International Conference on Biodiversity 2019 : IBD2019

22-24 May 2019

Centara Grand & Bangkok Convention Centre at CentralWorld, Bangkok Thailand

Organized by:
Ministry of Higher Education, Science, Research and Innovation
National Science and Technology Development Agency
Ministry of Natural Resources and Environment
Biodiversity-Based Economy Development Office

Supported by:
Fund for Sustainable Education (FUSE) – SAVITA FOUNDATION
Thailand Convention & Exhibition Bureau

In Cooperation with:
Office of Natural Resources and Environmental Policy and Planning
National Science Museum
National Research Council of Thailand
Thailand Science Research and Innovation
Department of National Parks, Wildlife and Plant Conservation
Department of Marine and Coastal Resources
Royal Forest Department
The Zoological Park Organization under The Royal Patronage of His Majesty The King Mongkut's University of Technology Thonburi
Center of Excellence on Biodiversity, Office of the Higher Education Commission

Sponsored by:
Electricity Generating Authority of Thailand
Toyota Motor Thailand Company Limited
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ABOUT THE CONFERENCE

International Conference on Biodiversity 2019: IBD2019
“Biodiversity for Sustainable Bioeconomy”

Biodiversity is fundamental for human life and vital for the functioning of ecosystems. Human welfare depends on biodiversity, as it provides natural services such as fresh water and clean air, biological resources such as medicinal plants and food, as well as economic benefits of industrial development. Recognizing the importance of biodiversity to the quality of life and the economy, Thailand has been ramping up the effort in research into biodiversity and sustainable utilization as well as conservation. The richness of biodiversity and intensive effort in diversity exploration and conservation in Thailand, therefore, serve as a perfect backdrop for IBD2019. IBD2019 will consist of scientific conference and comprehensive exhibition dedicated to showcase the work of various local and international research organizations, government agencies, universities, schools, non-profit organizations, local communities and private companies contributing to biodiversity research and conservation in Thailand and neighboring countries.

DATE AND VENUE:
22 – 24 May 2019 at Centara Grand & Bangkok Convention Centre at CentralWorld, Bangkok, Thailand

ORGANIZED BY:
- Ministry of Higher Education Science Research and Innovation
  National Science and Technology Development Agency
- Ministry of Natural Resources and Environment
  Biodiversity-Based Economy Development Office

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- Fund for Sustainable Education (FUSE) – SAVITA FOUNDATION
- Thailand Convention & Exhibition Bureau (TCEB)

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- Royal Forest Department
- The Zoological Park Organization under The Royal Patronage of His Majesty The King
- King Mongkut’s University of Technology Thonburi
- Center of Excellence on Biodiversity, Office of the Higher Education Commission
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| Breakout rooms                     | • Lotus Suite 1-2, 3-4, 5-6, 7, 10, 11 and 12 (22nd floor)  
|                                    | • World Ballroom A, B and C (23rd floor)                                 |
| File uploading for speaker         | Lotus Suite 13 – 14 (23rd floor)                                         |
| Exhibition and sponsor booths      | Convention Centre A2 (22nd floor)                                         |
| Poster presentation                | Pre-function (22nd floor)                                                |
| Registration counter               | 22nd floor                                                               |
| Information counter                | 22nd & 23rd floor                                                        |
| Conference secretariat             | Lotus Suite 15 (23rd floor)                                               |
| Lunch place                        | Convention Centre B2 (22nd floor)                                        |
| Welcome dinner                     | World Ballroom                                                           |

OFFICIAL LANGUAGE:
English will be the official language.

TRANSLATION TOOLS:
There will be translation support (English – Thai) for the Keynote sessions of each day. To receive the headphone, Thai participants are required to deposit ID card with the staffs. Please be noted that participants are fully responsible for any damage or loss with the tools.

NAME BADGES:
Participants and exhibitors are requested to wear their name badge at all times in order to participate around the conference area.

SOCIAL PROGRAMS:
All participants are invited to participate in the Conference Opening Ceremony, Welcome Dinner, Poster Award Announcement and Closing Ceremony.

- **Conference Opening Ceremony**
  - Date: Wednesday 22 May 2019
  - Time: 09.00 – 10.00
  - Location: World Ballroom

- **Welcome Dinner**
  - Date: Wednesday 22 May 2019
  - Time: 18.00 – 20.30
  - Location: World Ballroom
  - Cultural show: Klong Sabad – Chai, Khon (Masked dance-drama), Nat Ta Ya Muay Thai and Ganoptingtong (Mantis folk dance)

- **Poster Award Announcement and Closing Ceremony**
  - Date: Friday 24 May 2019
  - Time: 15.45 – 16.15
  - Location: World Ballroom
# IBD2019 SCIENTIFIC COMMITTEES:

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<td>• Dr. Young Ng, Danxiashan UNESCO Global Geopark, P.R. China and Association for Geoconservation, Hong Kong SAR</td>
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Daosavanh Sanamxay

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Kevin David Hyde

Transforming *in situ* biodiversity observation into digital atlas and conservation implication in Thailand

Yongyut Trisurat

Diversity of yeasts in the surface of rice leaves and biocontrol activity against fungal pathogens of rice plant

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Translational research of selected plant in Zingiberaceae

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Supayang P. Voravuthikunchai

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Samuel W. James

Natural history collections: why are they so important?

Jonathan Ablett

Why Flora of Thailand...How far we have reached?

Pranom Chantaranothai

Taxonomic study of Olethreutine moths (Lepidoptera: Tortricidae) in Thailand and new discoveries in last two decades

Nantasak Pinkaew

The priceless classical taxonomy of Southeast Asian tree snails *Amphidromus*

Chirasak Sutcharit

Ecology and evolution of enantiomorphism in the tree snails *Amphidromus*

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Diversity and conservation of bats in Southeast Asia – the role of taxonomy beyonds borders

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Abstract
KEYNOTE SPEAKERS
The Phadaeng Botanic Garden: a model for a regenerative tropical botanic garden

Rachel Warmington¹,*, Mike Maunder¹, Paul Stone¹, and Weerachai Nanakorn²

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ABSTRACT:
The proposed Phadaeng Botanic Garden (PBG) will reflect the ecological and education challenges facing Thailand, a facility designed in response to the Anthropocene. It is a garden that symbolises a change in ethos from extractive use of the landscape to a regenerative investment in tropical landscapes. The PBG will be constructed on land wasted by teak extraction and open cast mining, the core of its identity is regeneration of biodiversity and ecosystem services. We envisage the PBG as a hub that interprets and conserves the plant diversity of SW Forest Complex, from this hub a network of restored habitats protects watersheds and biodiversity. Conservation and research will focus on restoration ecology, plant systematics of the SW Forest Complex and the integrated conservation of native orchids and cycads.

KEYWORDS:
Botanic garden; regeneration; biodiversity; Anthropocene; plant diversity
Technical aspects of mine reclamation in the Rhenish Lignite Basin and possible ways of biodiversity, bioeconomy and public use

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ABSTRACT:
Since decades RWE is mining lignite in the “Rhenish Lignite Area” close to the city of Cologne in Germany. In this area RWE operates three large surface mines with an annual coal production of about 100 million tons and an overburden movement of 550 Million bench cubic meter of material in a very dense populated area.

The mining process requires the removal of all vegetation and overburden to uncover the coal seams that are mined for energy generation purpose. Within the mining process, care must be taken to remove, segregate and save the suitable topsoil and subsoil materials, since the soil resource is essential for reclaiming mined land for beneficial uses after mining.

The presentation explains the technical aspects of mine reclamation in the “Rhenish Lignite Area” and shows RWE’s experience in the field of agricultural and forest recultivation.

With respect to biodiversity, we will indicate aspects of stewardship and conservation of specialized species, bioprospecting of unique habitats for biotechnological use and the use of marginal soils for production of renewable resources.
KEYNOTE FORUMS
Biodiversity conservation and management in ASEAN

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ABSTRACT:
The ASEAN region is endowed with rich natural resources that sustain essential life support systems, both for the region and the world. However, the region is confronted by unprecedented environmental challenges. Population growth and urban migration, pollution, rapid economic development, regional economic integration, and increased consumption patterns, pose threats to biota and ecosystems. These factors can lead to pressures on biodiversity and ecosystems through increased deforestation, agriculture intensification, land conversion, genetic erosion, and unsustainable harvesting of natural resources such as fishing, mining, and wildlife species. Additionally, biodiversity loss and ecosystem degradation can have substantial impacts on people’s livelihoods, food security, and wellbeing. The region’s biodiversity and ecosystems are essential to the economic, social and environmental wellbeing of the ASEAN people, contributing to agriculture, food security and livelihoods, and the preservation of indigenous cultures. Sound management of nature conservation and biodiversity, thus, becomes integral to sustainably conserve the region's biota and ecosystems for a resilient ASEAN.

ASEAN Member States recognise the importance of coordinated regional responses to addressing the environmental challenges and protecting and supporting ecosystems and biodiversity towards sustainable development. They have worked closely together since 1977 in promoting environmental cooperation at national, regional and international levels in accordance with various domestic legislations and their respective priority areas, as well as international agreements including the United Nations Sustainable Development Goals (SDGs). ASEAN Member States are signatories to various international environmental conventions related to ecosystem and biodiversity protection such as the Convention on Biological Diversity (CBD), the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), and the Ramsar Convention on Wetlands.

This presentation will provide an overview of ASEAN’s response to biodiversity loss, covering regional strategies and action plans for biodiversity conservation and management that focus on six programmatic areas: (i) conservation of key terrestrial biodiversity areas including Protected Areas, (ii) urban biodiversity, (iii) agricultural biodiversity, (iv) access and benefit sharing, (v) knowledge management for biodiversity conservation, and (vi) the role of the ASEAN Centre for Biodiversity (ACB). The presentation will also highlight initiatives of the ACB, in particular, to mainstream biodiversity into key sectors, including tourism, infrastructure, agriculture, health, and education, Biodiversity...
mainstreaming is a vital entry point to ensure successful conservation and enable the ecosystem services it provides to achieve a “sustainable bioeconomy” in the ASEAN region.

KEYWORDS:
ASEAN; Southeast Asia; biodiversity conservation; biodiversity mainstreaming; Convention on Biological Diversity
Role of *ex situ* conservation and wildlife genome banking for conservation

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**ABSTRACT:**
Conservation biology aims at understanding and sustaining thriving biodiversity because the disappearance of even a single species can compromise the functioning of an entire ecosystem. The core of animal conservation is the maintenance of genetic diversity within populations that are large enough to be sustainable for the long term. In addition to protecting viable populations in their natural habitat (*in situ* conservation), it is critical to maintain populations in captivity (*ex situ* conservation) for subsequent reinforcements or reintroductions. Furthermore, many wild animal populations are small and scattered in their habitat with little or no opportunity for genetic exchange, which increases homozygosity and inbreeding that, in turn, leads to a bad poor adaptive capacity to environmental changes as well as fertility problems. The success of *ex situ* conservation or ‘conservation breeding’ is based on extensive knowledge of animal husbandry including reproductive biology. Assisted reproductive techniques, such as artificial insemination or *in vitro* fertilization also can enhance the genetic management of endangered species and overcome infertility issues. Tightly associated with these techniques, efforts in genome resource banking are essential. It refers to the collection, storage at freezing temperatures, and use of biomaterials for research and for propagations of populations (using frozen semen for artificial insemination for instance). While these approaches have been widely promoted over the past decades for sustaining small populations of rare and endangered species, there is an urgent need to conduct more research and mobilize more resources to fully integrate those technologies into conservation programs.
Sustainable management on biodiversity in Thailand

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ABSTRACT:
Thailand, approximately 513,120 km² in total area, is rich and major biodiversity hotspot due to varieties of geographical and climate conditions. There are abundant flora and fauna species including microorganisms in both the terrestrial and aquatic habitats. More than 12,000 plant species, 2,000 terrestrial invertebrate species and 1,000 species of birds can be found in the countries, however, there are numerous species of flora and fauna are unknown.

Biodiversity in Thailand is a vital important to economics and social particularly local community development, Biodiversity provides food, medicine, cosmetic and industrial raw materials. Unfortunately, biodiversity in the country is lost from time to time. The major causes are overharvesting, habitat loss and fragmentation, chemical pollution, climate changes and agricultural practices.

Presently, Thailand by the Ministry of Natural Resources and Environment has set the national strategy for integrated sustainable management plan on biodiversity in the year of 2016 to 2021 and also formulated in the Twelfth National Economic and Social Development Plan (2017-2021). The strategy plan is to be translated into action. Some important actions includes campaign in increasing awareness of biodiversity and its value, strengthening community-based sustainable production, conservation and rehabilitation, applying sufficiency economy on biodiversity utilization and lastly, development of legislation and other regulations provisions for biodiversity protection. However, key success of these actions to be effective full proper implementation, monitoring and evaluation should be strictly done with collaboration among all stakeholders.

KEYWORDS:
Biodiversity management; hot spot; Thailand
Biodiversity hotspots in Thailand: with a new model of approach for co-management and utilization of micro hotspot in Pattani Bay

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ABSTRACT:  
The concept of hotspot introduced by Norman Myers has now identified 36 hotspots throughout the world. For each hotspot, sites of global significance for biodiversity conservation were identified as Key biodiversity areas or KBAs to provide essential "watch lists" of sites to safeguard and help set national priority within the global context. Thailand, one of the most biodiversity-rich countries in the world located within two major biogeographical regions – the Indochinese region in the north and the Sundian region in the south, falls mainly in Indo-Burma hotspot and partly Sundaland hotspot in the southernmost part of the country. Altogether, 113 KBAs have been assigned all over the country. Another work done by Tantipisanuh and Gale on biodiversity hotspot in Thailand identified some hotspots highlighting an importance of unpublished data. This presentation will highlight some important hotspots and KBAs together with specific flora and fauna such as Kaeng Krachan National Park, Thungyai-Huai Kha Khaeng Wildlife Sanctuaries, Khao Yai National park, Khao Sok National Park and the KBAs/hotspots in the deep south of Thailand.

Additionally, a new approach for co-management and utilization of Pattani Bay, a 55 km$^2$ of unprotected KBA area will be introduced by mean of a multidisciplinary integrated area - based study from several disciplines. The aim is to know the bay completely, wise use with knowledge for a security, wealthy and sustainability of community. Four strategic plans have been conducted including (1) creating basic knowledge of economically and environmentally important species in the bay, (2) developing model of resources utilization for aquaculture, increasing productivity and promoting ecotourism, (3) establishing updated and accurate database and implementation of information technology application for management purposes, and (4) creating awareness and community participation in conservation, rehabilitation and management.
Potential climate change impacts on protected areas in Southeast Asia

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ABSTRACT:
Protected areas are the cornerstone of biodiversity conservation in tropical Asia, including Thailand. They serve to exclude incompatible uses, including agriculture, logging, and hunting, but because their position is fixed in space, they are potentially vulnerable to climate change. The ‘Spatial Planning for Protected Areas in Response to Climate Change’ project (SPARC), funded by GEF and administered by Conservation International, was designed to assess the risks from climate change to existing protected areas across the tropics and propose strategies by which these risks can be reduced. This presentation focuses on the Southeast Asian component of the project. This is a difficult region for modeling climate and, while the models generally agree on future changes in temperature, projections of future rainfall and other climate variables vary a lot between models, and there is little or no agreement for most of the region. Uncertainties about the impacts of climate change are added to these model uncertainties. SPARC assessed threats to each protected area by a variety of methods, including projected changes in climate, modeled changes in ecosystem function, and modeled climate-change responses of species for which there are enough distribution records. The regional analyses identified climate types, species and ecosystems that may lose representation due to climate change, and identified protected areas from which these losses are projected to occur. After consultation with regional protected area planners, SPARC-Asia is producing country reports outlining the threats and potential solutions, including additional protected areas, where practical, and changes to the management of existing areas.
Severe coral bleaching and impacts on biodiversity: the 2014-17 global bleaching event and prospects for the future

C. Mark Eakin*, William J. Skirving, Scott F. Heron, Gang Liu, Terry P. Hughes, Simon Donner, Erick F. Geiger, Jacqueline L. De La Cour, Andrea M. Gomez, Benjamin L. Marsh, and Denise Devotta

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ABSTRACT:
Mass coral bleaching, first documented in the early 1980s, has become one of the most visible marine ecological impacts of global warming. Severe coral bleaching has become more extensive, frequent, and intense with increasing global ocean temperatures. This can be seen both in the acceleration of heat stress events capable of causing mass coral bleaching and in new multi-decadal datasets of bleaching observations. Additionally, while the 1998 and 2010 global coral bleaching events lasted less than 12 months, propagating and teleconnected marine heatwaves in the most recent event caused bleaching from June 2014 – May 2017. This global heat stress and corresponding bleaching and coral death, previously seen in 1998 and 2010, was repeated in both 2015 and 2016. The extent and magnitude of this three-year event caused serious damage throughout the tropics, including widespread loss of corals and associated fauna. This was at a time when global surface temperature was around 1.0°C above the pre-industrial average – already halfway to the Paris Agreement’s 2.0°C target and two-thirds of the aspirational goal of 1.5°C, beyond which the future survival of coral reefs is greatly diminished. This presentation will consider the frequency and patterns of past global heat stress using NOAA Coral Reef Watch’s newest multi-decadal record of temperature and heat stress, CoralTemp, along with the two most recently developed global datasets of coral bleaching observations. It also will provide the latest update on the damage to tropical reef ecosystems caused by the 2014-17 global coral bleaching event and discuss the urgent need to limit global warming to protect coral reefs.
Natural products based molecules for target and drug discovery in pharmaceutical research

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ABSTRACT:
Natural products with their specific structural features deliver chemical starting points in drug discovery to develop innovative therapies for diseases for which no or only unsatisfactory treatments exist. The evolved function of natural products in regulating a plethora of diverse biological pathways in nature makes them to a biologically biased and complementary source of chemical probes to identify novel mechanisms of molecular interactions. As there is a high need for specific modulators of new targets, the identification of novel natural product chemotypes and the elucidation of their mechanism of action are gaining an increasing attraction in today’s drug research. Selected examples will illustrate how the investigation of new chemotypes from natural products and natural products-inspired synthetics in phenotypic assays can be shuttles to a new biological space of therapeutic relevance.

The technological driving forces of Synthetic Biology, genome sequencing and DNA-synthesis, are currently changing the face of natural products research. Whole genome data or the identification of cryptic natural products pathways in-silico shed light on so far un-accessed genetically encoded small molecules and helping us to print and refactor active pathways of scientific interest. There is increasing data that the proximity of products encoding genes can have biological relevance. These collocalisation signatures prompt the investigation of potential biological synergisms of the encoded metabolites or enables natural product-target pair analyses by comparative genomics.

The human gut microbiome became a new research field in modern natural product discovery where big data analyses open the door to the discovery of beneficial commensals with essential roles in the homeostasis of the human body.

The fragmentation of natural products is a further scientifically exciting example how the broad chemical diversity of natural products can be leveraged in the science of drug discovery.
Saving coral reefs and saving humans lives

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ABSTRACT:
Coral reefs are home to a quarter of the planet’s biodiversity, protect our coastlines, and support billions in ocean-subsistence communities. They also serve as rich sources of pharmaceutical inspiration for human disease. Marine animals and their microbes are particularly promising for medicines, given a rich history of reef-based drug discoveries such as the painkiller ziconotide from cone snails and the AIDS therapy AZT from sponges. Sadly, one quarter of Earth’s reefs are irreparably destroyed and 90% of remaining reefs are threatened by climate change. The complete loss of reef ecosystems in our lifetime is a real possibility. When a member of the reef community is lost, we not only risk threats in reef ecosystem collapse but also lose irreplaceable genomic information gained through millions of years of evolution. In today’s post-genomic revolution, this biological currency fuels new scientific breakthroughs and opportunities. In this presentation, I will highlight examples in which we have used modern genomics to capture, preserve and apply the genetic ingenuity of reef organisms— such as microbes, corals, sponges and seaweeds – to create important medicines for human health and to learn more about the natural roles of biochemicals in maintaining healthy reef ecosystems. By preserving the genetics of this rich ecosystem, we will be able to protect our reefs and ensure that they remain an integral resource for our planet and generations to come.

KEYWORDS:
Biodiversity; coral reef; human health; metagenomics; natural products; synthetic biology
Transforming Thailand: the shift to a sustainable bio-economy

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ABSTRACT:
“Bio-economy” refers to the set of economic activities related to the invention, development, production and use of biological products and processes (OECD, 2009). Over 50 countries have developed bio-economy policy strategies such as Malaysia, Japan, China and Germany. Despite the diversity in bio-economy strategies in countries around the world, the participants who joined GBS 2015 held in Berlin shared the vision of a sustainable bio-economy in which humanity lives with respect for nature, and where the economy benefits society and protects planet and local environments. (GBS, 2015 report)

The government of Thailand has identified the bio-economy is key to promote the country’s sustainable economic development. Thus, bio-economy is considered as one of the government’s new targeted industries (new S-curve industries). This presentation highlights bio-economy policy development in Thailand and how far the policy developments have been implemented.

Thailand is focusing on enhancing its bio-based industries to add additional value to agricultural inputs, for example, sugarcane and cassava roots. Having a diverse ecosystems and rich in biodiversity, Thailand aims to promote bio-economy by coupling eco-system services with conservation efforts to enhance its local economies, for example, through the eco-tourism industry and local product development. In addition, it has invested in infrastructure strengthening, such as Eastern Economic Corridor of Innovation (EECI).
Modelling and prediction for sustainable biodiversity

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ABSTRACT:
The increasing impacts of human activities on ecosystems put at risk the sustainable use of their resources and services. It is becoming urgent to predict the consequences of these impacts, and therefore to provide modelling frameworks, tools, and software applicable in a wide range of situations to improve the sustainability of living resources. In this presentation, we review the basic principles of biodiversity modelling and show how they pertain to a better understanding of ecosystem sustainability. We show examples of recent advances in biodiversity and ecosystem modelling, and discuss some crucial issues related to open source software and open knowledge. We conclude with perspectives on several important challenges ahead.
GIS ecosystem mapping and modelling

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ABSTRACT:
To achieve sustainable bioeconomy development it is necessary to face multiple challenges. Food security and energy production must be ensured, climate change must be addressed, natural resources have to be managed in a sustainable way balancing competition between different uses of biomass feedstocks, while guaranteeing that bioeconomy development benefits everybody. The vast majority of these issues has an important spatial component that must be taken into account to represent them properly. The availability of effective Geographic Information Systems (GIS) software and of a large amount of Spatial information have allowed a more comprehensive capability to analyse and process the multiple problems that are connected to bioeconomy. Spatial based data provided by GIS processing can produce a detailed and geographically based information that often becomes a base for political decision at local, national and international level. With GIS it is possible to map and model different ecosystems and in particular the ecosystem services they provide and their variation through time. For example, taking into account simultaneously biodiversity conservation, climate change issues, biomass production, recreational value (or specific problems like invasive species) it is also possible to produce spatial based scenarios that can be discussed with stakeholders and decision makers. The results of this participative process can improve the quality and effectiveness of final decisions. The process is being used in many different international research projects and is creating many examples of good practices at multiple scales. Nevertheless, the scale that is considered when addressing the problems may dramatically influence the results and the capability to represent properly different issues. We will examine some specific examples of GIS application used at different scale to discuss the limits and potential of the use of GIS in Bioeconomy in a rapidly changing world.
Making an environment where ecotourism thrives

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ABSTRACT:
Ecotourism is organic in the way in changes, grows and recedes subject to the environment where it lives. By working with governments, landowners, communities, protected area managers and marketers a business environment can be created where ecotourism thrives in a sustainable manner. When business people choose to follow a high standard pathway delivering sustainable, environmentally and socially responsible businesses everyone benefits but it needs to also make financial sense. By creating these business environments governments, landowners, communities and protected area managers can work with tour operators to create situations where business leaders decisions to run their businesses in a sustainable manner are rewarded and incentivised to continue these behaviours – it makes business sense.
Geotourism models for poverty alleviation in underprivileged areas

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ABSTRACT:
Geotourism is defined as ‘tourism which focuses on an area’s geology and landscape as the basis for providing visitor engagement, learning and enjoyment’. It concurrently integrates the biological and non-biological components available in the same geo-environment to enhance tourism experiences. It bears the ultimate objectives of inspiring participants to appreciate and protect the environment as well as bringing direct economic and social benefits to local communities. Geotourism has been strategically used by some countries such as China as a national poverty alleviation policy to address economic problems in underprivileged areas. These areas are deprived of natural and human resources where people are generally living in socio-economic conditions below the national average. In practice, geotourism involves attractive and interesting geological sites and landscapes, easy Earth’s story-telling interpretation, passionate and professional guides, safe and accessible routes, effective management and publicity. It often requires initial government supports particularly in planning, management and infrastructure development. Geotourism can be conducted in different models according to the resource availability of different countries and areas. Geopark is an effective geotourism model for a region or a larger area. It requires the identification of geological sites with national, regional or international scientific and aesthetic significance. It has to be managed with a holistic concept of protection, education and sustainable development. Mining park is another geotourism model to transform disused mining sites and areas into attractive mining heritages with the presentation of their geology, mining activities and history. For small areas or areas with limited resources, geotrail is an ideal, cost effective geotourism model. Geotrails are safe, accessible walking and driving routes linking geological sites in a small area such as a county or town. They are usually set up by local tourism authorities or communities to attract tourists. Their unique attraction is the interesting information relating the natural and cultural environment through easy, understandable interpretive panels for visitors. Geovillage is a new geotourism model adopted in recent years in China to revitalise old and declining villages particularly located outside the jurisdiction of geoparks and mining parks. It is a localised approach to incorporate geology, ecology and culture of a village. The model is used to enhance its tourism value and attraction for sustainable tourism development and livelihood improvement of local people. Cases are quoted for discussion and analysis in the presentation. It provides references for countries and areas which share the common interest of addressing the poverty issue.

KEYWORDS:
Geopark; geotourism; geotrail; geovillage; mining park; poverty alleviation
Butterfly vision – another view of our world

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ABSTRACT:

Although we humans share the physical environment with other organisms, all of them have their own “world” characterized by their sensory functions. For example, we do not hear ultrasound that is essential for bats to get food. Most animals can see ultraviolet light, but we cannot. Studying the sensory perception of animals is not only exciting but also indispensable to understand some aspects of biodiversity.

In this lecture, I will introduce how we study vision of butterflies, and what we have learnt so far about how they see colors. By combining the optical, molecular, physiological and anatomical techniques, we have found that butterfly eyes are extremely rich in the variety of color sensors. Analysis of their behavior has revealed that their color vision covers ultraviolet in addition to our visible light, and also that they have the capacity of discriminating angle of light polarization to which we are blind. Surprisingly, the eye organization in butterflies is almost species-specific and is often sexually dimorphic. Comparison among species would provide insights into how and why such sophisticated visual functions have evolved.

KEYWORDS:

Insect; color vision; compound eye; photoreceptor; spectral sensitivity; diversity
Non-flying mammal dependent pollination system of Asian *Mucuna* (Leguminosae)

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**ABSTRACT:**
Diversification of angiosperm relates to that of animals, because one of the reasons for this diversification is that they rely on pollination by animals. Though insects are the pollinators of most plants, other animals can also play a role as pollinators. For this current study on pollination systems, mammal-pollinated plants were chosen. Mammal-pollinated plants can be divided into bat-pollinated plants and non-flying mammal-pollinated plants. Although pollination systems of bat-pollinated plants are well-studied in Asia, few reports exist on non-flying mammal pollinated plants.

This study focussed on *Mucuna* (Leguminosae), which is an evergreen vine plant distributed in tropical and subtropical regions throughout the world. One of the interesting pollination processes of this genus is the “explosive opening” step in which stamens and pistil are exposed from petals. The flowers cannot explosively open by themselves and are, therefore, opened by an animal (explosive opener). The pollen grains get attached to the explosive opener, thus, rendering it the main pollinator. In addition, as strength is needed for opening, explosive openers (pollinators) are limited to large animals. Previous reports on *Mucuna* suggest pollination by bats or birds. However, pollination systems in Asia, where it is diversified, are not well known.

*Mucuna* is phylogenetically divided into three subgroups. One of them is composed of an Asian species and all of its known pollinators are non-flying mammals. Among the mammalian pollinators, *Callosciurus* squirrels, which diversified in tropical Asia, have contributed to the pollination in all the subgroups of *Mucuna*. Body weight of the squirrel is 400–500 g, which is heavier than most small fruit bats (<100 g). Flowers and veins of this *Mucuna* subgroup are larger than those of the other subgroups. The flower colour is purple or pale green, which is characteristic of a bat-pollinated flower. These evidences suggest that squirrels which diversified in Asia are related to the divergence of this subgroup of *Mucuna* and speciation. Furthermore, species belonging to another subgroup are pollinated not only by bats but also by non-flying mammals. The importance of non-flying mammals as pollinators has been neglected in Asia, but our study suggests that they contribute to diversification of plants.

**KEYWORDS:**
Explosive opening mechanism; mammal; *Mucuna*; pollination; tropical Asia
SPECIAL SESSION

WORLD BOTANICAL GARDEN AND *EX SITU* CONSERVATION
The need for endangered species conservation in the Botanical Garden of Quito-Ecuador

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ABSTRACT:
The future for the survival of endemic plant species in the Andes is very dire. Human population growth is the main pressure. The main economic income for the new generations born in rural areas is logging the remaining primary forests, which will disappear to slash-and-burn for pasture. Pastures replacing forests will generate regional desertification, which will prolong the dry season, where several weeks of no rain may kill several endemic species in a single year. The chain reaction will affect the local ecosystem and many other species of plants and insects will go extinct soon thereafter. Clouds may carry acids produced by forest fires and from the industry around the world, where the fog may envelope primary forests and kill the delicate mycorrhiza, an essential symbiotic organism to feed orchids and most other plants.

To preserve primary forests it is necessary to convert them into an economic engine, where the fastest and most efficient industry is eco-tourism. Ecuador has the greatest biodiversity of species by surface area in the world. The central government of Ecuador declared the nation a country of Orchids two years ago. Considering there are over 500 species in the metropolitan district of Quito, we have established with the prefecture of Pichincha the Avenue of Orchids with an initial 15 sites in the NW of the province, which includes private orchid collections and jungle trails. This already has proven very effective with similar attractions for birding and the Avenue of Chocolate.

On site conservation does not guarantee the survival of endemic species, in view that we can not shield these species in the wild from extended dry summers and acid rain. The secure the survival of endangered plants, these have to be saved in botanical gardens, private collections and commercial nurseries.

We are very proud of the Botanic Garden of Quito, which has been considered by the English newspaper The Guardian in September 2018 a choice to visit. We established in 1990 the Botanic Foundation of the Andes to implement and manage a botanical garden in the middle of the city of Quito. It was inaugurated in 2005 and currently highlights the orchid conservatory with about 2000 species, the bonsai museum, a Japanese garden, an ethnobotanic and spice garden among others. The main purpose is the conservation of the endangered Andean orchid species, but the garden is a fundamental educational instrument to demonstrate the young students and to the national and foreign visitors some of the wealth of our little known native flora, including Andean foods consumed on a daily basis.
Actual issues of climate changing for the world flora and vegetation

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ABSTRACT:
The progressing of global warming and issued changing of climatic conditions essentially amplifies current negative trends in world ecosystems. The main present day trend of climate drying along with worldwide deforestation, anthropogenic land development and urbanization leads to fast extinction of primary plant communities and radical transformation of landscape vegetation. This process covers all climatic zones of the earth. However, it often presents catastrophic character in arid and tropical areas. In such areas, the global warming in combination with the climate draining leads often to straight desertification of the lands. In such conditions endemic aboriginal plain and lowland local floras frequently extinct completely. In mountainous areas with well-pronounced vertical zonation, some species can survive shifting to higher altitudinal belts retaining appropriate ecological conditions. Such relocation is sometime observed in the case of herbaceous or frutescent species (e.g. plants with short life circle). At the same time large aboriginal trees, most important dominants and co-dominants forming backbone of plant community in fact are unable to such migration. In primary climax habitats, they often reach 1000 and more years old. The length of their maturing is a greater in several orders than the speed of environmental condition changing. Additionally, the shifting of zonation due to warming in many mountains systems is naturally limited by low elevations. Often species found their optimum in very small areas on mountain peaks and summits of highest elevations available in mountain systems. Communities of such species become extinct completely due to progressing warming and climate draining. Primary coniferous montane forests of Indochina (with endemic conifers such as Calocedrus rupestris, Pinus cernua, P. wangii, Xanthocyparis vietnamensis, etc.) show typical example of such highly endangered relictual plant formations. Some aboriginal plant species can survive temporarily due to their specific life form or particular ecology. These are some epiphytic ferns and orchids surviving on large remnant trees, or lithophytic herbs growing in humid crevices of north faced cliffs. However, in most cases endemic aboriginal plant species exhibit low tolerance, little ecological flexibility and miserable adaptation ability to changing environmental conditions. Numerous alien invasive weeds obtain obvious advantage in areas opened due to deep degradation of primary vegetation. Such species being well adapted to more warm and dry conditions (commonly originated from arid or southern areas) replace remained aboriginal species fast. As a rule, such species have broad capacity to adaptation in new conditions and often form oligodominant climax plant communities on vast areas of former primary vegetation. Species compositions of new plant formations almost lack any native aboriginal species. Only few native species can survive in weedy secondary plant formations of adventive species. As an example of such high-adaptive native species in Indochina may be mentioned such terrestrial orchids as Arundina
graminifolia, Geodorum terrestre, Habenaria spp., Peristilys spp., Phaius tankervilleae, Spathoglottis spp., Spiranthes sinensis, Zeuxine strateumatica and some others. Commonly such species present less than 1% of native species in any local aboriginal tropical flora.
Role of Chinese Union of Botanical Gardens in native plants conservation

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ABSTRACT:
Botanical gardens, which differ from recreational parks, have been playing important roles in *ex situ* conservation of local flora. Since its foundation in 2013, the Chinese Union of Botanical Gardens (CUBG) has worked closely with member gardens to promote native plants conservation through enhancing management capacity, assessing conservation status of all native species, developing and applying Big Data Platform for *ex situ* Plant Conservation, as well as initiating environmental education programs.

Over the last five years, through CUBG’s efforts, over 20 training workshops (each lasts for 2 weeks) regarding environmental education research, horticulture and landscaping, taxonomy and plant identification as well as botanical garden management etc. have been conducted for 760 trainees from all over the country; A nationwide program has been launched to promote native plants conservation by adopting rapid assessment protocols and large scale inventories. Till 2018, CUBG member gardens in 14 provinces and regions have completed comprehensive assessment of the conservation status of native plants in their vicinity, *ex situ* conservation strategies have been implemented to 445 critically endangered, 786 endangered and 1159 vulnerable species in different botanical gardens; A Big Data Platform for *ex situ* Plant Conservation (www.cubg.cn) has been developed and used for data sharing and living collection management; In addition, a series of environmental education programs have been conducted in all member gardens, so as to raise public attention of biodiversity conservation.

We believe that it is crucial for every botanical garden to take care of plants in its vicinity, and strongly suggest that conservation actions should occur locally, so as to achieve the goal of zero extinction of local fauna and flora.

KEYWORDS:
CUBG; Curating policy; Zero extinction; Plant Information Management System
The Habitat Penang Hill: a public-private partnership model for managing key protected areas for ecotourism and generating funding for conservation in Malaysia

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ABSTRACT:
The Habitat Penang Hill is a world class rainforest discovery experience that affords majestic views of the pristine rainforest of Penang Island from its iconic canopy walks, tree-climbing platforms, and ziplines. Captivating interpretation provided by staff naturalists brings nature to life in line with the Habitat’s vision to reconnect people to nature. The Habitat is run as a for-profit park which enables it to generate the funds needed to cover both staff and operational costs. Beyond this, the owners of The Habitat have pledged all proceeds from the park to biodiversity conservation through the work of The Habitat Foundation. A percentage of the annual revenue from the park is given to the state government in line with the conditions of its concession agreement. As a model of a private-public partnership and sustainable financing for protected areas (PAs), The Habitat has attracted considerable interest particularly among government PA agencies faced with steadily declining budgetary allocations for conservation and the management of parks and reserves. The paper shares some of the lessons learned since the park’s establishment in 2016 with the aim of providing valuable guidance and insights for those contemplating similar ventures. The Habitat is an ongoing concern, and its management involves continually adapting to new challenges. Nevertheless, the experience of the past three years has adequately demonstrated that the private sector can make a significant contribution to the effective management of key ecotourism sites while raising much-needed funding and public support for biodiversity conservation in the country.

KEYWORDS:
Penang Hill; Malaysian rainforest; ecotourism; sustainable financing; private-public partnerships; biodiversity conservation
How much do we know about the plant diversity of Southeast Asia

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Abstract:
There are approximately 50,000 vascular plant species in Southeast Asia (defined here as Thailand, Cambodia, Laos, Vietnam, Malaysia, Singapore, Philippines, Brunei, Indonesia, Timor Leste and Papua New Guinea). Estimates of the number of species in various parts of the region have varied greatly over time but have generally been revised upwards. Large numbers of previously undescribed species from Southeast Asia are published each year but progress on taxonomic revisions and Flora accounts is very slow. Many of the larger genera and families lack recent taxonomic research making identification of species difficult and potentially leading to underestimates of total diversity and inadequate data for informed conservation decisions. Progress on the major Flora projects across the region, the Flora of Thailand, the Flore du Cambodge, du Laos et du Vietnam, the Flora of Peninsular Malaysia, The Tree Flora of Sabah and Sarawak, and Flora Malesiana, will be discussed. A new project, the Flora of Singapore, will be highlighted. The plant families Apocynaceae and Gesneriaceae will be used as examples to assess the effects of differing plant collection densities across Southeast Asia on our understanding of plant diversity. The need for sound taxonomic data, the tools to be able to identify plants, and the need for continuous field surveys will be stressed.
Strategic roles of botanic gardens in conserving threatened plant species: a case of Indonesia

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ABSTRACT:
Indonesia has been known as one of the world’s mega-biodiverse countries, possessing a mixture of Asian and Australasian species, and comprising of approximately 10% of the world’s flowering flora. Indonesia is also one of the world’s biodiversity hotspots due to the very high endemism and endangerment with at least 437 threatened plant species occurred. This paper presents the strategic roles of Indonesian Botanic Gardens (IBGs) in conserving Indonesian threatened plant species. Botanic garden is one of the best practices in ex situ conservation in Indonesia in linking conservation to sustainable use of plant resource. Due to the strategic locations and large collections of the gardens, conservation education is accessible to everyone. IBGs have become the best ex situ conservation institution for promoting plant diversity conservation and sustainable utilization, as they are visited by nearly three million people annually (only four gardens: Bogor, Cibodas, Purwodadi, and Bali), accommodating more than 70,000 living specimens belonging to more than 8,000 flowering plant species. The success of any plant conservation effort in Indonesia will depend on the people’s concern and awareness. During the last decade the IBGs have been collecting rare and endemic species throughout the Archipelago and bringing some of those species back to the wild through a reintroduction program. Nearly 30% of the total 437 Indonesian threatened plant species has now been collected and accessible in the gardens. The threatened parasitic giant flower Rafflesia patma has been successfully grown at Bogor Botanic Gardens after nearly 10 years of trials and treatments making it a significant scientific achievement. The development of new botanic gardens throughout Indonesia has also been designated to strengthen the conservation efforts of the country threatened and endemic plants. Ecoregion concept is applied in the new botanic gardens development process in order to cover and represent the plant diversity occurred in the various ecosystems. There have been 37 botanic gardens in early 2019 located in 20 provinces belonging to 18 (out of 47) different ecoregions.

KEYWORDS:
Threatened plants; botanic gardens; plant conservation; Indonesia
Science and conservation at the Royal Botanic Garden Edinburgh

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ABSTRACT:
A major role of scientific botanic gardens is to understand the diversity, evolution, function and ecology of plants, to understand likely responses to contemporary pressures, to develop effective strategies to reduce biodiversity loss and extinction, and to increase human benefits from the world’s botanical resources. In this presentation I will give an overview of the science and conservation work of the Royal Botanic Garden Edinburgh, whose mission is to explore, conserve and explain the world of plants for a better future. I will summarise work ranging from species discovery, understanding the biodiversity of some of the most threatened habitats on earth, using DNA to understand plant species, using technology to monitor biodiversity loss, conserving and restoring threatened plant species, and connecting people with plants to support sustainable livelihoods.
The UBD Botanical Research Centre: collecting, mapping, describing, growing and protecting the Brunei flora

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**ABSTRACT:**

Universiti Brunei Darussalam (UBD) has recently established the UBD Botanical Research Centre. This Centre is a cooperation between the UBD Herbarium (UBDH), UBD Botanical Garden, and the Institute of Health Sciences. The Botanical garden is set in a natural heath forest, and has an additional showcase area where plants that are traditionally used in Brunei, with an emphasis on medicinal plants, are cultivated. The garden is used by the Institute of Health Sciences to grow plants known to have traditional medicinal uses which are then used to develop commercial medicinal products. The herbarium supports both the Botanical Garden and the medicinal research by providing identifications and storing voucher materials, as well as providing general and conservation information on plants of Brunei. In this talk I give an overview of some of the recent activities undertaken within the Botanical Research Centre.
Pha Tad Ke Botanical Garden, *in and ex situ* Lao PDR

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**ABSTRACT:**

“I used to think the top environmental problems were biodiversity loss, ecosystem collapse and climate change. I thought that with 30 years of good science we could address those problems. But I was wrong. The top environmental problems are selfishness, greed and apathy … and to deal with those we need a spiritual and cultural transformations and we scientists don’t know how to do that.”

**Gus Speth, US Policy Maker and Environmentalist**

The Pha Tad Ke Botanical Garden opened to the general public in November of 2018 and showcases the Flora of Laos and the region with a strong emphasis on ethno-botany. But a botanical garden is not just a collection of pretty flowers and to emphasize the words from Gus Speth above it is our mission to stimulate a fundamental change of awareness that leads towards a holistic view of nature and society for sustainable ecological and biodiversity conservation.

**KEYWORDS:**

Agro-forestry; biodiversity; botany; ecotourism; education; Perma-culture
The role of botanical gardens in the Philippines on biodiversity conservation

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ABSTRACT:
The Philippines is one of the megadiverse countries in the world with at least 9000 species of plants and over 65% floristic endemism. Most of these species are threatened by various factors like habitat degradation due to logging and overlap of mining claims and protected areas and ancestral lands, over-collection, and invasive alien species, degradation from climate change, weak capacities on natural resources management, undervaluation of ecosystem services from natural resources, weak integration of biodiversity concerns in landscape planning (PBSAP, 2016).

The government has instituted a protected areas system that covers important terrestrial ecosystems in the different biogeographic areas, sanctuaries of noteworthy plants and animals, unique landscapes, specific ecosystems like caves and peatlands as well as indigenous communities conserved territories and areas. Inspite of the government’s efforts and even in partnership with the private sector, these have fallen short of achieving the goals of the strategy of on-site conservation of biodiversity.

Botanical gardens in the Philippines have tried to complement the ex-situ activities of the government. To date, there are 14 botanical gardens in the Philippines in the Botanical Gardens Conservation International Registry. Eleven of these are found in Luzon Island, two in an island the Visayas Region, and one in Palawan Island. Only a few of these however are functional, and have very modest education, research, and conservation programmes. Among the gardens in the stage of development is the La Salle Botanical Gardens, which picks up from the experiences of thriving University gardens in the country. All these have served to conserve mostly lowland species, of very limited floristic and biogeographic representation. A network of botanical gardens in the country, in lieu, of a National Botanical Garden is recommended to fill the gaps and put the pieces together to achieve a more significant impact on plant conservation.
Conservation of threatened plant in Vietnam

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ABSTRACT:
Vietnam has been acknowledged as a country with high biodiversity, and as one of the prioritized nations for global conservation. The country is home to about 15,000 vascular plant species, many of them are of important economic and conservation value. The total number of endangered plant species in Vietnam is 464 (Vietnam Red Book, 2007). In the past two decades totally 732 new floral species have been discovered and described. Of these, 508 are new species on a global scale and 224 species present new records of the flora of Vietnam. By 2019, the forest coverage, including natural forest and plantation forest, increased by 41.65% (MARD 2019). Forest proportion has become more rational with 2.15 million hectares classified as special-use forest, 4.59 million hectares as protection forest and 7.75 million hectares as production forest. A system of 165 protected areas has been established all ecoregions nationwide covering an area of 6.7% of the territory (MARD 2019).

But natural forests, and especially primary forests in Vietnam are still experiencing degradation because of various reasons. However, Vietnam can also proof a lot achievements in plant conservation. Many species that were threatened by extinction in the wild have successfully been conserved and developed, such as Chukrasia tabularis A. Juss, Aquilaria crassna Pierre ex Lecomte, Panax vietnamensis Heret & Grushv., Taxus chinensis (Pilg.) Rehder, Keteleeria davidiana (Bertr.) Beissen and Glyptostrobus pensilis (Staunton ex D.Don) K.Koch, Dalbergia tonkinensis Prain.v.v.

KEYWORDS:
Conservation; forestry; plant diversity; threatened plant; Vietnam
ABSTRACT:
Biodiversity is the variation and variability of all life on Earth and covers all levels from genetic variation, over species diversity to the multitude of ecosystems. The Anthropocene is the current geological era, defined by the fact that humans are the most important driver of change in the global ecosystem. The human dominance is manifested not least in the global biodiversity. Instead of growing exponentially extinction has increased over the background rate since the year 1500. Since the beginning of human civilization 83% of wild animal populations have gone extinct and today domestic animals make up 60% of the Earth’s biomass, humans make up 36% and wild mammals only 4%. With good reason the Anthropocene is said to be the era of the sixth mass-extinction. The first mass-extinction was towards the end of Ordovician 440 million years ago when 60–70% of the Earth species died out due to severe cooling. The second mass-extinction was in the Devonian 360 million years ago when 70% of all species were eradicated – again due to climatic changes accompanied by sea-level fluctuations. The third mass extinction was in the end of the Permian 225 million years ago and it wiped out 95% of all species possibly because of volcanic and chemical changes in the seas. The fourth mass-extinctions was in Triassic 200 million years ago and it left about half of the species to survive following enormous volcanism and possibly meteors. The fifth mass-extinction, at the end of the Cretaceous 65 million years ago, was caused by a gigantic meteor and it wiped out the dinosaurs and left only one quarter of the Earth’s species to survive. Previous mass-extinctions mostly lasted for millions of years whereas the current Anthropocene mass-extinction has happened over few thousands of years caused mostly by the enormous changes in land-use patterns where wild species have increasingly reduced areas available for their survival. The fragmentation of natural habitats contribute equally and so does climatic change – also related mainly to human activities. If humans have started the sixth mass-extinction can we halt it? The changes needed will require enormous re-thinking of our human behavior.
Challenges of a botanical garden in the conservation in a megadiverse country

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ABSTRACT:
With continental proportions, Brazil occupies almost half of South America, the climatic differences existing in its territory lead to great ecological variations, forming six distinct biomes: the Amazon Forest, the Atlantic forest, the Pantanal, the Cerrado, the Caatinga and the Pampas. The variety of biomes reflects in a huge diversity of Brazilian flora and fauna, with regard to plants, of the 391,000 plant species known in the world, more than 46,000 are found in the country, making Brazil one of the megadiverse countries on the planet. Its biological diversity has not yet been fully mapped, about 250 species are discovered per year in the country. The work of risk assessment of Brazilian species is also underway, being carried out by the National Center for Plant Conservation, an organization linked to the Rio de Janeiro Botanical Garden, which has so far evaluated 6,046 species, of which 2,953 are threatened. The official Brazilian red list has 1,974 endangered species, of which 1,772 are endemic to Brazil. With such a high number of endangered species growing each year, the conservation work of the Brazilian botanical gardens is tremendous, in order to comply with GSPC Target 8 (At least 75% of threatened plant species in ex situ collections, and at least 20% available for recovery and restoration programmes). The complex task of conservation of plant diversity by Brazilian botanical gardens faces several challenges, among them we list: The training of researchers specialized in biodiversity and related areas so that they can complete the mapping of biodiversity, risk analysis and the development of management plans for endangered species; Better conditions for the botanical gardens to cultivate endangered species, produce seedlings to be reintroduced in the nature and make scientific dissemination of knowledge; Information sharing between institutions allowing them to work as a network and optimize their efforts; Partnerships and joint work between in situ and ex situ conservation institutions to increase the effectiveness of conservation interventions; The engagement of civil society in supporting the botanical gardens, in the identification and conservation of endangered species spread throughout the territory; and The elaboration of public policies that favor the conservation of biodiversity, transforming the scientific knowledge into effective instruments that guide scale actions to avoid the extinction of species. Success stories with some endangered species (Dimorphandra wilsonii and Terminalia acuminata) show us that there is hope for the country's biodiversity, but overcoming existing challenges is essential if we are to avoid the loss of thousands of endangered species in Brazil.

KEYWORDS:
Botanical garden; Brazil; challenge; conservation
The Botanical Garden of Parque de las Leyendas, Lima, Perú, an oasis of conservation in the middle of the desert

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ABSTRACT:
The Parque de las Leyendas is the main theme park of the city of Lima, capital of Perú, a seashore metropolis founded in 1532 by the Spaniards in the desert coast, watered only by three rivers that flow from the Andes mountains above 5000 masl. Due to the Humboldt Current coming from the South Pole, surface temperatures of our ocean can reach 16º C, instead of the mean 25º C that would correspond to latitudes 4º-18º S. This cold current to the west and the high Andes to the east reaching up to 6757 masl determine a natural temperature inversion above the coastal strip of Peru, with water trapped as a dense cap of clouds, and no rain (5-10 mm per year) except for some drizzles during the cooler months of the year (May to September). Profiting of this mild semitemperate climate many plants from some of the 11 ecoregions of Peru can be cultivated in Lima, but they all have to be watered artificially. When this park was founded in 1964 its aim was to display the natural regions of Peru inside an Archaeological Section of the city called the Complex of Maranga, by that time partially destroyed by the growth of the city, including many clay ruins inside the park to be saved from destruction. In year 1970 the old Zoo of Peru was closed and its animals were transferred to the new park. For 20 years the main interest of the park was Zoology. In the 90’s, the management restored the interest in Botany and Archaeology. In 1992 we began a project for a Botanical garden in 6 Hectares but the first plants were planted only in 1995. The idea was to display the evolution of the plants of all the world in this central garden, while the native plants of Peru were located in the respective displays of the coast, mountains and jungle. Most of the garden was developed in years 1995 to 2000, after a break the garden was continued in 2010 reducing it to 4.5 hectares. To start the evolution of terrestrial plants, a Pteridophyte display is at the entrance where Adiantum anceps, the giant Peruvian double edge maidenhair fern and Platycternium andinum, the Peruvian Staghorn Fern, the only Platycternium in the Americas are displayed among other ferns native to the tropical jungle of Peru,. We continue with the oldest living trees on earth, the Gymnosperms. From similar climates, species of Australia and South Africa have the best growth, while conservation is done with some Cupressaceae like Tetraclinis articulata and Taxodium huegelii. The only family with 10 native Peruvian species is Podocarpaceae, nearly all threatened, displaying Podocarpus glomeratus, Prumnopitys harmsiana and Retrophyllum rospigliosii. Close to them a Cycad display is shown with Dioon and Encephalartos and a greenhouse with many native Zamia species. Continuing evolution the oldest plants with complete flowers are shown with some Magnoliaceae, Lauraceae and the Annona family, with the national fruit of Peru: Chirimoya (Annona cherimola). In the next displays other native endangered species are shown, like Myrcianthes ferreyrae, an endemic almost extinct species with a
small number of individuals located only in hyperarid, fog oases known as lomas along the Peruvian desert, where fog is the main source of water. In the oak group Fagales, the endangered *Juglans neotropica*, the Peruvian walnut, and *Alnus acuminate*, the Peruvian alder of the Birch family are displayed. Other native endangered species from very dry environments like *Capparis scabrida* Kunth, *Capparis prisca* J.F. Macbr., *Loxopterygium huasango* Spruce ex Engl. are shown as well as endangered species from the high elevations like *Haplorhus peruviana* Engl. and many species of palms and trees of the Amazon basin. Perhaps the largest collection of plants displayed belongs to the Cactus family, with a central area from all America and succulents from all the world, and a very special Cactus display outside the garden, conserving all the endangered species of Lima region devastated by urban and agriculture development. Here the almost extinct cactus *Haageocereus tenuis* F.Ritter and others are held in a program to raise them from seed and perhaps reintroduce them to nature in the future.

**KEYWORDS:**
Botanical Gardens; Parque de Las Leyendas; Peru
Ex-situ conservation and Sok An-Phnom Kulen Orchid Research and Conservation Center

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ABSTRACT:
The Sok An-Phnom Kulen Orchid Research and Conservation Centre established in 2018 by General Secretariat for Sustainable Development /Ministry of Environment in Phnom Kulen National Park, Siem Reap Province, Cambodia. The Centre is working on conservation programmes and in particular to collaborate on fieldwork, scientific-based research in order to enabling and enhancing Ex-situ conservation, including establishment of botanical garden, orchid garden, herbarium, seed-bank, tissue culture, natural trail, artificial garden, and education facilities insight the centre. There are a lot of endemic, endanger, and local species of orchid have been collected, identified, and breaded with more than 200 species and 1500 specimens in February 2019.

Beside of the collection, centre is also focusing on capacity-building in the areas of plant identification skills, phenology studies, scientific plant collecting, and Ex-situ cultivation to ensure greater long-term conservation of plant genetic resources in Cambodia. Seed studies and seed bank, such as tests required to better understand seed storage requirements including post-harvest seed handling, germination tests and dormancy studies, moisture relation tests, seed morphology studies and diagnostic characterisation; Herbarium studies, such as the comparative observation, characterisation, analysis, databasing and imaging of the living and preserved specimens to better understand their identification and classification, including the carrying out of sampling for pollen, DNA and anatomical preparations; Horticultural studies, such as cultivation of plant material to better understand how to grow and reproduce the plant, including the use of micropropagation techniques where required; Genetic studies, such as DNA extraction, PCR amplification, DNA sequencing and banking of DNA from tissue samples for use to better understand phylogenetic relationship or to better understand population genetics for conservation planning purposes. International cooperation, distribute, transfer or use the material, the transferred data and/or the transferred Images for profits or for any other commercial application also considered.

KEYWORDS:
Ex-situ conservation; DNA; PCR; genetic; orchid
PARALLEL SESSIONS
SESSION 1
SUSTAINABLE MANAGEMENT OF BIODIVERSITY
ABSTRACT:
Thailand, as a Party to the Convention on Biological Diversity, has developed the National Biodiversity Strategies and Action Plans (NBSAPs) since 1998. The Plans have been evolved through time from the first NBSAPs, emphasizing on institutional and human resource strengthening as well as providing measures for conservation and sustainable utilization of 3 components of biodiversity; namely, species, genetic resources and ecosystems, which has been continued until the current NBSAPs, Thailand’s Master Plan for Integrated Biodiversity Management B.E. 2558-2564 (2015-2021) (MPBM). The MPBM, which covers a period of 7 years, is now under implementation in the way that national biodiversity targets and measures set by the MPBP are closely link to the Aichi Biodiversity Targets and focus on enabling actions in accordance to the United Nations Decade on Biodiversity (2011-2020) particularly in addressing the underlying causes of biodiversity loss through conservation, restoration and maintenance of as well as enhancing benefits from biodiversity and ecosystem services by the year 2020. On the edge of transition toward the 2050 biodiversity vision of “Living in harmony with nature,” the Conference of the Parties to the Convention on Biological Diversity at its 14th meeting adopted a comprehensive and participatory process for the preparation of the post-2020 global biodiversity framework to be adopted by 2020. This presentation will, therefore, look at the possible directions of Thailand’s actions toward post-2020 agenda taking into account global framework, Thailand’s National Strategies (2018-2037), and Thailand’s National Reform Plans. Both national plans set a long term strategic frameworks for Thailand, while putting substantive amount of efforts for biodiversity management infrastructure reform to link works and knowledge in biodiversity conservation and transfer them into practice to promote sustainable utilization of biodiversity and bioeconomy.

KEYWORDS:
National biodiversity management; National Biodiversity Strategies and Action Plans; NBSAPs; Thailand; Convention on Biological Diversity; post-2020 agenda.
Biodiversity mainstreaming across agricultural sectors: the role of multi-stakeholder dialogue and engagement in advancing the post-2020 agenda

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ABSTRACT:
Rapid population growth, increasingly frequent extreme weather events, and high rates of biodiversity loss are just few examples of an era in which humanity has become the driving force deciding the fate of the Planet. For instance, the latest IPCC special report on 1.5 degree warming brought alarming evidence about the cross-sectoral impacts of a warming climate, calling out for urgent multi-level action. In this context, many authors have been increasingly adopting the term ‘Anthropocene’ to define an epoch in which the boundaries between them human and natural worlds became blurred. The notion of the Anthropocene invites us, therefore, to rethink the approaches and strategies traditionally adopted to tackle current complex socio-environmental challenges. Among those, we would like to highlight the key-challenge of achieving food security and nutrition. More specifically, the challenge of feeding a growing population while taking into consideration aspects such as nutrition and the environment. It is known that only three staple crops (maize, rice, and wheat) and three animal species are responsible for the largest amount of calories consumed in human diets. Our argument is that biodiversity, and more specifically biodiversity mainstreaming across agricultural sectors is essential for achieving food security and nutrition while meeting Sustainable Development Goals (SDGs). According to the Food and Agriculture Organization of the United Nations’ Biodiversity Mainstreaming Platform, biodiversity mainstreaming across the agricultural sectors can be defined as “the process of embedding biodiversity considerations into all policies, strategies and practices that are adopted by public and private actors who either depend on biodiversity or whose actions have an impact on biodiversity”. Hence, biodiversity mainstreaming ensures that biodiversity is protected and used sustainably, while it brings a new systemic approach to policy making. It gives special attention to the role and interlinkages between ancient agricultural practices, cultural heritage, agroecology, and biodiversity conservation. Given that, this paper aims at discussing the relevance of biodiversity mainstreaming and the role of promoting
multi-stakeholder dialogues and stakeholder engagement for the preparations of the 15th Meeting of the Conference of the Parties (COP) to the Convention on Biological Diversity (CBD) in Beijing, and advancing the Post-2020 Agenda. Likewise, this paper will highlight the work of the FAO Biodiversity Mainstreaming Platform, and discuss the results and outcomes from its previous Multi-Stakeholder Dialogues on Biodiversity Mainstreaming.

