RESEARCH

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and Environmental Research
Universiti Brunei Darussalam

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Front cover photo:

Credit : Merlin Tuttle

Caption: The woolly bat *Kerivoula hardwickii* emerging from the pitcher plant *Nepenthes hemsleyana* after taking a nap. *Nepenthes hemsleyana* relies on a unique prey trapping strategy. It attracts woolly bats to roost in its upper pitchers in return for nitrogen-rich feces dropped into the pitcher by the roosting bats. It is estimated that the plant derives on average 33.8% of its total foliar nitrogen from the animals' droppings.

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IBER Institute for Biodiversity and Environmental Research

VISION

To be a Centre of Excellence for Biodiversity and Environmental Research

MISSION

Undertake Innovative Research, Education & Outreach Activities in
Tropical Biodiversity and Environmental Studies

Message from IBER Director

Associate Professor
Dr Kushan U. Tennakoon

Director,
Institute for Biodiversity and Environmental Research

Creating strength through its diversity of institution, Universiti Brunei Darussalam's Institute for Biodiversity and Environmental Research (IBER) enters its 3rd year. We are extremely proud of what we have achieved so far in the research frontier since our inception in September 2013.

The establishment of the Institute for Biodiversity and Environmental Research (IBER) by His Majesty the Sultan & Yang Di- Pertuan of Brunei Darussalam, Chancellor of Universiti Brunei Darussalam at the 25th Convocation Ceremony on 12th September 2013 highlights the importance accorded to biodiversity and environmental research by UBD.

The diversity of plants, animals and other life forms in the spectrum of biological habitats represented in Brunei Darussalam is sizeable, varied and comprises many unique features. Brunei Darussalam holds a wealth of natural richness. This is both a resource and heritage, which merits a special approach for its continued research, understanding and documentation, and presentation of its significant findings to conserve, especially protect, develop or manage. This approach for the systematic organization and enhancement of biodiversity knowledge finds its focus through the functions of the IBER.

Three major aims of the IBER are to further develop biodiversity research in Brunei Darussalam, help to achieve the economic vision of Wawasan 2035, and to help meet the objectives of the Convention on Biological Diversity (CBD), to which Brunei Darussalam is a party by accession.

UBD has a proud and long tradition of fostering and promoting biodiversity and environmental research dating back to the days of the University's founding in 1985. Milestones since then include the establishment of a world class Field Research Centre in Kuala Belalong (Kuala Belalong Field Studies Centre), participation and leadership of UBD staff and students in expeditions to Lanjak Entimau and Paya Maga in Sarawak, Malaysia, and to the Sungai Ingei Conservation Forest and Mount Pagon in Brunei Darussalam. Another expedition to Bukit Teraja in the Belait District of Brunei Darussalam is currently planned. A three-day rapid biodiversity assessment as a precursor to a full expedition to Bukit Teraja has already completed.

IBER research and educational projects focus on both terrestrial and marine biodiversity throughout Brunei Darussalam, as well as their interactions with its environment. Coordination of research, education and outreach activities of the UBD's premier international field research facility, the Kuala Belalong Field Studies Centre (KBFSC) is a special emphasis of the IBER.

Biodiversity and environmental research at UBD received substantial and significant support in recent years through sizeable amounts of research funding from the UBD research grant scheme (URC), Department of Economic Planning and Development (JPKE) and the Brunei Research Council (BRC). Some of our researchers have been able to attract external funding through organizations such as AKECOP (ASEAN- Korea Environmental Cooperation Project) and US-Fulbright Program.

Furthermore, a number of our academic staff members have established very fruitful self-funded research collaborations with reputed universities, research institutes, natural history museums and botanical gardens to carry our research and joint educational programs.

Some of these research projects and new discoveries are showcased for the first time in this book. It is with great pride and personal pleasure that I invite you to enjoy "IBER-Research Highlights" with the hope that these pages will give you a glimpse of Biodiversity and Environmental Research that the academics, researchers and students of IBER have done and continue to do.

IBER scope

The Institute for Biodiversity and Environmental Research (IBER) functions as the focal agency within UBD for the systematic organisation and enhancement of biodiversity and environmental knowledge through its research, education and outreach programs.

The establishment of IBER highlights the importance accorded to biodiversity and environmental research by UBD. The Institute's objectives are to:

- Organize, promote develop and undertake research, teaching, training and other professional programs in the areas of tropical biodiversity and environmental studies.
- Provide and coordinate facilities and logistic support for field and laboratory research, teaching, training and other professional programs.
- Establish, elucidate and collate environmental databases on Brunei Darussalam's biodiversity and environmental data.
- Develop human resources in the fields of tropical biodiversity and environmental sciences through long and short term research, training and educational programs.
- Establish close associations and collaborations with other universities, research institutes, natural history museums, botanical gardens and professional bodies.
- Be the institute of coordination for international and local programs related to tropical biodiversity and environmental studies and activities (including *iCUBE* and UBD's collaborations with the Heart of Borneo initiative).
- Coordinate research directions & education programs, funding contribution & other forms of support to KBFSC as a special research emphasis.
- Publish academic knowledge in reputed journals, bulletins, newsletters or other scientific literature, and organize conferences, workshops or symposia.

UBD/IBER Research Fellowship 2014/2015

The establishment of a Brand New 15-ha Large Tree Plot

The UBD/IBER Research Fellowship for 2014/2015 was awarded to Dr Shengbin Chen (Nanjing Institute of Environmental Sciences, Ministry of Environmental Protection of the People's Republic of China).

In cooperation with the Ministry of Primary Resources and Tourism (MPRT), particularly the Brunei Herbarium within the Forestry Department, a 15-ha vegetation plot has been established in the undisturbed forest compartments of the Andulau Forest Reserve. This plot is especially focused on 'giant trees', i.e. trees with a diameter of at least 50 cm, which are emergent trees with heights varying between 30 and 60 m. Such 'giant' trees have recently come into the spotlight because, as keystone components of tropical forests, they have gone in strong decline due to over-exploitation in many parts of the tropics.

In this study we focus mostly on the carbon storage potential of these trees, and how it fluctuates over time. Therefore, a large number of 'giant' trees (more than 500) were required to provide reliable estimates of carbon dynamics. Due to this, 15-hectare plot was set up since the density of such 'giant' trees is quite low (about 35 trees per 100 m x 100 m). All the trees were identified and labelled, along with their diameter and height measured. Based on these measurements, the total weight of carbon stored in each tree was calculated. The total weight for all trees then resulted in a total value of carbon biomass stored in the plot, which can be used to estimate the carbon stored in 'giant' trees across the whole Andulau Forest Reserve.

Long-lasting and flexible (using extension springs) plastic strips were placed around each tree so that the tree growth can be monitored easily in the next several years. Soil samples were collected and analyzed from the plot, in order to relate tree growth, mortality and recruitment rates to soil fertility and topography.

This plot is the first 'giant' tree plot in the world and will provide important information of how tropical forests contribute to controlling atmospheric green house gasses. There is considerable debate whether tropical forests are currently carbon sinks or sources, and this plot may contribute to solving this question. This is the first plot in what will hopefully become a network of similar plots across Brunei.

Dr Shengbin's local collaborators were AP Dr Ferry Slik, Dr Rahayu Sukri and Dr Faizah Metali, Faculty of Science, UBD.

Dr Shengbin Chen with a plot marker

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UBD/IBER Research Fellowship 2013/2014

Inventory of insect biodiversity of tropical forests in Brunei Darussalam and comparison of species traits of a functional guild along ecological gradients using multiple data

The IBER/KBFSC Research Fellowship for 2013/2014 has been awarded to Dr Claas Damken (School of Environment, The University of Auckland, New Zealand). Dr Damken will be doing research on "**Inventory of insect biodiversity of tropical forests in Brunei Darussalam and comparison of species traits of a functional guild along ecological gradients using multiple data sets**".

The aims of this project are to provide a digital inventory of the insect diversity of Tropical Forests in Brunei Darussalam and compare species traits of a functional insect guild.

Virgin tropical forests host an extraordinarily high but poorly inventoried insect diversity. While our understanding of the ecology and distribution of most tropical insects is still poor, tropical forest habitats worldwide are under threat by climate change and habitat loss/fragmentation following human land-use change still, and there is great concern that many species will go extinct without even being formally described. Baseline data of pristine tropical forests such as the forest of the Ulu Temburong National Park in Brunei Darussalam are required to monitor changes in species composition following climate change and to land-use change.

This research project will address both a contemporary ecological research topic – the analysis of species traits of a functional insect guild across ecological gradients – and a common shortcoming of previous (mostly internationally organized) ecological studies – the lack in knowledge transfer to the future local research community.

Dr Damken's local collaborators are Rodzay bin Haji Abd. Wahab and Teddy Chua Wee Li of IBER, and AP Dr Ulmar Grafe of FOS.

Dr Claas Damken examining insect specimen during the iCUBE Bukit Pagon Expedition

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UBD/KBFSC Research Fellowship 2012/2013

Bryophytes as indicators of ecological and climatic variation in different forest types of Brunei Darussalam

The UBD/KBFSC Research Fellowship for 2012/2013 was awarded to Dr Aline Horwath (Department of Plant Sciences, University of Cambridge, UK). Dr Horwath investigated the use of "**Bryophytes as indicators of ecological and climatic variation in different forest types of Brunei Darussalam**".

Dr Aline Horwarth surveying bryophytes on a tree

The objective of this project was to survey the forest canopy flora and demonstrate that species distribution patterns and ecophysiological properties of the epiphytic bryophytes (mosses and liverworts) can provide valuable clues about the microclimatic conditions found in different forest types of Brunei Darussalam.

Canopy access facilitated the recording of microclimatic data, and the collecting of plant specimens along microhabitat gradients and across a complex forest ecosystem matrix. Stable isotope markers (^{13}C, ^{18}O and D) will serve as sensitive tracers of environmental conditions, allowing the identification of the primary drivers, which are responsible for the observed bryophyte diversity patterns. Overall, these findings will not only provide important indications about the potential effects of climate change on the distribution and composition of bryophyte communities but also on the overall species richness of the forest ecosystem as a whole.

This project aims to raise scientific and public awareness about the uniqueness of the canopy biome and highlight the extreme vulnerability of canopy dwellers to future environmental change. The publication of the first checklist of epiphytic bryophytes will serve as an important bench mark for future conservation efforts of the exceptional biodiversity wealth of Brunei Darussalam. In addition, the new collaborative link between the University of Cambridge and UBD will enrich the expertise of both institutions and initiate fruitful future investigations of tropical forest ecosystems.

Dr Horwath's local collaborators are Dr Faizah Metali, Prof. Dato Haji Mohamed Abdul Majid, and AP Dr Kushan Tennakoon of the Biology Program, Faculty of Science, UBD.

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UBD/KBFSC Research Fellowship 2011/2012

Tree dynamics in a primary tropical forest: role of environmental variables on a fine scale

The UBD/KBFSC Research Fellowship for 2011/2012 was awarded to Dr Radim Hedl (Institute of Botany of the Academy of Sciences of the Czech Republic). During the year-long fellowship, Dr Hedl worked on a project entitled "Tree dynamics in a primary tropical forest: role of environmental variables on a fine scale".

The project utilized tree dynamics data generated over 20 years at KBFSC. In the study, precisely measured data on tree growth in 1-hectare permanent monitoring plots was correlated with soil and light parameters.

Martin Svatek using the FieldMap hardware to plot the trees

The main aim of this research was to elucidate how fine-scale variation in important environmental conditions influences the dynamics of trees in this lowland tropical rain forest. This is crucial for understanding the key processes shaping this ecosystem, but investigations in this field of tropical forest ecology remain relatively scarce.

The project employed novel techniques of data collection and evaluation and benefitted from collaboration with staff from Universiti Brunei Darussalam with the postdoctoral research fellow, and indirectly with his home team of experts. The project output will be of scientific and public importance, increasing our understanding of the valuable mixed dipterocarp forest ecosystems in the Sultanate.

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IBER/FoS Research Fellowship 2013

Ancient plant lineage filtering in Bornean tropical forests

South-East Asia is home to a large number of ancient vascular plant lineages, granting efforts to understand their distribution across different ecosystem types. Several studies have already looked at plant phylogenetic diversity in South-East Asian forest ecosystems.

Most of these however, focus on angiosperm trees, thus ignoring ferns and in some cases also gymnosperms, as well as herbaceous angiosperms. Including trees only makes sense in terms of looking for competition effects in structuring the dominant layer in forest ecosystems, and most of these are indeed angiosperms, but ferns and gymnosperms certainly include a large proportion of all ancient vascular plant lineages, and thus deserve special attention.

***Gnetum sp.* in a lowland Kerangas forest at the Andulau Forest Reserve**

Phylogenetic diversity calculations also mean that in some cases extensive radiations can obscure patterns of ancient lineage survival. This has been acknowledged in other approaches such as histograms of node age, and maps of ancient lineages based on cut-off values at different depths in a phylogenetic tree. This project approached this topic differently. Surveys were conducted by AP Dr Serban Proches, in collaboration with AP Dr David Marshall and Dr Rahayu Sukri, across vegetation boundaries in Brunei Darussalam that are in some cases reflecting gradients in various physico-chemical factors – recording both these factors (soil moisture, pH, the presence of N, P, and various cations potentially limiting plant occurrence) and the presence and levels of success of plant lineages, with a special focus on ancient lineages (ferns, gymnosperms, basal angiosperm lineages).

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Postdoctoral Fellowship of BRC11 grant

Physiology, Ecology and Biochemistry of *Acacia* invasiveness in Brunei Darussalam

The postdoctoral fellowship of UBD/BRC 11 grant for 2015/2016 was awarded to Dr Le Quang Vuong to investigate "Physiology, Ecology and Biochemistry of *Acacia* invasiveness in Brunei Darussalam". He completed his PhD in 2015 from UBD working on parasitic plants under the auspices of a Graduate Research Scholarship.

