method using gazetteer with representative points created from water system network.("w Water System") Using direct method, more than 80% data were simply located to center of each prefecture (Level 1), even though they include name of river or name of city, because the order of descriptions are not same as them in the gazetteer. In Japanese address system, Level 1(Prefecture level) possible contain about 100km error, thus the result is not sufficient and useful.

Using proposed method, nearly 60% data were located to more accurate points such as cities (level 2) and words (level 3). Generally level 2 may have 10km error, and level 3, 4, 5 may have 2km, 500m, 100m error. Therefore, if the result will be shown in national map, level 3 or higher are able to considered enough accurate. Level 4 or higher are sufficient for spatial analyze.

Fig. 4 shows the distribution of fresh water fish specimen in the National Science Museum of Japan, geo-coded by the proposed method.

## A Web-based Biodiversity GIS

Distribution maps of specimen data are not only useful for researchers, but also interesting for ordinary persons who are interesting in sustainability of natural environment. The Internet is one of the best tools to open the information to public, because it becomes popular even in developing countries. However, commercial WWW based mapping systems are generally very expensive, requiring well trained technicians to install and maintain. For most biologists who just want to publish their data for free via the Internet, these commercial systems are unaffordable for their purposes.

Therefore, as a prototype system, we developed a Web based GIS for publishing distribution map with search interface via the Internet. Since this system uses SVG (Scalable Vector Graphics) technology for displaying maps, it can simply enable to overlay two or more distribution maps which were created from different databases, or to overlay environmental maps such as elevation, climate and so on. This capability is highly useful for researchers in biology and taxonomy who don't need to have special knowledges of GIS, and who just want to comprehend geographical distributions of species.

Fig.5 shows the client side interface of developed system. Users can retrieve species by common name or scientific name; family name, genus and species. Additionally, in the map area, users can zoom in, out and scroll by simple mouse operations. As a result of retrieval, color points are shown on the map ( fig.5 is showing the result of retrieving family, *Bagridae* ). Each color means each species, thus the user can intuitively understand their spatial pattern.

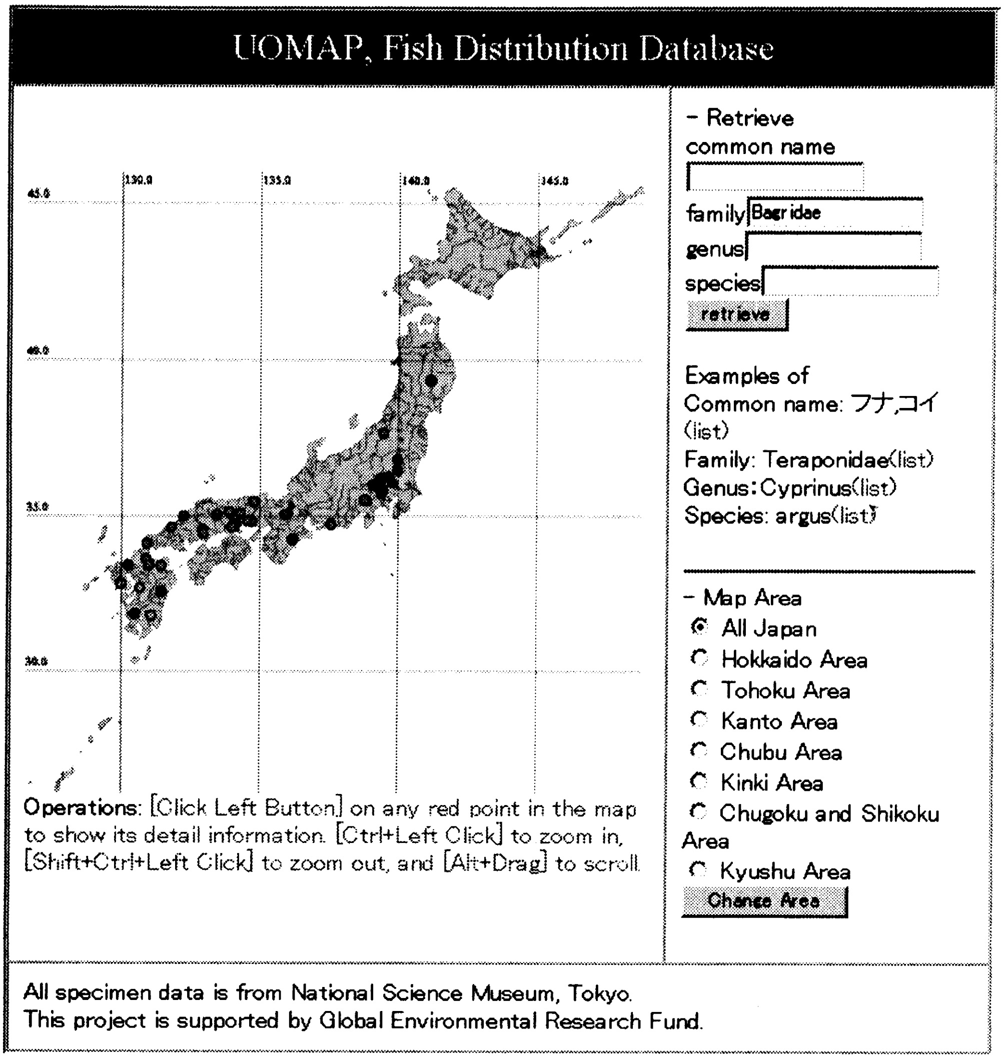


**Fig. 5 A prototype implementation of Web based GIS**

## Results and Discussion

First, we proposed a robust geo-coding algorithm for locality descriptions in specimen labels, confirmed its effectiveness by implementing the algorithm and applying for fresh water fish database which belong to National Science Museum of Japan. As a result, distribution maps of specimen are obtained. Second, for publishing the distribution map, we developed a simple Web based GIS using SVG.

Currently, the proposed geo-coding method can convert the name of places only in Japan, thus we plan to enrich the gazetteer in Far East and South East Asian area, where is behind in creating databases of biodiversity information.

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# The implementation of database applying Nomencurator schema and the development of the user interface for it

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## Abstract

**A schema that enables global searches on multiple sites, including specimen databases, scientific name databases, geographic information databases, etc., is necessary to carry out biodiversity informatics toward conservation biology. With regard to the scientific name databases, it is especially important to pursuit the transitions of names, which are the results of synonymization, transferring of a species to another genus, and so on. Nomencurator is a data structure that has been proposed to achieve this purpose (Ytow, Morse & Roberts, 2001). Nomencurator enables storage and handling of multiple views on taxonomic system. To make a good use the Nomencurator s data structure, however, the database, implemented with it, and a user interface are necessary. We have been studying the implementation of the Nomencurator data schema on RDBMS, in addition to the development of the interface for publication via networks, utilizing XML, SOAP and JDBC. The application of scientific names or to compare multiple taxonomic systems by making a good use of the characteristics of Nomencurator.**

***Key Words: Database, XML, Web service***

## Introduction

In recent years, connection with progress of biodiversity research, maintenance of biodiversity information databases is very important. There are a specimen database, a scientific name database, a Geographic database, as bio information database. Especially in biodiversity analysis, a scientific name information database serves as most fundamental information, and it is most important matter. However, in description of a scientific name, or the classification of a scientific name, views tend to differ for every taxonomy person. Therefore, it is difficult to unify scientific name information systematically.

The Nomencurator schema is proposed as a definition method between such different scientific name. In this paper, the technique of having used XML and SOAP is proposed as mounting by RDB of this Nomencurator schema as mounting called TaxoNote Java Application as an interface for public presentation of a scientific name information database.

## Schema

Various classification systems are used for expressing the same classification system depending on a field or a theory, and various classification systems from which a view differs for every taxonomy person were not able to be registered as they were in the conventional scientific name information database. Therefore, it is difficult to build the unific database about the scientific name information which becomes the most important on taxonomy originally. Now, the separate database is built and employed for each field.

The Nomencurator schema is proposed as a schema treating such taxonomy information. This Nomencurator schema is a schema which can permit the difference during a different scientific name description. It can treat them without a problem, even when various classification systems exist to one kind. However, it is a schema on the concept of a Nomencurator. Then, how to mount this Nomencurator as RDB is considered(Fig.1).

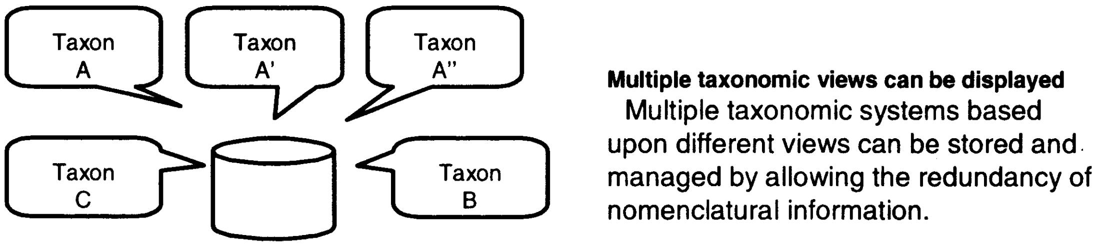


**Fig.1 Nomencurator data structure implemented on RDBMS**

## Application

The Nomencurator schema itself is a logic data structure on a concept. Therefore, this needed to be made to apply to RDB which is physical structure. The table of RDB was created for every object defined by the Nomencurator schema. In making it physical structure, it did not consider as special structure so that operation with a common database might be attained, but it considered as simple composition.

The link between the objects currently expressed on logic structure .following Fig.2 for RDB.