**KEYWORDS:**
Biodiversity mainstreaming; agricultural sectors; multi-stakeholder dialogue; post-2020 agenda.
Private sector’s perspective on biodiversity management

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ABSTRACT:

Through the years, SCG engages sustainable development into our business, balancing economics aspect with environment, communities and stakeholders in every step of concerning activities. SCG strongly aims to preserve the environment includes enhancing biodiversity management to reach the goal beyond. SCG’s Policy on Biodiversity Management has shown our robustly determination in biodiversity conservation throughout systematic management. In our quarry operated area, biodiversity is adequate rehabilitated and preserved by scrutinizing related biodiversity impact in multiple aspects such as Climate Change, Invasive alien species, Resource Utilization. SCG applies both national and international regulations and guidelines relating the conservation of biodiversity. The Biodiversity Management and Mitigation Hierarchy has been addressed, consists of (1) Prevention or Avoid (Conservation of high biodiversity value area) (2) Mitigation (Minimize negative impacts on biodiversity) (3.) Correction (Rehabilitate & Restoration Biodiversity Program) (4.) Compensation (Biodiversity Offset Program). With dedicated implementation, SCG enhances Thailand biological resources by rehabilitate operating area to recover as limestone ecosystem in the past. SCG also proliferates the biodiversity management to the area where are non-impact by our business through many standout activities such as creating check dam across Thailand for recovering the upstream forest, creating fish home in Eastern and Southern area of Thailand for marine fish aviculture, and enhancing the resourcefulness of coastal and marine ecosystem by planting mangrove and seagrass in Southern of Thailand.

Furthermore SCG works with experts vary from academic institutions to governmental and private sector including Business & Biodiversity Check Project with Biodiversity-Based Economy Development Office (BEDO) to embellish biodiversity management throughout business supply chain. Besides, quarry rehabilitation team is upskilled to reach the best practices in rehabilitation by knowledge sharing with external partners, technical workshop and field trip for integrated learning. SCG fosters multi-stakeholder cooperation under the concept “Business, Community and the Environment” could be coexist sustainably. These are key success factors improving SCG to grasp accomplishments in biodiversity management endeavor.

SCG energetically thrives to be business model that demonstrate the best practices in harmonizing business and biodiversity management. Our Quarry Rehabilitation Learning Center, allocated in every region of Thailand, warmly welcome all visitors to learn and nurture awarenesses in the society for sustainable prosperity in conserving biodiversity.
Youth voices for biodiversity

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ABSTRACT:
Biodiversity underpins environmental health, food security, climate resilience, and the sustainable development and well-being of mankind. More than 630 million people in the ASEAN region depend on biodiversity for their livelihood. Yet, unprecedented biodiversity loss due to habitat loss, over-exploitation, and climate change, amongst others, is threatening the planet’s ability to sustain life as we know it.

Now more than ever, young people around the world are seeing and, for some, living the consequences of environmental degradation and biodiversity loss. Youth of today, as well as future generations to come, are calling for new ways of thinking, new ways of inclusive governance, and new ways to live in harmony with nature.

In this session, we will hear voices from the youth—their hopes, vision, and commitment to the post-2020 framework towards ‘Living in Harmony with Nature’. We will showcase the work of inspiring young leaders implementing conservation initiatives in Southeast Asia and beyond. We will also describe how youth voices are represented at the Convention on Biological Diversity (CBD) through the Global Youth Biodiversity Network (GYBN), the CBD’s official youth constituency; as well as the ASEAN Youth Biodiversity Programme (AYBP), a partnership between GYBN and the ASEAN Centre for Biodiversity (ACB) to empower ASEAN youth for biodiversity. Finally, we will invite participants to join in a GYBN Youth Voices activity: Message to the Future Generation.

KEYWORDS:
Youth; future generation; convention on biological diversity; post-2020; ASEAN; Southeast Asia
SESSION 2
BIOINNOVATION FROM
THE UNSEEN BIODIVERSITY
Where are the missing fungi, thought in the molecular era

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ABSTRACT:

“How many species are there on earth?” is one of most challenging scientific questions asked by the Science journal. Public awareness on biodiversity has been mainly focused on plant and animal. Fungi, as one of the eukaryotic kingdoms of Eukaryotes, have been largely neglected in public concern. Considering the essential ecological roles and functions of fungi in various ecosystems on earth, it is extremely important to appear for the attention on the importance of investigation and conservation of fungal diversity. Fungi is most interesting in the fact that its total biodiversity is a status of “mostly unknown”, as hitherto described fungal species account for only a very small fraction (ca. 8%) of a relatively conservative estimation of global fungal diversity (1.5 M species). Therefore it is widely accepted that most fungi are missing from our understanding, or in other words, “where are the missing fungi?” is a fundamental question for mycologists. This paper presents some thoughts on this topic from the author, including some that had been proposed by previous researchers but updated in this paper with most recent examples, as well as several new attempts from the author applying novel technologies aiming to better explore the unknown diversity of fungi.

KEYWORDS:
Eukaryotes; fungal diversity; new culturing technology; uncultured fungi
Culture collection: managing the unseen biodiversity
Professionals underpinning sustainable exploitation of micro-biodiversity

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ABSTRACT:
Micro-biodiversity is essential for life on earth. The exploration and structured study of microbial diversity implies access to huge numbers of specimens. These must be conserved and made easily accessible with the highest level of reliability to ensure consistent research and knowledge build-up.

Long term ex situ conservation of living microbial material for further uses is essential to build microbiological research on solid ground. Culture Collections are infrastructures specialized in long term conservation and management of microbial resources and related data. Their mission is to provide technically and legally fit-for-use microbiological resources with associated data of consistent quality. These facilities are established worldwide with some famous ones in Thailand. Most are registered with the World Data Center for Microorganisms (WDCM) of the World Federation for Culture Collections (WFCC).

Culture collections evolved from centers for the mere conservation and distribution of microorganisms to specialized "Biological Resource Centers (BRCs)", i.e. infrastructures designed to provide all essentials for Research & Innovation in life sciences: microorganisms, data and expertise. Recently, members of the WFCC have contributed to the ISO 20387:2018 standard which designates as “biobanks” collections of any kind of biological material (human, plant, animal, microbial). Scientifically, this concept of “biobanks” opens the way to interdisciplinary researches across all living kingdoms. Biobanks facilitate holistic approaches to microbial interactions, both among microorganisms as between microorganisms and their biotic host or abiotic environment. This generates big data pools on microbiomes. In addition, faced with many legal constraints specific to their activities, including the Nagoya Protocol to the Convention on Biological Diversity, biobanks have proactively developed procedures for the management of administrative and legal metadata related to microorganisms and published the MOSAIC & TRUST Code of Conduct and the TRUST Guidelines.

The 21st century culture collections continue to evolve, becoming major R&D players and assuming as "biobanks" their increasing socioeconomic role in Knowledge Base Bio-Economy.

KEYWORDS:
Microorganisms; culture collections; biobanks; Nagoya Protocol; TRUST guidelines; MOSAIC & TRUST code
Microbial diversity: an undertapped industrial resource

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ABSTRACT:
Due to the geographical position, Thailand supports a rich diversity of habitats e.g. coral reefs, islands, mangroves, hot springs, limestone outcrops, tropical rain forests, and caves. The complex geographic characters in Thailand support the high microbial diversity. These illustrate the need for continued ecological and biodiversity studies, especially on the unseen microorganism. Studies on Thai fungi and actinobacterial diversity are increasingly realizing the importance of utilization and conservation. To show its importance, we have studied the fungal (arbuscular mycorrhizal fungi, microfungi and mushrooms) and actinobacterial diversities in northern Thailand since 1998 until present. More than 85 new fungal species have been found. The potential applications of the obtained fungi in agriculture, food and industry were discovered. Mycorrhizal fungi (arbuscular ectomycorrhizal, and orchid mycorrhizal fungi), form root symbiotic relationships and provide many benefits to plants, such as improved plant growth and development, increased nutrient uptake and enhanced plant tolerance to disease, and have been developed as biofertilizers. Effective mycofumigant agents were developed from the genus Muscodor and Nodulisporium for in controlling soil-borne plant and postharvest diseases as well as the decreasing of microorganisms on egg shells. Some endophytic fungi (Nigrospora aurantiaca and Spissiomyces endophytica) have the ability to produce natural pigments which can be used for industry colorants. Additionally, some wild mushrooms (ectoycorrizal and saprobic mushrooms) are edible and their nutritive value and biological actives have been determined. The Black bolete (Phlebopus portentosus) and oyster mushrooms (Pleurotus spp.) had an ability to produce fruiting bodies for large scale commercial cultivation. A hot issue- now in Chiang Mai, in Thailand was the first habitat of truffles in Southeast Asia. Two new truffle species (Tuber thailandicum and T. lannaense) and one new record (T. magnatum) were discovered. Research and development on large scale truffle cultivation are needed. All new species and strains that have good properties should be maintained at Thailand Bioresource Research Center (TBRC) to guarantee they are not lost before utilization.
Hidden diversity of insect fungi and their interaction with insects

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ABSTRACT:
Insect fungi are pathogenic fungi attacking insects and spiders. Their species diversity has been documented with more than 800 species around the world. However, many species are cryptic and thus species diversity is underestimated. In this talk, I will focus on my work about the enigmatic model of *Ophiocordyceps unilateralis*, also known as the “zombie ant” fungus, a species complex infecting specifically formicine ants and inducing behavior modification of the ants. I will show how the hidden diversity in this complex has been discovered through classic taxonomy and population genomics and highlight the specific nature of the interaction between these fungi and the host ants including molecular and chemical mechanisms mediating host-specificity and behavior manipulation.
Bio-conversion technology of chemical production from biomass

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ABSTRACT:
Lignocellulosic biomass is a sustainable feedstock for producing bio-based chemicals, biomaterials and bioethanol based on multi-products concept of biorefineries. When the production of cellulosic bioethanol and chemicals is considered, hemicelluloses are potentially a bottleneck as the industrial fermentation of pentoses, however, they would be a promising co-product by the giving of process integration opportunities. Xylan is a major component of hemicellulose from agricultural residues and hardwoods. Xylan-derived products have already found commercial applications such as xylitol and xylo-oligosaccharide (XOS). Furthermore, XOS has recently gained interest as prebiotics. The presentation is focused on the enzymatic conversion of xylan to prebiotic XOSs, including not only linear XOS but also branched XOSs such as arabino-XOSs and acidic-XOSs containing 4-O-methyl-D-glucuronic acid (MeGlcA) substituent.

XOS is produced by endo-xylanases hydrolyzing β-1,4-linkage in the xylan main chain. Most known endo-xylanases belong to glycoside hydrolase families (GHs) 10 and 11. These enzymes work well on unsubstituted xylan. Notably, a heterogeneous xylan decorated with α-L-arabinofuranose or MeGlcA residues is hydrolyzed at the cleavage sites determined by the substitution pattern. The resultant hydrolysate includes branched XOSs specific for each GH family xylanase. Thus, the discoveries of xylanases with novel specificities will further increase the scientific and industrial importance of this group of enzymes. We isolated and characterized three new xylanases, classified in GH30-7, from cellulolytic fungus Talaromyces cellulolyticus. These xylanases (termed Xyn30A, 30B, and 30C) possess unique mode of actions for xylan hydrolysis: Xyn30A; a reducing-end xylose-releasing exo-xylanase activity, Xyn30B; a bifunctional endo-glucuronoxylanase / exo-xylobiohydrolase activity, Xyn30C; a bifunctional endo-glucuronoxylanase / endo-xylanase activity. Rapid analysis with negative-mode ESI-multistage MS revealed the structures of acidic-XOSs from beechwood glucuronoxylan hydrolyzed by three GH30-7 xylanases. These structures were different from acidic-XOSs produced by the GH10 and GH11 xylanases. On the other hand, linear XOSs (n≥3) were efficiently produced by hydrolysis of glucuronoxylan using Xyn30C. The linear XOS production from wheat arabinoxylan was significantly enhanced by the combination of Xyn30C and GH62 α-L-arabinofuranosidase. GH30-7 xylanases could provide a new tool to tailor a series of prebiotic XOSs from biomass.

KEYWORDS:
biorefinery; endo-xylanase; glycoside hydrolase family 30-7 xylanase; lignocellulosic biomass; xylan utilization; xylo-oligosaccharide.
From biodiversity to microbial-based products for bioremediation

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\textbf{ABSTRACT:}
The contamination of petroleum hydrocarbons is one of major environmental problems since it poses risks for ecosystem, human health and economy. Our research aims at i) assessment of petroleum hydrocarbon biodegradation potential, bacterial community structures and functions in the environmental samples, ii) providing the collection of bacteria capable of degrading petroleum hydrocarbons, and iii) developing bacterial-based products for environmental remediation. Microbiome compositions and functions in hydrocarbon-contaminated environmental sample and in hydrocarbon-degrading consortium were examined. Several hydrocarbon-degrading bacteria were then isolated based on the microbiome data and enrichment technique. \textit{Pseudoxanthomonas} sp. RN402, \textit{Exiguobacterium} sp. AO-11, \textit{Sphingobium} sp. MO2-4, \textit{Bacillus megaterium} TL01-2, \textit{Mycicilbacterium} spp. PO1, PO2, J101 and Y502, \textit{Rhodococcus ruber} S103 and \textit{Bacillus} sp. FW1 were selected as good candidates for bioremediation due to their abilities to degrade a broad spectrum of substrates and some of them have potential for biosurfactant and biofilm production. Furthermore, the genes involved in hydrocarbon degradation and biosurfactant production were investigated in the selected strains. In addition, the defined consortia were constructed to enhance biodegradation efficacy. The genomic and biodegradation analyses demonstrated the synergistic degradation of petroleum hydrocarbons by bacterial members in the constructed consortium. The bacterial-based products in form of immobilized cells for bioremediation were then successfully developed. The immobilized cells of the individual strain and the defined consortia in different supporting materials such as plastic ball, agricultural waste, aquaporous gel and bio-cord showed high efficacy to remove petroleum hydrocarbons in various systems such as river water, seawater, soil and sediment.

\textbf{KEYWORDS:}
Petroleum hydrocarbon; biodegradation; biodiversity; microbiome; bacterial-based products
Microbial enzymes: tools for biotechnological processes

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ABSTRACT:
The world is now stepping towards the age of “Bio-based economy” where biotechnology will play an increasing role in development of more sustainable and environmentally-friendly modern industries. Microbial enzyme is a biocatalyst which has an indispensable role in biotechnology relevant industries involving those related to food, energy, chemical, and material production. Various enzymes have been utilized in many major industries of the country; however, most enzymes are imported with the annual value of thousands million bahts with a rapid growth in enzyme market together with those of related industries. Although there is a record of long time enzyme researches in Thailand, lab-to-industry enzyme production has been very limited. This is due to the lack of “Up-scaled process optimization technology”, which are an indispensable translational research step for optimizing technical parameters in fermentation and downstream processing to improve process economics and “enzyme formulation technology” for preparation of high-performance product prototypes for field testing and market evaluation. In order to overcome these limitations, our study aims to develop the lab-to-pilot translational research for production of enzyme prototypes which involves the establishment of required technical knowhow and technology in research-level up-scaling study for the use of microbial enzymes in industrial processes. In this study, ENZBleach (a pulp-bleaching xylanase obtained from metagenome of termite gut symbionts) and ENZease (a dual activity enzyme for simultaneous desizing and scouring process for cotton fabric) were used as the candidate enzymes. These BIOTEC developed enzymes have reached technology stages closed to commercialization and will be used as product candidates in order to generate the desired economic impact. The developed technology in this study will provide an important platform for further commercialization of enzymes and various microbial products from the country’s valuable microbial bioresources.

KEYWORDS:
Cotton preparing process; enzyme formulation; enzyme production; microbial enzyme; pulp biobleaching
SESSION 3
BIODIVERSITY AND HEALTH
Biodiversity and health: linking life, ecosystems and societies

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ABSTRACT:
Increasing spatial expansion of human activity (e.g., agriculture, urbanization and land-use change) is intensifying the interface between humans, domesticated animals and wildlife, while wildlife is undergoing a massive defaunation. Almost all indicators of the Aichi targets currently show negative trends. Anthropogenic pressure (human appropriation of biological productivity), biodiversity (Living Planet Index), biodiversity benefits (domesticated breeds, Red List of pollinators) show declines with negative consequences on resources and ecosystem services ultimately affecting human health and well-being. Here, I will use the conceptual framework of social-ecology that links “drivers” (food consumption, energy), “pressures” (land use, HANPP), “states” (biodiversity change), “impacts” (reduction of the quality of ecosystem services) and “responses” (governance, land planning, conservation), and show how this conceptual framework makes it possible to address the link between biodiversity and health. The incorporation of health components in social-ecology might provide effective governance tools for global biodiversity conservation and planetary health.
Biodiversity loss linked to emerging wildlife diseases

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ABSTRACT:
Epidemiological theory suggests that pathogens rarely cause extirpation or extinction of their hosts species, because the pathogen will go extinct in the population before the population is devoid of susceptible hosts. However, when there are other disease reservoirs, be it alternate and more tolerant hosts or long-term persistence in the environment, then diseases can cause catastrophic declines, extirpation, and rapid biodiversity loss. In recent history, several emerging infectious diseases have caused large-scale biodiversity loss. Amphibian chytrids caused the decline of over 200 amphibian species and white-nose syndrome is rapidly causing the decline of North American bat species. In addition, remnant populations may be particularly susceptible to an invasive disease, such as canine diseases affecting Ethiopian Wolves. Thus, conservation strategies for rare, threatened, and endangered species need to consider the potential impact of emerging diseases in conservation strategies. While not all emerging infectious diseases will have large-scale impacts on conservation, those with multiple hosts of differing susceptibility, environmental reservoirs, or affecting already threatened species are most likely to drive biodiversity loss.
Integration of biodiversity conservation in the health sector

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ABSTRACT:
Health is a basic human right and one of the fundamental indicators of sustainable development. Humanity rely on biodiversity and healthy ecosystems to support healthy communities and societies. Biodiversity and well-functioning ecosystems provide goods and services essential for human health. These include nutrition and food security, clean air and fresh water, protection from coastal storms and inland flooding, medicines, cultural and spiritual referents, and contributions to local livelihoods and economic development. Ecosystems such as in forests, freshwater and marine environments, directly contribute to human health, well-being and security by regulating climate and the proliferation of disease, purifying air and water, preventing soil erosion, while also providing places for recreation and leisure.

This presentation will provide an overview of the ASEAN’s response to address issues at the juncture of biodiversity and human health, as well as the ASEAN Centre for Biodiversity’s initiatives, including the conduct of the Regional Workshop to Address Inter-linkages between Human Health and Biodiversity in ASEAN held on 5-7 November 2018 in Manila, Philippines. It was jointly convened by the Convention on Biological Diversity Secretariat and the World Health Organization, and organised by the ASEAN Centre for Biodiversity with the United Nations University. The regional workshop brought together representatives from ministries of health and those responsible for biodiversity conservation in the ASEAN Member States. This presentation will expound on the national and regional levels of activities proposed by the ASEAN Member States on the thematic areas of Lifestyle Choices and Urban Health; Traditional Medicine and Food Systems; and Zoonotic and Vector-borne Diseases.

KEYWORDS:
ASEAN; Southeast Asia; human health; biodiversity conservation; biodiversity mainstreaming; Convention on Biological Diversity
Reproductive biotechnology for biodiversity preservation

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ABSTRACT:
In addition to protecting species in their natural habitat (in situ conservation), it is critical to maintain viable populations in captivity (ex situ) for eventual reintroductions. However, reproduction fitness may be impaired in captivity by small space, health and husbandry problems, non-adapted diets, modified sexual behavior or infertility. Therefore, conservation breeding can be optimized with assisted reproductive techniques (ART) to overcome the issues listed above. These approaches have been widely promoted over the past decades for enhancing breeding management and sustaining small populations of rare species. Besides the techniques of artificial insemination (AI), embryo transfer (ET), and in vitro fertilization (IVF), a wide range of methods and tools have been developed. These include non-invasive hormonal assessments for accumulating fundamental knowledge in diverse species (e.g., ovulatory mechanisms, seasonality, pregnancy, infertility) and manipulating the reproductive activities (e.g., superovulation, estrous synchronization). Among these critical tools, germplasm cryobiology also has played a key role to establish biorepositories for capturing extant genomic diversity. However, critical knowledge of reproductive traits is first needed before developing ARTs. Unfortunately, we know very little about species biology (reproduction in only 250 species has been properly described) with our efforts still remaining mainly concentrated on few taxa.
SESSION 4
ANIMAL ECOLOGY:
VERTEBRATE LIFE IN DIVERSE ENVIRONMENT
Comparative study on breeding ecology and life history in Japanese salamanders

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ABSTRACT:
In Japan, two families of salamanders occur, Cryptobranchidae and Hynobiidae. The former has only one species in Japan but the latter has 41 species in Japan, and all, except for one, are endemic to Japan. In Hynobiidae, the genus *Hynobius* is largest in the number of species with 34 species. One of the reasons why Japanese *Hynobius* is so much diversified is explained by the diverse breeding habit and life history. The Japanese species of *Hynobius* are divided into two breeding habits, one is lotic-breeding and the other is lentic-breeding. The species of the two breeding groups tend to separate their breeding sites and seasons, which must have gained by their past speciation events. Then, probably they have been interfered by each other especially in the selection of breeding site and season, which causes the present allopatric and sympatric distribution in the Japanese *Hynobius*. Other than breeding ecology, the Japanese *Hynobius* are quite differentiated in life history. Especially length of the larval life is diverse from within one year to three years, which also causes speciation and present species diversity in Japan.

KEYWORDS:
*Hynobius*, breeding ecology; lotic-breeding; lentic-breeding; life history
Effect of environmental factors on edible burrowing frogs in northeastern Thailand

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ABSTRACT:
The present study describes the habitat, life cycle, burrowing behavior, morphological variation and genetic diversity of *Glyphoglossus molossus*, *G. guttulata*, *Kaloula mediolineata* and *K. pulchra*, based on observation and data collection during 2015–2018 in the northeastern part of Thailand. These edible burrowing frogs are inhabitant of dry-dipterocarp and deciduous forest areas, and breeds in seasonal or temporary deep rain pools. All specimens were collected, during the breeding season (March to June), from eleven sites with elevation of 120-488 meters above sea level and represented eleven candidate populations. Study on morphological variation of *G. molossus* (n=297) in 2012 clarified the presence of interpopulational variation in external morphology characters between the population of the Sakon Nakhon and the Khorat Basins. *G. molossus* from the Sakon Nakhon Basin are relatively small in most measured characters compared to the Khorat Basin specimens, indicated that morphometric variation in *G. molossus* probably resulted from geographic barriers correlated with climate factors. In 2017, the effect of latitude on morphological variation of *G. molossus* was studied and showed that *G. molossus* (n=185) from different latitude exhibit statistically significant difference (p <0.05) in head and tibia lengths. In addition, Principal component analysis (PCA) of *G. molossus*’s morphology also explained the adaptive value of larger body size at higher latitude. We also investigated the physical factors affecting burrowing behavior in edible burrowing frogs and found that humidity had a significant effect on body size of *G. molossus* and burrow depth had a significant effect on body size of *K. mediolineata*. In 2019, our study on the genetic structure of *G. molossus* revealed the diversity, structure, and demographics of *G. molossus* populations from a unique habitat, the Khorat Plateau of northeastern Thailand. Its result demonstrated that the Phu Phan Mountain Range does not influence the genetic structure of *G. molossus* populations. However, we observed that geographical distance might influence genetic differentiation between the candidate populations in the southern part of the Khorat Basin (Ubon Ratchathani, Surin, and Burirum) and other areas of the Khorat Plateau. Despite the fact that the knowledge of frog utilization of Thais is relatively well understood, understanding of overexploitation of resources is still rarely mentioned. In order to manage conservation and sustainable use plans of these animals, understanding of environmental factors affecting the livelihood of frogs is inevitable.
Using ecological niche modeling to study distribution of lizards in highland of the Sunda Shelf

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ABSTRACT:
Java and Sumatra Islands are located in western part of Indonesia. These islands are also located in the pacific ring of fire with volcanic origins. However, the geographic pattern of these two islands is different. Java has several isolated volcanic mountains. On the other hand, Sumatra has only one range called Barisan Ranges. In addition, these areas are also member of Sunda Land biodiversity hotspot. In this area diversity of reptiles is still under estimated. With lately herpetological expedition, the taxonomy of Scincid lizard is re-examining since the Scincid lizard is one of the most diverse group of reptiles. In this study, the ecological niche modelling or species distribution modelling is used to determine species range and species boundary of Scincid lizards in Java and Sumatra. We cautiously used this technique as another evidence for taxonomic study. We examined suitable habitats for leaf-litter dwelling skink in the genus \textit{Tytthoscincus} and forest skink in the genus \textit{Sphenomorphus} since these two groups of skink are commonly found in highland of Java and Sumatra. We used GPS data from recently field surveys and the GPS data from voucher specimens and 19 biclimatic factors from WorldClim to model suitable habitats using the Maxent. We used the final model as an additional line of evidence of species boundary and to predict where new species may be discovered based on distinct biogeographic breaks. The final model of the leaf-litter dwelling skinks indicated that their habitat is in mid to high elevation forests leading to high potential of endemism leaving in each isolated mountain of Java. In case of the forest skink, the final model indicated that they can be found throughout the Barisan Range in Sumatra even they are highland species. However, with geographic breaks in central part of Sumatra, the species occurs in the north of Sumatra might be different lineage with those in the central or the south. In conclusion, we used ecological niche modelling to study species distribution and species boundary of skinks in Java and Sumatra. And it could be used as another tool for integrative taxonomy of reptile. Finally, this finding can elucidate hidden diversity of reptiles in Sunda Shelf.

KEYWORDS:
Endemism; geographic break; skink; species boundary; suitable habitat.
How stone tool use behavior emerged in long-tailed macaques: environment or genetics?

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ABSTRACT:
Among 505 species and 195 subspecies of non-human primates recognized by the IUCN, only four species of them; bearded capuchin monkeys (Sapajus libidinosus), white-faced capuchins (Cebus capucinus imitator), Burmese long-tailed macaques (Macaca fascicularis aurea; Mfa) and chimpanzees (Pan troglodytes) are customarily tool users. They are evolutionarily spanning from new world monkeys to old world monkeys to apes. Dated back to 1887, Mfa have broken the earliest record of stone tool users among all non-human primate species. They were first observed using stone tool to crack open oyster on the islands along Mergui Archipelago, Myanmar and were later discovered on Piak Nam Yai Island, Laem Son National Park, Thailand by our team after the survey of Tsunami impact on fauna and flora in the areas on December 26th, 2004. During the past 14 years, the research on macaque stone tool use has been more comprehensive and expanding to various fields, and about 20 scientific papers were published. However, one research question is still not resolved that is “how this stone tool use behaviour emerged in Mfa?”. The range of Mfa is between northern Myanmar (21 °N) and southwestern Thailand (9 °N). Tool-use behaviour occurs in a smaller part of this range, around the Mergui Archipelago (14 – 8 °N). The Mfa range merges with the common long-tailed macaque (M. fascicularis fascicularis; Mff), where they form hybrids between the two subspecies. Some of these hybrids use stone tool, such as on Koram Island, Khao Sam Roi Yot National Park, Prachuap Khiri Khan and Sire Island, Phuket. Interestingly, Mff do not use stones to open encased foods in similar natural setting to those Mfa inhibits. Captive studies have also failed to train them to use stone tools, but some Mff handle stones at temples. It therefore seems possible that inherited factors varying between each subspecies may affect natural tool-use behaviour. Recently, we analysed the partial Y-chromosome gene, whole mitochondrial DNA and whole genome sequence of Mfa and found that Mfa carry a unique genome diversity and are fallen into sinica species group which is different from those of Mff belonging fascicularis species group.

KEYWORDS:
Macaca fascicularis aurea, M. fascicularis fascicularis, mitochondrial DNA; Y-chromosome gene; whole genome sequence
Ecosystem services of insectivorous bats in Southeast Asia

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ABSTRACT:
With more than 330 species of bats in Southeast Asia, two third are insect-eating bats. With highest global deforestation rate and highest urbanization rate, this region experiences significantly habitat loss, which leads to bat mass extinction, up to 40% by 2100. In this particular region, in addition to pollination and seed dispersal services by frugivorous bats, recent studies indicated that insect-eating bats play major role in insect regulation service especially in farmland and agroforest habitat. A colonial species such as Chaerephon plicatus is one among most well-studied species that contribute in pest suppression in paddy field. Several studies confirm that this bat feed on the most serious rice pest, planthopper, which migrate within the region. Recent authors also demonstrate that it also feed on mosquito. Other insect-eating bats are thought to be important pest suppressor in different landscape, and more studies are needed. These findings raise the conservation concern of bats in the region, and serious conservation measure should be undertaken both at the local and regional level.
Reproductive phenology of tropical bats – it is all about the strategies to maximize survivability

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ABSTRACT:
Bats demonstrate various strategies to ensure the females and young have the greatest chance to survive. Plant-visiting bats are documented to give birth during flowering and fruiting seasons. Temperate bats are influenced by ambient temperature during late spring and summer in which warm temperature is positively related with insect fluctuation and maximum insect abundance matches the lactation period of bats. Seasonal breeding of insectivorous bats has also been documented in the tropics, however the studies directly linking resource availability and reproduction in tropical rainforests are still lacking. Using Malaysian tropical rainforest environment as an example, a strong breeding seasonality among insectivorous bats species is reported to be related to roosting ecology. Roost selection influences energy budgets, and this may shape reproductive strategies by influencing energetic costs associated with thermoregulation and commuting in bats. Climate change is projected to influence the timing of rainfall events in many tropical habitats, and this may disrupt relationships among rainfall, insect biomass and bat reproductive timing, further compromising reproductive success.

KEYWORDS:
cave-roosting bats; forest-roosting bats; time-lag; monoestrous; polyestrous
First record and range extension of the flying squirrel, *Petinomys setosus* (Rodentia: Sciuridae: Pteromyini) from Lao PDR

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**ABSTRACT:**
The first known occurrence of Temminck’s flying squirrel, *Petinomys setosus* in Lao People’s Democratic Republic (PDR) was recorded from a single specimen collected at Na Mouang village in Vientiane province, which is approximately 240 km from its nearest known distribution in northwestern Thailand. We describe the morphological and cranial features of this specimen and discuss its occurrence in Lao PDR. The focal Laos specimen is similar in pelage color to those from northwestern Thailand, particularly on the dorsal and ventral surfaces of the body, gliding membrane, face, and tail. The cranio-dental characters (bullae and dental patterns) are also similar. The *P. setosus* capture location was on the east side of the Mekong River, which is hypothesized to serve as geographical barrier that affects the dispersal and diversification of some rodent species, hence the formation of the Mekong River could also have led to genetic differences between *P. setosus* populations in northwestern Thailand and central Lao PDR.

**KEYWORDS:**
Distribution; Southeast Asia; Temminck’s flying squirrel
SESSION 5
FROM BIODIVERSITY TO
NATURAL PRODUCTS FOR DRUG DISCOVERY
Thailand’s fungal diversity and applied potential

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ABSTRACT:
Fungi are an understudied, but biotechnologically valuable group of organisms. In Thailand we are finding that as many as 96% of species in some genera are new to science. Because of their various lifestyles and habitats, with the need to forage for food, as well as the need to compete against other fungi and organisms, the fungi themselves have developed numerous ways to survive on earth. Humans can use these unique attributes in biotechnology and industrial exploitation. Fungi are also easy to grow in fermenters and therefore it is relatively easy to produce products. The search for fungal biodiversity, and building up a living fungal collection, provides a goldmine for searching for organisms with novel industrial use and will lead to novel products. With this in mind, we review ways in which we can potentially exploit fungi. We provide notes and examples for potential exploitation and give examples from our own work and the work of others. For example, our work has resulted in the discovery of at least ten new species of Agaricus which have the potential to be developed as novel industrial mushrooms. We also provide a flow chart that can be used to convince funding bodies just how important fungi are and their potential for biotechnological research and their potential products. Fungi have generally been neglected over time, despite the fact that they provided Penicillin, Lovastatin and various major medicines and are therefore an untapped source with huge industrial potential.

KEYWORDS: Biocontrol; biodiversity; biotechnology; food; fungi; mushrooms
Transforming *in-situ* biodiversity observation into digital atlas and conservation implication in Thailand

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ABSTRACT:
Being situated at the biogeographic crossroads, Thailand is recognized as the home of one of the global biodiversity hotspots. Plant species have been conducted since 1970 and recently nationwide wildlife and forest inventory were conducted but the results are limited used. This research entitled, “Digital Atlas of Tropical Trees and Wildlife Diversity and National Conservation Status in Thailand”, aims at transforming *in-situ* biodiversity observations across the country into digital localities, generating distributions of selected species, and evaluating their conservation status. Despite there were over 58,000 belonging to 157 families, 679 genera and 2,000 species recorded in the nationwide forest inventory system and the global Botanical Information and Ecology Network (BIEN), only 201 species have adequate records for modeling. In addition, 17 medium-large mammal species were included. A machine learning algorithm based on the maximum entropy theory (Maxent) was employed to generate ecological niche models at present (baseline) and in 2050 under the predicted climate change scenario (RCP 8.5). The predicted extent of occurrence at the baseline and in the future are shown in this presentation. Furthermore, their conservation status based on the geographical range used in IUCN Red List criteria is discussed. We use OpenLayers software was to query and display all GIS outputs and to report the outputs by the administration or protected areas boundaries.

KEYWORDS:
Species specimen; distribution modelling; conservation status; web-based GIS
Diversity of yeasts in the surface of rice leaves and biocontrol activity against fungal pathogens of rice plant

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ABSTRACT:
This talk is to show an example of coordination of yeast biodiversity research with yeast biotechnology research. Objectives of the present study were to investigate the diversity of yeasts in the surface of rice leaves, which is normally called phylloplane, by culture dependent approach using plating of leaf washing for yeast isolation and molecular taxonomy with phylogenetic analysis for yeast identification, and to obtain high potential antagonistic yeasts for biocontrol of economic crop diseases caused by fungal pathogens. A total of 282 yeast strains were isolated from 89 rice leaf samples collected from nine provinces in Thailand. Identification on the basis of the D1/D2 region of the large subunit (LSU) rRNA gene sequence analysis revealed that 273 yeast strains were identified to be 34 species in 14 genera of all three subphyla (Agaricomycotina, Pucciniomycotina and Ustilaginiomycotina) in the phylum Basidiomycota and 13 species in nine genera of the subphylum Saccharomycotina in the phylum Ascomycota. Six strains represented two new species, which were already described as Hannaella siamensis (five strains) and Yamadazyma epiphylla (one strain). Three strains were found to be potential new yeast species in two genera viz. Vishniacozyma (one strain) and Rhodotorula (two strains). Moesziomyces antarcticus was the most prevalent species, it found in 61.8\% of leaf sample. Number of strains in Basidiomycota (84.4\%) was higher than in Ascomycota (15.6\%). A total of 98 rice phylloplane yeast strains were in vitro determined for their antagonistic activities against 10 plant pathogenic fungi causing diseases of rice plant (Curvularia lunata causing dirty panicle disease, Fusarium moniliforme causing bakanee disease, Rhizoctonia solani causing shear blight disease and Pyricularia grisea causing blast disease), corn plant (Exserohilium turcica causing northern leaf blight disease, Fusarium moniliforme causing stalk rot disease, Macrophomina phaseolina causing stem rot disease and Bipolaris zeicola northern leaf spot), and sugarcane plant (Fusarium moniliforme causing red rot disease) by dual cultivation technique. Result revealed that two Torulaspora indica strains (DMKU-RP31 and DMKU-RP35) inhibited growth of all 10 fungal pathogens, whereas, the other 18 yeast strains of seven species namely Kodamae ohmeri (7 strains), Meyerozyma caribbica (4 strains), M. guilliermondii (2 strains), Wickerhamomyces anomalus (2 strains), and one strain each of Rhodotorula toruloides, R. taiwanensis and R. mucilaginosa, inhibited growth of at least one fungal pathogen. The main antagonistic mechanism of these 20 strains determined in vitro was the production of volatile organic compounds. Three
antagonistic yeast strains including *W. anomalus* DMKU-RP25, *T. indica* DMKU-RP31 and *T. indica* DMKU-RP35 were selected to determine their biocontrol activities of rice sheath blight disease caused by *R. solani* DOAC 1406 in rice plant, in greenhouse. All three strains suppressed the rice sheath blight disease up to 85%, which comparable with validamycin, an effective chemical fungicide. Therefore, these strains have potential to be biocontrol agents for rice sheath blight disease.

**KEYWORDS:**
Yeasts; diversity; rice; phylloplane; biocontrol activity; fungal pathogen
Translational research of selected plant in Zingiberaceae

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ABSTRACT:
Translational research is a crucial platform in the success of product development. Accordingly, the scientific evidence to provide the pharmacological data as traditional claim suggests the health benefit and further steps of suitable product design and clinical trial of the potential medicinal plant. With the high biodiversity of Thailand, several plants in Zingiberaceae have been investigated for their bioactivities. Krachidum or Kaempferia parviflora. *K. parviflora* is a traditional medicine that has been widely used as the health promoter among the mountain people of Thailand. Several pharmacological activities of the plant rhizome extract were reported, which include ant-inflammatory, immunomodulation, antimicrobials, increase blood fluidity and blood flow, hypocholesteremic and anti-obesity effect, improvement of the quality of life, antistress and enhancement of the physical endurance. Currently, many products in the forms of tea, wine, capsule are available in the market, but the product efficacy is still the concerned issue of the consumer. The results on pharmacokinetic studies of three major compounds of plant, which are 5,7-dimethoxyflavone (DMF), 5,7,4’-trimethoxyflavone (TMF) and 3,5,7,3’,4’-pentamethoxy-flavone (PMF) demonstrated the detectable levels of AUC, Cmax, Tmax, T1/2 and several target tissues distribution of these three compounds, but with their low bioavailability, suggesting the low oral absorption of these compounds in the intestinal tract. The nano-carriers containing the plant extract in the forms of cyclodextrin complex and self microemulsifying drug delivery system (SMEDDS) were successfully developed to increase these methoxyflavone bioavailability. Clinical trials of *K. parviflora* capsule demonstrated the positive modulation effect on health-related physical fitness in healthy elderly volunteers and the improvement of muscle endurance in soccer players. Moreover, the transdermal patch containing the plant extract was also developed to prolong the drug duration and clinically tested for anti-inflammation. Finally, the prototype products were translated to the industrial scale and the registered products are currently in the market.

KEYWORDS: *Kaempferia parviflora*, product development; pharmacokinetic parameters; nanotechnology
Plant-derived natural products as source materials for commercial utilization

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ABSTRACT:
Medicinal plants have historically proven their value as a source of molecules with therapeutic potential. At present, scientific knowledge on natural products with functional properties, legislative actions to reduce the use of synthetic compounds, as well as consumer demand for high-quality products have led to an increase in their applications. This communication aims to illustrate context information on a therapeutic lead molecule from *Rhodomyrtus tomentosa* extract as a challenged novel antibiotic. Furthermore, potential commercial applications of certain plant extracts from natural sources will be discussed, including their applications as antibacterial agents in cosmetics, pharmaceutical products and food industries. At present, nanoparticles are increasingly used to prevent microbial contamination as well as to treat infections. Looking at the growing concern about the environment and sustainability, nanomaterials from natural sources are receiving great attention in the scientific community as well as in industrial sectors. The talk will be later focused on the nanomaterials derived from natural products and their potential applications in different industrial sectors with specific reference to biomedical devices. Examples include the utilization of nanoparticles synthesized from medicinal plants in antibacterial coatings for medical devices to prevent infections. The antibacterial mechanisms of nanoparticles are poorly understood, but the currently accepted mechanisms include oxidative stress induction, metal ion release, and non-oxidative mechanisms. In this review, we discuss the antibacterial mechanisms of nanoparticles against microorganisms and the factors that are involved.

KEYWORDS:
Natural products; medicinal plant; application; drug discovery
Identification of potential drug candidates from plants and microorganisms in Thailand

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ABSTRACT:
Diarrhea disease is one of the common cause of death in both children and elderly. Secretory diarrheas resulted from active intestinal chloride secretion induced by bacterial enterotoxins, viral proteins or drugs especially cholera are considered as the major type of diarrheas causing significant morbidity and mortality worldwide. Active intestinal chloride secretion was mediated via two main types of apical chloride channels including cAMP-activated chloride channels (i.e. cystic fibrosis transmembrane conductance regulator or CFTR) and calcium-activated chloride channels (CaCC). Using both cell-based assays and electrophysiological techniques for testing CFTR and CaCC inhibitory effects of natural compounds isolated from plants and microorganisms found in Thailand, we have identified several novel types of CFTR and CaCC inhibitors, some of which have nanomolar potency and exhibit in vivo anti-diarrheal efficacy. To date, piperine isolated from black peppers and zearalenone purified from fungi are considered as the most promising drug candidates for the treatment of secretory diarrheas. Data on mechanisms of action and in vivo efficacy as well as perspective for further development as anti-diarrheal agents will be presented.

KEYWORDS:
Diarrhea; CFTR: CaCC; Cholera; Anti-diarrheal
ABSTRACT:
In almost all parts of the globe, taxonomy is currently largely being treated as a dead science even though most scientists know that biology cannot be advanced without an advancement in taxonomy and the collections that they are based upon. Within the residual but decreasing high level of biodiversity in Thailand, more than 10,400 invertebrate species, 6,100 vascular plants and 15,000 fungus species have been recorded so far, yet these likely represent only 10%, 60% and 6%, respectively, of the actual current, but declining, number of species. However, the number of active (funded) expert taxonomists available to improve this is severely limited. We started our surveys of Thai biodiversity and taxonomists under the H.R.H. Princess Mahachakri Siridhorn’s initiative, and a survey of the current status of Thai taxonomists in 2016 revealed 352 experts, comprised of 47%, 34% and 19% invertebrate, plant (especially vascular plants) and microbe (mostly mushroom experts) taxonomists, respectively. The age category of these taxonomists was 51% junior (less than 40 y old), 35% senior (45-59 y old) and 14% retirement (>60 y old), and they were comprised of 67 microbial, 120 plant and 165 animal taxonomists. The majority of experts (140) were invertebrate taxonomists followed by vascular plant (103) and fungal (42) taxonomists, while there were only 21 vertebrate experts. Because biodiversity research is based upon fundamental taxonomy, this survey is expected to highlight these important data to the attention of policy makers before applied biodiversity and/or bio-economy is implemented in the wrong ways.
Integrative taxonomy for earthworm biodiversity detection, conservation and applications to human-managed ecosystems

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ABSTRACT:
The pace of discovery continues to outstrip the global capacity for invertebrate species description, but lags behind the human capacity for causing extinctions and invasive species introductions. Earthworms are no exception, and considering their strong engineering effects on ecosystems, they should be a priority for discovery and characterization of their functional trait diversity. We have used morphological and molecular data to flag putative novel species in a variety of locations on several continents. This plus the common observation that earthworm diversity is very restricted in anthropogenic habitats indicate that local extinctions are very common. We have also uncovered cryptic diversity within several nominal earthworm species, several of them of high ecological and economic importance. As a shortcut to estimating the ecological functions of earthworms, some morphological traits can be used. This can guide choices of species for composting or other direct economic applications. However, much functional diversity could be behavioural or biochemical, and so not easily detected.

KEYWORDS:
Earthworms; functional traits; species discovery; invasive species; cryptic diversity
Natural history collections: why are they so important?

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ABSTRACT:
Natural History Collections are a vital resource for the study of biodiversity. The type collections housed in many museums are an integral part of our understanding of species diversity, description and taxonomy. Collections in general present an ideal means to research the natural world from the species level right up to a global perspective. They are one of the best tools for studying a range of disciplines that can help us to respond to global challenges including climate change, ocean acidification, and conservation issues such as species and habitat loss. This is made even more important at a time when many museums are undergoing funding cuts, and when there are a decreasing number of specialist workers with ever widening responsibilities, which can create a barrier to those wishing to access historical and scientifically important collections.

In addition, natural history collections are often well loved by non-scientific audiences, which make them an invaluable tool for increasing the public’s understanding of science and engaging a wider audience on a variety of topics and themes. Using the examples of collections held by the Natural History Museum in London, with emphasis on Mollusca, I will discuss their varied role with respect to biodiversity and conservation along with other areas of research and scientific outreach.

KEYWORDS:
Biodiversity; collections; museums; specimens; type specimens; outreach; public; taxonomy
Why flora of Thailand ... how far have we reached?

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ABSTRACT:
The conservation and sustainable utilization of plants are two of the most important goals of the Convention on Biological Diversity (CBD). They are achieved through programmes such as the Global Strategy for Plant Conservation (GSPC), Important Plant Areas (IPAs) and Invasive Alien Species (IAS). A shortage of taxonomic information and skills can hinder progress and cause problems for conservationists. Floristic studies are a key way of providing essential baseline information about plants in a given geographical entity such as Thailand.

The Flora of Thailand is one such example of an active and very successful floristic project. Its success is due, in large part, to a very efficient international collaboration and regular academic meetings which take place every three years. The project is spearheaded by the Forest Herbarium, Department of National Parks, Wildlife and Plant Conservation (BKF) in collaboration with national and international institutes. The project was established in 1963 and launched in 1967 under Thai-Danish cooperation. 6033 species of vascular plants (662 in ferns and lycophytes, 26 in gymnosperms and 5345 in flowering plants) have now been published in the Flora. The first part was published in 1970 (Volume 2 part 1). To date, 40 parts, up to Volume 14, part 2 (2019) have been published. Six large families (>150 species/family) have been published, namely Araceae (30 genera/210 species), Arecaleae (33/170), Asteraceae (107/240), Cyperaceae (29/248), Euphorbiaceae s.l. (87/435), Fabaceae (48/279, part 1-3.1) and Orchidaceae (87/397, parts 1 & 2). Several large families of flowering plants, including Acanthaceae, Annonaceae, Fabaceae (parts 3.2-3.4), Gesneriaceae, Lamiaceae, Orchidaceae (parts 3 & 4), Poaceae, Rubiaceae and Zingiberaceae, are progressing well. Progression of the project, shown in numbers of species treated per period of five years, surprisingly increased between 2000 and 2018. The present growth (2008-2018) is slightly higher than in the previous 10 years. The number of active collaborators is also slightly higher, especially with young Thai botanists involved in the project, often at PhD level. This information shows that the basic taxonomic and morphological data will be updated at regular intervals, thus keeping the Flora as current as possible.

In order to reach this goal and maintain progress the project needs Thai botanists working in collaboration with overseas colleagues. Training programmes for Thai botanists, to develop skills in taxonomic revisionary work and conservation, are needed. Universities, national and international organizations are welcome to collaborate in order to encourage more young Thai botanists to work on the project. It is hoped that the project can be completed by 2024 under the guidance of the Editorial Board and financial support from the Carlsberg Foundation, Denmark.

KEYWORDS:
Botanist; conservation; taxonomy
ABSTRACT:
Tortricidae is one of the largest groups of micromoths belonging to the superfamily Tortricoidae. There are three subfamilies of which Olethreutinae is the largest one that consists of about 4,400 described species worldwide. Olethreutine moths were studied and published from Thailand more than one century ago since 1907. There were many lepidopterists from many countries have been collected, reported or described new genera, new species and new records from Thai olethreutine moths specimens that deposited in many museums. The research of these moths can be divided into four major periods. Edward Meyrick was the beginner who firstly used one specimen from Siam (the former name of Thailand) as one of type series of *Temnolopha mosaica* that was described in 1907. The second period was in 1959-1973 which twelve new species and 6 new records were mostly reported by Alexi Diakonoff who contributed his knowledge to Southeast Asian fauna. The third period (1981-1995) was the major period of olethreutinae moths study in Thailand. Thirty seven new species and 120 new records were reported by Japanese lepidopterists. And the fourth period was studied by author since 2001 to present. Two new genera, 28 new species, and 11 new records were reported. There are totally 2 new genera, 78 new species and 137 new records were discovered from Thailand that showed the highly diverse of olethreutine moths in Thailand.
The priceless classical taxonomy of the Southeast Asian tree snails

*Amphidromus*

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ABSTRACT:
Southeast Asia is recognized as one of the most important ‘hotspots’ for biodiversity and contains an extensive diversity of land snail clades. This is especially the case for *Amphidromus*, a genus of tree snails that occurs over almost all of the region and has long been placed among the most highly sought after by shell collectors. They exhibit very peculiar and diverse shell-colour patterns and coiling, but the high variation in this both within and between species has long confused their traditional taxonomy. However, over the last two decades research on many *Amphidromus* species has turned out to be a key informative and fascinating subject, where several outstanding land snail research reports on their systematics and evolution have become available. Up to now, more than 350 nominal species have been placed into this genus, mostly based upon the high degree of shell-colour variations. However, approximately 100 names are recognised as distinct species. Molecular phylogenetic analysis supports the monophyletic nature of the genus and includes three subgroups. Most species are in the nominotypical subgenus and are monophyletic with the subgenus *Syndromus* clades, but *Amphidromus glaucolarynx* formed a distinct clade and should likely be recognised as a distinct genus/subgenus. This indicates that the classification at both the generic and specific levels needs to be improved by incorporating the morphological and molecular data, and the many undescribed taxa that are gradually being identified. The evolution of co-existing enantiomorphs (dextral and sinistral) has likely persisted as the ancestral state. This review aims to provide an insight into the systematics and evolutionary history of *Amphidromus* because their immediate threat is that their natural habitats have been greatly depleted, with the residual populations increasingly becoming isolated in fragments, and heavily collected for their shells.

KEYWORDS:
Tree snail; conservation; shell trade; enantiomorphs; molluscs; biodiversity
Ecology and evolution of enantiomorphism in the tree snails

_Anphidromus_

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**ABSTRACT:**
The midplane determined by the head-tail and dorso-ventral body axes physically divides the left and right in the bilaterian animals. Many of them exhibit visceral asymmetry along this left-right axis. The left-right polarity of visceral asymmetry represents the direction of primary asymmetry, which is expressed in early embryos. Whole-body enantiomorphs (situs inversus) develop when the direction of primary asymmetry is reversed by mutation. Virtually no reversed taxa are, however, found in groups of bilaterian animals, except for gastropods (snails) in which reversal has recurrently evolved. In most of snail groups, clockwise-coiled (dextral) and counterclockwise-coiled (sinistral) species are also reversed in visceral asymmetry, resulting from reversal throughout development. Evolution of reversal from the clockwise-coiled (dextral) to the counterclockwise-coiled (sinistral) or vice versa has most frequently occurred in pulmonates among the snails. Almost all species (populations) are fixed for either the dextral or sinistral in pulmonates as well as in other snail groups. However, three exceptional snail groups in three different families are known for including multiple species that are dimorphic for the direction of coiling/visceral asymmetry (i.e. enantiomorphic). Namely, the Hawaiian family Achatinellidae, South Pacific genus _Partula_ (Partulidae) and Southeast Asian genus _Anphidromus_ (Camaenidae), which are all tropical tree snails as well as enantiomorphic Cuban _Liguus vitattus_ (Orthalicidae). Many species of the former two groups have recently been extinct or threatened on oceanic islands. We discovered that diverse enantiomorphic species of _Anphidromus_ provide precious opportunities to tackle puzzling questions on the coexistence of enantiomorphs within populations on the same trees. Here we present the current outcome of our long-term field surveys of enantiomorphism in _Anphidromus atricallosus_ in Thailand and discuss what questions could be answered by further research.

**KEYWORDS:**
Left-right reversal; situs inversus; enantiomorph; maternal inheritance; population, Pulmonate
Diversity and conservation of bats in Southeast Asia – the role of taxonomy beyond borders

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ABSTRACT:
Bat is the most diverse mammals in Southeast Asia. It is critically crucial for maintaining balance and dynamics of ecosystems, which also indirectly benefit in the well-being of human communities. However, it is not until now that we can consider we are in the golden age of Southeast Asian bat research. This is particularly true for the study of taxonomy and systematics of bats in the region. Over 30 species have been discovered and named just during the last decade, and issues of many species complexes have been resolved. It is noteworthy that many of which have been done or led by local researchers. This sheds light on the clearer picture of biodiversity patterns, distribution, and population status of mammals in the region – and most importantly, provides information for the effective conservation. It would never have been this far without the endeavour of taxonomic capacity building supported by international networking that brought researchers in the region to work together. Nevertheless, the situation is still far behind the rapid rate of natural habitat loss and species extinction. Interdisciplinary integrative research and conservation network of researchers are crucial for safeguarding biodiversity conservation.

KEYWORDS:
Bats; conservation; diversity; international collaboration; networking; taxonomy
From governmental politics to school and company projects: museum as a think tank for prevalence of taxonomy-based biodiversity conservation

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ABSTRACT:
Museum is a center for exhibition of various items that appeal to the interest and curiosity of people in general. Its ordinary function include entertainment and education for visitors. In addition, a natural history museum usually possesses collection of specimens of various natural entities, such as plants, animals, and minerals, not only for exhibition, but also for research and higher education. Recent increasing awareness and appreciation of ecosystem service has lead to increasing demands of appropriate recognition and conservation of biodiversity as fundamentals for continuing enjoyment of the service. This situation enables the natural history museum to take another important role as a think tank for governments, as well as for various non-governmental organizations. I introduce attempts of our museum, Museum of Nature and Human Activities, Hyogo, as such think tank during the last two decades.
Millipede research through space and time

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ABSTRACT:
Millipedes (Class Diplopoda) are terrestrial decompositors. Recent tallies of described species range from 7,753 (Shear 2011, Zootaxa 3148: 159-164) to 12,116 (Brewer et al. 2012, PLoS ONE 7(5): e37240.), and estimates of the number of actually existing species go up to 80,000. Diplopoda is thus a major group of invertebrates desperately in need of more study. With a basis in my own >50 years’ research on millipedes, I will talk about several aspects of these, at least for me, extremely fascinating animals, including:
- geographical parthenogenesis in millipedes
- speciation and adaptive radiation of millipedes on islands
- millipedes as model organisms in historical biogeography
- epibiotic fungi on millipedes
- quantitative and qualitative diversity of millipedes, especially in Thailand

KEYWORDS:
Millipedes; Diplopoda; taxonomy; biogeography; parthenogenesis; Laboulbeniales
SESSION 7
HABITAT-BASED RESEARCH
(TERRESTRIAL, FRESHWATER, MARINE AND OTHERS)
The influence of microclimate on biodiversity of lichens in the tropical forests at Khao Yai National Park, Thailand

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ABSTRACT:

Lichens are epiphyte making up of fungus and/or algae, cyanobacteria in mutualistic association. They depend on resources for living from the atmosphere. As such, they are sensitive to climatic condition, and require relatively specific environment. Understanding lichen microhabitat leads to conservation and sustainable utilization of this unique bio-resource. The objectives of this work were to monitor microclimate of lichen habitats, and lichen communities along tree trunks from bases, mid trunks and canopies in five ecosystems at Khao Yai National park. Microclimates were recorded and lichens were observed in quadrates on three levels of tree trunks during 2010-2015.

Light intensity play major role influencing microclimate of lichen habitats in the five forests. The highest average light intensity and subsequently lower, measured at the tree bases and the canopies, were recorded from the Dry Dipterocarp Forest (DDF), the Secondary Forest (SF), the Tropical Rain Forest (TRF), the Dry Evergreen Forest (DEF) and the Lower Montane Forest (LMF) ranging from 256-3 µmol m^{-2}s^{-1}. The highest average temperature showed parallel pattern with light intensity ranged from 27.3-19.4 °C. Whilst, the highest average relative humidity had inverse pattern with those of light and temperature measured 87-64%.

A total of 115 lichen taxa were observed from these trees in the five forests. A single tree in the TRF hosted the richest taxa of lichens known as many as 43 species, and subsequently lesser in the DEF, SF, DDF, and LMF recognized for 26, 22, 15 and 14 species, respectively. Each taxa occupied specific microhabitats along tree heights and forests. The dominant species in the five forests included *Anisomeridium* sp. and *Chapsa asteliae* (TRF), Sterile soredia 2 (DEF), *Parmotrema tinctorum* (DDF), *Dichosporidium brunnthaleri* (LMF) and *Lecanora leproplaca* (SF). The canopies of all forests accommodated the richest diversity of lichens, except the SF where the highest taxa was noted from the mid trunk level. However, the DEF and DDF showed the highest similarity, whilst all lichens in the LMF were entirely different from the other ecosystems. Only *Dirinaria applanata*, *Graphidastra multiformis*, *Parmotrema tinctorum*, *Pertusaria velata* and *Platygramme caesiopruinosa* inhabited more than one habitat indicating that these lichens had adaptive capacities to live in diverse environment. Lastly and more importantly, biodiversity of lichen in Thailand needs long term intensive investigation to enhance our understanding on this bio-resource for conservation and sustainable utilization in the present environmental degradation.

KEYWORDS:

Epiphyte; microhabitat; tree trunk; canopy; dominant species
A future perspective on freshwater ecosystems in Thailand: biodiversity and research

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ABSTRACT:
Recent interest in freshwater biodiversity due to anthropogenic activities has been triggered by a growing awareness of threatened habitats. Many of the habitat degradation result in disturbances to aquatic biodiversity and can upset the ecological functioning of the freshwater ecosystems. Freshwater invertebrates have been the indicator organisms most widely used in water quality assessment of both lentic and lotic ecosystems. Lentic ecosystem also have an intimate contact with human activities and so land-use alterations affect them directly. Running waters are perhaps the most impacted ecosystem on the planet as they have been the focus for human settlement and are heavily exploited for water supplies, irrigation, electricity generation, and waste disposal. Freshwater benthic macroinvertebrates are important components of lotic ecosystem. They are generally considered to be indicator organisms of water quality of running water, because they exhibit a decrease in taxa richness with increased stream or river pollution and degradation. Aquatic insects taxa in orders Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) (EPT) are sensitive to many stressors and hence are commonly used in bioassessment programs. In case of Ephemeroptera, they are important components of aquatic assemblages in freshwater environments due to their high abundance and richness and their role in the trophic chain. Knowledge about the diversity of mayflies is still fragmentary in Thailand. Studies on systematics and ecology of mayflies are increasing in recent years. New genera and species of mayflies were continuously discovered in Thailand. Thus, mayflies diversity and ecological requirements could be used as tools to evaluate environmental impacts on water resources and drive future research on biodiversity conservation.