The general objective of this project is to understand the mechanisms and impacts of *Acacia* invasion into different terrestrial habitats in Brunei Darussalam. *Acacia* species were introduced to Brunei Darussalam in 1980s to 1990s and quickly dominated in many natural terrestrial habitats, especially in the coastal landscape and roadsides. The spread of *Acacia* species has negative impacts to local ecosystems such as biodiversity loss, fire incidence increase, soil chemistry and nutrient alteration.

Generally, exotic species, including *Acacia* species, adapt very different mechanisms to invade different habitats with complicated interaction with native biotic and abiotic factors. Therefore, the main drivers of invasion process in certain habitats and the key actions to restore ecosystems to desire states should be identified before applying any control methods. or active).

In this project, an approach of integration of knowledge from physiology, ecology and biochemistry of *Acacia* invasion process into different terrestrial habitats in Brunei Darussalam will be used. We will also evaluate the biotic and abiotic thresholds of *Acacia* invasion process in Brunei in order to decide the restoration strategies (passive or active).

The project will provide fundamental knowledge for land managers to develop strategies to eliminate the negative impact of *Acacia* invasion and to restore invaded ecosystems in Brunei Darussalam into desire states. This project will contribute some insight to fill the gap in the understanding of *Acacia* invasion and management.

Dr Le Quang Vuong's local collaborators are Dr Rahayu Sukri, AP Dr Kushan Tennakoon and Dr Faizah Metali of the Faculty of Science (FoS) and IBER, UBD.

Dr Le Quang Vuong carrying out gas exchange measurement on *Acacia* sp. using a portable Infra Red Gas Analyzer (IRGA)

For further details, please contact
Dr Rahayu Sukri
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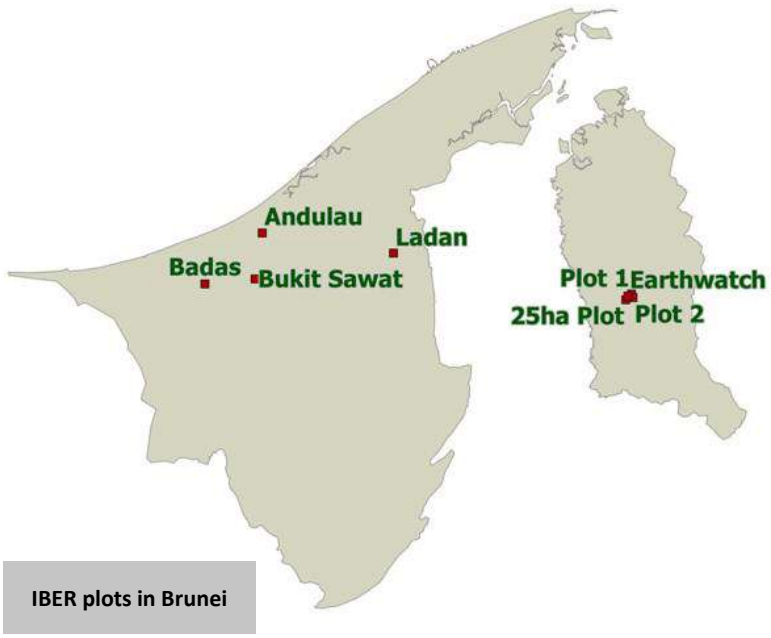
IBER Permanent Forest Dynamics Plot Network

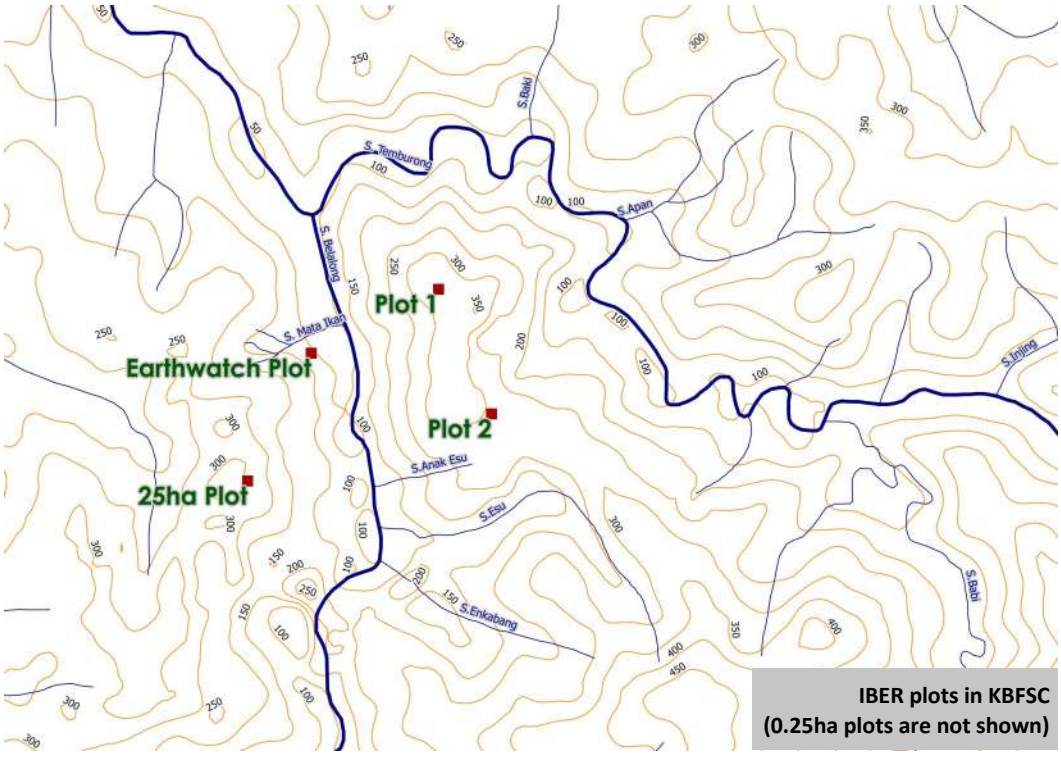


IBER plots in Brunei

The Institute for Biodiversity and Environmental Research (IBER) currently administers and manages a network of plots throughout Brunei Darussalam. The plots are mainly in lowland Mixed Dipterocarp Forests in the Belait, Tutong and Temburong districts, with two additional 1ha plots in heath (Kerangas) forest in the Belait district. Recently a 15ha large trees plot was established in Andulau Forest Reserve. In addition to these 1ha plots, IBER also administers and manages nine 0.25ha plots set up at three altitudinal ranges: Plots 1 to 3 (200 m a.s.l.), Plots 4 to 6 (500 m a.s.l.) and Plots 7 to 9 (850 m a.s.l.), as well as the 25ha UBD-CTFS Plot at the Kuala Belalong Field Studies Centre (KBFSC).

Researchers interested in working at any of these permanent plots are subjected to the IBER guidelines for the use of the IBER permanent plots. For details please refer to:

(http://www.ubd.edu.bn/faculties-and-institutes/iber/research/permanent-plots-under-iber/)



IBER plots in KBFSC (0.25ha plots are not shown)

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UBD-KBFSC/CTFS-Harvard University 25-ha Forest Dynamics Plot

One of the research assistants gathering field data from the Total Station (survey equipment) positioned at the 25-ha CTFS-AA/UBD-KBFSC 25-ha Forest Dynamics Plot

With sponsorship from HSBC Brunei, the Centre for Tropical Forest Science, the Arnold Arboretum of Harvard University (CTFS-AA) and Universiti Brunei Darussalam established a 25-hectare forest dynamics plot in lowland Mixed Dipterocarp Forest at the Kuala Belalong Field Studies Centre (KBFSC) in Ulu Temburong. By measuring and monitoring over 160,000 trees from more than 1,000 tree species, the project aimed to understand the effects of climate change on the forests of Brunei. Climate change impacts are continuously measured by monitoring carbon storage and carbon fluxes, as well as changes in tree diversity and dynamics.

The principal investigators of this project are Dr. Kamariah Abu Salim of UBD's Faculty of Science and Dr. Stuart Davies of CTFS-AA. Intensive fieldwork of started in October 2009. So far, five graduates from the UBD Environmental & Life Sciences Program have worked as field team leaders. To date about 94% of the estimated total of trees in the plot have been surveyed, mapped and measured across the entire 25-hectare plot.

Since the inception of this project, five Climate Camps at KBFSC have been organized for HSBC Climate Champions, in which the last one was held in October 2011. This on-going initiative has so far enabled more than 50 HSBC employees and UBD undergraduates to learn about the forests of Brunei and how climate change may affect these forests, and should lead to a better appreciation of the global forest dynamics programs.

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Conservation of root-holoparasite *Rhizanthes lowii*

***Rhizanthes* buds emerging from a parasitized host (*Tetrastigma pedunculare*) root**

***Rhizanthes* in bloom. The vegetative parts grow inside the roots of its host**

KBFSC is in the process of initiating a conservation plan for the iconic root holoparasitic plant, *Rhizanthes lowii*, found within the KBFSC forest. The plant belongs to the the family Rafflesiaceae, which is the same family as Rafflesia - the world largest flower. *Rhizanthes* does not show its presence until it flowers, in addition to its peculiar smell likened to rotting meat. As a parasite, the flowers emerge on the surface of the roots of its host plant. The host plant, *Tetrastigma pedunculare*, is a liana belonging to the grapevine family Vitaceae. Only one population of this species remains in Kuala Belalong. The only way of conserving this species is to enrich the habitat with its host liana. We are currently in the process of propagating *Tetrastigma* at the KBFSC to introduce the juvenile plantlets into the field, thus increasing the availability of the host plant and hopefully in turn. the parasite *Rhizanthes*.

The Development of KBFSC's Environmental Database and Local Biodiversity Database

Databases on the environment and the local flora and fauna are currently being developed and incorporated into a Geographical Information System (GIS). Previous GIS databases will be updated to include latest data gathered from the KBFSC research area.

Establishment of Environmental and Climate Monitoring Stations

In addition to the two existing weather stations located at 70m and 990m above mean sea level, the KBFSC will be setting up more climate monitoring stations for the purpose of collecting long-term weather data to support climate change related research.

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Bat Biodiversity Studies

Current research on bats at UBD/IBER is focusing on several areas:

- Expansion of standard bat trapping surveys to previously little-explored parts of Brunei (e.g. Peat Swamp Forests; Teraja Forest Reserve)
- Recording and characterizing echolocation calls, particularly, canopy-associated bats at Kuala Belalong, and open space foragers.
- Building an echolocation call library for remotely identifying bats and for monitoring bat activity in forest of varying preservation status.
- Population studies in Brunei of the large flying fox, *Pteropus vampyrus*, a species listed by IUCN as near threatened but which still occurs in large numbers locally.

Research collaboration involving intensive fieldwork by past and present UBD researchers have greatly expanded the knowledge of the bat fauna of Brunei.

Through a trapping programme using methods (upper right) that improve capture success for forest interior species, the bat inventory has been raised from 45 some 20 years ago, to a current total of 64 or 65 species, i.e. around 2/3 of the bat fauna for the whole of Borneo!

The uncertainty in the total arises from the possibility that a woolly bat form may turn out to be a cryptic (new) species.

Of particular interest are new Brunei records from the interior of the country, close to the Sarawak border, notably the horseshoe bat *Rhinolophus creaghi* that has been caught in exceptionally large numbers. This is a cave-roosting bat that very likely roosts in karst caves in the Mulu region over the border, travelling at sunset to forage nightly in the pristine Bruneian forests, thus demonstrating an important ecological Heart of Borneo linkage.

Noseleaf bats (Hipposideridae and Rhinolophidae) are particularly diverse in the interior lowland forests in Brunei and another horseshoe bat, *Rhinolophus philippinensis* is a spectacular and rare addition to the Brunei bat fauna list.

Recently, PhD candidate Kathleen Collier from University of Auckland (an ICUBE partner university) has found the uncommon forest-dependent Grooved-Tooth Bat (*Phoniscus atrox*) for the first time in Tasek Merimbun.

For further details, please contact
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Genomics Research on the stalk-eyed fly genus *Teleopsis* (Family: Diopsidae)

***Teleopsis* sp. found in KBFSC**

This research is a collaboration between Dr. Philip M Johns and Max Brown from Bard College, USA, Richard H Baker at the American Museum of Natural History, Gerald S Wilkinson University of Maryland, USA and local collaborator, Rodzay bin Haji Abd Wahab of KBFSC/IBER, Universiti Brunei Darussalam (UBD) to elucidate sex chromosome evolution across diopsid stalk-eyed flies. An ongoing research goal of this group entails generating next-generation RNA-sequence (RNA-seq) transcriptomes from the testes of stalk-eyed flies from several genera.

This research aims to accomplish the following:

1. The collection of specimens from natural populations of several species of stalk-eyed flies in Brunei.
2. The generation of RNA-seq transcriptomes.
3. To use the transcriptomes to test recent systematic hypotheses for *Teleopsis* and related genera. This include mapping the expression levels of genes of interest onto the resulting phylogeny to trace the evolution of genes important in the production of sperm.
4. To test for positive selection in these genes of interest across the clade. Measuring expression differences and the strength of selection will elucidate the evolution of sperm development in these flies.

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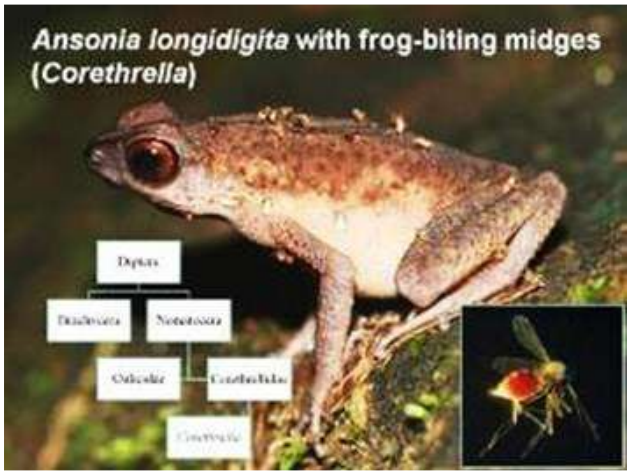
Studies on Frogs

Currently, AP Dr. Ulmar Grafe (Faculty of Science) and his students are carrying out three projects at KBFSC on:

1. the sensory ecology of frog-biting midges,
2. the community ecology of Bornean frogs, and
3. the movement patterns, habitat use, and diet of tropical ranid frogs.

