Internship Program for Taxonomic Capacity Building for Bryophytes And Pteridophytes

Queen Sirikit Botanic Garden, Chiang Mai, Thailand
January 20 – 30, 2015

Proceedings / Training Workshop Report
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ASEAN Centre for Biodiversity

The ASEAN Centre for Biodiversity (ACB) is an intergovernmental regional center of excellence, which facilitates cooperation among the members of the ASEAN, relevant national governments, and regional and international organizations on the conservation and sustainable use of biological diversity, guided by fair and equitable sharing of benefits arising from the use of such biodiversity. It was established in 2005 in response to the challenge of biodiversity loss and to assist the ASEAN Member States (AMS) to protect and conserve its valuable and unique biodiversity resources.

ACB’s core strategic goals include: serving as an effective coordinative body to facilitate discussion and resolution of cross-country biodiversity conservation issues; providing a framework and mechanism for sharing information, experiences, best practices and lessons learned for efficient access of ASEAN Member States; implementing a pro-active approach in monitoring and assessing biodiversity conservation status as a strategic approach towards identifying critical issues and future trends; delivering/facilitating conduct of capacity-building services and technology transfer through engaging relevant and appropriate expertise; enhancing common understanding of biodiversity conservation issues, strengthening ASEAN regional positions in negotiations and in compliance with relevant multilateral environmental agreements; promoting public and leadership awareness to develop champions and enhance support at different stakeholder levels on biodiversity concerns; and undertaking innovative resource generation and mobilization measures to pursue impact activities that will enhance biodiversity conservation in the region.

ACB supports the ASEAN governments in the following areas that are of global and regional importance: agrobiodiversity and food security including food certification; access to, and fair and equitable sharing of benefits from biological and genetic resources; climate change and biodiversity conservation; ecotourism; payment for ecosystem services and valuation of biodiversity; wildlife law enforcement; management of invasive alien species; peatland management and biodiversity; Global Taxonomic Initiative; support to the Program of Work on Protected Areas; and management of biodiversity information and knowledge. These areas have been identified in the various multilateral environment agreements such as the Convention on Biological Diversity (CBD), Convention on the International Trade of Endangered Species (CITES), RAMSAR Convention, and the Cartagena Protocol for Biosafety, where majority of the ASEAN member States are parties.

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East and Southeast Asia Biodiversity Information Initiative

East and Southeast Asia Biodiversity Information Initiative (ESABII) was launched by 14 countries in this region and relevant organizations to achieve goals of the Convention on Biological Diversity (CBD), to pursue capacity building in taxonomy, and the development of an information system on biodiversity in East and Southeast Asia in order to contribute to the promotion of biodiversity conservation and the implementation of the CBD Strategic Plan in the region.

In 1992, the CBD was adopted as an international framework for the conservation of biodiversity as well as for the utilization of biological resources in a sustainable manner. The 4th meeting of the Conference of the Parties to the Convention on Biological Diversity (CBD COP4) in 1998 decided to implement the Global Taxonomy Initiative (GTI). The CBD COP10 held in Nagoya City, Aichi Prefecture, Japan adopted the Strategic Plan for Biodiversity 2011-2020 (Aichi Biodiversity Targets), among which Target 19 was set to improve the knowledge, science base and technologies related to biodiversity.

The importance of taxonomy has increasingly been recognized as a global issue. While East and Southeast Asia have a much higher level of biodiversity than other parts of the world, there are insufficient number of personnel with the taxonomic knowledge and capacity required for biodiversity conservation. Moreover, information on biodiversity is limited and scattered, and information infrastructure for biodiversity is not fully developed.

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Queen Sirikit Botanic Garden

Queen Sirikit Botanic Garden (QSBG) was the first international standard botanical garden established in Thailand. Situated in the foothills of the mist-shrouded Doi Suthep-Pui mountains of Chiang Mai, Thailand, QSBG offers a mix of natural beauty along with curated gardens and glasshouses showcasing the richness of Thai, and other flora, for visitors to explore. Moreover, QSBG is home to a great number of valuable Thai plants, with a focus on rare, endemic, and endangered species. Although the main focus is on the Northern Thai flora and surrounding regions, QSBG has an integrated program of research, education and amenity with a global perspective.

The aim of QSBG and its satellite gardens are:

• to gather fundamental knowledge of Thai plants
• to conserve their genetic diversity, and
• to strengthen studies and research on Thai flora.

Following the Botanic Garden Office (BGO) establishment, the Mae Sa Botanic Garden at Mae Rim, Chiang Mai was transferred from the Royal Forest Department to be under the administration of the BGO. To honor Her Majesty Queen Sirikit of Thailand whose dedication towards biodiversity conservation is internationally recognized, the BGO requested for Her Majesty’s name to be the title of the Garden and was granted her royal permission in April 1994. Therefore, the Mae Sa Botanic Garden is known nowadays as Queen Sirikit Botanic Garden or QSBG as its short name. In addition to the Queen Sirikit Botanic Garden in Mae Rim, Chiang Mai, The BGO, under the Ministry of Natural Resources and Environment, oversees 5 other Botanic Gardens throughout Thailand. They are Romklao Botanic Garden (Phitsanulok province), the Rayong Botanic Garden (Rayong province), Koa Ra Botanic Garden (Phangnga), Meaung Pon Botanic Garden (Khon Kaen) and Phra Mae Ya Botanic Garden (Sukhothai).
Japan-ASEAN Integration Fund

With the aim of one ASEAN Community until 2015, in order to support ASEAN’s efforts to promote the integration of regional disparities, during the ASEAN Summit day held in December 2005, then Prime Minister Koizumi pledged to the ASEAN leaders, that it is placing 7.5 billion Yen for ASEAN integration support. Based on this assertion, the fund was established on March 27, 2006.

The purposes of the Fund are as follows:

1. Support the efforts of ASEAN countries to realize the ASEAN integration
2. Support the establishment of the ASEAN Social and Cultural Community (ASCC) to correct intra-regional disparities
3. Promote cooperation between Japan and ASEAN
4. Support the activities of regional institutions and sub-regional organizations
5. Other implementation activities that Japan and ASEAN is determined to be appropriate
The Internship Programme was held in the traditional spirit of ASEAN cordiality and hospitality. ACB acknowledged the support of the ASOEN and the National Contact Points in Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand and Viet Nam for sending in their participants to attend the Internship Programme for the Taxonomic Capacity Building for Bryophytes and Pteridophytes.

ACB also appreciated very much the enthusiasm and eagerness of the participants especially in the development of the Field Guide Manuscript on Bryophytes and Pteridophytes.

Our deep gratitude to our resource persons: Dr. Benito C. Tan, Dr. Boon-Chuan Ho, Dr. Edwino S. Fernando, Dr. Dedy Darnaedi, Dr. Bayu Adjie, Dr. Piyakaset Suksathan, for sharing to the participants their expertise and experiences.

ACB also greatly acknowledged the staff of QSBG for their assistance and Dr. Hidetsugu Miwa of ESABII Secretariat and Mr. Norihiro Matsushima of OMC, Incorporated, for co-organizing this Internship Programme.
Executive Summary

The Internship Programme for the Taxonomic Capacity Building for Bryophytes and Pteridophytes, was jointly conducted by the ASEAN Centre for biodiversity and the Queen Sirikit Botanic Garden of Thailand at Chiang Mai on 20 - 30 January 2015. The Internship included lectures on Bryophytes and Pteridophytes and sharing of experiences of experts to the participants. The general objective was to capacitate the participants in the rigors of taxonomy especially on the terrestrial plants group on Bryophytes and Pteridophytes.

The Internship participants included the representative from the AMS. A total of 27 participants attended. The distribution is as follows: Brunei Darussalam – 2; Cambodia – 3; Indonesia – 3; Lao PDR – 3; Malaysia – 3; Philippines – 3; Thailand – 3; and Viet Nam – 2.

Trainers/Experts for the course were the following: 1. Dr. Benito C. Tan, Bryologist, University of California – Berkeley, USA; 2. Dr. Boon-Chuan Ho, Bryologist, Singapore Botanic Gardens, NParks, Singapore; 4. Dr. Edwino S. Fernando, Plant Taxonomist, University of the Philippines Los Baños; 5. Dr. Dedy Darnaedi, Pteridologist, Research Center Biologi, LIPI, Indonesia; 6. Dr. Bayu Adjie. Pteridologist, Bali Botanic Garden, Bali, Indonesia; and Dr. Piyakaset Suksathan, Pteridologist, Queen Sirikit Botanic Garden, Chiang Mai, Thailand.

The outputs of the Internship were as follows: a) upgraded skills of the participants in terrestrial plants taxonomy especially on mosses and ferns; b) provided hands-on experience in collections management, and identification; and a Field Guide Book on Mosses and Ferns.
Backgrounder

The lack of trained human resources and inadequate capacities on taxonomy has been stressed as one of the obstacles in the implementation of CBD commitments, especially in the ASEAN region. ASEAN + 3’s (i.e. China, Korea and Japan), dynamic growth in recent years has increased the pressure on its natural resources. Human activities, the driving force behind the regional growth, threaten its biological resources. Lack of scientific information on biodiversity in this region is a crucial issue in the assessment and prediction of biodiversity changes, caused mainly by the lack of taxonomic capacity in data collection and analysis.

Under the CBD-COP-9, the programme of work with deliverable outcomes was adopted (Decision IX/22). The Programme of Work, as revised, was adopted in CBD COP10 (COP10/L.34). Hence, parties to the convention were urged to promote/carry-out the programme of work for the GTI through coordination of its implementations with existing national, regional, sub-regional, and global initiatives, partnerships and institutions, designation of national GTI focal points, provision of updated information about legal requirements for exchange of genetic/biological specimens, and about current legislation and rules for access and benefit-sharing in terms of the needs for the GTI, and initiatives of setting-up of national and regional networks to aid the Parties in their taxonomic needs in implementing the CBD.

To push the GTI programme of work, a series of GTI workshops were conducted in various venues: 2001 for Central America and Africa, 2002 for Asia, and 2004 for Asia-Oceania (Wilson et al., 2003; NIES, 2005). However, as far as the CBD Secretariat is concerned, the 2002 GTI Workshop is the First GTI Regional Workshop followed by the Second GTI Regional Workshop for Asia-Oceania in 2004.

Adequate taxonomy is one of the necessary fundamental tools required for the global community to be able to implement the MDGs and the development targets from the World Summit for Sustainable Development. Without adequate long-term investment in the human, infrastructural (including, important biological collections) and information resources necessary to underpin the science of taxonomy, the now well-recognized taxonomic impediment will continue to prevent adequate implementation of sound, scientifically-based sustainable, environmental management and development policies.

Objectives of the Internship Programme

Generally, the Internship capacitated the participants in the rigors of taxonomy especially on the terrestrial plants group on Bryophytes and Pteridophytes. Specifically, the training workshop:

1. Introduced the participants to the taxonomy of terrestrial plants particularly mosses and ferns.
2. Familiarized the participants with the general biology of these plants.
3. Provided the opportunity for the participants to apply their taxonomic skills on the following:
   • Methods of morphological observation
   • Specimen collection, processing and identification

Expected Outputs

The outputs of the training workshop are the following:

1. Skills of the participants in terrestrial plants taxonomy especially on mosses and ferns are upgraded
2. Provided hands-on experience in collections management, and identification.
3. A draft Field Guide Book on Mosses and Ferns

Participants to the Training Workshop

Participants of the Training Workshop were representatives of the ASEAN Member States who have background in botany, plant ecology and related field and preferably participants from the previous
training on bryophytes and pteridophytes. They must be less than 45 years old and who has an academic or government position who works on terrestrial botany or plant ecology. The directory of resource persons, participants and organizers (Secretariat) is in Annex 1.

**Agenda of the Training Workshop**

The agenda of the training workshop were as follows:

1. Brief orientation on the taxonomy and systematics of mosses and ferns
2. Field trip for hands on field collection and specimen management
3. How to make a field guide book

Trainers for the course were the following:

**Dr. Benito C. Tan**  
Bryologist, University of California – Berkeley, USA

Dr. Benito C. Tan is currently a Research Associate at the UC Herbarium of the University of California at Berkeley. He obtained his Ph D degree in Botany from the University of British Columbia in Canada in 1981. He then became a teacher at the University of the Philippines at Los Baños. He left the post in the Philippines on 1987 to become a Research Curator of Bryophytes at the Farlow Cryptogamic Herbarium of Harvard University for 6 and half years. He retired in 2012 as an Associate Professor in Botany from the National University of Singapore. Dr. Tan is a taxonomist who studies the diversity, evolution and biogeography of mosses in SE Asia, East Asia and Australasia. He has described more than 25 new taxa of mosses collected from Asia and has published more than 250 technical papers in various international botanical and bryological journals in his long three decades of professional career as a bryologist.

**Dr. Boon-Chuan Ho**  
Bryologist, Singapore Botanic Gardens, NParks, Singapore

Dr. Boon-Chuan Ho is currently holding a researcher position to specialize in legumes at the herbarium of the Singapore Botanic Gardens. He has special interest in plant biodiversity and evolution of tropical SE Asia region. His first botanical research interest is in bryology and has been involved and contributed in several floristic projects of mosses in tropical Asia. This passion has brought him to several field excursions in several tropical countries, including Ecuador, Malaysia, Indonesia (Java & Sumatra), Papua New Guinea, Thailand, Uganda and Vietnam. To date, he has published about 30 botanical contributions in various international and regional books and scientific journals, which includes checklists, floristic surveys, taxonomy of mosses, and description of new species. Serving since 2010 as a member of the editorial board of the international journal “Bryophyte Diversity and Evolution” (formerly “Tropical Bryology”), he has been doing editorial work including article reviews.

