Extended Taxonomic Capacity Building for Sustainable Use of Biodiversity:

Bryophytes, Pteridophytes and Economically-Important Insects (Predators and Parasitoids) in their Natural Habitats

Queen Sirikit Botanical Garden
Chiang Mai, Thailand
1-5 September 2014

PROCEEDINGS
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ASEAN Centre for Biodiversity

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

The ACB is ASEAN’s response to the challenge of biodiversity loss. It is an intergovernmental organization that facilitates cooperation and coordination among the ten ASEAN Member States and with regional and international organizations on the conservation and sustainable use of biological diversity, and the fair and equitable sharing of benefits arising from the use of such natural treasures.

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

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

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East and Southeast Asia Biodiversity Information Initiative

East and Southeast Asia Biodiversity Information Initiative (ESABII) was launched by 14 countries in this region and relevant organizations to achieve goals of the Convention on Biological Diversity (CBD).

It was also launched to pursue capacity building in taxonomy and the development of an information system on biodiversity in East and Southeast Asia in order to contribute to the promotion of biodiversity conservation and the implementation of the CBD Strategic Plan in the area.

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

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

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Queen Sirikit Botanic Garden

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

The aim of QSBG and its satellite gardens are:

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

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

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Japan-ASEAN Integration Fund

With the aim to support integration efforts to create the ASEAN Community, and promote greater cooperation between ASEAN and Japan, the Japan-ASEAN Integration Fund (JAIF) was established in 27 March 2006. Emanated from the pronouncement of then Japanese Prime Minister H.E. Junichiro Koizumi who pledged to contribute 7.5 billion yen to reinforce ASEAN’s integration at the Ninth ASEAN-Japan Summit held in December 2005.

In 2007, youth exchanges between Japan and ASEAN were promoted through the Japan-East Asia Network of Exchange for Students and Youths. Also, regional economic integration activities within ASEAN and between ASEAN and Japan are covered by the ASEAN-Japan Comprehensive Economic Partnership. Through JAIF, contributions also supported the improvement of emergency disaster response in the region. In 2008, the Japan-ASEAN General Exchange Fund and the Japan ASEAN Exchange Projects Fund merged with JAIF. The purpose of the Fund are as follows:

(1) support the efforts of ASEAN countries to realize the ASEAN integration;
(2) support the ASEAN Security Community (ASC), ASEAN Economic Community (AEC), and to support the establishment of the ASEAN Social and Cultural Community (ASCC), and to achieve the correction of intra-regional disparities;
(3) promote cooperation between Japan and ASEAN;
(4) support the activities of regional institutions and sub-regional organizations; and,
(5) implementation of other activities as determined to be appropriate by Japan and ASEAN.

The JAIF Management Team has been set up within the ASEAN Secretariat to oversee the formulation, review of project proposals, and inputs on financial and procedural matters.
Introduction

1. In the ASEAN region, the lack of trained human resources and inadequate capacities on taxonomy has been stressed as one of the obstacles in the implementation of commitments to the Convention on Biological Diversity (CBD). Dynamic growth in ASEAN continue to increase pressure on natural resources, and scientific information is crucial in the assessment and prediction of biodiversity changes. Taxonomic information and training are thus crucial to data collection and analysis further strengthen biodiversity conservation in the region. The need to strengthen taxonomic capacity in ASEAN provided the impetus for the Taxonomic Capacity Building on Bryophytes, Pteridophytes and their Allies project of the ASEAN Centre for Biodiversity, which is funded by the Japan ASEAN Integration Fund (JAIF).

2. The first activity of the project is the workshop on Extended Taxonomic Capacity Building for Sustainable Use of Biodiversity: Bryophytes, Pteridophytes and Economically-Important Insects (Predators and Parasitoids) in their Natural Habitats held on Queen Sirikit Botanical Garden (QSBG), Chiang Mai, Thailand on 1-5 September 2014. Specifically, the workshop aimed to provide an introduction to the taxonomy of predatory and parasitoid insects; impart knowledge on the general biology of these organisms; upgrade taxonomic skills in methods of morphological observation and sample collection, processing and management of specimens; and provide hands-on experience through a field exercise in collection.

3. Participants to the workshop included representatives of the ASEAN Member States with backgrounds in entomology, forestry, and ASEAN Heritage Parks management (Participants, programme and presentations are attached as Annex 1).

Opening Programme

4. Dr. Suyanee Vessabutr, Director, Botanical Garden Organization (BGO), welcomed the participants and provided highlights of the importance of the Queen Sirikit Botanical Garden. She stated that the Entomology section was started in 2006 and that this training workshop is an opportunity to show what the section has been doing. It is also a good opportunity to impart taxonomic knowledge of insects to counterparts in the ASEAN. She welcomed everyone to QSBG and hoped that everyone would have a successful training workshop.

5. Dr. Chaweewan Hutacharern, Adviser to the Director, BGO, stated that the training workshop is significant since it is the first to be held in QSBG since the start of the Entomology section in 2006. The entomology section was established by a number of experts with assistance from a number of very good institutions, including the National History Museum of London. She thanked ACB and JAIF for the opportunity to work together on this workshop, and hoped that future activities would include a training programmed focusing on entomology.

6. Dr. Filiberto Pollisco, Jr., Programme Management Specialist, ASEAN Centre for Biodiversity thanked the management and staff of QSBG for their invaluable assistance in organizing the workshop and explained the difference between the workshops conducted with the assistance of the Japan-ASEAN Integration Fund. He stated that the training workshop is generally a refresher course for him since in college he minored in entomology and took a special course on parasitoids for one semester. The participants will have to tackle the topic for only a few days, and he expressed the hope that they will be able to continue honing their knowledge and skills in taxonomy in their own country. The workshop will include a series of activities from introduction to insects and their biology, to catching, identifying and mounting specimens for collection. He thanked the participants for coming and hoped that everyone will enjoy the learning experience and apply the skills they have learned when they return to their own countries.

7. Dr. Robert Cunningham introduced the staff of the QSBG who will be working with the
participants during the workshop. Dr. Cunningham has worked with the ASEAN Regional Centre for Biodiversity Conservation and welcomed the opportunity to work on this current project with ACB. He explained that participants will work in pairs in the field, and will be working with partners from different countries.

8. **Dr. Monina T. Uriarte**, consultant of ACB-GIZ Biodiversity and Climate Change Project introduced the participants and described the programme of the workshop. She also expressed her gratitude to the staff of QSBG for their assistance.

**Presentations**

9. **Mr. Carl Callangan**, Junior Research Associate, Biodiversity Information Management, ASEAN Centre for Biodiversity, discussed the *Darwin Core 2 for Species Information Organization*. He explained that the Darwin Core 2 (DwC) is a structure or format that is globally accepted for recording and managing all species information as recorded by observations, specimen and samples. Developed by the Biodiversity Information Standards (TDWG - Taxonomic Database Working Group), the DwC includes species attributes on taxonomic classification, specimen identification, locality details, collecting event information, and biological data and images of specimens, among others. Using the DwC format, ACB has developed online and offline species encoding interfaces that are simple, easy to use, user friendly, requires no additional equipment and expertise, and uses MS Excel as back-end data for the offline encoder. Mr. Callangan then showed how the ACB Biodiversity Information Service System (BISS) works and gets its information.

**Discussion:**

Jeremy Naredo/UPLB: Is there a direct way to transfer the offline to online data so you don’t need to go over the process of encoding?

Carl Callangan: You can submit an excel file to database specialist.

Jeremy Naredo/UPLB: We have a lot of species that are not identified at the species level. Can we just enter data up to family level so that other specialists can see that we have this species but only up to the family level?

Carl Callangan: Yes you can do that as long as you have a description in the genus field first. We have information like that and you can just add spp 1 or spp 2. But it would be better if you have it to genus level to make it more distinct. If you are interested I can give copies of this encoder, you can practice and it will be useful for sharing information with other organizations. You can publish your data and it can be used by many organizations.

10. **Dr. Banpot Napompeth**, Advisor, National Biological Control Research Center, Kasetsart University, Bangkok, Thailand, made a presentation on *Capacity Building for Sustainable Use of Biodiversity: Bryophytes, Pteridophytes and Economically-Important Insects (Predators and Parasitoids) in their Natural Habitats*. The comprehensive presentation covered various topics, including:

**Prologue**

The prologue provided an overview of the workshop, and how it will help ASEAN Member States address commitments to the Convention on Biological Diversity (CBD) and the attainment of the Aichi Targets. It described the Global Taxonomy Initiative (GTI) of the CBD and the institutions that help strengthen taxonomy, including BioNET-INTERNATIONAL (the global network for taxonomy), its regional networks, and locally organized and operated partnerships. The GTI
aims to address the knowledge gaps in the taxonomic system, shortage of trained taxonomists and curators, and the impact of these deficiencies on the ability to conserve, use and share benefits from biodiversity. GTI and the workshop will help further efforts in achieving Strategic Goal E of the Aichi Targets, which is to: Enhance implementation through participatory planning, knowledge management (KM) and capacity building. It also addresses Aichi Target 19, which states that “By 2020, knowledge, the science base and technologies relating to biodiversity, its values, functioning, status and trends, and the consequences of its loss, are improved, widely shared and transferred, and applied.”

Part I:
Introduction to Insect Predators, Parasitic Insects and Parasitoids

There is a need to differentiate “insect predators” or “predatory insects” from “parasitoids” or “insect parasites” of agricultural and forestry importance. There is also a need to differentiate “parasitic insects” of medical and public health importance from “parasitoids” or “insect parasites” of agricultural and forestry as well as medical and public health importance.