KEYWORDS:
Freshwater; biodiversity; benthic macroinvertebrates; Ephemeroptera.
Relative contributions of biodiversity and environment to benthic ecosystem functioning of the South China Sea


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ABSTRACT:
South China Sea (SCS), semi-enclosed marine system touches nine countries. The SCS is one of the most productive seas in the world. Countries at this region have high population growth and relies heavily on its marine resources. In this study, biodiversity assessments such as species richness and abundance in relation to benthic environment were used to monitor ecosystem condition and function during oil and gas exploration and production at Malaysia SCS. This study investigates the effect of synthetic based drilling mud (SBM) on the benthic communities at one of oil and gas platform, offshore Terengganu, South China Sea. The subject was investigated from three different perspectives; 1. Biodegradability of the synthetic drilling mud, 2. The level of total organic carbon, total extractable lipids and total hydrocarbons and the particle size of the sediment 3. Assessment of the macrobenthos community in the study area. The SBM used in the drilling process is paraffin hydrocarbons. Under aerobic condition, SBM is highly biodegradable. However, when the oxygen is limited or depleting it will retard the biodegradation. The sediment in the study area is poorly sorted and this indicates that the study area is susceptible to a wide spectrum of energy which could suspend the sediment particles from the bottom and provides an aerobic condition for the microbial activities to decomposed SBM. The total hydrocarbons in the study area is low and well within the range of uncontaminated environment except a slightly higher total hydrocarbons contents in the station near to the production facilities. Nevertheless, the total hydrocarbons level is marginally higher than that recorded during exploration. There is no significant different in the total organic carbon in the study area. The benthic community shows a higher level of activities in the study area. The number of species, abundance, diversity and density of the benthic organisms are higher than those recorded during exploration. At present, the drilling mud did not cause detrimental effects on the environment. However, there is a noticeable change in the benthic community which indicates the needs of continual monitoring in the study area.

KEYWORDS:
Macrobenthos; drilling mud; biodegradation; benthic environment; oil and gas
Science to policy options – example of “P-CoRIE” project in Palau –

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ABSTRACT:
Palau coral reef Island ecosystem project (P-CoRIE) is a corroborative research and training program conducted by University of the Ryukyus, Palau International Coral Reef Center and Palau Community Collage supported by Science and Technology Research Partnership for Sustainable Development (SATREPS) scheme promoted by JICA/JST (Japan International Collaboration Agency / Japan Science and Technology Agency) from 2013 to 2018. The project’s major goals was to enhance the capacity of sustainable management of coral reef and island ecosystems in Palau. During the project, in order to reach the project goal, we have set five main components; “Environmental change”, “Coral monitoring”, “Biodiversity”, “Socio-Economic Evaluation” and “Human resource development/public awareness”. By analyzing changes in the ecosystems, the project proposed ways to mitigate the impact of environmental stressors on specific marine areas as well as to enhance conservation and management of coral reefs around Palau. The project conducted multiple symposiums, workshops and community meetings to share the scientific findings as well as to have feedbacks/requests from local society. For instance, “Science and Policy: Dialogue with OEK members (Senates)” held on July 2017 where a call for action was signed among OEK members, PICRC and the Project to develop a policy framework with scientific research on the conservation and sustainable use of the ocean & marine resources including coral reef. In the final term of the project, the results of these researches and trainings have been shared with Palau governments’ authorities in the forms of recommendations supported by P-CoRIE’s scientific research and activities.

KEYWORDS:
Coral reefs; climate change; international collaboration; local stress; SATREPS
Seagrass ecosystem service and restoration: Thailand perspective

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ABSTRACT:
South East Asia region including Thailand is located in biodiversity hotspot. There is a total of 19 seagrass species reported in the region, which 13 species belong to Thai water, including a recent new record in Thai water, *Halophila major* (Zoll.) Miquel. Seagrasses extend over 2,700 km2 along the Thai coastline, provide an important role as habitats, nursery grounds and shelters for our coastal habitat. They also home to exotic endangered species such as turtle and dugong. Here, we examined ecosystem services provided by seagrass e.g. supporting, provisioning, regulating and cultural services. We also included the recent important role on climate regulating service of seagrass bed as carbon storage, known as blue carbon. Seagrasses are, however, sharply declined, although restoration attempts and awareness are increasing in recent years. We discussed what are threats and challenges of seagrass ecosystem in Thailand.

KEYWORDS:
Ecosystem service; restoration; seagrass; Thailand
Marine exploration: lessons learned from research vessels

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ABSTRACT:
Marine exploration in Thailand, not including oil and gas exploration, is rather limited to be mostly near-shore area. Main part of the problem is the availability of research vessel. A ship or boat that are called research vessel should be designed, modified, or equipped to carry out research at sea. Most of the research vessels in Thailand were designed mainly for fisheries research purposes. Although it seems to have enough number of ships available for sea exploration, the availability for researchers to be used is bound only for projects of the owner organisations. Moreover, most of the research vessels are anchored most time of the year due to budget limitation. The main cost of all research vessels is the cost of fuels, and this is the major problem for all research ships. The fuel cost is not funding by most research agency as it costly and one cruise operation can serve much more than one research. National research ship operation with direct funding from the government is of important to making worthy use of the Thai research vessels.
SESSION 8
HUMAN AND WILDLIFE IN
THE ANTHROPOCENE
ABSTRACT:
The global scope and scale of trafficking of wild flora in fauna is a defining characteristic of human-wildlife interactions in the Anthropocene. Wildlife trafficking poses risks to the environment, including spreading invasive species, degrading animal welfare, and endangering species. Wildlife trafficking also poses risks to people, including fueling corruption and other forms of criminality, undermining the rule of law, spreading violence against rangers and degrading cultural resources. This talk will introduce conservation criminology as the science of conservation crime. Conservation criminology considers wildlife trafficking a function of conservation biology, criminology and criminal justice, and decision science. Two examples will be used to illustrate how conservation criminology can build scientific understanding about the causes and consequences of wildlife trafficking, as well as inform inclusive and sustainable solutions. The first case of urban bushmeat trafficking of pangolins, great apes and dwarf crocodiles in Democratic Republic of Congo and Republic of Congo will illustrate how participatory risk mapping has informed place-based interventions that reduce opportunities for illegal wildlife use. The second case of community-based policing in three Vietnamese protected areas will illustrate willingness of local guardians to intervene and stop illegal use of wildlife. Although the presentation will focus on wildlife trafficking, conservation criminology is widely applicable to biodiversity conservation and sustainable livelihoods in the Anthropocene, for example fisheries crime, illegal logging and mining.
Beyond the 6% Solution: the future of Asia’s tigers

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ABSTRACT:
As large tracts of wildlands decline globally, the need to define conservation priorities for species with large area requirements, like tigers, becomes critical. There has been an ongoing debate in the tiger conservation community about priorities for conservation, specifically whether conservation should focus on relatively small “source sites” or on larger landscapes. We suggest this is a false dichotomy, and that investments need to be made at both scales, with the timing and level of investment dependent on status of tigers, and the amount of resources available for investment. These decisions need to be made in light of the oncoming changes in numbers, poverty levels, and urbanization patterns of human populations in this Anthopocene period. While there are examples of progress in protecting tigers in source sites and across landscapes, the next 30-50 years will be critical in determining the fate of tigers.

KEYWORDS:
Conference; tigers, source sites, landscapes, urbanization
Urgent need to protect the endangered Gurney’s pitta and its habitat

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ABSTRACT:
In less than 20 years, over 80% of the Gurney’s pitta (Hydrornis gurneyi) habitat in Myanmar, lowland leveled close canopy pristine forest (max 150m elevation below 10° slope), have been converted by large scale palm oil plantation, declining from 3,225 to 656 km². Moreover, the remaining habitat has been heavily fragmented from road expansion and small scale plantation (betel nut and orchard) resulting in only three major strongholds, which could be inhabited by long-term surviving populations, constantly under threat. First described in Myanmar in 1875 Gurney’s pitta has been later recorded in southern Thailand. Not observed from 1952 to 1986 the species was rediscovered in southern Thailand in an area of about 30 km² of extreme lowland forest. Following his rediscover in Tanintharyi, southern Myanmar, in 2003 the population has been estimated at 5,152-8,586 animals over an estimated area of 3,496km² divided in five strongholds. Currently no data on the species status in each of the remaining strongholds are available. In the area hunting is an indirect threat to Gurney’s pitta as a significant rise in the use of drift nets for hunting ground-dwelling species (i.e. pangolin) has been reported. The remaining strongholds, located in Karen ethnic group controlled area, are not legally protected. The formal gazettement of the proposed Lenya National Park and its extensions, in which the remaining strongholds are located, are currently delayed due to long-running land ownership disputes between the government, local and indigenous organizations. In accordance with Conservation of Biodiversity and Protected Areas Law (2018), the Indigenous Community Conservation Area model has been legally approved. As a solution for protection of both biodiversity and customary village forests by ethnic Karen residents of Tanintharyi offering the possibility of engaging indigenous communities in the conservation management. In the end, palm oil plantation companies identified areas in their concessions not yet deforested and agree to survey for pitta and preserve them or to relocate animals from small to larger patch.
How can we influence decision makers to conserve biodiversity in the Anthropocene?

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ABSTRACT:
Influencing key decision makers to adopt pro-conservation behaviour through lobbying or advocacy is often key to save threatened habitats and species. However, making sure our behaviour change efforts go with the grain of how these decision makers really behave and make decisions can be difficult if we do not understand key principles in behavioural science. By the end of this talk, you will be familiar with: 1) three main triggers of behavioural change; 2) six psychological insights that can help encourage conservation behaviour with relevant case studies; and 3) a four-step framework of how to apply these insights to bring about behavioural change to help our conservation efforts.
Turtle conservation in Myanmar: impact of wildlife trafficking and conservation options

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ABSTRACT:
With at least 27 species – including eight endemic forms (species and subspecies) – the tortoise and freshwater turtle (i.e., chelonian) fauna of Myanmar is among the most diverse in Southeast Asia. However, most species of chelonians in Myanmar are ranked as globally threatened with extinction. While subsistence harvesting and habitat loss are responsible for some declines, illegal wildlife trafficking appears to be the primary driver of extinction in most cases. In the past demand was centered on food and traditional medicine markets of southern China, but today the high-end global pet trade appears to be the primary market force. Most chelonians illegally trafficked from Myanmar are destined for China and Thailand. With lengthy and highly-porous international borders, ineffective policing, and minimal governance in many border regions, interdicting wildlife trafficking networks in Myanmar has to date proven ineffectual. Despite these challenges, notable progress is being made by Wildlife Conservation Society and Turtle Survival Alliance, working in close collaboration with the Myanmar Forest Department, and using a suite of in- and ex-situ conservation strategies. A case in point is the endemic Burmese Star Tortoise (Geochelone platynota). Driven to functional extinction by the early 2000s, a highly successful captive-breeding program (assurance colony) founded with tortoises confiscated from the illegal trade is now producing >2000 hatchlings every year. Head-started, captive-bred tortoises are now being reintroduced into two protected areas within the historic distribution of the species. To date >2000 tortoises have been released using a “soft-release” approach; survival appears high and reproduction has been repeatedly documented. In 2017-18, an egg translocation program was initiated whereby eggs are directly transferred from assurance colonies to nesting sites in the wild. Nonetheless, poaching remains a threat and reintroduced tortoises have surfaced in global pet markets (Thailand, Canada, and China). Continued vigilance and aggressive law enforcement will be required into the foreseeable future to insure the survival of reestablished tortoise populations.

KEYWORDS:
Conservation; Geochelone platynota; law enforcement; Myanmar; pet trade; reintroduction; tortoise; turtle
Strong society and science for recovering wildlife in the Anthropocene
Thailand

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ABSTRACT:
Thailand has been considered as an Anthropocene country for decades with the intact forest ecosystem remaining only inside protected areas, comprising about 18% of the country area. The situation has led to severe negative impacts on large wild mammals. For instance, tiger remain only in 3% of the country area, banteng 1%, elephant 8%, and gaur and sambar only 7%. Their survivals are strictly depending on the protected area system. The government of Thailand (GoT), under the support from different sectors in the society, has tried to strengthen protected area management by using large mammals as an indicator of management success. The Western Forest Complex (WEFCOM), one of the largest remaining protected area systems in Southeast Asia and the last stronghold for the Indochinese tigers (Panthera tigris corbetti), is the site where the approach has been demonstrated. The key intervention is to strengthen the park ranger patrols using the system known as "SMART patrol system". The SMART patrol system provides managers with various scientific indicators such as patrol effectiveness, threat frequencies and patterns, distribution of target species. It has helped change the management style from top-down to adaptive management based on up-to-date information. WEFCOM is also equipped with a long-term rigorous population monitoring system to show the ultimate result of target wildlife species, especially tigers. Over a decade of such approach, tiger has responded by the increase of 50% of the population in the core area of WEFCOM. They have also dispersed to recover the adjacent protected areas once extirpated. Their main prey including banteng, gaur, and sambar are also returning in various well protected areas. Many times whenever development projects threatening important protected areas and wildlife in Thailand, movements of different sectors in the society have played a significant role to get GoT to consider stopping or suspending the projects. GoT has also given large investment to construct a sophisticated wildlife corridor linking Dong Phayayen-Khao Yai World Heritage Site (DP-KY). Now, various sectors have come together to try to support the recovery effort for tigers in DP-KY. In summary, to save endangered wildlife in an Anthropocene country like Thailand it requires involvement of all sectors in the society to work together under strong scientific guidance.

KEYWORDS:
Anthropocene; Tiger; Banteng; Elephant; Gaur; SMART patrol; WEFCOM; Dong Phayayen-Khao Yai
SESSION 9
ECOTOURISM & UNESCO GLOBAL GEOPARK
Abstract:
The pre-requisite for geopark development is an area that must consist of geological heritage of international value. This value can be established by assessing the scientific significance of several geosites located within a geopark. Therefore, developing geosites based on heritage value are the most important activities in the geopark. A geosite can be just a small site where the evidence of geological phenomena can be found, or a large geological landscape of natural beauty is identified. More often, a single geosite can contain all geological, biological and cultural heritages together. In developing geosites for conservation and geotourism purposes, the scientific knowledge of all those heritages have to be integrated. Public education on various aspects of geosites is not just about geological stories but they must highlight the close link between nature, culture and civilisation. This presentation will highlight the measures that should be taken to integrate the various heritages in the development of a geosite based on some example from the Asia Pacific geoparks.
Geotourism in geoparks in Japan: conservation and wise use of geodiversity

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ABSTRACT:
Geopark concept brought change of mindset of geologists in Japan. Before geopark concept, conservation had not been taken care much by most of the geologists. Only few geologists had been involved in conservation of the geodiversity which were designated as national monuments or part of conservation areas of national parks. After the introduction of the geopark concept to Japan, more and more geologists have been getting involved in geoparks in Japan and have noticed importance of geo-conservation and wise use of geodiversity.

People in Japan also has been changing slowly but steadily since the introduction of the geopark concept. There have been so much geodiversity in Japan and they have been actually wonderful tourists’ attraction from the ancient. Mt. Fuji, for example, is a volcano and variety of landscape around Mt. Fuji, which have been attractive tourism sites, is created by volcanic eruption and are part of geo-diversity in the Japanese Islands which reflects long and complex history of the formation process of the islands. Unfortunately, only the aesthetic value has been highly appreciated and scientific or geological value and wonder had not been known to ordinary people in the wonderful islands. Geopark is now bringing changes in this situation.

Promotion of geopark concept in Japan started in 2005. Scientists, municipal officers, mayers and local people cooperatively established two important organization which promotes geoparks in Japan, Japan Geopark Committee and Japanese Geoparks Network, in 2008 and 2009 respectively. Today there are 9 UNESCO global geoparks and 35 national geoparks in Japan. The activities have become much more diverse compared to the initial stage.

Education and community involvement in tourism are core activities in Japanese geoparks. Conservation of geoheritages is still in developing stage in Japanese geoparks. Conservation is heavily rely on the national system like national monument and national park, which does not always cover all the important geoheritages in geoparks. People have been attracted to geopark concept with its local economic development and education on earth but less with geo-conservation. After more than ten years of the initial introduction recognition on importance of geoheritage has been improved but not so much resources, budget and staff, are not allocated to geoconservation in Japanese geoparks. However, geotourism contributes to enhancement
of recognition of importance of geoheritages. Case study of good practices and challenges in Japanese geoparks will be shown in the presentation.

**KEYWORDS:**
Geoheritage; geopark; UNESCO; sustainable development; education; geotourism
Finance mechanisms for biodiversity: the case of Ngorongoro Conservation Area, Tanzania

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ABSTRACT:
The Ngorongoro Conservation Area (NCA) in Tanzania, managed by the Ngorongoro Conservation Area Authority (NCAA), is the only protected area in the World primarily established to protect biodiversity with three distinctive UNESCO’s categorization namely the World Mixed Heritage Site, the Man and Biosphere Reserve and the Global Geopark.

NCA is also the only true multiple land use area in Africa where the Authority is seeking to achieve optimal outcomes for biodiversity conservation, ideal outcomes for human development and optimum outcomes for finances through ecotourism, on one piece of land of 8,292 square kilometers.

The paper outlines avenues deployed by the Authority to scale up finances and optimize revenue from ecotourism to meet its operating costs for biodiversity conservation and human community development in NCA. The finance mechanisms also helped the Authority to pay all the government taxes.
Satun UNESCO Global Geopark: empowering local communities and people by creating jobs

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ABSTRACT:
The model of UNESCO Global Geopark is applied to that of Satun Geopark. Utilization for the conservation of geology, nature and culture can conduce to a Learning Resource Center. In geology an abundance of high diversity fossils, ecological system and archaeology can promote geotourism. Satun Geopark was inscribed as a UNESCO Global Geopark on 17 April 2018. This is the first UNESCO Global Geopark in Thailand and the fifth in South East Asia.

With attribution to geological research within the local communities, the geopark has been able to execute the creation of jobs. In communities such as Panya Batik, local resources have developed value products to sustain and create a better quality of life. Specifically, geological patterns in Palaeozoic fossils such as trilobites, nautiloids and brachiopods have been used to influence colorful fabrics, candles and paint. Nature has enhanced value products, adding unique tools within the community. In addition, Panya Batik is a reflection that people earn income from working in this community. Young people return to their homeland because of development and sustainable generation.
Biodiversity and ecotourism in Chinese geoparks: Danxiashan UNESCO Global Geopark of China as an example

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ABSTRACT:
Danxiashan is famous for its unique and magnificent danxia landform. It was listed as the first Global Geopark in 2004 and a World Natural Heritage site of China Danxia in 2010. It comprises 680 peaks, 70 villages, 15,000 indigenous residents in a total of 292 km² area. The geopark has an annual visitation of 3 million tourists. There are over 4,000 different types of flora and fauna with a significant amount of endemic species. To arouse the awareness and interest of the scientific value of its biodiversity among indigenous people, tourists and tourism operators, the management authority of Danxiashan has a strategy to promote science popularization of in its unique ecological and geological environment. Through the establishment of new attractions such its Natural Academy with the provision of nature education to students and the public. Over 2,000 indigenous resident, operators and volunteers have joined the protect and helped to promote the value of Danxiashan. Nearly 400,000 people attend nature education courses and activities every year. The geopark works to create the first science popularization community in China and eventually establish an environmental and economical sustainable development stronghold in the Chinese geoparks network.

KEYWORDS:
Danxia landform; geopark; World Nature Heritage; biodiversity; sustainable development
Ecotourism and geotourism: a reliable power engine for the sustainable development of local areas in Korea

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ABSTRACT:
In these days, local areas of Korea not developed like urban area face several substantial challenges; decreasing population, fast aging with little children, shrinking or slowing down of economic state, degradation of landscape by the past fast urbanization and varying agricultural productivity induced by climate change etc. Central and local government put enormous efforts to boost up the local economy applying diverse policies and measures. Among them, geotourism and ecotourism are considered as one of the best options while harmonizing both protection and development. The presenter will show some examples that places having excellent natural environment can grow without any heavy industrial sectors such as ship building, auto manufacturing, petroleum refining industry etc.

Even though the geotourism and ecotourism are only part of the growth of local development, their everlasting roles as power engines can be practical and reliable tools. The presenter will focus on the UNESCO Global Geoparks as an example. Everything on Earth is a part of abiotic, biotic and cultural elements, so effective connecting them with protection, education and tourism is the essential way to be a successful operation of Geoparks. Nowadays, the UNESCO Global Geoparks become more popularized all over the world; 147 UNESCO Global Geoparks in 41 countries, and are increasing at the rate of 10 new ones per year in the number of designation.

The progress of Jeju Island, Cheongsong and Mudeungsan UNESCO Global Geopark will be discussed as the case studies. As for the Jeju Island, it has all three UNESCO designated sites hence it is called a UNESCO triple crown area. Jeju Island is now moving into phase III of utilizing the UNESCO brands; Phase one is simply chasing stage for the designation, Phase II is mainly focusing on the revalidation, phase III is trying to connect the designated sites with economic development by much stronger involvement of local people. Owing to the excellent natural environment and its “Nature First Policy coupled with Human”, Jeju Island has been able to keep up the pace with whole national economic boom up during last forty years. As Jeju Island receives too many visitors currently, it started a visitor control programme to implement the sustainable development.

The other two UENESCO geoparks also enjoy increased visitors after joining UNESCO Global Geoparks, which enabled locals to start kinds of community based enterprises and activities leading to the sustainable use of natural and cultural assets. Becoming and active operation of UNESCO Global Geoparks means that it is equipped with a power engine for the sustainable development.

KEYWORDS:
Geotourism; ecotourism; Geopark; Biosphere Reserve; sustainable development
Geotourism, the engine of sustainable development for local communities in Satun UNESCO Global Geopark

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ABSTRACT:
The Satun UNESCO Global Geopark is located exclusively within Satun Province, which is one of the southernmost Thai provinces, adjacent to the Andaman Sea, covering two national parks and a wildlife sanctuary. The geopark covers Thungwa, La-ngu, Manang, and part of Mueang Satun district (Tarutao National Park), with a total area of 2,597.21 km², covers a total of 1,099.47 square kilometers of the land area of the province and 1,497.74 square kilometers of the sea area. The area is comprised of inland mountains and foothills, limestone karst formations, caves, beaches and coastal islands in the Andaman Sea. The population of Satun Geopark is approximately 114,651 (population data from 2017). Satun UNESCO Global Geopark famously referred to as the ‘Land of Palaeozoic fossils’, the area is renowned, in both Thailand and the whole of Southeast Asia, for its abundance and high diversity of fossil species as well as for the oldest succession of fossils including trilobites, brachiopods, stromatolites, conodonts, graptolites, tentaculites and nautiloids. The Cambrian trilobite fossils of Tarutao Island are the oldest in the Thai-Malay Peninsula.

The geotourism area in Geopark is divided into 3 zone: karst and cave area in Manang and Tung Wa district, beach and shore line in La-ngu district and Island in Mueang Satun district. For supporting sustainable development goal in Satun UNESCO Global Geopark, geotourism is necessary activities. It makes more income to local people and raise socio-economy in area. Geo-guides who work in each specific geotourism areas are the key person of geotourism activities. They must link between “geoscience knowledge” and “tourism activities”. High quality training course of geoscience, local history, culture and tourism should be provided to geoguides for making a well understanding of geological story and value of geoheritage sites and they also can link scientific knowledge and their daily life to present to tourists who visit geopark. It also makes natural resource awareness and protection to people. Geotourism handbooks and geopark panels are useful materials to help geoguides explain scientific information to tourists when they travel in geotrail and make them have more understanding of geological story of the area.

After Satun Geopark was announced to be UNESCO Global Geopark, number of tourists visited in area are increase. It follow by more income to local communities from geotourism activities. It drives local economy and make higher standard of life of people. Now people in Satun UNESCO Global Geopark
realise that geotourism and natural resources are important to their life and they need to protect and use it sustainably under concept of UNESCO Global Geopark.

**KEYWORDS:**
Geotourism; Geoguides; Geotrail; Socio-economy
SESSION 10
ECOSYSTEM SERVICES AND RESTORATION
A new age of forest restoration

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ABSTRACT:
Thirty years ago, restoring tropical forest ecosystems was the dream of a handful of ecologists. Such forests were considered too complex to be reconstructed. Conservationists claimed that restoration would divert attention and funding from preserving remaining primary forest, and effective restoration techniques had yet to be developed, particularly methods to propagate, plant and care for the large numbers of tree species that comprise tropical forests. Today, ecologists have largely overcome the technical barriers to restoration, having developed: i) techniques to propagate large numbers of tropical tree species, ii) silvicultural methods to ensure their high field performance and iii) protocols that balance natural regeneration with tree planting. As a result, tropical forest restoration has become routine. Attitudes towards restoration have also undergone a paradigm shift. It is now viewed as complementary to protection, as protected areas have failed to halt tropical forest loss. Realization that restoration can help mitigate climate change has prompted the UN to declare a “Decade of Ecosystem Restoration” (2021-2030) and to call for forests to be restored to 350 million ha by 2030.

However, restoration is often implemented with prehistoric tools: holes are dug with iron-age implements and trees are carried in baskets, on foot, to remote restoration sites. Restoration, on the vast scales envisaged by the UN, will require a technological revolution. Restoration often starts with seed collection. Locating seed trees from above, using drones and their cameras, could reduce the time and labour needed to find seed trees. The next step may be to develop drone-mounted tools to collect the seeds autonomously, such as robotic arms, suction tubes or rotating brushes. Aerial seeding by drones, as an alternative to conventional tree planting, is already operational, reducing time, labour and costs. However, further research is needed to develop appropriate seed delivery mechanisms, pelleting technologies or “designer seed-bombs”, which protect seeds from desiccation, whilst providing them with fertilizers, growth promoters and micro-organisms to facilitate seedling establishment. Use of such technologies, on large areas, would require seed collection on an industrial scale. Large seed banks and regional seed distribution systems would also be needed. The tiny seedlings that emerge from germinating seeds in the field are highly vulnerable to weed competition. Bioherbicides – using allelopathic chemicals, from the pioneer tree species that naturally colonize deforested sites – would most likely kill herbaceous weeds without killing trees. Combined with plant recognition technologies, drones might be able to spray such bioherbicides on weeds, whilst avoiding trees (“smart spraying”). Finally, monitoring restoration progress, using drone imagery and structure-from-motion software to
construct 3D forest models, is fast becoming routine, reducing the need for on-the-ground tree measurements and enabling rapid assessments of carbon sequestration.

Whilst ecologists have progressed well with overcoming the practical barriers to tropical forest restoration, progress with overcoming social, economic and political barriers has been less impressive. Thirty years ago, poor governance, inadequate funding mechanisms, failure to incentivize stakeholders and an ineffective science-policy interface were identified as the main socio-economic impediments to forest restoration – and they remain so today. Although FLR (Forest Landscape Restoration), PES (Payments and Environmental Services), REDD+ (Reduced Emissions from Deforestation and forest Degradation) and a plethora of other acronyms offer hope, primary forest destruction still outweighs forest ecosystem restoration. Over the past 30 years, ecologists have delivered, but to achieve a “new age” of forest restoration, social, economic and political scientists will have to do the same.

**KEYWORDS:**
Tropical forest restoration; drones; ecological services
Restoration of mangrove forests

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ABSTRACT:
The restoration of degraded mangrove forests and the establishment of new mangroves is primarily implemented through the planting of *Rhizophora apiculata*, which is not only expensive but often ineffective due to high mortality rates. Native forests could be restored more effectively through natural regeneration if propagules are sufficient, seedlings can establish and the site conditions allow their long-term survival. However, if one or more of these conditions are not met, interventions are necessary to assist their natural regeneration. Restoration approaches collectively known under the term ‘Ecological Mangrove Regeneration’ (EMR) have been successfully employed worldwide. The objective of this study is to outline possible interventions to tackle limitations that hinder the natural regeneration of mangrove forests.

In degraded mangroves, the restoration of the natural tidal regime are paramount and should proceed any other restoration activity, including planting. The hydrological conditions of mangroves can be improved by digging channels or breaking dykes, which frequently form a bottleneck for seed dispersal and deteriorate site conditions. In many cases, these hydrological interventions are sufficient to enable a natural regeneration. If the restoration site is located too far from a standing mangrove forest, manual seeding may be required to increase seed supply.

Tidal inundation does not only transport propagules to a site but also flushes out accumulated salt and, thus, ameliorates hypersaline conditions, which can develop in rarely inundated sites. However, if abiotic site conditions cannot be improved sufficiently facilitative plant interaction can be utilized. Established trees can act as nurse plants by ameliorating harsh environmental conditions for younger trees. These nuclei offer a starting point for regeneration and can be also established through the planting of dense seedling clusters. Moreover, herbaceous plants or shrubs are not only able to trap floating propagules but also provide a safe site for their establishment. Thus, existing vegetation should not be removed but utilized in restoration initiatives to enhance forest development.

KEYWORDS:
Ecological mangrove restoration; facilitation; nurse plants
Economic aspect of ecosystem services and restoration

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ABSTRACT:
In decision-making for ecosystem restoration, the concept of ecosystem services is aimed to be applied for better realization of ecosystem benefits. Presently, there are a number of studies applying ecosystem services in various ecosystems and their restoration initiatives. However, in practices, the concept of ecosystem services is still less influential than in academic world.

This paper explore an economic aspect of ecosystem services in real-life economic decision-making for restoration initiatives. First of all, the property rights of each resource in ecosystem play a crucial role in decision-making. Second, the characteristics of each ecosystem service’s utilizations; in other words its excludability and its rivalry, is also very important in designing the appropriate mechanisms for ecosystem services internalization in the Third step. Last, the public regulations and interventions are also useful for stimulating ecosystem restoration investments.

Several initiatives, including tree banks, crab banks, urban green areas, eco-tourisms and organic farming, will be reviewed, in order to show how economic aspect will lead to better decision-making in ecosystem restoration.

KEYWORDS:
Ecosystem services; market mechanisms; public regulations
Forest restoration of upland northern Thailand: an ongoing project in Nan province

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ABSTRACT:
Tropical deforestation leads to a loss of biodiversity and ecological services. Nan province in Northern Thailand has been facing large-scale deforestation due to rapid expansion of agricultural areas. To reverse the adverse effects of deforestation, it is necessary to restore forest ecosystems in Nan’s disturbed areas. Our ongoing project aims to find suitable plant species for forest restoration, to develop a viable design for seedling planting, and to engage farmers in restoring their own lands. In the first year, our team selected nine target sites for restoration in three districts (Wiang Sa, Phu Phiang, and Pua), and identified a reference forest for each district. Species richness of plants and birds in the reference sites was surveyed. Between 43 and 54 plant species and between 40 and 67 bird species were found at the reference sites. In each reference site, native tree species with at least five individuals were selected for phenology study and seed collection. Now, in the project’s second year, a tree nursery for seedling propagation has been established in each district, under an agreement in which the farmers act as seed collectors and seedling growers. Necessary trainings on essential concepts and skills have been provided have been provided to the owners of the nine target sites. In the upcoming rainy season, two planting designs (conventional and nucleation) will be tested and the recovery of the area will be compared with an adjacent no-manipulation site (control). This restoration project was established in the hope that integrating science and community engagement will empower local people and lead to larger scale landscape restoration.
The importance of social networks in the restoration of degraded forests

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ABSTRACT:
The exchange of information among communal forest organizations is potentially beneficial for the creation and transfer of knowledge, but the establishment and maintenance of links between distant communities can be challenging. Network facilitators can help to establish and strengthen ties or collect and relay information among organizations. For this purpose, communal forest organizations in Thailand organized provincial network committees in collaboration with the Royal Forest Department (RFD). This represents a unique example of inter-organizational network administration in the context of natural resource management. The objective of this study was to determine how these network committees influenced the information-sharing among communal forest organizations.

A network survey was conducted in order to gain information about the flow of information between community forest organizations in three Thai provinces, Chumphon, Kanchanaburi and Trat, which differed in the level of network maturity and activity. Descriptive network analysis was employed to assess the cohesion of the entire network and the position of network committee within the network. Network modelling was used to test whether the network committee enhanced information flow among community organizations.

Results indicated that trust-generating network structures, specifically network triangles and strong ties, facilitated information flow. However, geographical distances significantly impeded direct information transmission between communities. Network committees played an important role in connecting local clusters beyond geographical limits. The structural position of committee presidents showed that they coordinate the provincial network by bridging gaps between distant organizations or concentrating all information flow in a centralized position. Presidents increased the efficiency and resilience of information networks by acting as a central information hub. The findings suggest that a cohesive network committee can help to establish a strong network among all communal organizations. Network committees have the potential to facilitate the development of a cohesive inter-communal network given sufficient skills and resources.

KEYWORDS:
Community forestry; social network analysis; information-sharing
Round table discussion on “Ecosystem services and restoration:
what do we know? what more do we need to know?”

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ABSTRACT:
The term ‘Ecosystem Services’ has been entangle around academic research communities and become a popular trend in the global sustainable development agenda. Various types of ecosystem and its services around the world have been quantified and translated into direct and indirect benefits to the human well-being. The results of economic valuation of ecosystem services are used by decision-makers in many countries to balance the trade-offs between natural resource management and economic development. Practical conservation approach such as forest restoration have expanded an efforts to recovers ecosystem services in the landscape scale. Many restoration projects provide an outcomes from the ecosystem structure regeneration and their functional outputs (biodiversity, soil fertility, carbon sequestration for climate change mitigation). However, challenges still remain to measure the success of restoration by applied monitoring system to incorporate the social-ecological benefits from the restored ecosystem services. This round table will especially focus the known and unknown link between restoration academia, local practitioners, institutional dimension and discuss the drivers and proper incentive mechanism for them to participate in ecosystem services restoration in the long term.

KEYWORDS:
Ecosystem services; economic valuation; forest restoration; social-ecological benefits; incentive mechanism; sustainable development
SESSION 11
IMPACTS OF CLIMATE CHANGE ON BIODIVERSITY ACROSS SCALES
Monitoring remotely tropical forest diversity and structure

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ABSTRACT:
Tropical forests play a critical role in biogeochemical cycles and are among the richest and most complex ecosystems in the world. Yet, our ability to measure and monitor forest structure and biodiversity remains often restricted to rather small spatial and time scales in the tropics. In this talk, I will illustrate how remote sensing data, acquired from the air and the space, may improve our knowledge on the ecology of tropical forests. I will mostly focus on examples of on-going works currently performed in the Khao Yai reserve in Thailand. First, I will show that airborne LiDAR data can dramatically improve our ability to monitor forest carbon stocks at the landscape scale. Combining such carbon estimates with long-term satellite time series then provide critical information on the long-term carbon resilience of tropical forests, quantifying the high potential of secondary forests to sequester carbon. I will then show how LiDAR data can help to better characterize and map different successional forest types providing critical insights on the changes in forest structure during stand development. Finally, very high spatial resolution images appears to be promising to map the diversity of tropical forests at the regional scale, opening new perspectives for large-scale conservation planning. Altogether, these works illustrate that remote sensing data may significantly improve our knowledge of forest ecology and provide strong opportunities to manage and protect tropical forests in a science-driven way.

KEYWORDS:
LiDAR; forest dynamics; forest carbon; succession; remote sensing, resilience
Response characteristics of dry dipterocarp forest to El Niño in Thailand: results from multi-spatial scale observations

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ABSTRACT:
In the tropics, tropical deciduous forest (TDF) is one of the main forest types, occupying about 43% of forest area in the tropical belt with great diversity of species. To know and evaluate the impacts of climate change and variability, we have made the observations on various forest and climate parameters in this forest since 2001. Our observations included time series analysis of satellite image to track the changes of greenness indices in northern Thailand. Eddy flux tower to investigate changes in carbon, water and energy exchanges has been in operation since 2008 in a secondary dry dipterocarp forest in Ratchburi. Here, data on litterfall, root dynamics, soil respiration, leaf phenology of dominant species, and relevant climate variables have also been collected occasionally. In this paper, results of these observations are presented. At the regional scale and based on time series of Normalized Difference Vegetation Index (NDVI) extracted from Moderate Resolution Imaging Spectroradiometer (MODIS), dry dipterocarp forest in northern Thailand normally starts the growing season around the 106±7 day of the year (DOY). However, this is delayed to 132 DOY in El Niño year (e.g. in 2010) and advanced to 87 DOY in La Niña year (e.g. in 2011). The length of growing season is usually shortened during El Niño years but greatly varies among El Niño years. The effects of El Niño on carbon uptake and carbon ecosystem balance in this ecosystem are being investigated. On the other hand, at the ecosystem scale in secondary dry dipterocarp forest, we found that El Niño significantly changes the timing of litterfall and leaf phenology. These changes are induced by less rainfall and low level of soil moisture. The amount of carbon uptake by the secondary dry dipterocarp forest is also reduced during dry season (net loss of about 50 gC m\(^{-2}\)) and this was further reduced under El Niño conditions (net loss of 150 gC m\(^{-2}\)). El Niño has also resulted in decline of annual gross primary production (GPP) by 9.64%, and in ecosystem respiration by 17.71-21.67 % compared to preceding years. On the annual basis, however, net carbon uptake was not significantly different between normal and El Niño years. This may partly be due to continued growing nature of this secondary forest. Observations also reveal that emergence timing of new leaves and of litterfall were delayed to about 2-3 months compared to the normal years during El Niño years. The responses to El Niño are different among dry dipterocarp forest species. Timing of first leaf expansion of four dominant species including *Shorea siamensis*, *Shorea obtuse*, *Shorea Roxburghii* were
significantly delayed but that of *Sindora siamensis* was not observed. Changes induced by El Niño years were also observed in underground components such as root growth and senescence. Whether or not these changes in leaf and root phenology, and carbon and energy exchanges are typical for dry dipterocarp forest in general or specific to secondary and growing dry dipterocarp forest needs further investigation.

**KEYWORDS:**
Dry dipterocarp forest; leaf phenology; carbon and energy exchange; climate change and variability
Forest ecosystems in a warmer world

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ABSTRACT:
Increased temperatures due to anthropogenic greenhouse gas emission have been suggested to cause forceful positive feedback to future climate changes. Forest ecosystems, the largest carbon pools in terrestrial ecosystem, have been suggested to become stronger carbon sink, as temperatures increase; increased temperatures are hypothesised to stimulate nutrient mineralization, leading enhancement of C accumulation in forests.

Although many studies examining the responses to elevated temperatures, have been conducted across temperate and boreal forests, where the responses of the ecosystems are more vulnerable to increase in temperatures, less is known about tropical ecosystem responses to increased temperature.

In this talk I will present current understandings of forest responses to increased temperatures, and their challenges.
Spatiotemporal variation of net radiation over the different ecosystem in mainland Southeast Asia

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ABSTRACT:
The net radiation (Rn) is a key energy input to the ecosystem. Understanding the variation of Rn is a key to understanding the effects of climate change on the terrestrial ecosystem. Rn has long been measured from field observations. However, the study of Rn spatial-temporal variability over the Mainland Southeast Asia (MSA) is scarce due to the limitation of Rn and its components validation sites. Also, in early works was not cover the majority of land cover and climatic conditions and only focused on a short-term measurement particularly in the context of recent climate-driven changes. Here, we estimated Rn and its components from satellite remote sensing during August 2002 to December 2018 then compare with the in-situ measurements from Asia Flux network. Next, we assessed spatial and temporal variation of Rn in the different ecosystem over MSA. The components of the surface radiation budget estimated from the proposed method showed good statistical agreement. Monthly spatial variations of net shortwave radiation varied with cloud cover and surface albedo while net longwave radiation varied with the temperature difference between the surface and the atmosphere and surface emissivity.

KEYWORDS:
Net Radiation; Satellite Remote Sensing; Mainland Southeast Asia
Species’ traits inform migratory birds response to climate change

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ABSTRACT:
Species can respond differently to climate change, including a change in distribution range. Migratory birds have been predicted responses to climate change by shifts and expanses their distribution range to track climatic suitability, possibly related to their traits. A few numbers of studies on species’ traits influenced their response to climate change; even though species’ traits have been hypothesized to be important factors to determine species’ sensitive to climate change. Understanding what cause distribution range decreases by identifying species traits such as habitat preference, migration distance, dietary guild, and morphological variable related to change in the distribution range of species is crucial to guide conservation decisions. The aim of our study is to find the relative important variable of species’ traits in climate change driven the change of the distribution range size of migratory birds. We employed the Maxent model to estimate species distribution models from a unique occurrence dataset of 66 migratory birds who’s visited Thailand between 2000 and 2015, then projected potential mid-century (2050) climate changes. Consensus projections were derived from five general circulation models (GCMs) and one storyline derived from combinations of four representative concentration pathways (RCPs). We then used phylogenetic generalization least squares (PGLS) in the R-package to describe for interrelated variables to test the relative importance of traits best explain differences in distribution range trend. As expected, due to temperature increases most of the migratory birds predicted respond positively affected by increases their suitable range size, while some species dramatically decline. The short-distance migrants, herbivore, open habitats, and large species correlated with increases range size. However, we found that long-distance migrant species, insectivore, and sedentary species are correlated with a decline in their range size. Our findings imply that species responses to climate change depend on their traits and we argue that this is crucial more considered when modeling and predicting the effects of climate change on distribution range change, including to set priorities for conservation action.

KEYWORDS:
Climate change; migratory birds; response to climate change; range shift; species’ traits
Possible effects of climate change on recruitment of the wild rambutan tree *Nephelium melliferum* on the Mo Singto plot, Khao Yai National Park, Thailand

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**ABSTRACT:**  
The wild rambutan *Nephelium melliferum* (Sapindaceae), which resembles the domestic rambutan in appearance and flavor of its fruit, is a common tree species on the Mo Singto forest dynamics plot in Khao Yai National Park. In its fruiting season (mid-April through May) it is the most preferred food species of gibbons (*Hylobates lar*). The spatial distribution of new recruits (1–10 cm in diameter at 1.3 m height) differs greatly from the distribution of larger trees. The young trees tend to occur mainly in shady ravines or on north-facing slopes and are largely absent from areas receiving higher solar irradiation even though larger trees occur there. Experiments testing the germination of seeds and growth of seedlings were carried out in deer-exclusion cages in low and high irradiation areas of the plot. We found equal germination and similar growth in both areas, but mortality of seedlings during the dry season was greater in the high-irradiation areas. These results suggest that increased warming and soil drying are increasing the mortality of rambutan seedlings and changing their distribution in the seasonally-dry forest environment.
Linking sap flow to canopy fluxes

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ABSTRACT:
Canopy trees make up the bulk of forests’ biomass, thus driving the carbon and water cycles and productivity of forests. Nevertheless, canopy trees remain poorly studied due to the difficulty in canopy access for measurements. Most studies employ the eddy covariance technique (EC) for measuring carbon and water fluxes in forest ecosystems. However, EC data also contain fluxes from understory community and soil which may preclude analyses of canopy fluxes that represent the responses of forests to environmental changes, such as climate change and climate extremes. With this regard, we present an approach for estimating carbon and water fluxes from canopy trees using measurements of water flow in trees, i.e. sap flow measurements (SF). The tree-level SF data are further scaled up to canopy-level water flux, using various scaling techniques depending on variations of sap flow in the hydro-conductive areas (xylem areas) of tree stems. Carbon flux of a forest canopy, can be estimated using a process-based model which utilizes SF data and others related to canopy structures and leaf-level parameters. These approaches have been used to compute canopy transpiration (water flux) and gross primary productivity (carbon flux) in pine forests but have not been tested with tropical forest ecosystems. In light of the EU-SEA joint project which is partnered among Thailand, Sweden and France, we will implement these approaches to investigate the responses of Thailand’s tropical forests of different successional stages to climatic water stress. The study is important as frequency and intensity of droughts are predicted to increase in Southeast Asia. Such increases could drive rapid and large-scale shifts in forest structure and species composition as well as cause dramatic decreases in the amount of carbon stored by the forests in this region. Results from this study will provide necessary information to more accurately predict how climate change will affect the carbon and water cycles in tropical forests of Southeast Asia.
Invitation to forest canopy ecology: global scale collaboration opportunities

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ABSTRACT:
The canopy is the defining components of any forest ecosystem and is known to harbour a large proportion of global biodiversity. The canopy community is vitally important for the essential roles in ecosystem functioning and services. Over the last several decades there have been significant advances in canopy science, and we now better understand the importance of forests and their canopies in promoting biodiversity and ecosystem functioning. There remain many challenges in understanding canopy systems in order to make predictions about the consequences of global-scale human disturbances and their impact on forest ecosystems. Canopy science is undergoing an exciting, radical change of approach from descriptive studies to experimental manipulation with the aid of new technologies such as DNA metabarcoding and remote sensing, and a new array of infrastructure such as global network of canopy cranes. Here we examine recent progress in canopy science, and invite you to join global canopy networks which can be incorporated into multilateral, collaborative efforts to further develop our understanding of canopy ecosystems.
Variation in beta-diversity with microclimate across scales: cases from Bryophytes

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ABSTRACT:
Site-to-site variation in community composition, or beta diversity, is a major component of regional diversity. However, we have little understanding of factors that regulate beta diversity, especially in the tropical system. Being small and ubiquitous, bryophytes provide an excellent study system for understanding the patterns of beta diversity across multiple scales. In this talk, we will discuss how beta-diversity of tropical bryophytes with vary microclimate conditions at multiple scales. At the scale of individual host plant scale, beta-diversity increased with an increasing fluctuation of vapor pressure deficit (VPD). At the broader geographical scale (site level), beta diversity among sampling plots varied, while alpha diversity remained consistent among habitat types. The different patterns of alpha and beta diversity suggest the variation of beta diversity is not merely an artifact of random sampling from a larger species pool, but a result of actual ecological mechanisms.

KEYWORDS:
Epiphylls, Bryophytes; Community; Beta Diversity; Microclimate; Spatial scales
ABSTRACT:
Protected area offers provision to store carbon through conservation and ecosystem-based management. Thailand has a large number protected area and the Department of National Park, Wildlife and Plant Conservation (DNP) is responsible for conservation and management of about 22% of the protected areas, most of which are located in areas where drivers of deforestation are much higher. To ensure adequate protection and ecosystem-based conservation strategy, DNP has a system that combines satellite-based monitoring of forest cover as well as ground-based estimation of forest growth. However, prolong drought and reduce availability of moisture during dry-seasons resulting decline of Dipterocarpus and other dominant species, perceived as the impacts of climate change.

This study used 27-year long time series (1989-2016) data of 30-m Landsat to investigate the impact of climate change and ground-based measurements from 24 permanent sample plots (PSPs) from Ubonratchathani province and Chanthaburi province measured in 2015, to combine Landsat and inventory data in order to investigate the opportunity of country-scale biomass map. We used normalized difference vegetation index (NDVI) and normalized difference moisture index (NDMI) for time-series analysis of changes and, for the year 2015, compared 24 PSP values against corresponding NDVI or NDMI values from satellite data to develop a biomass map.

Our time-series analysis demonstrated areas of forest degradation which have been perceived as impacts associated to climate change. In addition, we also found higher correlation between 24 PSP measurements and NDMI ($R^2=0.77$) compared with 24 PSP measurements and corresponding NDVI pixel values ($R^2=0.49$). Our model needs further improvement in calculating accurate value of spectral indices, due to the effects of atmosphere in optical sensor, might be associated to haze and dust during dry-seasons, cloud during wet-seasons, topography. Our analysis also recommends to make improvement of the existing ground-based methods and investigate the potential of active sensor such as Sentinel 1. This pilot-study is limited to This lessons from this study is expected to benefit in designing methods for future studies that intend to combined ground data with satellite data. However, similar studies are needed to develop a country-scale biomass monitoring system in Thailand.

KEYWORDS:
Drought; biomass; forest monitoring.
Seasonal dynamics of carbon dioxide, water vapour and energy fluxes over a dry dipterocarp forest in Phayao, northern Thailand

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ABSTRACT:
Dry dipterocarp forest is one of dry tropical seasonal forest types. It is found only in continental Southeast Asia and makes up a significant portion of the Indo-Burma biodiversity hotspot. This hotspot is under severe threat from land use and climate change. As the effects of this change on CO₂, water vapor and energy fluxes are still not fully understood, long-term measurements of such fluxes are essential to understand the possible feedback cycles associated with the seasonal dynamics of functioning of these ecosystems. The aim of this study was to evaluate the CO₂, H₂O vapor and energy exchanges between atmosphere and dry dipterocarp forest ecosystem and to analyse the environmental factors that affect such exchanges. The 42 m tall micrometeorological tower with eddy covariance (EC) instrument was situated at dry dipterocarp forest flux Phayao site Thailand (DPT site, 19° 02’ 14.38” N, 99° 54’ 10.96” E, 512 msl) in Phayao province, northern Thailand. The fluxes and meteorological data have been measured continuously since 2014 until 2017. Net ecosystem CO₂ exchange (NEE) over the forest in 2014 to 2017 was 7.40 ± 6.31 tCha⁻¹yr⁻¹ (-1.95 ± 1.67 μmol m⁻²s⁻¹). NEE variation was high in rainy season and this forest turns into atmospheric CO₂ source during dry season. Diurnal NEE pattern mostly responded to incident photosynthetically active radiation (PAR), while annual NEE mainly responded to temperature and vapor pressure deficit (VPD) respectively. Ecosystem evapotranspiration (ET) was 854 mm an accounting for 87% of average annual rainfall in four years. The most of ET revealed higher in wet seasons. The soil water content and rainfall were the main factors regulating ET in the dry dipterocarp forest ecosystem. The mean annual fluxes of this energy were disaggregated into latent heat (61%), sensible heat (22%), and soil heat flux (4%). The energy closure in dry dipterocarp forest ecosystem presented 66% in dry season and 62% in wet season respectively.

KEYWORDS:
Eddy covariance; net ecosystem CO₂ exchange; ecosystem evapotranspiration; energy flux; dry dipterocarp forest
Linking plant hydraulic traits with drought induced mortality

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ABSTRACT:

Drought-induced tree mortality is the common phenomenon in areas where have extreme water stress and is projected to be exacerbated due to the increasing drought intensity and frequency in the future climate change scenarios. However, the occurrence of tree death under drought event often differs in cooccurring species with different phenology or life-forms. The underlying mechanism is still unclear although was often attributed to differentiated hydraulic properties. In the present study, we investigated a combination of hydraulic properties and related traits of stems and leaves for 37 common woody species in a hot-dry savanna valley southwest China, including 15 trees, 15 shrub and 7 lianas. Species were classified into evergreen, short-deciduous and long deciduous according to the leaf phenology. We also monitored the seasonal changes of water status and tree mortality. The results showed phenology had significant effect on wood density, stem cavitation resistance, as well as leaf drought tolerance. By contrasts, life-forms have no effect on most traits. Specifically, there were no difference in hydraulic efficiency, vessel length among the phonologic types. However, the long-deciduous species tend to have lower stem cavitation resistance and leaf drought tolerance compared to those of evergreen and short-deciduous, which were along with their higher leaf and stem water storage, lower leaf mass per area (LMA), and cell wall elasticity. Evergreen had comparable stem traits with short-deciduous but highest leaf drought tolerance, and LMA among the three groups. Although long-deciduous generally had larger and positive hydraulic safety margin (HSM) than others, most species had narrow (10/25) or negative (13/25) HSM which were in accordance with the mortality in each phenology types. We conclude that phenology determines the hydraulic design of plants in severe water-stressed regions, where plants show convergence across the life-forms. Our study highlights hydraulic traits can be used to predict the drought-induced mortality.

KEYWORDS:
Climate change; hydraulic failure; hydraulic safety margin; tropical savannah
How changes in nitrogen availability affect the cycling of carbon in forests

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ABSTRACT:
During the past decades humans have drastically alter the global nitrogen cycle, resulting in nearly a doubling of the input of nitrogen into terrestrial ecosystems. Because of the strong coupling between the carbon and nitrogen cycles in many terrestrial ecosystems, especially in nitrogen limited ecosystems, changes in nitrogen availability can drastically alter the cycling of carbon these ecosystems. In my presentation, I will summarize some of my work in this area with the goal of providing a more mechanistic understanding of how nitrogen additions affect different components of the carbon cycle in forested ecosystems. Some of these findings challenge the common dogma that nitrogen additions enhances gross primary production (GPP; carbon sequestration) as well as the general consensus that nitrogen additions reduces soil respiration. I will also show results from a unique \(^{13}\text{CO}_2\) pulse labelling study that was designed to investigate the effects of nitrogen addition on the cycling of carbon in forest understory vegetation. By synthesis the results from these studies it is possible to get a better understanding how nitrogen additions affect different components of the forest carbon cycle, which is essential in order to improve the parameterization of process-based models to more accurately predict how forested ecosystems will response to changes in nitrogen availability.
POSTER SESSIONS
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SUSTAINABLE MANAGEMENT OF BIODIVERSITY
Stimulating the access to biodiversity and technologies to combat climate change

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ABSTRACT:

On 13 November 2017, in a joint statement issued by the Executive Secretaries at the UN Climate Change Conference 2017 (“COP 23”) taking place in Bonn, Germany1, the Executive Secretaries of respectively the Convention on Biological Diversity (“CBD”), the United Nations Convention to Combat Desertification (“UNCCD”) and the United Nations Framework Convention on Climate Change (“UNFCCC”) called for establishing a financial mechanism, called Facility, to secure finance for large projects that will help to address common issues relating to climate change:

“We are calling for the establishment of a new Project Preparation Facility to bridge this gap and promote an integrated, coherent and multi-disciplinary approach to these related issues while supporting the respective mandates of the three Rio Conventions.”2

This declaration officially recognizes what was widely known; biodiversity and climate change are interconnected. Biodiversity is affected by climate change, and equally the conservation of biodiversity contributes to mitigate climate change impacts3. The promises made under the CBD and UNFCCC to conserve biodiversity and to combat climate change both rely on “access”. Facilitating the access to Genetic Resources (“GR”) under the CBD while facilitating the access to technologies under the UNFCCC and Paris Agreement (“PA”). This paper challenges the assumptions behind those promises (1) before it evaluates the financial mechanisms which are supposed to stimulate the access to biodiversity by developed countries and to climate change technologies by developing countries (2). It then investigates what are the legal mechanisms which could further stimulate the access to biodiversity and climate change technologies including empowering the Green Climate Fund (“GCF”) to own and license climate change technologies (3).


2Supra no. 2

3The CBD Secretariat has published two technical series on biodiversity and climate change to support the implementation of relevant adaptation activities. Technical Series No. 10 – Interlinkages between Biological Diversity and Climate Change; https://www.cbd.int/doc/publications/cbd-ts-10.pdf

Smart green house with various sensors for future organic farming and aquaponics

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ABSTRACT:
The aims of this study are modeling and experimental evaluation of smart greenhouses. Therefore, we test various types of physical sensors (Soil moisture sensor, Light sensor, Humidity and Temperature sensor, Soil pH meter and Anemometer) and four models of smart greenhouse, triangle tunnel, high tunnel, half-circular and triangular shape. All models include heat recovery ventilation, rain protection sheet and solar light transmission with transparent plastic. Arduino was applied, because arduino is open-source computer hardware and software and arduino microcontroller kits are available from many manufacturers. Microcontrollers receive data from sensors and send data to cloud. All sensors are placed to measure conditions inside the greenhouse. Here, LCpro-SD Portable (UK) and Konica Minolta-chlorophyll meter (JP) provide an excellent measurement of photosynthetic rate (A, μmolm⁻²s⁻¹), transpiration rate (E, molm⁻²s⁻¹), stomatal conductance of H₂O (gs, molm⁻²s⁻¹) and total content of Chlorophyll. Here, we show design and modeling of smart aquaponics greenhouse for organic rice farming with smart sensors-robot at Phayao province.

KEYWORDS:
Aquaponics; Organic Farming; Smart green house
Participatory approaches for *Volkameria inermis* conservation through herbal bioproducts at the Sirinart Rajini Mangrove Ecosystem Learning Center, Prachuap Khiri Khan province

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ABSTRACT:
The study aimed to examine participatory approach using commercial values of herbal bioproducts and local attitudes to expand the plant habitats inside the Sirinart Rajini Mangrove Ecosystem Learning Center at Pak Nam Pran Sub-district. *Volkameria inermis* was chosen among other mangrove plants for its values. Forty respondents, twenty of them whose incomes were promoted from *Volkameria inermis* herbal products, while another twenty respondents lived adjacent the Center. Their attitudes was collected by questionnaire surveys and analyzed by descriptive statistical analysis including percentage, mean, and One-way ANOVA with a significance level (α) of 0.05. Incomes increased by added values of mangrove herbal products made from the plant were analyzed. The study showed that respondents whose incomes were promoted through the herbal products had high level of awareness at 61.77% on the plant value and the mangrove forest conservation while the another group of respondents showed their moderate awareness with 44.28%. The results showed significant influence (p-value = 0.024) of knowledge on the plant benefits and the higher incomes earned from the herbal products on the attitude towards a plant and mangrove natural resource conservation. A total income obtained from selling the plant products of Center during January 2016 to September 2018 was totally 226,990 baht. Among the products, the incomes from selling the soap and hot balm made from the plant were 222,535 baht and 4,455 baht respectively, made by total fresh leaves of plant 109.34 kilograms or 2,076 baht per kilogram wet weights. It can be concluded that a community income promotion using local mangrove forest resources was an approach to the community’s values and awareness on the mangrove forest conservation, leading to community participation in tree planting, caring, and restoring of targeted plant species as well as using the natural resources in sustainable ways.