**Dr. Edwino S. Fernando**  
Plant Taxonomist, University of the Philippines Los Baños

Dr Edwino S. Fernando is Professor in the Department of Forest Biological Sciences, College of Forestry and Natural Resources, the University of the Philippines – Los Baños, specializing in plant taxonomy and biodiversity studies, plant genetic resources, and conservation biology. Dr Fernando is a graduate of the University of the Philippines – Los Baños where he obtained his Bachelor of Science and Master of Science degrees in Forestry. He also holds a Master of Science degree in Plant Taxonomy from the University of Reading, England. He earned his Doctor of Philosophy degree in Botany from the University of New South Wales in Sydney, Australia. His continuing basic research and extensive field work on the vascular plants of the Philippines and elsewhere in Southeast Asia has led to the discovery of at least 26 species as new to science. He has authored many scientific papers published in international refereed journals, including two books on the Flowering Plants and Ferns of Mt. Makiling (2004) and Forest Formations of the Philippines.
Dr. Dedy Darnaedi
Pteridologist
Research Center Biologi, LIPI, Indonesia

Dr. Dedy Darnaedi is a Research Professor in Plant Taxonomy, with special interest in Tropical Pteridophytes, working in Herbarium Bogoriense (BO) LIPI. Professor Dedy Darnaedi is a former Director of Bogor Botanic Gardens and director of Research Center for Biology, Indonesian Institute of Sciences (LIPI). He was formerly the Chair of the Flora Malesiana Foundation (2000-2012) and served as Indonesian National Focal Point of the Global Strategy for Plant Conservation (2000-2003), and GTI (2005-2011). He has represented Indonesia many times in meetings of the CBD Conference of Parties and Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA). He currently holds the position of Executive Director of Plant Resources of South East Asia (PROSEA) since his appointment in 2009. Recently, Dr. Darnaedi was selected as a Member of Expert Panel (MEP) for Interdisciplinary Platform for Biodiversity and Ecosystem Services (IPBES).

In the Asia Pacific region he on the Steering Committee of both Asia Pacific Biodiversity Observation Network (AP-BON) and ESABII since 2009, the two programs initiated by the Ministry of Environment, Japan with the Asia-Pacific countries. He also works closely with ACB in various activities related to capacity building, such as in training workshop on plant taxonomy, and many others.

Dr. Bayu Adjie
Pteridologist
Bali Botanic Garden, Bali, Indonesia

Dr. Bayu Adjie works as researcher at Bali Botanic Garden – Indonesian Institute of Sciences since 1998. After finished his Doctoral Research Associate at Graduate School of Sciences, Chiba University, Japan in 2008, he became a Research Coordinator. His majority is plant taxonomy, especially molecular biology. At the same year, he got the Best Paper Award 2008 from Japanese Society for Plant Systematic. For this last three years, he became the Head of Laboratory of Plant Conservation. Even he worked with mangrove and aroid, his biggest interest is fern. Now he is working with the fern from eastern part of Indonesia.

Dr. Piyakaset Suksathan
Pteridologist
Queen Sirikit Botanic Garden, Chiang Mai, Thailand

Dr. Piyakaset Suksathan finished his Bachelor’s and Master’s degree in Horticulture from Kasetsart University, Bangkok and Ph.D. in Systematic Botany from Aarhus University, Denmark. He has been working as a botanist and horticulturist at Queen Sirikit Botanic Garden since 1998. His field of expertise includes Pteridophyte, Marantaceae, Zingiberaceae, and Balsaminaceae.
Dates: 20 – 30 January 2015 (11 days)
Venue: Queen Sirikit Botanic Garden, Chiang Mai, Thailand

Day 0 (19 January): Arrival of participants
(7pm Meeting of Resource Persons with ACB at hotel lobby)

Day 1 (20 January)

<table>
<thead>
<tr>
<th>Time</th>
<th>Topic</th>
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<tbody>
<tr>
<td>7:30 – 8:15</td>
<td>Travel from Chiang Mai Hotel to Queen Sirikit Botanic Garden</td>
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<tr>
<td>8:15 – 8:30</td>
<td>Registration</td>
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<tr>
<td>8:30 – 9:00</td>
<td>Opening Program</td>
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<td>Opening Message – Dr. Miwa Hidetsugu, ESABII Secretariat</td>
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<td>Biodiversity Center, MOE-Japan</td>
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<td>Opening Message – Atty. Roberto V. Oliva, Executive Director, ACB</td>
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<td>Introduction of Participants and Lecturers</td>
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<td>Photo Opportunity</td>
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<td></td>
<td>Emcee: Dr. Edwino S. Fernando, ACB</td>
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<tr>
<td>9:00 – 10:30</td>
<td>Review of Bryophytes - Dr. Benny Tan and Dr. Boon-Chuan Ho</td>
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<td>10:30 – 10:45</td>
<td>Snack Break</td>
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<tr>
<td>10:45 – 12:15</td>
<td>Review of Pteridophytes - Dr. Dedy Darnaedi and Dr. Bayu Adjie</td>
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<tr>
<td>12:15 – 1:15</td>
<td>Lunch Break</td>
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<tr>
<td>1:15 – 2:15</td>
<td>Lecture on Developing a Field Guide Book - Dr. Edwino S. Fernando</td>
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<tr>
<td>2:15 – 3:15</td>
<td>Mechanics and groupings of the training course - Dr. Filiberto Pollisco, Jr., ACB</td>
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<tr>
<td>3:15 – 3:30</td>
<td>Snack Break</td>
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<tr>
<td>3:30 – 5:00</td>
<td>Orientation of the QSBG, its facilities and complex - QSBG Staff</td>
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<td>5:00 – 6:00</td>
<td>Travel back to Imperial Mae Ping Chiang Mai Hotel</td>
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<tr>
<td>6:00 – 7:00</td>
<td>Free time</td>
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<tr>
<td>7:00</td>
<td>Dinner</td>
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Day 2 (21 January)

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<tr>
<th>Time</th>
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<tr>
<td>7:30 – 8:15</td>
<td>Travel from Chiang Mai to QSBG</td>
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<tr>
<td>8:15 – 8:30</td>
<td>Registration</td>
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<tr>
<td>8:30 – 9:30</td>
<td>Special Lecture on Bryophytes - Dr. Junko Kawai, University of Tokyo, Japan</td>
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<tr>
<td>9:30 – 10:00</td>
<td>Open Forum</td>
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<td>10:00 – 10:15</td>
<td>Snack Break</td>
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<tr>
<td>10:15 – 12:00</td>
<td>Groupings and preparations for the internship</td>
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<tr>
<td>12:00 – 1:00</td>
<td>Lunch Break</td>
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<tr>
<td>1:00 – 3:00</td>
<td>Introductory Laboratory Session for Bryophyte (Plenary)</td>
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<td>3:00 – 3:30</td>
<td>Snack Break</td>
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<tr>
<td>3:30 – 5:00</td>
<td>Introductory Laboratory Session for Pteridophyte (Plenary)</td>
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<tr>
<td>5:00 – 6:15</td>
<td>Travel back to Chiang Mai Imperial Mae Ping hotel</td>
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<tr>
<td>6:15 – 7:00</td>
<td>Dinner on your own</td>
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Day 3 (22 January) Continue work in QSBG
Day 4 (23 January) Continue work in QSBG
Day 5 (24 January) Travel to Doi Inthanon National Park

7:00   Check out of Hotel
7:30   Depart Hotel for Doi Inthanon National Park
12:00  Arrive in Doi Inthanon National Park and Check in Caren Tribe Home Stay Village
12:30 – 1:30 Lunch Break
1:30 – 2:00 Lecture about Doi Inthanon National Park
2:00 – 5:00 Field exercise at Doi Inthanon National Park
5:00 – 6:00 Back to homestay
6:00   Dinner

Day 6 (25 January)

7:30 – 12:00 Continue with field exercise at Doi Inthanon National Park
12:00 – 1:00 Lunch Break
1:00 – 5:00 Prepare samples for transport
5:00 – 6:00 Free time
6:00   Dinner

Day 7 (26 January)

6:00   Early breakfast
7:30   Depart Doi Inthanon National Park for QSBG
12:30  Arrival at QSBG
1:00 – 2:00 Lunch Break
2:00 – 3:30 Processing of specimens in QSBG
3:30 – 4:00 Snack break
4:00 – 5:00 Continue processing and start write-up
5:00 – 6:00 Check-in at Le Meridien Hotel
6:00 onwards Dinner on your own

Day 7 (27 January)

7:00 – 8:00 Breakfast
8:00 – 12:00 Lecture of Dr. Chan Ho Park on Pteridophytes
12:00 – 1:00 Lunch Break
1:00 – 3:30 Continue with specimen processing and write-up
3:30 – 4:00 Snack Break
4:00 – 5:00 Continue with specimen processing and write-up
5:00 – 6:00 Travel Back to Hotel
6:00 onwards Dinner on your own

Day 8 (28 January)

7:00 – 8:00 Breakfast
8:00 – 9:00 Travel to QSBG
9:00 – 12:00 Continue with specimen processing and write-up
12:00 – 1:00 Lunch Break
1:00 – 3:30 Continue with write-up
3:30 – 4:00 Snack Break
4:00 – 5:00 Continue with write-up
5:00 – 6:00 Travel back to Hotel
6:00 onwards Dinner on your own
Day 9 (29 January)

7:00 – 8:00 Breakfast
8:00 – 9:00 Travel to QSBG
9:00 – 12:00 Continue with write-up
12:00 – 1:00 Lunch Break
1:00 – 3:30 Presentation of output with critique from resource persons
3:30 – 4:00 Snack Break
4:00 – 5:00 Presentation of output with critique from resource persons
5:00 – 6:00 Travel back to Hotel in Chiang Mai
6:00 onwards Dinner on your own

Day 10 (30 January)

7:00 – 8:00 Breakfast
8:00 – 12:00 Revisions per critique of resource persons
12:00 – 1:00 Lunch break at hotel
1:00 – 3:00 Revisions per critique of resource persons
3:00 – 3:30 Snack break
3:30 – 5:00 Closing Program at Le Meridien
  • Feedback from participants per country
  • Feedback from resource persons
  • Awarding of certificates
  • Closing messages
    - Dr. Benny Tan
    - Dr. Dedy Darnaedi
    - Dr. Edwino Fernando
    - ACB Representative
    - Dr. Suyanee Vessabutr, Director, QSBG

Day 12 (31 January)  Departure of the rest of the participants to their respective countries
Opening Programme

The opening program was held at Queen Sirikit Botanic Garden. Dr. Piyakaset Suksathan represented Dr. Sunayanee Vessabutr, the Director of the QSBG, and he thanked the AMS for coming to participate and hoped that there are future activities to be conducted in QSBG. He also hoped that the learning experiences of the AMS participants in the 10-day Internship Programme will be useful for them and share it to their colleagues. He looks forward to meeting them again in the future. He also said to explore the richness of biodiversity of QSBG and culture in the land of smiles, Thailand. He also thanked the Ministry of Environment and Natural Resources (MoNRE) of Thailand in agreeing that QSBG to host another Taxonomy activity.

Dr. Filiberto Pollisco, Jr. gave his message on behalf of Atty. Roberto V. Oliva, ACB Executive Director. He stressed that the Internship will not only provide opportunity to discuss and share ideas on formulating field guide manuscripts but will also further enhance the cooperation with other AMS.

Dr. Miwa Hidetsugu, Coordinator of the ESABII Secretariat and MOE-Japan also welcomed the participants and the organizers for inviting him to the internship program. He discussed the East and Southeast Asia Biodiversity Information Initiative (ESABII). He said that it was launched to pursue capacity building in taxonomy and the development of an information system on biodiversity in East and Southeast Asia in order to contribute to the promotion of biodiversity conservation and the implementation of the CBD Strategic Plan in the area. He further presented the efforts of ESABII to strengthen biodiversity conservation and management through capacity building in taxonomy in the ASEAN Region. He emphasized that ESABII is the supporter of the ASEAN Centre for Biodiversity.

The participants and resource persons introduced themselves by stating their name and agency/organization.

Mechanics and groupings of the training course

Dr. Filiberto Pollisco, Jr., ACB

Dr. Pollisco stated that the Internship Programme is a product of the Advanced Course on the Taxonomy of Pteridophytes and Bryophytes conducted in 25 – 30 November 2014 at the Universitas Dhyana Pura and Bali Botanic Garden, Bali, Indonesia. The general objective of the workshop was to capacitate participants in the rigors of taxonomy especially on the terrestrial plants group on Bryophytes and Pteridophytes.

This Internship Programme is designed for future taxonomist. Approaches included lecture, field study and manuscript development. The final output of the workshop will be a field guide manuscript on Bryophytes and Pteridophytes. He also discussed that the group will be divided into two – one for bryophyte and the other for pteridophyte. Each group was assigned a laboratory from which the groups would work in. The groups also went into the Fern Garden of the QSBG where they collected specimens of ferns and mosses. These were then brought back to the laboratories for processing and identification.

This Internship Programme included a field study to Doi Inthanon National Park, Thailand.

Abstracts of Paper Presentations

Review of Bryophytes

Dr. Benito C. Tan, Bryologist, University of California – Berkeley, USA
Dr. Boon-Chuan Ho, Bryologist, Singapore Botanic Gardens, NParks, Singapore

Bryophytes are the oldest group of Land Plants known as embryophytes; fossils approx. 470 mya (midOrdovician) and have about 25,000 species (Crum, 2001) which Mosses have 12,000 – 13,000 spp.; Liverworts about 7,500–8,500 spp. and Hornworts with 100–200 spp. It is the 2nd largest group after Magnoliophyta (flowering plants, estimated 250–350,000 spp.). It occurs in every ecosystem except marine.