Members of this research team are investigating the role of frog-biting midges in the lives of frogs to better understand disease dynamics in animal populations and as a model system of co-evolutionary relationships. The forests in Brunei Darussalam are ideal for such studies because one can study epidemiology and host-parasite relationships under natural conditions.

Radio tracking of frog distribution



The team is also studying the community ecology of anuran communities within the lowland mixed dipterocarp rain forests and comparing frog diversity across sites in north western Borneo. Relatively few studies have examined species turnover in tropical frogs despite such knowledge being important in understanding the relative roles of historical and current ecological processes in maintaining tropical frog diversity and predicting responses of animals to climate change.

Researchers are also comparing the movement patterns, habitat use, and diets of pioneer and native ranid frogs to better understand the structural features of frog assemblages and the factors involved in ecological meltdown in altered forest ecosystems.

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Studies on Exploding Ants

Dr Diane Davidson (University of Utah, USA) has been studying the evolutionary ecology of Borneo's exploding ants (*Colobopsis* spp.) at KBFSC since 2002. Quite by accident, Dr. Davidson and Dr. Kamariah Abu Salim (UBD) found *Trichoderma* species residing inside nests of carpenter ants (*Colobopsis*) in the forests surrounding KBFSC. Safe nesting space is at a premium for these ants, and the investigators suggested that the fungi might enhance available nest space for the ants.

Dr. Irina Druzhinina at the Vienna University of Technology, Vienna, Austria, identified one of the ant-associated *Trichoderma* as *T. reesei*. With her colleague and adventurer husband, Mr. Alexey Kopchinskiy, Dr. Druzhinina has begun more rigorous studies at KBFSC to analyze relationships between *Colobopsis* ants and various fungi, including *T. reesei*. These ants are often referred to as "exploding ants" because contents of greatly enlarged mandibular gland reservoirs are exploded onto enemy ants in suicidal defense of foraging territories high in the canopy.

After being attacked by a weaver ants, a territorial Colobopsis worker has exploded suicidally on the head of its attacker

Diane and Alexey in June 2014 in the Belalong forest

Over the next few years, and in collaboration with UBD researchers, Dr. Kamariah, Dr. Linda Lim and Dr. Chan Chin Mei, Dr. Druzhinina, Mr. Kopchinskiy and Austraian experts in ant's taxonomy (Dr. Herbert Zettel) and analytical chemistry (Dr. Rainer Schuhmacher) and their colleagues hope to characterize the effects of exploding ants on plants where they live and forage, and thereby to define a previously unrecognized role for ants in tropical forests.

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Movement of frogs at Riparian forest margins

Hanyrol Ahmadsah, a Bruneian PhD student under the supervision of AP Dr. Ulmar Grafe is currently investigating the movement patterns and habitat use of stream-breeding frogs in the forests of the Ulu Temburong National Park.

Although most species of frogs are encountered at streams or stream-side habitats, their use of riparian forest margins are not well understood. Extent of riparian forests and their microclimatic structuring features are likely to influence anuran assemblage composition as some species apparently rely heavily on riparian forests for dispersal and recruitment. Knowledge on these aspects of amphibian ecology will most certainly aid in the conservation of frogs especially from forest degradation and habitat destruction.

A juvenile Bornean Horned Frog (*Megophrys nasuta*) caught in a pitfall trap.

Hanyrol with one of her drift fences and pitfall trap used for the study of frog movement.

Movement patterns and habitat selection of frogs are determined using drift fences and pitfall traps arranged at 5m, 15 m, 30 m, 60 m and 120 m adjacent to each selected stream. Also included in the project are the studies of the diet of adult and juvenile frogs at these distances and also barriers to dispersal of these frogs by looking at their genetic differentiation.

Therefore, this research will be important in providing the baseline information on the habitat requirements, movement, diet and dispersal of amphibians in Brunei especially those from the UTNP; where most of its frogs can be found.

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Diversity of Fungus Gnats in a Primary Lowland Rainforest of Brunei Darussalam

A new wasp-mimicking fungus gnat from the genus *Leptomorphus* (Diptera: Mycetophilidae) represents one of the largest currently known fungus gnats, wing body length reaching almost 20 mm. This species has been collected at KBFSC and described as new to science

In February 2013 and January 2014, a quantitative study of fungus gnat communities (Diptera: Mycetophilidae and Keroplatidae) was carried out by Assoc Prof Jan Sevcik and PhD student, David Kasprak (University of Ostrava, Czech Republic), in collaboration with Rodzay Haji Abdul Wahab and Siti Rafhiah Haji Abd Kahar (IBER, UBD) at the Kuala Belalong Field Studies Centre in Ulu Temburong National Park.

More than 50 species of Mycetophilidae and 15 species of Keroplatidae were collected by means of Malaise traps situated in different microhabitats of the primary rainforest, out of which approximately 80% is represented by undescribed species. Some of the species represent genera previously unknown from the Oriental Region and in some cases also genera new to science. These numbers indicate that rainforests in Brunei host unique, species-rich and little-known fauna of fungus gnats.

Families of fungus gnats (Diptera: Sciaroidea) belong to the most abundant and diverse groups of insects in forest habitats, with some 6000 species described worldwide and at least the same number of species still awaiting the description. Their larvae are mostly associated with higher fungi or mycelia in rotting wood and the adults can be found near the larval habitat. For their enormous diversity and close associations with habitats, they are sometimes used as bioindicators of the level of forest disturbance.

The species composition of fungus gnat communities is generally little studied and it is almost completely unknown in the tropics, mostly due to insufficient sampling and the lack of specialists. This collaborative study between UBD and Ostrava University thus represents one of the first studies of fungus gnat communities in the tropics.

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Factors controlling Aluminium accumulation in plants: effects of phylogeny, soil conditions and external nutrient supply

One of the known Al-accumulating species from Melastomataceae, *Melastoma malabathricum*

Aluminium accumulation has been reported in numerous plant species from 60 angiosperm families. These families are distributed broadly within a major group of dicotyledons as well as monocotyledons, which suggests that a capacity to accumulate a high foliar Al concentration has arisen many times during angiosperm evolution. The current number of Al-accumulating species and families could increase, as many taxa still remain to be analysed for Al concentrations. The functional and ecological significances of this trait have not yet been completely determined, but it is hypothesised that it confers tolerance to high Al availability in the soils.

Currently, we are conducting experimental studies on the effects of Al on traditional rice plant varieties because Brunei soils are highly acidic and found to contain high concentrations of total and exchangeable Al.

Measuring Al and macronutrient elements in acid-digested leaf and soil samples using an Atomic Absorption Spectrophotometer

We are focussing on investigating the phylogenetic and ecological determinants affecting and controlling variation in foliar major elemental concentrations, in particular foliar Al concentrations, among and within tropical plant species. The approach adopted in our study combines cross-species phylogenetic analyses of existing and newly-collected data, studies of plants and their soil chemical environments in Brunei Darussalam and experimental studies of the effect of Al application on growth responses and nutrient uptake in an Al-accumulating plant species.

We are currently updating our list of Al accumulating species by sampling and analysing leaves from all plant species in the 1-ha UBD and KBFSC plots.

Future research should address the fitness costs and benefits of Al accumulation, the mechanisms of the local coexistence of Al-accumulating and non-Al accumulating plants and the practical aspects of using Al accumulating plants in cleaning Al-contaminated lands.

Determining Total N and P concentrations using a Flow-Injector Analyser

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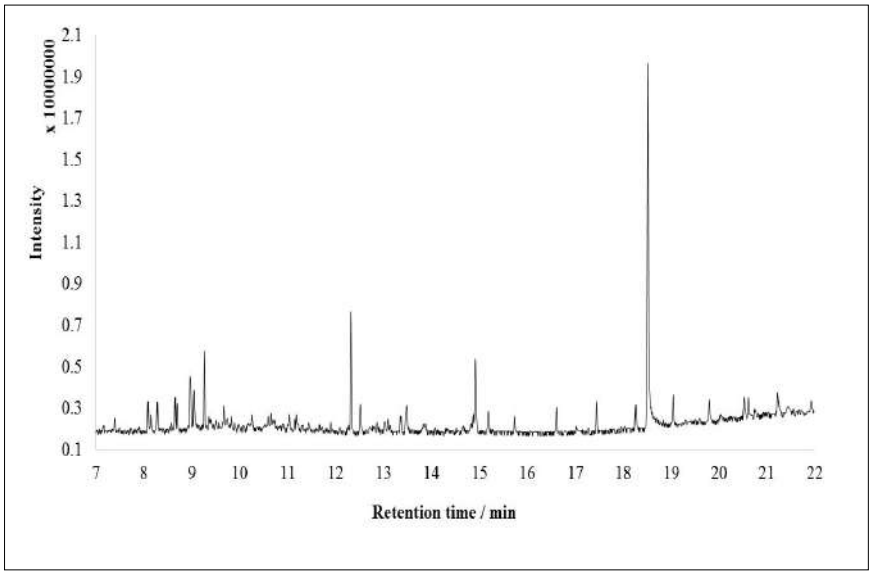
Phytochemical screening of medicinal plants in Brunei Darussalam



Chemical analysis by Gas Chromatography-Mass Spectrometry

a forest reserve

Brunei Darussalam lies on the island of Borneo, one of the world's top biodiversity hotspots. Around 75% of the country's land area is still covered with forests as estimated by the Global Forest Resource Assessment 2010, making it one of the top few nations that still has a high percentage of forest cover. The forests of Brunei Darussalam, which are mostly comprised of primary forests, undoubtedly have a significant biological wealth. The Checklist of the Flowering Plants and Gymnosperms of Brunei Darussalam recorded about 2000 tree species that have been discovered so far in the country while the Brunei National Herbarium has recorded a total of 3,786 species of angiosperms and gymnosperms. These numbers could increase more with more expeditions and discoveries.

The vast amount of plants in Brunei Darussalam is unfortunately not well studied yet. Therefore, in our research project, we are interested to carry out phytochemical screening of the plants that are found in this country, focusing mainly on the plants that have ethnomedicinal values. We are currently studying the chemical components, antimicrobial activities and antioxidant properties of several plants such as *Aidia racemosa*, *Vitex pinnata*, *Stenochlaena palustris*, *Melastoma bacaranium*, *Merremia borneensis* and so on.

Our preliminary results so far showed promising results. The outcomes of this research project would contribute significantly to our current but limited knowledge on the plants found in Brunei Darussalam while raising awareness of the importance of the ethnomedicinal plants. Moreover, there is also a potential in product development for commercialisation.

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Plant propagation as a means for *ex-situ* conservation and commercial production

With the rapid destruction of world habitats, it is very important to conserve our biodiversity. Wild plant species need to be preserved before they become endangered or extinct.

The IUCN Red List of 2012 has listed a total of 228 plants found in Brunei Darussalam are threatened, with 62 of them considered as Endangered or Critically Endangered, further justifying the urgent needs to conserve our biological wealth.

The preservation of species undoubtedly requires a multi-method approach involving an *in-situ* and *ex-situ* conservation. The later not only offers species protection from the inevitable habitat destruction but also provides an opportunity for species recovery programme such as species reintroduction and habitat restoration. Moreover, *ex-situ* plant conservation also provides an opportunity to make the plants easily accessible for future study or commercial use without the needs to harvest the plants from their native habitats, further providing protection from habitat destruction.

Ex-situ plant conservation can be achieved through several methods. We are interested in two techniques i.e. the highly efficient *in-vitro* micropropagation and also the low-cost propagation using plant stem cuttings. Suitable media and growth conditions are required to induce plant propagation such as the use of suitable plant hormones. The goal is to formulate propagating media that would allow successful and efficient propagation. Our main focus is on the plants that can be found in Brunei Darussalam especially the endemic and endangered plants, or any plants that have medicinal, ornamental or commercial values. We also want to extend this study to supply native plants for re-vegetation and rehabilitation programmes.

***Hoya coronaria* (Apocynaceae) flowers**

Treating stem cuttings of medicinal plant, *Aidia racemose,* Rubiaceae (Sambah bagangan) with commercial growth hormones

Stem cuttings of *Dillenia suffruticosa* to be used in revegetation programmes of degraded habitats

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Evaluation of Local Paddy Cultivars for Salinity Tolerance

Extensive efforts have been carried out in Brunei Darussalam to enhance rice production by cultivating fast-growing inbred paddy (*i.e.* introduction of new varieties such as *Laila*), increase of paddy cultivation areas, and improvements in irrigation facilities. However, the country has not been able to achieve the targeted 20% self-sufficiency by 2015. Soil salinity is one of the major constraints that cause this situation beside narrow range of genetic variability and lack of sufficient genetic information about traits inherited by the rice cultivars.

The constraints encountered by conventional breeders when selecting best parents for rice breeding program, in order to produce better and improved progeny, can be solved by using molecular breeding techniques *i.e*. Single Sequence Repeats (SSR).

In an attempt to overcome some of these issues, a study has commenced to assess genetic diversity in selected rice cultivars in Brunei Darussalam.

The local rice cultivars investigated include: *Adan, Arat, Bandul berminyak, Jongkok, Kuaci, Laila, Pusu, Pulut Keladi, Pusu Merah*, *Raden Pinang* and *Salleh*. Studies conducted on salinity tolerance and genetic variation perceptions have shown that a resultant of an intercross between *Arat* (moderately salinity tolerant cultivar) and *Sp1* (new-unnamed variety) showing a low genetic similarity (0.33) can produce a promising salinity tolerant cultivar to be grown in the low lying areas prone to seepage of salt water.

So far genetic variations of 12 different rice cultivars have been studied using 15 different SSR markers and their salinity tolerance mechanisms have been assessed by measuring growth and photosynthetic parameters.

Some key findings of this research project were presented at the 7th International Rice Genetics Symposium, which was held in Manila, Philippines organized by the International Rice Research Institute (IRRI).