A predator is an animal that overpowers, kills, and consumes other animals (prey) and has a mode of living where an animal kills and consumes another animal as food (predator-prey association).

Predatory insects appear taxonomically in several insect orders: Orthoptera, Hemiptera, Diptera, Coleoptera, Neuroptera, Lepidoptera. The immature stage of such insects requires more than one Individual of prey to reach maturity.

A parasite is an organism that lives on or in another organism (host), or at the expense of another organism (host-parasite relationship association). Parasitic insects (fleas, lice, etc.) are distinguished from parasitoids or insect parasites in several features: hosts are vertebrates; parasitic as larvae or nymphs and adults; their size is highly smaller than their hosts; they feed on all stages of their hosts; they do not kill their hosts.

A parasitoid or insect parasite is an organism, which resembles a true parasite in feeding behavior. Parasitoids are distinguished from parasitic insects in several features: parasitoids appear taxonomically restricted to orders Hymenoptera (sawflies, parasitic wasps, ants, wasps, and bees), Diptera (true flies) and Strepsiptera (stylops); hosts are typically other insects of the same taxonomic class, or rarely other arthropods; parasitoids are parasitic in immature stage as larvae and as a result, they are at times called “protelean parasites”; adult parasitoids are free-living; parasitoids are smaller than the hosts in or on which they develop, but in comparison with their hosts they are relatively large size; parasitoids only attack one stage of host (egg, larva, nymph, pupa, adult); immature stage develops at the expense of a single host individual to reach maturity; and parasitoids kill their hosts.

The role of predators, parasitoids and pathogens (3Ps) in biological control was also discussed.

Part II: Typical Morphology of Parasitic Hymenoptera

The head of an insect is composed of mainly rigid sclerites or sclerotized segments. The insect head is a capsule that contains compound eyes, mouth parts, and antennae.

The insect thorax is divided into three parts: the prothorax (pro=first), mesothorax (meso=middle), and metathorax (meta=last). Each segment consists of hardened plates, or sclerites. Dorsal sclerites are called nota (singular notum), lateral sclerites are called pleura (singular pleuron), and ventral sclerites are called sternum (singular sternum). The first segment of the prothorax is the pronotum. Each of the three thoracic segments contains one pair of legs. Wings are found only on the meso and meta thoracic segments.
The abdomen contains the reproductive organs and the majority of the organ systems. The dorsal and ventral abdominal segments are termed terga (singular tergum) and sterna (singular sternum), respectively. Spiracles usually can be found in the conjunctive tissue between the terga and sterna of abdominal segments 1-8. Reproductive structures are located on the 9th segment in males (including the aedeagus, or penis, and often a pair of claspers) and on the 8th and 9th abdominal segments in females (female external genitalia or copulatory openings and ovipositor).

The discussion also highlighted the features of the mesosoma and wings. The mesosoma is the apparent thorax in apocritan (bees, ants, parasitoids) Hymenoptera, consisting of the thorax and the fused morphological first segment of the abdomen (the propodeum).

Part III: Classification of Parasitoids

All insects belong to class Insecta or Hexapoda (= six-legged organisms). Class Insecta has been divided into at least 30 orders on the basis of structure of the wings and mouth parts; and type of metamorphosis (complete/incomplete metamorphosis). Classification of insects is regulated by the International Code of Zoological Nomenclature (1961, 1964, 1985). Insects have been classified in >30 orders and >700 families, and >800,000 species have been described and more remain to be described.

The newest order is Mantophasmatodea (gladiators, rock crawlers, mantos) erected in 2001, with a prehistoric specimen in amber from the Baltic region and live specimens from Namibia, South Africa (Mantophasma spp.).

Most parasitoids attacking insects are in the following orders: Hymenoptera (parasitic wasps, ants, wasps and bees) with >115,000 spp. (including phytophagous spp. in suborder Symphyta); and Diptera (true flies) with >150,000 species (including non-parasitoid flies). Some parasitoids are also found in Strepsiptera (stylops, or stylopids, or twisted-wing insects) with about 550 species; all stylops are parasitoids; and some genera in few families of Coleoptera (beetles) and Lepidoptera (butterflies and moths).

Part IV: Biology and Ecology of Parasitoids

Parasitoids are common among wasps (order Hymenoptera), less common among true flies (order Diptera), and few in beetles (order Coleoptera), moths and butterflies (order Lepidoptera), and lacewings (order Neuroptera). There are >65,000 spp. of parasitic wasps in order Hymenoptera alone which are parasitoids, and many spp. have not been described. The largest and most common parasitoids belong to superfamily Ichneumonoidea (Ichneumonidae and Braconidae), followed by Chalcidoidea (Chalcididae, Pteromalidae, Encyrtidae, Aphelinidae, Eulophidae, Trichogrammatidae, Mymaridae) and Proctotrupoidea (Proctotrupidae, Scelionidae, Platygasteridae).

Parasitoids reproduce through fertilization, where once mated, female parasitic wasps can control fertilization of their eggs during oviposition. Thus they can regulate the numbers of males (1n) and females (2n) according to whether eggs are fertilized. Males develop from unfertilized eggs (1n); females from fertilized eggs (2n). Females have an elongated tubular ovipositor, in some parasitoids it is even longer than the body.

Parasitoids can also reproduce without fertilization through parthenogenesis [Greek: parthenos = virgin; genesis = descent]. Parthenogenesis is common and characteristic of the entire Hymenoptera.

All parasitic wasps then undergo “complete metamorphosis” or “holometamorphosis” where the egg transforms to larva, then pupa, then adult (Egg → Larva → Pupa → Adult). Some undergo
“hypermetamorphosis.” Parasitoids often develop on immature stages of host insects (eggs, larvae or pupae or nymphs) and occasionally and rarely adults.

Parasitoids can be idiobiont or koinobiont. Idiobiont parasitoids do not permit the host to grow beyond the stage attacked. Koinobiont parasitoids allow their hosts to continue feeding and develop to the next stage.

Parasitoids act internally or externally. Internal or endoparasitoids insert eggs into the host and larvae and pupae develop internally to become adults. External or ectoparasitoids lay eggs on the host and larvae and pupae develop externally to become adults. In the food chain, there are both desirable and undesirable parasitoids. Primary or desirable parasitoids are parasitoids of nonparasitoid host insects (herbivore host insects), while secondary parasitoids or hyperparasitoids attack other species of parasitoids, and are undesirable parasitoids.

Parasitoids are also distinguished by different forms of parasitism, which can be solitary or gregarious. Solitary parasitism is when a parasitoid develops solitarily: one parasitoid larva utilizes an entire host to complete its development. In gregarious parasitism, some parasitoids attack a host which is large enough to support the development of several larvae. It may be the result of: multiple eggs are laid on or in a single host individual; or polyembryony, a phenomenon of repeated division of a single egg into several larvae in a single host individual.

Part V: Economic Importance of Parasitoids

The Hymenoptera, with more than 115,000 described species, includes as much as 10 percent of the species diversity of the planet. Economically and ecologically, they are one of the most important groups of organisms. Various Hymenoptera are either severe economic pests threatening both the forest industry and agriculture (sawflies); medical and noxious pests of urban landscapes (stinging wasps and ants); or pollinators (bees and others). They are also defenders of agricultural crops through their ability to parasitize and control pest insects (parasitic Apocrita).

Parasitoids, together with predators and pathogens, under natural conditions are important “natural enemies” of insect pests of agriculture and forestry and insect vectors of medical and public health importance. They are of high economic value but are not known or recognized by man. Their roles are not visible and their economic value is thus overlooked. Both parasitoids and predators have been used in biological control while pathogens (bacteria, fungi, viruses, protozoa and nematodes) have been used in microbial control. The first known use of parasitoids was in 1200 when the weaver ant (Oecophylla smaragdina) was used to control litchi stink bug (Tessaratoma papillosa) in China.

The species of Hymenoptera are important since they create food, pollinate crops, destroy countless insect pests, and only a small proportion are crop pests. Hymenoptera can be grouped as pestiferous Hymenoptera or beneficial Hymenoptera. Pestiferous Hymenoptera are forest and agricultural pests (e.g., sawflies and wood wasps) and medical, public health and household pests (e.g. vespid wasps, hornets, bees, and ants). Beneficial Hymenoptera are pollinators (e.g. bees, bumble bees, fig wasps); providers of commercial products (e.g. honey, bee pollens, royal jelly, bee wax); predators of insect pests; and parasitoids of insect pests.

Both predatory and parasitic Hymenoptera are “natural enemies” of most, if not all, insect species and insect pests in forestry and agriculture and insect vectors of medical importance. They are widely utilized in the “biological control” of noxious insect species.

Predators, parasitoids and pathogens are collectively known as “natural enemies” of noxious insects and are colloquially called “3Ps”. Under natural conditions they are responsible for “natural control” of insect populations under the phenomenon of “naturally-occurring biological control” or “natural biological control”.
Part VI: Collecting and Preserving Parasitoids

Dr. Banpot also discussed general techniques in collecting, rearing, and the preservation and storage of insects.

Collecting equipment includes the following:
- Insect net, killing jar
- Pillboxes, envelopes or paper for making envelopes, plastic boxes
- Vials, empty and filled with preservative
- Pocket knife, hand lens, magnifying glass
- Tweezers, forceps, camel-hair brushes
- Aspirators, sucking machines, vacuum machines
- Traps, yellow pan traps, light traps, etc.