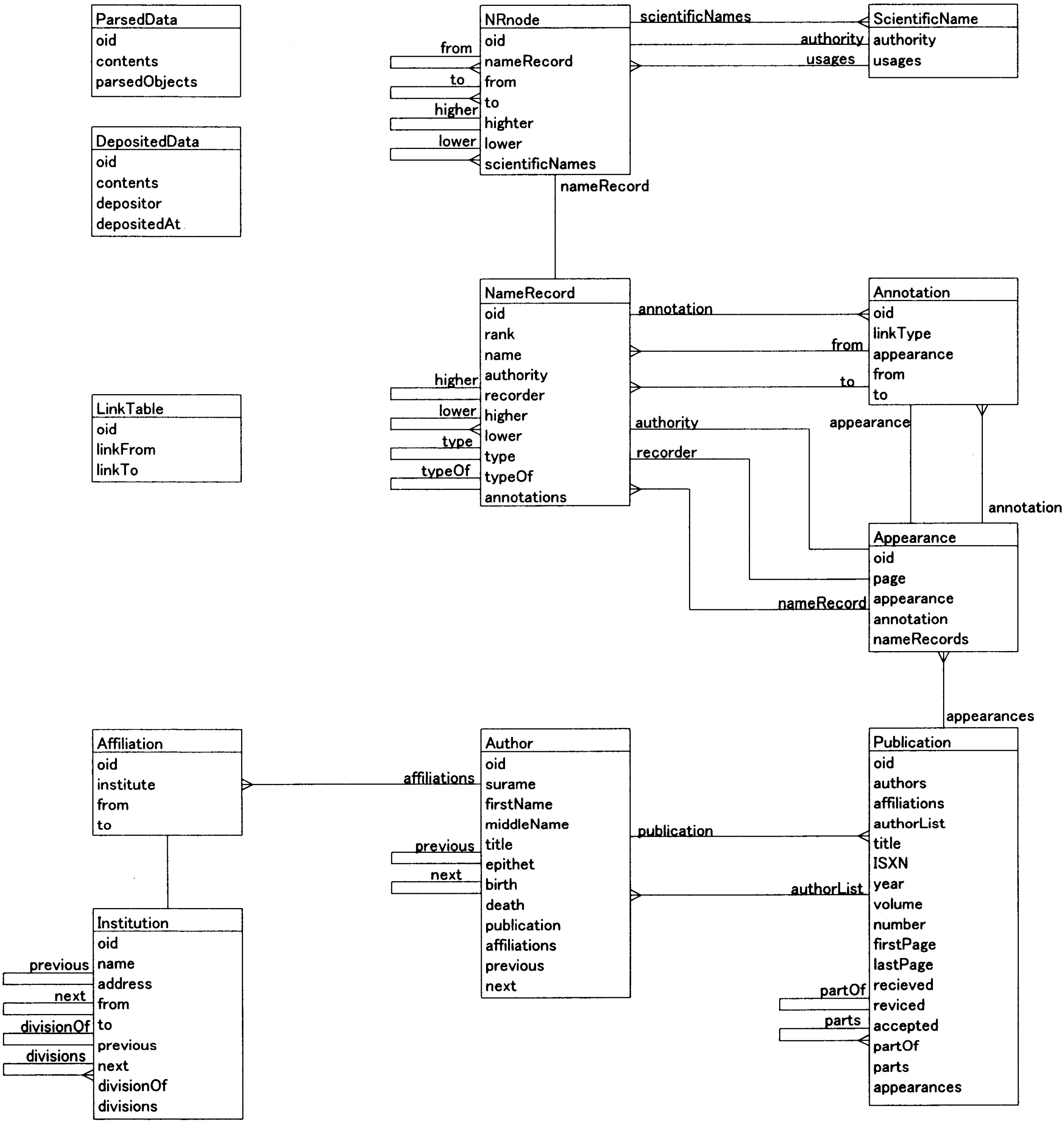


**Fig.2 Nomencurator ER Diagram**

## XML,SOAP,JDBC Interface

In TaxoNote Java Application, the interface of XML or JDBC is used as an interface for access to a database (Fig. 3). This is from the idea which can exhibit widely access to the database which used the Nomencurator schema in the future. It accesses using http and data is acquired by calling Servlet by the side of a server. The SOAP can do easily the data used for communication of data for XML.

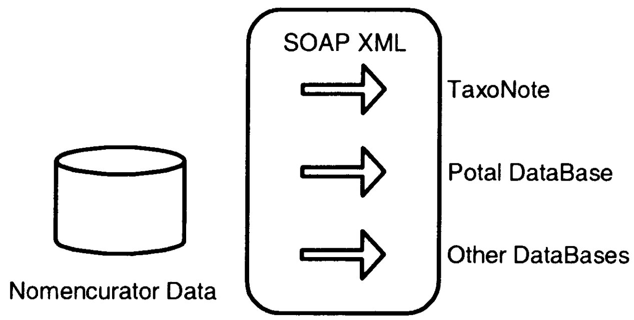


**Fig.3 Nomencurator ER Diagram**

It is carried out by calling API to the database server which used the Nomencurator schema for access to actual scientific name information. The object of scientific name information is acquirable in XML form with these two APIs.

getNamedObject
saveNamedObject
searchNameUsage

In addition, if API was constituted intricately, since it had to stop having to prepare API for every pattern of all data accesses, three APIs were defined as simplest form.

GetNamedObject API is API for object acquisition, and can call the object defined by the Nomencurator schema based on OID.

SearchNamedObject API is API for object preservation, and can save in a database the object defined by the Nomencurator schema by transmitting in XML form.

Each scientific name information is defined by form like Fig.4 by XML, and can be acquired using API. By the TaxoNote Java Application side, the contents of each object are actually parsing of the XML data acquired from the server.

SearchNameUsage API is API which searches scientific name information. As a key which searches a classification system with TaxoNote Java Application, a scientific name, a publication year, and author are defined and view of a classification system can be extracted by using these information as a key. Usually, in case information is displayed by TaxoNote Java Application, view of the classification system used as this bundle will be used. The call sequence of each API is the passage of Fig.5.

-<NameUsage>
- <oid>NameUsage::B1000000151</oid>
- <rank>species</rank>
- <name>Burkholderia andropogonis</name>
- <authority />
- <appearance>Appearance::B1000000047</appearance>
- <higher />
- </NameUsage>

**Fig.4 Description of nomenclatural information with XML**

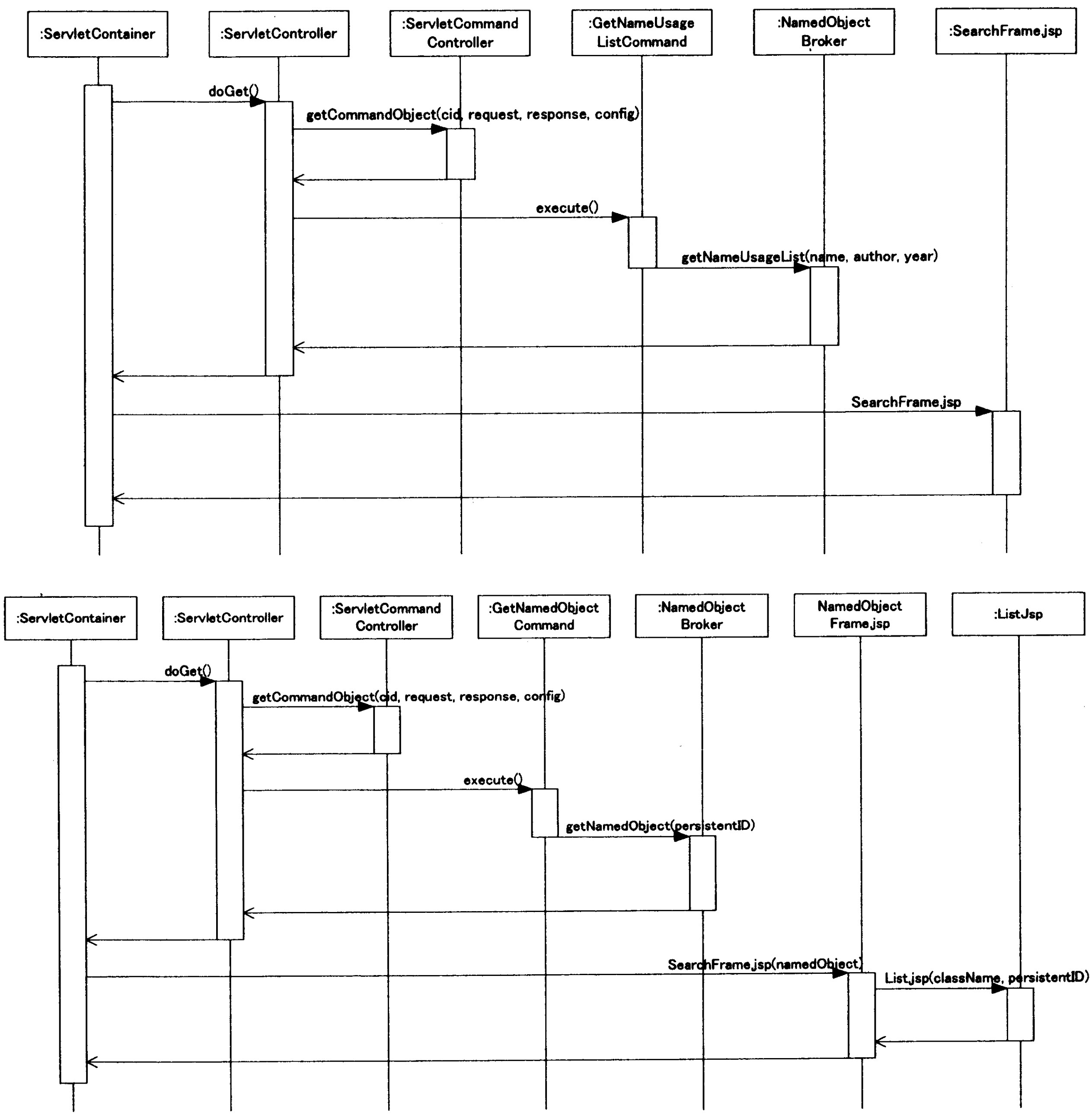


**Fig.5 Data access sequence**

## Comparison of taxonomic view

It is difficult for a Nomencurator schema to express the scientific name information based on although data expression can be carried out two or more such views by the expression method of the former to a certain scientific name information which it is between different scientific name description. For example, there is GUI of tree form as GUI used for expression of a classification system from the former. (Fig. 6) Although this system is used also by TaxoNote Java Application, it is difficult to compare and express two classification systems. In TaxoNote Java Application, in order to express the data during a different scientific name description more effectively as the expression methods other than tree form, GUI expression like Fig.7 can also be used.