KEYWORDS: Participatory approach; conservation; *Volkameria inermis*; herbal bioproducts
**ABSTRACT:**
Japanese Musk Melon is one of the most valued plants in Thailand. Under limited irrigation system, farmers can alternate Japanese Musk Melon with rice and maize. In sustainable agriculture, Japanese Musk Melon reduces negative impact on environment, land and water. Therefore, we studied growth by physiological parameters of Smart greenhouse project. Five replications of Japanese Musk Melon (50 plants/replication) were grown during February to May 2018. Drip irrigation system was applied to grow Japanese Musk Melon. Chlorophyll contents in leaves were estimated every 11 day with chlorophyll meter (SPAD-value). During growth we found regressions of chlorophyll contents in 22, 33 and 44 days old of plants ($y=0.081x+38.478$, $y=0.069x+41.272$ and $y = 0.072x+41.242$). The average of fruit weight after ripening was 1.13 kg. Fruit length was 40.5 cm, circumference 41.9 cm and radius 8.4 cm. The thickness of fruit from shell to fruit center was 2.0-3.5 cm. Fruit volume was 4,981 cm$^3$ and dry weight 7.28% fresh weight. Musk melon (33 days old), time kinetics formula (every 10 seconds for 5 minutes) of photosynthetic rate ($A$, μmolm$^{-2}$s$^{-1}$) was $y=0.066x+1.532$ ($R^2=0.99$, 160-180 min), transpiration rate ($E$, molm$^{-2}$s$^{-1}$) was $y=0.0016x+6.524$ ($R^2=0.99$, 40-60 min), stomatal conductance of $H_2O$ ($g_s$, molm$^{-2}$s$^{-1}$) was $y=0.0014x+0.673$ ($R^2=0.96$, 90-120 min) and intercellular CO$_2$ concentration ($C_i$) was $y=0.422x+0.326.55$ ($R^2=0.99$, 10-30 min). Here, intelligent greenhouse system with wireless internet operation was designed to manage crop productivity. Various sensors were applied in greenhouse to detect and report all physical parameters and autonomous watering during hot and dry climate.

**KEYWORDS:**
Alternative crop; Japanese Musk Melon; Photosynthesis
Plant diversity in riparian zones at Bueng Si Fai wetland, Mueang district, Phichit province

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ABSTRACT: Wetlands, which provide ecological services, such as water quality improvement, food and habitats for plants and animals, are an important ecosystem, but they have been threatened by urbanization, expansion of agriculture and tourism. The objective of this study was to inventory the plant community at Bueng Si Fai, located in the center of Phichit province. The wetlands in the area are under threat by developers, therefore it is necessary to study them for possible preservation. Seven 20x20-m plots were established along the pond edge and the plant community was monitored during July 2017 – May 2018. Eight 5x5-m subplots extended from the water’s edge into the water, and the other eight subplots expanded onto the land. Three 1x1-m square sampling plots were randomly selected in each zone to record plant species, frequency of occurrence, and ground coverage that scored from 0-5. The similarity coefficient between two zones were calculated to compare the community between terrestrial and aquatic zones. We observed the total of 86 species, containing 27 monocotyledons (31%) and 59 dicotyledons (69%), in 77 genera, 26 families. Eighty-five species were in terrestrial zone and 27 species were in aquatic zone. The month with the highest number of species was September, which is the wet season and 63 species were found. Lotus (*Nelumbo nucifera*), an aquatic plant, was the most common species with 100% frequency of occurrence but sparsely and low coverage (5-9%). The Sørensen’s similarity coefficient indicated that plant communities of terrestrial and aquatic zones overlapped by 46.43%. There were 30 exotic species, of which 17 (57%) were invasive species. The invasive species could affect the occurrence and abundance of native species, biodiversity, and ecosystems. This information can be used as the base to monitor changes in the content and health of the plant community and to gauge the impact of development plans.

KEYWORDS: plant diversity; wetland; Bueng Si Fai; ecology; riparian
From biodiversity on Kho Hong Hill to nature trail through geo-location APIs with traditional Thai medicine student application implementation

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ABSTRACT:
Each year, there are a hundred students from faculty of Traditional Thai Medicine (TTM) that have to study herbs in a nature trail route on Kho Hong hill. This nature trail is a path that attracts the walker’s attention to rare plants and other features. Most TTM students also use this hill as a first step to start looking for information and studying specific herbs from the pharmaceutical botany class. There is a 1.2 km-long route with a high slope hill and specific detail beside herb route. Who climbs this hill for collecting the herb knowledge taking a long time at least half a day? Hence, we have developed a nature trail application for the Traditional Thai Medicine students in each year with Geo-location APIs including useful resources for all Thai herb learners remotely through a mobile navigation as herbs’ route. In detail, application has made for giving the information about more than 30 herbs on Kho Hong hill neared by Prince of Songkla University. This application is also integrated with location-based API and cross-platform design. End-user can always enjoy learning the herb-nature trail program from everywhere.

KEYWORDS:
Kho Hong Hill; Nature Trail; Geo-location API; Traditional Thai Medicine; Mobile Application; Biodiversity application; Thai herbs
Reproductive biology and preliminary study of micropropagation of *Eulophia macrobulbon* (E. C. Parish & Rchb. f.) in Cok Hin Lad community forest, Maha Sarakham province

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ABSTRACT:
The reproductive biology and ecological aspect of *E. macrobulbon* were investigated in Cok Hin Lad community forest (altitudes ranging from 170 – 200 AMSL), which is a deciduous dipterocarp forest type, Maha Sarakham province, Thailand. The flowering and fruiting of the *E. macrobulbon* were determined from March 2018 to March 2019. Physical parameters of the collection sites including soil moisture, air temperature, relative humidity, and light intensity were recorded. The flowering period of the *E. macrobulbon* occurred from March to May, and it's highest blooming in April. The inflorescence of the plant was a raceme type, each consisting of 10 - 80 individual flowers. The sepals of the plant were in reddish brown, greenish yellow and purplish red while the petals were in dark yellow, lip dark yellow with brown markings. The flower was a perfect type. The development of a young fruit to mature fruit was approximately 8 months. The fruit was a capsule type (3 - 5 cm in length). The micropropagation of the *E. macrobulbon* was carried out using Murashige and Skoog (MS) and Vacin and Went (VW) media supplemented with 10% of potato extract (PE), potato homogenate (PH) and coconut water (CW). The results showed that the 4-, 6- and 8-month seed exhibited the highest germination rate in MS medium supplemented with 10% CW. Furthermore, it can develop into a plantlet within one year after cultivation.

KEYWORDS:
Biodiversity; *E. macrobulbon*; micropropagation
Conservation of *Tacca leontopetaloides* (L.) Kuntze. for utilization

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**ABSTRACT:**
*Tacca leontopetaloides* (L.) Kuntze. (Arrowroot) is a single-season plant. Naturally, it takes at least 3 years to cultivate this plant from seeds for being ready to use in flour and seed production. As a result, it possibly leads to the risk of extinction. This research study was carried out on the propagation of arrowroot for conservation by tissue culture technique and seedling propagation. The finding indicated that the *in vitro* propagation of arrowroot by using explants derived from the leaf midrib areas of seedling showed that the best development in both embryos and plantlets. White globular embryos at the edge of leaf blade after transferring to media containing MS + BA 0.5 mg/l + 2, 4-D 0.05 mg/l for 14 days were observed. The result revealed that the leaf explants had the significantly highest number of embryos (3.4 embryos) with the significantly highest length of plantlets (3.2 cm.) after 30 days. The plantlets were grown under *in vitro* for 8 months before being transplanted into greenhouses performed a survival rate of 60 %. In addition, the result revealed that the average germination rate of seeds after being stored for 1-3-years were 57.8-59.2 % and were not significant different. However, it was found that the starch content from starch processing of the green-stem plants having different tuber sizes was significantly different. The tuber weighed 601-800g showed the highest starch content (299 g. dry weight/ 1 kg. fresh).

**KEYWORDS:**
*Tacca leontopetaloides* (L.) Kuntze.; conservation; tuber size; seed; starch
The development of V cryo-plate protocol for cryopreserved protocorm of *Paphiopedilum niveum* (Rchb.f.) Stein, an endangered orchid species

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ABSTRACT:

*Paphiopedilum niveum* (Rchb.f.) Stein, which is endemic to Malaysia Peninsula, was considered as an endangered species. Cryopreservation is an efficient method for long-term storage under ultra-low temperature. This study aimed to develop the protocol for cryopreserved protocorms of *P. niveum* via V cryo-plate method. To examine the suitable condition for the 1st preculture, two-month-old protocorms were cultured in modified Vacin and Went medium (MVW) containing various sucrose concentrations (0.058 (control), 0.2, 0.4, 0.6 and 0.8 M) for 24 h. The survival percentage tested by TTC and histological observation of protocorm explants were evaluated. It was found that, the protocorms preculturing in 0.2 M sucrose provided the highest survival (96%) which was not significantly different to the control. The histological observation showed the severe plasmolysis after preculture in MVW containing high sucrose concentration. To develop the V cryo-plate protocol, two-month-old protocorms were preconditioned on MVW supplemented with 0.1 M sucrose for 7 days followed by two-step preculture with sucrose. Thus, the preconditioned protocorms were precultured in MVW containing 0.2 M sucrose for 1 day (1st preculture) before being transferred to the same medium with different sucrose concentrations (0.4 and 0.6 M) for 1 day (2nd preculture). After that, precultured protocorms were incubated in loading solution (LS) at different sucrose concentrations (0.4, 0.6 and 1.2 M) for 30 min and dehydrated with plant vitrification solution 2 (PVS2) at various exposure times (30, 45 and 60 min). The results exhibiting the suitable conditions for V cryo-plate protocol were revealed as follows: the 2nd preculture in 0.6 M sucrose, osmoprotection in LS at 1.2 M sucrose and PVS2 dehydration with for 60 min. These conditions also gave the highest survival percentage (60 %) of non-cryopreserved protocorm. Unfortunately, there was no survival of cryopreserved protocorm after liquid nitrogen (LN) exposure.

KEYWORDS:

*Ex situ* conservation; endangered species; Orchidaceae
Discover of giant chili in Nan province, Thailand

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ABSTRACT:
From our research project of Anthracnose resistance breeding in chili, we explored diversity of many wild types or native chili in northern region and north eastern region of Thailand. The result showed that almost of chili cultivars which Thai farmer planting after rice field season were commercial F1 hybrid. However, a few of them planted native wild types. The objective of Thai chili farmer was trade to the middle merchants or directly sent to seasoning factory. Diversity of Thai native chili was rather narrow genetic base because Thai farmer select dark red colour and large size fruit which factory need and discard the other characters. By incident, giant chili cultivar was discovered in remote valley of Tha Wangpha district, Nan, Thailand. Some giant chili fruits are 25-30 cm in length and 3-5 cm in width with dark red colour. This giant chili was an open pollinated cultivar which one or two farmers in that area collected them for more than ten years. The chili specialist of Department of Agriculture also never found chili with giant size as this cultivar. Anywhere, after our researcher group requested some seeds from a farmer and planted in Sukhothai Horticultural Research Center whereas nearby a lot of chili seasoning factories. Almost of them were died or became dwarf plants. That’s mean this giant chili cultivar was highly specific area base. We hope that there will be another researchers or scientists collect this giant chili to further elucidation in the future.

KEYWORDS:
Nan; chili; fruit size; Capsicum annuum
Parading behavior in freshwater shrimp and opportunities for sustainable ecotourism

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ABSTRACT:
“Parading behavior” is a migratory behavior in which hundreds of thousands of freshwater shrimp exhibit upstream migration by collectively walking on land. This unique phenomenon has captured the public’s interest and has been promoted as an ecotourism site in Ubon Ratchathani province, Thailand. An increase in tourism may disturb parading shrimp and may result in local extinction of the shrimp population and associated ecosystem disruption. An understanding of the biology and behavior of this shrimp will allow us to identify potentially disruptive human activities. However, fundamental knowledge regarding this shrimp and their behavior has never been explored. In this work, we (1) identified the species of parading shrimp using morphological and molecular 16S rRNA gene characters, (2) described population demography, (3) observed behavior in the field and identified environmental cues triggering the behavior, and (4) identified anthropogenic disturbances that affect the behavior during peak tourist season. Our findings reveal that 99% of parading shrimp are *Macrobrachium dienbienphuense* and 1% are *M. lanchesteri*, and that 92% of migrating shrimp were juveniles. Stream topology, environmental cues related to the behavior, and shrimp migratory behavior are described. Finally, we found that light from tourists’ flashlights disrupts terrestrial migration and might threaten this biologically-important behavior.

KEYWORDS:
Collective movement; Decapod; Ecotourism; *Macrobrachium*; Management; Migration
P2

BIOINNOVATION FROM THE UNSEEN BIODIVERSITY
Endophytic fungi as a potential biocontrol agent against 
Fusarium oxysporum in basil (Ocimum basilicum)

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ABSTRACT:
Fusarium wilt disease is a pathogenic fungus caused by Fusarium oxysporum has been a serious threat in basil. Biological control is an alternative and an environmentally friendly method to control plant diseases. This study evaluated the potential of several fungal endophytes to decrease disease incidence caused by the F. oxysporum. The secondary metabolites from endophytic fungi isolated from Mangrove were extracted and evaluated for their antifungal activity by in vitro and in vivo assay. The results from disc diffusion assay indicated that two strains of fungi including SRNE2BP and NG09B showed effective against F. oxysporum. The best result observed from poisoned food technique was crude extract from SRNE2BP showed 82.42% of inhibition of mycelium growth at crude concentration of 0.9 mg/ml. The SRNE2BP extract was able to decrease germination of pathogen spore to 3.18% compared to control (10.22% spore germination). The SRNE2BP extract was also a strong treatment to inhibited pathogen mycelium growth in vivo experiments, as showed in 10% of mycelium coverage on basil leave at 72 hr after inoculation. While, 43.33% of mycelium coverage was observed on basil leave in control treatment. Based on results from both in vitro and in vivo assay, we concluded that fungal endophytes strain SRNE2BP can be developed into an effective biocontrol agent to prevent F. oxysporum infection in the future.

KEYWORDS:
Endophytic fungi; antifungal activity; Fusarium oxysporum; basil
Molecular characterization of endophytic fungi associated with mangrove tree *Aegialitis rotundifolia*

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**ABSTRACT:**
Endophytic fungi are sources of interesting enzymes and bioactive compounds that effectively inhibit several pathogens. Literature survey indicates only 2 species of a shrubby mangrove in the world: *Aegialitis rotundifolia* and *A. annulate*. These plants are nearly extinct and rarely found according to the criteria of the IUCN (International Union for Conservation of Nature). Besides, there is no phylogenetic study for this plant but the study on ecology and pharmacology. Therefore, researchers are interested in studying the molecular phylogeny of the gene LSU (Large subunit) and ITS (Internal transcribed spacer) of endophytic fungi from this plant using molecular biology techniques. The samples of mangrove plant were collected from a mangrove area of the Mangrove Forest Development Station 36 in Satun Province, in collaboration with the Department of Marine and Coastal Resources, Thailand. Thirty one fungal strains were isolated and 11 fungal strains were chosen for the molecular biology study in order to clarify and confirm their taxonomic and phylogenetic position. The isolated endophytic fungi were divided into 2 major classes including Dothideomycetes and Sordariomycetes, 1 subclass including Hypocreomycetidae, 5 orders including Capnodiales Diaporthales Glomerellales Pleosporales and Xylariales, 5 families including Diaporthaceae Glomerellaceae Neodevriesiaceae Teratosphaeriaceae and Xylariaceae, 1 genus including *Neodevriesia*, respectively.

**KEYWORDS:**
Endophytic fungi; *Aegialitis rotundifolia*; phylogeny
Chloroplast DNA barcode for genetic relationship of *Tacca leontopetaloides*

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ABSTRACT:
*Tacca leontopetaloides* is known as “Thao Yai Mom” in Thai. It is an annual plant belonging to the family Dioscoreaceae. The starch from tuber is used for food and pharmaceutical production worldwide. Recently, cultivation areas have decreased and many varieties have become nearly extinct in Thailand. DNA sequence of chloroplast genome is a multi-purpose tool for plant species identification, barcoding and establishing genetic relationship among plant species. This research aimed to study genetic relationship using chloroplast DNA barcoding regions such as *MatK*, *RbcL* and *RpoC1* in *T. leontopetaloides*. Samples from different varieties were collected from Chanthaburi, Chumporn, Kalasin and Trung province and 25 samples were conserved at the Department of Agriculture’s plant germplasm. Total DNA was extracted from leaf tissues. PCR amplification and purification were performed using standard kits. DNA fragments were sequenced using Sanger method. Data analysis was supported by Mega7. All primers of the candidate regions showed good amplification in *T. leontopetaloides* samples. The DNA fragments of *MatK*, *RbcL* and *RpoC1* were approximately 900, 650 and 480 bp in length respectively. All 3 candidate DNA barcoding regions could identify species. The genetic distance analysis showed that *RpoC1* gave the best result in discriminating 25 samples of *T. leontopetaloides*. It could group 14 out of 15 samples from Chanthaburi together. Although *MatK* and *RbcL* could not discriminate samples within the same species, they could identify among species. Thus, this DNA barcoding can assist in screening and identifying plant families such as Dioscoreaceae, as well as helping to reconstruct phylogenetic relationship. Chloroplast DNA Barcoding can reduce time and costs when studying plant species identification with large-scale biodiversity inventories and rare species conservation.

KEYWORDS:
Chloroplast region; Phylogenetic; *MatK*; *RbcL*; *RpoC1*
Diversity of mushrooms at Mu Ko Chang National Park, Trat province

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ABSTRACT: Diversity of mushrooms at Mu Ko Chang National Park was carried out by surveying the mushrooms along natural trails inside the national park. During December 2017 to August 2018, a total of 246 samples were classified to 2 phyla Fungi; Ascomycota and Basidiomycota. These mushrooms were revealed into 203 species based on their morphological characteristic. They were classified into species level (78 species), generic level (103 species) and unidentified (22 species). All of them were divided into 4 groups according to their ecological roles in the forest ecosystem, namely, saprophytic mushrooms 138 species (67.98 %), ectomycorrhizal mushrooms 51 species (25.12 %), plant parasitic mushrooms 6 species (2.96 %) termite mushroom 1 species (0.49 %). Six species (2.96 %) were unknown ecological roles and 1 species as Boletellus emodensis (Berk.) Singer are both of the ectomycorrhizal and plant parasitic mushroom. The edibility of these mushrooms were edible (29 species), inedible (8 species) and unknown edibility (166 species). Eleven medicinal mushroom species were recorded in this study. The most interesting result is Spongiforma thailandica Desjardin, et al. has been found, the first report found after the first discovery in 2009 at Khao Yai National Park by E. Horak, et al.

KEYWORDS: Species list; ecological roles; edibility; protected area; Spongiforma thailandica
Four genera of rust fungi causing disease on legume trees from Thailand

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ABSTRACT:
Legume trees are very important for reforestation, they are used as pasture, fertilizer and ornamental plant in the park areas. Legumes are also grown on the roadsides and sales as valuable plant for Thai herbs, furniture or public purposes. To find out the rust disease and plant pathogens that infected this tree family, the fungal disease from many regions were studied by survey, collect and identify. This report described the morphological characteristics and geographical distribution of four genera of rust fungi, members of Raveneliaceae such as Ravenelia, Sphaerophragmium, Kernkampella and Cystomyces. These are new geographical records of rust disease on Fabaceaeus trees from Thailand.

KEYWORDS:
Rust fungi; disease of legume; Ravenelia; geographical distribution
Characterization of natural yeast strains for acid production from honey bee samples

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ABSTRACT:
Stress resistance to toxic byproducts of fermentation weak acids and genetic accessibility makes yeast a promising cell factory for custom tailored microbial acids. Acid is one of important groups of chemical compounds for bio-based chemical industries with various applications. The objective of this work was to screen natural yeast isolates using molecular markers in different sources of honey samples and mining for characteristic features linked to acid production. Some isolates from honey bee samples and yeast collection belonged to S. boulardii and S. cerevisiae strains were found. The presence of SDH1 and WHI2 genes, two major genes associated with acetic acid production in yeasts was examined using single nucleotide polymorphisms (SNP) markers. The PCR product were able to be identified allele mutation of both genes. The resulting strains could be further characterized for better understanding and potentially uses for future development of yeast acid production.

KEYWORDS:
Acetic acid; single nucleotide polymorphisms (SNP) marker; mutation allele; yeast
**Ophiocordyceps khonkaenensis** sp. nov. (Ophiocordycipitaceae), a new pathogen of cicada from Khon Kaen, Thailand

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**ABSTRACT:**

*Ophiocordyceps khonkaenensis*, a new insect pathogenic fungus on cicada nymphs found buried in the ground from Khon Kaen province, Thailand is described and illustrated using molecular phylogenetic analyses and morphological data. The phylogenetic analyses of four-loci (LSU, TEF, RPB1 and RPB2) and ITS sequence data show that *O. khonkaenensis* is in the genus *Ophiocordyceps* of Ophiocordycipitaceae and is in a separate clade from other allied species. It differs from other *Ophiocordyceps* allied species, such as *Ophiocordyceps longissima* and *O. sobolifera* in the shape and sizes of perithecia, asci, ascospores seen in the host and in culture. All produce hirsutella-like asexual morphs. Both molecular phylogeny and morphological characterization strongly support the distinctiveness of this species.

**KEYWORDS:**

New species; *Ophiocordyceps*; phylogenetic analyses
Characterization Bioactive Compounds from *Xylaria* spp.

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**ABSTRACT:**
The Characterization of bioactive compounds from *Xylaria* spp. Were survey and collected samples of family Xylariaceae in different location as follows; within Udonthani Rajabhat University, Khokkhumpoon forest Sampram Campus’s Udonthani Rajabhat University, Khoklam Sangaram community forest, Kut Mak Fai subdistric, Nongwuala district, Udon Thani province, Phuhinladchofah Nongbua Lamphu province and Phulangka National Park Nakhon Phanom province. Seventy one samples of Xylaria fungi were collected and were identified by basic morphology into 3 genera and 13 species as follows; *Daldinia concentrica* (Bolt. Ex Fr.) Ces. Et de Not., *Hypoxylon monticulorum* Mont., *Xylaria allantoidea*, *Xylaria arbuscula*, *Xylaria aristata* Mont., *Xylaria caespitulosa* Ces., *Xylaria cubensis* (Mont.) Fr., *Xylaria fejeensis*, *Xylaria hypoxylon* (L. Ex Hook.) Grev., *Xylaria nigripes* (Klotz.) Cooke., *Xylaria obovata*, *Xylaria oligotoma* Sacc. & Paol. and *Xylaria polymorpha* (Pers. Ex Mer.) Grev.. When assay bioactive compounds activity by mycelium of *Xylaria* spp., that had inhibited plant pathogenic fungi, *Fusarium P01-3* cause of wilt papaya, percent inhibition of radial growth average at 100-88% by dual culture method. Mycelium of *Xylaria* spp. inhibited growth of pathogen as follow *Candida albican* TISTR5239, *Escherichia coli* TISTR527 and *Staphylococcus aureus* TISTR2329. Crude extracts of *Xylaria* sp. inhibited growth of pathogen by agar well diffusion method and average inhibition zone in 1.16-1.34 cm.. Convey the research characterized *Xylaria* has well reported as the rich source produced of bioactive compounds.

**KEYWORDS:**
Characterization; bioactive compounds; Xylaria
Species diversity of macrofungi in Khao Soi Dao Wildlife Sanctuary, Chanthaburi province

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ABSTRACT:
Macrofungi specimens were collected from Khao Soi Dao Wildlife Sanctuary from May through June, 2017. Seventy-eight specimens were identified at species level into 26 families, 47 genera and 72 species. A large number of species of genera were found in Marasmius, Polyporus and Termitomyces. Fifty-one specimens were identified at the genera level. All specimens were classified into 2 major taxa groups, namely Ascomycota comprised of 11 species in 6 genera and 4 families and Basidiomycota with 138 species in 60 genera and 30 families. These were further classified into 21 species of edible mushrooms, 3 species of poisonous mushrooms, 19 species of mycorrhizal mushrooms and 94 species of decaying mushrooms. This study can provide a guideline manual for the study of biodiversity of mushrooms in Khao Soi Dao Wildlife Sanctuary. All collected specimens have been preserved in the mushroom herbarium of the Department of National Parks, Wildlife and Plant Conservation in order to take advantage of their bio-organic compounds in future research.

KEYWORDS:
Species diversity; macrofungi; Khao Soi Dao Wildlife Sanctuary
Records of potential antimicrobial activity of soil actinomycetes isolated from community forest, Ban Khoklam Sang Aram, Udon Thani province

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ABSTRACT:
The WHO (2015) released a report of an increasing number of infections due to global antimicrobial drug resistance crisis. Unexplored areas may be possible for sources of actinomycetes with potent antimicrobial compounds. This study was directed towards isolation of antimicrobial actinomycetes from unexplored area in Community Forest, Ban Khoklam Sang Aram, Udon Thani province. The survey showed diversity of actinomycetes and rare actinomycetes in this area. Ten of 232 isolated actinomycetes showed potent antimicrobial activity by growth inhibition of Bacillus subtilis, Candida albicans, Escherichai coli, Pseudomonas aeruginosa and Staphylococcus sp. after testing with agar disc diffusion and agar well diffusion. These isolates were classified as genus of Streptomycetes sp. (9 isolates) and genus of Microbispora sp. (1 isolate).

KEYWORDS:
Microbial diversity; Actinomycetes; antimicrobial activity; soil microorganism
AmiBase: The platform for comprehensive ASEAN microbial diversity data

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ABSTRACT:
ASEAN Network on Microbial Utilization (AnMicro) has introduced AmiBase (http://amibase.org), the comprehensive data hub for ASEAN microbial diversity. AmiBase has been designed to serve two main purposes; (1) to consolidate the collaboration and data sharing among ASEAN culture collections into an integrated platform, and (2) to facilitate the research and industrial adoption of potential microbes through well-managed service operations.

The microbial diversity data are systematically gathered from microbe culture collections in ASEAN countries and public biodiversity databases (such as NCBI Bioproject, GBIF, Catalogue of Life, etc.). AmiBase’s integrated data are publicly accessible via website interface or web service API. Moreover, as AmiBase exploits the standard protocol and OECD-compatible data format for microbial data sharing, the AmiBase data submission mechanism can be programmatically implemented into any culture collection management software, thus facilitating interoperability among microbiological research networks in ASEAN.

Undoubtedly, more insights into the microbial world would substantially expand our knowledge of a highly complicated biodiversity on the earth. With increase knowledge of microbes, more benefits to mankind could be achieved in several areas, including health and medicine, industrial and environment and food and agriculture. Therefore, AmiBase includes data analysis and visualization tools which display the relationship between microbial communities and habitats, the co-occurrence pattern among microbial taxa, and the taxonomic distribution of ASEAN microbes. The ultimate goal of AmiBase is to drive the knowledge synthesis and accelerate the academic and industrial uses of microbe-based bioresources in Southeast Asia.
Organic rice grain quality: morphological, structural characterization and bioinformatics analysis of rice incomplete filling gene

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ABSTRACT:
Rice supplies over half of world’s population caloric need. Thais 6.5 million still hunger and 600,000 children suffer from malnutrition. Consequently, high quantity and quality rice grain is requested. Recently, rice incomplete filling genes (GIF1 and GIF2) that determine grain weight, size, final yield and grain quality have been reported. In this context, we studied morphology, structure and microstructure of 27 trademarks of organic rice. We measured width, length, thickness and weight of 10 rice grains in 10 replications for hierarchical cluster analysis and One-way ANOVA by DMRT. Statistically highly significant differences in each parameter were found. Hierarchical cluster analysis revealed four clusters of morphology and structure. Cluster A: compact rice grain (number 16, 17), Cluster B: medium rice grain (number 26), Cluster C1: General-Medium rice grain (number 7, 11, 12, 28), and Cluster C2: General rice grain (1-6, 8-10, 13-15, 18-25, 27, 29). The focus was on starch grain and structure of cell before and after various cooking methods. Method of rice cooking will apply to provide instruction of rice cooking rice in Hom Nok Yung’s organic rice (University of Phayao). The temperature profile (ºC) during cooking was 25-46.7 ºC (t:0-10min), 25-70.3 ºC (t:0-30 min) and 25.0-90.0 ºC (t:0-60min). Notably, high temperature was found to change the form of starch grain in both milled and non-milled rice grain. Bioinformatics study of GIF1 and GIF2 was analyzed with GenBank (NCBI). Matches to gene expression profile (GEO) and conserved sequences with similar domain architecture (CDART) were estimated.

KEYWORDS:
GIF1; organic rice; starch grain
Cloning and expression of the α-amylase gene from the *Bacillus koreensis* HL12, and characterization of the enzyme

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ABSTRACT:
Alpha amylase is an oligosaccharide endoglycosidase, an enzyme that responsible for cleaving an internal glycosidic bond within a poly or oligosaccharide, resulting in maltose and glucose molecules. Therefore, amylases are one of the main enzymes commonly used in wide number of industrial processes such as animal feed, food, and pharmaceutical industries. In this study, the α-amylase (*bkAmy*) gene was identified from *Bacillus koreensis* HL12, amylolytic enzyme producing strain isolated from sago stem. Nucleotide sequence analysis showed that the *bkAmy* gene is composed of 1,488 bp (496 amino acid residues) without signal sequence. The deduced amino acid sequence of full length enzyme showed 98% similarity α-amylase (GH13) from *Bacillus koreensis*. The full length *bkAmy* gene was successfully cloned and heterologous expressed in methylotrophic yeast *Pichia pastoris* KM71. After 72 h induction using 3% (v/v) methanol, the recombinant α-amylase (BkAmy) was expressed as a secreted protein with predicted size approximately 55 kDa. The recombinant BkAmy exhibited amylase activity toward soluble starch with 4.4 U/ml. The production of α-amylase as secreted recombinant protein could potentially apply for conversion of starches from cassava pulp waste, which is by-product of cassava starch process into value added oligosaccharides.

KEYWORDS:
Alpha amylase; *Bacillus koreensis*; expression; sago; starch; application
**C. militaris** a potential fungus for allergic rhinitis healing

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**ABSTRACT:**

*O. sinensis* or the caterpillar fungus has been used in Traditional Chinese Medicine for over 700 years. The uses of this wild fungus are growing in popularity. Now, it is an endangered species. *C. militaris* is a widely distributed species. It can be cultivated to have mature fruiting bodies. Currently, *C. militaris* is now used as a substitute for *O. sinensis*. However, as caterpillar fungus, the composition of culture media always contain worms or larvae. According to the diversity of Thai rice, cereals and beans, we succeed in cultivated Vegan *C. militaris* by using the combination of these grains as carbon and nitrogen sources. Sulfate salts and peptone are not use in the cultivation process. Dry vegan *C. militaris* are used as compound sources for allergic rhinitis treatments. This invention pertains to methods of liquid-state and solid-state myceliation of rice, cereals, and beans. By optimizing temperature and humidity as occurred in nature, we are able to induce the fruiting bodies within a short period. The mature fruiting bodies can be harvested within 30-45 days instead of 90-120 days. The approximately yields per bottle is 3.5±1.2 gram (dry weight). The average cordycepin level is between 3-5 mg per gram dry weight. The average adenosine level is between 2-4 mg per gram dry weight. In addition we success to produce *C. militaris* with high level of β-glucan and oleic acid which can be used for allergic rhinitis treatment.

**KEYWORDS:**

*C. militaris*; cordycepin; β-glucan; oleic acid; allergic rhinitis.
Production and functional characterization of starch degrading enzyme from Bacillus koreensis HL12 isolated from sago stem

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ABSTRACT:
During cassava processing, cassava pulp waste is produced in large quantities. On a dry weight basis the pulp constitutes more than 55% of the original roots. Researches have shown a technically efficient, nutritional valuable and profitable use for this waste pulp by converting into a marketable products. There exists a great potential in the use of microbes for the production of high quality feedstuffs from the abundantly available agro-industrial wastes, specifically carbohydrate residues. Several experiments were conducted to examine the capability of bacteria for production of starch degrading enzyme. Based on this study, amylolytic producing bacterial strain was isolated from sago stem (Metroxylon sagu) from Trang Province using minimal medium agar supplemented with 1% (w/v) sago starch. Bacterial identification using 16s rRNA indicated that this amylolytic producing bacterial strain is most similar to Bacillus koreensis with 99% similarity. Crude enzyme exhibited amylolytic activity against soluble starch as a majority with slightly xylanase activity (0.284 U/ml) without cellulase activity. The highest amylolytic enzyme production was achieved after 48 h incubation in minimal medium supplemented with 1% (w/v) sago starch as the carbon source at 30 °C with continuous agitation at 200 rpm. Under optimized culture condition, 33.62 U/mL amylase activity was obtained which was 79.90% greater than crude enzyme produced in minimal medium (18.68 U/ml). The work gives insights into the development of a highly effective microbial starch degrading enzyme that could be capable of cassava pulp saccharification in order to convert into value-added components such as bioethanol, glucose syrup, bioplastic and sugar alcohol in bio-industry application.

KEYWORDS:
Bacillus; cassava processing; amylolytic enzyme; saccharify; cassava pulp; waste
Screening on anti-inflammatory property of 45 Thai human probiotics from Biodiversity Research Centre of TISTR

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ABSTRACT:
Biodiversity Research Centre (BRC) of Thailand Institute of Scientific and Technological Research (TISTR) is responsible for culture collection of bacteria, yeasts, molds and seaweeds which are beneficial to industrial and environmental usage. More than 500 human probiotics collected and isolated from Thai population kept in the bank of BRC. Probiotics have been promoted the affecting on innate immunity such as phagocytosis, bactericidal activity and anti-inflammatory activity. The anti-inflammatory effect of probiotics is attributed to the released cytokines from immune cells such as lymphocytes, mast cells and macrophages. Macrophages express a variety of surface receptors that including cytokine receptors (CRs), the interleukin-1 receptor (IL-1R) and complement receptor for pathogen associated molecular pathways (PAMPs) such as lipopolysaccharide (LPS). The present study was performed to determine the anti-inflammatory mediator effect of 45 TISTR human probiotic strains on lipopolysaccharide-induced macrophage RAW 264.7 cells. A total of 45 TISTR human probiotic strains (Med1 to Med 45) from the BRC bank were cultivated in de Man Rogosa and Sharpe (MRS) broth under anaerobic condition at 37°C for 48 hr. Probiotic suspensions were diluted or concentrated to the concentration of 10^8 CFU/ml. Cell pellets were obtained by centrifugation and washed 3 times with 0.85% NaCl before heating. Then, heat-killed supernatants of each sample were collected and subjected to anti-inflammatory activity assay in macrophage RAW 264.7 cells. The cells were treated with 100 µL of each probiotic supernatant (at 100% concentration) or β-glucan (100 µg/ml) for 24 hr. Culture media were replaced with 100 µL of LPS (10 µg/ml) to induce inflammation. After incubation for 24 hr, the culture media were measured on nitric oxide (NO) level using Griess reagent assay whereas the tumor necrosis factor-α (TNF-α) and interleukin-6 (IL-6) productions were analyzed by corresponding ELISA kits. Macrophages are a type of phagocytic cells of the innate immune system. They play a crucial role and function as one of the first line of host defense mechanism and inflammation. Activated macrophages can release pro-inflammatory cytokines and inflammatory factors such as NO in response to activate stimuli. In this study, anti-inflammatory capacity of 45 TISTR probiotic strains were determined on % inhibition of NO, TNF-α and IL-6 productions. It was found that 20 out of 45 TISTR probiotics yielded various degrees of their anti-inflammatory capacity with % NO inhibition ranging from 19.91±1.50 (Med 9) to 82.04±3.71% (Med 10) compared with β-glucan (83.93±0.07%, positive control). Stimulation of RAW 264.7 macrophages with LPS induced a high production of NO by 378.61 pg/ml. The reduction in TNF-α levels (% TNF-α inhibition) was seen in 16 TISTR probiotics with the highest activity at 52.46% (Med 8 strain) and the lowest at 5.69% (Med 9 strain). As for % IL-6 inhibition, among 45 TISTR probiotic strains, 18 strains expressed positive results by 5.79 (Med 40) to 68.79% (Med41). The results generated by this study suggest that many TISTR probiotic strains are potential of anti-inflammatory activity on macrophage RAW 264.7 cells. These findings can support the use of TISTR probiotics in preventing and down-regulating inflammation.

KEYWORDS:
Anti-inflammation; interleukin; nitric oxide; probiotics; RAW 264.7; TISTR; tumor necrosis factor-α
Mushroom diversity of Plant Genetic Conservation Project under the Royal Initiative of Her Royal Highness Princess Maha Chakri Sirindhorn at Khoa Wangkhmer, Kanchanaburi province, Thailand

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ABSTRACT:
This research was performed field surveys at Plant Genetic Conservation Project under the Royal Initiative of Her Royal Highness Princess Maha Chakri Sirindhorn (RSPG) at Khoa Wangkhmer, Saiyok districts, Kanchanaburi province during December 2017 and June 2018. Wild mushroom were collected for morphologic identification. The results have shown that 111 mushrooms were collected while 83 samples could be identified, based on morphological characteristics, into Phylum Basidiomycota (91.9%), Ascomycota (7.2%) and non-fungi Amebozao (0.9%), respectively. Then, the identified mushrooms were classified into 22 families, 40 genera which were divided into 5 groups according to their utilizations; edible, medicinal, poisonous, mushrooms that could be utilization in other areas and unknown utilization mushrooms. Edible mushrooms comprised of 11 samples while 2 samples of medicinal mushrooms were found. Two samples of poisonous mushrooms were established. In addition, 32 of mushrooms that could be utilization in other areas and 64 unknown utilization mushrooms were collected.

KEYWORDS:
Kanchanaburi province; mushroom; RSPG; species diversity; utilization.
Biodiversity of Xylariales in Padaeng Zinc Mine, Tak province of Thailand

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ABSTRACT:
Based on morphological data, one hundred and eighteen records of Xylariales, belonging to 8 genera Annulohypoxylon, Biscogniauxia, Daldinia, Hypoxylon, Kretzschmaria, Pyrenopolyporus, Sarcoxylon and Xylaria were collected and isolated from Pha Daeng Zinc Mine in Tak Province, Thailand. Only 94 records can be classified into 25 species, including Annulohypoxylon stygium, Biscogniauxia nummularia, Daldinia bambusicola, D. eschscholtzii, Hypoxylon fendleri, H. fragiforme, H. haematostroma, H. investiens, H. subgilvum, Kretzschmaria deusta, Pyrenopolyporus nicaraguensis, P. laminosus, Xylaria adscendens, X. allantoidea, X. anisopleura, X. arbuscular, X. badia, X. curta, X. escharoidea, X. feejeensis, X. fuscata, X. grammica, X. inthino-velutina, X. papulis and X. schweinitzii. Interestingly, some fungal species expected to be new species or new records of Thailand. These samples, belonging to the genera Daldinia and Pyrenopolyporus, were found at burnt area in Padaeng Zinc Mine. All fungal specimens needed to be further studied will be preserved as DNA barcoding for biological resource conservation and sustainable uses in the future.

KEYWORDS:
Graphostromataceae; Hypoxylacea; mixed deciduous forest; Xylariaceae
Comparative metagenomic profiling of soil microbiomes in low and high yield sugarcane farming via long read sequencing technology

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ABSTRACT:
Rhizosphere microbiomes are a key role component of growth, health, productivity and soil quality of sugarcane farming. These beneficial microbiomes, so called plant growth promoting microbes (PGPM), can fix atmospheric nitrogen, solubilize phosphate and potassium, and produce siderophores and phytohormones. These attributes can improve sugarcane cultivation, especially in the organic farming through varieties of underlying mechanisms. Nowadays, continuing technological advances and bioinformatics tools are allowing the applications of long-read sequencing to study metagenomic samples at an affordable cost within a reasonable time. Therefore, our study aimed to investigate the metagenomic profiles of the low and high-yield production sugarcane fields through Oxford Nanopore technology (ONT). Soil samples were collected independently from low and high-yield production sugarcane fields in Thailand. We developed DNA extraction strategy from soil samples to perform ONT sequencing, especially providing high quality genomic DNA with high molecular weight and large quantities. Sequencing libraries were constructed and sequenced on a MiniION sequencing device for approximately 48 hours. Sequencing Data were acquired by MinKNOW and base calling was done using Albacore. Adapters and low-quality reads were trimmed using Porechop with default parameters. After read pre-processing, the high-quality reads were retrieved for metagenomic data analysis. NanoComp was used to visualize read basic statistics including mean read length, mean read quality and N50. The high-quality data were then aligned against NCBI non-redundant (nr) protein database using DIAMOND protein aligner. Taxonomic classification and functional analysis were performed using MEGAN-LR. It was found that two bacterial phyla including Proteobacteria and Acidobacteria showed high abundance in both fields. However, Actinobacteria was predominant only in the low production field while Chloroflexi was predominant only in the high production field. In terms of microbial diversity, microbes in the high production field were more diverse than those in the low production one. Interestingly, genus Streptomyces which has been reported as plant pathogenicity was dominantly found in low production field while genus Sphingomonas which has been reported as a plant growth-promoting microbe was dominated in high production field. Moreover, functional analysis revealed the enrichment of genes related in the nitrogen metabolism the high-yield production field, including ammonia assimilation (GltB, GltD and Gs), nitrate and nitrite ammonification (NarG), nitrogen fixation (NifH (iscS)), nitrogen-resistant stress resistance (NorV). The data and information gained have demonstrated the advantages of the long-read sequencing technology in gaining a better understanding of the important roles of PGPB in sugarcane farming which can be applicable to organic farming of other economical plants.

KEYWORDS:
Oxford nanopore sequencing; Sugarcane; Metagenomics; Microbiome; Long read sequencing; Plant growth-promoting microbes
ABSTRACT:
Culture of economic species of agarophytic red seaweed, *Gracilaria tenuistipitata* var. *liui* Zhang & Xia under different nutrient recipes was conducted for seedling stock. Three nutrient recipes were used. They were Modified Grund's medium or MGM, half of MGM plus soil extract, and half of MGM plus seaweed extract. The experiment was done in outdoor hatchery with three replications for 4 weeks in white round plastic basket of 25 L with initial weight of 4 g L⁻¹. The seaweed was weight every week for followed the growth and the final product was done *in vivo* chlorophyll a fluorescence was measured at ambient carbon dioxide concentration by a portable PAM-2000 fluorometer. The growths and growth rates in those nutrient recipes were similar and showed double biomass at week 4th in the range of 8.2–8.5 g L⁻¹. The growth rates were in the range of 2.2–2.6% day⁻¹. The photosystem II maximum yield or Fv/Fm revealed that the alga in the half of MGM plus soil extract of nutrient recipe showed the best condition of 0.69±0.06. The growth of the red seaweed, *Gracilaria tenuistipitata* was low in the bucket and half of MGM plus soil extract provide the lowest stress when compared with the others. The soil extract could use to replace in some of the nutrient recipe from the chemicals.

KEYWORDS:
red seaweed; agarophyte; *Gracilaria tenuistipitata*; nutrient recipe; medium
Fungicide sensitivity of *Lasiodiplodia* sp., causal agents of durian fruit rot disease in Thailand

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ABSTRACT:
Durian fruit rot disease caused by *Lasiodiplodia* sp. has been a serious problem in Thailand. The use of fungicide is one of the main disease management measures. However, there is no data available on the sensitivity of *Lasiodiplodia* sp. to the common fungicides used in durian orchard and post-harvest management recently. This research aims to investigate the sensitivity of *Lasiodiplodia* sp. to six fungicides such as prochloraz, carbendazim, mancozeb, difenoconazole, hexaconazole and pyraclostrobin. Samples of diseased durian fruit were collected from 14 durian orchards in the eastern and southern Thailand. All 34 isolates showed similar colony features where mycelium were olivaceous-grey to dark grey. Via artificial inoculation using mycelia on wounded durian fruits, all isolates were pathogenic on durian fruits. Fungicides with the concentration as recommendation rate, also the higher and lower concentrations were determined the inhibition of *Lasiodiplodia* spore germination using microdilution plate technique. The most effective fungicides with 100% inhibition at all concentrations tested were mancozeb and pyraclostrobin, while difenoconazole showed 100% inhibition only at the recommended or higher concentration. Conversely, prochloraz, carbendazim and hexaconazole did not affect the spore germination. Fungicide evaluation for the post-harvest treatment under field conditions showed that pyraclostrobin at the concentration of 125 µg/ml was able to reduce disease severity by 50% on the freshly cut durian fruit. Overall these results suggest that pyraclostrobin can reduce the occurrence of durian fruit rot disease when it applied to the fruits shortly after harvest.

KEYWORDS:
Botryosphaeriaceae; fungicide resistance; post-harvest disease
Diversity of endophytic fungi from wild plants and their antifungal and plant-growth promoting properties

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ABSTRACT:
A total of 118 endophytic fungi were isolated from 21 wild plants in northeastern of Thailand. Most endophyte were isolated from Maesa ramentacea (Roxb.) A. DC. (12.7%), followed by Baeckea frutescens (11.9%) and Anneslea fragrans Wall. (6.8%), respectively. Endophytic fungi were more prevalent in the leaves (59.3%) than the branches/stems and the flowers. Isolate Gu02 and Gu03 from flowers of Gluta usitata (Wall.) Ding Hou exhibited board range of antifungal activity above 50% growth inhibition by dual culture technique toward to Colletotrichum gloeosporioides, Phellinus noxius and Rigidoporus microporus. Isolate Gu03 inhibited mycelial growth of the pathogenic fungi, P. noxius and R. microporus causing root rot disease of rubber tree with 74.1% and 88.1% inhibition, respectively. Isolate Gu03 produced plant growth hormone, indole acetic acid (IAA) at the concentration of 331.5 µg/ml. Volatile metabolite-producing endophytic fungus, isolate Cs05 was isolated from leaf tissues of Cycas siamensis Miq. The volatile organic compounds (VOCs) of isolate Cs05 were active against P. noxius and R. microporus with 100% growth inhibition.

KEYWORDS:
Antifungal activity; endophytic fungi; indole acetic acid; wild plant
Antifungal activity of endophytic fungi isolated from *Schefflera leucantha* against *Fusarium proliferatum* in chili

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ABSTRACT:
Endophytes harbourd in plants have been considered as potent biological control. *Schefflera leucantha* has been reported to possess antimicrobial and antioxidant activities. This study is aimed to evaluate antifungal properties of endophytic fungi isolated from *S. leucantha*. Endophytic fungi were isolated from *S. leucantha* leaves and identified using morphology analysis. Forty strains of endophytic fungi were isolated from leaves of *S. leucantha*. Most fungi were identified in a genera of *Colletotrichum*. The *in vitro* antifungal activity of all fungal strains was further investigated against pathogenic fungus *Fusarium proliferatum* in chili using the dual culture assay for a week. Isolated endophytic fungal strains showed inhibition value ranging from 35-92 % against tested pathogenic fungus. Endophytic fungus SL-32 showed the most effective antifungal activity with inhibition value of 92% and identified as *Trichoderma* genera by 18s rRNA analysis with ITS region. This study showed that *S. leucantha* leaves harbourd endophytic fungi suggest their antifungal effects against pathogenic fungus *F. proliferatum*.

KEYWORDS:
Antifungal; endophytic fungi; *Fusarium proliferatum*, *Schefflera leucantha*
Diversity of yeast from palms sap and their capability to produce ethanol

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ABSTRACT:
Two hundred and sixty-two yeast isolates were isolated from 90 samples of coconut inflorescence sap, toddy palm inflorescence sap and Nipa palm fruit stem sap (30 samples for each plant) collected in Thailand. They were isolated by dilution plate technique in YM broth supplemented with sodium propionate 0.025% and chloramphenicol 200 µg/ml. Yeasts were identified based on the sequence of D1/D2 domain of 26S rDNA, they were identified as 13 known species, Candida sanyaensis (1 isolate), C. tropicalis (15 isolates), Hanseniaspora guilliermondii (48 isolates), H. valbyensis (2 isolates), H. vineae (8 isolates), Lachancea fermentati (18 isolates), L. thermotolerans (1 isolate), Meyerozyma guilliermondii (1 isolate), Pichia kudriavzevi (8 isolates), P. manshurica (7 isolates), Saccharomyces cerevisiae (136 isolates), Torulaspora delbrueckii (2 isolates), Wickerhamomyces anomalus (2 isolates) and the remaining, 4 isolates were 3 new species candidate of genus Torulaspora (2 isolates), Moniliella (1 isolate) and Metschnikowia (1 isolate). The yeast were primarily screened for ethanol production in 16% glucose, 1% yeast extract and 2% peptone in flask scale, incubated at 28°C with a shaking speed of 120 rpm. Two hundred and fifty-seven yeast isolates produced ethanol ranged from 2.02 to 86.71 g/L and 24.96 to 76.74 g/L at 24 and 48 hr., respectively and the remaining 5 isolates of P. manshurica were not produced ethanol. The ethanol concentrations reached the highest level at 86.71 g/L (24 hr.) was found from L. fermentati strain YSP-404. The yeast that produced ethanol >80.00 g/L at 24 hr. which showed high potential for ethanol production were found from L. fermentati, H. guilliermondii and S. cerevisiae.

KEYWORDS:
Diversity; ethanol; yeast
Intertidal mangrove fungi from central and southern Thailand

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ABSTRACT:
Intertidal wood and decaying substrata (prop roots, pneumatophores, overhanging branches and twigs of mangrove trees) were collected from six mangrove stands located in Samut Sakhon and Satun Provinces to study the species diversity of marine fungi. The higher marine fungi on samples were identified and their percentage occurrence noted. One hundred fungi were recorded from the intertidal wood samples. The Ascomycota were the dominant group at all study sites. The average percentage occurrence of the fungi recorded from each site ranged from 0.2% to 16.9%. Based on the percentage of samples in which a particular taxon was found, the most frequent fungi were Verruculina enalia (16%), Aigialus parvus (15%), Ascocratera manglicola (15%), Quintaria lignatilis (11%) and Eutypa bathurstensis (10%). The results showed that 45 species were common to all two provinces. The Shannon-Wiener diversity index, equitability species evenness index and Margalef’s species richness index were the three highest in Mangrove Forest Resource Development Station 36, Mangrove Forest Learning and Development Center 2 and Mangrove Forest Learning and Development Center. In the present study, Aegerita sp., Nia vibrissa and Paraliomyces lentifer were recorded as rare fungi in Thailand. Moreover, Helicascus satunensis is recorded, described and illustrated as a new fungus from mangrove forest at Mangrove Forest Resource Development Station 36.

KEYWORDS:
Fungal diversity; marine fungi; occurrence
Species composition of higher marine fungi from the planted mangrove forests at Thasala District, Nakhon Si Thammarat province, southern Thailand

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ABSTRACT:
Mangrove forests play an important role in subtropical and tropical coastal ecosystems. Higher marine fungi are widely distributed in various marine ecosystems and have great contribution to global biodiversity. Local participation in mangrove forest restoration has highly impact for bio-resource conservation and sustainable utilization in Thasala District, Nakhon Si Thammarat Province. Therefore, we aimed to preliminary investigate species occurrence and diversity of filamentous marine fungi from these planted mangrove forests. Numbers of decaying woody substrata were randomly collected and examined for the presence of marine fungi during November 2018-February 2019. A total of 17 identifiable species of marine fungi were identified based on morphological characteristics, including 15 Ascomycota (83.33%) and 2 Basidiomycota (11.11%). Average percentage occurrence of marine fungi recorded ranged from 0.93% to 16.82%. The result shows that 13 species were common, 4 species were frequent and the most frequently encountered fungi were Nemania maritima (15.89%) and Verruculina enalia (16.82%). Percentage of colonization was relatively high for approximately 91%. Additionally, the average number of fungi per sample was moderately 0.91. Interestingly, two notably rare species encountered for the first time in Nakhon Si Thammarat Province including Pedumispora rhizophorae and Patellaria atrata. Further sampling needs to be conducted, especially a comparison of species composition between planted and natural mangrove forests. The result from this study develops a baseline for biodiversity of marine fungi in Nakhon Si Thammarat Province and provides an awareness for mangrove conservation for Thailand.

KEYWORDS:
Biodiversity; mangrove forest; marine fungi
Phenotypic and genomic diversity of BmNPV collected from different parts of Thailand

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ABSTRACT: Bombyx mori nucleopolyhedrovirus (BmNPV) is the most deadly disease of polyvoltine silkworm. We studied the occlusion bodies (OB) and occlusion derived virus (ODV) phenotype and genomic diversity of BmNPV isolates collected in different parts in Thailand. BmNPV infected silkworm larvae of the 4th-5th instar were sampled the Northeast; Roi Et, Bueng Kan, Ubon Ratchathani, Buriram, Surin, Udon Thani, Sisaket, Amnat Charoen, Loei, Nong Khai, Khon Kaen, Sakon Nakhon, Maha Sarakham, Chaiyaphum, Nakhon Ratchasima, the North; Chiang Rai, the West; Kanchanaburi, Ratchaburi, Uthai Thani, the South; Chumphon, Narathiwat. BmNPV were harvested from hemolymph of diseased larvae and OBs and ODVs phenotypes were investigated under scanning and transmission electron microscopy, respectively. There were four shapes of OB; tetragonal, hexagonal, octagonal, and globular. Two phenotypes of ODV; single and multiple embedded were observed. The highest number of nucleocapsids of a multiple capsid BmNPV was 14. The results suggest that phenotype of OB and ODV was not related to geography. Molecular characterization of BmNPV was performed. Three baculovirus marker genes; polh, lef-8, and lef-9 were used for identification and demarcation of 21 isolates. Phylogenetic analyses revealed that the nucleotide sequences were similar with the previous BmNPV isolates from China, Brazil, and India. The interesting isolates from the Northeast, the North, the West, and the South were selected for whole genome sequencing by Illumina next generation sequencing based on genetically and geographic different isolate. The complete genome of BmNPV isolates is the first report in Thailand. The benefits of whole genomic information can be used for diagnosis and also be a key to understanding the virulence and BmNPV infection in Thai silkworms.

KEYWORDS: Bombyx mori nucleopolyhedrovirus; occlusion bodies; occlusion derived virus; next generation sequencing
Morphological, molecular and 3D synchrotron X-ray tomographic characterizations of *Helicascus satunensis* nom. id., a novel mangrove fungus

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**ABSTRACT:**
A new species of *Helicascus satunensis* nom. id. on decaying *Nypa* palm fruit was collected from Satun Province, southern Thailand. Its morphological features were similar to the members in the genus *Helicascus*. Recently, a genus *Helicascus* comprising 12 species were investigated from worldwide aquatic habitats. The morphology of this fungus was studied and combined with multiple gene sequence analyses of the small subunit (SSU), large subunit (LSU) ribosomal (r) DNA, the translation elongation factor 1-alpha (TEF-1α) and the RNA polymerase II genes (RPB2). Morphologically, *H. satunensis* nom. id. characterized by having semi-immersed lenticular ascomata, multi-locules; bitunicate ascus; smooth, obovoid dark-brown ascospores, 1-septate and unequally 2-celled. Moreover, the 3D visualization using synchrotron X-ray tomography was performed to investigate the interaction of fruiting body and substrata. The multi-gene molecular phylogeny revealed that *H. satunensis* nom. id. belongs in family Morosphaeriaceae, order Pleosporales, Class Dothideomycetes. Furthermore, *H. satunensis* nom. id. forms a well-supported clade with *Helicascus* species described from marine habitats. Additionally, *H. satunensis* nom. id. strains constitute a separate group within the *Helicascus* spp. subclade from freshwater habitat with strong support. Therefore, with the unique morphological and molecular evidences, we propose this fungus, *H. satunensis* nom. id., as a new species for *Helicascus*.

**KEYWORDS:**
Dothideomycetes; *Helicascus*; phylogenetics analysis; new species; synchrotron X-ray.
In silico assessing the diversity of plant-pathogenicity effector proteins in Ganoderma spp.

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ABSTRACT:
Ganoderma is one of the most economically important fungi. While some species of Ganoderma, represented by G. lucidum and G. sinense, are well-known medicinal mushroom which produce a diverse range of bioactive compounds, Ganoderma spp. is generally considered an opportunistic plant pathogen, known as white-rot fungi, as its biodelignification activity can occasionally result in serious damages to cash crops such as oil palm tree. This study aimed to in silico assess the profiles of effector proteins of 4 Ganoderma species, namely G. australe (GanAu), G. lucidum (GanLu), G. sinense (GanSi) and G. boninense (GanBo). Protein-function prediction tools, including EffectorP and SignalP, were employed to identify plant-pathogenicity effector proteins in the annotated Ganoderma proteomes. 43, 58, 45, and 45 effector proteins were found in GanAu, GanLu, GanSi, and GanBo, respectively. It is noted that both GanLu and GanSi possessed Cytochrome C proteins in their effector protein profiles, while GanAu and GanBo, which are plant-pathogens, lacked the effector proteins of this family. Moreover, the dehydrogenase families were uniquely present in the profile of GanAu effector proteins, whereas Ras protein family which were rather common in the effector protein profiles of the other three species were conspicuously absent in that of GanAu. Such distinctiveness of effector protein profiles of Ganoderma species might hint at the biological mechanisms underlying different pathogenic properties, host specificity, and secondary metabolite biosynthesis among this mushroom genus.
Interaction between *Termitomyces* spp. and microbes isolated from termite nests

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**ABSTRACT:**
Termitophilic mushroom-producing fungi known as *Termitomyces* species are a group of basidiomycetous fungi which forms a symbiotic relationship with termites. *Termitomyces* are usually found on termite nests or the ground nearby. Although *Termitomyces* species are widely consumed and high demand which they cannot be commercially cultivated, these are the causes of high price of this mushroom. In this study, the specimens of *Termitomyces* were collected from three provinces in Thailand including (1) Ban Phao Tha Community Forest (Phitsanulok Province), (2) Padaeng Mine (Tak Province) and (3) Bankeesai (Trang Province). The taxonomy and interaction between *Termitomyces* and microbes isolated from termite nests were focused. Eleven isolates of *Termitomyces* were isolated from three sites. The taxonomy of *Termitomyces* was studied using morphological and molecular data. A morphological study was conducted at macroscopic and microscopic levels. Pileus, basidia and basidiospores were photographed and measured. Phylogenetic analyses of the combined ITS and LSU rDNA sequence data of 11 *Termitomyces* isolates showed that they can be assigned into four species. For interaction study, microbes were isolated from soil samples taken from termite nests at Padaeng Mine (Tak Province) using a dilution plate and soil plate methods. A total of 109 isolates of microbes were isolated the termite nests including 98, 8 and 3 of filamentous fungi, bacteria and yeasts, respectively. Interaction between *Termitomyces* and termite nest-associated microbes was studied using a dual culture method. The outcome of this research would facilitate the key understanding for cultivation of *Termitomyces* in a commercial scale.