Measuring the photosynthesis of the rice samples

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Biology and Physiology of the hemiparasitic *Cassytha filiformis* L.

Cassytha of the Lauraceae family also known as love vines/ 'akar janjang' is amongst the many species of angiosperms that live parasitically throughout the lifecycle, acquiring photosynthates from modified root structures called haustoria.

Cassytha is often confused with *Cuscuta* spp. which is of an unrelated genus from the Convolvulaceae family. At present, taxonomical studies based on its morphological features have substantiated the *Cassytha* species, which are prevalent in Brunei, is the *Cassytha filiformis* L. Such confusion is mainly due to the lack of general knowledge on parasitic plants in Brunei Darussalam and scarcity on scientific reports of *Cassytha* in the tropics.

This research is aimed at gathering preliminary findings of *C. filiformis*, particularly in determining the mechanisms of the establishment of its intimate haustorial connections with hosts, and its implications on the biology of hosts especially in relation to photosynthesis and the synthesis of selected bioactive compounds.

Extensive field observations have shown that this parasite is often found growing along the coastlines, parasitizing on 24 species which were further categorized into "starter host" and primary woody host plants. Anatomical studies revealed that haustorial penetration of *C. filiformis* is primarily enzyme mediated rather than mechanical based on a lack of collapsed host cells at the haustorial interface.

Photosynthetic experiments showed that the infection of *Cassytha* negatively impacted the hosts' performance, as well as their chlorophyll content. Suppressed photosynthesis of nationally significant hosts *Melastoma malabathricum* and *Dillenia suffruticosa*, implied eventual decrease in their vigour, which in turn may impede the natural establishment of these native pioneer species of Brunei Darussalam.

Findings on the bioactivity of hosts affected by *Cassytha* parasitism revealed that the antioxidant (total phenolic and flavonoid) contents of parasitized hosts *M. malabathricum* and *D. suffruticosa* were higher than that of non-parasitised hosts. Antioxidant activities measured by 2,2-diphenyl-1-picrylhydrazyl (DPPH) and Ferric Reducing Ability of Plasma (FRAP) assays too, showed positive results amongst the infected hosts compared to those that were uninfected. This study also indicated the presence of total phenolics and flavonoids as well as antioxidant activity in *C. filiformis* stems which infected these respective hosts, although their values were lower than those of their infected and uninfected hosts.

Key findings from this research was shared during an oral presentation at the 13th World Congress of Parasitic Plants (WCPP) in Kunming, China organized by the International Parasitic Plants Society (IPPS).

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The ecology of Acacia invasions into native ecosystems of Brunei Darussalam

UBD students working at plots set up in *Acacia*-invaded Kerangas forests

The negative impact of invasive alien species upon biodiversity is recognised as a serious threat to natural ecosystems. Three species of *Acacia* (*A. mangium*, *A. auriculiformis* and *A. cincinnata*) were introduced to Brunei Darussalam in the 1990s as plantation trees and for roadside vegetation. Rapid infrastructure development and anthropogenic fires along Brunei Darussalam's coastal areas have resulted in the spread of these *Acacia* species into native habitats. Despite extensive studies on *Acacia* invasions in other parts of the world, no comprehensive study has been conducted in Brunei Darussalam or elsewhere in Borneo island.

Through a grant awarded by the Brunei Research Council (UBD/BRC/11), IBER is conducting a multifaceted research investigation which aims to produce management plans and remediation strategies for dealing with *Acacia* invasion in the region. This investigation combines techniques and expertise from multiple disciplines such as ecology, physiology, molecular genetics, computational modelling, and remote sensing. Current work under this investigation includes studies of how *Acacia* establishment affects community composition and structure, growth rates under different microhabitat conditions, soil nutrient content and properties, and nutrient cycling. Work is also being done to identify the censured tree population to the species level in order to quantify the effects of *Acacias* on native plant diversity.

This project is being conducted by a team of researchers from UBD and UTB, in collaboration with research partners from the University of Aberdeen and Cambridge University in the United Kingdom, and Federation University in Australia.

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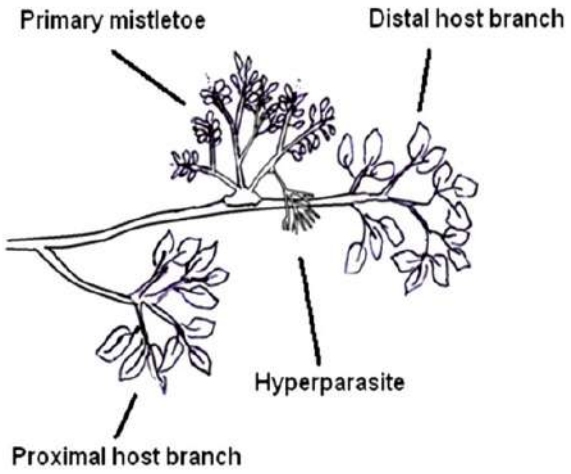
Nature's Scroungers: The Fascinating World of Parasitic Plants in Brunei Darussalam

Mistletoe-host association



Model of a hyperparasitic mistletoe-host

AP Dr Kushan Tennakoon and his team of researchers are working on the ecophysiology of mistletoes in Brunei Darussalam.

Understanding of mineral nutrition and carbon heterotrophy in mistletoes is derived largely from arid and temperate plant communities. Sharp differences between the tropical, temperate and arid communities, such as seasonality, water availability and mean temperature may influence basic assumptions regarding mistletoe physiology. Thus, we investigate nutritional profiles, solute partitioning and natural abundance carbon and nitrogen stable isotope data for tropical mistletoes and their respective hosts in Brunei Darussalam.

Parallel to these studies we investigate how varying climate parameters affect physiological attributes of mistletoes and their responses to global climate change are modulated by nature of associated host species.

In collaboration with a group of chemists lead by AP Dr Linda Lim (Chemistry Program, Universiti Brunei Darussalam) the team is also studying the novel bioactive compounds present in selected mistletoe-host associations grown under different microhabitat conditions.

In addition to mistletoes, they are working on the developmental biology of rare hyperparasites (plant parasite parasitizing another plant parasite) and holoparasites. Prof. Lytton Musselman (Old Dominion University, Virginia, USA) is one of the key collaborators of these investigations.

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Studies on the Developmental Biology of Mycoheterotrophic Plants in Brunei Darussalam

This is a joint collaboration between UBD, AP Dr. Kushan Tennakoon's research group and Prof. Jay Bolin (Smithsonian Research Institute, Washington DC, USA and Catawba College, NC, USA).

A number of flowering plants have either completely or partially abandoned photosynthesis. These falls into two categories: haustorial parasites and mycoheterotrophs. The mycoheterotrophs are sometimes mistakenly identified and recorded as saprophytes.

One of the main objectives of this investigation is to study the developmental biology and solute flux of a range of mycoheterotrophs and associated native hosts in Brunei Darussalam. Mycoheterotrophs obtain their nutrition indirectly from the associating (host) plant via a mycorrhizal fungus. The mycorrhizal fungus, attached to the roots of a photosynthetic plant, thus acts as a bridge between that plant and the mycoheterotroph, such that nutrients (carbon) flow from plant root, to mycorrhizal fungus to the mycoheterotroph.

Current studies mainly concentrate on the partial heterotrophy of the family Burmanniaceae using *Burmannia coelestis* in situ as a model. Here we address lack of empirical evidence for partial mycoheterotrophy in green Burmanniacea by applying stable isotopic methods, evaluating chlorophyll content, and identifying AMF symbionts with microscopy and molecular techniques.

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Trapping Strategies of Carnivorous Pitcher Plants

Nepenthes albomarginata

This is a joint project between UBD (Prof Ulmar Grafe and his students) and the University of Cambridge (Prof Walter Federle, Dr Ulrike Bauer).

There is a growing body of evidence that selective pressures for nutrient resource partitioning have driven adaptive radiation in the genus *Nepenthes*, making it an ideal model system to study mechanisms of plant evolution. Carnivorous plants supplement their nutrition with animal prey that they capture in highly elaborate traps. The ability to use this additional nutrient source enables them to colonize extreme habitats where soil nutrients are scarce.

Pitcher plants of the genus *Nepenthes* bear specialized mug-shaped leaves that possess several adaptations for the trapping of insects, including a viscoelastic fluid, slippery wax crystals and downward-pointing cells on the inner pitcher wall, and a superhy Drophilic pitcher rim (peristome) which is only slippery when wet. Trap morphology and prey spectrum vary substantially between the more than 100 species in the genus, indicating the presence of distinct trapping strategies.

This project investigates how the distinct varieties and species rely on different trap components and have evolved specific trap adaptations to target different prey.

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Large Tree Ecology and Dynamics

Large trees have recently started to attract attention of biologists because they are becoming increasingly rare due to their association with globally declining areas of pristine habitat. Large, 'old' trees are keystone components of forest ecosystems, providing nesting and sheltering cavities, creating distinct micro-environments, playing crucial roles in hydrological regimes and providing food for many animal species. Large trees also store large quantities of carbon due to their large wood volumes. Changes in large tree dynamics, for example due to climate change, may therefore have large consequences for forest ecosystems and forest carbon storage.

This project will map the location (GPS coordinates) of large trees with a diameter exceeding 50 cm across several tropical forest types in Brunei Darussalam. For each tree the exact diameter and height will be determined as well as the species identity. The trees will be permanently marked and fitted with dendrometers to monitor their growth. Vegetation structure and soil properties in the vicinity of the trees will be determined as well. The project aims to get a better understanding of large tree growth, recruitment and mortality patterns and how this is related to the site conditions where the trees are found. In the long term we hope to detect directional trends in large tree dynamics that could provide important information on how tropical forests may change due to the changing climate.

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Research on Anacardiaceae and Burseraceae

This is a joint research collaboration between UBD and the New York Botanical Garden (NYBG) . The UBD team is led by Dr. Faizah Metali from the Environmental and Life Sciences Program and NYBG is led by Dr. Douglas Daly, Director of Institute of Systematic Botany and Dr. John D. Mitchell, Honorary Curator. The research project is the Phylogeny, Diversification, and Evolutionary Trajectories in the Anacardiaceae and Burseraceae.

The two tree families studied are important ecologically and often economically in tropical forests around the globes. The Anacardiaceae include the various species of mango and other delicious fruits, as well as the Dreaded rengas trees (Gluta spp.) that can cause severe dermatitis; while the Burseraceae with edible fruits are best known in Southeast Asia as kedondong, kembayau, dabai, and seladah. The region around and including Brunei Darussalam is one of the diversity epicentres for both families and therefore a necessary focus for the long-term efforts to decipher the species and to understand how, where, and when these two ancient and closely related families diversified and diverged in their evolution.

The UBD-NYBG research team making plant collections at KBFSC

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Plant dynamics and diversity in a primary tropical forest

As part of long-running collabarative effort between UBD and three institutions from the Czech Republic, UBD researchers and students have been working with the Institute of Botany of the Czech Academy of Science, Palacky University and Mendel University in Brno to study tree dynamics at the 1 ha permanent forest plots at the Kuala Belalong Field Studies Centre. The project utilized tree dynamics data generated over 20 years at KBFSC where precisely measured data on tree growth in 1-hectare permanent monitoring plots was correlated with soil and light parameters. The main aim of this research was to elucidate how fine-scale variation in important environmental conditions influences the dynamics of trees in this lowland tropical rain forest. This is crucial for understanding the key processes shaping this ecosystem, but investigations in this field of tropical forest ecology remain relatively scarce. The project employed novel techniques of data collection via Field-Map.

More recently, the research team have also started investigating the diversity of ground herbs within these 1 ha plots. This had led to the discovery of two mycoheterotrophic species, Thismia hexegona and Thismia brunneomitra.The team has also set up seedling plots at KBFSC, which are censused and monitored yearly since 2014, in order to investigate the dynamics of Dipterocarpaceae seedlings.

The project output will be of scientific and public importance, increasing our understanding of the valuable mixed dipterocarp forest ecosystems in Brunei.

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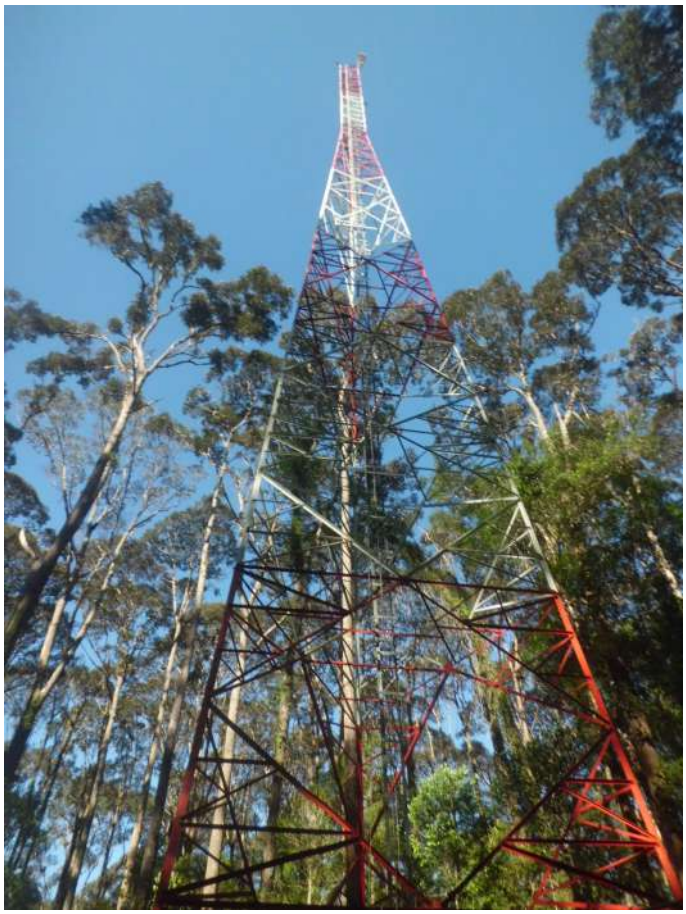
Peat swamp ecology, seedling dynamics and forest productivity



Peat swamp forests in Brunei Darussalam currently represent the most intact tropical peat forests globally. Under Brunei's Heart of Borneo Initiative, UBD is working with the Singapore -MIT Alliance for Research and Technology (SMART) to investigate peat swamp ecology, dynamics and productivity.