The characteristics of Bryophytes are as follows:
- Land plants — chlorophyll A & B, carotene, true starch, cellulose wall
Bryophytes consist of three major groups, namely: Liverwort, Hornwort and Moss.

Liverwort are the first land plants. These are:
- Liverwort Gametophyte - Either thalloid/thallose (undifferentiated & flattened) or leafy/foliose (differentiated into stem & leaves) and oil bodies present in the cells of gametophytic body
- Liverwort Sporophyte – Seta colourless, thin-walled, soft, short-lived; Capsule usually opens by 4 longitudinal lines; all spores in a capsule released at the same time; Peristome absent; and Elaters present, single-celled.

Hornwort Gametophyte are Flat thallus (no stem & leaves); Cells with a single or 2 large chloroplasts; Chambers with Nostoc — nitrogen-fixing cyanobacteria; and Sex organs embedded in upper layer of thallus.

Hornwort Sporophyte are capsule horn-like; Seta very short or absent; Capsule usually opens by 1–2 longitudinal lines; Columella present; Multicellular pseudo-elaters for spore dispersal.

Moss Gametophyte are always differentiated into stem and leaves with leaves generally radially arranged, rarely lobed; Leaves single layer, except costa & margin; Costa single or double or absent; and Rhizoids multicellular. Additional characters used in moss identification include leaf shape, sexuality, rhizoids, vegetative propagules or gemmae, as well as habitat preference, such as elevational distribution and substrate information.

Review of Pteridophytes
Dr. Dedy Darnaedi, Pteridologist, Research Center Biologi, LIPI, Indonesia
Dr. Bayu Adjie, Pteridologist, Bali Botanic Garden, Bali, Indonesia

Different species of Pteridophyte can be found at different habitat types. It can be found along the river bank, between the lowest and the highest water level. These are called Rheophyte.

The basic key character to the genera of the ferns is based on their form. The main character states are: (i). Simple; (ii). Lobed (pinnatifid); (iii). Simply pinnate; (iv). Bipinnate; and (v). Pinnate – pinnatifid. As the frond becomes more complex, the terms such as tripinnate, bipinnate-pinnatifid can be used.

The position and arrangement of spores on the frond are very important for the identification of the genera of ferns and fern-allies. Six different groups were recognized in tropical Australia by Andrew (1990). These can be used to identify several genera in the Malesian region.

The ornamentation of the surface layers of the spores can be a very useful taxonomic character. There are two major types of spores, namely: monolete, and trilete. Spore ornamentation is very important e.g. in the genus Asplenium and Athyrium. Spores are good indicators of different species.

Scales are very important for the identification of the ferns. Members of the family Aspleniaceae all have clathrate scales. The nature of the scales can also be used to distinguish the three groups in Cyathea. Paraphyses are important in some families.

They have been extensively used for the proposed subdivision of the family Vittariaceae into several genera. This work is still in process but current result indicate that they may closely reflect a subdivision of the family based on rbcL, into several distinct genera.

Collection of ferns is the same as other vascular plants with some points to record. The rhizome is very important – especially its habit and the scales/hairs. Reduce the size of the rhizome by cutting longitudinally if necessary. If the rhizome is absent it is often not possible to use the key for identification. When collecting ferns with large fronds – Dicksonia, Cyathea or Angiopteris it is very important to be very careful. Sometimes the fronds are dimorphic. Both sides of the fronds are important to observe hairs, scales etc. Many collections of large fern fronds are restricted to single pinna and quite inadequate. Collect spores and young leaves for
DNA if necessary. Take photograph as many as possible.

In describing new species, the following have to be collected and prepared:

1. DNA data (if any);
2. Spores (if any);
3. Chromosome (if any);
4. Habitat and ecology;
5. Line drawing and/or color pictures;
6. Herbarium specimens;
7. Morphological description;
8. Choose name;
9. Write the manuscript; and
10. Publish it

Economically important Pteridophytes are Coral deposits originated from vast pteridophyte forest that lived during the carboniferous era. Other economic values are food, vegetable, fibre, starch, medicinal plants, Building materials, handcraft, traditionally used as decoration such as kite, Alkaloids and the phenols compounds.

Hundreds of species are used as ornamental plants such as Staghorn fern (*Platycerium* spp.); the trunk of Tree Ferns (*Cyathea* spp.) are used as construction materials; medium for orchids; and handcraft and in tourist industry. Due to over exploitation of Tree Ferns (*Cyathea* spp.), it is considered an endangered species and protected under the CITES regulation.

**Lecture on Developing a Field Guide Book**  
**Dr. Edwino S. Fernando**, Plant Taxonomist, University of the Philippines Los Baños

Taxonomy is the starting point of any basic or applied biological research. It provides the database for ecology and conservation science. It lays the foundation for the phylogenetic tree of life (Wilson 2004). Taxonomic information is essential for addressing many critical issues on biodiversity conservation, including those across international borders, for example: spread of invasive alien species, conservation of migratory birds, the emergence of new diseases, the decline of amphibians, and the impact of wildlife trade (McNeely 2002).

Some ‘customers’ and stakeholders share an urgent need for taxonomy. These are:

- Senators and Representatives in Congress and Members of Parliament, who need to ensure that laws will protect all of our biodiversity and that their legislation is directed at the top priorities;
- Diplomats, who need to ensure that biodiversity-related conventions are meeting their conservation objectives;
- Customs and Quarantine officials, who should be on the lookout for potentially invasive alien species or illegally traded wildlife;
- Environmental Planners, who need to carry out EIAs for proposed projects that may affect biodiversity;
- Agronomists, who need to find species useful for integrated pest management (IPM), requiring a good understanding of species relationships;
- Horticulturists, who need to find potential new ornamental plants or edible fruit trees to introduce into commercial production;
- Field Biologists, Conservation workers, and Students, who need to identify the species with which they are working;
- Epidemiologists, who need to chart the distribution of diseases that may be transmitted between people and other animals;
- Ecotourists and naturalists, who want to identify the plants and animals they encounter in their travels; and
- Novices, who simply want to learn the names of the common plants in the area.

Taxonomy provides the core reference system and knowledge-base on which all discussion of biodiversity hinges. Taxonomy is central to the conservation of biodiversity.

The earliest field guides were created before the 14th century and were illustrated, utilitarian descriptions, such as herbals. Florence Merriam Bailey is credited to writing the first field guide, *Birds Through an Opera*
Glass in 1889. It contains wonderful descriptions, but only a few black and white illustrations. Field guides as stated by R.T. Peterson (1934) then developed the first modern field guide, A Field Guide to the Birds. Essential to his system were color plates with paintings of similar species in which Peterson indicated field marks.

Field guides are mainly written for general audiences, but they are also being used increasingly as authoritative references for species identification. Nearly five-fold increase in citations of field guides — from 50 to 248 per year — in scientific publications between 1990 and 2004 as indicated by Schmidt (2006). Who needs field guides? A diverse set of people needs them especially those who might be called ‘applied and recreational field biologists and naturalists’ (Stevenson et al. 2003). These include students, conservation workers, horticulturists, ecotourists, curious novices, amateur and professional field biologists, park rangers. In 2000, consumer demand for field guides were indicated when search at Amazon.com book titles for the keywords ‘field guide’ yielded 625 total entries (Stevenson et al. 2003). In 2012, a similar search yielded 1,849 titles, with 81 forthcoming and published titles for 2012–2013 alone. Of these later publications, there are 29 – birds; 19 - plants and fungi; 10 – mammals and herpetofauna; 8 – invertebrates; 7 - site-based treatments of multiple types of organisms; 8 - gems, fossils, animal tracks, weather, or astronomical objects (Farnsworth et al. 2013). Consumer demand for field guides continues to grow.

Stevenson et al. (2003) mentioned that there are limitations of commercially available field guides. The economics of traditional publishing dictate that paper field guides:

- Must have commercial viability
- Tend to focus on popular taxa
- Cover wide geographic areas
- Contain many species
- Mostly naturalists, rather than scientists, write commercial field guides

Today’s field guides typically consist of two sections:

1. An overview of the taxonomic group of interest (introductory paragraphs)
   - Short introduction on the area or site
   - Classification and general ecology of the group
   - Basic morphology and key characters
   - Life cycles (for ferns and bryophytes will be useful)
   - Terminology (glossary, often illustrated). Remember, readers will have no or only little background on technical terms
   - Simple keys
   - Instructions on how to use the field guide

2. Species accounts (Stevenson et al. 2003)
   - Scientific name, common name(s)
   - Descriptive text
   - Photographs, illustrations (up to >50% of all the printed material)
   - Information on geographical distribution, maps
   - Ecology and habitats
   - Conservation status

Identification, using field guides, process relies on a combination of simple keys as the user scans the illustrations or photos for a match and carefully compares what is known about the specimen in view or in hand with pertinent text and graphical information provided in the guide.

The keys help people focus their search in a section of the book in which the number of choices is relatively small. Field guides often have an implicit hierarchical tree of 2 to 4 levels for identification, e.g., life forms and then groups.

The problem of plant identification, are as follows:

1. Expert determination would generally be the most reliable method.
2. Recognition is based on experience.
3. Comparison covers a broad array of approaches, including searching through herbarium specimens, reading descriptions, reviewing illustrations, and studying field guide photos. The basic approach taken by most taxonomists to develop their expertise, but it is time-consuming and requires access to specimens and scientific literature).
4. Use of keys and related methods such as synopses, outlines, and tables of characters. Keys are generally used by scientifically trained people; it is the most widely used approach. Keys offer a step-by-step approach to identifying a species.

Field guides are a way for people to connect with the natural environment by putting a specific face on the term “biodiversity” (Stevenson et al. 2003).

Literature cited


Orientation of the QSBG, its facilities and complex

QSBG Staff

The participants and resource persons were oriented on the features of Queen Sirikit Botanic QSBG The participants and resource persons were oriented in the QSBG through the walk-through of its facilities and complex. Queen Sirikit Botanic Garden is situated at the edge of the Doi Suthep-Pui National Park with an area of about 1000 hectares.

The garden sprawls over a hillside climbing from the Mae Sa stream at about 500m reaching a highest point (in a conservation zone) at about 1200m. Encompassed within this area are gardens, glasshouses, trails and natural vegetation ranging from hill evergreen through dry dipterocarp forest to pine forest areas. Three streams flow through the garden into the Mae Sa stream, which also runs through the gardens and down the Mae Sa valley.

Within the garden one can explore walk trails, gardens and glasshouses all showcasing a rich diversity of plants either in their natural settings or arranged according to some theme or classification.

Among the facilities toured were Ornamental and Fern Garden; Tropical Rainforest House, Arid House and...
Orchid and Fern House. The Ornamental garden is a colorful mixture of plants to appeal to the visual senses. Colorful beds mixed with mature ornamental plants from as far off as Australia always make for good photo opportunities. The Fern Garden is by far the most verdant trail at QSBG and a rarely discovered gem. This moss covered wonderland of shade plants, ferns, and friends of ferns showcases ferns of every shape and color. The trail includes a fern pavilion from which you have a view of the whole trail. Along this trail you can also see Philodendrons reaching the sky from their shady oasis. Opened to the public in August 2002, the Glasshouse Complex comprises 4 exhibition conservatories and 8 glasshouses with themed plant collections. The Glasshouse Complex is more than an hour’s walk uphill from the entrance so most people prefer to travel by vehicle. The Tropical Rainforest house is the largest conservatory of the Glasshouse Complex. With a floor space of 1000 square meters and a height of 33 meters it holds a wide collection of tropical species, such as palms, bananas, and gingers, from Thailand and the Southeast Asian region. The Orchids and Ferns House features epiphytic and terrestrial orchids, and ferns with an emphasis on native species. The orchid family has some 25,000 species and 900 genera. It is one of the largest plant families and also one of the most widespread. Thailand is blessed with some 1200 species of orchids. The most common genera are *Dendrobium* and *Bulbophyllum*. Many Thai orchids are threatened by over-collection and deforestation.

The moss *Physcomitrella patens* (Funariaceae) as a model plant, and its ecotype

**Dr. Junko Kawai**, University of Tokyo, Japan

Dr. Kawai started out with the basic information that bryophytes, pteridophytes and seed plants belong to the land plants called “streptophytes” wherein the streptophyta algae also belong. She mentioned that 450 million years ago, the bryophytes already appeared well before the vascular plants at 400 million years. Kawai mentioned that researches with bryophytes may solve the mysteries of the evolution of the land plants.

The genetic material of the bryophytes started out with a gene which underwent a gene duplication process and branched out to a simple morphology and a more complex morphology which resulted to new functions and morphological diversification. Kawai discussed more in-depth the functional analysis of bryophytes that elucidates the evolutionary mechanisms in land plants. She showed that the bryophyte *Physcomitrella patens* has a simple body structure and morphology, whereas the streptophyte algae is unicellular and the angiosperm *A. thaliana* is quite complex.

Kawai continued to describe the moss *P. patens* and its life cycle to contextualize the main topic of her presentation. She went on to describe the morphological features of the spores and how the sporophytes developed during its culture. She mentioned that the *P. patens* is hermaphroditic and mutations occurred during her study of the moss.

Kawai also looked into the environmental stress tolerances of the moss. She highlighted the methodology that she used in analyzing the tolerances of the moss to environmental stresses. She then proceeded to provide information on the ecotypes, the research results and the taxonomy and biomimicry of the moss.