**KEYWORDS:**
Mushroom; microbial interaction; symbiosis; *Termitomyces*; termite nests
Novel species of invertebrates pathogenic fungi in Clavicipitaceae from Thailand

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ABSTRACT:
Clavicipitaceae (Earle) is one of the most heterogeneous fungal families in the order Hypocreales (Ascomycota) comprising fungi associated or pathogenic to plants, invertebrates and occasionally fungi. In Thailand, the majority of well-recorded species in Clavicipitaceae are pathogenic to invertebrates. They occur predominantly on insect orders Hemiptera followed by Lepidoptera and Coleoptera. Cryptic species in invertebrate pathogenic fungi are species that look morphologically similar but genetically different, and is a part of our research challenge to solve. The interesting natural specimens from community and conservation forests, as well as fruit orchards were studied by morphological comparison and multi-loci phylogenetic analyses. The results from our continued research on taxonomy, two new genera Nigelia and Helicocollum in Clavicipitaceae were erected and twenty species were proposed as new species from Thailand. Most of them were reported occurring on insect hosts belonging to the order Hemiptera, such as Aschersonia calendulina, A. luteola, A. minutispora, A. narathiwatensis, A. siamensis, Conoideocrella krunchingensis, Helicocollum chanthaburiense, H. krabiense, H. surathaniense, Moelleriella alba, M. chumphonensis, M. phukhiaoensis, M. pongdueatensis and Samuelsia mundiveteris that have been found occurring on scale insects or whiteflies. On the other hand, the insect hosts of Metarhizium chaiyaphumense, M. kalasinense, M. takense are reported as cicada nymphs and M. samlianese was found on a hopper, all belonging to Hemiptera. Two new species, Nigelia aurantiaca and Metarhizium prachinense, were found infecting larvae of Lepidoptera.

KEYWORDS:
Invertebrates pathogenic fungi; molecular phylogenetic; taxonomy
Termite diversity and functional significance of cellulolytic microbes in Plant Genetic Conservation Project Area at Nongrawiang Center, Nakhon Ratchasima province

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ABSTRACT:
Termite were randomly survey in 2 different forest types, dry dipterocarp forest (DDF) and mixed-deciduous forest (MDF) at plant genetic conservation project area under the royal initiative of Her Royal Highness Princess Maha Chakri Sirindhorn at Nongrawiang center, Nakhon Ratchasima province during January – November 2017. Total of 2 families, 3 sub families, 7 genera and 11 species were found in the studied areas including Odontotermes proformosanus, Odontotermes feae, Odontotermes sp1, Macrotermes gilvus, Macrotermes chaiglomi, Macrotermes annandalei, Microtermes obesi, Dicuspiditermes sp1, Microcerotermes crassus, Globitermes sulphureus and Coptotermes gestroi. Termite diversity was determined and found that MDF and DDF had H index value of 2.163 and 2.068, respectively. The DDF had indicated as higher evenness with 0.941 and 0.902 in MDF. Sorensen’s index was used for similarity of species components in each forest type which demonstrated the value of 0.9. The termite density was positively significant correlated with rainfall. Screening of cellulolytic microbes from termite mounds and digestive tract was performed. The microorganisms having different colony characteristics were isolated and subjected to the primary screening for cellulase production activity by the observation of clear zone on selective carboxymethylcellulose agar (CMC agar) using iodine method. Fifty-seven isolates demonstrated the degradation of CMC agar. According to the enzyme activity, 2 isolates (T30-026, T30-034) with highest index were evaluated for their cellulase activity by growing in CMC broth. It was found that isolate T30-034 displayed the highest enzyme activity (0.042 U/mL). The isolate will have to be further studied to identify species by molecular analysis. The optimal growth conditions such as pH, temperature, fermentation time will be further investigated in order to obtain enzymatic function information. In this study, we firstly describe the termite fauna in the study site. Overall, the findings of this present study provide the knowledge about biodiversity and variation of the termite population which can be applied for ecosystem conservation in the future.

KEYWORDS:
Termite; diversity; cellulolytic microbes; Nongrawiang Center
Species and productivity of mushrooms in Nong Khu Silvicultural Research Station, Surin province

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ABSTRACT:
Nong Khu Silvicultural Research Station is located in the forest area in the lower part of North Eastern Thailand that is naturally covered by the 2-needle pine (*Pinus merkusii*). Mixing of broad leaf trees and coniferous pines in this area provides diversity of wild edible mushrooms for consumption and sale by the around villagers. To study species and productivity of mushrooms in this area, 24 plots, each plot with the area of 1600 square meters, were distributed over the total area of 3.68 square-kilometers. During the wet season of 2018 (June-October) mushrooms were surveyed and collected from these plots once a week. Then the mushrooms were identified and weighed. The results revealed 47 mushroom species bloomed in these plots. Species of *Lactarius*, *Guyanaporus*, *Russula*, *Mycoamaranthus*, *Termitomyces*, and *Amanita* were species with high productivity. Mushrooms bloomed in three weeks of each month in June, July and August, two weeks in September, and one week in October. The productivity of mushrooms highly correlated with the amount of rainfall.

KEYWORDS:
Nong Khu Silvicultural Research Station; pine forest; wild edible mushroom; productivity.
Health benefit screening on 45 Thai human probiotics (TISTR strains): their safety and immunomodulatory activity in macrophage function

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ABSTRACT:
Probiotics are defined as living microorganisms which promoted as having various health benefits. They can inhibit overgrowth of pathogenic bacteria by antibacterial substance production and stimulating the immune system. They have been demonstrated the effects on the variety of immune cells such as phagocyte (macrophages and neutrophils), lymphocytes and natural killer (NK) cells. However, the immune system effects, which have been associated with a limited number of probiotic stains and species, cannot be presumed to exert the same effect. This study aimed to analyze the phagocytic activity and cytotoxicity on macrophage RAW 264.7 cells induced by 45 TISTR human probiotic strains. Forty five strains (Med 1 to Med 45) of human probiotics from the probiotic bank of Thailand Institute of Scientific and Technological Research (TISTR) were used in this study. For experimentation, heat killed supernatants were prepared from 48 hr culture anaerobically grown in de Man Rogosa and Sharpe (MRS) broth supplemented with 0.05% L-cystiene. Cell pellets were collected and suspended in Dulbecco’s Modified Eagle Medium (DMEM) without antibiotics before being heated. The heat killed supernatants were tested without dilutions (at 100% concentration). Their cytotoxic property and phagocytic activity were determined on macrophage RAW 264.7 cell line (ATCC® TIB-71™) using the water-soluble tetrazolium salt (WST-1) and neutral red uptake assays, respectively. WST-1 assay was quantitated by the ability of living RAW 264.7 cells to reduce the yellow dye 3-(4,5-dimethyl-2-thiazoyl)-2,5-diphenyl-2H-terazolium bromide (MTT) to a blue formazan product. The results were expressed as % cell inhibition compared with the control cells. It was found that most TISTR probiotic strains (27 out of 45 strains) showed no significant cytotoxic activity against RAW 264.7 cells. In contrast, 10 strains clearly demonstrated a cell-proliferation promoting activity with cell survival rate greater than 100% compared with the untreated cells. It is clearly known that macrophages contribute to the activation of immune responses against infectious agents through phagocytic activity. In this study, phagocytic activity of all 45 TISTR probiotics were determined by their capability on up-taking phenol red particles which acted as foreign bodies. Beta-glucan (100 µg/ml) was selected and used as a positive control. The results revealed that 16 out of 45 TISTR probiotic strains possessed positive phagocytosis in macrophage RAW 264.7 cells. An increase in percentage of phagocytosis (% phagocytic activity) in RAW 264.7 cells induced by these 16 TISTR probiotic strains was found in a range of 2.58 (Med 6 & Med 36) to 39.89% (Med 1 & Med 39) in comparison to control (0% phagocytic activity) and β-glucan (64.43% phagocytic activity). Among 45 TISTR probiotic strains, Med 1, Med 31, Med 39 and Med 42 are considered to be the most active strains regarding to their safety and phagocytic activities on macrophage RAW 264.7 cells. These results suggest that administration of these four TISTR probiotic strains may result in an initiation of immune reaction against foreign materials. Therefore, they can be employed as a natural resource for development to healthy dietary supplement such as functional food products.

KEYWORDS:
Immunomodulation; macrophages; phagocytosis; probiotics; RAW 264.7; TISTR
Co-cultivation of amylase producing bread expired moldy and \textit{Saccharomyces cerevisiae} in starch solution for ethanol production

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ABSTRACT:
This research aimed to offer producing of ethanol from co-culture between bread fungus from expiration date and \textit{Saccharomyces cerevisiae} which is the waste back to build useful. The ethanol production obtained from the degradation process of 4 starch samples including glutinous starch, cassava starch, corn starch and rice starch by bread fungus. The identified Rhizopus fungus was used and was cultured in Yeast Malt broth starch 0.5g (YMB starch) containing 0.5g Starch powder at 30°C under co-cultivation with \textit{Saccharomyces cerevisiae} Yeast Malt broth starch 0.5g (YMB starch) containing 0.1% (w/v) soluble starch at 30°C for 4 days under a shaking condition to obtain exogenous crude enzymes. Amylase activity of the crude enzymes was determined using starch agar plates with a DNS method. The starch agar plates for the enzymatic hydrolysis contained four types of starches (glutinous starch, cassava starch, corn starch and rice starch). The results showed that the crude enzymes had the highest activity when the glutinous rice starch was used as a substrate. The maximum reducing sugar produced from the glutinous rice starch was 0.52 mg/mL after 7 days of incubation. This amount was equivalent to 0.52% (w/w substrate). \textit{Saccharomyces cerevisiae} cultured in glutinous starch with bread fungus after 7 days were obtained 2.74% of ethanol concentration.

KEYWORDS:
Amylase; crude enzymes; ethanol; bread fungus
Enhancing the survival of biocontrol agents *Pseudomonas putida* KnCo4 Thai strain under salinity condition by osmoadaptation

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ABSTRACT:
The efficacy of biocontrol agents are greatly dependent on environmental conditions. Previously, the method of osmoadaptation has been used for improve ecological fitness of biocontrol agents under unfavorable environments such as drought and salinity conditions. In this study, the survival of bacterial antagonist *Pseudomonas putida* KnCo4 under osmotic stress was developed by osmoadaptation. Screening the optimal of osmotic agent (NaCl) concentrations and exogenous osmolytes on bacterial growth revealed that KnCo4 was able to grow in M9 medium supplemented with NaCl up to 3.5% (w/v) and 1 mM glycine betaine (GB) was the osmolyte that show highest efficacy to improved growth of KnCo4 under osmotic stress. For intracellular glycine betaine contents analysis by LC-MS technique, the highest accumulation of GB in KnCo4 cells when cultured in osmotic stress condition (M9+3.5% NaCl medium) was observed. The expression of glycine betaine transporter gene of KnCo4 was also strongly induced under osmotic stress conditions when determined by qRT-PCR. Interestingly, we also observed the decreasing of content or gene expression of glycine betaine on M9+3.5% NaCl+1mM GB condition. To assess the efficacy of KnCo4 osmoadapted cells on survival under osmotic stress condition, the growth of KnCo4 cells from M9+3.5% NaCl+1mM GB medium was similar to that of KnCo4 from M9 (non-osmotic stress condition) suggesting that exogenous glycine betaine enhance salinity tolerance of KnCo4. Both of conditions increased 3-4-fold OD of the cultures. These findings demonstrated that the applications of osmoadaptation have improved the growth of antagonistic bacteria KnCo4 under salinity condition.

KEYWORDS:
Compatible solute; limiting environmental conditions; osmoadaptation; osmolyte; osmotic stress; salinity tolerance
Antifungal activity of endophytic fungi isolated from tea 
(Camellia sinensis) against gummy stem blight disease in melon

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ABSTRACT:
Endophytes have shown the beneficial roles of host-endophyte associations as resistance to pathogenic fungi, nutrient uptake and stress tolerance in various plants including agriculturally important crop. Gummy stem blight is a major disease of many cucurbits. This disease can occur at any point in plant growth, from seeding stage to fruit. The goal of this study was to evaluated antifungal activity of endophytic fungi isolated from tea (Camellia sinensis) using in vitro assay. The 109 endophytic fungi were isolated from tea plants cultivate in organic and conventional systems. Crude extracts of those endophytic fungi were obtained after grown in Potato Dextrose Broth (PDB) media for 4 weeks at 28ºC, followed by extraction with Ethyl acetate. Ten endophytic fungi that showed possible of mycelium inhibition from disc diffusion assay were furthered evaluated in poisoned food technique. Interestingly, crude extract of two endophytic fungi (SI-006 and YI-101) at 0.9 mg/ml displayed strong inhibition (95.319 – 95.796% inhibition) in the same level of recommended fungicide (Carbendazim, 95.756% inhibition). These suggested that endophyte fungi from this study have high potential to develop into important biological agents to control pathogens caused gummy stem blight disease in the future.

KEYWORDS:
Endophytic fungi; antifungal activity; Camellia sinensis
Nutritional study of edible wild mushrooms collected from Ba Hi forest, Phanna Nikhom District, Sakon Nakhon Province

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ABSTRACT:
In this study, our research group have examined nutrition value of wild edible mushrooms collected from the Ba Hi forest in Phanna Nikhom District, Sakon Nakhon Province during May to July, 2018, in order to provide basic information for selection of mushroom species for consumption, and transfer knowledge back to the local communities. Based on collecting of 94 edible wild mushrooms specimens and their data, including local names, they were classified into 49 species. Among them, Russula is the most popular among the community. Further nutritional examination of 10 mushrooms were performed by standard proximate analysis. As results, Termitomyces sp. BEDO0100 contains high protein percentage at 37.04. Amanita egregia BEDO00062 contains fat percentage at 7.98. Astraeus cf. odoratus BEDO00027 has the highest percentage of carbohydrate at 57.47. Boletus sp. BEDO00053 provides energy most at 370 kcal/100g. The total sugar analysis with High-performance liquid chromatography (HPLC) showed that Russula cf. nobilis BEDO00040 has a high sugar content at 0.93g /100g of dry weight. In contrast, no sugar have been detected in Amanita sp., Boletus sp., Xerocomus sp., Russula paludosa and Termitomyces sp.

KEYWORDS:
Community; nutritional; edible mushrooms
Biocatalytic microfungi isolated from *Nepenthes* (Monkey cup) digestive fluid

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ABSTRACT:

*Nepenthes* carnivorous plant, well-known as Monkey cup, evolved its pitcher as a passive trap to bait insects and arthropods. It secretes enzymes that co-working with microbes inside the pitcher fluid to digest the preys under the acidic condition. In this preliminary study, twenty local *Nepenthes* plants from southern Thailand were surveyed and investigated the digestive fluid pitchers to isolated and identified biocatalytic microfungi by morphological and molecular techniques. Those fungal databases were provided for the pH profiles from 2 to 5. As the results, Thirty three microfungi isolates in 10 species were identified. They belong to 2 phyla, 4 classes, 5 orders, 6 families and 8 genera. The most abundance biocatalytic microfungi are *Penicillium* sp. and *Aspergillus* sp. with 40% and 25% respectively. This research further aimed to investigate relationship of bacteria, yeast, fungi, actinomycetes and uncultururable microbes in *Nepenthes* digestive fluid and identified them for further knowledge as potential source for commercial.

KEYWORDS:
Acidic condition; Microfungi; *Nepenthes* plant; Pitcher; Taxonomy
Cloning and expression of glucoamylase gene from *Aspergillus aculeatus* BCC17849

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**ABSTRACT:**
Glucoamylases are exo-acting starch degrading enzymes releasing glucose from the non-reducing ends of starch and related substrates. In this study, glucoamylase *(aqGa)* gene was isolated from fungal strain *Aspergillus aculeatus* BCC17849. Based on amino acid sequence analysis, glucoamylase (AqGa) contains 2 domains of glucoamylase catalytic domain (GH15) and starch-binding domain (SBD) with signal sequence at the N-terminus. The mature glucoamylase *(aqGa)* gene with 1,869 bp was cloned in-frame with α-factor in pPICZαA vector and expressed in *Pichia pastoris* KM71 under the control of methanol inducible promoter (AOX). The secreted recombinant glucoamylase was observed as a single band with expected size of 68 kDa. AqGa glucoamylase exhibited hydrolytic activity toward soluble starch with 44.27 U/ml at 50°C, pH5. These demonstrated the potential application of recombinant glucoamylase that could be used for converting of starch and waste from cassava processing into fermentable sugar and high value added products in biorefinery industry.

**KEYWORDS:**
Glucoamylase; *Aspergillus aculeatus*; recombinant; starch; biorefinery
Diversity of entomopathogenic fungi in protected forest in the eastern of Thailand

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ABSTRACT:
The entomopathogenic fungi or insect fungi are widespread in nature. They are a well-known as a rich source of bioactive compounds which prove to useful in medicinal and agricultural applications. There are about 400 species recorded from natural forests in Thailand. However, our knowledge of entomopathogenic fungi species diversity in the eastern of Thailand is limited. During June 2017-December 2018, we studied species diversity of entomopathogenic fungi in Khao Soi Dao Wildlife Sanctuary, Chanthaburi province and Mu Ko Chang National Park, Trat province. A total of 537 samples were classified to 3 families; Clavicipitaceae, Cordycipitaceae and Ophiocordycipitaceae in the order Hypocreales. These fungi were revealed into 43 species based on morphological character study. The infected insects were in 8 major orders including Coleoptera, Hemiptera, Hymenoptera, Isoptera, Lepidoptera, Neuroptera, Orthoptera and spider in Araneae order of class Arachnida. The most infected insects were in Hymenoptera order (44.87 percentage). The most abundant species was Ophiocordyceps unilateralis. In addition, Ophiocordyceps species found on Coleoptera larvae and Orthoptera in Mu Ko Chang National Park will be tentatively described as new species based on morphology and phylogenetic analysis.

KEYWORDS:
Entomopathogenic fungi; diversity; taxonomy; protected forest; eastern
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BIODIVERSITY AND HEALTH
Prevalence of blood parasites in wild birds of northeastern Thailand

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ABSTRACT:
Blood parasites in birds generally have a negative impact on bird health and often cause mortality in wild birds. The objective of this study was to investigate blood parasite infection in wild birds at Khon Kaen University. Birds were caught using mist-nets during March-October 2018. A total of 79 blood samples were collected from 15 resident birds species and 53 samples from 8 migratory species. The result shows that 45.45% of the samples of 15 bird species were infected. Four genera of parasitic protozoa were detected and identified including Haemoproteus (71.67 %), Plasmodium (23.33 %), Trypanosoma (10 %) and Microfilaria (13.33%). The infection in resident birds 54.43 % (n=43) was significantly higher than the migratory birds 32.08 % (n=17) ($X^2 = 6.3935, p < 0.05$). Scaly-breasted Munia (Lonchura punctulata) was the highest incidence of infection with a prevalence of 93.55% which higher than the previous report in the same area. Thick-billed Warbler (Arundinax aedon) was the highest prevalence infection in migratory birds (85.71%). Resident birds have all level of infection from low to very high levels while migratory birds have low and medium levels. In addition, 18.33 % of the samples infected by more than one genus of parasites. The study shows that blood parasites protozoa infection in wild birds in this area is higher than other reports either within the country or from other areas of the world. The results from this study will be useful information for infection pathway management of avian hosts as well as epidemiology management of those diseases which can affect both bird and human populations. This is an important issue to be monitored and surveillance in both of other animals and human.

KEYWORDS:
Avian blood parasites; avian malaria; parasite prevalence; wild birds; wildlife disease
Diversity of *Vibrio* spp. in three major food mollusks from central region of Thailand

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ABSTRACT:
Divergence of important seafood-borne pathogens of five *Vibrio* spp. including *V. parahaemolyticus*, *V. cholera*, *V. vulnificus*, *V. alginolyticus* and *V. mimicus* from three commonly consumed mollusk species in Thailand; *Paphia undulate* (surf clam), *Anadara granosa* (cockles) and *Perna viridis* (green mussels) were examined. Thirty-five samples from three major distributing markets in Central region of Thailand (Pathumthani, Nakhon Pathom, and Samut Sakhon) were purposively sampling and collected. DNA preparation from seafood samples was established using a modified method from Wizard® SV Genomic DNA purification System. The presence of *Vibrio* spp. was identified using *Vibrio* specific primers. From thirty-five samples, 71.43% (25/35) of the samples were positive to free-living/uncommon-pathogenic *V. alginolyticus* following by 68.75% (24/35) of the renowned seafood-borne pathogenic *V. parahaemoliticus*. While *V. vulnificus* was found in 9 of 35 samples (25.71%). Unlike the others, two of the causative agents of seafood gastroenteritis and a public health concern *V. cholera* and *V. mimicus* were discovered in only one mussel sample (2.86%) and in two mussels and a cockle (8.57%) respectively. *Vibrio* spp. was not detected in five samples (14.29%). Co-infection of at least two *Vibrio* species in one mollusk type was found frequently (43%). Interestingly, differences of *Vibrio* spp. in each mollusk and source markets were distinguished. These results indicate that environmental variation at least in the Gulf of Thailand may affect the survivals and the host range of important seafood-borne/ environmental indicator pathogens *Vibrio* species in marine mollusk classes. This finding might not only have an impact on animal-human-agent-environment equilibrium, but also have an impact on public health awareness of seafood-borne pathogen monitoring and control program planning in Thailand.

KEYWORDS:
*Vibrio* spp.; seafood-borne; molluscs; PCR; Thailand
Effect of water temperature on growth, survival and health status of East Asian bullfrog (*Hoplobatrachus rugulosus*) larvae

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**ABSTRACT:**

East Asian Bullfrog (*Hoplobatrachus rugulosus*) is an economically and nutritionally important animal in Thailand. However, many factors including UV radiation, infection and especially the fluctuation of temperature adversely affect the East Asian Bullfrog culture. Thus, the aims of this study was to investigate the effects of water temperature changes on the survival and growth as well as oxidative stress of the *H. rugulosus* tadpoles. In the first experiment, frog tadpoles were divided into seven groups of 90 each (3 replicates). Group 1-3 were served as cold shock groups and groups 4-6 were served as heat shock groups. For cold shock groups, the initial temperature was set at 25°C and then decreased to 23°C, 20°C and 17°C. For heat shock groups, the initial temperature was set at 25°C and then increased to 27°C, 30°C and 33°C. The control group was maintained at 25°C throughout the experimental period. After 7 days of exposure, the survival rate of the tadpoles was measured and their body lengths were measured to determine growth rate. The liver of frog tadpoles were collected for histological investigation. In the second experiment, frog tadpoles were divided into 3 groups of 90 each (3 replicates). They consisted of 1 cold shock (23°C), 1 heat shock (27°C) and control group. The tadpoles were exposed to heat and cold temperatures until they reached Gosner stage 42. They were then collected for determining oxidative stress by measuring the level of malondialdehyde (MDA). The result showed that cold shock and heat shock significantly decreased the survival rate of the tadpoles when compared to those of control groups. In addition, the highest survival rates were found in cold shock at 23°C and heat shock at 27°C. However, there was no significant difference (p>0.05) of their body length at day 0 and day 7 among the experimental groups. Histological examination showed blood congestion and a large number of melanomacrophage centres (MMCs) in the liver tissue of tadpoles exposed to cold and heat shock when compared to those of controls. Furthermore, cold and heat shock groups significantly increased MDA level in whole body of the tadpoles.

**KEYWORDS:**

Growth; *Hoplobatrachus rugulosus*; survival; tadpole; temperature
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ANIMAL ECOLOGY:
VERTEBRATE LIFE IN DIVERSE ENVIRONMENT
Foraging ecology of the green cat snake: a major avian nest predator in dry evergreen forests of Sakaerat Biosphere Reserve, Thailand

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ABSTRACT:
Snakes have been identified as significant predators of avian nests through a number of studies investigating reproductive success in birds. However, only a few studies have attempted to directly examine these predators and their interactions with prey. An ongoing nest monitoring study, initiated in 2013 in the dry evergreen forests of Sakaerat Biosphere Reserve (SBR) in northeastern Thailand, revealed that the Green cat snake (Boiga cyanea) is the primary avian nest predator, responsible for approximately 25% of all documented avian nest predations. In order to gain an insight into the free-ranging ecology of these cryptic predators, we have radio-tracked a total of 12 adult B. cyanea since August 2017, in the same forest fragment as the nest monitoring study. We present the home range estimates of our radio-tracked B. cyanea between August 2017 and May 2019 in the SBR, using dynamic Brownian Bridge Movement Models (dBBMMs). We further attempt to explore the relationship, if any, between our radio-tracked individuals’ activity patterns and predations caused by B. cyanea within the dry evergreen forests of the SBR. This study will help elucidate baseline information on the spatial and foraging ecology of a relatively unstudied species of tropical, arboreal, nocturnal snake. Furthermore, the results will enhance our overall understanding of the role of snakes in nest predation and failure, especially in the tropics, and will ultimately allow us to better predict these predator-prey dynamics.

KEYWORDS:
Avian nest predation; radio-telemetry; spatial ecology; foraging ecology
The Study Karyotype of *Betta mahachaiensis* and *B. smaragdina* in Thailand

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**ABSTRACT:**
The karyotypes study of *Betta mahachaiensis* and *B. smaragdina* from Thailand by using conventional staining technique. The chromosome preparations were taken from gill and kidney tissue of 10 fishes. The results showed that the diploid chromosome number of *B. mahachaiensis* and *B. smaragdina* were 2\(n\) = 42. The fundamental number (NF) of *B. mahachaiensis* was 70 and *B. smaragdina* was 50. The type of chromosomes were 6 large acrocentric, 6 large telocentric, 2 medium submetacentric, 20 medium acrocentric and 8 medium telocentric of *B. mahachaiensis* and the type of chromosomes were 4 large acrocentric, 4 large telocentric, 4 medium acrocentric and 30 medium telocentric of *B. smaragdina*. The karyotype formulas are as follows: *B. mahachaiensis* (2\(n\) = 42): L\(a_6\) + L\(t_6\) + M\sm\(2\) + M\m\(20\) + M\t\(8\) and *B. smaragdina* (2\(n\) = 42): L\(a_4\) + L\(t_4\) + M\a\(4\) + M\t\(30\).

**KEYWORDS:**
Karyotype, *Betta smaragdina*, *Betta mahachaiensis*, Chromosome
Circadian cycle of corticosterone secretion in the hawksbill turtle *Eretmochelys imbricata* in captivity at Talu Island, Prachuap Khirikhan province

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**ABSTRACT:**
Hawksbill turtle, *Eretmochelys imbricata*, is one of the four sea turtles that have been reported to lay their eggs on beaches in Thailand. With the current rate of population decline, *E. imbricata* has been listed as a critically endangered species by the IUCN. In Thailand, stable number of hawksbill turtle nesting was found at the Talu Island, Prachuap Khirikhan province. As a result, a head-start program has been established at the island so that the eggs are incubated semi-naturally until hatch, and hatchlings are reared in captivity to increase the survival rate before release back to the wild. Raising turtle in captivity may lead to stress response including corticosterone secretion and, consequently, suppression of immune system. However, there is a limitation on using corticosterone level as a marker of health status since level of corticosterone is known to varied throughout the day. This study thus aims to examine circadian variation in corticosterone secretion of the hawksbill turtle in captivity. Blood samples were collected from juvenile hawksbill turtles (n=70) at Talu Island in October 2018. Plasma samples were assayed for corticosterone with ELISA kit. In addition, environmental factors such as water temperature, water salinity, water pH, air temperature and light intensity were recorded. The results on cycle of corticosterone secretion in hawksbill turtle will be presented, and its potential correlation with environmental factors will be discussed. The results can be used as a basis for the understanding of the stress physiology of the hawksbill turtles in captivity.

**KEYWORDS:**
Diurnal rhythm; environmental factors; sea turtle; stress physiology
Ovipositional preferences of Tawny Coster *Acraea terpsicore* (Linnaeus, 1758) in wild and cultivated *Passiflora* spp.

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**ABSTRACT:**
Ovipositional preferences of butterflies to host plants are crucial for biodiversity conservation. *Acraea terpsicore* (Linnaeus, 1758), a very common nymphalid butterfly in Thailand, utilizes some specific host plants, particularly in family Passifloraceae, such as *Passiflora foetida*, *P. edulis* and *P.* ‘Lady Margaret’, and several of these plants are economically important. This study aims to compare wild and cultivated host plants of *A. terpsicore* for ovipositional and larval preferences. *Acraea terpsicore’s* eggs and caterpillars were observed on six plants species in 2 experimental plots (size 7x11 m²), a wild *Passiflora* sp. host plants (*P. foetida*), a cultivated *Passiflora* fruit crop plant (*P. edulis*), cultivated *Passiflora* ornamental plant (*P. x alato-caerulea* and *P.* ‘Lady margaret’), a reported non-*Passiflora* host plant (*Cucumis sativus*) and a non-host plant species (*Vigna unguiculata*) in Chulalongkorn center of learning network for the region, Saraburi campus. Population of adults *A. terpsicore* in the area was estimated with point counts around the study sites in four 250m transects. In this study, we found the total of 4,059 eggs and 3,135 caterpillars in experiment plots from the 2 locations. Most eggs were found on *P. foetida* (50.63%) followed by *P.* ‘Lady Margaret’ (23.40%) and caterpillars were equally found on *P. foetida* (38.66%) and *P.* ‘Lady Margaret’ (38.50%), respectively. Moderate amount of eggs (20.65%) and caterpillars (17.86%) were found on *P. edulis* and we could not find any egg and caterpillar in *C. sativus* and *V. unguiculata*. In surrounding area, *A. terpsicore* is the 4th most abundant butterfly species with 225 individuals from the total of 2,905 surveyed butterflies. From these results, we conclude that *A. terpsicore* prefers though not exclusively to oviposit on *P. foetida*, which is a common wild *Passiflora* in South-east Asia. The presence of other *Passiflora* spp. provide alternative host plants to *A. terpsicore* to a certain degree, and diversity of host plants would benefit a broad specialist as *A. terpsicore*.

**KEYWORDS:**
Agroecosystem; host plant preferences; Lepidoptera; microhabitat; Nymphalidae; Passifloraceae
Breeding behavior of Indochinese Spitting Cobra (*Naja siamensis*) in Sakaerat Biosphere Reserve, Nakhon Ratchasima, Thailand

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ABSTRACT:
Though Thailand is thought to have over 200 species of snake, very few have been documented as exhibiting nesting attendance. Of those 200 only 5 species have been documented attending a clutch. Nest attendance is thought only to occur in King Cobras (*Ophiophagus hannah*) in the family *Elapidae*; however, we report evidence of Indochinese Spitting Cobra *Naja siamensis* staying with their clutch until neonate arrival. From January 2015 through July 2018 we radio tracked 15 (8 male, 7 female) *Naja siamensis* in the Sakaerat Biosphere Reserve, Northeastern Thailand. Through radio tracking and utilizing field cameras, we recorded two mating pairs and a total of 5 nests attended by 4 different radio tracked females. Unfortunately, one female was killed by local villagers during nesting. Using camera trap data and in-field observations, we recorded potential nest predators in the nesting area. For example, one of the nesting sites was unsuccessful due to predation caused by Small Banded Kukri *Oligodon fasciolatus*. In total, we documented 35 neonate cobras. The information gathered here has wide reaching implications for understanding the behavior and natural history of the medically important, yet misunderstood species.

KEYWORDS:
Breeding strategy; *Elapidae*, parental care; reproduction
Body condition index and pathological infection in mahseers (Cyprinidae: *Neolissochilus soroides*)

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ABSTRACT:
Nam Tok Phlio National Park in Chantaburi province has been known for the abundance of mahseers and frequently visited by tourists compared to nearby Nam Tok Khlong Kaeo National Park in Trat province. All mahseers in these national parks were identified as *Neolissochilus soroides* (Cyprinidae). Analysis of body condition index in *N. soroides* (N = 81) showed significant differences between these two sites. Many individuals from Nam Tok Phlio National Park showed nematode infection, which was corresponded with unusual body shape, while those in Nam Tok Klong Kaeo National Park were not infected. The nematodes were identified as *Ascaris* sp., which was normally found in humans and pigs but first reported in freshwater fish in this study. Sources of *Ascaris* sp. remain to be investigated but they are likely related to tourist activities and waste management.

KEYWORDS:
Mahseer, *Neolissochilus soroides*, morphology; nematode infection; national park
Biodiversity decline in the tropics: Local extinctions revealed by
the recent fossil turtle record of the central plain of Thailand

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ABSTRACT:

With more than 50 extant turtle species, Southeast Asia hosts one of the most important hotspot of turtle biodiversity. However, the distribution areas of most species are decreasing as a consequence of human activities. The causes of this decline are multiple: habitat and natural resources destruction, introduction of invasive species, hunting, etc. Historical data are, however, still lacking for a detailed understanding of that regional trend as well as for forecasting its evolution in the future. Indeed, while oral testimonies and text data can provide a rather good appreciation of the decline of biodiversity over the last few decades; nothing is known about the dynamic of turtle biodiversity over the Holocene. This lack of data is especially damaging in areas where human activities are interacting for a long time with the wild fauna, as the central plain of Thailand, which is now dominated by agricultural landscape.

In order to solve these issues, we investigated five holocene localities in Thai central plain which provided assemblages of turtle remains ranging from Neolithic to Dvaravati periods (4000 to 1000 BP). The studied archaeological assemblages showed a very high species richness. Species such as Malayemys macrocephala, Cuora amboinensis, Heosemys annandalei, Heosemys grandis, Siebenrockiella crassicolis, Amyda cartilaginea were among the most abundant. We also found several plates and a cranial material belonging to a species of the genus Batagur and tortoise remains including Indotestudo elongata and a few plates probably belonging to the genus Geochelone. Batagur is absent from living turtle assemblages in the central plain but is present in Myanmar, Cambodia, Indonesia or Southern Thailand in small declining populations. Batagur is usually found in coastal areas and its disappearance from central plain is interpreted as resulting from the destruction of a fragile habitat and possibly from the rapid geomorphological evolution of the Chao Phraya deltaic plain. Tortoises are no more present in the investigated areas; their disappearance likely results from deforestation and possibly hunting. Cutting traces showed that most turtles were used as food resources at these times, suggesting that turtle hunting was a common practise. Furthermore, occurrence of holes in the margin of the carapace of specimens from Kheed Khin (Saraburi Province) and Promthin Tai (Lopburi Province) suggests that turtles were sometimes kept captive alive or transported. This study shows that investigation of recent fossil localities allows for a better understanding of the role of past human populations in the alteration of the biodiversity through time. Furthermore, it points out the importance of archaeological and paleontological data for a more accurate estimation of extinction rates. In the case of the central plain of Thailand, our study shows that the effects of human activities are more dramatic than by only considering archives from the litterature, or inferences from genomic data.

KEYWORDS:
Anthropocene; biodiversity; Holocene; Southeast Asia; turtles
Population estimates of three co-existing Sparrows (*Passer* spp.) in Khon Kaen city

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**ABSTRACT:**
Little is known about population biology or ecology of three co-existing sparrows in Thailand. Most of the information is from personal communications about their population trends where Plain-backed sparrow is decreasing while a new colonist House sparrow is increasing. The objective of this study was to investigate distribution and population sizes of Eurasian Tree Sparrow (*Passer montanus*), Plain-backed Sparrow (*P. flaveolus*), and House Sparrow (*P. domesticus*) in Khon Kaen city. The line transect surveys were conducted during August-October 2018 and Distance program version 7.2i was used to analyses population density. As expected, the density of House Sparrow was highest with the population estimate of 1,255.70 ± 42.12 (SE) birds/km². The Eurasian Tree Sparrow density was 1,154.80 ± 25.98 (SE) birds/km². These two species common in the urban area or human settlements and found in all sampling areas. Plain-backed Sparrow mostly found in agricultural areas or pasture with the lowest density of 14.82 birds/km². Since the house sparrow is a new colonist, the results show its population size is unexpectedly high. This suggests that the house sparrow is well-adapted to new environments and may have a high reproductive rate which can be a potential competitor that could affect other native birds in the urban ecosystem. Long-term monitoring on population changes as well as expanding the survey areas will provide clearer information of population trends of these three co-existing species.

**KEYWORDS:**
Distribution; Eurasian Tree Sparrow; House Sparrow; Plain-backed Sparrow; Population estimate; urban ecosystem
Diurnal variation of hematological parameters in the hawksbill turtle, *Eretmochelys imbricata* in captivity at Talu Island, Prachuap Khirikhan province

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**ABSTRACT:**

Rhythmic changes of environmental factors such as temperature, pH and light intensity, can be varied across the day and season. Therefore, organisms need to adapt their behavior and also physiological processes in response to the changes. One of the biological parameters that can be changed along the environmental factors is hematological parameter. In this study, we aim to observe diurnal variation of hematological parameters in the hawksbill turtle, *Eretmochelys imbricata*, a critically endangered species of sea turtles that can be found in Thailand. Blood samples were collected from the juvenile hawksbill turtles reared at the Talu Island, Prachuap Khirikan province before and during monsoon season of 2018. Blood samplings were carried out at both day time and night time. All samples were subjected to hematological evaluation for differential leukocyte count and packed cell volume (PCV). Environment factors such as water temperature, water salinity, water pH, air temperature and light intensity were measured. Diurnal variation of hematological parameters will be presented, and correlation between environmental factors and hematological parameters will be discussed. The result from this study can be used for the health assessment of hawksbill turtle reared in captivity in the future.

**KEYWORDS:**

Blood; differential leukocyte count; marine turtle; packed cell volume
Gastropod diversity and abundance in relation to the physio-chemical parameters in paddy fields of Chiang Rai province, Thailand

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ABSTRACT:
A study on species diversity and abundance of gastropod in paddy field ecosystem was investigated in Chiang Rai province, Thailand in October 2018. The survey was carried out in 5 stations with 5 sampling sites of 9 m$^2$ in each station. Gastropod samples were collected by 1 m$^2$ Quadrat and in situ measurements of the physico-chemical characteristics of water were conducted using field meters. All data were analyzed to determine gastropod abundance, ecological indices, and statistical analyses were conducted to examine the extent to which the physio-chemical properties and abundance of gastropods.

A total of 943 gastropods were collected and classified into 8 species belonging to 6 families and 6 genera. The gastropod species, total number and relative abundance were: Filopaludina sumatrensis polygramma 9 (0.95%), F. martensi martensi 33 (3.50%), Bithynia funiculata 12 (1.27%), B. siamensis siamensis 776 (82.30%), Lymnaea sp. 7 (0.74%), Melanoides tuberculata 8 (0.85%), Pomacea canaliculata 95 (10.07%) and Indoplanorbis sp. 3 (0.32%). The average abundance of gastropod was estimated to be 108.78±31.15 ind/m$^2$. The most dominant and widest distribution species was found on B. siamensis siamensis which can be found at all sampling sites. The average ecological indices of richness index, diversity index and evenness index were 0.591±0.14, 0.618±0.27 and 0.474±0.22, respectively. Analysis of the data revealed that some physio-chemical parameters of water (electrical conductivity and total dissolved solid) were significantly negative correlations with gastropod abundance, F. martensi martensi (p<0.05), while P. canaliculata was correlated positively with water temperature (p<0.05). In addition, 5 out of these 8 species are of medical importance. The presence of a high number of gastropod species of medical importance (B. siamensis siamensis) indicates that the people participating in various activities on the paddy field are predisposed to infections harbored by this organism.

KEYWORDS:
Gastropod; paddy field; species diversity; physio-chemical parameters; Chiang Rai province
**P4-11**

**Distribution status of two otter species on the southern Andaman coast of Thailand**

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**ABSTRACT:**

Information regarding several globally threatened small mammalian carnivore species in Thailand comes from surveys of terrestrial forests, leaving knowledge gaps in other important ecosystems. This project aimed to evaluate the distribution and status of two threatened otter species (Asian Small-clawed Otter [AScO] and Smooth-coated Otter [ScO]) in mangrove forests of southern Thailand. From July 2016 to December 2018, surveys were conducted in four provinces (Ranong, Phang-nga, Krabi and Trang), covering 4,275 sq.km. In total, 748 line-transects were surveyed along rivers and canals (1,193 km), 750 locations were camera-trapped (15,446 trap-days) in 171 grid cells (5 x 5 km), and 187 local people were interviewed. From our analysis of the camera-trap data, occupancy probabilities of both otter species were positively related to the amount of aquaculture and mangrove forest in a given area. AScO occupied approximately 45% of the surveyed area, while ScO occupied 66%. If otters were present, the chance of detecting AScO by camera-trap was approximately 10% per survey day within surveyed grids, while for ScO it was 25%. Comparing among provinces, occupancy probability of AScO in Ranong Province was significantly lower than in other provinces (20% VS 40-50%), while for ScO the probability was highest in Krabi and Trang Provinces (75%). Regarding activity patterns, both species were diurnal, having activities mainly from 6AM to 6PM and there was 78% overlap between the species. More than half of the local fishermen interviewed (54%) believed that currently otter populations were declining compared with the past 20-30 years (1987-1997) mainly due to anthropogenic activities, prey depletion and habitat conversion. The findings from this study show that currently both AScO and ScO can still be found in all provinces along the Andaman coast of southern Thailand although the numbers are varied. However, due to several anthropogenic threats, their populations have been declining and this trend continues. To prevent their extinction, conservation management specifically suitable for this region where the majority of the land is dominated by people is needed.

**KEYWORDS:**

Asian Small-clawed Otter; camera-trap survey; line-transect survey; occupancy probability; Smooth-coated Otter
Distribution and habitat use of wild pig (*Sus scrofa*) in Sakaerat Biosphere Reserve, Nakhon Ratchasima, Thailand

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ABSTRACT:
In Thailand, wild pig (*Sus scrofa*) was the most widely distributed mammal species in protected areas. The dietary are diverse including plants and animals. Thus, the study of the distribution and habitat selection are important to provided baseline information for conservation and management of wild pig. We estimated the probability of wild pig occurrence in different forest types and the areas close to agriculture land by using sign surveys, and studied habitat selection of pigs in dry and wet season at Sakaerat Biosphere Reserve, Nakhon Ratchasima from July 2015 to March 2016. We surveyed 60 strip transects throughout Sakaerat, and measured environmental variables that might affect the habitat selection and detection probability of wild pig at a transect level. Based on the final inferential model, the distribution of wild pigs occupied 89% (95% CI 67-99%) in the wet season and 51% (95% CI 27-79%) in the dry season and probability of detection 41% (95% CI 35-49%). Habitat selection of pigs was strongly based on complex forest structure with a high density of ground cover. Moreover, the frequency of habitat used indicating high in the evergreen forest than the other forest type. Our results suggest that the distribution of pigs was effected from the human present in the forest. However, the distribution in different seasons was not related to the distance to agriculture land. Nevertheless, the wild pig was damaged crop due to the agriculture land are adjacent to the park boundary, which animals easily moved through the cropland where the movement of animals near the park edge. Forest buffer is important for management implication to reduce the human-animals conflict in the area. The alternative, the non-edible plant may help reduce the problem of crop damaged.

KEYWORDS:
*Sus scrofa*; distribution; Sakaerat; habitat
Comparison of the breeding patterns between northern and southern Thai long-tailed macaques (*Macaca fascicularis*)

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**ABSTRACT:**
It was reported that long-tailed macaques (*Macaca fascicularis; Mf*) inhabiting northern (16°51′N) and southern (7°12′N) Thailand carried different levels (50% and 15%, respectively) of genetic admixture of rhesus macaque (*M. mulatta; Mm*) ancestry, analyzed by autosomal SNPs (Bunlungsup et al., 2017). Since **Mf** are non-seasonal breeder and **Mm** are seasonal breeder (mating peak in October-April), we, thus, hypothesized that the breeding patterns between northern and southern populations of Thai **Mf** are different. Ten adult female **Mf** in each population were selected as focal animals and followed for 12 months (7 days/month/population), from January to December 2018. In each month, the frequency of sexual behaviors (proceptivity, attractivity and receptivity), number of newborn, and sex skin swelling at the base of tail, which implied estrogen levels and ovulation time in **Mf** (scored at 0-4), were recorded. Both populations showed the proceptivity and attractivity behaviors throughout the year. However, the northern population showed a higher frequency of all three sexual behaviors in November-February, while the southern population was higher in January-April. The newborns were observed in every month, except January-March, May, August and October-November for northern population, and March and April for southern population. Average scores of the sex skin swelling were 0.65 ± 0.16 and 1.59 ± 0.27 for the northern and southern populations. In conclusion, the patterns of sexual behaviour, birth and sex skin swelling in northern Thai **Mf** were prone to that of **Mm** than the southern population. From our results, it denotes that the level of genetic admixture of **Mm** into **Mf** has influenced the breeding pattern of **Mf**.

**KEYWORDS:**
Rhesus macaque; SNPs; sex skin swelling; sexual behaviors
Intersex condition in the male rice frog *Fejervarya limnocharis* (Gravenhorst, 1829) living in CU forest and research station, Saraburi province

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**ABSTRACT:**
Frogs has been used as a sentinel for environmental health hazards since their skin is relatively permeable to xenobiotics and their development can be affected by an environmental contamination. Prior study in Nan province revealed that the rice frog, *Fejervarya limnocharis*, living in agricultural areas with different degree of herbicide utilization showed testicular ovarian follicles (TOFs) in adult male testis. It is unclear whether the presence of TOFs is linked to a background contamination of herbicide in the agricultural areas or a normal developmental process of the testis in this species. This study thus aims to examine histological structure of testis in the male rice frog living in areas with no background contamination of herbicide. In 2018, male frogs were field collected after visual encounter surveys from the Chulalongkorn University Forest and Research Station, Saraburi province. After euthanasia, frogs were measured for snout-to-vent length (SVL) and body weight. Testes were weighed and fixed in Davidson's fixative for 24 hours, followed by preservation in 70% ethanol. Testicular tissue was processed through paraffin method and subjected to hematoxylin and eosin staining. Histology of testis was examined under a light microscope and an incidence of TOFs was recorded. An additional set of frog samples was subjected to freeze-dry, extraction, and assay for herbicide contamination (atrazine, glyphosate and paraquat) by ELISA kits to verify that the background level of herbicide residue in frogs from this area is below the detection limit. The results on overall health and gonadosomatic index of the frog in different age- and size class, as well as an incidence of testicular ovarian follicle will be presented and discussed. Association between herbicide contamination and an incidence rate of TOFs will be further used for a validation of using the TOFs as a biomarker of effect and susceptibility for herbicide contamination in this frog species.

**KEYWORDS:**
Amphibian; sentinel species; testicular ovarian follicle; herbicide; histology
Nesting sites and successes of the oriental magpie-robin 
(*Copsychus saularis*) at Naresuan University, Phitsanulok, Thailand

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**ABSTRACT:** The university campus with a mosaic of human facilities and natural areas, are an important habitat for animals, and may influence the population and behaviors of them. In this study, the breeding biology and the nest successes of the Oriental magpie-robin (*Copsychus saularis*) between two cavity types (natural VS artificial) at Naresuan University, Phitsanulok, Thailand, were observed between February and June, 2018. We found fifteen nests, in which only 8 (53%) were successful. Females spent an average of 5.2±0.2SD days (n=4) building their nests, and the average clutch size was 3.8±0.6 eggs (n=11). The incubation period was 11.5±0.5 days (n=9), while the nestling was 13.5±0.5 days (n=9). The daily survival probability was 0.974, and Mayfield’s overall nest success was 51.60%. Five nests were found in natural cavities (e.g., trees) and 10 were in artificial cavities (e.g. mailboxes, poles, control boxes). The nest successes were not significantly different between the natural cavities at 48.6±0.4% and the artificial ones at 54.7±0.2%. Four of the seven failed nests (57%) were depredated by a domestic cat (*Felis catus*) and a Shikra (*Accipiter badius*). The others failed due to nest competition between the Oriental magpie-robin, the Common Myna (*Acridotheres tristis*) and the White-vented Myna (*Acridotheres grandis*). This study suggested that the Oriental Magpie-robin adapted well to urban environments by using human facilities as nesting sites. The breeding biology of urban birds is required to enhance the understanding of urbanization on wildlife and their adaptation to urban environments.

**KEYWORDS:** Breeding biology; cavity-nesting birds; *Copsychus saularis*; nest success; nesting sites; wildlife in urban areas
Distribution, conservation status and the effect of human disturbance on Galliformes in the lowland forest of southern Thailand

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ABSTRACT: Lowland forest in the Sundaic region has been greatly reduced over the past 50 years, especially in southern Thailand where most natural habitats have been degraded due to intense human activity. Consequently, many lowland specialist vertebrate species, mostly birds, have become threatened. Efforts to develop appropriate conservation and management action plans are hampered by a general lack of quantitative information and poor understanding of their ecology in this increasingly degraded habitat. Therefore, the aim of this study was to examine the presence, status and habitat suitability for Galliformes, focusing on the poorly known forest partridges species and larger-bodied species, in the remaining lowland areas in Khlong Saeng Wildlife Sanctuary during Feb-Apr 2017. A total of 13 line transects were surveyed at different distances from the edge of the Chiew Larn Reservoir. Only two species of Galliformes were detected, Great Argus (Argusianus argus) and Red Junglefowl (Gallus gallus). The density estimate for Great Argus was 4.6 (95% CI, 2.1-10.0) calling males/km², increasing in abundance with increasing distance from the reservoir. None of the targeted lowland specialist partridge species were detected. The apparent absence of these partridge could be either due to the low quality of the habitats close to the reservoir edge due to the past disturbance from the reservoir construction, or more alarming, due to a general decline of these species in the area. More areas need to be surveyed to determine their status in the remaining forest patches in the rest of the Sundaic forest range of southern peninsular Thailand, although the sites we surveyed so far represent the largest remaining patches of forest in the peninsula.

KEYWORDS: Forest partridges; Great Argus; Khlong Saeng Wildlife Sanctuary; Sundaic region
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FROM BIODIVERSITY TO NATURAL PRODUCTS FOR DRUG DISCOVERY
In vitro seed sterilization procedures of Som-Phuwua ( Abelmoschus sp. )

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ABSTRACT:
Som-Phuwua ( Abelmoschus sp. ) is a member of Malvaceae family utilized in traditional medicine. Its dried roots help getting strong, having more energy and anti-aging. The flowers, pods, seeds and roots of Abelmoschus species accumulate a lot of secondary metabolites such as phenolic compounds, flavonoids, sterols and fixed oil. These biological compounds could be induced under in vitro culture conditions. The preparation of sterilized explants is the one of the most important process for the success of in vitro propagation. Therefore, this study was designed to optimize sterilization protocol for seeds by comparing between different concentration of sterilant sodium hypochlorite (5, 10, 30 and 50% v/v) and heating in a flame. Sterilized seeds were cultured on 1/2 MS medium for 14 days to evaluate the percentage of disinfection. The results shown that the best surface sterilization procedure with 44.44 % of disinfection seeds shook for 60 min in a 50 % v/v sodium hypochlorite while the seeds sterilized by heating in a flame after dipping in 95% ethanol gave a result for only 24.44 % of disinfection seeds. However, fungal contamination was observed to be a main problem in this study.

KEYWORDS: Som-Phuwua; Abelmoschus sp.; seed sterilization
Evaluation of the antifungal activity of endophytic fungi isolated from *Barleria prionitis* leaves

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**ABSTRACT:**
Natural products are a rich source of secondary metabolites with a wide range of structure diversity, related with agriculture, therapeutic potential, and biological activity. Endophytic fungi is microorganism that reside in the internal tissue of plant tissue without causing any negative effects. The purpose of this research was to study the antifungal activities of the endophytic fungi isolated from *Barleria prionitis*. The endophytic fungi were isolated from leaves of *B. prionitis*, and thirty-six isolates (BP1-BP36) were obtained. *Colletotrichum* spp. were the predominate species among the isolated endophytic fungi. All isolates were screened for antifungal activities against *Neodeightonia rattanicola*, palm rot disease, using dual co-culture assay for a week. It was found that six endophytic fungi isolates showed antifungal activity against *N. rattanicola* with %inhibition ranging from 25-68%. Endophytic fungus BP4 showed the greatest antifungal activity with %inhibition value of 68%. These results indicated that endophytic fungus BP4 isolated from *B. prionitis* was potential sources of antifungal compounds against the tested fungal pathogen.

**KEYWORDS:**
Antifungal; *Barleria prionitis*, dual co-culture; endophytic fungi; *Neodeightonia rattanicola*
Diversity of indigenous vegetables in Puparn Royal Development Centre, Sakon Nakhon province

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ABSTRACT:
A study on diversity of indigenous vegetables in Puparn Royal Development Centre, Sakon Nakhon Province during June 2015 to May 2016 was purposed to collect and classify the indigenous vegetables with revealing their potential as food resources, consumed parts and utilization method. Sixty-three species, sixty genera and forty-three families were identified. The four majorities of plant families are Zingiberaceae, Fabaceae, Araceae, and Asteraceae, respectively. Additionally, identified indigenous vegetables could be classified into six groups based on consumed part including underground stem (4 species), leaves and young shoots (35 species), stem (2 species), flower (5 species), fruit (6 species) and whole plant (21 species). Most of utilization methods were used as salad, steamed or boiled vegetables eaten with chili paste, mined meat, or seasoning in food ingredients.

KEYWORDS:
Ethnobotany; indigenous vegetable; plant utilization; Sakon Nakhon province
From biodiversity to natural products for pest control

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ABSTRACT:
Bio-pesticides are pesticides derived from natural materials as animal, plant and bacteria which are considered as safety for human and other non-target organisms as eco-friendly pesticide. This report is a compilation of the efficacy study of various plants in the prevention of insect and mite pests performed at Natural Products for Pest Control Research Center (NPCRC) project, Faculty of Agricultural Technology, King Mongkut’s Institute of Technology Ladkrabang (KMITL), Thailand. Extract (EX) and essential oil (EO) of plants are well-known substances showing repellent, antifeedant and kill properties against many insect and mite pests tested by using various methods such as direct spray, residue contact and fumigation. Clove and cinnamon EOs were reported with most effective acaricide in controlling house dust mites (Dermatophagoides pteronyssinus and Bromia tropicalis), stored product mites (Tyrophagus sp. and Suidasia sp.) and also showed high toxicity to some insect pests of crop plant (Frankliniella schultzei, Thrips palmi, Aphis gossypii, Bemisia tabaci, Pseudococcus sp.). Black piper, lemon grass and citronella grass EOs were highly effective in controlling mushroom mite pests (Luciaphorus perniciosus, Formicomotes heteromorphus and Dolichocybe indica) as well as high effectiveness against stored product mite and those mentioned insect pests. While, the lemon grass EO expressed the most effective property in controlling the Nilaparvata lugens, the economic insect pest of rice. Star anise and dill plants performed the best insecticidal property against stored product insect pests (Oryzaephilus surinamensis, Tribolium castaneum, Rhyzopertha dominica and Sitophilus zeamais). Where, kaffir lime and cajuput EOs were extremely effective in controlling the Cimex hemipterus. Besides, turmeric and black piper EOs were evaluated highly effective oils against Eutetranychus africanus. As for effective plant extract studies, a part of extract of lemon, eucalyptus, marigold, bottle brush, piper genus, some wild plants (Gloriosa superba, Elaeagnus latifolia and Tectona grandis) performed high potentials to control the larva of Plutella xylostella. The extracts of star anise, dill, clove, long pepper and lemon grass were extremely effective in controlling some stored product insects pests (S. zeamais, Callosobruchus chinensis and Callosobruchus maculatus). Plant EXs and EOs play high efficiency and eco-friendly pesticide with no pest resistance. Then uses of those bio-pesticides are one of alternative method to be applied to fulfill the Integrated Pest Management (IPM) program. However, this bio-pesticide would contain 3 mainly properties; high effectiveness, practical in use and it should not so expensive.

KEYWORDS:
Plant extract, plant essential oil, insecticides, acaricides, green-pesticide
**Xylaria** extract is a substrate of ABC transporter and enhanced antifungal activity in the model yeast *Saccharomyces cerevisiae*

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**ABSTRACT:**
The *Candida* specie is one of leading causes of life-threatening infections, particularly in patients with compromised immunity. Failure treatment is due to repetitive uses of antifungal drugs such as azoles which are the most commonly used in clinical practice, leading to drug resistance. Up-regulation of ABC transporter genes such as *PDR5* (*S. cerevisiae*), *CDR1* (*Candida* sp.) is one of important mechanism of azoles resistance. Natural products with effective antifungal activity have been used to combat against the emergence of drug-resistance. In this study, crude extract from *Xylaria* was ineffective against mutant yeast model overexpressing ABC transporter but active against drug efflux pump deficient strain ADDA. These results suggested that *Xylaria* extract might be a substrate of ABC transporter. The crude extract isolated from *Xylaria* also exhibited antifungal activity against mutant yeast strain and induced genes in lipid metabolism. Moreover, interfering of cellular component was observed in some mutant strains after induced with the *Xylaria* extract. Overall, results demonstrated that *Xylaria* extract, a substrate of ABC transporters, could interfere with organization of cellular components, resulting in increased sensitivity.