It is possible by specifying two or more classification systems by this expression method to output clearly the differences (family, genus, species, etc.) for every class.

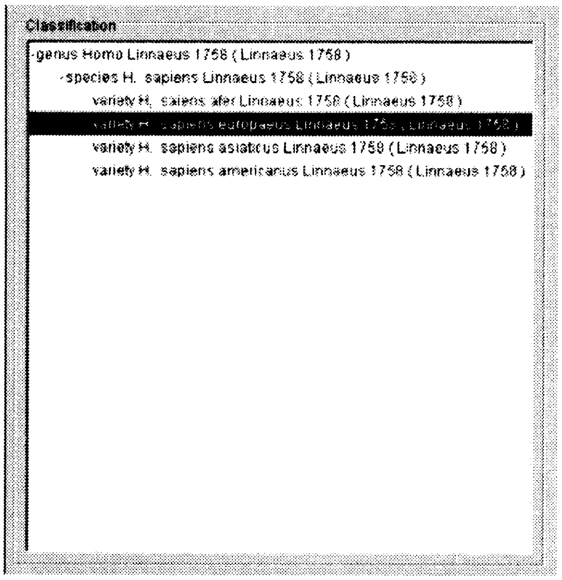


**Fig.6 Data access sequence**

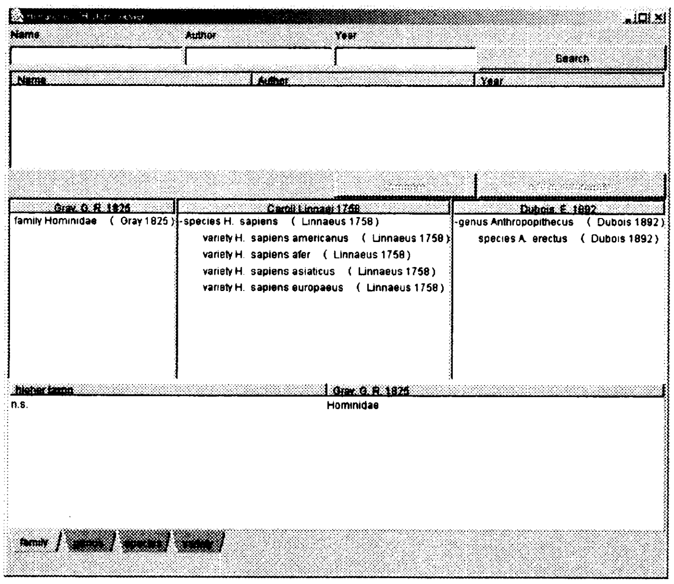


**Fig.7 Data access sequence**

## Conclusion

In this paper, the technique for mounting the Nomuncurator schema expressing between different scientific name description by RDB and the expression technique between the interface which exhibits them by XML-SOAP, and a different scientific name description were proposed.

Practical use of taxonomy information will be more easily urged to the open method of such taxonomy information, and it enables cooperation of the database in the large area using the Internet. This is applicable to cooperation of a specimen database, a scientific name database, a Geographic database, etc. in research of biodiversity.

It is improving this mounting in the future, and it is thought that dealing with Web Service easily is possible, and the seamless cooperation with all scientific databases is attained.

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# Biodiversity Informatics in Germany: ongoing projects and their possible contribution to the Global Taxonomy Initiative (GTI)

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## Abstract

**Several major biodiversity informatics projects in Germany can be considered as important modules for building up the national Global Taxonomy Initiative. Examples are the Entomological Data Information System (http://www.insects-online.de/), which will bring together important entomological collections housed at different museums within one "Virtual Museum" (for Orthoptera: see http://www.dorsa.de). Another example is the "Global Register of Migratory Species" (http://www.groms.de), a cross-sectional database and geographical information system, specialising on migratory species. Finally, there is the "Inventory of biological research collections in Germany (ZEFOD)", collecting metadata on biological collections in Germany (www.genres.de/zefod).**

***Key Words: Biodiversity informatics, museum collections, migratory species***

## Introduction

European museum collections contain important type material from all over the world, and therefore play a key role for any taxonomic work based on these reference collections. Traditionally, taxonomists made a “pilgrimage” to visit the collections relevant for their group of interest, to examine and photograph type specimens. With the rise of the WorldWide Web, it is possible to provide museum information on-line, thereby facilitating access to lists of type material, pictures or any other information related with type specimens. Due to the federal political landscape of Germany, there are several museum collections of similar importance, which means that the material is even more scattered than in other European countries, such as Britain and France (Fig. 1). By digitising this scattered information, it can be published on the WWW as one “Virtual Museum”, facilitating access and provide a “virtual centralisation”.

As an example, I present the EDIS- project (Entomological Data Information System), highlighting data sets elaborated by the sub-project DORSA, which is digitising Orthoptera type specimens housed in German museums. EDIS forms part of a major German Research & Development network supported by the German federal ministry of education and research (www.bmbf.de) called BIOLOG (Biodiversity and Global Change), focussing on terrestrial biodiversity research and biodiversity informatics. The sub-programmes on biodiversity informatics are organised into clusters focusing on groups of organisms, such as fungi, higher plants and insects. Applied fields are represented (e.g. phytopathogens), as well as molecular systematics (for details, see http://www.bgbm.org/BioDivInf/biolog/Projektliste.htm). It is evident that all of its bioinformatics components are relevant both for the Global Taxonomy Initiative (GTI) and the Global Biodiversity Information Facility (GBIF).

In addition, there are several on-going biodiversity informatics projects focussing on conservation biology, supported by the Federal Environmental Ministry (www.bmu.de) through the Federal Agency of Nature Conservation. As an example, I describe the Global Register of Migratory Species (GROMS: www.groms.de), which has been designed to support the UNEP Convention on the Conservation of Migratory Species of Wild Animals (CMS: http://www.wcmc.org.uk/cms/).

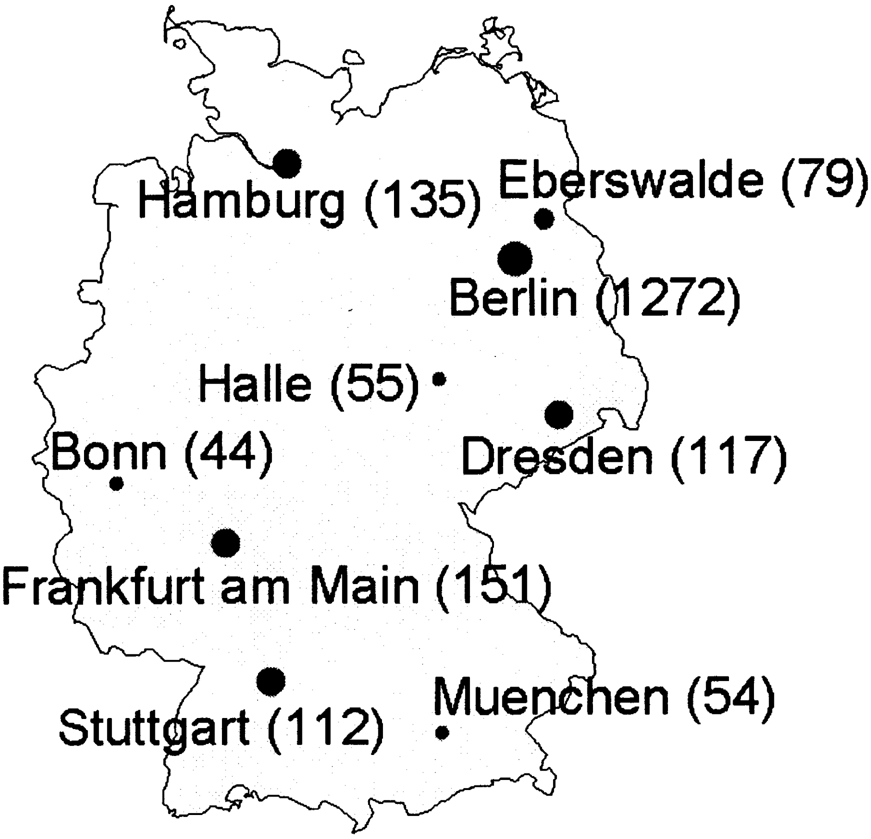


**Fig. 1 Orthoptera (crickets and grasshoppers) collections in Germany – number of holotypes in major museums. A similar distributed pattern is observed for type material of other groups of organisms housed in german museums or research institutions.**

## Collection databases: EDIS - DORSA

The Entomological Data Information System (EDIS: www.insects-online.de) is supported by the German Federal Ministry of Education and Research to provide access to relevant information about insects and other arthropods for research and the general public and to promote digitisation of the data distributed over various entomological collections in Germany in a comprehensive database. DORSA (Deutsche Orthopteren-Sammlungen -German Orthoptera Collections) is a specimen based database with internet access to the Orthoptera held in German museum collections including geographic information on a world-wide basis as well as media data like illustrations of type specimens and sound recordings ("Virtual Museum"; overview: Lampe and Riede 2001). The aim of the sub-project DORSA is to provide database access to important Orthoptera (grasshoppers and crickets) specimens in German research collections. DORSA will be internet-linked to the global species database 'Orthoptera

Species File' (OSF: http://OSF2.orthoptera.org/basic/HomePage.asp), which provides the taxonomic backbone of the specimen database (for a comprehensive description of OSF, see Eades 2001). DORSA includes multimedia information such as pictures and insect sounds (December 2002: 4,000 sound files and 20,000 pictures). ). Based on the DORSA song database, a rapid assessment tool is developed for automated song recognition (Dietrich et al. 2002)

As a first result, the majority of type specimens in German research museums has been checked and databased. Mapping of type distribution on a country level reveals a focus of German collections on South East Asia and Australia (Fig. 2).