**Diversity of Pteridophytes**

**Dr. Chan-Ho Park**, National Institute of Biological Resources, Korea

Taxonomy is the science of discovering naming describing classifying. Taxonomy from Greek word *taxis* means division/arrangement and *nomos* means law organisms. It is to understand biodiversity.

Classification matters in your daily life. It is part of our everyday life. It allows us to place things in order, such as in a stock inventory in a supermarket. Would you look for dairy products next to household cleaning items? NAMES matter in your daily life.

Names are needed for communication. Common or vernacular names are useful for everyday communication but are limited by location and language. On the other hand, scientific names ensure that we are talking about the same organism regardless of our geographic location or language. It is used for global communication.

The life cycle of pteridophytes involves alternation of generations. This means that a diploid generation (the sporophyte, which produces spores) is followed by a haploid generation (the gametophyte or prothallus, which produces gametes). Pteridophytes differ from mosses and seed plants in that both generations are
independent and free-living, although the sporophyte is generally much larger and more conspicuous. The sexuality of pteridophyte gametophytes can be classified as follows:

- **Dioicous**: each individual gametophyte is either male (producing antheridia and hence sperm) or female (producing archegonia and hence egg cells).
- **Monoicous**: each individual gametophyte produces both antheridia and archegonia and can function both as a male and as a female.
  - **Protandrous**: the antheridia mature before the archegonia (male first, then female).
  - **Protogynous**: the archegonia mature before the antheridia (female first, then male).

These terms are **not** the same as **monoecious** and **dioecious**, which refer to whether a seed plant sporophyte bears both male and female gametophytes (i.e. produces both pollen and seeds), or just one of the sexes.

Pteridophytes consist of two separate **classes**:
1. **Lycophyta**
   - Lycopodiidae (clubmosses)
   - Selaginellidae (spikemosses, quillworts)
2. **Polypodiopsida**
   - Psilotidae: Psilotales (whisk ferns) and Ophioglossales (e.g. grape ferns)
   - Equisetidae (horsetails)
   - Marattiidae (marattioid ferns)
   - Polypodiidae (leptosporangiate ferns, the most species-rich group)

In addition to these living groups, several groups that are now extinct and known only from fossils are considered to belong to pteridophytes. These groups include the Rhyniophyta, Zosterophyllophyta, Trimerophytophyta, and the progymnosperms.

Modern studies of the land plants agree that all pteridophytes share a common ancestor, which is also the ancestor of seed plants. Therefore, pteridophytes do not form a clade but a paraphyletic group. Pteridophytes are Free-sporing tracheophytes. Paraphyletic group of Pteridophytes are Nonvascular plants (bryophytes); Fern and Fern allies; Gymnosperms; and Angiosperms.

K-Bon Monitoring Application is developed for the K-BON. This software aims for collecting pictures of species with GPS data through personal smartphones. Many people can use this application to collect pictures of diverse plants and animals easily. You can take a picture and write a simple note for the species. You can see all plants and animals you've collected via this program on the map.

**Closing Programme**

The Internship Programme closed with impressions presented by each of the participants (experience during the internship; problems met; how to improve the course). Each country representative expressed their appreciation to the ASEAN Centre for Biodiversity, QSBG, MoE-J, ACB secretariat, speakers, and other participants for providing a conducive and collaborative learning experience.

Many of the AMS, if not all, enjoyed the Internship program as one of their feedback. They said that the exercises and activities done will provide valuable contributions to their work and enhance their knowledge on the Bryophytes and Pteridophytes and field guide development. However, they said that the internship program needs to be a longer one and that there should be shorter lectures. The participants took last minute pictures of their newly found friends and had lunch together before going on their separate ways.

The resource persons, Dr. Benny Tan and Dr. Dedy Darnaedi, begged off in delivering the closing messages since they have already imparted to the group what knowledge and expectations they have for the participants during the open forum in the presentations of outputs.

Dr. Piyakaset Sukasatan represented Dr. Suyanee Vessabutr, the Director of the QSBG, and he too said so many things to the participants during the course, he just thanked the AMS for coming to participate and he hoped that there are future activities to be conducted in QSBG. He looks forward to meeting them again in the future.
Dr. Miwa Hidetsugu of the ESABII and MOE-Japan, also thanked the participants and the organizers for inviting him to the internship program.

Dr. Filiberto Pollisco, Jr. of ACB also thanked the organizers and the participants. He requested the organizers from QSBG, OMC, and ACB, to stand up and be recognized for their support in making the internship program a success. He also mentioned that the internship program may be the last activity of the one-year project, but he hoped that it is not the last to be conducted with QSBG and MOE-Japan.
ACB’s resource persons and participants toured Doi Inthanon National Park as the field study site. It is the highest mountaintop in Thailand (2,565 meters above the sea level), followed by Doi Huamodluang (2,330 meters above the sea level). Doi Inthanon is the source of many rivers including Mae Klang, Mae Pakong, Mae Pon, Mae Hoi, Mae Ya, Mae Chaem, Mae Khan, and being part of Ping River, where the Bhumipol Dam is situated and generating the electrical power.

The forest in the park is one of the country’s very significant and valuable heritage. Forests include Moist Evergreen Forest (Ang Ka Nature Trail), Pine forest and Mixed Deciduous Forest are composed of Dipterocarp spp., Xylica sp., xylocarpa sp., Pterocarpus sp., macrocapus sp., Terminalia sp. and Lagerstroemia sp., to name a few. In addition to these, there are many beautiful flowers including vanda orchid, phycastylis and rhododendron. Sphagnum Moss and osmanda fern are found at higher levels in the park.

Fifty years ago, the mountain peaks were home to the hill tribe people. The biggest village was Ban Khun Klang, whose agriculture method was often destructive to the forest ecosystem.

Currently the several Royal Projects, assists the villagers in growing cold-climate fruit such as strawberries, grapes and apples as well as flowers. Because of its broad altitudinal range and the cool climate of its upper reaches, the park supports the largest number of bird species of any site in Thailand. The Center for Wildlife Research at Mahidol University records a present total of 362 species and expects many at the summit are migrants from northern Asia. Species restricted to Doi Inthanon are Ashy-throated Warbler and an endemic race of the Green-tailed Sunbird; the park is the only site where the Chestnut-bellied Rock-Thrush and the Yellow-bellied Flower pecker are known to over summer and probably breed.

They also had a Field work in Kew Mae Pan Nature Trail. The Trail is 4 km long and can be trekked for 3-4 hrs. The trail boasts of 21 stations around its course. Each station describes the features of the ecosystem and its content. This stunning three to four-hour walk takes you through primitive forests, past giant Rhododendrons, around waterfalls and streams and leads to a cliff where the mountain views will take your breath away.

The Bryophyte Group went into the trail at a counter-clock-wise direction, i.e. from stations 1 – 21, whereas the Pteridophyte Group took the clock-wise direction of the trail, i.e. stations 21 – 1. The groups met at the Mae Pan Mountain Range Peak at Station 6.

During the trek, each group was briefed on their assignments on the mosses and ferns of the Mae Pan Trail. Some specimens were collected for later processing. Pine Forest in the National Park, Siribhume Fern Garden and Waterfall, Doi Inthanon National Park, Inthanon Royal Project and Wachirathan Falls.
Lessons learned from the Internship Programme

There are several lessons learned in the implementation of this program:

1. **Partner Organization.** The Queen Sirikit Botanic Garden is an excellent place for taxonomic capacity building for terrestrial plants and insects. They have good laboratory and herbarium facilities and have good complement of expert staff who can be tapped as resource persons and for logistical arrangements.

   The QSBG staff are very helpful and fully cooperative. Future collaborative activities requiring the facilities and staff of the QSBG can be implemented with minimal problems.

2. **Schedule of Activity (Timing).** Organizing a workshop in Chiang Mai in January is difficult especially in arranging for the accommodation, since it is the peak season for tourists to come to Chiang Mai. Most of the hotels and other accommodations are fully-booked and the organizers had a hard time arranging the accommodations of the participants.

3. **Selection and Proper Nomination of Country Representative.** One participant believed he held a managerial position in his country’s ministry; thus he did not join in the laboratory and field collection work since, according to his reason back in his country, he will just order his staff to do things. This irked the resource persons very much. Lesson learned here is that the AMS should screen their nominees thoroughly to prevent a repeat of the situation.

4. **Field trips and collection expeditions.** The field and collection expeditions were very helpful in appreciating the rigors of taxonomy. This activity should be retained in future training-workshops.
## Annex 1: List of participants, resource persons and organizers

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<tr>
<th>No.</th>
<th>Country/Organization</th>
<th>Title</th>
<th>Name</th>
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Annex 2: Paper and Powerpoint Presentations

A Review of Bryophyte Taxonomy - I

Dr. Benito C. Tan
Researcher / Plant Taxonomy
The University Herbarium
University of California
Berkeley, CA USA

Dr. Ho Boon Chuan
Researcher / Plant Taxonomy
Singapore Botanic Gardens Division
National Parks Board, Singapore

What are bryophytes?

- Oldest group of Land Plants
  Also known as embryophytes

- Fossils approx. 470 mya (mid-Ordovician)

- About 25,000 species (Crum, 2001)
  - Mosses 12,000–13,000 spp.
  - Liverworts 7,500–8,500 spp.
  - Hornworts 100–200 spp.

The 2nd largest group after
Magnoliophyta (flowering plants,
estimated 250–350,000 spp.). Occur
in every ecosystems (except marine)
Characteristics of Bryophytes

- Land plants — chlorophyll A & B, carotene, true starch, cellulose wall
- No vascular tissues (xylem & phloem);
  Lacks true roots, stems, leaves;
  Have rhizoids, caulidia, phylidia
- No lignin => small plant size
- Dominant gametophyte body (1n) with simplified sporophyte (2n) body
Gametophyte (haploid=1n)
- dominant
- "stems" & "leaves"
- morphologically diverse

Sporophyte (diploid=2n)
- short-lived
- Unbranched
- Single terminal sporangium per sporophyte
- always attached to the gametophyte and partially dependent on gametophyte for nutrient

Stem Anatomy

central strand

cortex

epidermis

hypodermis

leptoids

hydroids

Deudorixtrichium dendroides stem hydroids (ss).

Schuster, 1984 New Manual Bryal 2
Sex Organs & Gametes in Bryophytes

Female sex organs = archaegonia

Male sex organs = antheridium

Water required for fertilization!

Asexual reproduction by gemmae and propagules
Bryophytes consist of three major groups

Liverwort

Hornwort

Moss

Liverworts are the First Land Plants

Vascular plants (ca. 400,000 sp.)

Hornworts (220-240)

Mosses (12,000)

Liverworts (8,500)

Charales or Zygamenataes

Anthoceros

Physcomitrella

Marchantia

www.unigrad.at
Plant Evolution through Geologic time

Bryophyte Classification

**Division Marchantiophyta** (Hepatics, liverworts)
- Class Haplolepidae
- Class Marchantiopsida
- Class Jungermanniopsida

**Division Bryophyta s. str.** (Mosses)
- Class Takakiopsida
- Class Sphagnopsida
- Class Andreaceopsida
- Class Andreaeopsida
- Class Polytrichopsida
- Class Bryopsida

**Division Anthocerotophyta** (Hornworts)
- Class Leiosporoceropsida
- Class Anthoceropsida

*Note: Traditional concept of division Bryophyta s. lat. includes: Class Hepaticae, Class Musci, & Class Anthoceratae*
Liverwort Gametophyte

- Either thalloid/thallose (undifferentiated & flattened)
- Or leafy/foliose (differentiated into stem & leaves)
  - Oil bodies present in the cells of gametophytic body

Oil bodies of liverworts

Photos by Ru-Liang Zhu
Liverwort Sporophyte

- Seta colourless, thin-walled, soft, short-lived,
- Capsule usually opens by 4 longitudinal lines

http://www.youtube.com/watch?v=WeAWo6QmAk
Liverwort Sporophyte

- All spores in a capsule released at the same time
- Peristome absent
- Elaters present, single-celled

Liverwort Classification

7,500–8,500 spp

- Leafy II......................... 2,600 spp
- Leafy I.......................... 1,800 spp
- Simple thalloids II.......... 230 spp
- Pleuroziaceae............... 11 spp
- Simple thalloids I......... 160 spp
- Complex thalloids......... 440 spp
- Bazzaciaceae............... 2 spp
- Haploporaceae.............. 8 spp
- Treubiaceae............... 10 spp

Forrest et al. 2000. Bryologist 103: 303-324
Class Marchantiopsida: Complex Thalloid Liverwort

Marchantia

Transverse section of Thallus

 Archaeogonophore

 smooth

 pegged

 Anthelidiophore

 Class Jungermanniopsida
 Simple Thalloid Liverworts

 Metzgeria

 Schwager, 1984
 New Manxian Bryot. 2

 Photo by Qin Ling Zhu
Common thalloid liverworts

Aneura pinguis

Common thalloid liverworts

Pellavicinia iyellii

photo by SEABAL Dys 2012
Class Jungermanniopsida
Leafy Liverworts

Leaves often in 2 or 3 rows

Succulent leaf insertion

Incubous leaf insertion
Common leafy liverworts

Radula

Common leafy liverworts

involucre (n)

Pleurozia
**Hornwort Gametophyte**

- Flat thallus (no stem & leaves)
- Cells with a single or 2 large chloroplasts
- Chambers with *Nostoc* — nitrogen-fixing cyanobacteria
- Sex organs embedded in upper layer of thallus