The following steps should be followed for collecting flying species:
- Sweep for general collection and small species; smaller species can be removed by aspirator, the larger species transferred directly to alcohol.
- Use a hand net for large species; transfer to killing jar.
- Trap with yellow-pan trap or Malaise trap for large, general samples.

Invented by Rene Malaise, a Swedish entomologist, the Malaise trap is a tent-like structure that is somewhat similar to mosquito net. The yellow-pan trap is a shallow tray painted bright yellow on the inside, and black on the outside. It is laid on the ground surface and filled with water. Other traps for collecting flying species include light traps, use of pyrethrum sprays, and pitfall traps for crawling insects.

To collect non-flying species:
- Collect by hand, forceps, or aspirators.
- Extract specimens from various substrates using a Berlese funnel. The Berlese funnel was invented by Antonio Berlese, an Italian entomologist who pioneered acarology or the study of ticks and mites.

Insect rearing is important for biological study or adult specimens for identification. The necessary data for insect rearing includes date and place of collection; habitat; host plant; and stages of host insect. When an adult emerges the date of emergence should be noted. It should also be allowed enough time to harden off before being killed. For gregarious parasitoids, count brood size. Specimens should be preserved with individual larval/pupal remains.

The following should be noted in preservation and storage:
- Specimens collected in the field or reared are to be preserved prior to being prepared for examination or identification.
- Freshly collected large specimens may be preserved dry or in 70-95 percent ethyl alcohol or mounted later if desired.
- Small and minute specimens are preferably preserved wet in 70-95 percent ethyl alcohol and mounted on microscopic slides. To avoid damage, dry specimens are to be relaxed prior to mounting by leaving the specimens for 12-24 hours in an airtight plastic box containing some cotton wool moistened with a few drops of water or glacial acetic acid.
- Specimens may be mounted by direct pinning, or indirect pinning, or card pointing, or card rectangles.

Data labels should be reasonably small, neat and legible, and logically arranged. Insect mounting media should use Canada Balsam, where the thick balsam is diluted with xylol (xylene). This is a general permanent mounting medium for dehydrated whole specimens. Specimen must be dehydrated in alcohol/xylene series.
Discussion:

Dr. Monina Uriarte: How does the parasitic fly and vedalia control the cottony cushion scale?
Dr. Banpot: The vedalia is predatory, it will eat the prey. The other one is parasitic.
Dr. Chaweewan Hutcharern: The fly was brought in from Australia in 1886 and released in 1888. When was the year they claimed success?
Dr. Banpot: 1889. Just one year. We call it the three year theory in parasitic control. Parasitoid should be able to establish itself in three generations to determine if they are effective. This is called the three generations or three year theory to determine if they are successful or not.

Benidecto Golosino: When you spray acidic materials, is this effective?
Dr. Banpot: You have to balance synthetic and biological and make it compatible. Chemicals will never be compatible with beneficial organisms. In reality it’s not possible, you cannot use them together. You have to apply your chemicals properly. Instead of blanketing the treatment, you have to monitor the density of the insects to make it cost effective to use the chemical. If you lose half of the leaf and it doesn’t affect the yield, then there is no need to use chemicals. When the density and damage is high, then that may warrant the use of chemicals.

11. Ireneo L. Lit, Jr., PhD, Professor of the Institute of Biological Sciences and Director of the Museum of Natural History, University of the Philippines Los Banos (UPLB), discussed the Identification of Major Groups of Predatory Insects, which he co-authored with Jeremy Carlo B. Naredo, Research Associate, Museum of Natural History, UPLB. The presentation was divided into various topics, including the following:

Identification of Major Groups of Predatory Insects

The presentation focused on economic and environmental importance; life cycles; general ecology; morphology; and classification of major groups of predatory insects.

There are 950,000 known insect species from an estimated 100,000,000 species of insects worldwide. Predatory insects and parasitoids are economically important in biological control. Most predatory insects are generalists so their contribution to pest mortality is difficult to quantify when compared to parasitoids. However, that does not mean that their contribution is always lower. These insects also have environmental significance since they are a great part of and contributors to the world’s biological diversity. They are natural population regulation factors that prevent herbivores and other groups from reaching population levels that will be detrimental to the environment. They are also part of environmental resistance factors that maintain “pests” within carrying capacity.

In terms of life cycles, predatory insects are either paurometabolous/hemimetabolous or holometabolous. Paurometabolous/hemimetabolous (gradual/incomplete) insects transform from egg-nymph-adult, while holometabolous (complete) insects move from egg-larva-pupa-adult.

Why scientific names are italicized and other FAQs about biological nomenclature

Scientific names are used in taxonomy because they are universal, compared to common names, which vary among languages and dialects, cultures and subcultures. The use of scientific names strengthens the searchability of data, making information more available, accessible, and citable.

The use of scientific names is important in systematics, the science of the diversity of all organisms and their relationships. This encompasses Phylogenetics or the unraveling of evolutionary history. The use of scientific names is part of taxonomy, or the theory and practice of classifying and naming organisms. Taxonomy is a product of systematics, provides the database
for systematics, and is ‘at the core of all things biology.’ Taxonomy involves the classification of species or the ordering of organisms into groups or sets on the basis of relationships; and ordering of populations and groups of populations at all levels by inductive procedures. The most important aspects of classification are grouping and ranking (according to a hierarchy of categories such as Kingdom, Phylum, etc.). Identification of species is the extension work of taxonomists. Identification is the placing of individuals by deductive procedures into previously established classes. Taxonomy also follows specific codes in nomenclature, or the application of distinctive names to each of the groups recognized in a classification system.

Dr. Lit emphasized the need to identify organisms as every scientific endeavor that involves living organisms requires that an investigator correctly identifies the organism. The scientific name holds the key to a treasure chest of information. The important properties for the names of taxa are uniqueness, universality, and stability. Every name has to be unique because it is the key to the entire literature relating to that species or higher taxon. Universality is important as it provides ease of communication since scientific names follow codes in nomenclature and each code is independent and used worldwide. Scientific names also provide stability and prevent confusion and impediments to information retrieval that would likely result from any change of a well-established name.

Identification of Major Groups of Predatory Insects

Dr. Lit then discussed major groups of predatory insects, focusing on their scientific names and descriptions. The insects discussed included the following:

<table>
<thead>
<tr>
<th>Order</th>
<th>Insects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coleoptera</td>
<td>Beetles</td>
</tr>
<tr>
<td></td>
<td><strong>Family</strong> Coccinellidae</td>
</tr>
<tr>
<td></td>
<td>Staphylinidae</td>
</tr>
<tr>
<td></td>
<td>Carabidae</td>
</tr>
<tr>
<td></td>
<td>Cicindelidae</td>
</tr>
<tr>
<td></td>
<td>Lampyridae</td>
</tr>
<tr>
<td>Dermoptera</td>
<td>Earwigs</td>
</tr>
<tr>
<td>Hymenoptera</td>
<td>Ants, bees, wasps</td>
</tr>
<tr>
<td>Neuroptera</td>
<td>Antlions, lacewings</td>
</tr>
<tr>
<td>Diptera</td>
<td>Predatory flies</td>
</tr>
<tr>
<td>Mantodea</td>
<td>Preying/Praying mantises</td>
</tr>
<tr>
<td>Hemiptera</td>
<td>Predatory bugs</td>
</tr>
<tr>
<td>Orthoptera</td>
<td>Predatory crickets, katydids</td>
</tr>
<tr>
<td>Odonata</td>
<td>Dragonflies, damselflies</td>
</tr>
<tr>
<td>Lepidoptera</td>
<td>Predatory caterpillars</td>
</tr>
<tr>
<td>Thysanoptera</td>
<td>Predatory thrips</td>
</tr>
<tr>
<td>Ephemeroptera</td>
<td>Mayfly naiads</td>
</tr>
<tr>
<td>Plecoptera</td>
<td>Stonefly nymphs</td>
</tr>
</tbody>
</table>
Other predatory arthropods

<table>
<thead>
<tr>
<th>Araneae</th>
<th>Spiders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acari</td>
<td>Predatory mites</td>
</tr>
<tr>
<td>Chilopoda</td>
<td>Centipedes</td>
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<tr>
<td>Scorpionida</td>
<td>Scorpions</td>
</tr>
<tr>
<td>Chelonethida</td>
<td>Pseudoscorpions</td>
</tr>
<tr>
<td>Uropygi</td>
<td>Whip scorpions</td>
</tr>
<tr>
<td>Amblypygi</td>
<td>Whip spiders</td>
</tr>
</tbody>
</table>

**Laboratory and Fieldwork**

12. In the first laboratory work, the participants were each given a case with 20 insect specimens and were asked to identify each specimen. The participants worked in pairs and using materials from the previous presentations, all the groups were able to positively identify all of the specimens in their assigned cases.

13. During the fieldwork, the participants were asked to preserve, mount and identify parasitic insects and parasitoids to be collected in a portion of the Queen Sirikit Botanical Garden. The collected insects would then be mounted and identified in the insect laboratory. The participants worked in pairs, and were each given kits containing the following:

- Catching net
- Vials (with 85 percent Ethyl Alcohol)
- Folded Paper/plastic container
- Killing jar
- Tweezers, forceps
- Aspirators

During the collection, the participants were brought to two Malaise traps set up in the garden. They observed the insects collected in the trap, and Dr. Cunningham explained how the traps were set up and how insects were collected using the trap. The participants were then given the opportunity to set up a Malaise trap with the assistance of QSBG staff.

The participants were also given the chance to collect specimens from pitfall traps. Dr. Cunningham explained how the traps were set up and what materials can be used should the participants decide to set up pitfall traps on their own.