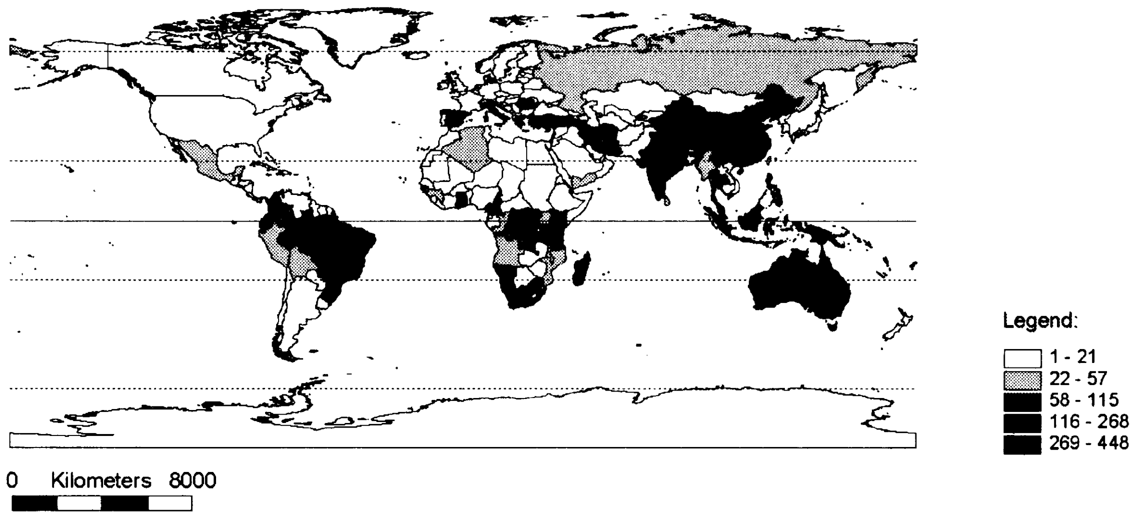


**Fig. 2 Distribution of Orthoptera type specimens (including Para- and Lectotypes) housed in German Museum collections. Note the high number of types from Africa, South East Asia and Australia, collected in the last centuries and described by F. Karsch (1891a, b, 1893), W. Ramme (1929, 1940) and Y. Sjöstedt (1921, 1935) [only major papers].**

Locality information is now refined further by geo-referencing localities, which can be visualised by a Geographic Information System (GIS). A web-based GIS mapping tool is already available at www.dorsa.de. It is based on approximately 1,200 localities of katydid (Tettigonioidea) sound records made by K.-G. Heller (cf. Willemse & Heller 2001).

## Meta-Databases: ZEFOD

The example from EDIS-DORSA presented above illustrates the complex situation of botanical and zoological collections in Germany. Analysis and web-presentation of these collections has reached different stages of progress. Meta-data giving an overview of collections are presently collected by ZEFOD ("Inventory of biological research collections in Germany" (ZEFOD) - www.genres.de/zefod). The aim is to provide structural and content-oriented descriptions of biological collections in Germany, to be published as an expandable, interactive information network for a broad range of users in science, administration and the general public. ZEFOD is part of the BIOLOG network. In addition, ZEFOD is constituting the national node for the European BioCASE ("Biodiversity Collection Access Service for Europe", see also Güntsch et al 2001) and is a direct contribution to international initiatives like the Global Taxonomic Initiative (GTI)', the Convention on Biological Diversity (CBD), and the 'Global Biodiversity Information Facility (GBIF)'.

## Conservation database: GROMS

Among the major long-term goals of biodiversity informatics is to provide data for conservation. Meanwhile, conservationists have established a parallel universe of information infrastructure, mainly focussing on vertebrates and environmental data (Tab. 1).

**Table 1. Examples of major information networks focussing on conservation. Most of those are focussing on higher vertebrates**

| Acronym | full name | Website | focus | type | Status |
|---|---|---|---|---|---|
| BCIS | Biodiversity Conservation Information System | www.biodiversity.org /simplify/ev.php | networking | framework; network, conservation | In progress |
| BLI | BirdLife International | www.birdlife.org | Threatened birds, Important Bird Areas | expert network, database | Book publications, web fact sheets |
| IUCN Red List 2000 | IUCN Red List 2000 | www.redlist.org | Threatened species | Database | Published on Web and CD |
| IUCN SIS | IUCN Species Information Service | www.iucn.org/theme s/ssc/sis/sisuse.htm | species data sets, threat analysis, customised products | information system based on expert network | planned |
| UNEP-WCMC | UNEP World Conservation Monitoring Centre | www.unep-wcmc.org .uk/ | environmental data, information brokerage, species database | Organisation, databases, GIS environmental datasets | multiple information services, including species databases for CMS and CITES |
| FishBase | FishBase | www.fishbase.org | A Global Information System on Fishes | Database, network | Published as CD, book and Web |

One of the main users for these products are the secretariats of Multilateral Environmental Agreements committed to species and habitat conservation, such as Ramsar, CITES and CMS (Ramsar: The Ramsar Convention on Wetlands: www.ramsar.org; CITES: UNEP Convention on International Trade in Endangered Species of Wild Fauna and Flora: www.cites.org; CMS: UNEP Convention on the Conservation of Migratory Species of Wild Animals: http://www.wcmc.org.uk/cms/). In the mid-1990s, the CMS Secretariat became aware that scientific information on migratory species within the CMS definition was scattered and very difficult to collect. With the development of new technologies such as increasingly powerful computers, networks and the Internet, the idea was born to develop a special database that could become the focus for any research on migratory species. The aim was to have this database provide an additional tool for fact finding and decision-making by the bodies of CMS and related regional Agreements and Memoranda of Understanding (MoU). It was also intended that the database would be available on the Internet to serve as an additional information tool on migratory species within, *inter alia*, the Clearinghouse Mechanism of the Convention on Biological Diversity (CBD).

The database has now been published on the WWW (www.groms.de) and as a CD-ROM, together with an extensive report (Riede 2001). Because migration is observed in a wide variety of species,

distinct information sources had to be evaluated, ranging from species databases to GIS datasets. The experiences gained during data integration for such a cross-sectional database might be useful for the ongoing process of harmonising biodiversity informatics initiatives. At present, GROMS has concentrated on migratory vertebrates, but even within this comparatively well-studied group major inconsistencies concerning taxonomic reference lists were observed (Fig. 3).

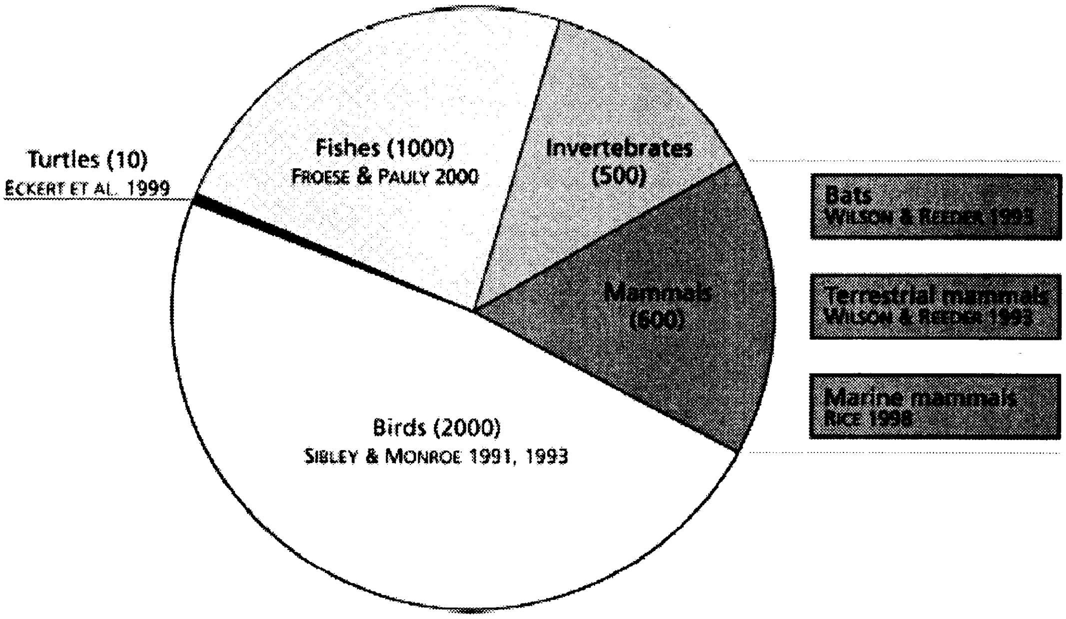


**Fig. 3 Taxonomic reference lists used by CMS, the GROMS and several other conservation databases. In brackets: number of migratory species.**

For fishes, the taxonomic backbone provided FishBase (www.fishbase.org) was an excellent starting point. Because it is available as a database on CD-ROM, transfer of species names was easy. Therefore, GROMS could concentrate on its core task: identification and key-wording of the migratory status of fishes as diadromous, anadromous, or oceanodromous (McDowall 1988). Future data exchange between both databases is facilitated by a direct hyperlink, which allows switching from GROMS to Fishbase on the World Wide Web.