**Hornwort Sporophyte**

- Capsule horn-like
- Seta very short or absent
- Capsule usually opens by 1–2 longitudinal lines
- Columella present
- Multicellular pseudo-elaters for spore dispersal
Common hornworts

Notothylas

Common hornworts

Phacoceros
Common hornworts

Dendroceros

Cam on
Salamat
Thank You
Dank u we!
Terima Kasih
Khawp khun khrap
Moss Gametophyte (n)

- Always differentiated into stem and leaves
- Leaves generally radially arranged, rarely lobed
- Leaves single layer, except costa & margin
- Costa single or double or absent
- Rhizoids multicellular
Leaves of mosses vs. leafy liverworts

Vanderpoorten & Cuff, 2009 Introduction to Bryophytes

Small plant size
Double leaf plate

Oval-oblong and smooth leaf cells and no costa
Crenulate leaf margin; quadrate, mammillose leaf cells with thick cell walls

Dentate leaf margin and elongate leaf cells
Strongly and irregularly toothed leaf margin

Differentiated leaf layer of linear cells, oval laminar cells
Unipapilllose and elongate leaf cells with thick, porous cell walls

Pluripapilllose leaf cells with thin cell walls
Strongly differentiated leaf alars

Few alar cells with elongate to linear, smooth leaf cells
No leaf alar differentiation; short double leaf costae

Position of Sporophytes

Pleurocarpous
Macrotiannium macrocarpum

Acrocarpous
Rhodobryum giganteum
Position of Sporophytes

Pleurocarpous

Acrocarpous

Moss sporophyte is a long lasting structure
Cucullate calyptra on capsule; seta papillose

Straight capsule; seta smooth
Curved and asymmetric capsules

Pendant, oblong capsules showing operculum with blunt tip
Immersed capsule with very short seta; arrow pointing at perichaetial leaf

Immersed capsule of Archidium with no seta and very big spore
Additional characters used in moss identification include leaf shape, sexuality, rhizoids, vegetative propagules or gemmae, as well as habitat preference, such as elevational distribution and substrate information.
CLASS TAKAKIOPSIDA
TAKAKIA (A PRIMITIVE MOSS)

Takakia with capsule
Class Sphagnopsida
*Sphagnum* (Peat Mosses)

*Sphagnum*

Pseudopodium (n)!
not beta (2n)!!!
Sphagnum junghuhnianum

Sphagnum cuspidatum
Class Polytrichopsida:  
*Pogonatum* (Hairy capped Mosses)
Polytrichum
(Hairy capped moss)

Dawsonia
Class Bryopsida: True Mosses

Subclass Buxbaumiidae
Diphasciun (Pregnant Moss)
Subclass Bryidae
Campylopus

Subclass Bryidae
Dicranoloma
Subclass Bryidae
Leucobryum (White Moss)

Subclass Bryidae
Philonotis (Apple Moss)
Subclass Bryidae
Macromitrium

Photo by Binh Nhât Lương

Subclass Bryidae
Spiridens
Subclass Bryidae
Distichophyllum

Subclass Bryidae
Benitotania
**How rich is the moss flora of Malesia?**

<table>
<thead>
<tr>
<th>Country</th>
<th>Family</th>
<th>Genus</th>
<th>Species</th>
<th>% of endemic spp.</th>
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<tr>
<td>Malesia</td>
<td>74</td>
<td>302</td>
<td>1770</td>
<td>ca 20%</td>
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<tr>
<td>New Guinea</td>
<td>61</td>
<td>263</td>
<td>918</td>
<td>ca 18%</td>
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<tr>
<td>Borneo</td>
<td>20</td>
<td>185</td>
<td>721</td>
<td>ca 7%</td>
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<tr>
<td>Philippines</td>
<td>59</td>
<td>246</td>
<td>743</td>
<td>ca 5%</td>
</tr>
<tr>
<td>Java</td>
<td>50</td>
<td>204</td>
<td>566</td>
<td>?</td>
</tr>
<tr>
<td>Malay Peninsula</td>
<td>46</td>
<td>159</td>
<td>522</td>
<td>ca 1%</td>
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<tr>
<td>Sulawesi</td>
<td>49</td>
<td>162</td>
<td>490</td>
<td>?</td>
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<tr>
<td>Sumatra</td>
<td>42</td>
<td>145</td>
<td>340</td>
<td>?</td>
</tr>
<tr>
<td>Lesser Sundas Is.</td>
<td>45</td>
<td>367</td>
<td>367</td>
<td>ca 1%</td>
</tr>
<tr>
<td>Moluccas</td>
<td>75</td>
<td>318</td>
<td>1132</td>
<td>ca 19%</td>
</tr>
</tbody>
</table>

China          | 65     | 413   | 2457    | ca 9%             |
Japan          | 68     | 332   | 1135    | ca 12%            |
Korea          | 48     | 158   | 429     | ?                 |
Mongolia       | 37     | 184   | 412     | ?                 |
Indochina      | 55     | 236   | 995     | ca 9              |
India          | 355    | 1706  | 1132    | ca 15%            |
North America  | 75     | 318   | 1132    | ca 19%            |

Thank You for your attention!
The 3rd Taxonomic Capacity Building on Bryophytes and Pteridophytes and their Allies

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Indonesian Institute of Sciences,

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**) Eka Karya Botanic Gardens-LIPI, Bali

20 - 30 January 2015  
Queen Sirikit Botanic Garden, Chiang Mai, Thailand

Taxonomy of Pteridophyte:

1. Pteridophyte in the world, region, local population  
2. Morphology  
3. Life cycles and mode of reproduction  
4. Ecology and distribution  
5. Classification  
6. Key identification to Genera and Species  
7. Field work and fern collection  
8. Economic importat
Ecosystem: Different species at different habitat types

Along the river bank, between the lowest and the highest water level... *rheophyte*

S. Mendalam TN Betung Kerihun, West Kalimantan; Desember 2010

Doc. Darnaedi
Reophyte:

Oligate reophyte, diploid sexual

Trigonospora calcarata

The origin of Rheophyte is in the Question?
Morphology
Early Morphological Study in Bogor Botanic Gardens
ILLUSTRATED GLOSSARY

Frond parts (morphology)

A. frond tip (apex)
B. pinnae
C. rachis
D. basal pinnae
E. stipe
F. rhizome
G. blade
H. frond
I. blade
J. crossier
K. pinnal
L. stipe
M. rhizome
N. roots
O. pinnal stalk
P. pinnule
Q. costa
R. costule
S. rachis
T-V. ultimate segments

Daniel D. Palmer, 2003
Blade Shapes (Dissection)

A. simple  
B. pinnatifid  
C. pinnatisect  
D. pectinate  
E. 1-pinnate, pinnae opposite  
F. 1-pinnate, pinnae alternate (diagrammatic)  
G. 1-pinnate-pinnatifid  
H. 2-pinnate-pinnatifid, pinnae alternate  
I. 2-pinnate, pinnae alternate  
J. 3-pinnate, pinnae alternate  
K. 2-pinnate, pinnae opposite (diagrammatic)  
L. 3-pinnate, pinnae alternate (diagrammatic)  
M. hastate

Daniel D. Palmer, 2003

Rhizome types

A. tufted, with roots and stolons  
B. short-creeping  
C. decumbent  
D. caudex  
E. long-creeping  
F. with phyllopodia  
G. jointed
FROND, PINNA, AND ULTIMATE SEGMENT: MARGINS, TIPS, SHAPES

- entire
- undulate
- crenate
- crenulate
- serrate
- dentate
- denticulate
- pinnatifid
- incised
- lacerate
- lobed
- shallow
- sinuses
- decurrent
- auricle
- auriculate
FROND, PINNA, AND ULTIMATE SEGMENT: MARGINS, TIPS, SHAPES

emarginate  truncate  acute  acuminate  attenuate  apiculate  caudate  obtuse

spatulate  falicate  discoid  trapeiform  tetrate

linear  ovate  lanceolate

oblong  ovate-lanceolate  ovate

obovate  oblong-lanceolate  oblanceolate

triangular (deltate)  elliptic

Stipe cross sections showing characteristic arrangements of vascular bundles: A. Athyriaceae (Athyrium, Cystopteris, Deparia, Diplaziurn), Thelypteridaceae (Anomyriella, Christella, Cyclonemia, Macromitrium, Parametopodium, Pseudopogonocercus); B. Aspleniaceae, of mid to upper stipe (Asplenium, Dryopteris, C); Polypodiaceae (Lepisorus, Microsorum, Phlebodium, Phyllitis, Pteridium, Polypodium); D. Dryopteridaceae (Anemia, Ctenitis, Cyrtomium, Dryopteris, Nephrolepis, Polyglossa, Tectaria); E. Dryopteridaceae, small fronds; F. Marattiaceae (Angiopteris, Marattia).
Life cycle and reproduction
Life cycle of ferns (sexual)

Adult Sporophyte (2n)

Meiosis

Spore (n)

Young Sporophyte (2n)

Fertilization

Archegeonum

Gametophyte (n)

Egg (n)

Sperm (n)

Antheridium

Hauffler, C.H.

Figure 1. Homosporous pteridophytes alternate between two entirely independent generations. Bisexual gametophytes produce both egg-containing archegonia and sperm-producing antheridia. Fertilization occurs when the motile sperm swim down the necks of the archegonia and unite with the egg, forming the diploid zygote. Not all gametophytes of homosporous species become bisexual, and not all bisexual gametophytes are capable of self-fertilization. The single-celled zygote divides mitotically and matures to form the sporophyte. On the underside of sporophyte leaves are clusters of sporangia (sori). Meiosis occurs in the sporangia, producing tetrad of spores that are released into the air. Under suitable conditions, the spores germinate and grow by mitotic cell divisions to form the gametophyte.
Breeding System

a. Intragametophytic selfing

b. Intergametophytic selfing

c. Intergametophytic crossing

Figure 2. Breeding system options for homosporous pteridophytes. (a) Intragametophytic selfing. Sperm from a single gametophyte fertilizes the egg of that same gametophyte. (b) Intergametophytic selfing. Sperm from one gametophyte fertilizes the egg of a neighboring gametophyte, but both gametophytes arose from spores of the same sporophyte. (c) Intergametophytic crossing. Sperm from one gametophyte fertilizes the egg of a neighboring gametophyte, and the two gametophytes arose from spores of different sporophytes.

Allopolyploid

Figure 3. Allopolyploid speciation is initiated when hybridization occurs between diploid species A₁ and A₂. The resulting hybrid is reproductively incompetent (sterile) because, although homoeologous haploid genomes A₁ and A₂ are sufficiently similar to form a vigorous sporophyte (the considerable similarity of the genomes is denoted by having both share the letter A), the two genomes are sufficiently divergent to prevent bivalent formation during meiosis (critical differentiation of genomes is denoted by separate subscripts 1 and 2). Through polyploidization, that hybrid regains reproductive competency, because bivalents can form between the duplicated homoeologous diploid genomes A₁A₂ and A₁A₂.
Life cycle of ferns (apogamous)

- Adult Sporophyte (2n)
- Young Sporophyte (2n)
- Gametophyte (2n)
- Spore (2n)
- Meiosis

Fertilization is not present in this cycle.

Hybridization between apogamous species and its related sexual species

Apogamous 3x

Hybridization

Sexual 2x

However, most apogamous ferns are 3x.
In order to test the hypothesis…

Artificial crossing experiments between closely related apogamous and sexual fern species

How high is crossing ability of apogamous ferns?

Crossing ability of the apogamous *D. erythrosora*

<table>
<thead>
<tr>
<th>Formation rate</th>
<th>0</th>
<th>18</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apogamous X Sexual</td>
<td>50</td>
<td>180</td>
</tr>
<tr>
<td>Sexual X Sexual</td>
<td>4x hybrids</td>
<td>3x hybrids</td>
</tr>
</tbody>
</table>
Reticulate evolution in apogamous ferns

- High crossing ability of apogamous ferns may lead to complicated reticulate evolution
- Apogamous ferns often make ‘agamic complex’
- Clarifying actual processes of reticulate evolution is necessary for taxonomical understanding of apogamous ferns.
- Can apogamous ferns hybridize only with closely related sexual species?

![Diagram of reticulate evolution]

- Hybridization – Gaining fertility
- Apogamous ferns can perform complicated reticulate evolution.
D. caudipinna tooks part in the reticulation of D. varia complex

Morphological variation of D. pacifica

Fronds: thick & shiny  thick & dull  thin & shiny

very thin & shiny  very thin & dull
Morphological, cytological and genetic information along latitudinal distribution of Dryopteris spore

complex:

D. Yakusilvicola (3x), derived from hybridization follow by speciation (D. sparsa (4x) with D. sabaei (2x))
(improved by morphological and genetic (enzym electrophoresis)
Different micro-ecology (*Asplenium nidus* in one tree has different genetic variation):

2. *Asplenium nidus* L.

*Asplenium nidus* sensu lato

Taman Nasional Gunung Halimun-Salak, 1998


---

*Asplenium nidus* (type A dan B), proposed as 2 different species

Genetic differences at micro climate


Next to Phylogeny

Taxonomy in Malesian region:

Flora Malesiana (1950)
**Flora Malesiana**

Malesian region:
- Brunei
- Filipina
- Indonesia
- Malaysia
- Papua Nugini
- Singapura
- Timor Leste

Rich in numbers of species and endemic genera

Reconstructions of Malesian region
SE Asia Reconstructions
50-0 Ma

© Robert Hall 1995
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Proceedings on the Internship Programme for the Taxonomic Capacity Building for Bryophytes and Pteridophytes

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Proceedings on the Internship Programme for the Taxonomic Capacity Building for Bryophytes and Pteridophytes
Taxonomy: Flora and Monograph

- **Flora Malesiana** (South East Asia region)

- **Local Flora**: Flora of Thailand, Flora of Philippines; Flora of Peninsular Malaysia; Flora of Java; (country and or island by island)

  Flora of Mt Gede-Pangrango National Park; Mountain Flora of Java; Checklist Flora of Bali. (smaller region, only in one National Park or Mountains in Java)

  Monograph: *Platycerium, Bolbitis.* All species world-wide. Whole distribution range.
Read keys & make a key
What is Identification Key?