SMART and UBD researchers currently focus on two main field research sites in Ulu Mendaram, Belait: the 'Mendaram' site which is situated in an area dominated by *Shorea albida* trees, and the 'Damit' site which is a peat swamp forest logged by rails for over 30 years. At both of these sites, basic research quarters were established to ease fieldwork. The Mendaram site is in particular a unique site as it contained the last remaining largest pristine stands of *Shorea albida* forest to be found anywhere in the world.

Eddy-covariance flux tower with the height of 65m and 35m were also erected at Mendaram and Damit respectively to measure gases exchange. Other current ongoing research include peat swamp hydrology, peat accumulation processes and also on the dispersal patterns and ecophysiology of the dominant *Shorea albida* trees.

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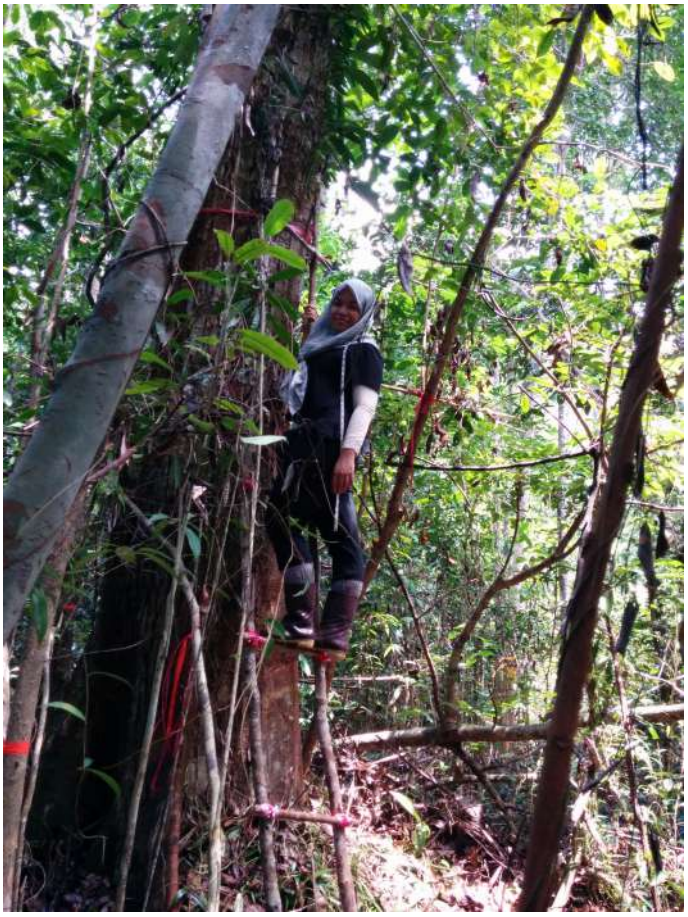
The Tutong White Sands Heath Forest – a rare ecosystem of Brunei Darussalam



Kerangas (Heath) forests in Brunei cover only about 0.6% of Brunei forests but harbor high numbers of endemics. In Tutong, Kerangas forests found along the Tutong-Belait Highway is increasingly under threat and highly susceptible to disturbance by urban development. This area, known as the Tutong White Sands, is also especially vulnerable to forest fires during the dry season and invasion of exotic *Acacia* species.

Through research conducted by Dr. Rahayu Sukmaria Sukri and Dr. Faizah Metali (PIs) and UBD students Hazimah Din, Hadijah Haji Haji and Faten Saman, the biodiversity and conservation values of the Tutong White Sands is becoming apparanent. These studies quantified the floristic diversity and the influence of soil and environmental characteristic on the plant community composition, and provide data on the ecological importance of the Tutong White Sands.

Our results have indicated that the floristic composition of Kerangas forest in the Tutong White Sands is unique and exhibit high levels of plant endemism. The Tutong White Sands harbour plants endemic to Brunei as well as species currently listed as endangered or vulnerable in the IUCN Red List. Several species in these Keranagas forests also have high medicinal and economical values. Further studies are being conducted to highlight the conservation values of these Kerangas forests in the Tutong White Sands.

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Rehabilitation of degraded heath and peat swamp forests in Brunei Darussalam

Heath and peat swamp forests are currently facing major anthropogenic threats from logging, forest fires and land use changes, resulting in major losses in forest coverage over the years. Losses in biodiversity and ecosystem services of these forests may be irreversible if natural regeneration is limited. It is therefore crucial to implement rehabilitation programs to assist natural regeneration of heath and peat swamp forests in Brunei Darussalam.

As the focal point for Brunei Darussalam's ASEAN-Korea Environmental Cooperation Project (AKECOP) regional research, Dr. Rahayu Sukmaria Sukri and Dr. Faizah Metali (project PIs) and UBD MSc student, Wardah Haji Tuah are currently working in heath and peat swamp forests in Lumut, Belait district to identify selected native tree species that can become good potential candidates for rehabilitation of logged heath and peat swamp forests. The species selected for planting are native Dipterocarp species such as *Dipterocarpus borneensis* (Kapur paya), *Dryobalanops rappa* (Keruing), *Shorea albida* (Alan) and the tropical conifer, *Agathis borneensis* (Tulong). In addition, species richness and diversity of the plant communities on degraded areas are also being quantified.

The result obtained from this can become the basis for future rehabilitation projects of native tree species in Brunei and provide further understanding on the effect of logged heath and peat swamp forests on the diversity of plant communities. Additionally, it can help strengthen and develop future collaborations with current and other agencies.

This project is being conducted in collaboration with the Brunei Forestry Department, Wetlands International and Brunei Liquefied Natural Gas Company (BLNG).

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Historical Biogeography and Diversification of Tropical Fagaceae

In this joint project between Guangxi University and UBD, we sample and study the diversity and evolutionary history of Fagaceae across the major ecosystems of Brunei. During a short visit to Brunei in July 2014, Assoc Prof Joeri Strijk (Guangxi University) worked with Assoc Prof Ferry Slik and Dr Rahayu Sukri (UBD) and two UBD students to collect botanical vouchers and leaf samples for DNA study from Fagaceae species present in several forest sites in Brunei. The project aims to eventually sample all species present in Brunei. Duplicate sets of herbarium vouchers will be stored in the Brunei herbarium (BRUN) and the College of Forestry herbarium (Guangxi University - GXU) for floristic studies. Dried leaf material will be exported to GXU for extraction and sequencing to obtain selected portions of the nuclear and chloroplast genome.

Herbarium vouchers will be used in the construction of an interactive diagnostic key for the Fagaceae of Brunei, to be published and placed online with an SCI-rated manuscript. Molecular data generated will be included in a pan-Asian molecular phylogenetic and biogeographical dating study of tropical Asian Fagaceae. This study will provide a unique opportunity for sampling the rich community of Fagaceae native to Brunei and will allow for the assessment of the current conservation status of the ~45 spp. within the country.

Dr Joeri Strijk at the Andulau Forest Reserve

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Above-ground Carbon Stock in Tropical Forests – It's all About the Trees

Tropical forests are a key component of the terrestrial carbon pool, accounting for 40-50% of the total carbon stored in land vegetation. It is an important and challenging task to quantify tropical forest biomass and understand how it responds to climate change. Direct monitoring of forest carbon on ground, i.e., through measuring permanent plots, remains an irreplaceable approach.

Dr Lan Qie from University of Leeds (UK) is currently conducting a systematic re-census of ong-term plots in Brunei as part of her Southeast Asia field campaign, supported by the European Research Council project, Tropical Forests in the Changing Earth System: T-FORCES (www.tforces.net), a pan-tropical study looking at biomass dynamics of world's tropical forests and what mechanism(s) are driving their potential changes under climate change scenarios.

During her first field trip between 30 June and 17 Jul 2014 at KBFSC, she re-measured three 1-ha plots which were last measured in 2011 by a team led by Dr Radim Hedl (Czech Academy of Sciences). Two students from the Faculty of Science (FOS), Meria Aires Anak Kuyah and Kim Ching Ejau volunteered in parts of the fieldwork, gaining first-hand knowledge of tropical ecology and why this type of work remains especially important in global change research. Lan Qie will return for a second trip to complete re-census of a few other plots and collect soil nutrient samples.

Measuring a forest giant (Photo: Dr Lan Qie)

This work is being carried out in collaboration with Dr Kamariah Abu Salim, Dr Rahayu Sukmaria Sukri, Dr Faizah Metali (FOS, UBD), and Dr Radim Hedl (Czech Academy of Sciences).

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Patterns in the Biodiversity of Small Soil Animals in Brunei: a Metagenetics-Based Study

Up until recently, it has been very difficult to study the community structure and diversity of small soil animals. However, new techniques based on DNA sequencing allow the rapid, low cost identification of whole communities of soil animals. Pilot studies in several parts of the world have shown the effectiveness of this technique.

AP Ferry Slik and Dr Rahayu Sukri (UBD) are working with Prof Jonathan Adams of Seoul National University (SNU) to explore patterns in small soil animal diversity across the major ecosystems of Brunei: primary dipterocarp forest, heath forest, swamp forest, secondary forest and mangrove. In July 2014, two SNU students worked with several UBD students to sample soils at these forest types.

Alpha and beta diversity, and community composition, will be related to land use, and soil parameters. The results will be compared with those of our studies in other parts of the world, to give clues to the broad scale patterns of diversity and community functioning.

This study will give a true perspective on a considerable part of Brunei's native biological diversity, never before revealed. It will also make clear the conservation implications of loss or modification of each land cover type, in terms of gain or loss of diversity. It will also give new insights on how specific the soil animal community is to its role in the ecosystem of each habitat type: a perspective on how resilient the ecosystem services of small animal communities are in the tropical environment of Brunei.

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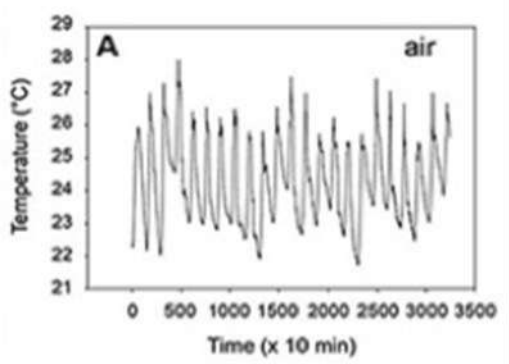
Thermal spatial and temporal variation in coastal wetlands



Spatial and temporal variation of ecologically relevant environmental parameters is one of the conundrums of mangrove ecology. In such extremely dynamic environments, communities cope with ever-changing conditions due to daily, monthly, seasonal and stochastic fluctuations. The spatial structure of the mangrove forest determines a sharp heterogeneity gradient from sea to land, establishing numerous different microhabitats, whose conditions presumably change differently, at the spatial scale of the organisms that live there. No data is presently available on such dynamics; however, they are of pivotal importance to understand the behavioural ecology and ecological physiology of mangrove resident animals, which are typically small (cm) and live in drastically different microhabitats. Dr Gianluca Polgar and AP Dr David Marshall are investigating the spatial and temporal variation of temperature in mangrove habitats of Brunei.

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Acoustic Ecology of Tropical Rainforests

Prof David Monacchi making sound recording of the forest sound

Prof David Monacchi (University of Macerata, Italy) is investigating the circadian rhythms of tropical forest sounds and how they integrate to form unique soundscapes. In collaboration with Assoc. Prof. Ulmar Grafe, Dr. Ang Bee Biaw and PhD Candidate Hanyrol Ahmadsah, the goal was to sample fragments of the entire circadian cycle in various habitats at Kuala Belalong, in order to examine whether the high biodiversity of the area displayed a defined and assessable sonic diversity.

The broader aim is to analyze and compare the multi-channel audio data with other similar soundscape recordings previously carried out in two other biodiversity hotspots: the Dzanga-Sangha in the Congo basin of the Central African Republic and the Rio Jauperì in the Amazon basin.

Another aim of this preliminary field research is to assess the suitability of Kuala Belalong as a site to conduct longer term field work with multiple sound recording systems, which will focus on the dynamics and interactions of biophony, geophony and anthrophony components within primary and secondary equatorial forest ecosystems. The project thus integrates across the disciplines of ecology, bioacoustics, music, art and anthropology. This proposed new research initiative will include a 4-5-day workshop falling under the objectives of the Global Sustainable Soundscape Network, a US National Science Foundation project for which Prof. Monacchi is organizing the Borneo section.

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Plant habitat associations in Brunei's lowland forests

Plant habitat associations are well documented in Bornean lowland tropical forests, where variation in underlying geology gives rise to diverse soil types supporting forests with contrasting species compositions.

Dr. Rahayu Sukmaria Sukri (IBER and Faculty of Science, UBD) focused on investigating the mechanisms that enable various plant species to coexist and maintain high plant diversity at two contrasting lowland mixed dipterocarp forests in Brunei Darussalam: Andulau and Belalong. Separated by approximately 100 km, these sites shown contrasting topography, altitudinal ranges and soil characteristics, all of which generates local and landscape scale edaphic and environmental variation that encourage resource partitioning.

Fruits of *Dipterocarpus* sp. at the Andulau Forest Reserve

The Family Dipterocarpaceae in particular provides an excellent model system for studies of habitat associations, as most dipterocarps are habitat specialists. The study involved a census of all Dipterocarpaceae trees within transects set up along topographic gradients at both Andulau and Belalong, with the aims of determining whether coexisting Dipterocarpaceae species show differential distributions along topographic gradients, and whether differentiation of species distributions and community composition along topographic gradients are associated with soil resource availability.

Dr. Rahayu Sukri and her research team is currently continuing this line of investigation at other lowland forest sites in Brunei Darussalam and expanding the work to examine the influence of habitat effects on the community structure of non -dipterocarp trees as well.