For birds, considerable nomenclature differences complicated data exchange with a variety of sources, requiring management of synonyms and parallel taxonomies. Given the huge number of ornithologists, and the comparatively low number of unknown species, it is strange that there is still no „Birdbase“ available. Taxonomic problems were even worse on the level of subspecies, where the GROMS seems to provide the first digitally available subspecies list of migratory non-passerine birds. Such a higher taxonomic resolution is necessary for an adequate assessment of migration behaviour, which differs between populations. Therefore, effective conservation plans will have to take into account such a higher level of taxonomic resolutions. In addition, an efficient management of population data requires links to museum specimen databases and gene banks.

The taxonomic inconsistencies became particularly obvious during integration of data from the IUCN Red List 2000 in its digital format (Hilton-Taylor 2000). Using the scientific name, automatic linkage of the GROMS and IUCN databases for approximately 90% of the common 600 threatened migratory species. But the remaining species were „overlooked" due to minor differences in spelling (*Lepidochelys kempii* vs. *L. kempi*) or different taxonomies. Besides simple differneces in nomenclature (bowhead whale: *Physeter catodon – Physeter macrocephalus*), most differences resulted from controversial classification of subspecies as full species (e.g. gorillas, or albatrosses, see Robertson & Nunn 1997). In several cases, english names turned out to be more stable and reliable for database linking than scientific names!

An effective management of such controversial taxonomic views would require a much more sophisticated database scheme, using „potential taxa" (Behrendsohn 1995). However, it is evident that databases used in conservation should use common taxonomic standards. Though most conservation databases cite the same taxonomic reference lists, there are in practice still considerable deviations, because most of the taxonomic authority files are not available in digital format. The case of the GROMS demonstrates that time-consuming checks „by hand" were necessary to harmonise and link different databases, even for species-poor groups such as vertebrates!

## Discussion and perspectives

There is a great potential for digitised museum information and other resources, but the task ahead is huge. The complex situation described above for Germany is also observed at the next higher, European level. Meanwhile, the Biological Collection Access Service (BioCase: www.biocase.org) project has been launched, and will hopefully remedy the situation. Due to the continent's colonial past, European type collections are particularly important for tropical countries. Therefore, providing improved collection access using web-based technologies should be among the top priorities and responsibilities of the European biodiversity research agenda.

Another important task is an improved transfer of biodiversity information between conservationists and scientists. Museum collections harbor a huge amount of information on historic species distribution, and could provide answers to difficult taxonomic questions. An increasing amount of this information is now available on-line, and it is therefore high time to provide effective links between museum and conservation databases. A prerequisite for an effective information exchange is a general availability and acceptance of taxonomic authority files, which is among the core tasks of the Global Taxonomy Initiative.

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# Pacific Basin Information Node: Overview of Activities

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## Abstract

**The US National Biological Information Infrastructure has begun building an information system for Hawaii and US territories in the Pacific. The system has begun by focusing initially on the Hawaiian Islands and building the needed infrastructure and data content to address invasive species problems. Plans are being implemented to develop a regional ITIS Pacific to support taxonomic needs of the islands and a geospatial capability to capture and display spatial data. It is hoped that the system can become part of a regional information system for Pacific Islands.**

***Key Words: Pacfic Basin, Distributed information systems, Taxonomy, Biodiversity, ITIS, HBS***

## Introduction

The Pacific Basin Information Node (PBIN) is part of a United States national information system called the National Biological Information Infrastructure (NBII). The NBII is being developed to provide access to biodiversity data and information as well as tools (such as mathematical models and visualization software) to support biological resource decision-making. It is partnering with several global and regional information systems (such as the Global Biodiversity Information Facility [Organization for Economic Cooperation and Development, 1999] and the Inter-American Biodiversity Information Network [the Summit for the Americas, 1996]) as a part of a global biodiversity information system. PBIN was established for the dual purpose of providing regional representation within the U.S. national system and to represent the U.S. in fostering a regional pan-Pacific biodiversity information system.

PBIN is beginning by developing an information system to address needs in Hawaii and the U.S. territories in the Pacific region. The initial activities are being directed toward building information content beginning with basic foundational data with a specific emphasis toward invasive alien species, a key biodiversity management problem. The basic foundational data were defined as the data and information that could address two key questions: what is it? and where is it?. This paper addresses the development of a taxonomic authority for PBIN to help in addressing the "what" question. The answer to this question is more complex than is evident at first glance. There is a subtle but important distinction between a "taxon name" and a "taxon concept". Difficulties arise when taxonomists disagree on species concepts and come to recognize different taxonomic entities under the same scientific name. What is important for an information system perspective is that the species name provides the critical link to data and information related to specific organisms. Without this critical "name authority" it is impossible to identify or integrate species-related information or data from different sources. The species name is critical to linking potentially disparate data sets; it is a key unifier of biological information systems.

The starting point for the PBIN taxonomic authority is the Integrated Taxonomic Information System, ITIS. ITIS (2002) was selected because it currently serves as the taxonomic authority for NBII, it is multi-national in scope, and it has a history of success with taxon-based information shared through a collaborative, distributed environment. This paper presents a possible approach for an information system to address taxonomic needs for the Asia-Oceania region. The paper begins with a brief history of ITIS, followed by a summary of efforts related to a Pacific region implementation of ITIS, and then concludes with a recommendation for a taxonomic information system for Asia-Oceania.

## Integrated Taxonomic Information System

ITIS began in the United States as a multi-agency partnership to serve the taxonomic information needs of U.S. Federal natural resource agencies. The partnership has expanded considerably and now includes agencies representing Canada and Mexico as well as the U.S. The ultimate goal is to include all relevant sectors of the scientific community to help build and maintain the system. The customer base has also grown and now includes federal and state governments, museums, academic institutions, libraries, and the public. ITIS began with the list of marine organisms developed by the U.S. National Oceanographic Data Center but has now expanded over the years to include all biological kingdoms. Its geographic scope has also grown to include worldwide treatment of some taxonomic groups important to North America. The data contained in ITIS include accepted taxonomic names, synonyms, common names, authors, references, and distribution information. The system is accessible on the web in English, French and Spanish versions.

The system is operated as a centralized master database located in the U.S. with a mirror site in Canada and web interfaces for Canada and Mexico. The data are contained in a relational database and are edited (added or removed) through a Microsoft Access-based "workbench" interface. Each scientific name is assigned a unique, non-intelligent taxonomic serial number (TSN) and names are linked hierarchally from Kingdom to species (in some instances subspecies). Data quality is assured by a small staff of data developers working with data stewards and taxonomic experts. All data are given a credibility rating to indicate whether and to what extent the data were reviewed.

A second group of experts serve to advise and manage the technical aspects of the system. The central system in the U.S. is Informix based, while Canada operates an Oracle version of the data set and web interfaces for Canada and Mexico. All information related to ITIS and the full taxonomic database can be downloaded in a number of formats.

Both the Canadian and Mexican sites utilize XML to allow for interoperatibility of distributed databases while the US site links to key information through the NBII. ITIS is currently collaborating with GBIF and Species 2000 to create a global electronic "Catalogue of Life."

## ITIS Pacific

While ITIS is expanding in scope and adding additional partners to cover North America, including Hawaii and other Pacific islands requires a different, more region-based approach. The rationale for a regional approach is based upon four specific arguments. First, the biota of Hawaii and the Pacific region is highly endemic and quite different from that of North

America. Most taxonomic treatments involving Hawaiian and Pacific organisms also tend to be regionally focused.

Second, taxonomic resources tend to be regionally based. These resources include specimen collections, field survey data, cultural knowledge and ongoing monitoring programs. The specimens data and information that are derived from the type of activities that are generally best suited to scientists who are present, who have a considerable knowledge of the region and can maintain programs for time periods beyond discrete data collection visits.

Third, most taxonomic expertise tends to be regional. That is to say many of the experts on the biota of a particular region live and work in that region. They are the people most familiar with the endemic organisms, the general environment that they inhabit and the pressures exerted on these organisms. This can help in gaining access to key sampling areas, distinguishing between native and naturalized alien species and understanding the perceived value of a species to the peoples of the region. This is a key component of the ITIS Pacific concept.

Finally, the Hawaii-Pacific region, which is mostly tropical, faces a different array of environmental threats than does the rest of mostly temperate North America. Island ecosystems are also particularly sensitive to invasion by alien species.

Fig.1 presents one example on how a regionally based effort such as Bishop Museum's Hawaii Biological Survey (HBS) can advance taxonomic knowledge in a specific area and serve to address a local biodiversity issue. The vertical bars represent the number of reports of alien species occurrences from 1990 through 1999. There was a significant increase in the number of species reported midway through the decade. This change is consistent with the publication by HBS of comprehensive species checklists and the creation in 1994/1995 of the "Records of the Hawaii Biological Survey" publication series as an outlet for reporting all new findings.

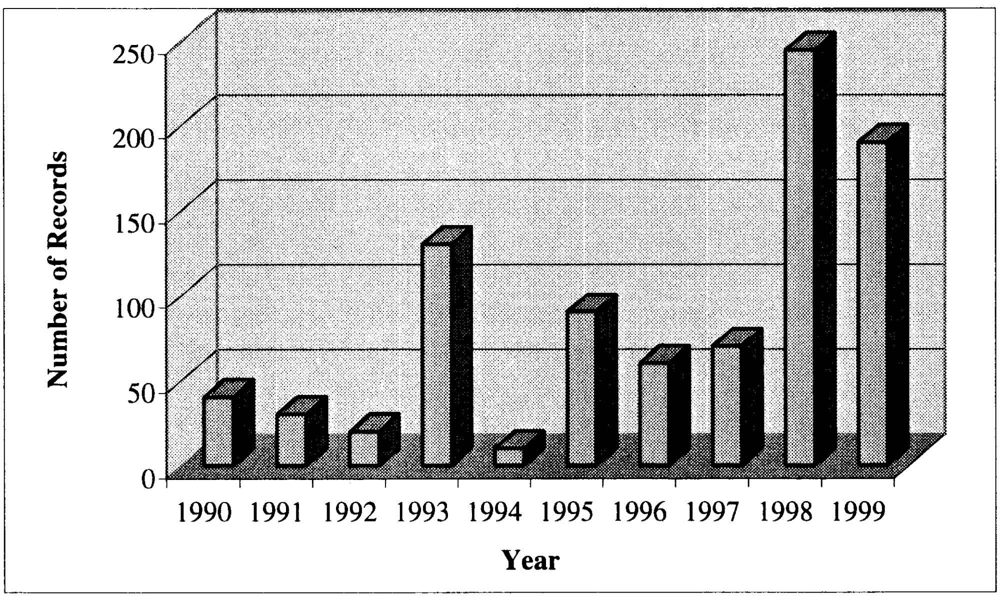


**Fig. 1 Number of Invasive Species Reported Over Time**

ITIS Pacific is envisioned as a collaborative regional partnership(s). Collaborative partnership in this case means bi-directional data flow, and delegation of taxonomic "authority" to those with regional expertise. This is important, because it's based on the idea of two organizations with mutual interests and complementary data *collaborating* on *mutual data exchange* for the benefit of both.