Follows by:
- *Scientific name*; local names; references
- Type specimens
- *Description* (latin diagnoses; english description)
- *Distribution*
- Habitat
- *Notes* (chromosome numbers etc.; status: endemic, cosmopolit etc.)

specimens examines

Daniel D. Palmer. 2003. Hawai’i’s Ferns and Fern Allies

Example of Key Identification

Key to Genera of Family Psilotaceae

The numbers in parentheses after the couplet numbers are those of the referring couplets, making it possible to backtrack through the key to the beginning.

![Image of key to genera of fern allies as found in Hawaii]
Example of
Key identification

Key to species of genus Psilotum

Description and illustration

Hand drawing illustration
Monograph *Platycerium* Hennipman

Hennipman, E. and M.C. Roos, 1982.

A monograph of the fern genus *Platycerium* (Polypodiaceae)

7 and 8 in this key means the species number 7 and 8.
Flora Malesiana

Holtum, R.E. 1991
Key to genera

p.4. in the bracket means page 4
Proceedings on the Internship Programme for the Taxonomic Capacity Building for Bryophytes and Pteridophytes
<table>
<thead>
<tr>
<th>Key to the species of Selaginella in Taiwan</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Stem single, erect and forming a main axis...</td>
</tr>
<tr>
<td>2. Stem caespitose, trophophylle on the scale-like stems branching...</td>
</tr>
<tr>
<td>3. Trophophylle uniformly attached on stems...</td>
</tr>
<tr>
<td>4. Trophophylle broadly lanceolate to ovate, two main veins apparent...</td>
</tr>
<tr>
<td>5. Stem creeping, ascending or caespitose...</td>
</tr>
<tr>
<td>6. Thirdly derived branches usually unbranched, epinastic leaves...</td>
</tr>
<tr>
<td>7. Sporangia arranged in a raceme, forming subumbrelliform clusters...</td>
</tr>
<tr>
<td>8. Margin of dorsal trophophylle loosely laxate...</td>
</tr>
<tr>
<td>9. Sporangia arranged in a raceme, forming subumbrelliform clusters...</td>
</tr>
<tr>
<td>10. Sporangia arranged in a raceme, forming subumbrelliform clusters...</td>
</tr>
<tr>
<td>11. Sporangia arranged in a raceme, forming subumbrelliform clusters...</td>
</tr>
<tr>
<td>12. Sporangia arranged in a raceme, forming subumbrelliform clusters...</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Key to the species of Selaginella in Taiwan</th>
</tr>
</thead>
<tbody>
<tr>
<td>13. Smooth on the upper surface of ventral trophophylle...</td>
</tr>
<tr>
<td>14. More or less mucronate on the upper surface of ventral trophophylle...</td>
</tr>
<tr>
<td>15. Margin of ventral trophophylle loosely laxate at base...</td>
</tr>
<tr>
<td>16. Margin of ventral trophophylle loosely laxate or shortly laxate...</td>
</tr>
<tr>
<td>17. Margin of ventral trophophylle narrowly lanceolate to broadly lanceolate at creeping branches...</td>
</tr>
<tr>
<td>18. Margin of ventral trophophylle narrowly lanceolate to broadly lanceolate at creeping branches...</td>
</tr>
<tr>
<td>19. Margin of ventral trophophylle narrowly lanceolate to broadly lanceolate at creeping branches...</td>
</tr>
</tbody>
</table>
Proceedings on the Internship Programme for the Taxonomic Capacity Building for Bryophytes and Pteridophytes
Make a Dichotomous Key

Economic important
Economically important:

Coal deposits originate from vast pteridophyte forest that lived during the carboniferous era

Others economic value

Food, vegetable, fibre, starch
Medicinal plants
Building materials, handcraft
Decoration, kite
Alkaloids and the phenols compounds

Cyathea gardens (Bali Botanic Gardens)
Hundreds species used as ornamental plants

Staghorn fern, *Platycerium* spp.
Outdoor ornamental plants

- *Platycerium* bifurcatum with *Lycopodium* sp
- *P. holtumii*
- *P. bifurcatum* ssp. *willinckii*

Ornamental plants,

- Attractive to consumer

Adiantum, Asplenium, Nephrolepis, Ruhmora, Selaginella, Pteris, Microsorium
Angiopteris evecta
for ornamental plants

Trunk of tree Ferns:
_Cyathea spp._
- Construction materials;
- Medium for orchids
- Handicraft and tourist industry
- Protected by CITES
Cibotium barometz
bulu jambe (Ind), penawar jambi (Mal), borabor (Phil).

Golden-coloured hairs as a styptic to stop bleeding

Over exploitation, protected as endangered species, CITES regulation

Lygodium Sw.
materials for baskets, handicraft, fishes trap (buwu);

Doc. Tien Ng. Praptosuwiryo
Vegetables:
Diplazium esculentum (cultivated)
Stenochlaena palustris,

Achrostichum aureum,
Angiopteris evecta,

Traditional used by local people:
Children using dry based frond for a kite.

Drynaria rigidula
How to Describe and Collect Fern Specimens

Bayu Adjie & Dedy Darnaedi

JAIF – MoEJ – ESABII – QSBG – ACB – ASEAN
FROND FORM

The basic key character to the genera of the ferns is based on their form.
The main character state are:
(i). Simple
(ii). Lobed (pinnatifid)
(iii). Simply pinnate
(iv). Bipinnate
(v). Pinnate – pinnatifid

As the frond becomes more complex the terms such as tripinnate, bipinnate-pinnatifid can be used.

SORAL CHARACTERISTICS

The position and arrangement of spores on the frond are very important for the identification of the genera of ferns and ferns-allies

Six different groups were recognised in tropical Australia by Andrew (1990). These can be used to identify several genera in the Malesian region.
SPORES

The ornamentation of the surface layers of the spores can be a very useful taxonomic character.

Simply there are two major types of spores
- monolette, and
- trilette

Spore ornamentation is very important e.g. in the genus *Asplenium* and *Athyrium*. Spores are a good indicator of different species.

TRUNK/RHIZOME ANATOMY

Trunk of *Cyathea* s.l. show that the different species apparently each have their own distinct anatomy.

Rhizome anatomy also can distinguish between
- *Diplazium*, and
- *Athyrium*
SCALES AND HAIRS

Scales are very important for the identification of the ferns.

Members of the family Aspleniaceae all have clathrate scales

The nature of the scales can also be used to distinguish the three groups in *Cyathea*.

PARAPHYSSES

Paraphyses are important in some families

They have been extensively used for the proposed subdivision of the family Vittariaceae into several genera. This work is still in process but current result indicate that they may closely reflect a subdivision of the family based on rbcL, into several distinct genera.
COLLECTING FERNS

- Collecting ferns is the same as other vascular plants with some points to records.
- The rhizome is very important – its habit and the scales/hairs. Reduce the size of the rhizome by cutting longitudinally if necessary. If the rhizome is absent it is often not possible to use the key for identification.
- Collecting specimens with fertile fronds. Sometimes the fronds are dimorphic. Both sides of the fronds are important to observe hairs, scales etc.
- When collecting ferns with large fronds – Dicksonia, Cyathea or Angiopteris it is very important to be very careful. Many collections of large fern fronds are restricted to single pinna and quite inadequate.
- Collect spores and young leave for DNA if necessary.
- Take photograph as many as possible.

Describing a New Species
What you have to prepare:

- DNA data (if any)
- Spores (if any)
- Chromosome (if any)
- Habitat and ecology
- Line drawing and/or color pictures
- Herbarium specimens
- Morphological description
- Choose name
- Write the manuscript
- Publish it

Dicksonia (DICKSONIACEAE)
DNA and phylogenetic analysis

Spores

Dicksonia antarctica

Dicksonia blumei

Dicksonia sp.
Habitat and ecology

In recent observations of their natural habitat, the species has a remarkable hemi-epiphytic phenomenon: young plants are always deeply attached to and growing on Cyathea trunks about 1 m from ground level; no young plants found grown on soil. Once the Dicksonia roots reach the ground, the Cyathea fronds die and fall. And then, after the roots and trunk of Dicksonia are strongly attached in the ground, the Cyathea trunk will fall. In some adult trees it was observed that the base of the Cyathea host trunk remains attached to the Dicksonia trunk. We assume this hemi-epiphytic habit to gain some “ecological” advantage from the host. The presence of hemi-epiphytic on tree fern trunk has been reviewed by Page & Browney (1966), but mostly by flowering plants such as Aechmea roseoflava (Aechmeaceae), Metrosideros robusta (Myrtaceae), Pseudopanax arboreus, P. edgerleyi (Araucariaceae), and Weinmannia racemosa and W. silvicola (Canoniaceae). Therefore, the hemi-epiphytic habit in Dicksonia is firstly described. The hemi-epiphytic habit can be seen in Fig. 5.

Line drawing and/or color pictures
Herbarium specimens

Morphological description

Tree fern with pale brown hairs covered stipe base, closely resembles to *D. fibrosa* in frond morphology and persistency, differ in stipe length and number of sori per pinna lobe. It is readily distinguished from *D. blumei* by the hair color and spore morphology. — Type: Indonesia, Timor Island, Nusa Tenggara Timur, Mutis Nature Reserve, Bukit Lelofoi, 1760 m, cultivated in Bali Botanic Garden, Bayu Adjie RA653 (Holotype the Herbarium of Bali Botanic Garden; Isotype BO, K; frond mounted in two sheets).

Tree fern with trunk up to 5 m in height, diameter 20 cm, number of fronds up to 36, stipe bases persistent; stipe covered by pale brown hairs 15–20 mm long; lower part of stipe and main rachis green. *Frond* total length 170–230 cm; stipe 33–55 cm long, width 1.5–2 cm, thickness 1.5 cm; rachis 130–170 cm long; distance from basal pinna to next pinna 11–13 cm, number of pinna 44–46 including final terminal pinna. *Pinnas* longest pinna 28–36 cm long, 8–11 from base position on rachis, number of sori per pinna lobe 3–5 rarely 6, large, globose, marginal, and under the hooded edges of the lobes; indusia oblong to circular; lobes not reduced when fertile; fertile pinnas 7–10; basal pinnas not reduced but much smaller, 10–22 cm long, sterile; *pinnules* to 50 by 10 mm; costules of tertiary leaflets 5 mm apart; largest fertile tertiary leaflets lobed throughout almost to the costule, with 2 pairs rarely 3 of soriferous lobes, the lowest lobes usually bilobulate with forked vein, rest veins in pinnule lobes pinnate or simple. *Spores* yellow, triletie, proximal face depressed between partly obscured lacunae with distal face densely granulate, margins somewhat shrunk (as can be seen in Fig. 4).
Choose name

- *Lecanopteris darnaedii*
- *Asplenium cardiophyllum*
- *Gaga (Pteridaceae)*
- *Diplazium esculentum*
- *Diplazium proliferum*

Write the manuscript

**DICKSONIA TIMORENSE (DIKSONIACEAE), A HEMI-EPIPHYTIC NEW SPECIES OF TREE FERN ENDEMIC ON TIMOR ISLAND, INDONESIA**

Received March 22, 2012; accepted July 28, 2012

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**ABSTRACT**


**Keywords:** Dicksonia, Timor, Indonesia, new species, endemic, hemi-epiphytic, cpDNA.
Publish it

- International Code of Nomenclature for algae, fungi, and plants (ICN)
- Name must be **effectively published** in a journal generally available to botanists

*Dicksonia timorenses* B. Adjie
Reinwardtia 13 (4): 2012
Developing a Field Guide Book on Plants

Edwin S. Fernando
Department of Forest Biological Sciences
University of the Philippines - Los Baños

Taxonomy . . . the starting point of any basic or applied biological research.

It provides the database for ecology and conservation science.

It lays the foundation for the phylogenetic tree of life.

(Wilson 2004)

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Taxonomic information... essential for addressing many critical issues on biodiversity conservation, including those across international borders, for example:

- spread of invasive alien species
- conservation of migratory birds
- the emergence of new diseases
- the decline of amphibians
- the impact of wildlife trade

(McIntosh 2012)

Some 'customers' and stakeholders share an urgent need for taxonomy.

- **Senators** and **Representatives** in Congress and **Members of Parliament**, who need to ensure that laws will protect all of our biodiversity and that their legislation is directed at the top priorities.

- **Diplomats**, who need to ensure that biodiversity-related conventions are meeting their conservation objectives.

(McIntosh 2012)
Customers and stakeholders of taxonomy.

- **Customs and Quarantine officials**, who should be on the lookout for potentially invasive alien species or illegally traded wildlife.

- **Environmental Planners**, who need to carry out EIAs for proposed projects that may affect biodiversity.

(McIntosh 2001)

---

Customers and stakeholders of taxonomy.

- **Agronomists**, who need to find species useful for integrated pest management (IPM), requiring a good understanding of species relationships.

- **Horticulturists**, who need to find potential new ornamental plants or edible fruit trees to introduce into commercial production.

(McIntosh 2002)
Customers and stakeholders of taxonomy.