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How Does Ecosystem Functioning in Tropical Peatlands Influence Potential Fire Emissions?

Regional tropical peatlands are among the most important terrestrial carbon stores and hence are of major significance in the global carbon cycle. Peatland burning is estimated to cause up to 90% of seasonal haze in Southeat Asia and very little is known of the actual gaseous and particulate emissions produced by burning peat. There are large uncertainties in estimates of greenhouse gas (GHG) emissions tropical peat swamp forest. In such areas the GHG emissions from the burning peat will very likely greatly outweigh those from the burning of the overlying vegetation.

A collaborative project between Dr Thomas Smith and Dr Michael Chadwick of King's College London (KCL) and Dr Rahayu Sukri (UBD) is currently ongoing to investigate the uncertainties related to the biomass burning emissions factors in tropical peatlands aims to target.

A peat swamp tree destroyed by forest fires

Dr Thomas Smith sampling peat in the Anduki Forest Reserve

The project involves sampling peat from various pristine, degraded, and converted peat swamp forests in Brunei, conducted in July 2014. Peat samples have been exported to KCL, UK and will undergo profiling and laboratory testing for composition, microbial communities and microbial enzymes. Small samples from each site will also be burned to measure greenhouse gas and reactive gas emissions.

Successful measurements from this pilot study will lead to a number of publications, and will bolster future collaborative activity between King's College London and UBD, under the iCUBE initiative.

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Monitoring of seawater conditions in coral reefs

Coral reefs are one of the representative marine ecosystems in the tropics and subtropics and have important roles from various perspectives: biodiversity, food resources, tourisms, economy, etc.

Pulau Pelong-Pelongan in Muara, Brunei

Scleractinian corals at Pulau Pelong-Pelongan in Muara, Brunei

Despite the importance, coral reef ecosystems have been degraded during the last several decades. Mostly because of human activities: landfills, overfishing, nutrient and chemical pollution, global climate changes, etc.

In Brunei, many coral species can be found off the coast. For example, the diversity of mushroom coral species (*Fungiidae*, belonging to the family of Scleractinian corals) in Brunei waters is similar to that in the Coral Triangle and other areas around northern Borneo.

The list of coral species has been published in scientific journals.

During the next step we are proceeding to evaluate the transition of marine environmental conditions by regular monitoring. In particular, the monitoring of water conditions is an urgent need because water quality is easily affected by local activities and finally determines the diversity and habitat distribution of organisms. If the marine ecosystem of Brunei has not been affected by global and local streams, it is fortunate and we need to establish an efficient way to maintain the present coral reef diversity for the future. If it has already been affected, it is important to figure out the major causes and to find a best solution to conserve and recover a pristine ecosystem.

Our studies will show the present status of coral reefs including seawater quality and will propose how we can preserve and manage coral reef environments for sustainable marine resources of Brunei.

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Ecophysiological effects of environmental changes on coral reef organisms

A fragment of crustose coralline algae prepared for a culture experiment

Global and local environmental changes have been threatening coral reef ecosystems. In my research, coral reef organisms are cultured under laboratory conditions and their responses to changing environmental factors are studied.

For reef-building corals, interactive effects of ocean acidification and nutrient enrichment have been studied using post-settlement juvenile coral polyps. While ocean acidification (increase in the partial pressure of carbon dioxide in seawater) significantly reduced the growth rate of the juvenile corals, moderate enrichment of nutrient concentrations in seawater ameliorated the negative effect of ocean acidification. The results showed that the effect of ocean acidification on calcifying organisms such as corals is not that simple but would be influenced by the other environmental conditions and biological metabolism.

Crustose coralline algae (CCA) are important hard substrates for many coral reef organisms to settle on and acquire their habitats. A species of CCA (*Hydrolithon onkodes*) was cultured under laboratory conditions to study their tolerance to high seawater temperature and elevated phosphate concentrations. The study showed the temperature threshold for the growth of this species was between 30°C and 32°C and that the phosphate enrichment did not directly affect the algal growth rate.

These manipulative experiments would help us to predict the status of organisms and ecosystems in coral reefs of the future.

A juvenile coral polyp prepared for a culture experiment (diameter 1 mm)

Laboratory culture experiments of marine organisms

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Predicting how tropical marine animals will respond to climate change

Associate Professor Dr David Marshall, his team of graduate students, and local and international collaborators, are undertaking research to improve understanding of how tropical marine organisms are likely to respond to environmental and climate change. With a focus on estuarine, mangrove and other coastal intertidal ecosystems, this research mainly concerns predicting responses to acidification and warming of marine environments.

The approach followed is mechanistic, involving determining as accurately as possible pH, salinity, and temperature regimes in habitats, and relating these to the physiological capacities of organisms. This has required fine-scale temporal monitoring in the field of these various environmental parameters using data-logging sensors. The physiological component involves measuring metabolism and energetic balance during exposure to, and tolerance limits of, varying environmental conditions in laboratory experiments. Further studies have aimed to understand, by empirical or theoretical means, the capacities of species to modify physiological functioning and tolerance through acclimation and adaptation.

Although the key organisms of this research are gastropod molluscs, ecological studies are being undertaken on all marine invertebrate animal groups, and a spin of this work has been the construction of biodiversity inventories for Brunei marine systems. The primary study locality is the Brunei system.

AP Dr David Marshall is also involved in a multinational macroecological study (Thailand, Malaysia, Singapore,Taiwan, China, and Hong Kong – coordinator- and Portugal), monitoring rocky-shore thermal regimes (every 1 hour) across a vast marine biogeographical region in Asia. Significant research collaborators of David Marshall include Jason Hall Spencer (Plymouth, UK), Gray Williams (Hong Kong), Christopher McQuaid (South Africa), Yunwei Dong (China) and Brian Helmuth (USA).

Tree-dwelling pagurid crab

Sponges near Pulau Bedukang

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Diversity of macrofaunal communities in estuarine habitats of Brunei

Dr Gianluca Polgar has been conducting field surveys since one year in Brunei, in collaboration with AP Dr David Marshall, collecting and identifying specimens of gobies (Teleostei: Gobioidei), grapsoid crabs (Brachyura, Grapsoidea) and gastropod snails (Gastropoda). Collaborating with several taxonomy experts in Singapore, Australia and United States, he aims at gradually building up checklists for these dominant animal groups in the intertidal habitats of Brunei. In mangrove ecosystems, biodiversity assessments are also being conducted together with studies of the spatial ecology of some of these animals.

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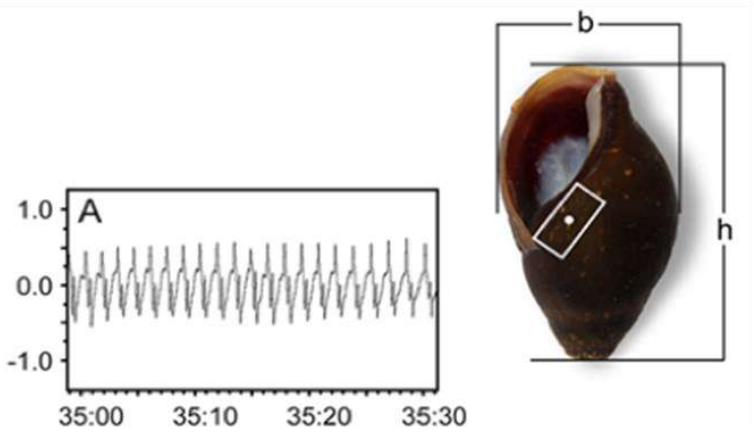
Metabolic responses to temperature change, in aquatic and semi-aquatic animals

The metabolic responses of organisms that live at the interface between water and land often offer invaluable insights into how biological systems adapt and cope with such dynamic environmental conditions. Heart-rate responses in particular, are easily measured and analysed to investigate comparative physiological scenarios, which can be overlapped to phylogenetic patterns, thus differentiating between evolutionarily adaptive vs. Conservative patterns. Current research by Dr Gianluca Polgar and AP Dr David Marshall conducted researches on snails (Gastropoda), which offer excellent experimental models; other semi-aquatic or semi-terrestrial organisms are being considered for future researches.



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The ecology and evolution of mudskippers: vertebrate model of water-to-land transitions

Mudskippers (Gobiidae*: Periophthalmus*) include species exhibiting the most extreme degrees of adaptation to semi-terrestrial habitats among fishes. Understanding their evolutionary ecology may provide insights and help in hypothesis-building, while reconstructing the history of how the ancestors of all terrestrial vertebrates colonised land, 400-350 million years ago. More in general, they offer a unique opportunity to investigate such ecological dynamics in a living and diverse animal group, adopting a comparative approach. Dr Gianluca Polgar has been approaching this topic from different perspectives since several years, adopting different methods and theoretical approaches, from spatial ecology to bioacoustics, behavioural ecology and molecular phylogeny and phylogeography. Several projects are being conducted both in the field and in the laboratory, including a tank with simulated tides to observe mudskippers in semi-natural conditions, to study mudskippers and their adaptations.

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Climate warming effects on tropical marine gastropods

Nursalwa Baharuddin, a PhD student under the supervision of AP Dr David Marshall investigated how invertebrate especially tropical marine gastropods - model of ectothermal animals are vulnerable to climate warming. She is interested in the gastropods physiological performance, acclimation and or adaptation in prediction of future increases of global temperature. This is in relation to theories that tropical ectotherms live close to their lethal limits and are restricted in capacity to thermally acclimate these limits.

The questions on whether microhabitats, environmental temperature as well as phylogenies of these gastropods have effects to their physiological performance will be further investigated. By synthesizing these factors, we will be able to understand the generality of predicted climatic vulnerability and whether this can be applied to tropical ectotherms especially tropical mangrove and rocky shore gastropods. This will provide a comprehensive understanding as how semi- terrestrial and marine will respond to ecological and climate warming.

Nursalwa has investigated more than 31 species (7 superfamilies) of gastropods living in mangrove forests and rocky shores around Brunei Bay. Nursalwa is also supported by UBD Graduate Research Scholarships (GRS) and in-service training with Universiti Malaysia Terengganu (UMT).

Periwinkle, *Littoraria pallescens* at Meragang mangrove forest, Brunei

Whelk, *Indothais gradata* fed on mussel *Musculista senhousia* during an acclimation experiment

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Chemical ecology of the Brunei estuarine system (BES): acidification and pollution

Sorya Proum, a PhD candidate under the supervision of Dr David Marshall and Dr Lim Lee Hoon, undertook a project to characterize the carbonate system and acidification of the Brunei estuary, to understand the accumulation of metals in key species, and to understand behavioural and physiological responses of key species to estuarine acidification. Her study developed from the fact that Brunei estuary presents a steep gradient of acidification (between pH 6 to 8), largely derived from Acid Sulphate Soil (ASS) inflows, and supports an abundance of typically marine faunas. Additionally, the Brunei estuary receives heavy loads of domestic inorganic and organic pollutants, which are perceived to intensify the physical and chemical stress of the biological system.

Furthermore, this already acidified estuary presents and an ideal study case to explore the potential for further impacts resulting from elevation of atmospheric CO_2. Very few studies have explored behavioural and physiological responses to acidification on estuarine animals. The key study species in this respect is the gastropod whelk, *Indothais gradata*. To understand the variation in salinity and pH along the BES, these parameters are being monitored at a fine spatial scale (every 10 min), using data-logging probes and sensors. This study is being done in cooperation with Dr Stephane Bayern, National University of Singapore, and Dr Jason M. Hall-Spencer, Marine Biology and Ecology Research Centre, UK.

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Acidification effects on macroinvertebrate communities in the Brunei Estuarine Systems (BES)

Dr Mohammad Belal Hossain was a PhD student supervised by AP Dr David Marshall when he investigated the effects of estuarine acidification on benthic community structure and functioning in the Sg. Brunei estuarine system (BES). The BES, having an established pH gradient, is a model estuarine system to study the effects of acidification at community level. His research will answer the question how the benthic communities are responding to the acidification gradient in the BES. Preliminary results shows diversity indices (species richness, diversity and abundance) for epifauna were concomitantly greatest at the most seaward station (relatively high pH and salinity), lowest at the middle stations and relatively high again at the most landward (low pH and salinity) of the Sungai Brunei estuary. The epifaunal community shifted from a tanaid-polychaete dominated one to a mussel-dipteran one, and then a mussel-amphipod-dipteran one, from the landward to the seaward stations, suggesting the abundance of shell forming organism (e.g. mussel) reduced in the low pH zone. The results will help us understanding the predicted impacts of oceanic acidification and to take appropriate measures for conserving and managing the estuarine and marine ecosystem.

Epifaunal community (mussel - barnacle) forming mat in the hard surface of Sg. Brunei estuary

His research also involves describing new species of polychaetes and crustaceans from the Sg. Brunei estuary. Recently he recorded a wood boring isopod, *Sphaeroma terebrans* for the first time from the Sg Brunei. This small animal has destructive effects on the wooden structure of Kg. Ayer as it bore holes for creating its own shelter and it seems highly tolerant of variable and low pH.

Attack of *Sphaeroma terebrans* on the wooden piles of Kg Ayer in the Sg Brunei

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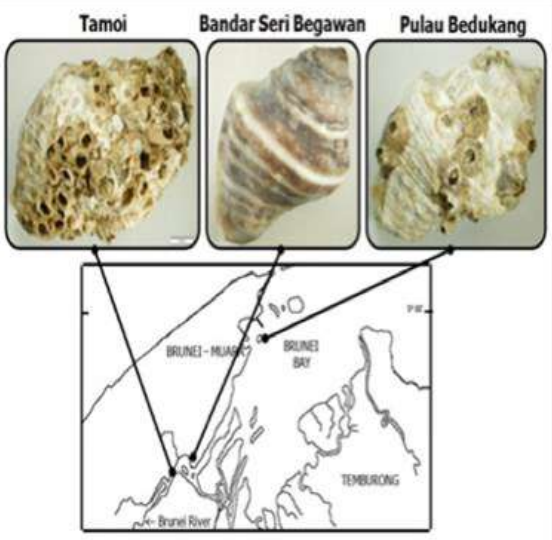
Impact of acidification on ecological patterns and processes in the Brunei estuary



Colonization of barnacles on *Indothais* sp. varies along the pH gradient of Sg. Brunei estuary

Aimimuliani Adam was a PhD student who worked under AP Dr David Marshall on how acidification impacts the ecological patterns and processes in the Brunei estuary. The study contributes to understanding the biological impacts of tropical estuarine acidification, which has been poorly explored, despite the importance to marine systems of acidification in general.