With these two points in mind, the general approach for ITIS is a regional collaboration based upon the ITIS distributed information infrastructure. The last piece of the conceptual design for ITIS Pacific is identifying and implementing a methodology for collecting, describing and sharing regional taxonomic data. The Hawaii Biological Survey offers a tested methodology (Fig. 2). Using this approach HBS scientists have catalogued 23,680 taxa from Hawaii including more than 18,000 native and 9,456 endemic species (Eldredge and Evenhuis, 2002). It is estimated that an additional 7,000 native species have yet to be scientifically named in Hawaii.

1. Develop computerized bibliographies of the literature (technical, popular and gray) for all major groups of plants and animals in Hawaii
2. Develop species authorities of all major taxonomic groups
3. Database collections (the largest such collection of Hawaiian material in the world) using the species authorities
4. Link our databases to other sources of information on the Hawaiian biota as part of an overall information system (PBIN)
5. Identify gaps in geographic areas surveyed, and survey these areas on a priority basis
6. Identify gaps in knowledge and address this on a priority basis with appropriate research projects.

**Fig. 2 HBS Methodology**

The first efforts directly related to building the bibliographic authority into PBIN were begun last year. This initial work is focused on reconciling differences between the database systems utilized by the Bishop Museum's six major specimen collections (entomology, ichthyology, vertebrate zoology, invertebrate zoology, malacology, and botany). This was necessary as a prelude to implementing a museum-wide data model that will serve as the basis for Pacific ITIS. Steps are being taken to consolidate and update electronic bibliographies of relevant literature and improving the existing software infrastructure to provide for a much more robust structure that will allow for both specimen data management, and maintenance of a richer and more robust taxonomic data model. Biolink v 1.5 is currently being evaluated for this application. As noted above, bibliographic data are central to the planned taxonomic authority data model. Using the existing data for the Entomology and Botany collections as a template, development of a centralized bibliographic system is beginning. All locality data have been consolidated into an electronic gazetteer and this is being used to consistently geocode all specimen data. Museum staff are working collaboratively with colleagues from the Hawaii Natural Heritage Program to ensure that all data in available through PBIN are geocoded to the same standards and are accompanied by full metadata.

Source data are integral to the emerging system. Therefore, primary data resources such as voucher specimens and the literature will be used. The data model will also be careful to consider differences between taxon names and taxon concepts. A common difficulty with many taxonomic databases is maintaining the distinction between representing taxon *names*, versus taxon *concepts*. The draft HBS data model is being developed with this distinction at its core. It proposes to use a reference-based data model to track how different concepts as referenced by a given name have been used historically (Pyle, 2002). The data model derives from the Vegbank taxonomic data model (Peet, et al. 2002).

Thus PBIN seeks to integrate the best components of two systems. It will leverage the existing working model provided by ITIS for a coordination of taxonomic information across individual organizations with the successful region-based taxonomic collection activity from HBS to create a robust taxonomic information system.

## Asia-Oceania

The regional approach being developed under PBIN provides a good model for an Asia-Oceania taxonomic authority. Bishop Museum scientists are in the process of developing a Pacific Biological Survey (PBS) based on the HBS model. The first step, now underway, is to develop species checklists for all terrestrial and marine vertebrates. The next step, now in the planning stages, will be to develop comprehensive bibliographic databases and to compile checklists of the vascular plants and invertebrates. This will be a major undertaking. The Pacific is home to an estimated million species, mostly insects, many of which remain unknown to science. We envision establishing collaborative partnerships between many organizations and working with hundreds of scientists to fully develop PBS within the PBIN framework. An important focus of our approach will the repatriation of data to the nations and territories of the Pacific region.

We envision that field survey and research activity will increase through the development of comprehensive databases and the identification of information gaps across the Asia-Oceania region. This will likely lead the consortium to link relevant data and information through regional collection centers, or hubs modeled after the Pacific ITIS. This approach would complement the existing efforts of partner organizations by allowing them to retain their collections, disseminate their data and information, foster collaboration between existing partners and other interested research organizations to address critical systematic, evolutionary or biodiversity questions.

How can such a project be implemented? A subset of representatives from GBIF member countries met in Hawaii in June 2002 to discuss the desirability for and possibility of a "Pacific Basin" information system to support biological diversity research and decision-making. The meeting attendees included representatives from (Australia, Japan, Korea, New Zealand and the United States). While there were concerns related to the definition of the geographic region defined by the term "Pacific Basin", the attendees were in full agreement that the concept merited further discussion and consideration. One substantial benefit identified was data repatriation especially to Pacific island nations. An Asia-Oceania taxonomic initiative such as that proposed above, with a goal of data repatriation could serve as a critical beginning point for such are regional biodiversity information initiative.

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# ERRATA

**Research Report from the National Institute for Environmental Studies, Japan**
**No. 171, 2002 (ISSN 1341-3643)**
***To the interoperable "Catalog of Life" with partners -***
***Species 2000 Asia Oceania***

**page148 -151 must be corrected as following pages.**

# Species Information Database KONCHU on Japanese, East Asian and Pacific Insects on INTERNET

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## Abstract

**A publicly available entomology database KONCHU is a general database name which includes 5 main files of bibliographical, checklist, image, dictionary and type specimen databases. A total of the records is 130,000 at present. One of the files, KONCHUR is a taxon-based entomology reference database based on main Japanese entomological journals (19 journals (= files) at present). Therefore, it includes many records of East Asian and Pacific insects including spiders and mites as well as Japanese ones. It has a taxonomical feature as well as a bibliographical one because it treats one taxon, *e.g.* species, genus, family, as one record. The records of KONCHUR are written mainly in English, and in Japanese with katakana and kanji characters. Each record of the database is composed of 13 items, such as bibliographical (author, title, journal, volume, page and year), taxonomical (order, family, synonymy), distributional data, key words (taxonomy, morphology, ecology, biology, etc) and notes including useful information such as the type locality and the type depository of new species, and host record of parasite. The KONCHU is managed by a text database management system SIGMA. The KONCHU has been opened to the public on INTERNET as well as at Computer Center of Kyushu University, Fukuoka, Japan. A user can access to the KONCHU by retrieving the following URL: http://konchudb.agr.agr.kyushu-u.ac.jp/. Outline and homepages of the 5 main files in the KONCHU are presented.**

***Key Words: Biodiversity, species information, database, Japan, East Asia, Pacific Area, insects, spiders, mites, KONCHU, INTERNET***

An entomology database KONCHU (= insects in Japanese) is a general database name which includes 5 main files of bibliographical, checklist, image, dictionary and type specimen databases. One of the files, KONCHUR is a taxon-based entomology reference database based on the main Japanese entomological journals (19 journals (= files) at present) and treats a taxon as one record, i.e., species, genus, family, etc. The KONCHUR includes many records of East Asian and Pacific insects, spiders and mites as well as Japanese ones. Each record is written mainly in English, and in Japanese with katakana and kanji characters and composed of 13 items, such as bibliographical (author, title, journal, volume, page and year), taxonomical (order, family, synonymy), distributional data, key words (taxonomy, morphology, phylogeny, ecology, biology, physiology, genetics, cell biology, biogeography, etc) and notes including useful information such as the type locality, and the type depository of new species, and host record of parasite. It has been opened to the public at Computer Center of Kyushu University, Fukuoka, Japan since 1987 (Tadauchi, 1987). The files of database KONCHU are managed by a text database management system SIGMA (Arikawa *et al.*, 1987, 1988) working at the Computer Center of Kyushu University. The system SIGMA had recently modified for use on a work station. The KONCHU was also reproduced on a work station in the Entomological Laboratory, Kyushu University and was opened to the public on INTERNET as well as from the Computer Center of Kyushu University.

A user can access to the KONCHU by retrieving the following URL: http://konchudb.agr.agr.kyushu-u.ac.jp/. Outline and usage of the KONCHUR are shown in Tadauchi (1987, 1994, 1996) and Tadauchi *et al.* (1999). A user can also get information about the KONCHU including its usage on the homepage. Some files in the KONCHU are summarized in Tadauchi (1985: MUSHI file), Tadauchi (1994, ESAKIA file), Tadauchi & Takematsu (1995: AKITU & TMU files), Tadauchi *et al.* (1997: INMS file), and Takematsu *et al.* (1996: SHIKOKU file) and usage of the SIGMA system is explained in Arikawa *et al.* (1987, 1988).