After the specimen collection, the participants headed to the insect laboratory to prepare and mount their specimens.

14. The participants then made a presentation based on their field and laboratory work. The presentations showed the insects collected, identified and how they were mounted for display (Group presentations are attached as Annex 2A – 2I).

**Closing Programme**

15. The participants were asked to speak on their experience and provide suggestions regarding the workshop. The participants provided the following comments:

**Brunei Darussalam** – The team from Brunei expressed their appreciation for the experience and lessons they learned during the workshop. They also expressed their appreciation for all the speakers, particularly Dr. Banpot.
Cambodia – The participant thanked everyone on what he considered a good training course. He said that he learned a lot despite a lack of training in entomology. He expressed the hope to get more training materials to improve his knowledge in entomology.

Lao PDR – The group thanked organizers for the opportunity to learn more about insects and expressed appreciation to the expert speakers. They also suggested that an insect identification key would be helpful particularly for people with little background on insects.

Malaysia – The team thanked ACB and QSBG for their invitation to participate in the workshop. They expressed their appreciation for the opportunity to meet insect experts such as Dr. Banpot, Dr. Lit and Dr. Cunningham. They really enjoyed the workshop, particularly the knowledge and information on spiders and in the future hoped for more hands on experience, field, and laboratory work.

Myanmar – The group thanked the organizers for the opportunity to learn more about insects. They stated that they learned a lot and hoped to have more of such workshops in the future.

Philippines – The team reiterated that an insect identification key would be helpful to participants. It is also important to have proper equipment at hand such as forceps and killing jars to properly handle flying insects and prevent accidents such as wasp stings.

Singapore – The group stated that the course was very good and can improve on materials provided to the participants. Insect identification keys can be downloaded from the Internet. In the laboratory, some participants don’t really know what they caught and they have to go to a book and look at pictures to link the pictures and insects to the order. It would be good to have an insect key and they can learn how to use that as well.

Thailand – The group expressed their appreciation for the chance to join the workshop, gain new experiences, meet new friends and partners and learn more about insects. They hoped to have more of the same type of workshop particularly since they enjoyed the laboratory exercise, but want to get more experience in specimen collection. They also want to learn more about the differences between predatory insects and parasitoids and have more practice in collecting, preserving and displaying insect specimens.

Viet Nam – The team expressed gratitude for organizers and thanked the speakers and QSBG staff. They appreciated the opportunity to acquire more knowledge and practice what they learned through the field and laboratory exercises. They hope to keep in contact with ACB, QSBG and their counterparts so that they can learn more, conduct more research and pay more attention to the role of insects in biodiversity.

16. Dr. Filiberto Pollisco, Jr., Programme Management Specialist, ACB, stated that the participants in the workshop were equally split into two groups: half were experienced in entomology while the rest were foresters or protected area management staff with little experience in entomology. This provided the basis for the pairings of the participants, so that everyone can learn from both speakers and their partners on the taxonomy of parasitic insects and parasitoids. He expressed his appreciation for the efforts of QSBG, and thanked the participants for their enthusiasm for the workshop. He hoped that the participants would be able to bring the lessons of the workshop back to their respective countries and help spread interest in the importance of taxonomy.

17. Dr. Robert Cunningham expressed his satisfaction with the outcome of the workshop and in the future hoped for more inputs on arachnids to provide a better understanding of the species. The QSBG entomology section was quite successful in their development of the program for the workshop. The participants did well and the workshop also provided an opportunity for QSBG staff to impart their knowledge and gain confidence in working with a regional group of participants.
18. **Dr. Robert Cunningham** and **Dr. Chaweewan Hutacharern** then presented some of the participants with books and other materials from QSBG as a part of a surprise programme. QSBG materials were given to Jeremy Naredo for guessing the identity of an insect; Paula Jade Matias as the most foolhardy/adventurous participant for getting a wasp sting; and Benidecto Golosino for the best technique.

19. **Dr. Banpot Napompeth** stated that he was happy to recruit more entomologists to become more entomological since it was very hard to recruit entomologists. He thanked Dr. Pollisco, ACB, and QSBG and the participants. He felt that the participants composed a very good group and stated that this was not the end, but the beginning of more learnings in taxonomy for the participants.

20. **Dr. Ireneo Lit** said that he was very happy to accept the invitation as speaker in the workshop because of the opportunity to advance his advocacy. He reiterated the importance of taxonomy in biodiversity conservation and while not everyone can become taxonomists, he encouraged the participants to become supporters of the campaign to strengthen taxonomy (Dr. Lit’s closing message is attached as **Annex 3**).

21. **Dr. Chaweewan Hutacharern** thanked ACB, QSBG staff, and all the participants for ensuring a successful workshop. She expressed appreciation for everyone’s inputs and insights, and that lessons from the workshop will help in the design of future workshops on insects.

22. **Dr. Suyanee Vessabutr** expressed her appreciation for Dr. Pollisco and ACB for their support and dedication in capacity building on biodiversity conservation in Southeast Asia. She thanked ACB for again choosing Thailand and QSBG as venue for the workshop. She stated her gratitude to the speakers for sharing their experience and knowledge and the entomology team for all their hard work. She also thanked Dr. Hutacharern for working tirelessly on the workshop. She wished everyone a safe and pleasant trip home and hope to see each other again in future activities with ACB.
## Annex 1 Participants, Programme and Presentations

### List of Participants

<table>
<thead>
<tr>
<th>No.</th>
<th>Country / Organization</th>
<th>Title</th>
<th>Name</th>
<th>Job Title / Organization</th>
<th>Contact Details</th>
</tr>
</thead>
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| 9   | Malaysia                | Ms.   | Ong Su Ping | Research Officer  
Organisation: Division of Forest Biodiversity, Forest Research Institute of Malaysia, Kuala Lumpur | Tel. No: 03-6279 7717  
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<table>
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<tr>
<th>No.</th>
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<tbody>
<tr>
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<td>Myanmar</td>
<td>Ms.</td>
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<td>Thailand</td>
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<td>17</td>
<td>Thailand</td>
<td>Ms.</td>
<td>Tanyalak Somboonchai</td>
<td>Project assistant, QSBG Entomology</td>
<td>Tel:</td>
</tr>
<tr>
<td>18</td>
<td>Philippines</td>
<td>Mr.</td>
<td>Benidecto Golosino</td>
<td>Forest Ranger Integrated Protected Areas System, Mt.Kitaglad Range Nature Park</td>
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<tr>
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<td>Philippines</td>
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<tr>
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<td>Philippines</td>
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<tr>
<td>21</td>
<td>Philippines</td>
<td>Ms.</td>
<td>Paula Jade Matias</td>
<td>Executive Assistant ASEAN Centre for Biodiversity</td>
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<td>Philippines</td>
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<td>23</td>
<td>Viet Nam</td>
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<td>Viet Nam</td>
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<tr>
<td>25</td>
<td>CBD</td>
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<td>ACB-BCCP</td>
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<td>QSBG Entomology</td>
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<tr>
<td>29</td>
<td>University of the Philippines Los Baños</td>
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<td>ASEAN Centre for Biodiversity</td>
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<td>QSBG</td>
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<td>34</td>
<td>QSBG</td>
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<tr>
<td>35</td>
<td>QSBG</td>
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<tr>
<td>36</td>
<td>QSBG</td>
<td>Ms.</td>
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<td>37</td>
<td>QSBG</td>
<td>Miss</td>
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<td>38</td>
<td>QSBG</td>
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<td>Public relation staff</td>
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</tbody>
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Extended Taxonomic Capacity Building For Sustainable Use Of Biodiversity: Bryophytes, Pteridophytes and Economically-Important Insects (Predators And Parasitoids) in their Natural Habitats