- **Field Biologists, Conservation workers, and Students**, who need to identify the species with which they are working.

- **Epidemiologists**, who need to chart the distribution of diseases that may be transmitted between people and other animals.

(McIver 2002)

Customers and stakeholders of taxonomy.

- **Ecotourists** and naturalists, who want to identify the plants and animals they encounter in their travels.

- **Novices**, who simply want to learn the names of the common plants in the area.

(McIver 2002)
Taxonomy provides the core reference system and knowledge-base on which all discussion of biodiversity hinges.

Taxonomy is central to the conservation of biodiversity.

Four principal features of the core reference system / knowledge base

- classification (based on an understanding of phylogenetic relationships)
- nomenclature
- descriptions
- identification aids (e.g. field guides)

Framework within which biodiversity is recognized and in which species diversity characterization occurs.

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Field guides

... are a way for people to connect with the natural environment by putting a specific face on the term ‘biodiversity’.

... can help enhance public understanding and participation in biodiversity monitoring and conservation.

(Stevenson et al. 2003)

What are field guides?

Syntheses of information usually specific to a particular taxon (plant group) or life form and covers a limited geographic area that can be defined by political or biogeographic boundaries and used to identify plants in the field.

(Stevenson et al. 2003, Plantsworth et al. 2013)
What are field guides?

...broadly encompassing; may be in various formats, including printed field checklists, non-technical illustrated posters, picture keys, flash cards, brochures, or digital field guides.

Checklists

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Checklists

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Annexes

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Picture Keys

Flash Cards

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Digital Field Guides

- **Internet-based** (online)
- **Stand-alone apps**
  (in smartphones, tablet computers, and other portable devices)

Uses a variety of media, including **text**, **drawings**, **photographs**, **audio**, and **video**, set in visually appealing user interfaces that facilitate taxon identification with a minimum of steps

(Leppert & Kitchoff 2011)
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Digital Field Guides

Emphasis is on **usability** for **novices** and **experts**.

**Stand-alone apps** and **online** guides can be simultaneously accessible to **beginners** and useful for **specialists**.

The **usefulness** of any digital field guide is **dependent** on the **availability** and **accuracy** of species-level data.

(Thosunath et al. 2013)

**What are field guides?**

...more commonly or traditionally field guides are in a **book** format, with lots of color photos and illustrations.

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Field guides

The earliest field guides were created before the 14th century and were illustrated, utilitarian descriptions, such as 'herbals'.

(Crane, 2006)

Field guides

Florence Merriam Bailey is credited to writing the first field guide, *Birds Through an Opera Glass* in 1889; contains wonderful descriptions, but only a few black and white illustrations.
Field guides

R.T. Peterson (1934) then developed the first modern field guide, *A Field Guide to the Birds.*

Essential to his system were color plates with paintings of similar species in which Peterson indicated field marks.

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Who needs field guides?

A diverse set of people . . . who might be called ‘applied and recreational field biologists and naturalists’

(Stevenson et al. 2003)

May include students, conservation workers, horticulturists, ecotourists, curious novices, amateur and professional field biologists, park rangers . . .

Are field guides cited in the scientific literature?

Field guides are mainly written for general audiences, but they are also being used increasingly as authoritative references for species identification.

Nearly five-fold increase in citations of field guides — from 50 to 248 per year — in scientific publications between 1990 and 2004.

(Simmard 2006)
Consumer demand for field guides

In 2000, a search of Amazon.com book titles for the keywords 'field guide' yielded 625 total entries (Stevenson et al. 2001).

In 2012, a similar search yielded 1,849 titles, with 81 forthcoming and published titles for 2012–2013 alone.

Of these latter publications,

- 29 - birds
- 19 - plants & fungi
- 10 - mammals & herpetofauna
- 8 - invertebrates
- 7 - site-based treatments of multiple types of organisms
- 8 - gems, fossils, animal tracks, weather, or astronomical objects

Consumer demand for field guides continues to grow.

Limitations of commercially available field guides

The economics of traditional publishing dictate that paper field guides:

- must have commercial viability
- tend to focus on popular taxa
- cover wide geographic areas
- contain many species
- mostly naturalists, rather than scientists, write commercial field guides

(Stevenson et al. 2001)
How is a field guide in book format arranged?

Today's field guides typically consist of 2 sections:

1. An Overview of the taxonomic group of interest (introductory paragraphs)
   - short introduction on the area or site
   - classification and general ecology of the group
   - basic morphology & key characters
   - life cycles (for ferns and bryophytes, this will be useful)
   - terminology (glossary, often illustrated)
     (Remember, readers will have no or very little background on technical terms.)
   - simple keys
   - Instructions on how to use the field guide

2. Species accounts
   - scientific name, common name(s)
   - descriptive text
   - photographs, illustrations
     (up to >50% of all the printed material)
   - information on geographical distribution, maps
   - ecology and habitats
   - conservation status

Photos must be standardized; they should be of the same plant part(s) consistently in every and all species accounts. Consider only aspects of images useful in identification. Photo backgrounds should not distract from the subject.

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Identification using field guides

Identification process relies on a combination of simple keys as the user scans the illustrations or photos for a match and carefully compares what is known about the specimen in view or in hand with pertinent text and graphical information provided in the guide.

The keys help people focus their search in a section of the book in which the number of choices is relatively small.

The problem of plant identification

1. Expert determination
2. Recognition
3. Comparison
4. Use of keys and related methods such as synopses, outlines, and tables of characters

Dr. Benita C. Tan with Dr. James R. Shevock identifying species in the herbarium at UPLB.

1. Expert determination would generally be the most reliable method.
2. Recognition is based on experience.
3 **Comparison** covers a broad array of approaches, including searching through *herbarium specimens*, reading *descriptions*, reviewing *illustrations*, and studying field guide *photos*.

*(the basic approach taken by most taxonomists to develop their expertise, but it is time-consuming and requires access to specimens and scientific literature)*

4 **Keys** are generally used by scientifically trained people; it is the most widely used approach.

**Keys** offer a step-by-step approach to identifying a species.

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**Oleandra nerviformis Cav.**

*Description:* Plants with main stems creeping or ascending, 1–2 mm in diameter. Branches usually slightly decurved or erect, sometimes straight, 3–8 cm long. Leaves alternate, simple, 1–2 cm long, 0.8–1 mm wide, base attenuate, apex acute, margins entire, often pubescent on both surfaces. Flowers green, 3.5–4.5 cm in diameter. petals 6, lanceolate, 3.5–4.5 cm long, 0.8–1 cm wide, base attenuate, apex acute, margins entire, often pubescent on both surfaces. Fruit a schizocarp, 3.5–4.5 cm long, 2.5–3 cm wide, dehiscent, seeds numerous, 0.5–1 cm long, 0.2–0.3 cm wide, surface rough, black, shiny.

20–30 January 2015
Queen Sirikit Botanic Gardens
Chiang Mai, Thailand
“Field guides are a way for people to connect with the natural environment by putting a specific face on the term biodiversity.”
(Bestmann et al. 2003)

Literature cited


20-30 January 2015
Queen Sirikit Botanic Gardens
Chiang Mai, Thailand

20 January 2015

20-30 January 2015
Queen Sirikit Botanic Gardens
Chiang Mai, Thailand


The moss *Physcomitrella patens* (Funariaceae) as a model plant, and its ecotype

Junko Kawai, the University of Tokyo, JAPAN

**Phylogenetic Relationship of Green Plants**

Researches with bryophytes may solve the evolution of land plants
Gene Duplication and Change of Morphology

Gene duplication,
Gene Duplication and Change of Morphology

Gene duplication $\rightarrow$ New functions

Gene Duplication and Change of Morphology

Gene duplication $\rightarrow$ New functions $\rightarrow$ Morphology diversification
A Comparison of the Family and Number of Transcription Factor in Genome

Gene Duplication and Morphology

<table>
<thead>
<tr>
<th>plant</th>
<th>gene</th>
<th>MADS-box</th>
<th>AUX/IAA</th>
<th>Morphology/Body structure</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>A. thaliana</em> (angiosperm)</td>
<td>38</td>
<td>29</td>
<td>complex</td>
<td></td>
</tr>
<tr>
<td><em>P. patens</em> (bryophyta)</td>
<td>6</td>
<td>3</td>
<td>simple</td>
<td></td>
</tr>
<tr>
<td><em>C. psil. complex</em> (streptophyte algae)</td>
<td>1 or 2</td>
<td>?</td>
<td>unicellular</td>
<td></td>
</tr>
</tbody>
</table>

Study of functional analysis of bryophytes will elucidate evolutionary mechanisms in land plants.
The Moss *Physcomitrella patens*

- The whole-genome sequencing was completed in 2006. size=511Mb, n=27 (Rensing et al, 2008)
- Sterile culture and long-storage are easy. Life cycle is about 3 months. Spores are clones as self-fertilization.
- Gene targeting protocol is established.
- Highly efficiency of homologous recombination and transformation.
- Deletion mutant collection also exist (forward genetic approach).
- The determination of *P. patens*-specific genes is progressing.
- The collections of mutants, transformants, and ecotypes exist.

The Life Cycle of *P. patens*

Key-character of bryophytes: The haploid gametophyte is dominant, while sporophyte has no branching and lateral organs.
Culture Conditions of *P. patens* - Media

★ **Germination medium** for spore germination:
   BCDAT + 10mM Ca + 0.8% agar, + cellophane (TAIKO, Hyogo, Japan)

★ **BCDAT, BCDATG medium** for protonemata and gametophores:
   BCDAT + 1mM Ca + 0.8% agar
   BCDATG + 1mM Ca + 0.8% agar

★ **BCD medium** for gametophores and sporophytes:
   BCD + 1mM Ca + 0.8% agar
   
   **B**: Stock B (x100) : 0.1mM MgSO₄ · 7H₂O
   **C**: Stock C (x100) : 1.84mM KH₂PO₄
   **D**: Stock D (x100) : 1M KNO₃, 4.5mM FeSO₄ · 7H₂O
   **A**: Alternative TES (x1000) : 0.22mM CuSO₄ · 5H₂O, 10mM H₂BO₃,
   0.23mM CoCl₂ · 6H₂O, 0.1mM Na₂MoO₄ · 2H₂O, 0.19mM ZnSO₄ · 7H₂O,
   2mM MnCl₂ · 4H₂O, 0.17mM KI
   **T**: 500mM Ammonium Tartrate (x100)
   **Ca**: 50mM CaCl₂ · 2H₂O (x50)
   **G**: 0.5% glucose

Culture Conditions of *P. patens* - Media

★ **Jiffy7 media** *(Jiffy Products International AS, Kristiansand, Norway)*

Expansion by H₂O

121°C, 15min
Culture Conditions of *P. patens* - Cultivation

1. **Germination medium + cellophane**
   - 25°C, continuous light
   - After over 1 week, transferred to BCDAT medium to induce the gametangia and sporophytes.

2. **Transferred to Jiffy7 medium**
   - 25°C, continuous light
   - After 1-1.5 months, moved to 15°C, 8h light/16h dark.

3. **Culture Conditions of *P. patens* - Cultivation**
   - 16°C, 8h dark/16h light
   - 2 weeks after moving to 15°C:
     - Sperms
   - 3 weeks after moving to 15°C:
     - Sporophytes development
     - If necessary, pouring water to the surface of moss for improving the fertilization rate.
Sporophyte of *P. patens*

- capsule (sporangium)
- seta
- foot

A sporangium contains thousands of spores

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Culture Conditions of *P. patens* - Cultivation

- 16°C, 8h dark/16h light
- 20 days
- 23 days
- 25 days
- 28 days
- 50 days

Pick up the capsule of sporophyte, transferred to 1.5ml micro tube, and stored at 4°C for at least 4 years after drying.

Scale bar = 100 μm

(Phot by Dr. Naoki Aono)
The Moss *Physcomitrella patens*


★ The whole-genome sequencing was completed in 2006. size=511Mb, n=27 (Rensing et al, 2008)

★ Sterile culture and long-storage are easy. Life cycle is about 2 months. Spermatophores clones or self-fertilization.

Genetic manipulation is easy and efficient!

★ Gene targeting protocol is established.

★ Highly efficiency of homologous recombination and transformation.

★ Deletion mutant collection also exist (forward genetic approach).

★ The determination of *P. patens*-specific genes is progressing.

★ The collections of mutants, transformants, and ecotypes exist.

Transformants ~ Functional Localization Analysis

**Tissue localization**

**MKN1-GUS (KNOX2)**

*Class 2 KNOTTED1-LIKE HOMEBOX (NKOX2)*

transcriptome factor (Sakakibara et al, 2013)

**Intracellular localization**

**PpHxk1-GFP**

Chloroplast stromal *HEXOKINASE (HXK)*

Glucose-phosphorylating enzyme (Olsson et al, 2003)
Transformants ~ Loss-of-Function Analysis

Class 2 KNOTTED1-LIKE HOMEobox (NKOX2) in *P. patens.*
Transcriptome factor
(Sakakibara et al., 2013)

Actin-related protein 2/3 complex subunit (Arpc1)
Regulator of actin filament dynamics.
(Harries et al., 2005)

Environmental Stress Tolerance ~ Loss-of-Function Analysis ~

- ABA (abscisic acid): A phytohormone to play a key role in the acclimation process in vascular plants.
- *ABA1*: A gene related to ABA biosynthesis in angiosperms.
- *ppaba1*: A abscisic acid (ABA)-deficient mutant in *P. patens*

→ ABA is required for the development of dehydration stress tolerance through osmotic acclimation.
⇒ A acquisition of its mechanisms for osmotic acclimation might play a crucial role in terrestrial adaptation.
(Takezawa et al., 2014)
Transformant with a Gene from the Liverwort
~ Gain-of-Function Analysis ~

10μM

NT_ - ABA  NT_ + ABA  W-2_ + ABA

**W-1 to W-4**: Transformants of expressing *MpABI1* (ABSCISIC ACID INSENSITIVE 1, a ortholog related ABA-dependent signaling processes) in *P. patens*.