**KEYWORDS:**
Antifungal; Drug resistance; Natural product; *Xylaria* sp.; Ergosterol biosynthesis, Drug transporter
Phytochemical screening, antioxidant and antibacterial activities of *Olax psittacorum* (Lam.) Vahl

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ABSTRACT:
Nanjai-krai (*Olax psittacorum* (Lam.) Vahl) belong to family Olacaceae which is annual plant found in Northeast of Thailand. This work was aimed to investigate phytochemical compositions, antioxidant and antibacterial activity of stem and leaves of *O. psittacorum* crude extracts with two different solvents of ethyl acetate and methanol. Standard methods were used for qualitative detection of phyto-compounds, and quantitative detection of antioxidants was done using DPPH radical scavenging assay, total phenolics were expressed in mg GAE/g dry weight and the antibacterial activity were tested against some opportunistic bacteria. Our study showed that phytochemical screening of ethyl acetate and methanolic extracts of leaves and stem from *O. psittacorum* revealed the presence of bioactive substances such as saponins and flavonoids. The terpenoids, tannin and alkaloids were also tested but not found. The ethyl acetate fraction obtained from leaves extract exhibited the highest total phenolics content (2.88±0.07 mg GAE/g) and also displayed antioxidant activity (4.55±0.67 mg TEAC/g). In addition, the ethyl acetate extracts from stem was the most active against the tested bacteria, especially *Bacillus subtilis*.

KEYWORDS:
DPPH radical scavenging assay; total phenolics; opportunistic bacteria
Biodiversity and cytotoxic activities of economic potential mushrooms from the Ba Hi family forest and Dong Yai community forest in the northeastern Thailand

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ABSTRACT:
Mushrooms are important natural resources. They are not only decomposers in ecology system but many of them are also beneficial to humans as food and herbal medicine. In order to study mushroom biodiversity in Thailand, our research team have surveyed and collected mushrooms in the Ba Hi family forest in Sakon Nakhon province, and in the Dong Yai community forest in Amnat Charoen province under the Plant Genetic Conservation Project under the Royal Initiation of Her Royal Highness Princess Maha Chakri Sirindhorn (RSPG). Initially, we have classified 45 samples of mushrooms with economic potential by using the taxonomic morphology together with DNA barcoding in the ITS region, into 37 species. We furthermore investigated the cytotoxic activities of mushroom extracts against human esophageal cell Het-1A, liver hepatocellular cell HepG2, colon cell Caco2 and monkey kidney cell Vero. As results, at a concentration of 100 micrograms per milliliter of mushroom extracts from 6 mushroom fruiting-body samples and 39 mushroom culture samples, only the culture extract from Lentinus cf. fasciatus, RSPG00590 inhibited the metabolic activity of HepG2 liver cell line by 50 percent (IC50) at a concentration of 89.89 micrograms per milliliter. The results of the study will be the basic information for the future use of these mushrooms.

KEYWORDS:
Mushroom biodiversity; mushroom utilization; cytotoxic activity
Utilization of wild plants in Mae Takhrai National Park, Chiang Mai province

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ABSTRACT:
The survey of utilized wild plants by strip plots width 10 m along the two nature trails in Mae Takhrai National Park, Chiang Mai Province in Thailand, 1) Mae Takhrai Reservoir Nature Trail in Amphoe Mae On, distance 4 kilometers (km), at 500–700 meters above mean sea level (m amsl), and 2) at the Park Head Office Nature Trail in Amphoe Doi Saket, distance 3 km, at 400–700 m amsl, were recorded during January 2016 to February 2018. Thirty-two species, 30 genera in 21 families were found to use in daily life of local people nearby. Six species were used for medicinal herbs, 22 species were used for cooking as vegetable dishes and four species were used in basketwork. The local people can collect wild plants part only in the permission areas of the national park for using in their household and according to regulations of the Department of National Parks, Wildlife and Plant Conservation.

KEYWORDS:
Local people; Mae Takhrai National Park; utilization; wild plant
A DNA barcoding for identification of wild flowers, the royal name and medicinal plants in Pha Taem National Park, Thailand

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ABSTRACT:
Wild flower fields at Soi Sawan waterfall, Pha Taem national park are 6.72 ha (42 rai) covered with variety of herbaceous plants as well as carnivorous plants. Most of them manifested colourful flowers and sweet-scented prominent characteristics but they can be seen abloom flowering in only specific season at wetland habitat (November-February). The great pride for Thailand and the Thai people, that Her Majesty Queen Sirikit granted the five most common wild flowers the royal names: ‘Dusita’ (Utricularia delphinioides), ‘Soi Suwanna’ (U. bifida), Thip Kesorn (U. minutissima), Sarassa Chandhorn (Burmannia coelestris), and Manee Dheva (Eriocaulon smitinandii). In this study, carnivorous genera of Utricularia spp. as U. minutissima (Lentibulariaceae) and the medicinal plant as Drosera burmannii (Droseraceae), the mycrotrophic to autotrophic genus of Burmania spp. as B. coelestis (Burmaniaceae) and the genera of Eriocaulon as E. smitinandii and Xyris pauciflora, as shown in the report of those wild flowers that described by Dr. Thawatchai Sunitsuk, Thai botanist and chemist, Fellow of Royal Institute, Academy of Science, the fresh leave samples of Nine species from eight families were collected. Analysis of DNA sequences were done on chloroplast genome at rbcl gene regions using Chain termination method and examined their abilities of species identification and phylogenetic construction were done by using Neighbour Joining and performed relationship with other closed related species obtained from NCBI nucleotide databases. Results were shown Utricularia spp., Drosera spp., Burmania spp., and Eriocaulon spp. can be classified in there lineages. Moreover, two samples of Manee Deva (Eriocaulon smitinandii) were classified as different species. According to assess species identification in conservation biodiversity hotspots, an application on monitoring the illegal international trade of medicinal plant species are benefits.

KEYWORDS:
DNA barcodes; rbcl regions, chloroplast gene, Wild plants; The royal name; medicinal plant; Pha Taem national park
Discovery of plant antimicrobial peptides and laboratory scale production

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ABSTRACT:
Plant antimicrobial peptides (PAMPs) are natural peptide molecules derived from plants with antimicrobial properties. Their targets range from viruses, bacteria to fungi with the activities of replication or growth inhibition, slow and abnormality growth induction, bactericides and fungicides. With the availability of genome, transcriptome and metabolome databases, bioinformatics has been successfully identified these beneficial molecules and in silico study of their properties. Four peptides including P5, P9, P25 and P36 were selected from retrieved genomic and transcriptome data of monocots including maize, sorghum, rice and sugarcane. Their properties were analysed online tools such as the predicted protein server, Phyre2 and AMPA. The molecules had potential to be antimicrobial peptides. In order to determine their activities, E. coli expression system was used to produce these peptides in fusion form. The fusion proteins were selected, digested, purified and concentrated using affinity absorption and size selection methods. Spectrophotometry indicated that the purified peptides had high concentration and can be used for further study.

KEYWORDS:
Plant microbial peptides; defensin; bioinformatics; E. coli expression system; laboratory scale production; protein stability.
ABSTRACT:
Biotransformation of chemical compounds by microorganism is an appropriate approach to obtain significant added value natural compounds under controlled environmental friendly conditions. In this work, the biotransformation of 1,8-cineole, the main compound of *Amomum testaceum* essential oil by 52 endophytic fungi isolated from *Melodorum fruticosum* flowers was investigated. Six pure fungal plugs of each endophytic fungus were placed in 250 mL of potato dextrose broth and individually cultured at room temperature for one week. Thirty microliters of *A. testaceum* essential oil obtained from hydrodistillation were added to each culture broth and the fungus were further cultured at room temperature for three weeks. After the culturing period, each culture broth was partitioned with 100 mL of dichloromethane for three times and the organic solution was then concentrated prior analysis of their chemical compounds by gas chromatography-mass spectrometry compared to those obtained from pure essential oil of *A. testaceum*. The results showed that the biotransformation of 1,8-cineole was achieved by only endophytic fungus MFX-31. A 78% of bioconversion was detected. Three different pure compounds were produced and identified as 3-oxo-cineole, exo-2-hydroxycineole and 3-exo-hydroxycineole. The obtained natural compounds may be potential considerable used in perfume industrial application.

KEYWORDS:
*Amomum testaceum*; biotransformation; 1,8-cineole; endophytic fungi; gas chromatography-mass spectrometry
Antioxidant activity and hair growth promoting activity of flavonoid extracts from *Phyllodium pulchellum* and *Uvaria rufa* blume on cultured mouse vibrissa hair follicles

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**ABSTRACT:**
This study aims to determine antioxidant activity and hair growth promoting activity of flavonoid extracts from the aerial parts of *Phyllodium pulchellum* and the stems of *Uvaria rufa* Blume on cultured mouse vibrissa hair follicles. Flavonoid extracts of both plants were tested for their antioxidant activities using total antioxidant assay, 2,2'-azino-bis (3-ethylbenzthiazoline-6-sulphonic acid) (ABTS), 2,2-diphenyl-1-picrylhydrazyl (DPPH) and nitric oxide radical scavenging assays. To investigate hair growth promotion, vibrissal follicles of mouse were isolated and cultured in 95 % CO₂, 5 % O₂ and 37 degree Celsius. Cultured vibrissal follicles were treated with flavonoid extracts of *P. pulchellum* (PPE) and *U. rufa* (URE) at concentrations of 0.01-20 µg/ml for three days. The length of hair follicles was measured every 24 hours for three days. We found that PPE and URE had total antioxidant at 10.534 ± 0.257 and 11.286 ± 0.043 mg ascorbic acid equivalent per gram extract, respectively. Moreover, PPE and URE markedly exhibited antioxidant activities with the IC₅₀ values at 1.671 mg/ml and 2.440 mg/ml for ABTS assay, and 1.336 mg/mL and 2.445 mg/ml for DPPH assay, and 4421.530 µg/ml and 343.402 µg/ml for nitric oxide radical scavenging assay. PPE at 1 µg/ml significantly increased the length of hair follicles at 24 and 48 hours while URE at 0.01-1 µg/ml significantly elongated hair follicles at 48 and 72 hours when compared to those of controls. The results suggest that the flavonoid extracts from *P. pulchellum* and *U. rufa* are the new sources of antioxidants and the potential promoting hair growth agents.

**KEYWORDS:**
Antioxidant; hair growth; *Phyllodium pulchellum; Uvaria rufa* Blume 

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Study of chemical composition and antioxidant properties of Sangyod and Tubtimchumpae rice bran oil

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ABSTRACT:
Sangyod rice bran oil is a local rice in Phattalung province. Tubtimchumpae rice bran oil is an oil from tubtimchumpae rice in Kamphaeng Phet province. Both types of red rice containing high anthocyanin were cold press extraction which does not pass through the heat so they are useful for the body because they have rich nutrition. The aim of this study was to study the chemical composition and antioxidant properties of Sangyod rice bran oil and Tubtimchumpae rice bran oil. The results revealed that, the chemical compositions of these two rice bran oil in terms of free fatty acids, acid value, peroxide value, unsaponifiable matter and saponification were significantly different (p≤0.05). From the study of fatty acid composition, Sangyod rice bran oil and TubtimChumpae rice bran oil consisted of high unsaturated fatty acid (80.46 and 80.35%, respectively). Main components of fatty acid were oleic acid and linoleic acid. TubtimChumpae rice bran oil contained higher tocopherol than Sangyod rice bran oil (118.8 and 91.3 mg/100g, respectively). Total phenolic compounds were 1.48±0.05 and 1.54±0.03 mg gallic acid equivalent/100 g oil, respectively. DPPH (IC50) were 13.90 and 13.97 mg/ml. ABTS (IC50) were 15.99 and 16.09 mg/ml, respectively. It showed that the two types of rice bran oil possesses important nutrients for the body such as unsaturated fatty acids including antioxidants and vitamin E (α-tocopherol) These oil can be used to increase health benefits in food products.

KEYWORDS:
Sangyod rice bran oil; Tubtimchumpae rice bran oil; chemical composition; antioxidant properties
Phytochemical, antioxidant capacity and pancreatic lipase inhibitory activity of Clitoria ternatea L. (Fabaceae)

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ABSTRACT:
Clitoria ternatea L. has long been recognized a useful plant. The C. ternatea L. is widely used for food coloring, beverage, stress and Ayurveda. Phytochemical (total phenolic content (TPC), total flavonoid content (TFC) and Phenolic acids using High performance liquid chromatography (HPLC)), antioxidant capacity (Ferric reducing antioxidant power (FRAP) and 2,2-diphenyl-1-picrylhydrazyl (DPPH) assay), and pancreatic lipase inhibitory activity of C. ternatea L processing (dried flower, crushed 100% powder and sprayed dry powder) were investigated. The results revealed that dried flower has a higher TFC (314.58±6.32 µg RE/g), and antioxidant activity than crushed 100% powder and sprayed dry powder using FRAP (28.28±1.37 mmol FeSO4/g) and DPPH (96.16±0.13 mg Trolox /10g), while it has a slightly lower TPC (4.98±0.54 mg GAE/g) than others. Phenolic acids; gallic acid, syringic, cumaric and myricetin are most abundant in sprayed dry powder (320.01±22.99, 51.57±1.82, 122.69±5.73 and 6.48±0.68 mg/10g, respectively and catechin is most abundant in crushed 100% powder 65.06±1.03 mg/10g. C. ternatea L. flower extract showed high inhibitory activity toward pancreatic lipase (0.21±2.42 E-05) mmol Orlistat/g dry weight). The results indicated that C. ternatea L. with less processing product such as dried flower has the higher TFC and antioxidant activity than others, however, when compared to phenolic acids using HPLC, the sprayed dry powder has a higher than dried flower and crushed 100% powder. Its dried flower also could be potential to anti-obesity.

KEYWORDS:
Thai medicinal plant; phenolic; FRAP; DPPH
Phytochemical screening and antimicrobial activity of Indian almond leaf extract

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ABSTRACT:
The antimicrobial activity of Indian almond leaf extract which was extracted with distill water, 70% ethyl alcohol and 95% ethyl alcohol. The efficacy test was conducted by paper disc diffusion method on Muller Hinton Agar (MHA). The experiment result revealed that Indian Almond leaves extract by using distill water, 70% ethyl alcohol and 95% ethyl alcohol could inhibit growth of Staphylococcus aureus with the inhibition zone of 4.33 mm, 3.33 mm and 6.67 mm, respectively. However, it couldn't inhibit the growth of Escherichia coli, Klebsiella sp., Citrobacter sp. and Enterobacter sp. The Indian almond leaves extract was subjected to Gas Chromatography–Mass Spectrometry (GC-MS) analysis and compounds was matched with data in the library. A total of 31 compounds and the highest abundance was Benzenethiol 1,2,3-Benzenetriol “Pyrogallol”.

KEYWORDS:
Antibacterial; Indian almond leaves extract; Phytochemical
Epiphytes isolated from *Annona muricata* and *Zea mays* exhibited antibacterial activity

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**ABSTRACT:**
Screening for antibacterial agents producing phylloplane was conducted using an agar overlay technique. Antibacterial activity of ethyl acetate extracts was determined by disc diffusion assay. Two epiphytic bacterial isolates from *Annona muricata* leaves and an epiphytic yeast isolated from *Zea mays* leaves exhibited promising potential. Disc diffusion assay showed antibacterial activity of crude extract of epiphytic bacteria AML8 against *Staphylococcus aureus* TISTR746 and *Bacillus cereus* TISTR121, whilst that of epiphytic bacteria AML14 inhibited the growth of *Klebsiella pneumoniae* TISTR186. Ethyl acetate crude extract of epiphytic yeast ZML2-1 exhibited antibacterial activity against *B. cereus* TISTR121. MICs/MBCs of the crude extract of AML8 against *B. cereus* and *S. aureus* were 6.25/50 and 3.12/100 μg/mL, respectively. The crude extract of AML14 exhibited MIC/MBC of 3.12/100 μg/mL against *K. pneumoniae* and that of the epiphytic yeast ZML2-1 showed MIC/MBC of 6.25/50 μg/mL for *B. cereus*, respectively.

**KEYWORDS:**
*Annona muricata* Linn; antibacterial activity; epiphytes; phylloplane; *Zea mays* Linn.
Outstanding biological resources in Lam Phaya Valley, Lam Phaya sub-district, Mueang district, Yala province

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Abstract:
The status of Lam Phaya Valley is a rain forest. It is abundant with Plateau floor in addition to high biodiversity in both plants and animal species. The lowland areas are used for rice farming. Some areas are small peat swamps or streams which are habitats for fish and a variety of aquatic animals. From such abundance, the study of the outstanding biological resources of Lam Phaya Valley, Lam Phaya Sub-district, Mueang District, Yala Province. The objective being to study biodiversity and utilization of outstanding biological resources such as, economic crops, medicinal plants, food plants and freshwater fish (Betta fish) according to the local wisdom.

The population and sample groups are, the villagers, community leaders, knowledgeable people, local wisdom including organizations and other groups in the community that are involved. The information is collected by organizing a community forum, interviews and field data collection along with exploring the local wisdom in how they use biodiversity then analyzed using textbooks to verify the accuracy of the collected information by academics.

The results show that the two outstanding economical plants are 1) Native Durian (Durio zibethinus Murr.) 149 trees found, mostly used for food consumption. Eaten ripe. The rest is processed by agitation. The seeds are then cultivated as a source. It is also found that the mucus of the durian granules can be applied to wounds from the durian thorn to relieve pain. 2) Garcinia (Garcinia atroviridis Griff.) 11 trees found. Typically, the fresh fruits are cut into pieces and dried to put in various curries to give a sour taste. As for medicinal and food plants, it is found that Lam Phaya people have access to 2 sources. 1) The trading community source found 80 families and 163 species. 2) The natural source found 37 families, 52 genera, 64 species. The medicinal plants that were outstanding were the Longjack (Eurycoma longifolia Jack.) which is used to get rid of poisoning in the body along with nourishing the body. The outstanding food plant is the Bon Som (Homalomena rostrata Griff.) is impressive in the distribution of its species and consumption. The outstanding biological species in water is the wild Southern fighting fish (Betta imbellis) 109 were found. There is a distinctive morphology. The head is a black color while the cheeks have 2 green to blue dashes. The scales are a green to dark blue color all over the body. The fins are a fan shape. Most of the fish found were female since the villagers, in and out of the area, may have taken the male fish due to the popularity of fighting fish in Lam Phaya. From the outstanding characteristics of the all the 3 biological resources, leads to the management of biological resources through community participation processes for sustainability.

KEYWORDS:
Economic crops; Medicinal plants; Food plants and Freshwater fish
Chemical composition and antibacterial activities of essential oils of *Lavandula × hybrid* ‘boysemberry ruffles’, *L. pedunculata* ‘princess’ and *L. × hybrid* ‘high five purple’

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ABSTRACT:
Essential oils of *Lavandula* plants are used in perfumery and therapeutic applications. They are mainly planted in Mediterranean area and several regions in Asia. According to its beneficial property, chemical composition and bioactivity of various species of *Lavandula* plants have been studied. Thus, this study was aimed to extract the essential oils of three species from *Lavandula* plants grown in Thailand including *L. × hybrid* ‘boysemberry ruffles’, *L. pedunculata* ‘princess’ and *L. × hybrid* ‘high five purple’. The chemical composition and antibacterial activity of all essential oils were also investigated. The yield of essential oil obtained among these samples were 0.11–0.24% w/w. The gas chromatography-mass spectrometry was used to identify the chemical composition of essential oil. A total of 89 volatile compounds were identified. Four main compounds including 1,8-cineole, fenchone, camphor and α-pinene were detected in all samples with different contents. For the antibacterial activity assay, the experiment was performed by agar disc diffusion method against four Gram-negative bacteria (*Klebsiella pneumonia, Salmonella typhimurium, Escherichia coli* and *Pseudomonas aeruginosa*) and five Gram-positive bacteria (*Staphylococcus epidermidis, S. aureus, Bacillus subtilis, Enterococcus faecium* and *Streptococcus pyogens*). The result showed that the great antibacterial activity was obtained from the essential oil of *L. pedunculata* ‘princess’ compared to those found in essential oils of *L. × hybrid* ‘boysemberry ruffles’ and *L. × hybrid* ‘high five purple’, respectively. Difference of antibacterial activity among these samples was correlated with quantification of their chemical composition. It was indicated that essential oil of *L. pedunculata* ‘princess’ may be used as natural antibacterial agent in therapeutic applications.

KEYWORDS:
Antibacterial; chemical composition; essential oil; gas chromatography-mass spectrometry, *Lavandula.*
Potential of Thai herbal ethanol extracts for hair greying treatment

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ABSTRACT:
Hair greying (Canities) is a visual sign of aging which can lower self-confidence and also indicate unhealthy conditions. Factors that trigger hair greying have not yet been clearly identified and several exogenous and endogenous factors are discussed. Production of melanin, as the main hair pigment in melanocytes, via conversion of tyrosine by tyrosinase copper-containing enzymes reduces with increasing age and genetic dependency. Environmental stress also results in overproduction of hydrogen peroxide radicals and consequently leads to melanocyte apoptosis. There is no known medical cure for hair greying which can be reversed by colour dyeing; however, use of chemical products is becoming a major health concern. Several Thai herbs with traditional formulations are claimed to prevent hair greying but scientific evidence is lacking. Chemical and biological properties of ethanol extracts comprising of eight herbs as Bengal root (Zingiber cassumunar Roxb.), kaffir lime (Citrus hystrix L.), lemon grass (Cymbopogon citratus Stapf.), ginger (Zingiber officinale Roscoe.), galangal (Alpinia galanga L.), curcuma (Curcuma longa L.), pandanus (Pandanus amaryllifolius Roxb.) and soap pod (Acacia concinna Willd.) were investigated for prevention of hair greying. Main constituents of ethanol extracts were anthraquinone, tannin, flavonoids and saponin which typically acts as a natural surfactant due to its amphiphilic property. Total phenolic content was 50.94±0.11 mg equivalent of gallic acid (GAE). A low IC₅₀ value (0.46±0.02 mg/ml) determined by DDPH assay indicated satisfactory extract antioxidant activity. Cytotoxicity was also determined using MTT assay with follicle dermal papilla cells (1x10⁴cells/ml). At tested extract concentration of 1 mg/ml, no cytotoxicity was observed with stimulation of 22% follicle dermal papilla cell growth compared to control, while at only 0.05 mg/ml concentration, herbal extracts increased melanin content in melanoma cell lines. Results showed promising hair greying treatment activity of ethanol extracts from the eight herbs. Further research is required to better understand the mechanisms of bioactive compounds for hair greying prevention.

KEYWORDS:
Hair greying treatment; herbal extracts; melanin synthesis
Relaxant effects of *Caesalpinia sappan* L. extracts on isolated rats’ prostate strips

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**ABSTRACT:**
Benign prostatic hyperplasia (BPH) is a urological disorder mainly occurs in aging men. Synthetic drugs commonly used to treat BPH by relaxing the prostate smooth muscles have adverse side effects. Thus, phytotherapeutic agents are a popular alternative to treat BPH. *Caesalpinia sappan* L. has been used to treat urological disorders including BPH, in Thai traditional medicine. However, its pharmacological property as regards the relaxation of prostate smooth muscles has not been reported. This study, therefore, was done to determine the relaxant effects of *C. sappan* on rats’ prostate strips *in vitro*. The relaxant efficacy of ethyl acetate and ethanolic extracts from the stems of *C. sappan* (CS-EtOAc and CS-EtOH) was tested on isolated rats’ prostate tissue pre-contracted by adrenaline. The results showed that all of the extracts, as well as tamsulosin, a synthetic drug, exhibited relaxant effects (*P* < 0.001) on prostate smooth muscles. The EC⁵₀ values of the CS-EtOH and CS-EtOAc were 226.35 ± 7.16 and 236.24 ± 5.05 µg/ml respectively, while tamsulosin was 86.83 ± 8.96 µg/ml. Phytochemical investigation showed the more contents of phenolics and flavonoids in the CS-EtOH than the CS-EtOAc extracts. We concluded that the ethanolic and ethyl acetate extracts from the stems of *C. sappan* were the potent in relaxing the prostate smooth muscles, and they may be useful to relieve the urological symptoms caused by the BPH.

**KEYWORDS:**
*Caesalpinia sappan* L.; extracts; prostate strip; relaxation
Chlorophyll content (SPAD-Value), morphology and anatomy of organic medicinal plants and ornamental plants

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ABSTRACT:
Organic medicinal plants hold promising potential in Thailand. Here we investigated via hierarchical cluster analysis the clustering of principal variables of ornamental plant and medicinal plant species out of 27 families. High chlorophyll content was found in Dracaena fragrans L., Erythrina variegate L., Dracaena loureiroi Gagnep, Pseuderanthemum atropurpureum and Bougainvillea hybrid. In leaf, the enlargement of cystoliths were observed in abaxial and adaxial epidermis in Andrographis paniculata (Burm.f). Diacritic stomata with trichomes were observed in abaxial epidermis. Diacritic stomata were located on both sides of leaf epidermis in Ocimum sanctum L. whereas anomocytic stomata were found in Eucalyptus globulus Labill. Stomatal crypta with numerous trichomes were found on abaxial epidermis of Nerium oleander L. Numerous tetracytic stomata were observed in Piper betle. Seven-Eight layers of collenchymatous hypodermis and xylem contained lactone in midrib of leaf in A. paniculata whereas single layer of collenchyma was found in O. sanctum. Midrib of leaf in N. oleander L. presents 2-3 layers of mesophyll isobilateral in adaxial epidermis and 1-2 layers in abaxial epidermis. Moreover, six layers of spongy parenchyma with numerous druses in parenchyma and great U shape of vascular tissue group (bicollateral bundle) and xylem containing steroids were found. Nonglandular trichomes were observed in midrib of leaf in P. betle and terpenes were in pericycle fiber. Epicuticular waxes, thick cuticle, druses in collenchyma and phenolic compound from phloem and sclerenchyma vascular system were observed in E. globulus. Accumulation of anthocyanin containing cells was observed in petioles of O. sanctum.

KEYWORDS:
Chlorophyll content; Medicinal plant; Morphology
P6
FRONTIERS IN TAXONOMY
The effectiveness of basic bait traps for collecting adult flies

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ABSTRACT:
The aim of the present study is to compare the effectiveness of pork meat bait traps (PMBTs) and fish meat bait traps (FMBTs) for collecting adult flies. Bait traps used to collect these species can be damaged by anthropogenic or environmental effects. In this study, PMBTs and FMBTs were hung from trees in the three areas (tree near the pig farm, tree near the dormitories and tree near the fresh market) of the Kasetsart University, Kamphaeng Saen Campus, Nakhon Pathom province, Thailand. This activity was carried out on the first Monday of each week for two months. During the study, 4,252 specimens were collected. Of all these species, 2,903 (68.27%) were obtained from PMBTs, while 1,349 (31.73%) were obtained from FMBTs. Calliphoridae, belonging to three species [Chrysomya megacephala (Fabricius), C. rufifacies (Macquart) and C. nigripes (Aubertin)] were the most abundance in this study. The number of species collected from PMBTs was the same found in the FMBTs, but the number of each individual in each species was different. This study provides baseline information on the necrophilous fauna for estimating postmortem interval in cases of human death in Thailand.

KEYWORDS:
Basic meat bait trap; biodiversity; Diptera, forensic entomology
Apodida (Echinodermata: Holothuroidea) of Thailand

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Abstract
The number of known species of Apodida in Thailand has increased from 11 to 23 during my work and distributing among 7 genera in only 1 family, Synaptidae. Thirteen of them are the new records in Thailand and three species are found as the type locality i.e. \textit{Polychaera echinata}, \textit{Opheodesoma lineata} and \textit{Synaptula violacea}. This revision includes a thorough morphological revision of the entire order Apodida as well as detailed descriptions of external morphology and ossicles and a key for identification.

Key words:
Andaman Sea; Apodida; Gulf of Thailand; Holothuroidea; Thailand
Multiple introductions of Mediterranean recluse spider into Thailand: an analysis of mitochondrial DNA lineage

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ABSTRACT:
Loxosceles rufescens or the Mediterranean recluse spider is a cosmopolitan species with toxic venom, which can occasionally cause dermatological injuries in humans. In 2016, L. rufescens was officially discovered in Thailand from Wang Pra limestone cave in Kanchanaburi Province, which initially believed to be the only locality for this spider in the country. Nevertheless, more L. rufescens specimens were collected from limestone caves in other provinces throughout western and upper-southern Thailand. Here, we report additional locations where the spiders are present along with phylogenetic analyses of L. rufescens partial mtDNA COI gene. DNA sequences of L. rufescens collected were analyzed accompanied by sequences obtained from samples collected from the Mediterranean, Americas, Africa, Australia, and China. Our results suggest that there are at least two mitochondrial lineages of L. rufescens populations in Thailand. These two lineages were postulated to disperse from their natural habitats from the Mediterranean in different times. This finding suggest that more than one introduction events of L. rufescens into Thailand are probable; however, until nuclear DNA evidences provided by microsatellite and/or SNPs data are available to corroborate our hypothesis, we still cannot confirm the origin of this non-native spider in Thailand.

KEYWORDS:
Cave, Loxosceles rufescens, loxoscelism; phylogenetic analysis
Record and nesting structure of a Mygalomorph spider genus *Atmetochilus* Simon, 1887 (Araneae, Nemesiidae) from Thailand

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**ABSTRACT:**

Spiders of genus *Atmetochilus* Simon, 1887 (Mygalomorphae, Nemesiidae) currently comprise of six known species from India, Indonesia, and Myanmar. *Atmetochilus* is long-lived, ground dwelling, and highly endemic. Every described *Atmetochilus* species were reported only from their type localities, no dispersal ranges has been reported. In this study, we reported nesting structure of a putative new species of *Atmetochilus* collected from Phra Thaen Dong Rang Forest Park, Kanchanaburi province. The spider’s nest parameters including burrow entrance diameter, burrow depth, and food remains were discussed. In addition, 3D structure of nest was studied and visualized using plaster of Paris and CT-scan. The results show that *Atmetochilus* constructs single entrance J-shaped burrow with a secondary chamber (refuge). Prey carcasses of the spiders were found at the end of the burrow including ants, beetles, and millipedes.

**KEYWORDS:**

Ecology, Burrow; Wish bone spider
Review of the marine isopod species genus *Cirolana* (Crustacea: Isopoda: Cirolanidae) in the Southeast Asia region

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ABSTRACT:
Southeast Asia is located in a tropical zone connected and linked between Pacific Ocean and Indian Ocean. This area has been proposed to be the extremely high biodiversity of marine organisms. With few of intensive research and uncleared taxonomy, the knowledge on marine faunal crustaceans, especially non-decapod remains minimal and might be underestimated on the number of species biodiversity in this region as found in recently reports in amphipod, tanaidacean and isopod group having shown the increasing of number of species discovery since 2000. The aim of this study is to review and report the diversity and taxonomy of a marine isopod genus *Cirolana*, which show the high diversity and widespread distribution in Southeast Asia region. A total of twenty-nine species were recorded of which twelve species were founded in Thailand, thirteen species in Indonesia, nine species in Singapore, two species in Philippines and one species in Myanmar.

KEYWORDS:
Marine isopod; *Cirolana*, diversity; taxonomy; Southeast Asia
Distribution and habitats of the Philippine tarantula *Phlogiellus bundokalbo* (Araneae: Theraphosidae) in Northern Mindanao and Zamboanga del Sur, Philippines

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**ABSTRACT:**

*Phlogiellus bundokalbo*, a Philippine endemic tarantula is still understudied but is alarmingly at risk to habitat degradation and illegal trafficking. In this study, two regions in Mindanao, Philippines were surveyed to determine the distribution and habitats of this species. Microhabitat requirements and behavior both in the wild and in a laboratory set up were also observed. Of the ten sampling sites, four positive sites have been established. Three of the sites are from Northern Mindanao and one from Zamboanga del Sur. Results also showed that *P. bundokalbo* can be terrestrial, semi-arboreal, or cave dwelling. *P. bundokalbo* prefers moist substrate to semi dry, a 5-meter to 15-meter distance range from the water source, limestone rock formations, and high abundance of prey. It is generalist in nature and although solitary tends to aggregate in clusters. It is sensitive to high temperatures and less active at day time. Its ability to thrive appears to depend on substrate type, nearby water source, prey abundance, and presence of limestone rock formations. It usually occurs in places like bat caves, riparian area or agricultural lands where abundant prey is usually found.

**KEYWORDS:**

Abundance; degradation; endemic; microhabitat
Preliminary study on taxonomic relationship of two species of *Dryocalamus* from Borneo

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ABSTRACT:
Bridle snake, *Dryocalamus* Günther, 1858, is a small arboreal snake, distributed in South Asia and Southeast Asia. Two species of the genus, *D. subannulatus* and *D. tristrigatus*, are known from Borneo Island. Patterns of coloration of the two species are completely different, but those of scalation of the species are relatively similar. We examined the systematic relationship of the two species from Borneo. We collected seven individuals of *D. tristrigatus* from three localities and four individuals of *D. subannulatus* from three localities in Borneo. The molecular phylogenetic analysis of the samples based on the mitochondrial gene indicated close and polyphyletic relationship of the two species. Morphological examination of our samples and museum specimens showed that two species were nearly identical. Our study suggests that *D. tristrigatus* and Bornean populations of *D. subannulatus* are same species. Further molecular phylogenetic and morphological analysis of the species from other localities is needed for taxonomic reassessment of *D. subannulatus* and *D. tristrigatus*.

KEYWORDS: *Dryocalamus*, taxonomy; molecular phylogeny; morphology
DNA barcodes for bamboo-inhabiting beetles (BIBS) in live and post-harvested bamboos in Southeastern Mindanao, Philippines

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ABSTRACT:
The Bamboo-inhabiting beetles (BIB) are known to have the most damaging potential to live and post-harvest bamboos, including finished products and are considered agricultural pests. The study aims to assess the utility of DNA barcoding in the identification of these BIBs. Samples were collected through direct capture in 3 sampling sites. A total of 47 CO1 barcodes from 19 morphologically identified species (morphospecies) of BIBs were collected from Southeastern Mindanao, representing 12 families and 19 genera. Moreover, DNA barcodes revealed 32 genera in 15 families, with only one identified at the species level. This indicates that more molecular studies are needed to be conducted on Philippine Bamboo-inhabiting beetles in order to determine the efficiency and effectiveness of DNA barcoding. Furthermore, intraspecific sequence divergences of BIBs ranged from 0 to 1.9% while interspecific sequence divergences ranged from 0 to 9.5%. The study provides the first DNA barcode records for BIBs from Southeastern Mindanao in the Barcode of Life Data System (BOLD).

KEYWORDS:
Cytochrome oxidase 1; morphospecies; neighbor-joining tree; sequence
Ant alien species in Erawan National Park

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ABSTRACT:
At present, the conservation area has found more exotic species. Ants are a type of organism that has been found to invade into protected areas. Alien ants have a negative effect on the native species. Our objectives were to know ant alien species and distribution for guidelines to prevent and eliminate in protected area. Erawan National Park, Kanchanaburi is a place were examined for the presence of ant alien species. Three sites were conducted include Visitor Center (Site A), Nature Trail beside Erawan waterfall (Site B) and undisturbed forest (Site C). Searches consisted of a baiting trial using tuna and nectar. Baits were places on the ground and examined over a 2-hr period between 08.00-18.00 hours. A total of 34 species were collected from bait traps. Eight species, 23 species, and 19 species were found in Site A, Site B, and Site C, respectively. Four species of alien ant were found: Anoplolepis gracilipes, Monomorium pharaonis, Paratrechina longicornis, and Tapinoma melanocephalum. One of four alien species, Anoplolepis gracilipes are listed as alien invasive species in Thailand which found in disturbed area (Site A and Site B).

KEYWORDS:
Ant; Alien species; Erawan National Park; Protected area
Species richness and distribution of marine spider crabs (Majoidea) in Thailand

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ABSTRACT:
The spider crabs are classified into Superfamily Majoidea. Species richness of spider crab in Thailand were studied by collected specimens from local fishing boat along the coast of the Gulf of Thailand and some specimens were also examined from museums and institutes collection during September 2013 to December 2018. A total of 811 specimens were identified into 4 families, 21 genera and 40 species. Family Epialtidae were found the highest number of spider crab species, comprising 23 species (57.5%). The species richness of spider crab from Andaman Sea were higher than from Gulf of Thailand at 35 and 19 species, respectively. Among these, there were 2 species, *Tiarinia angusta* and *Tylocarcinus styx* are supposed to be as new record in Thailand. Furthermore, this study indicated that the richness of spider crab species was diversified due to habitat variation in marine ecosystem.

KEYWORDS:
Majoidea; Marine environment; Species diversity; Spider crab; Thailand.
Distribution of some invasive plants in sub-urban ecosystem, northeastern Thailand

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ABSTRACT:
Invasive alien species is one of the most serious threats to global biodiversity. While the invasion rate is rapidly increased, and many new species of exotic plants can be found naturally across the country, but the information on their distributions is not updated. The objective of this study was to investigate distribution and abundance of eight selected exotic plants in Khon Kaen University. Three species are listed category 1 invasive species in Thailand including Chromolaena odorata, Mikania micrantha, Mimosa diplotricha and Mimosa pigra. A total of 139 rectangular plots (2 x 10 m) were measured along two main routes cover the distance of 7.23 km. Seven of eight selected species were found in 121 plots (87.05% of sampling plots) including Asystasia gangetica subsp. micrantha, Praxelis clematidea, Alternanthera brasiliana, Chromolaena odorata, Mikania micrantha, Asystasia gangetica subsp. gangetica and M. diplotricha but only M. pigra was not found in the plots. The most abundance species with highest percent cover was Asystasia gangetica subsp. micrantha (35.75%) while P. clematidea was the most frequently detected species which found in 64 plots (27.35% frequency). In each sampling plot, 1-5 selected species can be found together with the average of 1.66 species/plot. Most of the selected species were found in abandoned areas (44% of sampling plots). This study shows that four species not listed as invasive species in Thailand are more abundance with wider distribution than those species in category 1. Further investigation on wider scale of their distribution and effect on local plant community will be useful data for management and control as well as updating their invasion status.

KEYWORDS:
Abundance; Distribution; Invasive plant; Northeastern Thailand; Sub-urban ecosystem
Diversity of birds in deciduous forest areas within school

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ABSTRACT:
The purpose of this research is to create a prototype database of bird diversity in school areas. So that it can be used as information in managing forest areas within schools and promoting school botanical work. We selected San Pa Yang Wittayakom School, San Pa Yang Sub-district, Mae Taeng District, Chiang Mai Province, as a prototype school. In which the school has more than 0.16 square kilometers of deciduous forest but still lacking information on wildlife that lives in the area. From the study of bird diversity in the school area, comparing between the rainy season (September – October 2015) and the winter season (November – December 2015). Data was collected four times per month using the line-transect survey method along the 1,890-meters study route, from 0600 h to 0900 h and/or 1500 h to 1800 h. Overall, seven orders consisting of 40 species within 25 families of birds were found. Thirty-one species were resident birds and nine species were migratory birds. In the rainy season, there were 28 species from 20 families in six orders. Twenty-three species were residents and five species were migrants. In the winter season, 37 species from 23 families in seven orders were found. Twenty-nine species were residents and 8 species were migrants. The Shannon-diversity-index value was higher in the winter than in the rainy season. This shows that seasonal performances affect the species and number of birds found because, in the winter, there were many migratory birds that come to live or make use within the area. When considering the evenness index, it was found that the rainy season was more consistent than the winter season. Although there were many migrants in the area but the number of each species was still low. The similarity of birds found in both seasons was similar (76.92%). When calculating the relative abundance of birds in each season, it showed that, in the rainy season, there were three abundant species, two common species, nine moderately common species and 14 uncommon species. Whilst the winter season had six abundant species, seven common species, six moderately common species and 18 uncommon species.

KEYWORDS:
Bird diversity; deciduous forest; school forest; evenness index; similarity index; relative abundance
Taxonomy of mason bees genus *Chalicodoma* subgenus *Callomegachile* in Thailand (Hymenoptera; Megachilidae)

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**ABSTRACT:**
Mason bees in subgenus *Callomegachile* Michener, 1962 (genus *Chalicodoma* Lepeletier, 1841) collect mud, pebbles, resin, and/or petals as materials for their nest constructions. Despite that *Callomegachile* is one of the most diverse groups of megachilid bees in the world, their taxonomic works are largely obscure because of the difficulties in their morphology. We studied 292 *Callomegachile* specimens collected from 1967 to present. These specimens were retrieved from the Natural History Museum of Chulalongkorn University, Kasetsart University Kamphaeng Saen campus, Chiangmai University, and Department of National Parks, Wildlife and Plant Conservation. Four new species are described with two new species records to Thailand. In addition, novel diagnostic characters are discussed and species distribution maps are updated.

**KEYWORDS:**
Diversity, *Megachile*, Pollinator
Marasmius (Basidiomycota, Agaricales) section Marasmius from lower northern Thailand

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ABSTRACT:
In order to investigate diversity of agarics in Si Satchanalai National Park, Sukhothai Province, Thailand over a hundred of agarics samples were collected in 2018. Twenty five collections were documented and belonged to the genus Marasmius section Marasmius consisting in tiny umbrella-like mushroom. Ten species were classified, viz., Marasmiusapatelius, M. crinis-equ, M. aff. crinis-equ, M. delicatulus, M. guyanensis, M. aff. leucorotalis M. nigrobrunneus, M. purpureosetosus and other two new species candidate. Species delimitations are based on comprehensive morphological descriptions and molecular phylogenetic reconstructions based on ITS data set.

KEYWORDS:
Internal transcribed spacer; marasmioid fungi; phylogeny; Southeast Asia; tropical fungi
Species delimitation of fungi using whole genome-based molecular phylogenetic species criterions

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ABSTRACT:
Fungi are cryptic in their nature, with very versatile morphology and permeable genetic barrier (horizontal gene transfer, interspecific vegetative compatibility). In this regard, the classification of fungi was problematic for a long time until the advent of molecular biology techniques which allowed the acquisition of molecular data for various taxa. The concept of phylogenetic species, i.e. the concordance of various molecular markers to designate monophyletic clades as distinct species or taxa, has been since then adopted as a major tool in delimiting species in fungi. However, a typical approach in fungal molecular taxonomy would be based on at most five markers which are not statistically representative of the whole genetic materials. In this study, we tested the capacity of Illumina technology 1) to recognize already well-delimited species in the Ophiocordyceps unilateralis complex, and 2) to discover hidden diversity among natural populations that should be delimited as new species or sub-species. Using Illumina HiSeq3000, we were able to generate around 600,000 single nucelotide polymorphisms (SNPs). These SNPs were used to construct a whole-genome molecular phylogeny that recognized well-known species in Thailand with a better resolution. Furthermore, inside the well-recognized species, we were able to delimit highly supported monophyletic clades that should be considered as potential new species or subspecies. We argue that mycologists may underestimate the fungal diversity with current widely used tools and that, with the rising of next-generation sequencing (NGS), NGS should be used more to delimit species in fungi, particularly for ambiguous closely related species.

KEYWORDS:
Cryptic species; species delimitation; phylogenetic species; whole-genome sequencing; Ophiocordyceps unilateralis
Notes on resin bee genus *Anthidiellum* subgenus *Ranthidiellum* in Thailand with description of a new species

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ABSTRACT:
Bees tribe Anthidiini (Apoidea: Megachilidae) are solitary bees known to utilize various nesting strategies. Interestingly, resin bees subgenus *Ranthidiellum* Pasteels, 1972 of genus *Anthidiellum* Cockerell, 1904 burrow their nests in soil plastered with translucent tube-like resin structure. All *Ranthidiellum* currently described are from Southeast Asia and were hypothesized to morphologically mimic large stingless bees. In Thailand, two species were reported—*A. (R.) apicepilosum* (Dover, 1929) and *A. (R.) ignotum* Engel, 2009. We examined *Ranthidiellum* specimens deposited at the Chulalongkorn University Natural History Museum that was collected from throughout the country. We described a new putative species of *Ranthidiellum* and their nesting architecture (n = 8) from Ubon Ratchathani province during December 2018–January 2019. Nests were dissected, descriptions of nesting structure are provided. The bee offspring were preserved and composition of pollen masses and resin were analyzed. This *Ranthidiellum* sp. nov. burrows its nest perpendicular to the steep sandy earth bank and lining its nest and entrance using resin. In addition, we also described male of *A. (R.) ignotum* for the first time as well as updated the distribution and provisional key to *Ranthidiellum*. This study provides essential information for the conservation of anthidiine bees.

KEYWORDS:
Nest structure; Anthidiini; Solitary bee; Southeast Asia
Diversity of caterpillars (order Lepidoptera) in Khao Yai National Park, Nakhon Ratchasima province

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ABSTRACT:
The study of caterpillars diversity was started by sampled caterpillars from 500 meters line transect every 100 meters above mean sea level from 100 meters above mean sea level thru 1,200 meters above sea level in Khao Yai National Park. Caterpillars were sampled every month from January 2017 – June 2017. A total of 3,434 specimens were identified to 86 species, 55 genera, and 19 families and 37 morphospecies. The most abundant species was \textit{Eurema blanda} (n=1,280). The highest diversity was found in 500 meters above mean sea level (H\textsuperscript{'}= 2.66) and the similarity of caterpillar that occurred in different elevation was low.

KEYWORDS:
Caterpillars, elevation, diversity, Khao Yai National Park
Uncover species diversity of the butterfly lizards (Squamata, Leiolepididae: *Leiolepis* spp.) in northern Thailand with the potential of undocumented variation in Mae Hong Son province

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**ABSTRACT:**
Northern Thailand is an important hotspot harboring several *Leiolepis* populations yet remains poorly explored. We sampled 72 individuals of *Leiolepis* from 14 localities in northern Thailand and examined their morphological characteristics. *Leiolepis* could be separated into three groups as diagnosed by contrast markings along flanks and dorsal spot pattern. Two of these groups consisted of contrast marking along flanks with light color inserted by dark color but differed in the number of dorsal spot. They fitted well with the description of *L. belliana*, common in central Thailand, and *L. ocellata*, which is endemic to and commonly found in northern Thailand respectively. A third group from Mae Hong Son Province, the western area of northern Thailand, showed contrast markings along flanks with dark color broken by light stripes clearly different from the two known species. Thus, there are two recognized species and one unknown *Leiolepis* in northern Thailand.

**KEYWORDS:**
Butterfly lizard; *Leiolepis belliana*, *Leiolepis ocellata*, morphological variation; northern Thailand
Cryptic diversity of freshwater rotifers in the family Lecanidae in Thailand

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ABSTRACT:
This study aims to analyze potential species complexes of rotifers within the family Lecanidae, to test the hypothesis whether cryptic diversity is indeed as common as is being put forward. Moreover, this study analyzed the geographic distribution and genetic divergence within species complexes in Thailand. The tests for the presence of cryptic species were applied using three methods on both COI and ITS1 datasets: Automatic Barcode Gap Discovery (ABGD), a Poisson Tree Processes (PTP) model, and the Generalized Mixed Yule Coalescent (GMYC) model. Genetic divergence and geographic distance were analyzed using Mantel test. The results from three DNA taxonomy approaches, ABGD, PTP, and GMYC from COI and ITS1 markers clearly indicated the existence of cryptic species in the family Lecanidae. This study reveals the existence of cryptic species in Lecane bulla, Lecane closterocerca, Lecane crenata, Lecane curvicornis, Lecane hamata, Lecane leontina, Lecane ludwigii, Lecane luna, Lecane lunaris, Lecane nitida, Lecane quadridentata, Lecane signifera, and Lecane unguitata. The highest estimated number of species within the complex was found in Lecane bulla with at least 20 species supporting both COI and ITS1 markers. The species estimated using COI marker is congruent among different DNA taxonomy methods, while there is incongruence among different methods based on ITS1 marker. The geometric morphometric analyses from this study cannot separate some Lecane bulla from one another. There is a geographic overlap in rotifer distribution in Thai waters. No correlation occurs between genetic and geographic distances in all species complexes, except in Lecane curvicornis. Although Lecane curvicornis demonstrates a significant difference, only a few specimens were used for the analysis. Thus, more samples of all species complexes are needed for further analysis. An improved species recognition in these organisms might refine our understanding of the global distribution of cryptic species within cosmopolitan taxa and lead to better understanding the biogeography of Thailand.

KEYWORDS:
Biogeography; cryptic diversity; DNA taxonomy; rotifer; Thailand; zooplankton
Species diversity of climbing plants at Phu Rua National Park

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ABSTRACT:
Climbing plants typically contribute 2-15% of leaf biomass and about 5% of wood biomass in forest ecosystem, presently, climate change potentially affects forest dynamics, especially uncommon forest types such as the mountain forest in Thailand. The peak of Phu Rua National Park with the elevation of ~1,400 m. MSL is classified as Pine forest dominated by Pinus merkusii. This study focused on surveying climbing plants along the nature trail on the top of Phu Rua National Park in March 2017. Identification of climbing plants was performed by taking pictures and collecting samples by the Taxonomists from Forest Herbarium Office of Department of National Parks, Wildlife and Plant conservation.

The results showed that climbing plant at Phu Rua National Park consisted of 14 families 20 species including Apocynaceae with 3 species were Amalocalyx microlobus Pierre ex Spire, Alyxia sp. and Streptocaulon juventas (Lour.) Merr., Combretaceae with 2 species were Combretum sp.1 and Combretum sp.2, Convolvulaceae with 2 species were Argyreia sp. and Argyreia capitiformis (Poir.) Ooststr., Fabaceae with 2 species were Dalbergia imosa Roxb. var. foliacea (Wall. ex Benth.) Thoth. and Mucuna bracteata DC. ex Kurz, Rosaceae with 2 species were Mucuna bracteata DC. ex Kurz and Rubus sp.1, Dioscoreaceae with 1 specie was Argyrea capifformis (Poir.) Ooststr., Gnetaceae, with 1 specie was Gnetum macrostachyum Hook. f., Primulaceae with 1 specie was Embelia sp.1, Rhamnaceae, with 1 specie was Berchemia floribunda (Wall.) Brongn. Rubiaceae with 1 specie was Paederia pilifera Hook. f., Rutaceae with 1 specie was Toddalia asiatica (L.) Lam. Smilacaceae with species was Smilax sp.1 and Vitaceae with 1 specie was Cissus discolor Blume.

KEYWORDS:
Climbing plant; Phu Rua National Park
Diversity of acorn barnacles (Crustacea: Cirripedia) in family Chthamalidae in eastern Thailand

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ABSTRACT:
Acorn barnacles are sessile crustaceans widely distributed in the intertidal areas of tropical and temperate regions worldwide. We previously reported the presence of three families of acorn barnacles including Balanidae, Chthamalidae and Tetractididae in Thailand and three species of chthamalid barnacles; Euraphia depressa, Euraphia hembeli and Chthamalus malayensis were identified. Along the coastline of eastern Thailand, chthamalid barnacles show great variety of shell plate morphology, which is obstacle for taxonomic identification using only pattern of shell plate. Here we aimed to identify additional species of barnacles in Family Chthamalidae, based on Scanning Electron Microscope (SEM)-based ultrastructure of arthropodal characters (cirri, setal types and mouth parts) and mitochondrial gene analysis. Based on SEM, we identified additional new-record species including Chthamalus alani, Chthamalus moro and Chthamalus panamensis. In addition, mitochondrial gene analysis provided more information for species identification, leading to discovery of possible new records of chthamalids on the eastern coast of the Gulf of Thailand.

KEYWORDS:
Acorn barnacles; chthamalid barnacles; Chthamalidae; crustaceans; eastern Thailand
Subspecific hybrid zone of Burmese long-tailed macaque
\textit{(Macaca fascicularis aurea)} and common long-tailed macaque
\textit{(M. f. fascicularis)} in Thailand

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\textbf{ABSTRACT:}
Long-tailed macaques (\textit{Macaca fascicularis}, \textit{Mf}) were classified into 10 subspecies following Fooden (1995). Among those 10 subspecies, \textit{M. f. aurea} (\textit{Mfa}) is the only stone-tool user and distributes closely to \textit{M. f. fascicularis} (\textit{Mff}). \textit{Mfa} can be distinguished from \textit{Mff} by its infra-zygomatic cheek hair pattern, while \textit{Mff} has trans-zygomatic cheek hair pattern. In the southern Thailand, at 12°24’N to 8°10’N, the heterogeneous cheek hair pattern of long-tailed macaques was reported. We surveyed and collected samples of \textit{Mf} populations in the southern Thailand and determined their subspecific status using mtDNA (HVS1) and \textit{Y}-chromosome (SRY) sequence analysis. The 835 base-pair of HVS1 were amplified, sequenced and constructed the phylogenetic tree. Although SRY marker showed low genetic diversity, the two polymorphic sites (no.187 and 277) were enough to distinguish \textit{Mff}(T/A and T) from \textit{Mfa} (T and C). Based on the mtDNA and \textit{Y}-chromosome results, we found six hybrid populations. The northern most population is Koram island, Prachuap Khiri Khan (12°14’N, 100°00’E), and the southern most population is Sire island, Phuket (7°54’N, 98°25’E), which is a bit southward from the previous report. However, the more sensitive markers such as autosomal SNPs will further be used, and the stone tool-used behaviour will be observed.

\textbf{KEYWORDS:}
\textit{Macaca fascicularis aurea}, \textit{M. f. fascicularis}; HVS1; SNPs; SRY
Using NGS (Nest-Generation Sequencing) to resolve taxonomic problems of Cleptoparasitic bee genus *Thyreus* Panzer, 1806 in Thailand

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**ABSTRACT:**

Bee genus *Thyreus* Panzer, 1860 is rarely studied in Southeast Asia. A recent review suggested there are six *Thyreus* species in Thailand; however, identification key for the group is inadequate since cryptic species and sexual dimorphism pose difficulties to the taxonomy of the group. Therefore, DNA Barcoding methods were implemented to resolve the problems via using mtDNA gene, cytochrome c oxidase I (COI), as a genetic marker for species identification. All *Thyreus* specimens were identified to morphospecies. The COI gene of specimens preserved in 95% EtOH was amplified using primers LepF1 and LepR1. For dried museum specimens, which their DNA cannot be recovered for a full-length of barcoding region, we designed additional 5 pairs of primers to generate short amplicons using Next-Generation Sequencing (NGS). Sequences were aligned using MUSCLE. Phylogenetic tree was inferred using Bayesian inference in BEAUti and BEAST version 1.8.4 using a Metropolis-coupled Markov Chain Monte Carlo (MCMC) algorithm from randomly generated starting trees for 200 million generations. The phylogenetic analysis of Thai *Thyreus* displayed strong support (>0.95 posterior probability) for eight monophyletic clades including *T. massuri*, *T. callurus*, *T. cf. cyathiger*, *T. ceylonicus*, *T. himalayanensis* and three new putative species. In addition, the male genitalia and 7th sternite of the new putative species are different from the other described taxa, despite the similarity in color patterns on thorax and abdomen.

**KEYWORDS:**

Degraded DNA; DNA barcoding; Pollinators.
Diversity of endophytic fungi isolated from *Diospyros decandra* Lour.

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**ABSTRACT:**

*Diospyros decandra* Lour. is one of important indigenous herbs in Thailand. The aim of this study was to evaluate the diversity of endophytic fungi associated with leaves and twigs of *D. decandra*. Using a combination of triple surface sterilization technique and rose Bengal agar, more than 200 isolates were obtained from 145 leaf tissues, including midrib and lamina, and 194 twig tissues, including wood and bark. Identification of these endophytes was carried out based on morphological characters of living culture (i.e. colony and sexual and asexual spores). We found that most of the obtained isolates with sporulation are in the genus *Colletotrichum*, *Phomopsis/Diaporthe* and *Lasiodiplodia*. Some of the species were found to exhibit tissue preference. The endophytic fungi in the genus *Colletotrichum* were mostly isolated from leaves while *Phomopsis/Diaporthe* and *Lasiodiplodia* were mostly acquired from twigs. We also retrieved isolates without sporulation, which require additional molecular evidence for identification.

**KEYWORDS:**

Endophytes; fungal diversity; fungal taxonomy
Abundance and potential enhancement for molluscs in Pattani bay

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ABSTRACT:
Molluscs are recognized as a second major invertebrate groups followed Insecta in phylum Arthropoda. Approximate 578 mollusc species were reported in Thailand. This study is one part of Pattani bay project that aimed to investigate species abundance and potential enhancement for molluscs in Pattani Bay. This preliminary study was conducted between July 2018 to December 2018. Based on difference of bed-sediment characteristics, 7 sampling sites in Pattani bay were designed for mollusc field collecting and then samples were classified and identified to taxa.

Preliminary results indicated that a total of 99 species, 56 families of all molluscs were record including; 42 species from 25 families of gastropods, 52 species from 29 families of bivalve and 2 species from 2 families of cattle fish. The common species of gastropods recorded were Fairbankia sp., Chicoreus sp., Melanoides sp., Cerithium sp. whereas the dominant bivalve being Anodontia sp., Oliva sp., Anadara sp., and Donax sp. The finding confirmed that Pattani bay is home of seashell ground particularly blood cockle (Anadara granosa) and short necked clam (Paphia undulata). Therefore, species diversity, abundance and potential enhancement for molluscs in Pattani Bay is very important both for population enhancement and aquatic ecological rehabilitation.

KEYWORDS:
Abundance; Biodiversity; Mollusc; Pattani Bay; Gulf of Thailand; Marine habitat
The diversity and current status of Baetid mayflies (Ephemeroptera: Baetidae) in Thailand

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ABSTRACT:
Baetidae is a very diverse and worldwide family of mayfly around the world. This baetid mayfly nymphs can be found in both running and standing waters. There are about 100 genera and 900 species were recorded. This mayfly group has been studying by many researchers in all the world regions. Although in the Oriental realm, the baetid mayflies were reported in many countries and islands such as Malaysia, Sri Lanka, India, Taiwan, Hong Kong, and the Philippines. The majority of the Oriental realm remains nearly unknown, especially in Thailand. This study presents the current status of baetid mayflies in Thailand from the data collection and field collection. The results found 15 species which is belonging to 10 genera. There are expected to be diversified due to the fact that this survey data from the northeast, north and south regions of Thailand found increased baetid mayfly species. Additionally, the morphology of mayfly eggs was studied and reported in this recent work. This information will feed into the Thai biodiversity database and enable more accurate species identification.