The ocean acidification has become a global concern as many marine organisms are very sensitive to small changes of pH, and predictions are that future variation in seawater pH could be relatively substantial, in line with atmospheric CO_2 elevation.

Her study, considered different acidification regimes along the estuary, should enable better understanding of how ecological processes vary in response to pH change.

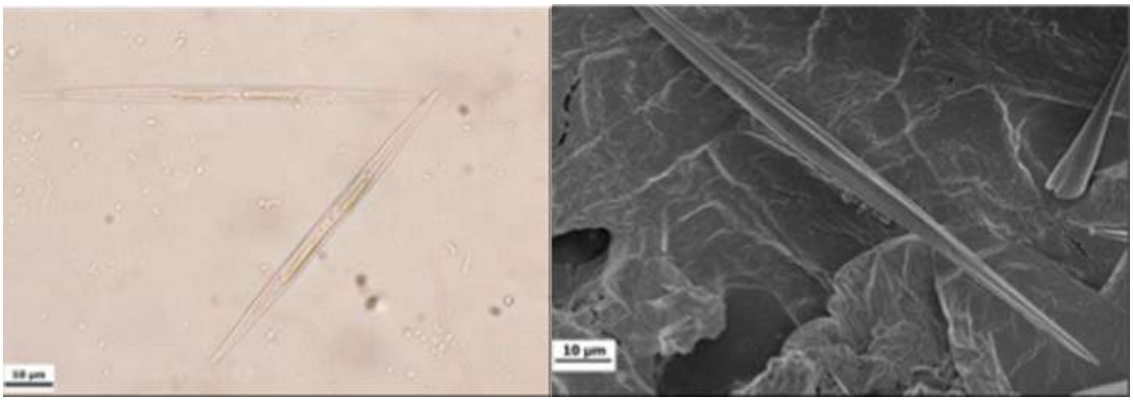
Five projects are being carried out to answer the following questions:

(1) How is phytoplankton diversity and density affected by turbidity and acidification?

(2) How are early larval development, larval settlement and growth affected by acidification (through an analysis of barnacles growing on gastropod (*Indothais*) shells, and woody and rocky substrata)?

(3) What is the nature and development of the macrofouling community on woody substrata along the acidified estuarine gradient?

(4) How does acidification impact on gastropod (*Indothais*) fitness components?



***Nitzschia* sp.; the most abundant phytoplankton species found in Sg. Brunei estuary**

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Impacts of deforestation on macroinvertebrate communities in tropical freshwater streams

Tropical freshwater streams and rivers in Southeast Asia are increasingly threatened by deforestation as a result of changing land use. However, the impacts of habitat degradation on stream communities are poorly understood.

This study examined the effects of disturbance arising from gravel quarrying and its associated deforestation on freshwater macroinvertebrate communities in streams and river of the Temburong catchment in Brunei Darussalam, Borneo. Comparisons were made between communities in streams and rivers that flowed through deforested catchment areas and those in pristine forest areas and, the relationship between community structure and the abiotic environment was assessed. The effects of seasonal rainfall on temporal changes in the community structure were also examined to determine its interaction with primary disturbance explored in this study.

Impacted (disturbed) streams and river stations showed significant changes in macroinvertebrate community structure although significant reduction in abundance and species richness was only observed in the impacted streams.

One stream showed dramatic change in community structure comprising chironomids and oligochaetes, while another showed moderate community changes with high abundance of a grazing gastropod species. The impacted river stations were slightly more diverse with respect to ephemeropteran and coleopteran taxa compared to the pristine river station. Only impacted streams showed significant changes in physicochemical variables (water temperature, pH, dissolved oxygen, total dissolved solids, substrate heterogeneity and canopy cover). Water temperature, pH and canopy cover were the most important predictors of macroinvertebrate community structure in the impacted streams. Only impacted streams showed significant changes in physicochemical variables (water temperature, pH, dissolved oxygen, total dissolved solids, substrate heterogeneity and canopy cover). Water temperature, pH and canopy cover were the most important predictors of macroinvertebrate community structure in the impacted streams.

Community structure showed significant temporal variation with higher abundance and richness observed during the dry periods compared to wet periods of the year. Additionally, the abundance and species richness of the macroinvertebrate community in each stream/river varied more during the wet periods but became relatively stable during the dry periods.

The shift from a highly diverse community to a depauperate community in the impacted stream suggests detrimental effects of quarrying and deforestation on the stream ecology. Notwithstanding the effects of quarrying, change in the abiotic environment was strongly linked to the loss of riparian vegetation, highlighting the value of riparian forest buffers in moderating the effects of disturbance on aquatic ecosystems and their communities.

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Preserving Traditional Knowledge - Ethnobotany and the Holy Writings

In an interesting mix of disciplines between Science and Religion, IBER's visiting Fulbright Specialist Scholar Prof. Lytton John Musselman explores the vast possibilities of ethnobotany in the holy books to find out the traditional uses of plants. He is collaborating with Assoc. Prof. Kushan Tennakoon, Prof. Dato Hj Mohamed bin Hj Abdul Majid, Prof Datuk Dr Osman bin Bakar and Dr Norhayati Ahmad in an interdisciplinary research project that provide interesting insights into the connections between botany, religion and culture.

> In this specific project, Prof Musselman has found that approximately 80 plants are mentioned in the Holy Bible and about 30 in the Holy Qur'an. The Holy Bible and the Holy Qur'an were written in cultures that have high appreciation of plants, and as such, the plants and their products are powerful symbols because of their link with that culture.

To investigate these plants, a combination of several disciplines is needed, including ethnology, botany and linguistics in order to understand how people used plants in the past and in the present. Among the plants described in the Holy Books are those that are used for products, which today come from different plants, some of which are of unclear identity. There is so much interest in studying those plants, because it has been shown clearly, that plants mentioned in the Holy Writings have scientifically proven medical value.

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One of these plants, which Prof Musselman's research tried to identify with certitude, is *Oud al-Hindi* (Incents of India) which is mentioned in the Qur'an to cure seven diseases. While the name is usually associated with several plants like *Saussurea costus,* grown in the Himalaya or Aloe, Prof Lytton's research concludes however, that the most likely plant to be *Oud al-Hindi* is grown in Brunei (and elsewhere in Brunei) under the local name "*Gaharu / Agarwood* (*Aquilaria malaccensis* Family: Thymelaeaceae).

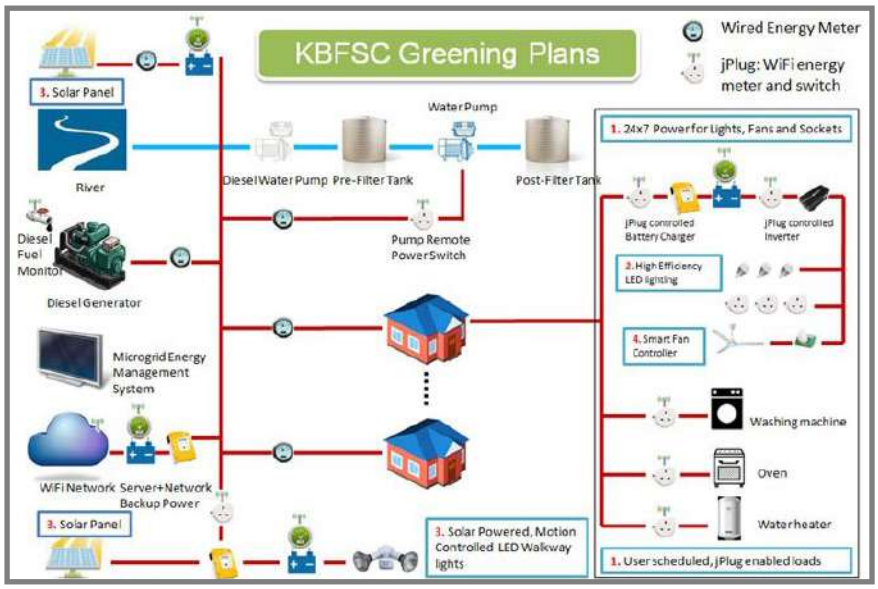
The aromatic resinous material produced in Agarwood is believed to be producing one of the most expensive ingredients used for high-end perfumes in the world. The aromatic material is estimated at about USD 10,000/kg.

UBD's Sultan Omar 'Ali Saifuddien Centre for Islamic Studies (SOASCIS) expertise in the field of Islamic Studies could provide some of the historical and textual knowledge connected to these plants.

Gaharu - The Agarwood tree is one of the plants mentioned in the Holy Books

KBFSC Greening by UBD|IBM Centre

The KBFSC Greening Project initiated by IBER and UBD|IBM Centre focused on increasing power availability at the remote Field Studies Centre while reducing diesel consumption. The Centre has been dependent on power generated by a diesel generator (DG). Through extensive instrumentation and data analysis, it was found that the DG is sub-optimally loaded much of the time. The following aspects have been accomplished to reduce diesel consumption while maintaining user experience at the Centre:



- A site wide network has been established to provide visitors with Internet access. This allows visitors to check with their mentors and peers about the research they are performing, making them more productive and potentially improving the outcome of their research. A battery backed power system has been put in place specifically to support the network.
- Since visitors require computing equipment, lighting and fans, the DG was kept running for 8-10 hrs a day. Researchers at IBER and the UBD|IBM Centre have installed a battery system and a set of power inverters to provide power to visitors for these needs. This enables the DG to be turned off except to recharge the batteries. This initiative can reduce DG run hours to about 4-6 hrs a day (depending on how much energy is used from the batteries). During charging, the DG operates more efficiently at a higher loading factor, consuming less diesel for the same amount of energy. The battery bank currently supports the lighting, fans and small plug loads in the residential buildings.
- A solar panel system has been installed to augment the energy from the diesel generator. Solar power is used to charge the battery bank above, whenever available. The solar panels are located in the sunniest part of the centre, maximizing the energy that can be harvested.
- Walkway lighting has been installed to improve visibility and reduce energy waste. This LED based lighting is custom designed for bidirectional motion sensing. The lights turn on as the walkway is approached from a distance from either direction. Light intensity has been increased by 5x and the energy has been reduced by more than 50%.

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DNA Barcoding and Community Structure Assessment in a Tropical Forest: A 25 ha Mixed Dipterocarp Forest at Kuala Belalong Brunei Darussalam as a Model

Dr Michael and Jacqueline working in the laboratory at KBFSC

Fiona (field assistant), Jacqueline, Dr Michael and Prof. Rose in the field on the way to the plot

This project aims to answer the question "what is the phylogenetic structure within the subplots of the 25 Ha plot of Mixed Dipterocarp forest at Kuala Belalong?" To answer this question, we will use DNA barcoding to identify the species in a 25 ha forest plot by sampling 100 subplots each of 10x10 sq.m. Subplots will be taken randomly, considering the different ecological niches of this forest. For barcoding, we will sequence plastid regions rbcL and matK, as recommended by Consortium for the Barcode of Life (CBOL), including all individuals >1cm dbh. These barcode sequences will be used to reconstruct a robust phylogenetic tree using Bayesian inference and maximum parsimony (MP). Trees will be compared with expected phylogenetic patterns (APG III) to confirm the presence of phylogenetic clustering or over-dispersion. Barcoded species of well represented Angiosperm families of these plots will be incorporated into the available rbcL and MatK sequence matrices to get the molecular phylogeny of the family concerned.

Since 21st June 2014, 38 subplots have been sampled (silica gel dried leaf samples) having a total of approximately 2000 individuals. Laboratory work on DNA extraction is in progress and we have already extracted 450 individuals, which will be amplified using the DNA barcoding markers such as rbcL and matK. We plan to have the phylogenetic community structure of some of the plots by the end of this year. This barcoding project will be a contribution to identify the species in this 25 ha plot as well as identify new species if any. Phylogeny of the Dipterocarpaceae using the next generation RAD sequencing will help us to resolve the existing taxonomic problems of some of the genera such as *Shorea*, *Hopea*, and give us the evolutionary history of this economically important family.

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Tree Frog Adhesion: Biology and Biomimetic Implications

This is a joint research collaboration between UBD (Prof Umar Grafe and PhD student Hanyrol Ahmadsah, Environmental and Life Sciences Program) and the University of Glasgow (Prof Jon Barnes, Thomas Endlein, Niall Crawford).

Tree frogs (and also torrent and rock frogs) possess adhesive toe pads of the tips of their digits, which aid their adhesion as they climb trees, rocks and even, in the case of torrent and rock frogs, waterfalls. We looked at the anatomy and physical properties of the toe pads and extraordinary powers of adhesion under different experimental conditions.

In 2012, Thomas Endlein from the Centre of Cell Engineering, University of Glasgow, visited the KBFSC where he and his fellow researchers investigated the remarkable attachment abilities of the torrent frog, *Staurois guttatus*. He found that elongated cells in the periphery of the toe pads, with straightened channels in between them facilitated drainage of excess fluid underneath the pad and thus increased adhesion ability under wet conditions. These findings were published in the journal Plos One in 2013.

Currently, other researchers have built on these results leading them to develop a biomimetic hexagonal surface micropattern in disposable shaving blades.

***Polypedaes otillophus,* file-eared tree frog**

Thomas Endlein (centre) and his team of collaborators (from left to right): Prof Jon Barnes, Niall Crawford, Prof Ulmar Grafe and Hanyrol Ahmadsah

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Value Addition to Biodiversity: Use of Native Plant Pigments for Dye-Sensitized Solar Cells (DSSCs)

This is a joint project between the Dye Sensitized Solar Cells Research Group (led by Dr Piyasiri Ekanayake) and AP Dr Kushan Tennakoon.