Programme of Activities

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Responsible Person/s</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Day 0 (31 Aug)</strong></td>
<td><strong>Arrival of participants</strong></td>
<td></td>
</tr>
<tr>
<td>7:30 – 8:15</td>
<td>Travel from Chiang Mai to QSBG</td>
<td></td>
</tr>
<tr>
<td>8:15 – 8:30</td>
<td>Registration</td>
<td>Workshop secretariat</td>
</tr>
<tr>
<td>8:30 – 9:10</td>
<td>Opening Session</td>
<td>Dr. Suyanee Vessabutr&lt;br&gt;Director, Botanical Garden Organization&lt;br&gt;Dr. Chaweewan Hutacharern&lt;br&gt;Adviser to the Director of BGO&lt;br&gt;Atty. Roberto V. Oliva&lt;br&gt;Executive Director&lt;br&gt;ASEAN Centre for Biodiversity</td>
</tr>
<tr>
<td>9:10 – 9:20</td>
<td>Introduction of Participants, Lecturers</td>
<td>Dr. Filiberto Pollisco, Jr.&lt;br&gt;Policy &amp; Research Specialist&lt;br&gt;ASEAN Centre for Biodiversity</td>
</tr>
<tr>
<td>9:20 – 9:30</td>
<td>Photo Opportunity</td>
<td>Workshop secretariat</td>
</tr>
<tr>
<td>9:30 – 10:30</td>
<td>An Introduction to the ACB taxonomy information databases important to taxonomy information management</td>
<td>Mr. Carl Callangan&lt;br&gt;Biodiversity Information Management Unit, ACB</td>
</tr>
<tr>
<td>10:30 - 10:45</td>
<td>Coffee/tea break</td>
<td></td>
</tr>
<tr>
<td>10:45 – 12:00</td>
<td>Familiarization of Queen Sirikit Botanic Garden</td>
<td>QSBG Staff and Resource Persons</td>
</tr>
<tr>
<td>12:15 – 13:00</td>
<td>Lunch break</td>
<td></td>
</tr>
<tr>
<td>13:00 – 15:00</td>
<td>Familiarization of Insect Laboratory and equipment</td>
<td>QSBG Staff and Resource Persons</td>
</tr>
<tr>
<td>15:00 – 15:15</td>
<td>Coffee/tea break</td>
<td></td>
</tr>
<tr>
<td>15:15 – 17:00</td>
<td>Familiarization / orientation</td>
<td>QSBG Staff and Resource Persons</td>
</tr>
<tr>
<td>17:15 – 18:15</td>
<td>Travel back to Chiang Mai</td>
<td></td>
</tr>
<tr>
<td>18:30 onwards</td>
<td>Dinner</td>
<td>Sponsored by ACB</td>
</tr>
<tr>
<td><strong>Day 1 (1 Sept)</strong></td>
<td><strong>Opening and Start of Training</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Day 2 (2 Sept)</strong></td>
<td><strong>Lecture and Laboratory Exercises</strong></td>
<td></td>
</tr>
<tr>
<td>7:30 – 8:15</td>
<td>Travel from Chiang Mai to QSBG</td>
<td></td>
</tr>
<tr>
<td>8:15 – 8:30</td>
<td>Registration</td>
<td>Workshop secretariat</td>
</tr>
<tr>
<td>8:30 – 9:00</td>
<td>Prologue&lt;br&gt;Part I. Introduction to Insect Predators, Parasitic Insects, and parasitoids</td>
<td>Dr. Banpot Napompeth&lt;br&gt;Advisor, National Biological Control Research Center, Kasetsart University Bangkok, Thailand</td>
</tr>
<tr>
<td>9:00 – 9:30</td>
<td>Part II. Typical Morphology of Parasitic Hymenoptera</td>
<td>Dr. Banpot Napompeth&lt;br&gt;Advisor, National Biological Control Research Center, Kasetsart University Bangkok, Thailand</td>
</tr>
<tr>
<td>9:30 – 10:00</td>
<td>Coffee / Tea Break</td>
<td></td>
</tr>
<tr>
<td>10:00 – 12:00</td>
<td>Part III. Classification of Parasitoids</td>
<td>Dr. Banpot Napompeth&lt;br&gt;Advisor, National Biological Control Research Center, Kasetsart University Bangkok, Thailand</td>
</tr>
<tr>
<td>Time</td>
<td>Activity</td>
<td>Responsible Person/s</td>
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<tr>
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</tr>
<tr>
<td>12:00 – 13:00</td>
<td>Lunch Break</td>
<td></td>
</tr>
<tr>
<td>13:00 – 14:00</td>
<td>Part IV. Biology and Ecology of Parasitoids</td>
<td>Dr. Banpot Napompeth&lt;br&gt;Advisor, National Biological Control Research Center, Kasetsart University, Bangkok, Thailand</td>
</tr>
<tr>
<td>14:00 – 15:00</td>
<td>Part IV. Economic Importance of parasitoids</td>
<td>Dr. Banpot Napompeth&lt;br&gt;Advisor, National Biological Control Research Center, Kasetsart University, Bangkok, Thailand</td>
</tr>
<tr>
<td>15:00 – 15:30</td>
<td>Coffee / Tea Break</td>
<td></td>
</tr>
<tr>
<td>15:30 – 17:00</td>
<td>Part V. Collecting and Preserving parasitoids:</td>
<td>Dr. Banpot Napompeth&lt;br&gt;Advisor, National Biological Control Research Center, Kasetsart University, Bangkok, Thailand&lt;br&gt;and QSBG Staff</td>
</tr>
<tr>
<td></td>
<td>• Introduction to field and laboratory equipment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Preparation of Laboratory equipment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Field collecting Insects in QSBG compound and the vicinity</td>
<td></td>
</tr>
<tr>
<td>Day 3 (03 Sept)</td>
<td>Lecture and Laboratory Exercises</td>
<td>Workshop secretariat</td>
</tr>
<tr>
<td>8:15 – 8:30</td>
<td>Registration</td>
<td></td>
</tr>
<tr>
<td>8:30 – 9:30</td>
<td>• Introduction to Predatory Insects</td>
<td>Dr. Ireneo Lit, Jr.&lt;br&gt;Director, UPLB Natural History Museum, Los Banos, Laguna, Philippines</td>
</tr>
<tr>
<td></td>
<td>• Classification of Predatory Insects</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Life Cycles of Predatory Insects</td>
<td></td>
</tr>
<tr>
<td>9:30 – 10:00</td>
<td>Coffee/tea break</td>
<td></td>
</tr>
<tr>
<td>10:00 – 12:00</td>
<td>• Morphology of Predatory Insects</td>
<td>Dr. Ireneo Lit, Jr.&lt;br&gt;Director, UPLB Natural History Museum, Los Banos, Laguna, Philippines</td>
</tr>
<tr>
<td>12:00 – 13:00</td>
<td>Lunch Break</td>
<td></td>
</tr>
<tr>
<td>13:00 – 14:00</td>
<td>• Ecology and Economic Importance of Predatory insects</td>
<td>Dr. Ireneo Lit, Jr.&lt;br&gt;Director, UPLB Natural History Museum, Los Banos, Laguna, Philippines</td>
</tr>
<tr>
<td>14:00 – 15:30</td>
<td>Laboratory Exercises in identification of Predatory Insects</td>
<td>Dr. Ireneo Lit, Jr.&lt;br&gt;Director, UPLB Natural History Museum, Los Banos, Laguna, Philippines&lt;br&gt;With assistance from QSBG staff</td>
</tr>
<tr>
<td>15:30 – 15:45</td>
<td>Coffee/tea break</td>
<td></td>
</tr>
<tr>
<td>15:45 – 17:00</td>
<td>Continuation of Laboratory Exercises in identification of Predatory Insects</td>
<td>Dr. Ireneo Lit, Jr.&lt;br&gt;Director, UPLB Natural History Museum, Los Banos, Laguna, Philippines&lt;br&gt;With assistance from QSBG staff</td>
</tr>
<tr>
<td>5:15 – 6:15</td>
<td>Stay overnight in QSBG Resort Hotel</td>
<td>QSBG</td>
</tr>
<tr>
<td>18:30 onwards</td>
<td>Dinner in QSBG Resort Hotel</td>
<td></td>
</tr>
</tbody>
</table>

Day 4 (4 Sept) In QSBG

6:00 - 7:15 Breakfast
7:15 – 7:30 Registration
Extended Taxonomic Capacity Building For Sustainable Use Of Biodiversity: Bryophytes, Pteridophytes and Economically-Important Insects (Predators And Parasitoids) in their Natural Habitats

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Responsible Person/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>7:30 – 12:00</td>
<td>• Field collecting of predators and parasitoids</td>
<td>Dr. Ireneo Lit, Jr. Director, UPLB Natural History Museum, Los Banos, Laguna, Philippines</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dr. Banpot Napompeth Advisor, National Biological Control Research Center, Kasetsart University Bangkok, Thailand</td>
</tr>
<tr>
<td></td>
<td></td>
<td>and QSBG staff</td>
</tr>
<tr>
<td>12:00 – 13:00</td>
<td>Lunch Break</td>
<td></td>
</tr>
<tr>
<td>13:00 – 17:00</td>
<td>Laboratory processing, preservation and identification of specimens</td>
<td>Dr. Ireneo Lit, Jr. Director, UPLB Natural History Museum, Los Banos, Laguna, Philippines</td>
</tr>
<tr>
<td></td>
<td>(predators and parasitoids)</td>
<td>Dr. Banpot Napompeth Advisor, National Biological Control Research Center, Kasetsart University Bangkok, Thailand</td>
</tr>
<tr>
<td></td>
<td></td>
<td>and QSBG staff</td>
</tr>
<tr>
<td>17:15 – 18:15</td>
<td>Travel to Chiang Mai Hotel</td>
<td>Chiang Mai</td>
</tr>
<tr>
<td>18:30 onwards</td>
<td>Dinner is on your own</td>
<td></td>
</tr>
<tr>
<td><strong>Day 5 (5 Sept)</strong></td>
<td><strong>Closing Programme &amp; Departure (Chiang Mai Hotel)</strong></td>
<td></td>
</tr>
<tr>
<td>8:30 – 10:00</td>
<td>Presentation of results of identification Evaluation, Feedback and General discussion on the training</td>
<td>ACB, QSBG and Resource Persons</td>
</tr>
<tr>
<td>10:00 – 10:30</td>
<td>Snack Break</td>
<td></td>
</tr>
<tr>
<td>10:30 – 11:00</td>
<td>Closing Programme</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Awarding of certificates</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Closing messages</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Dr. Suyanee Vessabutr</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Dr. Ireneo Lit, Jr.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Dr. Banpot Napompeth</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Dr. Filiberto Pollisco, Jr.</td>
<td></td>
</tr>
<tr>
<td>11:00 onwards</td>
<td>Free time</td>
<td></td>
</tr>
<tr>
<td><strong>Day 6 (6 Sept)</strong></td>
<td>Departure of everyone for Bangkok and respective countries</td>
<td></td>
</tr>
</tbody>
</table>
Extended Taxonomic Capacity Building for Sustainable Use of Biodiversity: Bryophytes, Pteridophytes and Economically-Important Insects