KEYWORDS:
Baetid mayflies; Diversity; Egg morphology; Thailand
Identification of *Dalbergia cochinchinensis* from other *Dalbergia* spp. using SNPs in maturase K gene

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**ABSTRACT:**

Siamese rosewood (*Dalbergia cochinchinensis*) is protected species and one of the CITES appendix II list. Due to high demand from internationally illegal trade, Siamese rosewood has been heavily illegal logged in Thailand and ASEAN region. To identify whether the confiscated timber and wood product are from this species by physical features is sometime difficult. Wood morphology of Siamese rosewood (*D. cochinchinensis*) is similar to Black wood (*D. oliveri*), Kra phi khao khwai (*D.cultrata*), Ket dam (*D. assamica*) and Burmese ebony (*Pterocarpus macrocarpus*). Therefore, it is difficult to classify these species by naked eyes. To solve this problem, the single nucleotide polymorphisms (SNPs) from Maturase K gene were developed and compared among *Dalbergia* spp. and *Pterocarpus macrocarpus*. DNA extracted from the wood samples were PCR amplified and Single Nucleotide Polymorphisms (SNPs) were genotyped by sequencing from 713 bp maturase K gene. A total of 57 variable nucleotide sites that were different from Kra phi khao khwai, Ket dam and Burmese ebony were identified in Siamese rosewood. The number of SNPs that were different in Siamese rosewood from Black wood, Kra phi khao khwai, Ket dam, and Burmese ebony were 19, 18, 16 and 49, respectively. The results clearly indicate that the SNPs reported in this study could be used in identification of the wood from five species mentioned above. The outcome of this study provides efficient molecular genetic tool to identify the confiscated wood and product whether it is came from *D. cochinchinensis* and also could be helped to enhance law enforcement and protect genetic resources of this species.

**KEYWORDS:**

Identification; *Dalbergia cochinchinensis*, *Dalbergia* spp.; SNPs; maturase K gene
Genetic studies of upland rice (*Oryza sativa* L.) in Thailand by InDel marker

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**ABSTRACT:**

Upland rice is the most popular option for rice production in slope areas under rainfed conditions. This rice has been growing in Northern, Center and Northeast of Thailand. However, genetic information of upland rice, especially collected from farmers or is indigenous varieties collected from minority farmers is still unclear. The objective of this research was to investigated identity of 15 upland rice accessions by 25 Indel markers. The phylogenetic tree revealed three major groups among 15 upland rice accessions. Three upland rice accessions collected from Prachuap Khiri Khan including PLU-SU-0007, PLU-SU-0011, and PLU-SU-0012 were identified as *indica* rice. The CM-001, NY-SU-001, and PLU-SU-002 accessions which collected from Chiang Mai, Petchaburi, and Prachuap Khiri Khan, respectively were identifies as *japonica* rice. On the other hand, 9 accessions were showed genetically closely to *japonica* rice. These data suggested the high genetic diversity of upland rice that grow throughout Thailand. In addition, this genetic information will provide a high opportunity for successful rice study under *in vitro* or genetic improvement of these upland rice.

**KEYWORDS:**

InDel marker; upland rice; *japonica, indica*
Studies on caddisflies larvae (Insecta, Trichoptera) in Thailand

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ABSTRACT:
Trichoptera, or caddisflies, are common members of freshwater ecosystems as larvae and are important indicators of aquatic system health. As such, the species are relatively rare studied in the larval stage. Research on Trichoptera in Thailand has been restricted mainly to descriptions of the adult stage, of which more than 1,000 species have now been identified, very few larvae are known at the species level. Of the 1,000 species of caddisflies known from Thailand, the net-spinning Hydropsychidae are relatively well studies in the larval stage, of which more than 31 species are described and figured from the known of 128 species in the adult stage. The remains caddisflies species will be continued documented in Thailand.

KEYWORDS:
Caddisflies larvae; indicator species, Hydropsychidae
Assessing the possibility of candidate DNA barcodes and chemical profiles supporting the systematics of medicinal *Lasianthus* (Rubiaceae)

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ABSTRACT:
A number of *Lasianthus* species, distributed throughout the tropical forests of Southeast Asia, are extensively used as traditional medicine to treat a fever, wound infection and analeptic. Identification by traditional morphology alone is rather difficult so far. Therefore, an accurate supporting identification through molecular information is required for species diagnosis. In the recent years, Phylogenetic correlation and DNA barcodes have been applied to provide explanatory power for taxonomical support, especially in the large plant genus and pharmacological property. Herein, *Lasianthus* spp. were surveyed and collected from the natural forest of Thailand. These plant samples were identified and compared with type specimens and specimens in herbarium. To facilitate the identification process, this current study explored for potential DNA barcodes by estimating four DNA loci from cpDNA (*rps16* and *trnTLF*) and nrDNA (ITS and ETS) and determined the chemical profiles among twenty Thai *Lasianthus* and six medicinal species. The results revealed that four candidate regions of all *Lasianthus* DNA samples were successfully amplified and sequenced with the rate of 100%. It was also disclosed that ITS region has tended to species-specific nucleotides position and different molecular characteristic as DNA barcoding that also conformed to phylogenetic relationship. In addition, the combination of all regions was proposed as a potential barcode for identifying *Lasianthus* species. In terms of the chemical profiling, the different specific characteristics on leaves and stem bark extracts of medicinal *Lasianthus* were encountered. However, the coumarins and intense scopoletin among all stem bark extracts in medicinal species group by using chromatographic techniques could also be detected. Consequently, our findings scientifically showed molecular information from ITS which tended to be DNA barcode for medicinal *Lasianthus* and four DNA regions combination were supported taxonomical grouping. Thus, molecular and chemical characters might be benefit to important encourage the species identification among plants in the same genus.

KEYWORDS:
DNA sequences; Genetic variation; Phylogeny; Phytochemistry; Taxonomy
Current record of “primitive” trapdoor spider genus *Liphistius* in Thailand and nesting biology of *L. maewongensis* in Mae-Wong National Park

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ABSTRACT:

“Primitive” trapdoor spiders of the genus *Liphistius* (Araneae, Mesothelae) retain many plesiomorphic characters such as the presence of segmented abdomen and the position of the spinnerets on the median area of the opisthosoma. These spiders have been intensively researched by many arachnologists, since they are the most basal group of all extant spiders. However, most studies focused mainly on systematics of the taxa hindering studies on their natural histories. In this study, we review a current record of all *Liphistius* species in Thailand plus new putative species that were collected during expeditions in 2016–2018. In addition, nesting structure and morphological characters of *L. maewongensis*, a recently described species from Mae Wong National Park, is discussed. Trapdoor length, width, and burrow depth are significantly correlated with the spider body length (Pearson’s correlation *r* = 0.80, 0.73, 0.51 respectively, *n* = 46, *p* < 0.01) suggesting that burrow size and depth increase as the spider grow. *L. maewongensis* generally constructs two types of burrows—a simple linear burrow or a T-shape burrow. The Chi-Square test reveals the association between trapdoor length and the type of burrow constructed (*X^2^* = 92.23, 2; *p* < 0.01) implying changes of burrow types from simple linear to T-shape burrow as spider aged.

KEYWORDS:

Araneae; Liphistiidae; Living fossil; Mesothelae
Proposal to reduce anthocyanin-deficient banana *Musa siamensis* to a *M. rubra* variety

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**ABSTRACT:**
*Musa rubra* Wall. ex Kurz and *M. siamensis* Häkkinen & Rich. H. Wallace are small wild banana species with erect inflorescences of orange and yellow bracts, respectively. While *M. rubra* is commonly found in North-East India, Myanmar to Western Thailand, *M. siamensis*, described from a specimen collected in Eastern Thailand bordering Cambodia, is known only in cultivation. Striking characters shared by both *M. rubra* and *M. siamensis* include extended rhizome, shape and texture of inflorescence bracts, micro-morphological characters of flowers and smooth-surface seeds. Bract coloration caused by changes in cellular anthocyanin contents and revealed by expression levels of genes involved e.g. dihydroflavonol 4-reductase (*DFR*) is the lone recognized difference between the two taxa. Due to high similarities, it is therefore proposed here to reduce this yellow-bract taxon to *M. rubra* var. *siamensis*. These and other bananas with a wide range of colorful bracts are useful as the proper models for genetics, biochemistry, cytology and biotechnology in flavonoid biosynthesis pathway.

**KEYWORDS:**
Anthocyanidin; ‘Chek Meas’ banana; flavonol biosynthesis pathways; *Musa laterita* Cheesman; *Rhodochlamys*; ‘Thai Gold’ banana
An annotated checklist of scorpion (Arachnida; Scorpiones) in Thailand

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ABSTRACT:
Scorpions (Arachnida; Scorpiones) are invertebrate predators well recognized for their dominant characteristics, including a pair of chelae and narrow poisonous tail. These animals have been described for more than 2,400 species distributed throughout most continents around the world. A preliminary revision of Thai scorpions by F. Kovarik in 1995 recognized only 4 families and 13 species from 4 genera; however, in recent years, several new scorpion species were described resulting in increasing number of the taxa. The objective of this study is to provide an updated annotated checklist and identification key for scorpions in Thailand based on literature review and intensive field collecting using UV light as well as pitfall trap. As a result five scorpion families are confirmed comprising of Buthidae Simon, 1979, Scorpionidae Latreille, 1802, Hormuridae Laurie, 1896, Euscorpiidae Vachon, 1980, and Cheirilidae Pocock, 1893. In addition, numbers of new scorpion species are currently being described by the authors.

KEYWORDS:
Systematics; Taxonomy; South East Asia; Catalogue
Diversity of spiders (Opisthothelae, Araneomorphae) in Chon Buri province, eastern Thailand

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ABSTRACT:
Spider is an arthropod distributing in various areas across the world, mainly in the tropical rainforest and also in urban areas. In term of taxonomy, spider is classified into Phylum Arthropoda, Class Arachnida, Order Araneae, two suborders: Suborder Mesothelae and Suborder Opisthothelae. Opisthothelae can also be further subdivided into two infraorders, based on striking direction of fangs and the number of book lung: Infraorder Mygalomorphae (fangs are downwards and forwards, 2 pairs of book lung) and Infraorder Araneomorphae (The true spider, fangs are from sides to center, a pair of book lung). Diversity and distribution of spiders in Chon Buri province (Eastern Thailand) is still under investigated. Here we aimed to survey diversity of spiders in two area types: forest and community area in Chon Buri during January - December 2018. Our result show that total number of spider families found in Chon Buri so far was 15 families in only Infraorder Araneomorphae and the abundance or number of spiders ranged from the most to the least as following: Family Lycosidae, Zodariidae, Salticidae, Araneidae, Corinnidae, Oxyopidae, Sparassidae, Tetragnathidae, Gnaphosidae, Anapidae, Ctenidae, Thomisidae, Philodromidae, Nephilidae and Hersiliidae, respectively. The abundance of spiders in Family Lycosidae, which are wolf spiders spending their time on the ground and more resistant to environmental pressures, fits well with the current status of land use in Chon Buri that is mainly urban-agricultural areas.

KEYWORDS:
Araneomorphae; diversity; eastern Thailand; Lycosidae; Opisthothelae; spider
P7
HABITAT-BASED RESEARCH
(TERRESTRIAL, FRESHWATER, MARINE AND OTHERS)
Phylogeny of *Padina* species with new lineage revealed in the Gulf of Thailand

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**ABSTRACT:**  
*Padina* is one of marine brown seaweed that has worldwide distribution along the intertidal and subtidal zone. In previous research, based on small sample size, two distinct lineages of *Padina boryana* were reported along the Thai peninsula. However, the small sample size has led to ambiguity on the precision of species identification in that study. Therefore this study was conducted to verify and explain the distinction between these two clades. Samples of *P. boryana* were collected during a year covering on the coast of Gulf (9°22'22.1"N 99°57'27.6"E to 6°16'56.7"N 102°01'56.4"E). The samples were identified base on morphological classification prior to the analyses using *Cox3* and *rbcL* markers. Phylogenetic analysis was carried out by Maximum Likelihood and Bayesian Inference and then the combined gene tree was tested for Operation Unit Taxonomy (OUT) by ABGD and PTP. The results strongly confirmed the evolutionary difference of these two clades. Furthermore, the results indicated that one of them should be remained *P. boryana* and another may belong to different species. According to the type locality, *P. boryana* was originally found in Tonga Island, Pacific Ocean and wide spreads to the Indo-west area where the specimens of Andaman sea clade was found. The sample group of the Andaman clade represents the species of *P. boryana* while the Gulf of Thailand clade is the different species. This lineage is identified as the cryptic species or the proposed new species. More detailed morphological study is on-going to ensure the state of this Gulf clade.

**KEYWORDS:** Andaman Sea; Gulf of Thailand; *Padina; Padina boryana*, phylogeny
Microplastics in corals from the Upper Gulf of Thailand

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ABSTRACT: Microplastics are recognized as important pollution in marine ecosystems worldwide. Coastal and marine habitats, such as sandy beaches, inshore coral communities, are particularly impacted by microplastics because they enter the marine environment through fragmentation of larger plastic components from land-based pollution. A few studies reported ingestion of microplastics by scleractinian corals and the presence of microplastics in coral reef waters adjacent to inshore reefs. This study examined the abundance of microplastics in six scleractinian corals, i.e. Acropora muricata, Galaxea fascicularis, Pocillopora acuta, Porites lutea, Favites abdita and Favia speciosa from Mu Ko Sichang, the Upper Gulf of Thailand in April 2018. The fragments of each coral species were collected and preserved in 10% formalin in seawater before being decalcified in 3% formic acid over a period of four days. Then the decalcified tissues were dissected using a stereo zoom microscope to separate individual polyps. The coral polyps were then sectioned longitudinally. Ingestion of microplastics was examined by the presence of microplastics in the mouth and among the mesenteries of the polyps. The most abundant microplastics were found in G. fascicularis. However, we found no microplastics in A. muricata. This study provides important information concerning microplastic contamination in natural scleractinian corals in the Gulf of Thailand.

KEYWORDS: Coral; Galaxea fascicularis; Gulf of Thailand; microplastics; pollution
Assessment of water quality in the inlet and outlet of Kasiow dam based on larvae of *Amphipsyche meridiana* (Insecta, Trichoptera)

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**ABSTRACT:**
*Amphipsyche meridiana* (Insecta, Trichoptera) larvae were used as indicators of stream contamination in the inlet and outlet of Kasiow dam, Suphan Buri Province, central Thailand. This research aimed to monitor gill abnormalities in *Amphipsyche meridiana* larvae in relation with water quality and some heavy metals. Samples were collected four time from December 2018 to February 2019 at inlet and outlet of Krasiao Dam. Statistical analyses showed significant correlations between environmental variables and aquatic insect larvae, concentration of metals in larval bodies. For the gill abnormalities, gills of *Amphipsyche meridiana* larvae were classified as either healthy, slightly damaged, or seriously damaged. Scar-like darkening were not classified as gill damage.

**KEYWORDS:**
Gill abnormalities; Hydropsychidae larvae; stream water quality; heavy metals
Microplastics contamination in oysters from islands in the Gulf of Thailand

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ABSTRACT:
Microplastics contamination is one of the current threats to marine ecosystem. Disposals of plastics waste to the environment can lead to microplastics formation by the breaking down of plastics by UV, light or physical damages until the particle size is smaller than 5 millimeters. Presence of microplastics in marine environment can lead to contamination in filter feeders such as bivalves. In 2017, examinations of microplastic contamination in 3 invertebrates: oysters Saccotrea forskalii, barnacle Balanus amphitrite and periwinkle Littoraria sp. from Chonburi province in the eastern part of Thailand showed 4 types of microplastics residues including polystyrene, polyethylene, polyamide and polyvinyl chloride. The contamination of microplastics in bivalves can lead to potential health effects to the bivalves as well as animals that consume them, including human. Objective of this research is to examine an extent of microplastics contamination in oysters from islands in The Gulf of Thailand. During 2018-2019, oysters were collected from 4 representative sites covering inner part of the Gulf of Thailand including 1) Talu Island, Prachuap Khiri Khan province (western part of the gulf), 2) Si Chang Island, Chonburi province (inner eastern part of the gulf), 3) Samaesarn Island and 4) Mah Jor Port, Chonburi province (the outer eastern part of the gulf). After cleaning and weighing, oyster samples were digested in potassium hydroxide and filtered through 1.2-micrometer filter membranes. Each membrane was placed in a centrifuge tube containing sodium iodide solution and subjected to sonication for 10 minutes. After that, a suspension was centrifuged at 500 xg for 5 minutes and filtered through filter membrane. Filter membranes with microplastics residue were examined under a stereomicroscope, and type and number of microplastics per gram of oyster were recorded. The results on an extent of microplastics contamination in oysters in the Gulf of Thailand will be presented. Species-, site- and seasonal related difference on number and type of microplastics will be discussed. The data could be used as an indicator of microplastics pollution in the Gulf of Thailand, as well as an early warning of potential microplastics transfer through food web to human.

KEYWORDS:
Bivalve, invertebrate, marine pollution, plastics
MICROPLASTIC pool: an evaluation of microplastic threats to fish resources in Benoa bay, Bali

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ABSTRACT:
Plastic pollution in the marine environment is now recognized as a serious threat with a global-scale distribution and documented adverse effects spanning from molecular level, physiological performance and organism’s health, up to the loss of ecosystem services. Microplastics and associated pollutants easily enter food webs and have the potential to bio magnify with increasing trophic levels. The issue of microplastics is particularly important in Indonesia, which has a high population density, large use of plastics, and high levels of plastic emissions, and is located in the centre of the Coral Triangle, a global biodiversity hotspot. Benoa Bay is the main fishing port of Bali and an important seascape, housing a large area of mangroves, which provides a nursery and spawning ground for marine organisms. The Bay has low exchange with the ocean and receives input from six tributary rivers that contain domestic and industrial effluent, combined with plastics. In this research, we investigate the hypothesis that Benoa Bay is a sink for plastics, and a significant source of microplastics (1 μm to 5 mm particles) that are accumulating in the water column, sediment, and even marine organisms. Data on the water column (trawl net), sediments (cores) and fish (hand-line) were collected at six sites during the dry season (September-October) of 2018. A total of 336 pieces of plastics were collected in the water column, 117 in the sediments and 3 pieces were found in the stomachs of three fish analysed to date. Microplastics in the seawater were mostly < 1 mm (94%), with the remainder in the 1-5 mm size class (6%). In the sediments, although the dominant size class of plastics was 1-5 mm (39.7%) with 11% < 1 mm, mesoplastics (59.6%): 5-10 mm (24%), 10-20 mm (8.6%), and > 20 mm (17%) made a greater contribution to the total pool of plastics than microplastics. The size of microplastic particles found in fish ranged from 0.7 mm to 2.7 mm. The concentration of microplastic particles was 1.65 pcs/m³ in the seawater, 724 x 10⁻³ gr/gr of sediment in the sediment, and 0.3 pcs/fish in the fish. The dominant microplastic types differed between the different receiving environments: 36% fragments in the seawater, 67% film in the sediment, and 100% fibers in the fish. These initial results highlight that microplastics are found in the water column and sediments where mesoplastics were also significant and that fish were ingesting plastics. Further sampling will be carried out in the rainy season when the volume of water and plastics flowing into Benoa Bay is likely to be significantly greater than in the dry.

KEYWORDS:
Pollution, water column, sediments, fish, particle size, microplastic origin
Burrow characteristics of ovigerous and non-ovigerous female
*Tubuca rosea* (Tweedie, 1937) in southern Thailand

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**ABSTRACT:**
We investigated how burrow characteristics differ between ovigerous and non-ovigerous females in *Tubuca rosea* (Tweedie, 1937). We measured the burrow characteristics including shapes, diameter, total and horizontal length, total depth, ground and mid angle, and volume of 22 ovigerous females and 17 non-ovigerous females. We observed I- and J-shaped burrows in both ovigerous and non-ovigerous females with higher numbers of J-shaped burrows in ovigerous females. Whereas, in non-ovigerous females, I- and J-shaped burrow numbers were not different. Other burrow characteristics were higher in ovigerous females than in non-ovigerous females. This is the first time to show that burrow characteristics differ based on reproductive status of female fiddler crabs in *T. rosea*.

**KEYWORDS:**
Burrow characteristics; ovigerous and non-ovigerous females; *Tubuca rosea*
Why doesn’t the invasive mussel *Mytilopsis adamsi* spread faster?  
A case study in the Songkhla Lagoon System

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ABSTRACT:

*M. adamsi* Morrison, 1946 is a brackish, false mussel (Bivalvia: Dreissenidae) originally described from Panama Bay, that has invaded the Indo-Pacific region. In Thailand, populations of this mussel were found in many coastal areas along both the Andaman (Phuket and Krabi) and the Gulf of Thailand (Bangkok, Nakhon Si Thammarat, Songkhla and Pattani) coastlines. The introduction to Thai waters was probably via ballast waters of cargo ships that carried their planktonic offspring from ports of donor countries. The mussel can survive under extreme and wide-ranging conditions; and usually form dense patches on water bottom or attach densely on submerged substrates. In some of the invaded areas in other countries they completely dominated the benthic communities and caused economic damage. *M. adamsi* has been recognized as an aggressive invader; therefore, it has the potential to monopolize the brackish coastal waters, and a wide distribution range had been expected. From observations in several locations in Thailand, however, each population have restricted distribution range, that is, they do not take over whole estuaries or brackish part of river basins, given that the habitat seems suitable.

This work addresses several hypotheses of why the species does not exhibit its invasiveness as strong space occupier to the degree that was expected by using the data from monitoring of a population in the Songkhla Lagoon System (SLS) as a case study. The establishment of *M. adamsi* populations in areas around the mouth of the SLS, was first reported in 2008. A survey made in 2016 suggested that mussel colonies were found only within several of the rivers that are connected to the lower part of the Songkhla Lake and they were not found within the lake itself. Moreover, they were absent from the upper parts of the lagoon system. Two questions are raised here: (1) Why were mussels found only in the rivers but not in the lake? and (2) Why were mussels absent from the upper part of the surveyed system? It is likely that the timing of the mussels’ reproduction, along with the seasonal hydrodynamics and changes of chemical properties of the lake limit larval ability to disperse. Although adult mussels could be found in wide range of salinity, a previous report suggested that larvae could not survive in salinity >25 ppt. They might be restricted to the rivers because the fluctuation of salinity is not extreme, compared to the lake where salinity range recorded was from 0 to 35 ppt (near the mouth). Recent observation in 2017-2018 in a river flowing into the lake revealed that mussels were only present when the salinity are in the middle range (18–28 ppt), they disappeared from some stations where salinity were >28 ppt or became rare when salinity was very low (0–5 ppt). The observation also suggested that spawning period of the mussels was probably from June to after October; and triggered by sudden decline of salinity after heavy rainfall during southwest monsoon season when water current in the lagoon system is dominated by freshwater runoff flowing towards the mouth of the lake. It is possible that larvae are carried by the current out towards the sea. They, therefore, have little chance to migrate to the upper part of the lagoon system. Currently, several experimental studies on salinity tolerance of mussels’ larvae and adults, and a survey of mussels’ larvae distribution are being carried out to test these hypotheses and give more insight into processes and mechanisms regulating the mussel population within this system.

KEYWORDS:

Alien mussel; false mussels; invasive species; *Mytilopsis adamsi*, Songkhla Lake
Abundance of economically important Cephalopholis fish from coral communities in the Gulf of Thailand

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ABSTRACT:
Coral reefs are the most diverse marine ecosystems and provide important ecosystem services, including larvae nurseries, fisheries, shoreline protection, and recreation. Several natural and anthropogenic disturbances lead to a degradation of coral reefs and a decrease in fish diversity and abundance. The Cephalopholis grouper is one of the economically important fish in coral reefs. This study aimed to examine the abundance of Cephalopholis fish from coral communities at Mu Ko Chang, Mu Ko Samet, Mu Ko Chumphon, and Mu Ko Anthong, the Gulf of Thailand. The field surveys were conducted in 2018 by using Fishes visual census technique. The abundance of Cephalopholis fish was significantly different among coral community groups. High abundant Cephalopholis fish were recorded at Mu Ko Samet, Mu Ko Chang, and Mu Ko Anthong. The lowest population density was observed at Mu Ko Chumphon. This study provides important baseline data of reef fish in the Gulf of Thailand and implies high economic values of coral reef ecosystem services from fisheries. Further studies should be investigated on relationships between human activities, such as fishing, tourism and pollution, and the population density of Cephalopholis fish in the Gulf of Thailand.

KEYWORDS: Cephalopholis; coral community; ecosystem service; Gulf of Thailand; Reef fish
Coral recruitment and connectivity in Mu Ko Samet National Park, the Gulf of Thailand

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ABSTRACT:
Coral reef degradation in most ASEAN countries is a major concern for managing marine and coastal resources. Understanding on coral recruitment and connectivity is needed for managing of coral reef ecosystems. This study examined the coral recruitment patterns and their potential of connectivity at Ao Kiew Na Nai, Ao Kiew Na Nok, Ao Platom and Ao Phrao, Mu Ko Samet, Rayong Province, the Eastern Gulf of Thailand. The live coral cover at Ao Platom was significantly lower than that at other study sites. The difference in coral recruitment patterns among the study sites in Mu Ko Samet was clearly observed. Ao Kiew Na Nok showed the highest degrees of coral self-seeding and diversity of coral recruits compared to the other reef sites. The brooding coral Pocillopora spp. were observed at Ao Kiew Na Nai and Ao Phrao. However, their recruits were found only at Ao Kiew Na Nai. A long-term coral reef monitoring program should investigate the maintenance mechanisms of Pocillopora spp. in the Eastern Gulf of Thailand. Understanding on the potential for inter reef connectivity and successful recruitment in down-current populations is needed for proper management strategies as well as planning for coral reef restoration in Thailand.

KEYWORDS:
Connectivity; coral bleaching; Gulf of Thailand; management; recruitment; self-seeding.
Distribution of restricted range butterfly species: a potential indicator of habitat modification

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ABSTRACT:
Assam is one of the Northeastern States of India. It is a part of Eastern Himalaya biodiversity hotspot and Indo-Burma biodiversity hotspot. Assam is rich in butterfly fauna. Fifty percent of the total butterfly diversity found in India occurs in Assam. Butterflies are reckoned as bio indicators. Butterflies are highly sensitive to habitat modification, and change in the habitat can adversely affect their population. The study was carried out in Karbi Anglong District of Assam. The study for the first time investigates the distribution of butterfly species that are restricted to specific ranges of Karbi Anglong, Assam. The study was carried out from 2015-2018 in different seasons of the year. The distribution maps were obtained to locate the butterfly species restricted to particular areas, and various factors like temperature, humidity, rainfall, elevation and vegetation responsible for vulnerability of the restricted range species of butterflies were analysed. From the study, 12 species of butterflies were recorded having restricted distribution. The restricted range species recorded during the study were indicator of specific habitat type and microclimatic conditions prevailing in that area. As such, the presence or absence of these species can be used to trace habitat modification in the study area in future. In spite of butterflies being biotic indicators, less conservation activity is directed towards their conservation in the area. Therefore, the study would also help to take necessary measures for the conservation of butterflies.

KEYWORDS:
Butterfly; conservation; distribution; habitat modification; indicator; restricted range.
Spatial patterns of coral bleaching and recovery following the 2010 coral bleaching event in Thai waters

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\textbf{ABSTRACT:}

Extensive coral bleaching has been repeatedly observed in many regions of the world’s tropical oceans over the last decades, including the Andaman Sea and Gulf of Thailand. Interactions of the intrinsic and extrinsic factors of corals may lead to variations in bleaching response due to differential fitness weights of different resulting traits among environments. Spatial information on how corals respond to stress events and fare after bleaching will provide vital clues to such a multi-faceted system of bleaching response. Hence this research examined corals reefs along Thai Waters spanning from inshore, turbid water and offshore, clear water following the 2010 coral bleaching event in order to determined spatial variabilities in both bleaching resistance and post-bleaching symbiotic recovery of corals. The secondary data of live coral cover before bleaching, after bleaching, and environmental condition: sea surface temperature (SST), degree heating weeks (DHW), diffuse attenuation coefficient (DAC), ocean currents and bathymetry were assessed and analyzed. There was a significant difference in bleaching response of corals between the Andaman Sea and the Gulf of Thailand. Recovery rates of turbid-zone reefs were significantly higher than clear-zone reefs in the Andaman Sea. NRAD-based MDS ordination plot of the first two axes indicated a significant spatial difference in community structure between turbid-zone reefs and clear-zone (offshore) reefs. Our observations show that although coral’s survival is partly dependent on bleaching resistance, it is considerably influenced by recovery capacity of corals, suggesting that an ability to maintain symbiosis during extreme stress may not be a strong determinant of heritability of the trait for corals examined in this study. Knowledge of spatial variability in bleaching response from our study aid in developing adaptive management of coral reefs with a focus on assisted evolution and propagation through selective breeding and transplantation. Such an active management intervention approach for building resistance and resilience in natural coral populations requires understanding of evolutionary mechanisms and knowledge of phenotypic variations across spatially and temporally heterogeneous environments.

\textbf{KEYWORDS:}

Coral bleaching; high temperature; resistance; resilience
Genetic diversity of symbiodiniaceae ITS2 sequences in coral species from eastern Thailand

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ABSTRACT:
Symbiotic algae in the family Symbiodiniaceae plays important roles in the adaptation of corals to environmental changes. Understanding the variation in symbiotic algae-coral associations can provide insights into how corals respond to the environment. We examined genetic diversity of Symbiodiniaceae in scleractinian coral belonging to families Merulinidae, Acroporidae, Pocilloporidae, Poritidae, Agariciidae, Lobophylliidae, Oculinidae, Dendrophylliidae, and Fungiidae at four locations in the Gulf of Thailand, namely Sichang Island, Samaesan Island, Chonburi Province, and Mon Islands and Hin Ploeng Pinnacle, Rayong Province. Based on the sequences of Internal Transcribed Spacer-2 (ITS2) DNA revealed by Denaturing Gradient Gel Electrophoresis (DGGE), we observed eight ITS2 haplotypes in the genus Durusdinium (D1, D1-4, D1-6, D6) and Cladocopium (C15, C3u, C3u*). Durusdinium spp. (D1) were common in all coral hosts across all sites. Cladocopium sp. (C15) was highly abundant in Porites lutea. Zooxanthellae community compositions greatly varied upon coral host taxa and locations, suggesting the importance of host-symbiont co-adaptation as well as environmental conditions. We are currently detecting additional zooxanthellae diversity based on high throughput sequencing.

KEYWORDS:
Hard coral; zooxanthellae; Gulf of Thailand; DGGE.
Macrophyte community of remnant wetland in Nong Khai urban area

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ABSTRACT:
Wetland is one of the main ecosystems present in Nong Khai province, agricultural activity and urban settlement cause wetland loss in some part of the province including Nong Khai municipal area. However, there is one remnant wetland remains in urban area. Survey of macrophyte diversity and distribution along with site characteristics and water quality in this remnant wetland were studied between March and April, 2018 corresponding to the dry season. From our preliminary survey, two prominent macrophyte communities were classified, namely pitcher plant’s community which distributes in patches surrounded with *Colocasia*-dominated community. Data of macrophyte species, number of plants, some site characteristics and water sample were collected in 2x2 m² plots sampling systematically in the whole studied area. Plant species composition differed between both plant communities. The pitcher plant’s community is mainly composed of ferns and pitcher plant (*Nepenthes mirabilis*) with frequency of 100% and 70%, respectively. The presence of shrubs (*Salix tetrasperma* and *Phyllanthus reticulatus*) and some wetland specific species such as *Eleocharis* sp. and *Actinoscirpus grossus* on the edge is remarkable. Substrate is characterized by accumulation of plant debris on the top soil or floating root mats depending on water levels which was about 20 cm depth at the time of study. For the *Colocasia*-dominated community, *Colocasia esculenta* is the prominent species which is accounted for 85% frequency whereas others are mostly less than 50% and the substrate is characterized by inundated soil. *Colocasia esculenta* forms monotypic stand in some parts of the area and its invasion into pitcher plant’s community significantly occurs. Water parameters (data from plots where standing water presented) were mostly similar between two plant communities, except total phosphorus concentration and total dissolved solid which were higher for pitcher plant’s community. The present study showed that the only remnant wetland in urban area provides natural habitat for pitcher plant which is the species of conservation significance, as well as threat to its existence by invasion of *C. esculenta*.

KEYWORDS:
*Colocasia* sp.; pitcher plant; remnant wetland
Community of the macroinvertebrates on rocky shores of southern Thailand

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ABSTRACT:
Southern Thailand is situated on the Thai-Malay peninsula, separating the Andaman Sea from the Gulf of Thailand. The coast facing the Andaman Sea is characterized by patches of rocky shores, interspersed with mangrove forests and sandy beaches. The Gulf of Thailand coast consists of natural rocky reefs that occur patchily as the coastline is dominated mainly by sandy beaches. Artificial coastal defence structures characterized by piles of rock boulders are one of the main features along this coastline. Few studies have been performed on rocky intertidal habitats in Thailand, and most were concerned with a specific taxonomic group (mostly molluscs) or with the community of a restricted area. The objectives of this study are to quantify species richness and community composition of macroinvertebrate community on both natural and artificial rocky shores of southern Thailand. Comparison of community composition between the two coastlines was also performed. Sampling was done on 13 shores in Trang and Satun province on the Andaman coast; and 17 shores in Nakorn Si Thammarat and Songkhla province on the Gulf of Thailand coast (7 were artificial). A total of 96 species were found on the Andaman coast and 36 species on the Gulf of Thailand coast. Dominant groups on most shores were molluscs, arthropods, annelids and sponges. The gulf of Thailand is considered as a close system; therefore, it was expected that the richness was lower because the lack of propagule supply from outside. Number of species on artificial shores were lower than natural shores (22 compared to 37 species). Although when the artificial shores were created was unknown, it is unarguably fact that this habitat is younger than the natural rocky shores; therefore, provided shorter time for species to established. Moreover, community composition of these macroinvertebrates was different between Andaman and the gulf coastlines. There is evidence to suggest that the species distribution and genetic diversity of marine organisms are influenced by the Thai-Malay peninsula as a geological barrier; and this work provides support that the peninsula is important as a barrier for rocky intertidal macroinvertebrates as well.

KEYWORDS:
Intertidal; macroinvertebrates; rocky shores; the Andaman Sea; the Gulf of Thailand
Seasonal variation of phytoplankton at Hat Pak Meng, the Andaman Sea

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ABSTRACT:
Hat Pak Meng is one of the high productivity coastal environments in the Andaman Sea because it locates near a river-mouth. There are several fishing practices by local communities at Hat Pak Meng and nearby areas. The seasonal variation of phytoplankton in coastal areas is related to several physico-chemical and biological factors. This study aimed to examine seasonal variation of composition and abundance of phytoplankton at Hat Pak Meng, Trang Province, the Andaman Sea during 2017 – 2018. Phytoplankton samples were collected by using a standard 20 μm mesh plankton net with a mouth diameter of 30 cm by horizontal hauls in the day time. Thirty-three major taxa of phytoplankton were recorded. The dominant groups were Coscinodiscus sp., Rhizosolenia sp. and Chaetoceros sp. The density of phytoplankton in September was much higher than that in April. The high seasonal variation taxa were Bacillaria paxillifera, Gyrosigma sp. and Leptocylindrus sp. The differences in the composition of phytoplankton taxa during the seasons may reflect the influence of water exchange and the impact of human activities.

KEYWORDS:
Abundance; Andaman Sea; environment; Hat Pak Meng; phytoplankton.
Aquatic insect diversity and water quality in Rasi Salai Dam, Rasi Salai district, Sisaket province

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ABSTRACT:
Diversity of aquatic insect and water quality in Rasi Salai Dam, Rasi Salai District, Sisaket Province were observed during June 2015 to January 2016. The samples of aquatic insects were collected 5 times from 8 sites. The 9,169 aquatic insects from 38 families in 6 orders were collected and identified. We found that Hemiptera, Ephemeroptera, Diptera, Odonata, Coleoptera and Trichoptera were dominant orders observed. The dominant families were Micronectidae, Baetidae, Corixidae, Chironomidae, Caenidae and Gerridae. The diversity indices of all taxa in each sampling site were 0.682, 0.777, 0.917, 0.814, 0.829, 0.814, 0.822 and 0.845, respectively. The Evenness numbers of all taxa in each sampling site were 0.713, 0.814, 0.949, 0.850, 0.873, 0.888, 0.863 and 0.889, respectively. The average water qualities; air temperature of 31°C, water temperature 31°C, Secchi depth 47.33 cm, conductivity 287.98 µs/cm, TDS 149.45 mg/l, alkalinity 32 mg/l, pH 7.46, DO 7.2 mg/l, BOD 2.6 mg/l, orthophosphate 0.04 mg/l, nitrate 0.10 mg/l, chlorophyll a 1.31 µg/l, total coliform bacteria 339.67 MPN/100 ml and faecal coliform bacteria 258.33 MPN/100 ml. The ASPT and AARL PC Score were 5.45 and 2.4, respectively and this could be used to classify the quality of water as mesotrophic status and identify as standard surface water type 3. The correlation analysis of dominant aquatic insects and water qualities including physical and chemical properties using MVSP can be divided into two groups. In the first group, we found that insects in the family of Chironomidae are related to Total coliform bacteria. The second group, we observed that Baetidae and Caenidae are related to Secchi depth.

KEYWORDS:
Aquatic insect diversity; Water quality; Rasi Salai Dam; Sisaket
Abundance of microplastics in some zooplankton groups at Hat Pak Meng, Trang province, the Andaman Sea

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ABSTRACT:
The occurrence of plastic waste in marine environment has become a growing problem worldwide. The high abundance of microplastics in different trophic levels of marine and coastal ecosystems has also been reported. However, scientific data on the ingestion of microplastics by zooplankton in Thai waters are limited. The aim of this study was to identify the characteristics and abundance of microplastics that are ingested by different groups of zooplankton, i.e., calanoid copepods, chaetognaths and shrimp larvae at Hat Pak Meng, Trang province, the Andaman Sea. The zooplankton samples were collected by using a standard 120 μm mesh plankton net with a mouth diameter of 30 cm by vertical hauls. The microplastics were investigated from at least 50 individuals from each zooplankton group. The results clearly showed that microplastics were detected from all zooplankton groups. The major microplastics were fibre. The high abundance of microplastics was observed in chaetognaths and shrimp larvae. Our results show that microplastic accumulation in zooplankton which may be passed through the marine food chain. Therefore it is necessary to determine the strategies to reduce the number of microplastics in marine and coastal ecosystems.

KEYWORDS:
Andaman Sea; copepod; microplastic; shrimp larvae; zooplankton.
Diversity and structure of caddisflies larvae (Insecta, Trichoptera) in stream, northern Thailand

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ABSTRACT: The influence of water quality variables on the abundance and diversity of caddisfly larvae was conducted in the Mae Yean stream, northern Thailand during January to November 2017. A total of 1,217 individual of caddisfly larvae belonging to 9 family and 17 genera were found. The larvae of family Hydropsychidae were the most abundance, followed by Glossosomatidae and Calamoceratidae. The genus Hydromanicus, Hydropsyche, and Diplectrona were the most abundance genera in this study. Results of CCA ordination showed the total dissolved solids, electrical conductivity and water temperature were the most important factor affects the abundance and diversity of caddisflies larvae. Changes in the caddisfly larvae may indicate changes in physicochemical factors owing to urbanization or other human activities. Results revealed that the order Trichoptera, identified to species or genus, can be potentially used to assess environmental water quality status in freshwater ecosystems.

KEYWORDS: Caddisfly larvae; diversity; water quality variables; freshwater ecosystems.
Roles of zooxanthellae associated with cauliflower corals, *Pocillopora* under temperature and light stresses

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**ABSTRACT:**
Symbiotic algae as known zooxanthellae are necessary for nutrition process, productivity, thriving and survival of corals. Symbiotic relationship between corals and zooxanthellae might be affected by elevated temperature and excess light. It has been found that coral holobiont is under threat due to high temperatures and excessive light which lead to coral bleaching (loss of zooxanthellae and/or photosynthetic pigments). Changes in symbiotic algae may represent an adaptation as temperature-tolerance in some location which had been experienced extreme environment. The response of symbiotic algae to temperature and light might depends on their thermal history. This research examined response of zooxanthellae associated with *Pocillopora acuta* collected from different environmental conditions. Nubbins of corals from Panwa Cape and Maiton Island, Phuket were collected and grown in four treatment tanks: 1) ambient temperature, ambient light, 2) ambient temperature, high light, 3) high temperature, ambient light, and 4) high temperature, high light for 1 week of stress phase and 1 week of recovery phase. Zooxanthellae density and chlorophyll a, c₂ concentrations were analysed. In addition, coral species was certain by the mitochondrial open reading frame sequences. The results showed that zooxanthellae and chlorophyll concentrations decreased under the combination of high temperature and high light stresses. Remarkably, zooxanthellae associated with corals from extreme reef, Panwa Cape seemed to be more resistant comparing to corals from Maiton Island. This study suggested that zooxanthellae associated *P. acuta* from extreme environment might be more resistant to heat stress, which enhances coral capacity to survive from coral bleaching event.

**KEYWORDS:**
*Symbiodinium*, coral bleaching; pigment; high temperature; excessive light.
Assessment of yeast diversity in Khan Thuli and Khuan Kreng peat swamp forests by culture-independent approach

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ABSTRACT:
In this study, the diversity of soil yeasts from peat swamp forests, Khan Thuli (KT) and Khuan Kreng (KK) swamp forests located in Surat Thani and Nakhon Si Thammarat, Thailand, respectively was investigated using polymerase chain reaction (PCR) and restriction fragment length polymorphism (RFLP). The sequence-based analysis of the D1/D2 domains of the large subunit ribosomal DNA sequences was performed. Sixteen samples of soils were collected from 3 different areas including primary swamp forest at Khan Thuli (PKT, 5 samples), secondary swamp forest at Khan Thuli (SKT, 5 samples) and secondary swamp forest at Khuan Kreng (SKK, 6 samples). A total of 732 clones were collected from 16 clone libraries. 256 clones (35.0 %) were closely related to yeast strains in GenBank database. Yeast sequences obtained from PKT, SKT and SKK were clustered into 10, 7 and 12 operational taxonomic units (OTUs), respectively, with a similarity threshold of 98 %. The diversity indices (H) revealed that yeast community in PKT (H = 1.20) was more diverse than that of SKT (H = 0.81). However, we found that yeast community in SKK soils was most diverse (H = 1.41) than other areas. In this study, the only identified yeast species found in all areas was Saccharomyces cerevisiae. Geotrichum silvicola was detected in Khun Thuli swamp forest, both PKT and SKT. Whilst Sterigmatomyces halophilus was only found in secondary swamp forest soils, SKT and SKK. Sollicoccozyma keelungensis was only obtained in SKK. Additionally, most of the D1/D2 sequences obtained were unable to be identified as known yeast species and these sequences may represent the sequences of new yeast taxa.

KEYWORDS:
PCR; RFLP; soil yeast; swamp forest; yeast ecology
Temperature tolerance of Thai freshwater fishes exposed to dynamic change in the temperate rivers: global warming implication

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ABSTRACT:
Critical thermal maxima (CTmax) for fish acclimatized to an ambient river temperature between 23.0 °C and 28.0 °C was the same as the CTmax for fish, acclimated to these experimental temperatures. CTmax the four species; Rasbora rasbora, Channa gachua, Devario regina and D. annandalei, examined were significantly related to the temperature values (p<0.05). CTmax were the lowest at 36.0 °C and 36.2 °C for D. regina and D. annandalei, respectively, acclimated to 23.0 °C and found the highest at 38.6 °C for M. chilopterus, R. rasbora and C. gachua, acclimated to 28.0 °C. The amount of heat shock protein 70 (Hsp70) was found lowest at 23.0 °C acclimation temperature while the amount of Hsp 70 was higher at 28.0 °C for four species. The lowest amount of Hsp70 was found in D. regina and D. annandalei, and the highest amount of Hsp70 was found for M. chilopterus, R. rasbora and C. gachua, respectively. Interestingly, tropical river fish increasingly produced amount of Hsp 70 when water temperature in the rivers was gradually increasing. Hence, higher concentration of Hsp 70 in fish could be expected to fish physiological process adapted to protect for thermal river condition, where water temperature is altered from global warming phenomena.

KEYWORDS:
Critical thermal maximum; Acclimation temperature; Freshwater fishes; Heat shock protein 70; Global warming
Diversity of phytoplankton and water quality assessment in Kwai Noi River, Kanchanaburi province, western Thailand

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ABSTRACT:
Diversity of phytoplankton and water quality assessment in upstream and midstream areas of Kwai Noi River were studied at 8 stations during August to December 2015. The physico-chemical parameters were measured at all sampling sites and water samples were collected with filtering of water by plankton net. One hundred and thirty-six species belonging to six divisions of phytoplankton were found in this study. The highest number of species were in Division Bacillariophyta 54 species (39.7%), followed by Chlorophyta 42 species (30.9%), Cyanophyta 29 species (21.3%), Euglenophyta 6 species (4.4%), Dinophyta 4 species (2.9%) and Heterokontophyta 1 species (0.7%). Diversity index of phytoplankton was higher in the midstream ($H'$=2.8) than in upstream ($H'$=2.3) regions. The dominant species of upstream were Fragilaria spp., Navicula spp. and Chlorella spp. while Cosmarium spp., Navicula spp. and Synedra spp. were most common in the midstream. The mean rainfall had a negative correlation with species number whereas water temperature had a positive correlation with species number and density of phytoplankton. Finally, the water quality assessment by Applied Algae Research Laboratory Phytoplankton Score (AARL-PP Score) of Kwai Noi River was 5.3 in upstream and 4.3 in the midstream. Therefore, the water quality showed a moderate level based on species number and density of phytoplankton in this study.

KEYWORDS:
Diversity; Kwai Noi River; Phytoplankton; Water quality; Western Thailand
Assessing population structure of the wedge clam on sandy beaches in a shellfish protected area in Trang province

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ABSTRACT:
The wedge clam, *Donax scortum* is the shallow-bottom bivalves generally found in sandy beaches. It is capable of reaching high population densities in some areas and is one of the economic bivalve species in the Andaman coast of Thailand. The local fishers collected the clams by observing siphons of the clams and digging by a PVC pipe tipped. A management strategy for conservation of the clam in Trang Province is an establishment of a shellfish protected area. This study aimed to examine population structures of *D. scortum* in a shellfish protected area compared to non-protected areas on a sandy beach at Hat Pak Meng in 2018. The results of this study showed that the 5-6 cm size class of *D. scortum* in the shellfish protected area was higher than those in non-protected areas. Recruitment of *D. scortum* was also observed in the shellfish protected area. This study shows the importance of *D. scortum* and sandy beach ecosystem services. The efforts of conservation groups and local communities in the Pak Meng area and nearby can help conserve marine and coastal resources. The shellfish protected area can be a learning centre for tourists and promotes ecotourism in Trang Province as well.

KEYWORDS:
Andaman Sea; bivalves; conservation; *Donax scortum*; management; protected area
Diversity of coral reef fishes at Racha Yai Island, Phuket, Thailand (2013-2018)

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ABSTRACT: Reef fish plays an important role in the community dynamics of coral reefs and maintaining healthy reefs. In this study, the reef fish diversity, richness, evenness, and fish feeding habits were studied at Patok Bay from 2014-2018 and Khonkae Bay from 2013-2018, Racha Yai Island, southern Thailand. The fish visual census technique was done using Line Intercept Transects (LIT) method in both bays. In Patok bay, three 50-m permanent line transects, and in Khonkae bay, four 50-m permanent line transects (each covering 250 m²) were set up along the reef slope at 8-10 m depth. Each transect area was separated from each other by 10 m. The number of fish species, the number of fish individuals in each bay were recorded. Shannon index (H), species richness (D) and evenness (e) of fish in each bay were analysed. Shannon index (H), species richness (D), and evenness (e) of fish decreased significantly from 2013 to 2014, and after that increased in 2015 to 2018. At Patok Bay, the number of fish individuals, Shannon index (H), species richness (D), and evenness (e) of fish did not vary between years, but the number of fish species increased among years from 2014-2018. Our results show that fish species was more evenly distribute in Khonkae Bay than in Patok Bay. This is because in Patok Bay, there were high numbers of Pomacentrus pavo compared to other fish species.

KEYWORDS: Fish feeding habits; Khonkae Bay; Patok Bay; Racha Island; Shannon index (H)
Assessing available substrates for coral recruitment on shallow reef flats in the Western Gulf of Thailand

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ABSTRACT:
Although shallow reef flats are in extreme environment, especially high temperature and light intensity, juvenile corals are also found in some reef sites. Available substrate for scleractinian coral recruitment is one of the important factors controlling coral community structures and recovery after disturbances. This study aimed to assess the available substrates for coral recruitment on shallow reef flat at five reef sites, i.e. Ko Mattra, Ko Kula, Ko Lawa, Ko Rang Kachiu, and Ko Maphrao. The field surveys were conducted in April 2018 by using a random quadrat method for assessing percentages of dead corals and rubble on benthic components. The results showed that percentages of available substrate for coral recruitment were significantly different. The high percentages of the available substrate were observed at Ko Maphrao and Ko Rang Kachiu. The available substrates for coral recruitments at Ko Kula were limited (17%). This study highlights the importance of available substrates for coral recruitment on shallow reef flats. Further studies on coral reef restoration should develop proper passive and active methods for enhancing coral reef resilience and coral recovery after severe disturbances.

KEYWORDS:
Available substrate; coral recruitment; Gulf of Thailand; reef flat; restoration; resilience
ABSTRACT:
Some scleractinian corals are found on shallow reef flats and they can adapt to high-stress environment, particularly negative impacts from high temperature and irradiance. These tolerant corals are appropriate for coral stocks when coral reefs are degraded by coral bleaching events. Previous coral reef studies in Thailand were focused on the reef with the depth of more than 3 meters. Therefore, ecological data on coral reefs in shallow reef flats is very limited. This study aimed to examine live coral cover and composition in shallow reef flats at Mu Ko Chumphon, Chumphon Province. A random quadrat method was applied at five study sites i.e. Ko Mattra, Ko Kula, Ko Lawa, Ko Rang Kachiu, and Ko Maphrao. The field surveys were conducted in April 2018. The high percentages of live coral cover were observed at Ko Mattra (68%), Ko Lawa (57%), Ko Rang Kachiu (49%), and Ko Maphrao (43%). The most degraded coral community was found at Ko Kula with live coral cover only 9%. The dominant corals were Porites lutea, Pavona decusata, P. cactus and Favites pentagona. This study emphasizes the importance of shallow reef flats in the Gulf of Thailand which has high potential to be as parent coral colonies contributing to the natural recovery of impacted coral reefs under the global change crisis and supporting the coral restoration projects in some areas as well as maintaining the quality of coral reef ecosystem services.

KEYWORDS:
Coral community; Favites; Gulf of Thailand; Pavona; Porites; reef flat
Coral recruitment on settlement panel experiments from Mu Ko Anghong, the Western Gulf of Thailand

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ABSTRACT:
Coral recruitment is a major process in maintaining coral reef ecosystems and in facilitating coral recovery after natural and anthropogenic disturbances. Studies on coral larval supply and recruitment patterns in Mu Ko Anghong are very limited. The aim of this study was to quantitatively examine the recruitment patterns of corals by using settlement panel experiments at Ko Sam Sao (East), Ko Sam Sao (West) and Ko Wua Kan Tang in Mu Ko Anghong National Park, the Western Gulf of Thailand. The densities of coral recruits on settlement panels at Ko Sam Sao (West) was significantly higher than that at Ko Sam Sao (East) and Ko Wua Kan Tang. The highest diversity of coral recruits on settlement panels was also recorded at Ko Sam Sao (West), followed by Ko Sam Sao (East) and Ko Wua Kan Tang. Pocilloporiids were the most dominant taxa of coral recruits on settlement panels at Ko Sam Sao (West). This study provides the important baseline scientific data to the understanding of coral recruitment patterns in Mu Ko Anghong. A long-term monitoring program for coral recruitment in other island groups in the Western Gulf of Thailand is needed.

KEYWORDS:
Coral; Gulf of Thailand; monitoring; Mu Ko Anghong; recruitment; settlement.
Temporal variation of zooplankton from Trang province, the Andaman Sea

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ABSTRACT:
Zooplankton plays a major role in the trophic link between primary producers and consumers in marine and coastal ecosystems. Knowledge on the structure of zooplankton community is needed for understanding of marine ecosystem processes. The zooplankton data were also applied for prediction of recruitment of commercially important species. The data on temporal patterns in zooplankton composition in Thai waters are limited. This study aimed to examine seasonal variation of composition and abundance of zooplankton from Hat Pak Meng, Trang Province, the Andaman Sea. Zooplankton samples were collected by using a standard 120 μm mesh plankton net with mouth diameter of 30 cm by horizontal hauls in day time. Twenty-three major taxa of zooplankton were found. The dominant groups were cyclopid copepods, calanoid copepods, gastropod larvae, Sagitta spp. and nauplius larvae. The density of zooplankton in September was much higher than that in April. The high seasonal variation zooplankton taxa were ostracods and ophiopluteus larvae. This study provides important baseline data of zooplankton in coastal areas of the Andaman Sea.

KEYWORDS:
Abundance; Andaman Sea; diversity; sandy beach; variation; zooplankton.
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HUMAN AND WILDLIFE IN THE ANTHROPOCENE
Documenting human-snake conflict in the Sakaerat Biosphere Reserve

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ABSTRACT:
Human-snake conflict occurs across Southeast Asia; when people attempt to remove snakes there is a chance of envenomation and injury. Mitigating snake-bites, a neglected tropical disease, requires knowledge of snake behaviour and rescue teams trained to safely remove snakes. We have opportunistically documented instances of human-snake conflict in Nakhon Ratchasima province, at the Sakaerat Biosphere Reserve. The captures reveal hotspots of rescue team demand and human-snake conflict. During this time, we also radio-tracked a king cobra that exemplifies the issues facing humans and snakes living in close proximity to a protected area boundary. The adult male king cobra would repeatedly leave the protected area, entering human settlements—a behaviour more frequently observed during king cobra breeding season. We believe that efforts to train rescue teams across the region will reduce snake-bites. The seasonal changes in snake behaviour suggest than rescue teams may be put under greater pressure during certain times of the year.

KEYWORDS:
Conservation; human-snake conflict; spatial ecology; snake.
An assessment of habitat connectivity for the endangered Malayan tapir in Thailand

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ABSTRACT:
The Malayan tapir (Tapirus indicus) is threatened by habitat loss and fragmentation, causing populations to become small and isolated. An assessment of habitat connectivity patterns is crucial for the survival of the species because connectivity facilitates species movement and gene flow. Our goal was to identify habitat connectivity networks for the Malayan tapir in Thailand. We first defined suitable habitat for tapirs using average home range size. We then applied circuit theory analysis to assess potential dispersal corridors using Circuitscape software. We identified 42 suitable habitat forest patches and 22 potential dispersal corridors for tapirs in Thailand. Chumphon forest complexes had the highest number of potential dispersal corridors. Our study highlights important potential suitable forest patches and dispersal corridors for the Malayan tapir within and between forest complexes. We suggest that habitat connectivity assessment can assist conservation efforts for the Malayan tapir and other endangered mammals in the region.

KEYWORDS:
Circuit theory; Conservation; Corridor; Habitat connectivity; Mammal.
Minimum effort required to estimate abundance and habitat selection of elusive nocturnal primates

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ABSTRACT:
Information on a species status and the appropriate conservation management can be gathered using estimates of their abundance and habitat preferences. Obtaining this information from nocturnal arboreal primates is particularly challenging due to their cryptic behaviour, often resulting in a small sample size. Limited approaches are available to assess abundance from these small data sets and most techniques require strict assumptions which are difficult to meet. Our aim was to produce reasonable estimates of nocturnal primate abundance and habitat selection when sample size was small and to determine the minimal effort required to achieve these estimates. N-mixture hierarchical modelling was applied to data from a previous study on Bengal slow loris (Nycticebus bengalensis) and simulations were run to explore various survey protocols. We found a non-bias estimate (5%) in the constant model required a minimal effort of at least 50 transects and 8 sample occasions for datasets with a lambda of 0.5 and probability detection ($p$) of 0.2. Meanwhile for the in the model stratified by two habitat types, required each habitat to have at least 25 transects and 10 sample occasions with a lambda of 1 individual and 2 individuals per site and a constant $p$ of 0.2. As demonstrated in this study, preliminary surveys are a useful technique to gauge the specific lambda and probability of detection so that surveyors can establish the effort required to produce reasonable estimates of abundance. Our findings indicate that robust abundance estimates of nocturnal arboreal species can be obtained from using count data. However, N-mixture incorporates detection probability and habitat preferences yet does not require additional trained field technicians, unlike simple encounter rate.

KEYWORDS:
Abundance estimation; Bengal slow loris; N-mixture model; Nycticebus bengalensis; Sakaerat Biosphere Reserve
The influence of habitat structure on the dominant predators of Scaly-crowned Babbler *Malacopteron cinereum* in seasonal evergreen forest in northeastern Thailand

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**ABSTRACT:**
Nest success of forest birds is usually low due to high rates of predation, but still poorly known regarding how different dominant predators affect nest-site selection and nesting success, particularly in the tropics. We studied the influence of habitat structure on the dominant predators of Scaly-crowned Babbler *Malacopteron cinereum* in seasonal evergreen forest in northeastern Thailand during four breeding seasons. We identified nest predators using the 24-hour surveillance infrared video cameras monitoring and examined relationships between vegetation structure at nest site and nest predation by dominant predators. Nest sites had significantly higher concealment and liana density than random sites. Daily nest survival and overall nest success was low 0.918±0.04SE and 13±0.04SE %, respectively. Most nests failed due to predation; 59 predation events from nine predator species were recorded such as Northern Pig-tailed Macaque (*Macaca leonina*) (47.5%, *n*=28), five species of avian predators (32.2%, *n*=19), and two species of snakes (18.6 %, *n*=11). Density of small saplings was significantly higher at nests depredated by macaque, while density of vegetation at 5–10m above ground was significantly higher at nests depredated by snakes, but nests depredated by avian predators were not related with any measured variables. Vegetation structure probably alters which predators are likely to locate nests within sites, and therefore impacts from human disturbance such as from deforestation and logging may be particularly difficult to predict as these effects are likely to vary among sites and regions depending on the dominant predators.