Osmotic stress and freezing treatments after ABA (+ or -) treatment.

W-2 reduced freezing and osmotic stress tolerance.

*MpABI1* is a negative regulator of ABA signaling.

Similar molecular mechanisms for stress tolerance are likely to be conserved in all extant land plants.

(Tougane et al. 2010)

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The Moss *Physcomitrella patens*


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★ The determination of *P. patens*-specific genes is progressing.

★ The collections of mutants, transformants, and ecotypes exist.
P. patens-specific genes

(Zimmer et al. 2013)

At least 13% of all gene loci are orphan genes and 832 gene clusters are expanded in P. patens.

These genes are possibly the lineage- or species-specific adaptive genes.

The Moss Physcomitrella patens


★ The whole-genome sequencing was completed in 2006. size=511Mb, n=27 (Rensing et al, 2008)

★ Sterile culture and long-storage are easy. Life cycle is about 3 months. Spores are clones as self-fertilization.

★ Gene targeting protocol is established.

★ Highly efficiency of homologous recombination and transformation.

★ Deletion mutant collection also exist (forward genetic approach).

★ P. patens-specific genes has been decided.

★ The collections of mutants, transformants, and ecotypes exist.
Information of *Physcomitrella*

Several moss mutants, transformants, and ecotypes are collected and available. COSMoss (http://www.cosmoss.org/), IMSC (http://www.moss-stock-center.org/)

Information of Ecotype

**Ecotype**: the type that differentiated by each environment (niche) in DNA and fixed hereditarily.
Information of Ecotype

Ecotype: the type that differentiated by each environment (niche) in DNA and fixed hereditarily.

It is useful to identify some traits like forms and properties suitable for the environment and its respective genes.

Information of Ecotype

Physcomitrella patens ssp. patens [ecotype Nene Washes], collected 03-10-12 in Nene Washes, Cambridge, England; moist, disturbed & very humidified peat, pH 6.0, with Bryum klinggraeffii & Leptobryum pyniforme (Grid ref. TF 319000) by Chris Preston

No image

Physcomitrella patens ssp. californica [ecotype Del Valle Lake], location: USA, California, Alameda County, Del Valle Regional Park. South end of Del Valle Lake, 13 km SSE of city of Livermore, long 121deg 41' 40" W, lat 37deg 34’ 40” N.† On muddy bank of reservoir, covered by water earlier in the year, in full sun. collector: B.D. Mishler. † date: Oct. 24, 2004.

Physcomitrella patens ssp. readeri [ecotype Melton], collected in Victoria, Australia, Volcanic Plain (locality: Melton Reservoir, immediately on the N side of Ballarat railway line bridge crossing over the reservoir, (E bank), AMG Ref: 55 283300 5822700. Lat.: 37° 43’02’’S Long.:144° 32’29’’E. Vic. Grid Ref.: N 40), notes: on wet mud on newly exposed and drying our river bed to drought. Growing only inside the crevices of the cracking mud. Abundant over several hundred metres. 03-05-19 by Stajsic, V.

Physcomitrella patens ssp. magdalenae [ecotype Bisoke l] collected 2003-03-23 in Rwanda, Africa, Province Ruhengeri, Parc National des Volcans, at the foot of Mt. Bisoke, above national park border, in Hagenia-Hypericium forest, between 2684m and 2961m, soc. Physcomitrium spec., S01° 28’07.9” E009° 29’59.2” on soil near path, leg. A. Solga det. Volker Buchbender, RWA-1034
Information of Ecotype

North America  Europe  Africa

Japan  Australia

Sequence data

The internal transcribed spacers (ITS) as well as parts of the adenine S’ phosphohydrolase reductase (apd) and phosphoenolpyruvate
phosphohydrolase reductase (pap) genes have been sequenced from accessions out of Africa, Europe, Japan and Australia. The
sequences are available as fasta files below.

ITS: AP1 introns. APR exons. PAPR introns. PAPR exons.

Research of Ecotype ~Physcomitrella subspecies~

Physcomitrella patens ssp. patens [ecotype Nene Washes], collected 03-10-12 in Nene Washes. Cambridge, England; moist, disturbed & very humidified peat, pH 6.0, with Bryum klinggraeffii & Leptobryum pyriforme (Grid ref. TF 319000) by Chris Preston.

Physcomitrella patens ssp. californica [ecotype Del Valle Lake], location: USA, California, Alameda County, Del Valle Regional Park. South end of Del Valle Lake, 13 km SSE of city of Livermore, long 121deg 41’ 40” W, lat 37deg 34’ 40” N. † On muddy bank of reservoir, covered by water earlier in the year, in full sun. collector: B.D. Mishler. † date: Oct. 24, 2004.

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Physcomitrella patens ssp. magdalena [ecotype Bisoke I] collected 2003-03-23 in Rwanda, Africa, Province Ruhengeri, Parc National des Volcans, at the foot of Mt. Bisoke, above national park border, in Hagenia-Hypericum forest, between 2684m and 2961m, soc. Physcomitrium spec., S01° 28'07.9”E029° 29’59.2”, on soil near path, leg. A. Solga det. Volker Buchbender, RWA-1034
Research of Ecotype - *Physcomitrella* subspecies

★ Molecular phylogenetic analyses

⇒ The *Physcomitrella* phenotype arose three times within the *Physcomitrium-Physcomitrella* species complex.

★ Similar morphological characters of the sporophytes

⇒ *Physcomitrella* has been classified as a single species.

The molecular analyses were performed some with all four *Physcomitrella* subspecies and further Funariaceae.

- Nuclear gene BRK1 as a phylogenetic marker:
  - analyses of phylogenetic, sequence polymorphisms, high-resolution-melting, and expression
- Genome sizes
- Genic microsatellites
- Comparison of gametophytic morphological features

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Research of Ecotype - *Physcomitrium-Physcomitrella* species complex

A hypothesis of speciation within the *Physcomitrium-Physcomitrella* species complex with molecular data. ⇒ *Physcomitrella* subspecies has been revised.

Allopolyploid speciation

The independent evolution of a reduced sporophyte

The convergent evolution

*Beike et al. 2014*
**Taxonomy and Biomimetics/ Biomimicry**

**Biomimetics/ Biomimicry:**
Technology for purpose of solving human problems by imitation of natural phenomena.

- *Xanthium strumarium*  
  (Common cocklebur)

- The hook-and-loop fastener  
  (known as Velcro and Magic-tape!!)

- Dried *Sphagnum*  
  After water absorption

- Sport wear by Teijin and Nike

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**Taxonomy and Biomimetics/ Biomimicry**

Many information for biomimicry are collected in AskNature  
(http://www.asknature.org/)

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![AskNature Image](http://www.asknature.org/)
The Main Laboratories

★ The moss Physcomitrella patens

- The HASEBE laboratory in National Institute for Basic Biology (NIBB) (http://www.nibb.ac.jp/evodevo/)
- The RESKI laboratory in University of Freiburg (http://www.plant-biotech.net/)

★ The liverwort Marchantia polymorpha L.

- The KOHCHI laboratory in Kyoto University (http://www.plantmb.lif.kyoto-u.ac.jp/)
- Marchantia Labs List (http://synbio.org.uk/marchantia/labs.html)

THANK YOU
Diversity of Pteridophytes

Chan-Ho PARK
National Institute of Biological Resources, KOREA

Training Workshop on Plant Taxonomy:
Pteridophyte and Bryophyte
Chiang Mai, 20-30 January 2015

Origin of Pteridophytes

[Diagram showing the origin of land plants, vascular plants, and Pteridophytes, with timelines and evolutionary relationships]
Derived Traits of Plants

- Four key traits appear in nearly all land plants but are absent in the charophytes
  - Alternation of generations (with multicellular, dependent embryos)
  - Walled spores produced in sporangia
  - Multicellular gametangia
  - Apical meristems

Life cycle of Pteridophytes

(a) Sporophyte dependent on gametophyte (e.g., bryophytes)
(b) Large sporophyte and small, independent gametophyte (e.g., ferns)
(c) Reduced gametophyte dependent on sporophyte (seed plants)
Life cycle of Pteridophytes

Alternation of Generations and Multicellular, Dependent Embryos

- Plants alternate between two multicellular stages, a reproductive cycle called **alternation of generations**.
- The **gametophyte** is haploid and produces haploid gametes by mitosis.
- Fusion of the gametes gives rise to the diploid **sporophyte**, which produces haploid **spores** by meiosis.
Life cycle of Pteridophytes

Alternation of Generations and Multicellular, Dependent Embryos

- The diploid embryo is retained within the tissue of the female gametophyte
- Nutrients are transferred from parent to embryo through placental transfer cells
- Land plants are called embryophytes because of the dependency of the embryo on the parent

Modified from Hasebe et al.

Apogamy (Apomixis) in Fern
Derived Traits of Pteridophytes

Apogamy (Apomixis) in fern group

A. Reduced spore (ea. 64), B. Unreduced spore (ea 32)

Walled Spores Produced in Sporangia

- The sporophyte produces spores in organs called sporangia
- Diploid cells called sporocytes undergo meiosis to generate haploid spores
- Spore walls contain sporopollenin, which makes them resistant to harsh environments

Modified from Amstrong 2005
Transport in Xylem and Phloem

Vascular plants have two types of vascular tissue: xylem and phloem.

- Xylem conducts most of the water and minerals and includes dead cells called tracheids.
- Water-conducting cells are strengthened by lignin and provide structural support.
- Increased height was an evolutionary advantage.

- Phloem consists of living cells and distributes sugars, amino acids, and other organic products.
- Sugar-Conducting Cells of the Phloem:
  - Sieve-tube elements are alive at functional maturity, though they lack organelles.
  - Sieve plates are the porous end walls that allow fluid to flow between cells along the sieve tube.
  - Each sieve-tube element has a companion cell whose nucleus and ribosomes serve both cells.

Fig. 35-10d

XYLEM

Tracheids and vessels (colorized SEM)
Perforation plate
Vessel element
Vessel elements, with perforated end walls

Pits

Tracheids
Paraphyletic group of Pteridophytes

Nonvascular plants (bryophytes)
Fern and Ferns allies
Gymnosperms
Angiosperms
Pteridophytes = Free-sporing tracheophytes

- Equisetum
- Osmunda
- Polypodiaceae
- Marsilea
- Salvinia
- Botrychium
- Pellotum
- Lycopodium
- Isoetes
- Selaginella

- sporangia in sori
- heterosporous aquatic
- leptosporangiate cincinate vernation
- strongly mycotrophic
- unique protoxylem distribution
- cpDNA inversion
- megaphylls [reduced in some taxa]

- microphylls sporangia in leaf axils

Modified from Pryer et al.

K-Bon Monitoring Application

- Lots of filed information: How to deal?
  - K-Bon Monitoring Application is developed for the K-BON
  - This software aims for collecting pictures of species with GPS data through personal smart phones.
  - Many people can use this application to collect pictures of diverse plants and animals easily.
You can take a picture and write simple note for the species.

- You can see all plants and animals you’ve collected via this program on the map.

Gyeryong mountain in Korea
Extinction risk from climate change


**Climate-warming scenarios 2050**

- Minimal scenarios: 18%
- Mid-range scenarios: 24%
- Maximum-change scenarios: 35%
SDMs (Species Distribution Models)

Maximum Entropy model
✓ Presence-only data

ROC (Receiver Operating Characteristic) curve

Threshold: Maximum training sensitivity plus specificity

5-folds cross-validation
Analysis Boundary

- Southern limit: South Korea
- Endemic: Korea
- Northern limit: Korea + Japan

Pteris species

Bio17 (Precipitation of Driest Quarter)
DEM (Elevation)
Bio12 (Annual Precipitation)

Current | A1B 2050 | A1B 2080
**Dicranopteris pedata**

Bio11 (Mean Temperature of Coldest Quarter)
Bio17 (Precipitation of Driest Quarter)
Bio12 (Annual Precipitation)

Current | A1B 2050 | A1B 2080

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**TAXONOMY IS...**

the science of

discovering  
naming  
describing  
classifying  

organisms

to understand biodiversity (and more...)

Taxonomy from Greek words:  
taxis = division/arrangement; nomos = law
CLASSIFICATION matters
in your daily life

Classification is part of our everyday life. It allows us to place things in order, such as in a stock inventory in a supermarket.

Would you look for dairy products next to household cleaning items?

NAMEs matter
in your daily life

Imagine if people and things didn’t have a name...
NAMES are needed for communication

Common or vernacular names are useful for everyday communication but are limited by location and language.

SCIENTIFIC NAMES for global communication

A scientific name ensures that we are talking about the same organism regardless of our geographic location or language.
WHO AM I?

Want to know?
Ask a taxonomist
Or click on this link...

TAXONOMY: advancing ur knowledge

Thank you!
Annex 3: Photo Documentation

Photo by Edwino S. Fernando

Photo by Edwino S. Fernando

Proceedings on the Internship Programme for the Taxonomic Capacity Building for Bryophytes and Pteridophytes

Photo by Edwino S. Fernando
Proceedings on the Internship Programme for the Taxonomic Capacity Building for Bryophytes and Pteridophytes

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