Contents of the homepage are as follows: 1) Search KONCHUR database (for registrant), 2) How to use, 3) List of journals, 4) Items of data, 5) Example of a record, 6) Manuals and explanations available at present, 7) Copyright notice, 8) Inquiries and comments and 9) Link. We have two searches, simple and advanced modes in our KONCHUR. A user can retrieve taxa by any key words in the 13 items, such as bibliographical, taxonomical, distributional words, key words and notes. The homepage and examples of the use of the KONCHUR are presented in Figs. 1-3 with another homepage of our database MOKUROKU based on "A Check List of Japanese Insects" (Fig. 4), which includes all the Japanese insects and is the most related to biodiversity databases. Both databases are useful for applied entomologists as well as taxonomists interested in Japanese, East Asian and Pacific insects. Figs. 5-7 show image database on bees, HANABACHI, Dictionary of Japanese insect names, DJI and type specimen database based on the Collection of Entomological Laboratory, Kyushu University, ELKUType.

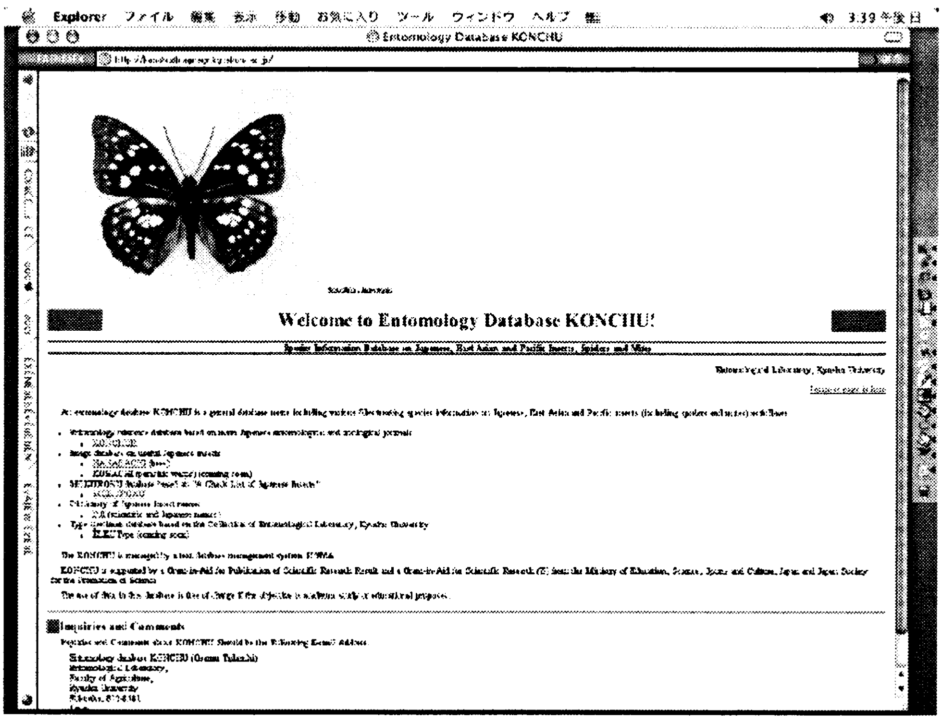


**Fig. 1.** A homepage of a taxon-based entomology database KONCHU treating species information on Japanese, East Asian and Pacific insects, spiders and mites.
The URL is http://konchudb.agr.gar.kyushu-u.ac.jp/.

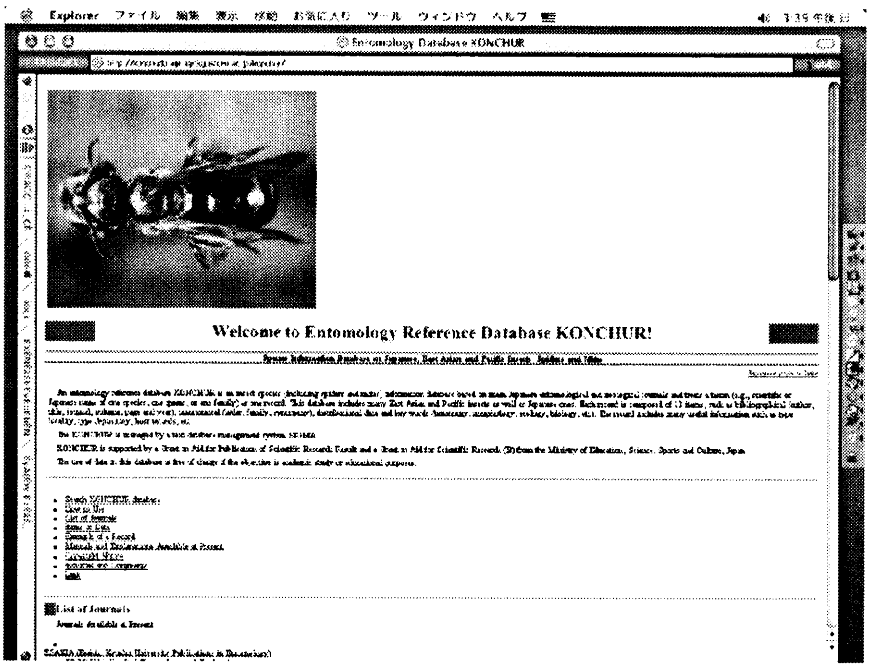


**Fig. 2.** The KONCHUR, one of the KONCHU files, is an entomology reference database based on the main Japanese entomological and zoological journals and treats one taxon as one record including 13 items, such as bibliographical, taxonomical, distributional data, key words and notes. http://konchudb.agr.agr.kyushu-u.ac.jp/konchur/.

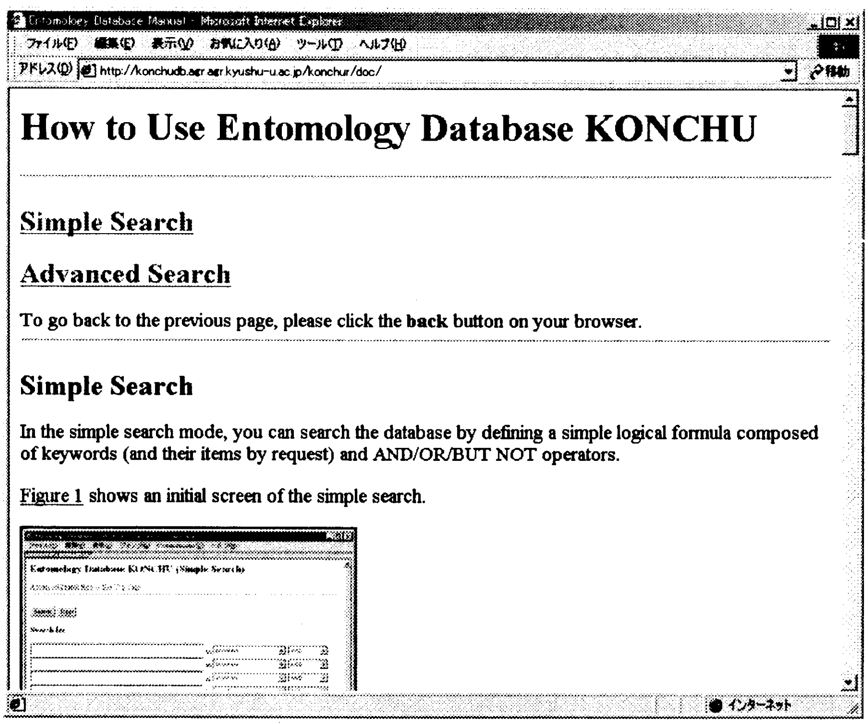


**Fig. 3.** A user can get information how to use entomology database KONCHUR on the homepage. It shows the first page of the usage. http://konchudb.agr.agr.kyushu-u.ac.jp/konchur/doc/.

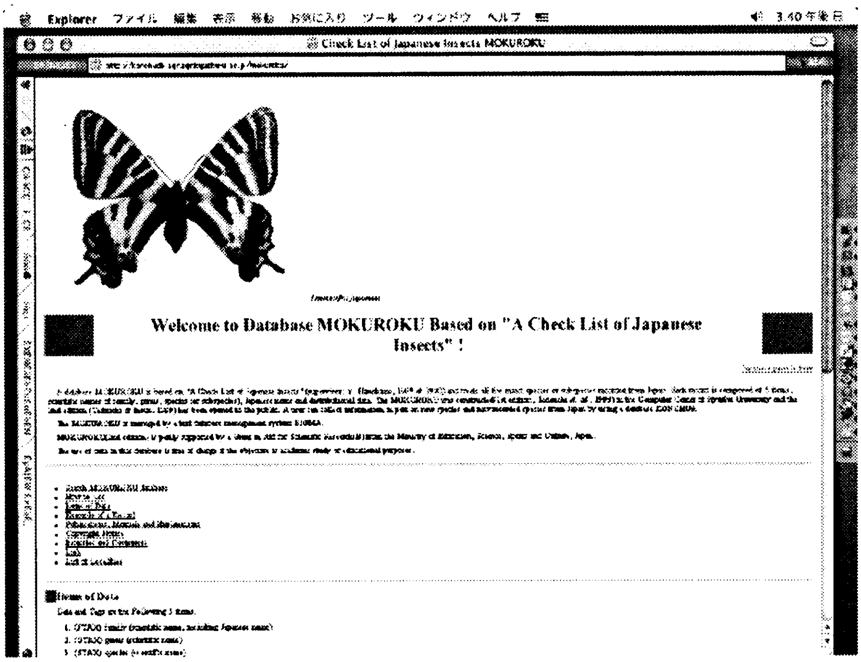


**Fig. 4.** A homepage of a database MOKUROKU based on "A Check List of Japanese Insects" treating all the Japanese insects with distributional data.
The URL is http://konchudb.agr.agr.kyushu-u.ac.jp/mokuroku/.