Dye sensitized solar cells (DSSCs) have become attractive and inexpensive devices for the conversion of solar energy into electrical energy using the principles of the photochemical phase of photosynthesis. Researchers use prototype solar cells to evaluate the performance of a range of native plant dyes used as sensitizers. Synthetic dyes used in DSSCs are very expensive and have complex synthesis processes, whereas the use of natural pigments has merits from economic and environmental points of view.

Main aims of this investigation (from biological point of view) are to elucidate the absorption spectra solar cell, and the evaluation of conversion efficiency of dyes prepared under different environmental parameters.

One of the key factors that enhance the efficiency of sensitizer is the ability of the dye to absorb wider range of light from visible to NIR wave length regions. This is difficult to be achieved by using a single dye. As a probable solution to this problem, a mixture of two or more dyes (dye-cocktail solution) having the ability to absorb in lower and higher wavelength regions are currently evaluated to enhance the performance of DSSCs. Here we take special emphasis to avoid unfavourable interactions among random dye absorptions that lead to decreased photovoltaic performance. We are comparing the simultaneous or successive absorption of dyes that enhance both the adsorption capabilities and electrochemical properties in the visible range.

A successful patent has been awarded pertaining to these studies.

Examples of some native plants studied

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Use of Plants in Traditional Postpartum Treatment: Perceptions and Practices Among the Indigenous Tribes of Brunei Darussalam

Western medicines, which emphasizes the scientific rationality of diseases, is widely accepted today and placed at the top pinnacle of the medical system. However, the World Health Organization (WHO) estimates that 80% of the world population still depend on the traditional medicine as their primary healthcare. Some of the world's population depend on traditional medicine because modern medicine is not accessible. Others choose to use traditional medicine through a deeply ingrained history and cultural practice.

A. *Piper retrofractum* B. *Cryptocarya massoiav* C. *Piper cubeba*, D. *Terminalia chebula*, E. *Curcuma sp 1*, F. *Curcuma sp 2*, G. *Curcuma zedoaria*, H. *Curcuma xanthorhiza*, I. *Zingiber*

The utilization of plants is extensive in traditional medicine and this is highly evident in the postpartum treatment especially among the people in Southeast Asia. This research, conducted by Ms. Aziah Muhamad, under the supervision of Prof Dato Hj Mohamed Hj Abdul Majid and Dr. Saiful Islam, focuses on the bioprospecting of plants used in traditional postpartum treatment among the three indigenous tribes of Brunei Darussalam: Brunei Malay, Kedayan and Murut. The objectives of this research are to compile the medicinal plants use, to determine if the medicinal plants are shared among the three tribes as well as to identify the traditional postpartum practices those are employed by the three tribes. Several focus groups were interviewed to include the parents, older generation, postnatal caregivers as well as traditional healers in the three districts of Brunei Darussalam; Brunei Muara, Tutong and Temburong.

***Blumea balsamifera* (Sambung)**

Brunei Darussalam is modernized with well-developed infrastructure, affordable and easily accessible healthcare. Therefore this research aims to find out if modernization has erased the traditional knowledge of medicinal plants among the tribes in Brunei Darussalam. Furthermore, this study acts as a stepping stone to new research avenues such as phytochemical studies in the search for new drugs, psychosocial studies, the physiological studies of plants and humans as well as the conservation of the medicinal plants.

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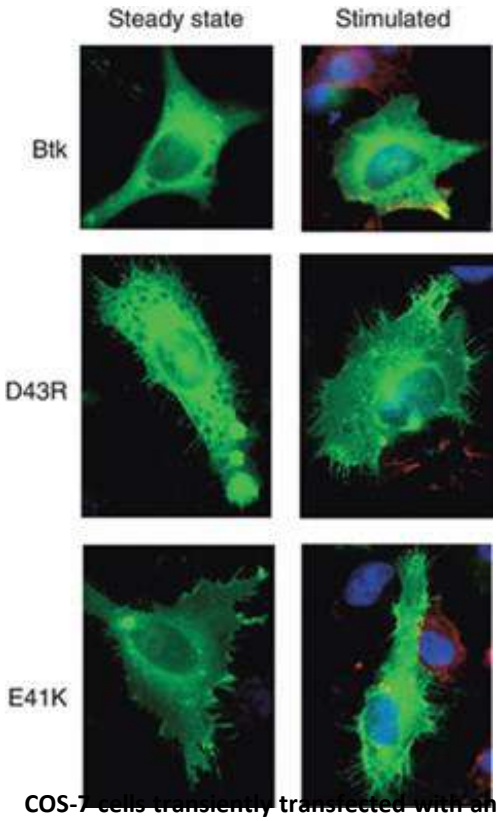
Medicinal Plants in the Rainforest – Potential Source for Bioactive Compounds for Basic Research in Biology and Medicine

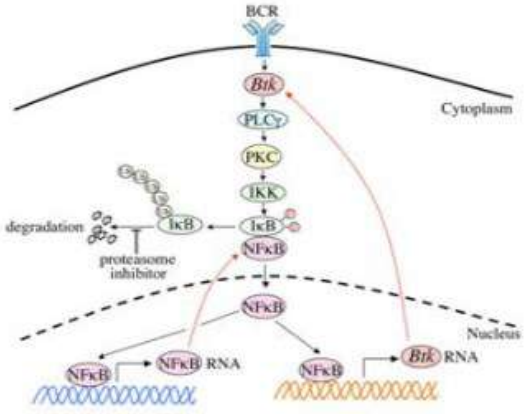


COS-7 cells transiently transfected with an expression vector encoding the fusion protein, BTK- GFP. Green (BTK-GFP), Blue (a chromatin-binding dye which stains the nucleus). Left column (resting cells), right column rum-stimulated cells). D43R and

It is an open secret that discovering new antibiotics in the 21st century is becoming a thing in the past. Moreover, a good number of the microbial pathogens that is responsible for the major infectious diseases are increasingly becoming resistant to most antibiotics. Therefore, it is paramount to look for alternative source(s) for identifying novel drugs for both old and new diseases. The rich biodiversity in the rainforest of Borneo could provide unlimited supply of potential bioactive products, which could be harnessed using a combination of biochemical techniques, natural products chemistry and the tools of modern molecular biology.

In light of that, our laboratory is planning to explore the rainforest for naturally occurring bioactive compounds/ reagents that might find applications in biotechnology and medicine. Reagents such as these could also be utilized in basic research in the biological and biomedical sciences. We are particularly interested in investigating extracts of local medicinal plants for possible biological activity in mammalian cells. Currently, we are working on a research project that addresses the effect of thymoquinone (TQ), the active component of *Nigella sativa,* on cellular signaling.

Thymoquinone has been shown to inhibit the NF-kB signaling pathway following inactivation of the 26S proteasome. NF-kB signaling is critical in immunity and inflammation and is known to regulate transcription of several thousand genes, many of which, are important in cell proliferation/survival and apoptosis.



At present, there are few proteasome inhibitors that are approved for treating patients with cancer (multiple myeloma), but they are highly toxic limiting broader utilization in the clinic. In stark contrast, seeds from *Nigella sativa* (black seed) are routinely used in many parts of the world for medical purposes and are even consumed in foods and drinks.

A proteasome inhibitor based on a compound from the well known and ancient medicinal plant, *Nigella sativa*, will have implications in the treatment of chronic diseases such as rheumatoid arthritis, cancer and AIDS.

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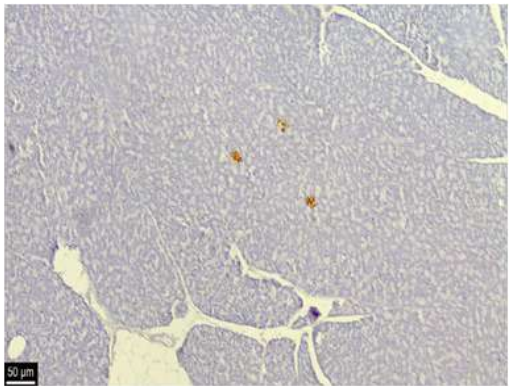
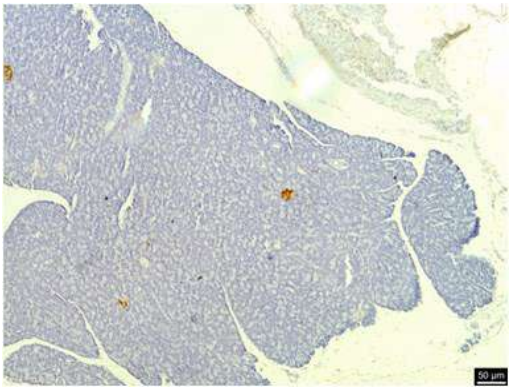
Research on Diabetic Animal Model Using Bioactive Compound Thymoquinone

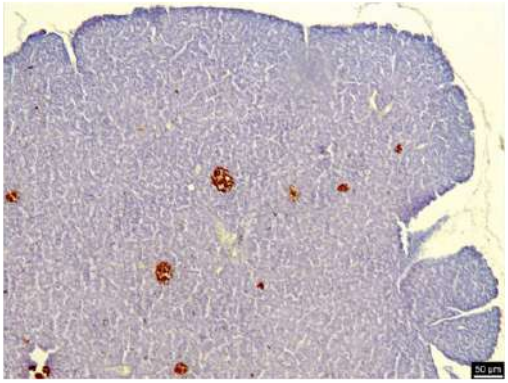
The use of active components from natural resources has been shown to have diverse therapeutic and medicinal effects in previously studied models of human diseases. Current work is focused on thymoquinone (TQ) which is the active component from *Nigella sativa* (black seed) on pancreatic islet regeneration in a diabetes animal model. This study is relevant in light of the increasing incidence of diabetes not just locally but also on a global scale. A graduate student is currently working on the quantification of extent of regeneration in a diabetic animal model. The outcome of this study has a direct implication in the treatment of diabates where damaged islets have the potential to expand and recover in response to TQ administration. Currently the use of TQ is being expanded to determine its effects in different cell lines.





Immunostained sections showing insulin positive cells in 2 months diabetic control animal vs TQ treated animals

2 months diabetic control



Sections form TQ treated animals show an improvement in islet architecture

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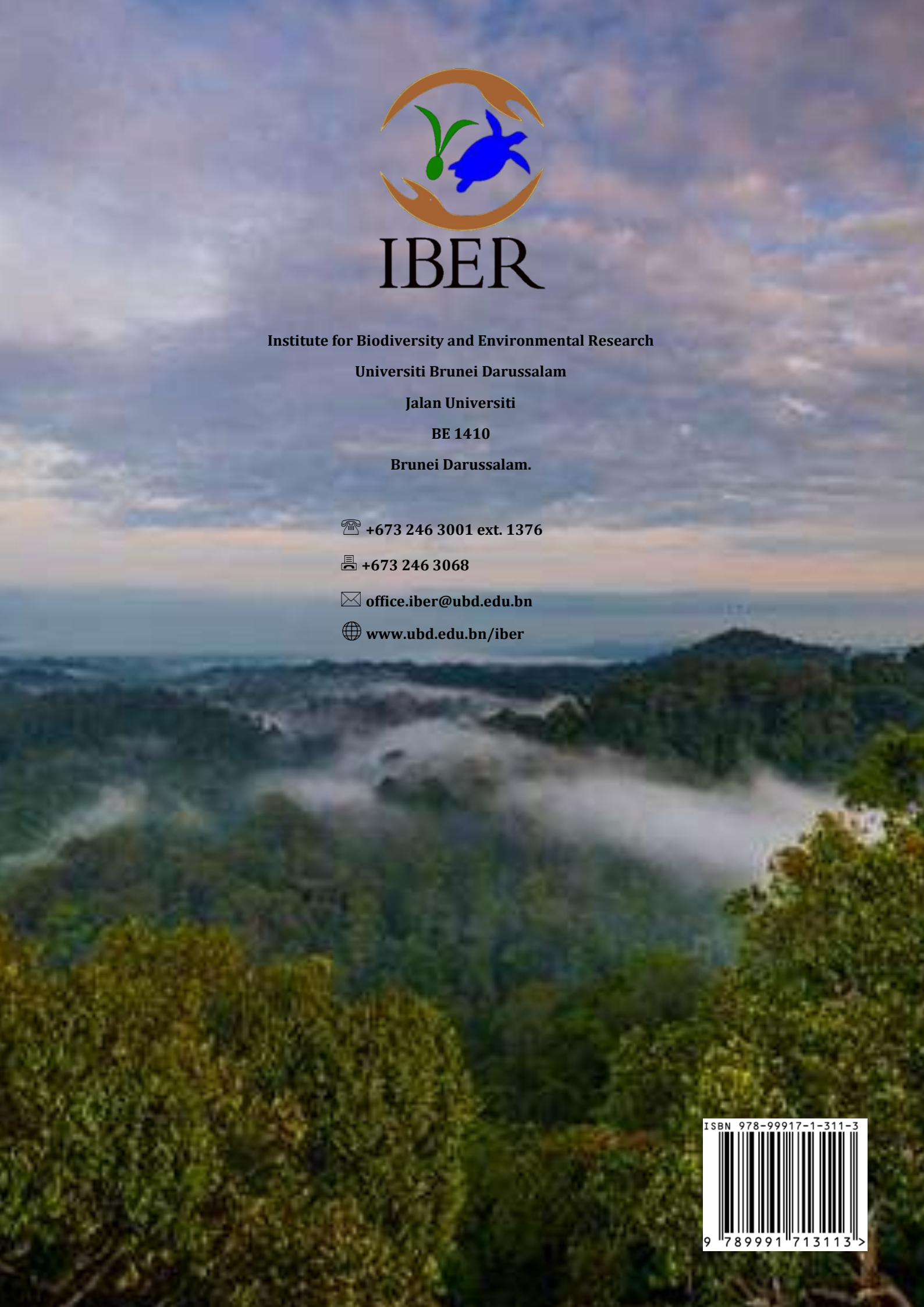

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