**KEYWORDS:**
*Malacopteron cinereum*, nest predation; nest survival; nest-site selection; tropical birds
Community based Enterprise: a conflict solution between wild Elephants and local people Eastern Forest Complex: Thailand

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ABSTRACT:

Eastern Forest Complex cover 6 provinces in Eastern part of Thailand That has 2,380 Sq.Km consists of 5 National Parks and 3 Wildlife Sanctuaries. Population of wild elephants are about 500. Habitat of wild elephants have been destroyed by agriculture expansion around the area. There is not enough space for wild elephants to live. Elephants encroach to agriculture land and destroy people’s crops and properties. It is a big threat in large areas of Eastern Forest Complex. The people are lost the money a lot of from this problem. So economic system is one of a big problem in Eastern part of Thailand.

Sappan Tree (Ceasalpinia sappan Linn.) One of spp found within the Eastern Forest Complex. That Wild elephants do not eat. The farmer can be harvested within 3 years and easily grow in local farms under Agroforestry system. It gives medical values: antitirist, blood purifying, nourish the heart, and antidiabiatic The heartwood has long been used in Thai traditional medicine to treat tuberculosis, diarrhea, dysentery, skin infections and anemia. In traditional Chinese medicine, it is used for treatment of increased blood circulation, promotes menstruation and exhibit analgesic and anti-inflammatory potentials. Modern day researches confirm its treatment in cytotoxic, antitumor, antimicrobial, antiviral, and immunostimulant.

Community Based Enterprise it means “Community business relating to the production of goods, services or other activities carried out by a party of persons with a commitment. They have a way of life together and are involved in the business. Community Based Enterprise is a conflict solution between wild elephants and local people in Eastern Forest Complex. They are made some products for sale by Sappan Tree. The products have various qualities and various product about food, drink, herb and cosmetic techniques. They are have a lot of money enough for live and are not interested when the wild elephant come to their agriculture land.

KEYWORDS:
Community Based Enterprise; Sappan Tree; Wild Elephant; Eastern Forest Complex
Effects of park size and distance from urban center on resident bird species richness in public parks, Bangkok

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ABSTRACT:
Public parks which characterized as main green space in the cities were largely established for providing ecological service to citizen. However, the researches on the diversity of animals including birds in the public park which reflects habitat function were scarce in Thailand. Thus, this study focuses on testing the effects of public park size and distance from urban center on the richness of resident bird in 24 public parks (1.5 to 80 ha) in Bangkok metropolis. A total of 46 species of diurnal resident birds were found during survey. 4 species were observed in every park including *Copsychus saularis*, *Pycnonotus blanfordi*, *Passer montanus* and *Psilopogon haemacephalus* while 6 species were found in 23 out of 24 parks. Within 24 parks, species richness ranged between 14 and 35 with an average of 22. According to the analyses done by generalized linear model, we found that resident bird richness significantly increased with park size. But distance from the urban center defined as a centroid of the most populated district in Bangkok did not affect the richness directly, even when it was considered with park size. In conclusion, public park in the city can provide habitats for birds and the larger parks are likely to support more resident bird species.

KEYWORDS:
Birds; habitat island theory; public park; species richness; urban ecology
Parentage assignment using molecular markers and incomplete observational records to identify candidates for translocation and inform management in a population of the southern white rhinoceros

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ABSTRACT:
The southern white rhinoceros (Ceratotherium simum simum; SWR) show low genetic diversity due to the historical bottleneck of the species. The conservation strategy that aimed to conserve the species within relatively small but closely protected areas resulted in the rapid increase of SWR overall growth. However, this strategy contributes to an issue of small and fragmented populations, which raises concerns about the negative effects of genetic drift. Further, the SWR reproductive strategy in which one or a small number of dominant bulls is expected to sire all the offspring within a population reduces effective population size and reduces genetic diversity. Translocation of SWRs among populations has become routine practice to introduce gene flow and enhance genetic diversity. To efficiently identify candidates for translocation, an accurate and complete pedigree is necessary. Here, field records with a high degree of uncertainty regarding the observed parents-offspring relationships and genotypes of 18 microsatellite loci of a fenced population of 55 SWRs (10 founders and 45 offspring) in Botswana were used for parentage assignments. We used the combination of four different assignment approaches to determine the pedigree of the population in this study, including observational records, exclusion based on allelic mismatch, likelihood-based, and Bayesian-based assignments. Next, we estimated kinship coefficients to predict the risk of reproducing an inbred offspring for each pair of individuals. Out of 45 offspring, we could identify 29 sire-dam-offspring trios, six sire-offspring duos, and four dam-offspring duos. The pedigree that was generated was subsequently used to estimate mean kinship (mk) at both individual and population levels, and we then identified eight young bulls that had high individual mk compared to the overall population mk as candidates for translocation. These bulls were considered to be a high risk for inbreeding if they were retained and able to reproduce. We also found that multiple bulls contributed to offspring after the original dominant bulls were removed, which was contrary to expectations. This finding suggests that inbreeding in a fragmented population of SWR can be reduced by regularly relocating recently dominant bulls and young bulls with high estimates of mk. Although the results obtained in this study indicate that even a molecular marker set with low diversity can improve the rate of successful parentage assignments, we propose that the development of a larger set of genetic markers as well as the cost-effective protocol that would allow genotyping in many individuals are necessary to achieve a complete pedigree.

KEYWORDS:
Fragmentation; Kinship coefficient; Microsatellite; Parentage assignment; Translocation; White rhinoceros
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ECOTOURISM & UNESCO GLOBAL GEOPARK
A new locality of leaf fossil and its paleoenvironment of Wat Doi Ton, Tambon Mae Kasa, Mae Sot district, Tak

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ABSTRACT:
The characteristics of plants in each area of the earth are controlled by the environment surrounding it. Due to plant incapable to move, so it is forced to adapt their characters to survive in each environment. Moreover, the characteristics are strongly influenced by climate, which is the difference by latitude. This means we can use the plant to be proxies for interpreting paleoclimate. The popular proxies are petrified wood and leave fossil. This study uses leaf fossil combine with sedimentology and stratigraphy for analyzed paleoenvironment of the study area. The leaf fossils were selected from Wat Doi Ton, Mae Kasa Sub-district, Mae Sot District, Tak Province, which is a new site of leaf fossil in Thailand. The result shows leaf fossils are imprinted in sandstone with plant debris and some of bivalve fossil. The sedimentary rock consists of a cycle of reddish brown to white conglomerate, sandstone, and siltstone with the fining-upward sequence. The leaf fossil can classify as dicot leaf with an unlobed and pinnate leaf with untoothed margin and non-lobed secondaries. From the analysis of stratigraphy and leaf fossil indicate the sediments are deposit in the fluviatile environment under warm and humid climate. In addition, the morphology and lithology can clue this area can be Tertiary sedimentary formation of Mae Sot group. The study in this area is important to the area in aspects of being new an educational landmark which will make people cherish and protect the fossil and geological resources and may be developed into a geological tourist attraction of Tak province in the future

KEYWORDS:
Leaf fossil; Tertiary; Sandstone imprint; Wat Doi Ton; Mae Sot Group.
Geopark as an effective tool in enhancing sustainable geotourism and local communities engagement – the case study of Hong Kong

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ABSTRACT:
The UNESCO Global Geoparks (UGGp) stipulates one of the main strategic objectives of a Geopark is to stimulate sustainable economic development through geotourism. Geotourism is interpreted as geological tourism with focus on geology and its interaction with ecology and culture (Chen, AZ, Lu, YT, Ng, YCY 2015, Principles of Geotourism, Springer Geography, Science Press Beijing, p. xiii). Hong Kong has been famous for being a dazzling metropolitan offering numerous attractions, ranging from shopping paradise, western and eastern food fusion to mesmerizing Victoria Peak, Repulse Bay and Ocean Park. With the establishment of Hong Kong Geopark in 2009 and later accepted as Global Geopark in 2011 because of its spectacular and distinct geoheritage as well as naturalness, excellent management and interesting culture, Hong Kong has attained an important international renowned brand to attract tourists. The philosophy and vision of geoparks are to provide a balance between conservation of geoheritages, local socio-economic development and local community empowerment. UGGp aims at actively involving local communities and indigenous peoples as key stakeholders in the Geopark. If the local communities are not involved, Geopark will not have its soul. However, most of the attractions of Hong Kong Geopark situate in remote areas where some villages have even been dilapidated, populations are declining and communications are inconvenient. Though UGGp has set up guidelines, engaging local communities and enhancing sustainable economic development mainly via geotourism, these are not easy to be concretely put into practice. The author, using Hong Kong case, tries to study how Geopark helps to promote geotourism and enhance local engagement. It also attempts to assess the compatibility of geoconservation and geotourism, the challenges and opportunities of geotourism development in Hong Kong.

KEYWORDS:
Geopark; geotourism; local communities engagement; sustainable economic development; geoconservation
Building a sustainable forest trail in Perlis State Park: an innovative approach to invigorate protected areas and connect them with local communities

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**ABSTRACT:**
Perlis State Park in the northern Malaysian state of Perlis is a protected area of 5,075 ha situated. Together with Thale Ban National Park in Thailand it is part of an important transboundary conservation area that is known for rare flora and fauna and ancient limestone formations. Although, the park initially benefited from an infusion of donor funds after its establishment in the late 2000s, this infrastructure has since deteriorated due to lack of upkeep and repair. The number of visitors to the park has also declined over the past decade. However, recently there are signs of new life being breathed into Perlis State Park with the development of a 12 km Sustainable Forest Trail to Gunung Perlis (733 metres). This is the highest peak along the Malaysian-Thai border. The Gunung Perlis trail project was proposed by the Forestry Department as a means of renewing public interest in the park and also justifying increased funding allocations for improvement. Sustainable Forest Trails are essentially simple earth trails that are shaped within forest landscapes using basic engineering principles and tools. Once the trail alignment is designed and marked out, the trails themselves are inexpensive to build. Local forest and outdoor enthusiasts are enlisted to participate in the construction and generally tend to form a close association with the trail they have helped build. This then provides the motivation for their continued involvement in its upkeep. Technical assistance and training for the Gunung Perlis trail were provided by a Malaysian trail-building social enterprise which was funded by a local environmental foundation. Based on observations, the Gunung Perlis trail is helping to restore interest in the park among locals and visitors alike. This experience has helped to demonstrate the value of engaging local communities in the life of the park and the use of Sustainable Trails to facilitate this.

**KEYWORDS:**
Protected area management; sustainable forest trails; community participation; ecotourism; Perlis State Park; Malaysian rainforest
Green peafowl (Pavo muticus Linnaeus, 1766) of Phayao province, Thailand: human-green peafowl relationship under ecotourism and organic farmland

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ABSTRACT:
Phayao province is one of the most importance area for organic farmland, origin of up stream and water resource under forest conservation and management. Human and wildlife animal such as green peafowl show significantly interrelationship for surviving and development. Our study are five categories which including strategic review, status and requirements of biogeography-ecology, human-agriculture-green peafowl relationship, city of green peafowl and ecotourism. Green peafowl distribution and its feeding plant species have analyzed and reported. Green peafowl-agriculture and conservation balance model has designed and tested. Green peafowl conservation community and its connections have initiated. This work can be supported the green peafowl city project and biodiversity-human empowerment.

KEYWORDS:
Biodiversity; Green Peafowl; In situ conservation; wildlife
Thailand’s petrified forest: a flagship symbol toward sustainable community development and management

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ABSTRACT:
Abundant Mesozoic to Cenozoic petrified trees have been found throughout Thailand, especially in the north and northeast. Prominent fossil tree sites include Tak, Phichit, Nakhon Ratchasima, Khon Kaen, and Kalasin provinces. The sites are in national parks, educational institutions, community forest areas, and private property. Conservation and management strategies have been established by several government agencies, such as the Department of National Park, Wildlife, and Plant Conservation, the Royal Forest Department, and the Department of Mineral Resources over the past decade. For example, Doi Soi Malai National Park (formerly Petrified Forest National Park), Tak Province, is in the process of obtaining full protection status to maintain large fossil angiosperm trees. The park includes Namtok Huai Mae Khai and Namtok Kaeng Huai Tak forest parks. Most petrified trees at this site, including all large trunks, belong to Fabaceae. This site has great potential to develop both geo- and eco- tourism with biodiversity as the main focus. Unfortunately, the number of visitors in recent years has declined by more than 50% from 2006 as a result of the fossil deterioration and ineffective conservation techniques. In order to raise public awareness, we organized public outreach educational programs and seminars with local schools and communities in 2018 and 2019 assisting a thousand people to understand the Geopark concept in Tak province and to learn about petrified wood conservation. We found that local people are enthusiastic about holistic management techniques to facilitate local economic growth by connecting petrified trees to other natural resources, archaeological sites, cultures, food and local products. Following the example of Lesvos Island UNESCO Global Geopark, the use of petrified tree sites as a flagship in geoconservation from a bottom-up approach seems to be more effective for long term sustainable development and management in Thailand.

KEYWORDS:
Conservation; community; petrified forest; sustainable management; Tak
Khorat National Geopark and conservation of biodiversity

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ABSTRACT:
The Khorat Geopark was recognized in 2018 as the Khorat National Geopark. This park covers five districts in Nakhon Ratchasima Province and has geological sites of international significance, including cuestas, excavation sites of dinosaurs and other Mesozoic vertebrates, and abundant deposits of Cenozoic mammals and other vertebrates. The geopark is playing a significant role in the conservation of both biodiversity and geodiversity and is bringing together local officials, villagers, and religious leaders to be involved in the conservation efforts. The following examples illustrate the conservation activities. At Loet Sawat (or Khao Chan Ngam) temple in Sikhio District, at the site of ancient pictographs on the sandstone walls, the geological and archaeological features as well as dry evergreen forest and the resident wildlife is being protected with the involvement of monks and local villagers. The locals also offer instructions on the various uses of medicinal plants. At Pha Yai Thiang, a cliff in Sikhio District, local children perform puppet shows for visitors promoting conservation of the local forests. Dry evergreen forest in Sung Ngoen District is protected at Wat Pa Phu Pha Sung at the top of a 700 meter cuesta. At the Khorat Fossil Museum in Mueang District, some of the natural deciduous dipterocarp forest is being preserved. In Chaloem Phra Kiat District, where numerous ancient elephant and other animal and plant fossils have been discovered, natural vegetation is being conserved along the Mun River, including an immense fig tree, Ficus benjamina. In all of these sites of the Khorat National Geopark, local officials, local tour guides, monks, teachers, school children, and villagers are involved in education about and protection of the local resources.

KEYWORDS:
Conservation; cuestas; Khorat National Geopark; Nakhon Ratchasima Province.
Satun UNESCO Global Geopark, the readiness for sustainable tourism

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ABSTRACT:
Satun Province is the province with high tourism potential. There are sources of natural tourism especially in Satun geopark which covered three of seven districts of Satun Province namely Thungwa, Manang, Lang, and Meung Satun. The tourist attractions in the area can be divided into four zones: sea-island zone; inland ecological zone; fossil zone; and intangible heritage zone (Department of Mineral Resources, 2015). The famous tourist attractions are Li-Pe Island, Hin Ngam Island, Adang-Ra Wi Islands, and Dong Islands located in Tarutao National Park, Pak Bara Beach, Satun Karst Zone composed of caves such as Stegodon Sea Cave, Chet Khot Cave, and Phu Pha Phet Cave. Furthermore, there are also lapiés, waterfalls, and streams for kayaking.

As UNESCO announced to Satun geopark is UNESCO global geopark on April 17, 2018, creating pride for the people in the country. Being a global geological park can attract the eco-tourists from all over the world. Therefore, in the Satun geopark, there must be efficient and proper tourism management to preserve the existing ecosystem and also impress the tourists. Logistics management is consequently applied to sustainable tourism. With four components of logistics management for sustainable tourism: geological resources and landscape; transportation; amenities; and environmental management as well as creating value of tourism products using three supporting factors: information and communication technology; innovation; and sustainable management provide tourism value for the tourists in terms of flexible, convenient, fast, and safe. This paper aims to discover the component of logistics management and to evaluate the logistics management potential for sustainable tourism for Satun UNESCO Geopark. The results could be used for government agencies, and the private sector involved such as Satun Provincial Administration Organization, Sub-district Administration Organization in the area as well as travel service operators.

KEYWORDS:
Satun UNESCO geopark; logistics management; sustainable tourism
The potential of post-mining management as a sustainable geopark in Thailand- a case study from the Muskauer Faltenbogen/ Łuk Mużakowa UNESCO Global Geopark, Central Europe

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ABSTRACT:
Thailand is located in a complex tectonic setting zone, so, there are many mineral resources and mines. The significant developing post-mining areas consist of ore mining (Tin, Zinc, Copper, Lead, Gold) in western, southern, and North-central parts, coal mining (Lampang and Loei), clays mining (Lampang), gemstone mining (Kanchanaburi, Trat, and Chantaburi), and limestone mining all over this region. However, these sites were not managed as a good place for tourism or education. This is one of the most important problems of environment management in Thailand. The main goal of this research is defining the development guidelines of the post-mining areas as good attractions/geoparks for Thai sustainability via literature, inventory, field observation, and characterization in the Muskauer Faltenbogen/ Łuk Mużakowa UNESCO Global Geopark. This Geopark was created in Polish–German transitional zone for developing geotourism in brown-coal, clays, and glass sands post-mining areas. The glacier process in 350,000 years ago created the tongue-shaped ice thrust ridge with deep soft sediment deformations. Moreover, the ice sheet is the reason for the arch in the Oligocene and Miocene sediments with brown coal layers and also transported the erratic boulders from the Scandinavia region to deposit in this area. The unique landscape of the geopark has been influenced not only by the natural glaciotectonic structures that occur in its basement, however, it also results from the mining activities and commercial use of the geological features. According to the difference of language, economy, and administration, this geopark was divided into two headquarters, which are located in Poland and Germany. Although it has different organizations, this geopark has been developing as the same way, which has the aim for sustainable development. The organization created the geo-trails, infrastructures (museum, viewpoint towers, geologic panels, online information, rock and mineral gardens) as well as mine-reminders for educating people about their earth sciences that reach from natural to man-made climate change, use of raw material and later re-naturalization of historical mining areas. They also made good facilities for tourists and students such as trail developments (floor and handrail), rest areas, public restrooms, garbage bins, small food courts, souvenir shops, and local guides. Meanwhile, the mixed forests, acid springs, varied post-mining lakes have been conserved as good ecosystems of exhibiting significant ecological diversity. Since local people cooperate with the authorities, this community have got the biospheric, social and economic sustainability. Geotourism and ecotourism industries are the advantages of geoparks, which is social entrepreneurship and one of the ways to achieve sustainable management. This scheme can make local people have better livelihoods and also conserve their historical, natural, and geological monuments. These viewpoints should be extremely applied with the post-mining areas in Thailand for increasing their own values and giving the benefits to local people and society.

KEYWORDS:
Post-Mining Management; Muskauer Faltenbogen; Łuk Mużakowa; UNESCO Global Geopark; Sustainable Development
ECOSYSTEM SERVICES AND RESTORATION
Fruits, seeds and seedlings of forest trees for restoration in northern Thailand

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ABSTRACT:
The forests in northern Thailand are one of Thailand’s most important natural resources, as is a source of biodiversity. But within 50 years, these forests have widely been destroyed. Consequences, the number of species of plants and animals were rapidly decreased. Forest Restoration Research Unit was established to study and development of tools and promotes the regeneration of natural forest ecosystems. The aim of the unit is to development effective methods to complement and accelerate natural forest regeneration on deforested sites within conservation areas, to increase biodiversity and protect watershed. During 25 years, FORRU was to gather basic ecology data about the very large number of tree species which grow in the in northern Thailand, including seed germination, seedling growth in the nursery and seedling growth in the planting site. With more than 1,100 species are large enough to use for forest restoration in northern Thailand. From the output of the research, the database of ecological and morphological of seed and seedling of 723 species was set up. The project “Fruits, seeds and seedlings of forest trees for restoration in Northern Thailand” was funded by the National Science and Technology Development Agency, to conduct a research and gather information on the ecology and morphology of the trees in northern Thailand. The output of the research project, including ecological and morphological species of 312 will allow us to choose the right tree species for the most efficacies in forest restoration program. In addition, the information obtained through this project was recorded into the database, which makes data storage and data access to be effective.

KEYWORDS:
Database, Morphological, Ecological, Seed, Seedling, Forest tree species
Germination performance of *Nymphaea rubra* Roxb. cv. ‘Maeploi’ seeds produced from conventional breeding *in vivo*.

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ABSTRACT:

This research was aimed to develop the culture medium enhancing the germination and survival percentage of cross-pollinated seeds in *Nymphaea rubra* Roxb. cv. ‘Maeploi’ produced from the conventional breeding. Firstly, *N. rubra* Roxb. cv. ‘Maeploi’ and *N. pubescens* Wild. were collected from the Lotus museum, Division of Building and Site Administration, Rajamangala University of Technology Thanyaburi, which used as the plant materials. In the experiment I, the interspecific hybridization between *N. rubra* ‘Maeploi’ and *N. pubescens* was performed by hand pollination technique. In the experiment II, the self-pollinated seeds of *N. rubra* ‘Maeploi’ were investigated about the first surface sterification in 20% (w/v) Sodium hypochlorite (NaOCl) in various times (5, 10, 15 and 20 min.), following the second surface sterification with NaOCl at different concentrations (5, 10, 15 and 20% (w/v) for 10 min. In the experiment III, the *in vivo* culture of self-pollinated seeds of *N. rubra* Roxb. cv. ‘Maeploi’ using MS medium at different strengths (MS, 1/2MS, 1/4MS, 1/8M) was studied. In the experiment IV, to rescue of self and cross-pollinated seeds on 1/8MS semi solid culture medium act as suitable medium strength from the experiment III, compared to the control. Each experiment was performed by a completely randomized design (CRD) and then compared the means using Duncan’s multiple range test (DMRT) at the significant differences at *p* = 0.05. The results showed that the fertility of self-pollination of *N. rubra* ‘Maeploi’ and *N. pubescens* were 1.67% and 11.17%. While the fertility of the cross-pollination in group I (N. pubescens X N. rubra ‘Maeploi’) and group II (N. rubra ‘Maeploi’ X N. pubescens) were 5% and 3.33%, respectively. The self-pollinated seeds of *N. rubra* ‘Maeploi’ were soaked with 20% (w/v) NaOCl for 5 min., following the sterification with 5% (w/v) NaOCl for 10 min. showed the lowest microbial contamination (0%). The seeds cultured on 1/8MS semi solid medium and incubation under dark condition gave the highest germination and survival percentage when compared to the others. The germinated seedlings were immediately produced shoots (60%), immature leaves (51.67%) and roots (48.33%) after 4 weeks of culture. The immature leaves of seedlings cultured under dark condition were yellowish more than the seedlings cultured under light condition. According to the seed culture on suitable culture medium, the germination of self-pollinated seeds in *N. rubra* ‘Maeploi’ and *N. pubescens* was the same resulted at 51.67%. Whereas, the germination of cross-pollinated seeds in group I and II were 35% and 31.67%. Moreover, this study is not only mentioned to the ordinary or conventional plant breeding by hand pollination and embryo rescue of cross-pollinated waterlily seeds, but also handled by the gardeners. It will be used as a procedure for further studies and research involved in *ex situ* conservation of waterlilies and several aquatic plants in the future.

KEYWORDS:

Hand pollination; germination; *Nymphaea rubra* Roxb. cv. ‘Maeploi’; *ex situ* conservation
Fishes and figs: effect of fig seed passage through fish gut on germination

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ABSTRACT:
Riparian Fig trees (Ficus) are produced fruits or figs year-round as a keystone species. It is generally assumed that their fruits and seeds are important resources for different fish species during the filling or flood and in the beginning of low water periods. For riparian plants, the important role of fish in seed dispersal is increasingly recognised, however many species which are clearly not specially adapted to fish dispersal. In this study, we studied the potential role as fig seed disperser of two species of fresh water fish. To evaluate the role of both seed and fish traits in ichthyochory, we fed seeds of three riparian fig tree species (Ficus ischnopoda, Ficus montana, and Ficus racemosa) to two cyprinids fish species with differing feeding mechanisms. Cyprinids have neither oral teeth nor stomachs, but the pharyngeal jaws are probably as effective in masticating plant tissues. Mystacoleucus chilopterus (ray-finned fish) has only tiny oral and has a pharyngeal ‘mill’, which it uses physically to crush hard food and chewed, while Barbodes schwanenfeldi (tinfoil barb) has grinding teeth and/or a bony plate on their pharyngeal bone as well, but it has larger mouth gapes that permit fruits and seeds to be swallowed whole. To facilitate the experimental study of internal seed dispersal by fish, this study divided into a series as follows: seed uptake, seed retention time, seed survival, germination probability and germination rate after gut passage (which may be inhibited, enhanced or unaffected compared to control seeds). Using feeding experiments, we answered the following questions: 1) Does seed passage through fish digestive tracts increase seed germination? 2) Does seed ingestion by fishes accelerate seeds’ time until germination? 3) Is there an effect of germination conditions, fish species and plant species on seed germination? and 4) Is there an effect of fish feeding mechanism on seed germination? For the results, compared to controls, seed passage through tinfoil barb digestive tracts significantly increased accelerated seed germination. However, ray-finned fish was granivory (seed predator) in case of the seeds damaged and not viable. Tinfoil barb has a bigger in body size and feeding behaviour with swallowed whole of seed during the experiment, suggesting that body size and the correlated bite force is an important fish trait in ichthyochory. Seed traits such as size and hardness appeared crucial for the survival of seeds passing through the guts of fish. Seed survival and germination varied with fig tree species, the smallest seed of F. racemosa responded to fish gut passage in positive way and there has a negative relation in the biggest of seed size, F. ischnopoda. This evidence indicates a potential for effective seed dispersal by tinfoil barb. Although seeds in riparian forests also can be carried by water and by a variety of nonaquatic vertebrates, we argue that fishes should be important seed dispersers when seeds are nonbuoyant or when there are few nonaquatic dispersers.

KEYWORDS:
Barbodes schwanenfeldi; Cyprinidae; Ficus; ichthyochory; Mystacoleucus chilopterus; Thailand
Influences of invasive plants on soil fauna communities: a meta-analysis

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ABSTRACT:
Invasive plants can greatly impact on local plant and soil fauna communities when they successfully invaded into habitats. However, it remains unclear that how attributes of invaders shift diversity and abundance of soil fauna in various habitats. A meta-analysis of 34 independent experiments from 29 peer-reviewed papers were conducted to examine: (1) whether invasion of alien plant species causes a reduction in the diversity and abundance of the soil fauna at different levels of invaders; (2) which plant life form (woody tree and herbaceous) causes more effect on soil communities; and (3) which habitat are more susceptible to plant invasion in term of soil community shift. The results showed that plant invasion cause negatively impact on both diversity and abundance of soil fauna, but the diversity attribute was more susceptible. Studies conducted in multiple species of invaders revealed no significantly different impacts compared to those studied on single species of invader. Woody tree had a stronger negative impact on the fauna communities than herbaceous. Experiments on woodland habitats showed larger change in diversity than grassland habitats. The study demonstrates that belowground communities are negatively affected by plant invasions, which may have substantial effects on local ecosystem functions, such as nutrient cycling, which soil communities play important role on this. Loss of belowground diversity may directly associated with loss of native plant species richness. Therefore, the reduction could be causally connected to the effect of the invader on the habitat.

KEYWORDS:
Alien species; exotic species; meta-analysis; plant invasion; soil mesofauna; species abundances
Lowland forest loss in mainland Southeast Asia

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ABSTRACT:
Lowland tropical forest is often very species rich and thus important for conserving biodiversity. However, due to its proximity to human settlements, this habitat type has been highly threatened for several decades. Most studies that have evaluated forest loss typically sample a wide range of elevations from lowland to montane; however, only a few studies have specifically focused on lowland forest, which typically have higher rates of species richness and higher destruction rates than other forest types. This study (1) evaluated forest remaining and forest loss in lowland areas (elevation below 200 m) within 20 years between 1998 and 2018 in Mainland Southeast Asia, and (2) evaluated the protection of lowland forest remaining designated protected areas. Supervised classification techniques and visual interpretation were used to classify 226 Landsat satellite images. The images were classified into two types: forest and non-forest (other land covers), then forest areas were overlaid with a map of protected areas to determine the relative protection. Almost half of mainland Southeast Asia region (c. 900,000 sq.km. – 45%) is lowland. In 2018, the lowland forest remaining was approximately 18% (c. 165,000 sq.km.). Most remaining lowland forest patches are small and scattered, with only a few large patches in northeastern Cambodia and southwestern Myanmar. Regarding lowland forest loss, half of the lowland forests present in 1998 (>120,000 sq.km.) were lost within the past 20 years. Cambodia is the country with the highest loss (c. 47,000 sq.km.), followed by Myanmar (c. 27,000 sq.km.) and Vietnam (c. 18,000 sq.km.). Only c. 33,000 sq.km. (~20%) of lowland forest remaining are currently inside protected areas. Considering lowland forests that have been protected before 1998, only half of them (c. 11,000 sq.km.) still remain in 2018. Results from this study together with results from other studies indicate that the greatest forest loss in Mainland Southeast Asia occurred in lowland areas, and that establishment of protected areas alone seems to be inadequate to prevent forest loss. This indicates an urgent need for better management planning specifically for lowland forest areas to prevent further loss.

KEYWORDS:
Landsat satellite images; lowland forest loss; lowland forest remaining; protected areas; supervised classification.
Floral visitations and pollinators of invasive Asteraceae in northeastern Thailand

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ABSTRACT:
Pollination is one of the most important processes affecting reproduction success in flowering plants and most of them rely on animals to pollinate their flowers. *Praxelis clematidea* R.M. King & H. Rob. and *Bidens pilosa* L. (Asteraceae) are important weed and invasive plant in Thailand which widely distributed in many areas, especially agricultural and protected areas. The objective of this study was to investigate the pollinators and floral visitation in *P. clematidea* and *B. pilosa* in Khon Kaen University. Field surveys were conducted during September to October 2018 by observing the focal plants for 30 hours per species. There were least 41 species of floral visitors of 4 orders observed including Lepidoptera, Hymenoptera, Hemiptera and Diptera. There were 36 species visited *B. pilosa* and 22 species visited *P. clematidea* and both plants shared 17 common species of floral visitors (41.46% of all floral visitors). There were a total of 822 floral visits at *P. clematidea* with the average visitation rate (± S.D.) of 27.40 ± 39.52 visits/plant/hr while *B. pilosa* attracted 1,007 visits with the average visitation rate of 33.57 ± 28.02 visits/plant/hr. Hymenopterans were the most common floral visitors for both plants (69.97% of all visitors). Bees (*Apis* spp.) are the most common floral visitors of *B. pilosa* while Wasps (*Camsomeris* spp.) were the major floral visitors of *P. clematidea*. While both plants are continually expanding their range across Thailand and other countries, the information on their pollination ecology is still lacking, especially competition for pollinators with native plants and crop plants. Furthermore, the effects of these invasive plants on local biodiversity and in protected areas are needed.

KEYWORDS:
Asteraceae; *Bidens pilosa*, Invasive plant; Pollination; *Praxelis clematidea*
Treatment of nutrient in wastewater from a dairy farm of morning glory (*Ipomoea aquatic* Forsk.)

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**ABSTRACT:**
This research used morning glory (*Ipomoea aquatic* Forsk.) to uptake of nutrient in wastewater from a dairy farm at Kasetsart University, Kamphangsaen Campus. In the experiment used 62x30 x32 cm plastic bucket, three buckets were planted with morning glory in soilless culture as treatment and another three plantless buckets were the control. Samples were collected on day 0, 7, 14, and 28 to analyze different parameters. i.e. potential of hydrogen (pH), temperature (TEMP), turbidity (TUR), electrical conductivity (EC), total dissolved solids (TDS), biochemical oxygen demand (BOD), chemical oxygen demand (COD), nitrate (NO$_3$), total nitrogen (TN), ammonium (NH$_4$), total phosphorus (TP). The results showed that treatment was better in water quality of control on 21 days and worse on 28 days due to increasing of TDS, COD, NO$_3$, TN, NH$_4$, and TP. In last few days, morning glory was also died out a decomposed at that time. The result also showed parameters with significant difference (p<0.05) were EC (30.66%), TUR (73.16%), COD (70.00%), BOD (70.10%), NO$_3$ (64.82%). Parameters which decreased in number without significance difference (p>0.05) were pH (8.76%), TDS (13.25%), TEMP (1.24 %), TN (67.09%), TP (63.11%), and NH$_4$ (97.93%). From this result could be concluded that the morning glory, grown in soilless culture was efficient for treating wastewater.

**KEYWORDS:**
*Ipomoea aquatica*; phytoremediation; water spinach; water treatment
Controlling function of aerial predators on arthropod community in dipterocarp plantation during wet season

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ABSTRACT:
Aerial predators, particularly birds and bats, can provide top-down control of herbivorous insects. Extensive studies have shown the negative effects of herbivorous arthropods on agriculture crops when aerial predators were excluded. In this study, an exclusion experiment was used to examine the top-down effects of aerial predators on arthropod community in a dipterocarp restoration area at Lainan Research and Technology Transfer Station (LRTTS), Nan province during the wet season (August – October 2018). Exclusion cages were set up over dipterocarp saplings so that either bats, birds or both bats and birds were prevented from entering the plots with either in the exposed or shaded areas with tree cover. Arthropods were then collected, identified and designated as herbivorous or predatory taxa. Leaf-rolling weevil (Apoderous notatus), grasshoppers and lepidoptera larvae were common dipterocarp pest species, causing major branch and leaf damages, while hemipterans caused minor damages. Average arthropod abundance was highest in the bird-and-bat exclusion treatment in the exposed plots and lowest in treatments where birds and bats had access in the shaded plots. The most commonly-encountered predatory arthropods were spiders of the families Salticidae and Oxyopidae, followed by long-legged flies, mantises and assassin bugs. The abundance of predatory arthropods was highest in the bird-and-bat exclusion treatment, possibly explained by the mesopredator release hypothesis. The results suggest that both birds and bats play important roles as the top predators in this restoration system with dipterocarp plantings. Habitat enhancement to attract aerial predators could therefore offer arthropod pest control benefits for the forest restoration system.

KEYWORDS:
Aerial predators; arthropod community; controlling function; mesopredator release; top-down control.
Analysis of factors related to bamboo structure for preventing erosion and restoration of coastal area on the Upper Gulf of Thailand

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ABSTRACT:
Coastal erosion caused by anthropogenic, as well as natural processes in the coastal region of Thailand and other countries is becoming a big issue at present days, because coastal erosion have negative impact on human and coastal ecosystem. To prevent the coastal erosion in the Upper gulf of Thailand, the Department of Marine and Coastal Resources (DMCR) carried out a project for the installation of bamboo structures and planting of trees in the coastal area. At the end of the project, it has been found that the restoration of coastal ecosystem and prevention from further coastal erosion were succeeded in some area, on the other hand different result shown in other area. Based on the DMCR project outcome, this study analyzed the factors related to prevention of erosion and the restoration of the coastal zone structure, in the Upper Gulf of Thailand. This study found that, success of the project that is the prevention of erosion and restoration of the coastal area related with people’s participation, strong leadership, government support and specification of bamboo. From focus group discussion, it was found that strong policies for the protection and maintenance of installed bamboo structures and thereby appropriate revision of policy are also important factor for sustainability of the project. Moreover, devoted local leader, and active committee members are needed to maintain, and monitor the project. This study results are applicable for other coastal regions of different countries, with similar soil characteristics, to prevent erosion and restoration of coastal areas.

KEYWORDS:
Coastal erosion; bamboo structure; Upper Gulf of Thailand
Active pollination of *Ficus squamosa* by two *Ceratosolen* fig wasp pollinators and species boundaries in northern Thailand

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**ABSTRACT:** Fig trees (*Ficus*, Moraceae) are an ecologically significant group of mainly tropical plants. They depend for pollination on female fig wasps (Agaonidae) that enter figs to lay their eggs. It is becoming clear that many *Ficus* support more than one species of host-specific pollinator, though pollinator distributions rarely overlap. *Ficus squamosa* is a small riparian dioecious shrub distributed in SE Asia. In northern Thailand, *F. squamosa* was found to be pollinated by two species of *Ceratosolen* fig wasps, one yellow and one black. The full extent of the distributions of these two pollinators remains largely unknown and factors that affect the distribution of fig wasp species also remain largely unexplored. In this research we aimed to compare plant reproductive success and to determine the distribution of these two pollinators. We also to assess whether the main river body was acting as a biogeographic boundary to dispersal or the abundances of the two pollinators changed with differing stream characteristics. The study area was established with in the Ping river basin of northern Thailand. A total of 11 of the Ping river tributaries were sampled, each being spilt into 3 transects. Transects were selected at random based on the accessibility to the river. To understand the co-existence mechanism, Figs were collected based on the maturity. We compared plant reproductive success at sites where one or both pollinators were present. Figs entered by the black species pollinators often had a slightly higher proportion of flowers that generated seeds and pollinator offspring (measures of the reproductive success of female and male plants respectively). The difference occurred despite fewer black foundresses entering the figs, suggesting they offer rewards more effectively and that pollinators sharing a host *Ficus* can differ in the quality of services they provide. We also found that out of the 11 sampled tributaries, 9 had established populations of *F. squamosa*. Mutually exclusive populations of the yellow fig wasps were found to both the east and the west of the Ping river of 9 sites. The distribution of the black fig wasps was only found from 3 sites and mainly confined to the mountainous area. Altitude was also found to have a significant effect on the distributions of both species of fig wasps, with black wasps being largely present only in higher altitude areas (P=0.002, Z=2.977, df = 60). Thus, the river boundary did not act as a barrier to dispersal between the two species, but altitude gradient seems to influence the abundance of the black species also fitted with the hypotheses of altitudinal and thermal melanism.

**KEYWORDS:**
Agaonidae; competitive exclusion; dioecious; *Ficus*; pollination services; Thailand
Diversity of predatory arthropods and aphid pests in yard-long bean cropping system

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ABSTRACT:
Yard-long bean is one of the vegetables that requires high usage of insecticides to control insect pests, particularly aphids. Besides insecticides, there are several predatory arthropods that could control these aphids, but the understanding of interactions between these predatory arthropods and their aphid preys are required. Fifteen plots of yard-long bean at Chulalongkorn University Land Development Project were weekly assessed for the abundance of aphids by visual assessment from August to November 2017. Predatory arthropods were also weekly sampled by sweeping net and pitfall. Oxyopidae was the most abundant spider family collected by sweep-netting, followed by Salticidae and Thomisidae, respectively. In the pitfall traps, Lycosidae was the most abundant family followed by Salticidae and Oxyopidae, respectively. Lycosidae and Salticidae were the only two taxa found in both pitfall and sweeping net sampling as their guild composition were foliage-dwellers and ground hunters. *Menochilus sexmaculatus* (Coleoptera: Coccinellidae) was the most abundant predatory lady beetles over the cropping season followed by *Coccinella transversalis*. The only one aphid species found on yard-long bean plant was *Aphis craccivora*. In the first three weeks, the number of cowpea aphid remained relatively low at <145 individuals per plant; however after four weeks, the cowpea aphid number was emerged to 6000 individuals per plant after nine weeks. The abundance of both predatory arthropods found in this study was highest on the fifth week consistent to the great number of cowpea aphid on yard-long bean plant. Spiders and lady beetles are reportedly some of the most important predatory arthropods in many agricultural systems. The results suggest that the biological control of cowpea aphid by predatory arthropods in the early season before week 4 could potentially control the onset of cowpea aphid outbreak. Moreover, providing supplementary food resources early in a cropping season could attract predatory arthropods, including spiders, subsequently suppressing aphid population.

KEYWORDS:
Aphid; Coccinellidae; niche partitioning; predator; spider; yard-long bean.
Effects of ascorbic acid and culture media on PLB induction of *Phalaenopsis cornu-cervi* (Breda) Blume & Rchb. f. from bisected and protocorms *in vitro*

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**ABSTRACT:** *Phalaenopsis cornu-cervi* (Breda) Blume & Rchb. f. is a beautiful pot plant orchid. In nature, this orchid was difficult to propagate. Thus, this study developed protocol for proliferation and plantlet regeneration. Seeds of *Phalaenopsis cornu-cervi* (Breda) Blume & Rchb. f. were collected 6 months after pollination. All seeds were aseptically germinated *in vitro* on MS (Murashige and Skoog) medium supplemented with 15% coconut water (CW). After 2 months of culture, the seeds germinated into protocorms and used as initial explants for induction and proliferation of protocorm-like bodies (PLB). Bisected protocorms and protocorms at Growth Index 3 (GI3) were cultured in ND (New Dogashima) medium or VW (Vancin and Went) liquid medium supplemented with ascorbic acid at various concentrations. The results showed that protocorms cut longitudinally into half (bisected protocorms) and cultured in VW liquid medium supplemented with 150 mg/l ascorbic acid gave the best proliferation of PLB at 21 PLB/explant after being cultured for 50 days. Upon transferring these PLB to ND medium supplemented with 0.2% (w/v) activated charcoal (AC) and 4% (w/v) sucrose for 5 months the best results in vegetative growth. Regenerated plants were gradually acclimatized to greenhouse (95% survival) and they showed normal morphology as that of control plants.

**KEYWORDS:** Activated charcoal; plantlets; proliferation; protocorm-like bodies; Vancin and Went.
The role of frugivorous birds on seed removal along the forest edge, northeastern Thailand

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ABSTRACT:
Seed dispersal is one of the most important parts of tropical forest dynamics. The objective of this study was to gather information on frugivory by forest birds on fleshy-fruited trees along the forest edge of the Plant Genetic Conservation Project Area, Chulabhorn Dam, North-eastern Thailand. Fruiting trees with at least 5% ripe fruits were chosen. Data on frugivory were collected during April-May 2017 at 19 individuals of 11 tree species for 200 hours. A total of 36 bird species were observed to eat fruits. Three most important frugivores of fleshy-fruited trees were Black-crested Bulbul (*Pycnonotus melanicterus*) shared 28.46% of all fruiting tree visitations, Moustached Barbet (*Psilopogon incognitus*) 9.46% and Asian Fairy Bluebird (*Irena puella*) 7.67%. Frugivory by woodpeckers (considered to be insectivores) was surprisingly higher than expected, while green pigeons showed specialization on fig trees. Average visitation rate on fruiting trees for all species combined was 6.34 visits/hr. Frugivory activity was extremely high on *Syzygium cumini* with an average of 115.7 visits/hr. *Ficus altissima* attracted the highest number of frugivorous birds (27 species). Birds spent an average of 366 seconds on each feeding visit. Larger and cryptic birds (green pigeon) spent longer feeding time than smaller birds. The data suggest that bulbuls (Pycnonotidae) are the most important seed dispersers of small to medium-sized fruit trees in this area.

KEYWORDS:
Avian frugivores; fleshy-ruited plants; frugivory; seed dispersal; tropical forest
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IMPACTS OF CLIMATE CHANGE ON BIODIVERSITY ACROSS SCALES
Plant defense mechanism and repellent activity of organic rice plant

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ABSTRACT:
Soil supplemented with chitin powder from marine shrimp shell enhanced growth, development and defense of organic rice plant. Repellent activity of various young rice seedlings was investigated. Rice (Oryza sativa L.) ‘KDML 105’, ‘Sang Yod Phattalung’ and ‘Riceberry’ and Tenebrio molitor L. were used for olfactometry analysis by two-choice bioassay. Interestingly, ‘KDML105’ (21, 28 day old) had significantly increased repelling index in contrast to other seedlings (7, 14, 21, 28 day old) grown on soil with chitin from cuttlebone and bat guano (0.5% v/v). Repelling index of ‘KDML105’ (21, 28 day old) was -0.36 and -0.56. Moreover, heat shock (40°C 5 min) and anthocyanin played a role in plant-arthropod interaction. 7-day old anthocyanin containing rice seedling (‘Kum Muang Phayao’) after heat shock was more repelling (-0.8) than ‘KDML 105’ (-0.3), during 20-300 min after heat shock. Notably, at control temperature (22°C) anthocyanin containing rice was attractive 7d old (+0.24), whereas it was repelling 14d old (-0.25). After heat shock 7d old was also repelling (-0.25). In contrast to anthocyanin containing rice seedling (‘Kum Muang Phayao’) the cultivar ‘KDML 105’ was attractive after heat shock at the age of 7 and 14d showing positive effects (+0.20 and +0.34). Our results indicate a promising potential of some rice cultivars for insect repelling, and the correlations with anthocyanins and heat shock provide solid starting points for further analysis of the mechanism. In total, this can support biological insect control in agriculture in Thailand.

KEYWORDS:
Chitin; heat shock; meal worm; repellent activity
Using drone to survey cycads in limestone mountains

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\textbf{ABSTRACT:}
To study the plants living on high cliffs or limestone mountains is very difficult. Using drone can be a new and most effective way to survey these plants in very limited access locations. We used this method to study \textit{Cycas tansachana}, the endangered and endemic plant in Saraburi and Lop Buri provinces of Thailand. We surveyed many cycad populations at Khao Phraphutthabat Noi and Khao Khamin, Saraburi province in November 2018. We used drone, binocular and monocular to count the number and identify gender of cycads from a distance around both mountains. A total of 1,082 cycads were found in steep, high cliffs where no other plants covered in the studied areas. We counted 874 cycads at Khao Phraphutthabat Noi and 208 cycads at Khao Khamin. Most of the cycads were female (660), followed by male (264), young (101) and unknown gender adult (57). Using drone proved to be very successful, we can use it to get to the far reach, limited access areas, take photographs of the studied areas from above, get close to each individual plant, and take video of plants from different angles. However, there are some disadvantages of using drone such as it is still expensive, it cannot operate in windy condition, it cannot access to some area because radio signals can be blocked by mountain peaks and we need high skill people to operate the drone smoothly and safely.

\textbf{KEYWORDS:}
Community forest; \textit{Cycas tansachana}; drone; Khao Phraphutthabat Noi; limestone hill
Fine root production in different successional stages of seasonal evergreen forest at Khao Yai National Park

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ABSTRACT:
Forest ecosystems are important in carbon and nutrient cycles, which mainly function as a carbon storage in the form of above- and below-ground biomass. However, knowledge of below-ground part has been relatively little studied in tropical forest of Southeast Asia, particularly in a human-dominated landscape. Thus we investigate fine root (≤2 mm diameter) mass production in three different successional stages, i.e. early, intermediate and old-growth, using the ingrowth core technique during the wet season (July to October 2018). The results show that fine root mass production was not significantly different among successional stages. When root productivity was normalized with the total basal area, the fine-root productivity tended to decrease, but was not significantly different. However, below- and above-ground productivity was not associated. We also test nutrient limitation such as N and P. The result show that below- (fine-root production) and above-ground productivity did not significantly respond to either N or P. However, the study was conducted during the wet season, which rain may mask effect of nutrient. Thus, the whole year study is required to test the consistent of results.

KEYWORDS:
Fine-root; biomass; ingrowth core; succession; tropical forest
Above ground biomass and carbon stock in homegarden based agroforestry systems at Bang Kachao subdistrict, Thailand

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ABSTRACT:
Homegarden agroforestry systems are suggested to hold a large potential for climate change mitigation and adaptation. According to their mulilayered vegetation structure, they provide various ecosystem services such as income generation, food products and carbon (C) sequestration. Tree species composition and aboveground carbon (AGC) stocks of traditional homegardens were assessed in Bang Kachao Subdistrict, Phra Pradaeng District, Samut Prakan Province, Thailand. They were dominated with a few tree species selected by an owner and half of the land used as a reservoir. A total of 10 homegardens were surveyed through stratified random sampling. A sampling plot of 400 m² was used in each homegardens for plant data (trees with diameter at breast height; DBH ≥ 5 cm) collection. Shannon-Wiener diversity index was used to compute species diversity and species composition respectively. Aboveground carbon stocks of trees were quantified using allometric equations, assuming C as 46% of biomass. A total of 498 trees were sampled and 30 tree species were identified. The most common plant was found Banana (Musa spp., 55.62 %), Swamp Erythrina (Erythrina fusca Lour., 11.04%), Coconut palm (Cocos nucifera L., 6.22%), Betel palm (Areca catechu L., 5.62%), and Neem (Azadirachta indica A. Juss., 4.62%) respectively. The total mean value of the above ground biomass (AGB) was found 2.87 t ha⁻¹. The first three highest C stocks homegardens contain large DBH trees with a component of 4 - 5 tree species. The highest AGB (4.93 t ha⁻¹) was recorded in the DBH range of 5.1 - 56.1 cm. The average carbon stock was 1.32 ± 0.56 t C ha⁻¹. Species diversity and DBH variation have non-significant relationships with standing AGB (P < 0.05). Besides, AGB had a correlation with mean DBH (R²= 0.238, P < 0.05). The Shannon Wiener index ranged from 0.67 to 2.14 with a mean value of 1.21 ± 0.48 indicating a medium evenly distributed diversity of sampled tree species. This study gives a highlight for the responsible bodies to consider the role of homegarden agroforestry systems particularly for climate change mitigation strategies. Meanwhile, homegardens meet up with the immediate needs of the gardeners such as food and income generation.

KEYWORDS:
Aboveground biomass; agroforestry system; Bang Kachao subdistrict; carbon stock; homegarden; species diversity
Variation of wood specific gravity and carbon storage in a second-growth evergreen forest of Thailand

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ABSTRACT:
Carbon sequestration in a tropical forest plays an important role in reducing greenhouse gas emissions. Wood density or wood specific gravity (WSG) is one of the most important parameters for biomass or carbon storage estimation. However, intraspecific variation of WSG may propagate uncertainty. Since large-scale disturbances in pan-tropical forest in the past few decades, secondary forests have become a major type of forest in many areas, however, there has no research investigate this source of error in second-growth forest. Here we therefore aim to investigate variation of WSG in a second-growth forest of Khao Yai National Park, Thailand, and then evaluate its effect on the assessment of carbon storage estimating based on an allometric equation of biomass. We compared variation in two stages of secondary forests i.e. the stand initiation and stem exclusion stages. We also compared the variability of WSG of dominant species (determined by % accumulated basal area) in different succession stages and sites. Results show that variation determined by coefficient of variance (CV) of WSG of dominant species was not different among the stages of succession. The CV of Symplocos chochinchinensis was highest among all species. To assess an impact on carbon estimation, we compared between our dataset and the global database of WSG, and found that the difference of Schima wallichii, Symplocos cochinchinensis, Cratoxylum cochinchinense were 11.80%, 7.43% and 1.70%. We found the succession stage, DBH is one of the most important predicators. Our study suggest that further investigation to understand plasticity of WSG is one of an important essential factor for reducing uncertainty of biomass estimation.

KEYWORDS:
Above-ground biomass; carbon sequestration; carbon storage; wood specific gravity; tropical forest; secondary forest.
Organic rice farming during dry season in Phayao, Thailand

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ABSTRACT:
There are 800 million people suffering from hunger worldwide, especially in developing countries. Food security and improved nutrition are central. Thus, integration of science and technology can improve economic prosperity and environmental protection. Field study (14,582 m\(^2\)) has been performed with growing rice ‘Phitsanulok 2’. RCBD method and statistical analysis was performed with One-way ANOVA by DMRT (P≤0.05). We measured growth and physiological parameters (photosynthetic rate (A, μmolm\(^{-2}\)s\(^{-1}\)), transpiration rate (E, molm\(^{-2}\)s\(^{-1}\)), stomatal conductance of H\(_2\)O (gs, molm\(^{-2}\)s\(^{-1}\)), intercellular CO\(_2\) concentration (C\(_i\)) and content of Chlorophyll a, b and total carotenoid (SPAD-value) in juvenile and adult rice plants. Average number of tillers was 8-10, number of leaves was 27-35 per each group of tiller and average of height was 85-91 cm. Dry weight of root was increased in similar ratio of above ground parts when fresh weight was dramatically increased 60 to 90 days old. Before booting stage 15 and 55 days, it was found that average of physiological parameter was 8.95, 8.20 μmolm\(^{-2}\)s\(^{-1}\) (A), 0.38, 0.40 molm\(^{-2}\)s\(^{-1}\) (gs), 330.48, 357.24 μmolm\(^{-2}\) (C\(_i\)) and 5.09, 4.28 molm\(^{-2}\)s\(^{-1}\) (E), respectively. Average of total chlorophyll contents (SPAD-value) was significantly different and 90 days old of rice plant showed the highest SPAD-value. Acetone (96% v/v) shows higher ability for total carotenoid extraction than ethanol (99% v/v). At harvest time, yield of rice grain was 1,000 kg per 1,600m\(^2\). We conclude that: The results can be used to support improvement of rice cultivation and reduction of investments in rural and urban areas.

KEYWORDS:
Dry season; Organic farming; Photosynthesis
Leaf vein traits of dominant tree species in two different water availability sites of tropical secondary forest in Thailand

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ABSTRACT:
Tropical forest plays an essential role for mitigating climate change via carbon sink. Soil moisture or water availability is a limiting factor for carbon sequestration efficiency, in which secondary forest is able to store carbon at a greater rate than that of old-growth forest. However, tropical forest may be a carbon source when water availability decrease dramatically in a severe-drought year. Leaf vein traits (e.g. vein density, vein length, etc.) are proposed as good predictors of how plant response to water availability. Here we examine leaf vein traits in two second-growth tropical forests with contrast water availability in Khao Yai National Park, Thailand, aiming to understand how community response to drought. We sampled dominant species from both sites (determined by accumulated basal of those species >80% of total basal area of all species). Four traits, i.e. vein density, vein distance, vein length and vein tortuosity were examined. Results show that vein length and tortuosity of the wet site were significantly greater (t, P<0.001), whereas vein density was greater in the dry site (t, P<0.001). However, leaf vein trait of individual trees did not respond to local soil moisture (SAGA soil moisture index). While considering at the community level by weighing with species abundance with traits mean, vein density of dry site was obviously greater than that of in the wet site, suggesting that trees adapt to drought by increasing vein density for preventing water loss.

KEYWORDS:
Khao Yai National Park; Leaf vein traits; secondary forest; soil moisture; tropical forest
Climatic factor effecting in-season and off-season mangosteen production in southern Thailand

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ABSTRACT:
Understanding how to inducing mangosteen to produce off-season would be beneficial to mangosteen orchard farmers. This study aim at (1) investigating climatic factor differences between four weeks drying period inducing flowering and flowering period during in-season fruiting period and (2) investigating the differences between the dry period inducing flowering between in- and off-season mangosteen production in southern Thailand. Our results showed that in order to inducing a 24 days short drying period, climatic factors had to be higher air temperature, soil temperature, lower soil moisture, and lower relative humidity than flowering period. In addition, if we want to induce off-season flowering, climatic condition during inducing off-season flowering had to be even hotter and drier than inducing during in-season fruiting period. This indicates that mangosteen orchard farmers in southern Thailand could induce off-season mangosteen which would increase the profit for mangosteen orchards by more than fifty folds by setting climatic condition appropriately.

KEYWORDS:
Climatic factor; mangosteen; off-season fruiting; Thailand
Seedless grape cultivation in drought-countryside area of Thailand – “Plan for organic fruit development in local organic market”

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ABSTRACT: Various stresses endanger grape cultivation in Northern Thailand. Therefore, this study analyzed the use of Smart farming technology for NEW S-CURVE of Thailand in grapevine farmland and conducted a new strategy for growth and development of grapevine in the drought area. In detail we measured: plant growth (388 d), time kinetics formula (every 10 seconds for 5 minutes) of photosynthetic rate (A, μmolm⁻²s⁻¹) was y = 0.001x+12.609 (R²=0.99, 130-150 min), transpiration rate (E, molm⁻²s⁻¹) y = 0.008x+8.7014 (R²=0.99, 30-50 min), stomatal conductance of H₂O (gs, molm⁻²s⁻¹) y = 0.002x+1.216 (R²=0.98, 130-150 min) and intercellular CO₂ concentration (Ci) was y = 0.109x+332.63 (R²=0.99, 230-250 min). Chlorophyll contents were estimated in grapevine 'Beauty seedless' every 2 weeks for 4 months with chlorophyll meter (SPAD-value). In 382, 398, 410, 441 and 468 day old plant it was y=0.1266x+24.069, y=0.1498x+29.208, y = 0.11x+33.218, y=0.1065x+38.116 and y=0.1504x+36.987. Number of shoot per plant was 50 and number of inflorescence per plant was 9-11. The average of fruit weight of 1 bunch of grape was 368 g (90 fruits). Fruit shape was 18x20 mm, dry weight of single fruit 15% fresh weight and sugar 12.2-15.7 Brix. This data of growth and physiological changes was analyzed from 48 samples of grapevines in 8 greenhouses by One-way ANOVA. Weekly plant maintaining, cane pruning and pest management were performed by 10 professional gardeners. Moreover, organic farming program was applied.

KEYWORDS: Drought; Organic market; Seedless grape
Exploring the suitability map of wild banana (*Musa serpentina* Swangpol & Somana) in Thailand using species distribution models with the limited occurrence data

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**ABSTRACT:**
Species distribution model (SDM) is one of powerful tools to predict the suitability map to address the ecology and conservation approaches. However, the limited number of occurrence data has been problem on model performance. Here, the three algorithms (Maxent, Generalized linear model: GLM, and Random Forest: RF) were selected to project the suitable map with eight occurrences of *Musa serpentina* Swangpol & Somana which was a wild banana which endemic to the west of northern and central Thailand and eleven environmental variables. Due to a limitation of occurrence data, the fuzzy logic had been applied to GLM and RF model to enhance the occurrence data. While Maxent is presence-only data, it could not use the fuzzy logic. The results showed that three climatic variables had affected all three models especially precipitation of warmest Quarter (Bio18) and precipitation of coldest Quarter (Bio19). All algorithms could predict the suitable map with best model because they had the high AUC value (> 0.9) which GLM had the highest performance with AUC value of 0.991.

**KEYWORDS:**
Maxent; Random forest; GLM; Fuzzy logic; *Musa serpentina*
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