Predators and Parasitoids

Queen Sirikit Botanic Garden
Chiang Mai, Thailand
1-5 September 2014
Extended Taxonomic Capacity Building for Sustainable Use of Biodiversity: Bryophytes, Pteridophytes and Economically-Important Insects

Predators and Parasitoids

Queen Sirikit Botanic Garden
Chiang Mai, Thailand
1-5 September 2014
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Extended Taxonomic Capacity Building for Sustainable Use of Biodiversity:
Bryophytes, Pteridophytes and Economically-Important Insects
(Predators and Parasitoids)

Queen Sirikit Botanic Garden, Chiang Mai, Thailand
1-5 September 2014

- 5 days

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Responsible Person/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 0 (31 Aug) <strong>Arrival of participants</strong></td>
<td></td>
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</tr>
<tr>
<td>7:30 – 8:15</td>
<td>Travel from Chiang Mai to QSBG</td>
<td></td>
</tr>
<tr>
<td>8:15 – 8:30</td>
<td>Registration</td>
<td>Workshop secretariat</td>
</tr>
<tr>
<td>8:30 – 9:10</td>
<td>Opening Session</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Messages/Welcome Remarks</td>
<td>Dr. Suyanee Vessabutr, Director, Botanical Garden Organization</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dr. Chaweewan Hutacharern, Adviser to the Director of BGO</td>
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<tr>
<td></td>
<td></td>
<td>Atty. Roberto V. Oliva, Executive Director, ASEAN Centre for Biodiversity</td>
</tr>
<tr>
<td>9:10 – 9:20</td>
<td>Introduction of Participants, Lecturers and assistants</td>
<td>Dr. Filiberto Pollisco, Jr., Policy &amp; Research Specialist, ASEAN Centre for Biodiversity</td>
</tr>
<tr>
<td>9:20 – 9:30</td>
<td>Photo Opportunity</td>
<td>Workshop secretariat</td>
</tr>
<tr>
<td>9:30 – 10:30</td>
<td>• An Introduction to the ACB taxonomy information databases important to taxonomy information management</td>
<td>Mr. Carl Callangan, Biodiversity Information Management Unit, ACB</td>
</tr>
<tr>
<td>10:30 - 10:45</td>
<td>Coffee/tea break</td>
<td>QSBG Staff and Resource Persons</td>
</tr>
<tr>
<td>10:45 – 12:00</td>
<td>Familiarization of Insect Laboratory and equipment</td>
<td>QSBG Staff and Resource Persons</td>
</tr>
<tr>
<td>12:15 – 13:00</td>
<td>Lunch break</td>
<td></td>
</tr>
<tr>
<td>13:00 – 15:00</td>
<td>Familiarization of Queen Sirikit Botanic Garden</td>
<td>QSBG Staff and Resource Persons</td>
</tr>
<tr>
<td>15:00 – 15:15</td>
<td>Coffee/tea break</td>
<td></td>
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<tr>
<td>Time</td>
<td>Activity</td>
<td>Responsible Person/s</td>
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<tr>
<td>15:15 – 17:00</td>
<td>Familiarization / orientation</td>
<td>QSBG Staff and Resource Persons</td>
</tr>
<tr>
<td>17:15 – 18:15</td>
<td>Travel back to Chiang Mai</td>
<td></td>
</tr>
<tr>
<td>18:30 onwards</td>
<td>Dinner</td>
<td>Sponsored by ACB</td>
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</table>

**Day 2 (2 Sept) Lecture and Laboratory Exercises**

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Responsible Person/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>7:30 – 8:15</td>
<td>Travel from Chiang Mai to QSBG</td>
<td>Workshop secretariat</td>
</tr>
<tr>
<td>8:15 – 8:30</td>
<td>Registration</td>
<td></td>
</tr>
<tr>
<td>8:30 – 9:00</td>
<td>Prologue</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Part I. Introduction to Insect Predators, Parasitic Insects, and</td>
<td>Dr. Banpot Napompeth&lt;br&gt;Advisor, National Biological Control Research Center, Kasetsart University Bangkok, Thailand</td>
</tr>
<tr>
<td></td>
<td>parasitoids</td>
<td></td>
</tr>
<tr>
<td>9:00 – 9:30</td>
<td>Part II. Typical Morphology of Parasitic Hymenoptera</td>
<td>Dr. Banpot Napompeth&lt;br&gt;Advisor, National Biological Control Research Center, Kasetsart University Bangkok, Thailand</td>
</tr>
<tr>
<td>9:30 – 10:00</td>
<td>Coffee / Tea Break</td>
<td></td>
</tr>
<tr>
<td>10:00 – 12:00</td>
<td>Part III. Classification of Parasitoids</td>
<td>Dr. Banpot Napompeth&lt;br&gt;Advisor, National Biological Control Research Center, Kasetsart University Bangkok, Thailand</td>
</tr>
<tr>
<td>12:00 – 13:00</td>
<td>Lunch Break</td>
<td></td>
</tr>
<tr>
<td>13:00 – 14:00</td>
<td>Part IV. Biology and Ecology of Parasitoids</td>
<td>Dr. Banpot Napompeth&lt;br&gt;Advisor, National Biological Control Research Center, Kasetsart University Bangkok, Thailand</td>
</tr>
<tr>
<td>14:00 – 15:00</td>
<td>Part V. Economic Importance of parasitoids</td>
<td>Dr. Banpot Napompeth&lt;br&gt;Advisor, National Biological Control Research Center, Kasetsart University Bangkok, Thailand</td>
</tr>
<tr>
<td>15:00 – 15:30</td>
<td>Coffee / Tea Break</td>
<td></td>
</tr>
<tr>
<td>15:30 – 16:30</td>
<td>Part VI. Collecting and Preserving Parasitoids</td>
<td>Dr. Banpot Napompeth&lt;br&gt;Advisor, National Biological Control Research Center, Kasetsart University Bangkok, Thailand</td>
</tr>
<tr>
<td>17:30 – 18:30</td>
<td>Travel back to Chiang Mai</td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>Activity</td>
<td>Responsible Person/s</td>
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</tr>
<tr>
<td>8:15 – 8:30</td>
<td>Registration</td>
<td>Workshop secretariat</td>
</tr>
</tbody>
</table>
| 8:30 – 9:30  | • Introduction to Predatory Insects  
• Classification of Predatory Insects  
• Life Cycles of Predatory Insects | Dr. Ireneo Lit, Jr.  
Director, UPLB Natural History Museum, Los Banos, Laguna, Philippines               |
| 9:30 – 10:00 | Coffee/tea break                                                         |                                                                                      |
| 10:00 – 12:00| • Morphology of Predatory Insects                                       | Dr. Ireneo Lit, Jr.  
Director, UPLB Natural History Museum, Los Banos, Laguna, Philippines               |
| 12:00 – 13:00| Lunch Break                                                              |                                                                                      |
| 13:00 – 14:00| • Ecology and Economic Importance of Predatory insects                   | Dr. Ireneo Lit, Jr.  
Director, UPLB Natural History Museum, Los Banos, Laguna, Philippines               |
| 14:00 – 15:30| Laboratory Exercises in identification of Predatory Insects              | Dr. Ireneo Lit, Jr.  
Director, UPLB Natural History Museum, Los Banos, Laguna, Philippines               |
| 15:30 – 15:45| Coffee/tea break                                                         | With assistance from QSBG staff                                                       |
| 15:45 – 17:00| Continuation of Laboratory Exercises in identification of Predatory Insects | Dr. Ireneo Lit, Jr.  
Director, UPLB Natural History Museum, Los Banos, Laguna, Philippines               |
| 17:15 – 17:30| Travel to QSBG Resort Hotel (overnight here)                             | QSBG                                                                                 |
| 18:30 onwards| Dinner in QSBG Resort Hotel                                             |                                                                                      |

**Day 4 (04 Sept) In QSBG**

<table>
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<tr>
<th>Time</th>
<th>Activity</th>
<th>Responsible Person/s</th>
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<tbody>
<tr>
<td>6:00 - 7:15</td>
<td>Breakfast</td>
<td></td>
</tr>
<tr>
<td>7:15 – 7:30</td>
<td>Registration</td>
<td></td>
</tr>
</tbody>
</table>
| 7:30 – 12:00 | • Field collecting of predators and parasitoids       | Dr. Ireneo Lit, Jr.  
Director, UPLB Natural History Museum                                                  |
<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Responsible Person/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>12:00 – 13:00</td>
<td>Lunch Break</td>
<td>Los Banos, Laguna, Philippines&lt;br&gt;Dr. Banpot Napompeth&lt;br&gt;Advisor, National Biological Control Research Center, Kasetsart University Bangkok, Thailand&lt;br&gt;And QSBG Staff</td>
</tr>
<tr>
<td>13:00 – 17:00</td>
<td>Laboratory processing, preservation and identification of specimens (predators and parasitoids)</td>
<td>Dr. Ireneo Lit, Jr. &lt;br&gt;Director, UPLB Natural History Museum &lt;br&gt;Los Banos, Laguna, Philippines&lt;br&gt;Dr. Banpot Napompeth&lt;br&gt;Advisor, National Biological Control Research Center, Kasetsart University Bangkok, Thailand&lt;br&gt;And QSBG Staff</td>
</tr>
<tr>
<td>17:15 – 18:15</td>
<td>Travel to Le Méridien Hotel</td>
<td>Chiang Mai</td>
</tr>
<tr>
<td>18:30 onwards</td>
<td>Dinner is on your own</td>
<td></td>
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</table>