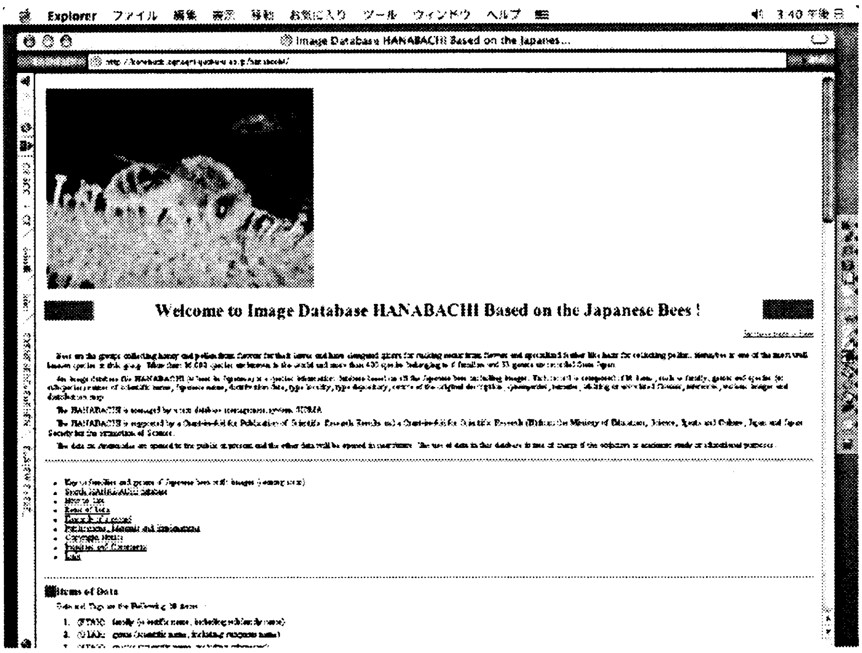


**Fig 5.** A homepage of an image database HANABACHI treating various information such as taxonomy, morphology, biology and distributional data.
The URL is:http://konchudb.agr.agr.kyushu-u.ac.jp/hanabachi/.

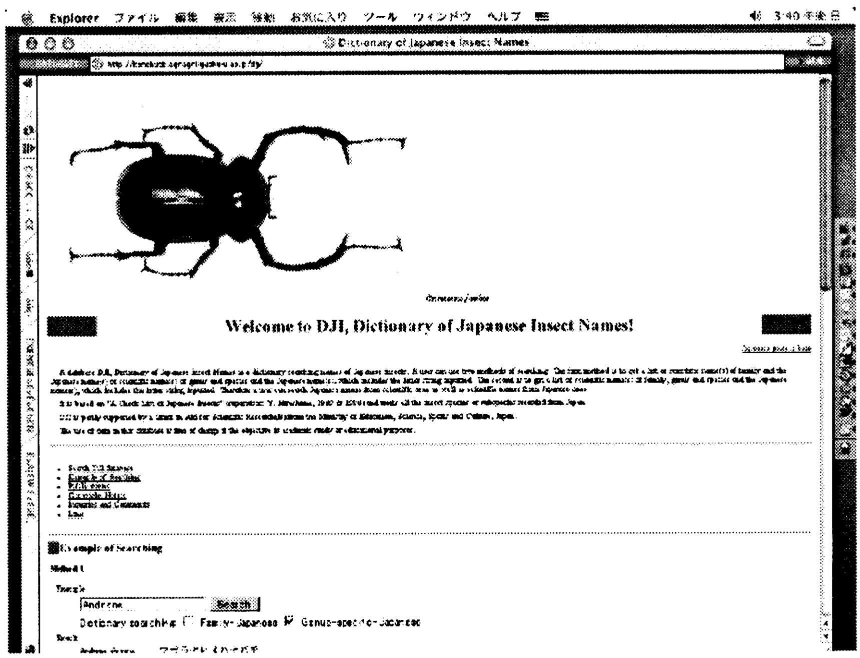


**Fig 6.** A homepage of a dictionary database DJI treating all the Japanese insect names. A user can retrieve from the Japanese name to scientific one, and the reverse as well as make a list of species names in any taxon, such as family, genus, etc.
The URL is http://konchudb.agr.agr.kyushu-u.ac.jp/dji/.

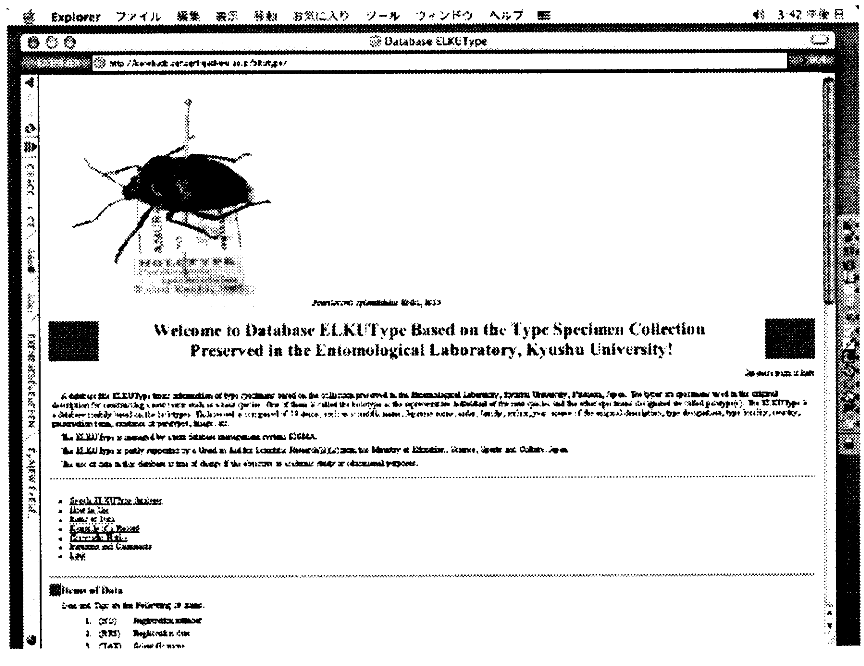


**Fig 7.** A homepage of a database ELKUType based on the type specimen collection preserved in the Entomological Laboratory, Kyushu University.
The URL is http://konchudb.agr.agr.kyushu-u.ac.jp/elkutype/.

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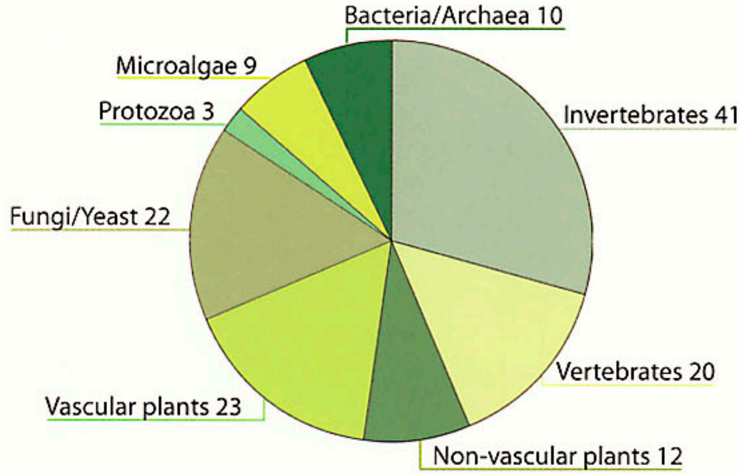
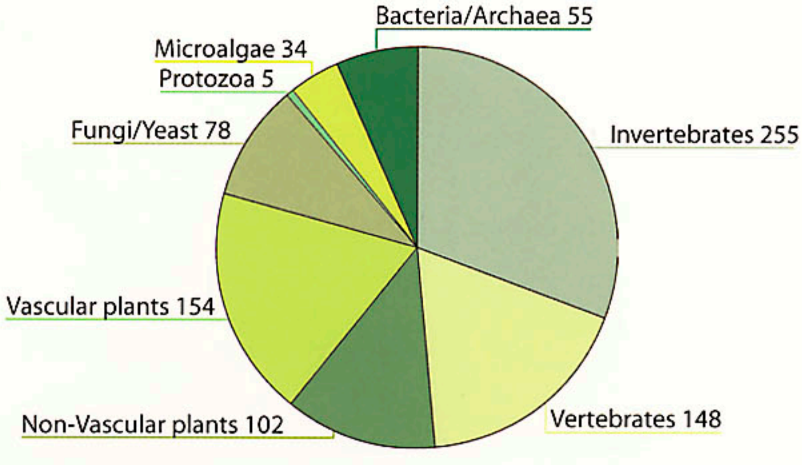
## An overview of the status of taxonomy in the Asian Region

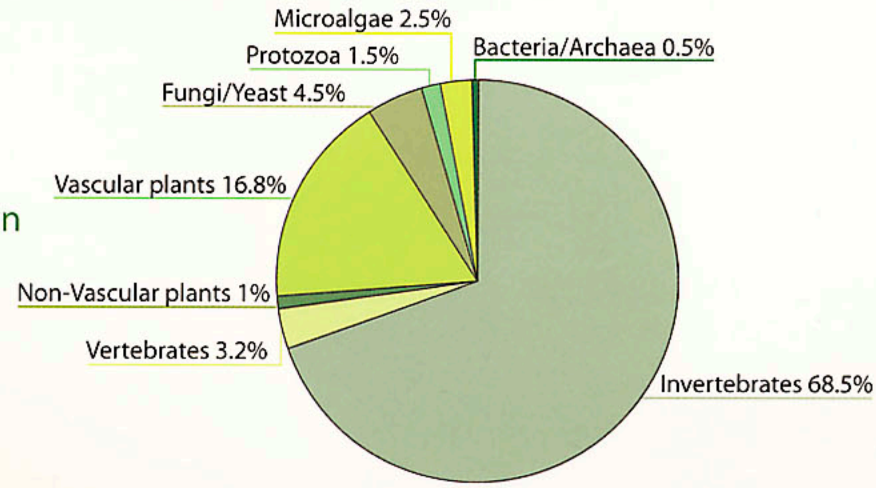
### Number of Collections




### Number of Experts




### Ratio of known Species




## A pictorial comparison for the major groups of organisms

**The percentage of known species versus the number of experts and collections**