**Day 5 (5 Sept) Closing Programme & Departure (Le Méridien Hotel)**

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Responsible Person/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:30 – 10:00</td>
<td>Presentation of results of identification Evaluation, Feedback and General discussion on the training</td>
<td>ACB, QSBG and Resource Persons</td>
</tr>
<tr>
<td>10:00 – 10:30</td>
<td>Snack Break</td>
<td></td>
</tr>
<tr>
<td>10:30 – 11:00</td>
<td>Closing Programme&lt;br&gt;• Awarding of certificates&lt;br&gt;• Closing messages&lt;br&gt;  ○ Dr. Suyanee Vessabutr&lt;br&gt;  ○ Dr. Ireneo Lit, Jr.&lt;br&gt;  ○ Dr. Banpot Napompeth&lt;br&gt;  ○ Dr. Filiberto Pollisco, Jr.</td>
<td></td>
</tr>
<tr>
<td>11:00 onwards</td>
<td>Free time</td>
<td></td>
</tr>
<tr>
<td><strong>Day 6 (6 Sept)</strong></td>
<td>Departure of everyone for Bangkok and respective countries</td>
<td></td>
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</tbody>
</table>
An introduction to the ACB taxonomy information databases important to taxonomy information management

— Carl Callangan
Parasitoids

— Banpot Napompeth
Capacity Building for Taxonomy of Economically Important Insects (Predators & Parasitoids) in Their Natural Habitat

Banpot Napompeth
@ASEAN Center for Biodiversity (ACB)
Training Project
Queen Sirikit Botanic Garden (QSBG)
Chiang Mai, Thailand
1-5 September 2014

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Resource Person

Banpot Napompeth, PhD, FRES
Founder & Advisor
National Biological Control Research Center
Kasetsart University, Bangkok, Thailand
(aprban@ku.ac.th)
Areas of expertise: Biological Control of Insect Pests and Weeds, Integrated Pest Management (IPM), Biosafety of Genetically Modified Crops

With Assistance from:

Samaporn Saengyot, PhD
Maejo University Biological Control Laboratory (MU-BCL)
Plant Protection Program
Faculty of Agricultural Production
Maejo University, Chiang Mai, Thailand
(sama_mju@yahoo.com)
Areas of expertise: Agricultural Entomology, Biological Control of Insect Pests and Weeds, Insect Pathology, Integrated Pest Management (IPM)
Under the Auspices of

BASTARD

(Banpot Agricultural Science and Technology for Agricultural Research and Development)

Worldwide Consultancy Services

Tel/Fax: 66 0 2942 8252 Mobile: 66 0 81 841 5264
Email: agrban@ku.ac.th

c/o National Biological Control Research Center
Kasetsart University
P.O. Box 9-52, Chatuchak, Bangkok 10900, Thailand

Topics of Presentation

- Prologue (20 minutes)
- Part I: Introduction to Insect Predators, Parasitic Insects and Parasitoids (10 minutes)
- Part II: Typical Morphology of Parasitic Hymenoptera (30 Minutes)
- Part III: Classification of Parasitoids (2 hours)
- Part IV: Biology and Ecology of Parasitoids (1 hour)
- Part V: Economic Importance of Parasitoids (1 hour)
- Part VI: Collecting and Preserving Parasitoids (1 hour)

Shall We Begin now?

Hi There! Try it, You’ll like it!
Prologue

ASEAN Region
Where we are in the world?

ASEAN Member States
Training Overview

- ASEAN Center for Biodiversity (ACB)'s ASEAN Cooperation Project on “Extended Taxonomic Capacity Building for Sustainable Use of Biodiversity: Bryophytes, Pteridophytes, and Economically-Important Insects (Predators and Parasitoids).”
- Addressing the Global Taxonomy Initiative (GTI) of the Convention on Biological Diversity (CBD) and Target 19 of the Aichi Targets of 2011-2020.

Convention on Biological Diversity (CBD)

- CBD Objectives
  1. Conservation of biological diversity,
  2. Sustainable use of its components, and
  3. Fair and equitable sharing of the benefits arising out of the utilization of genetic resources.
Global Taxonomy Initiative (GTI)

- Taxonomy is the science (or an art) of naming, describing and classifying organisms and includes all plants, animals and microorganisms of the world.
- Taxonomists identify, describe and arrange species into classifications, including those that are new to science by using morphological, behavioral, genetic and biochemical observations.
- Unfortunately, taxonomic knowledge is far from complete.
- In the past 250 years of research, taxonomists have named about 1.78 million species of animals, plants and microorganisms, yet the total number of species is unknown and probably between 5 and 30 million.

Global Taxonomy Initiative (GTI)

- The CBD Conference of the Parties (COP) established the Global Taxonomy Initiative (GTI) in 1998.
- GTI is a set of activities and objectives agreed to by governments.
- These activities highlight issues, facilitate exchange of information and promote technical cooperation.
- GTI provides guidance to governments, taxonomists, non-government and international organizations, responsible for implementing the GTI.

Global Taxonomy Initiative (GTI)

- Operational objectives 1-5:
- Planned Activity 1: Country-based taxonomic needs assessments.
- Planned Activity 5: Global and regional capacity building to support access to and generation of taxonomic information.
- Planned Activity 15: Invasive alien species.
- Etc.
Global Taxonomy Initiative (GTI)

- GTI is implemented through a wide range of actors, including governments, non-government organizations, as well as taxonomists and the institutions they represent, such as:
  - Food and Agriculture Organization of the United Nations (UN FAO)
  - International Union for Conservation of Nature (IUCN)
  - Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)
  - Consortium for Barcode of Life (CBOL)
  - Global Biodiversity Information Facility (GBIF)
  - BioNET INTERNATIONAL - the global network for taxonomy.

What is BioNET-INTERNATIONAL?

- BioNET-INTERNATIONAL, the Global Network for Taxonomy, is dedicated to creating sustainable mechanisms to assist developing countries to overcome the Taxonomic Impediment by becoming self-reliant in taxonomy, i.e., self-reliant in the skills, infrastructure.

BioNET LOOPs

- LOOPs (Locally Organized and Operated Partnerships) are Technical Cooperation Networks of institutions and individuals that either use or provide taxonomic expertise, information and resources. Their goal is to help build taxonomic capacity to enable developing countries to achieve sustainable development.
BioNET INTERNATIONAL Regional Networks

- BioNET INTERNATIONAL Regional Networks (LOOPS – Locally Organized and Operated Partnerships)
  - ANDINONET (Andean countries)
  - CARINET (Caribbean)
  - LATINET (South America Southern Cone)
  - MesoAmeriNET (Mesoamerica)
  - EAFRINET (East Africa)
  - NAFRINET (North Africa)
  - SAFRINET (Southern Africa)
  - WAFRINET (West Africa)

BioNET INTERNATIONAL Regional Networks

- BioNET INTERNATIONAL Regional Networks (LOOPS – Locally Organized and Operated Partnerships)
  - EuroLOOP (Europe)
  - NEURASIANET (North Eurasia)
  - ASEANET (South-East Asia)
  - EASIANET (East Asia)
  - SACNET (South Asia)
  - PACINET (Pacific Islands)

ASEANET

- ASEANET comprises all 10 members of the ASEAN group - Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam.
  - The ASEAN region has some of the richest and yet most threatened biodiversity on this Earth. The 500 million inhabitants within the nations of ASEAN continue to rely on this biodiversity for their livelihoods.

- Technical Secretary:
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The Banana Slugger

*Erioheyla (= Pelopidas) thraax*
BioNET INTERNATIONAL Funding

- Both the LOOPS and the Technical Secretariat are not-for-profit, donor funded programs. The BioNET-INTERNATIONAL Fund supports the operations of the Technical Secretariat and provides catalytic funding of some US$130,000 over two years to establish LOOPS.

Global Taxonomy Initiative (GTI)

- Governments, through the Convention on Biological Diversity, have acknowledged the existence of a "taxonomic impediment" to the sound management of biodiversity.
- The purpose of the Global Taxonomic Initiative (GTI) is to remove or reduce this taxonomic impediment - in other words, the knowledge gaps in our taxonomic system (including those associated with genetic systems), the shortage of trained taxonomists and curators, and the impact these deficiencies have on our ability to conserve, use and share the benefits of our biological diversity.

Aichi Biodiversity Targets
(2011-2020)

- **Strategic Goal E:**
  
  Enhance implementation through participatory planning, knowledge management (KM) and *capacity building*.

- **Aichi Target 19**
  
  By 2020, knowledge, the science base and technologies relating to biodiversity, its values, functioning, status and trends, and the consequences of its loss, are improved, widely shared and transferred, and applied.
ACB Training Aims and Objectives

- The focus of taxonomic study will be on those predatory and parasitic insects found in the natural habitats like forests in protected areas and other ecosystems, different from agricultural insects.
- Familiarization with their classification, biology and ecology, and economic importance.
- Field trips to provide hands-on experience in collecting insect specimens and processing them for preservation and taxonomic work.

Target Beneficiaries

- Protected area managers and staff
- Park superintendents, managers and staff
- Technical staff of the ASEAN Member States implementing the projects

ASEAN CENTRE FOR BIODIVERSITY

Typical ASEAN Ministerial Meeting
Typical ASEAN Spirit!

The End of Prologue

A trichogrammatid egg parasitoid
Part I
Introduction to Insect Predators, Parasitic Insects and Parasitoids

Insect Predators, Parasitic Insects and Parasitoids

- There is a need to differentiate “insect predators” or “predatory insects” from “parasitoids” or “insect parasites” of agricultural and forestry importance.
- There is also a need to differentiate “parasitic insects” of medical and public health importance from “parasitoids” or “insect parasites” of agricultural and forestry as well as medical and public health importance.

Insect Predators or Predatory Insects

- **Predator** = An animal that overpowers, kills and consumes other animals (prey).
- A mode of living in which an animal kills and consumes another animal as food.
- Predatory insects appear taxonomically in several insect orders: Orthoptera, Hemiptera, Diptera, Coleoptera, Neuroptera, Lepidoptera.
- Immature stage requires more than one individual of prey to reach maturity.
- Predator-prey relationship association.
Insect Predators or Predatory Insects

Parasitic Insects

- *Parasite* = An organism that lives on or in another organism (host), or at the expense of another organism
- *Parasitic insects* (fleas, lice, etc.) are distinguished from parasitoids or insect parasites in several features:
  - Hosts are vertebrates
  - Parasitic as larvae or nymphs and adults
  - Their size is *highly smaller* than their hosts
  - They feed on all stages of their hosts
  - They *do not kill* their hosts
- Host-parasite relationship association

Parasitic Insects
Parasitoids or Insect Parasites

- *Parasitoid* = An organism which resembles a true parasite in feeding behavior
- Parasitoids are distinguished from parasitic insects in several features:
  - Parasitoids appear taxonomically restricted to orders Hymenoptera (sawflies, parasitic wasps, ants, wasps, and bees), Diptera (true flies) and Strepsiptera (stylops)
  - Hosts are typically other insects of the *same* taxonomic class, or rarely other arthropods

Parasitoids or Insect Parasites

- Parasitoids are parasitic in immature stage as larvae
- As a result, they are at times called "prolecan parasites"
- Adult parasitoids are free-living
- Parasitoids are *smaller* than the hosts in or on which they develop, but in comparison with their hosts they are relatively *large* size

Parasitoids or Insect Parasites

- Parasitoids only attack *one stage* of host (egg, larva, nymph, pupa, adult)
- Immature stage develops at the expense of a *single* host individual to reach maturity
- Parasitoids *kill* their hosts
- Host-parasitoid relationship
Parasitoids or Insect Parasites

- *Idiobiont* parasitoids do not permit the host to grow beyond the stage attacked
- *Koinobiont* parasitoids allow their hosts to continue feeding and develop to the next stage

Parasitoids or Insect Parasites

Natural Enemies

- Predators, parasitoids, and pathogens (3Ps) are the three major groups of "Natural enemies" of insect pests in "Biological control" (or "Biocontrol" for short)
- "Insect predators" and "insect parasites" or "parasitoids" are collectively called "Entomophagous insects"
- Together with insect pathogens, they are called "Biological control agents" or "BCAs"
3Ps as Natural Enemies

- Predatory coccinellids
- Hymenopterous parasitoids
- Insect pathogenic (entomopathogenic) fungi

An Act of Parasitization

End of Part I
Introduction to Insect Predators, Parasitic Insects and Parasitoids
Part II
Typical Morphology of Parasitic Hymenoptera

Classical Reference in Insect Morphology
Robert Evans Snodgrass (1875 – 1962)
Entomologist at USDA and US Natural History Museum, Smithsonian Institute, Washington, D.C.

Class Insecta: External Morphology and Adaptations

External Morphology:
Head

- **HEAD:**
  - The head of an insect is composed of mainly rigid sclerites or sclerotized segments
  - The insect head is a capsule that contains:
    - Compound eyes
    - Mouthparts, and
    - Antennae
External Morphology: Thorax

- THORAX:
- The insect thorax is divided into three parts: the prothorax (pro=first), mesothorax (meso=middle), and metathorax (meta=last)
- Each segment consists of hardened plates, or sclerites
- Dorsal sclerites are called nota (singular notum), lateral sclerites are called pleura (singular pleuron), and ventral sclerites are called sterna (singular sternum)
- The first segment of the prothorax is the pronotum
- Each of the three thoracic segments contains one pair of legs
- Wings are found only on the meso- and metathoracic segments

External Morphology: Abdomen

- ABDOMEN:
- The abdomen contains the reproductive organs and the majority of the organ systems
- The dorsal and ventral abdominal segments are termed terga (singular tergum) and sterna (singular sternum), respectively
- Spiracles usually can be found in the conjunctive tissue between the terga and sternae of abdominal segments 1-8
- Reproductive structures are located on the 9th segment in males (including the saccus, or penis, and one pair of claspers) and on the 8th and 9th abdominal segments in females (female external gonialia or copulatory openings and ovipositor)
Internal Morphology

- Internal morphology consists of:
  - Digestive System
  - Excretory System
  - Circulatory System
  - Nervous System
  - Respiratory System
  - Reproductive System

MORPHOLOGY OF INSECTS
(With emphasis on Natural Enemy Identification)

- SUBMISSIONS & MESSAGES
  - e.legner@ucr.edu
- Additions and corrections are invited for consideration
- They may be accompanied by citations of published documents or other credible references
- This website may be viewed optimally with a PC and Microsoft Internet Explorer or Safari
- [Fire Fox & Apple Browsers may require Converter]

References on Morphology of Hymenoptera

References on Morphology of Hymenoptera

- Handbook of the families of Nearctic Chalcidoidea
- An online version of the key by Eric E. Grissell and Michael E. Schauf to the families of Chalcidoidea
- First published in 1990 by the Entomological Society of Washington. Includes a pdf version of the key for download and new photographs added to many of the original illustrations

HymAToL

Hymenoptera:

- Assembling the Tree of Life
- Analysis of superfamilies at the family, subfamily, tribal, genus and species levels of Hymenoptera
General morphology of Hymenoptera upper-side

Some Hymenopteran Forms

Head of an Ichneumonid

HEAD OF AN Ichneumonid ANTERIOR AND POSTERIOR VIEWS
Legend
1. 13. Vertex
2. Supra-antennal area
3. Supraclypeal area
4. Malar space (= cheek)
5. Clypeus
6. Groove between face and clypeus
7. Anterior tentorial pit (= clypeal fovea)
8. Labrum

Legend
9, 10, 11. Paraocular area
12. Genal orbit
14. Occiput
15. Foramen magnum
16, 17. Occipital carina (17 = genal carina)
18. Hypostomal carina (= oral carina)
19. Gena (= temple)

Mesosoma
- Mesosoma. The apparent thorax in apocritan (bees, ants, parasitoids) Hymenoptera, consisting of the thorax and the fused morphological first segment of the abdomen (the propodeum)
Mesosoma

MESOSOMA OF AN ICHNEUMONID
LATERAL VIEW

Legend

AREAS:
1. Median lobe of mesoscutum
2. Lateral lobe of mesoscutum
1. 2. Mesoscutum
3. Scutellum
4. Metanotum (= postscutellum)
5. Hind margin of metanotum
6. Tegula
7. Subalar ridge (= subtegular ridge)
8. Collar

Legend

8, 9, 10. Pronotum
10. Hind corner of pronotum
11, 12, 18. Mesopleuron [mesepisternum]
12. Hypoepimeron (= speculum)
13. Mesepimeron
14. Upper division of metapleuron
15. Lower division of metapleuron
16. Juxtacoxal area
17. Propleuron
18. Epicnecium (= prepectus)
Legend

20. Fore coxa 25. Third lateral area
21. Middle coxa 26. First pleural area
22. Hind coxa 27. Second pleural area
23. First lateral area 29. Propodeal spiracle

Mesosoma

MESOSOMA OF AN ICHEUMONID
DORSAL VIEW

Legend

AREAS:
1. Median lobe of mesoscutum
2. Lateral lobe of mesoscutum
1, 2. Mesoscutum
3. Scutellum
4. Postscutellum
5. Hind margin of metanotum
6. Tegula
7. Subalar ridge (= subtegular ridge)
Legend

8. Collar
8, 9. 10. Pronotum
10. Hind corner of pronotum
11. Mesopleuron [mesepisternum]
14. Upper division of metapleuron
15. Lower division of metapleuron
23-32. Propodeum
23. First lateral area
24. Second lateral area

Legend

25. Third lateral area
26. First pleural area
27. Second pleural area
28. Third pleural area
29. Propodeal spiracle
30. Basal area
31. Areola
32. Petiolar area
33. Axillary trough of mesonotum
34. Axillary trough of metanotum

Legend

CARINAE AND GROOVES:
J. Pleural carina
K. Lateral longitudinal carina of propodeum
L. Median longitudinal carina of propodeum
M. Anterior transverse carina of propodeum
(= basal transverse carina)
N. Posterior transverse carina of propodeum
(= anterior transverse carina)
O. Propodeal apophysis or crest
P. Costula [part of anterior transverse carina]
Metasoma

The apparent abdomen in apocritan (bees, ants, parasitoids) Hymenoptera, not including the morphological first segment which has transferred to the thorax as the propodeum.

Legend

1. Petiole
2. Postpetiole
3. Tergite 1
4. Sternite 1
5. Tergosternal suture
6. Ventrolateral carina
7. Dorsolateral carina
8. Median dorsal carina
9. Tergite 2
10. Thyridium
11. Glymma

Ovipositor

ICHNEUMONID OVIPOSITOR
APICAL REGION
End of Part II
Typical Morphology of Parasitic Hymenoptera
Part III
Classification of Parasitoids

Insect Classification

- All insects belong to class *Insecta* or *Hexapoda* (= six-legged organisms)
- Class Insecta has been divided into at least 30 orders on the basis of:
  - Structure of the wings and mouthparts
  - Type of metamorphosis (complete/incomplete metamorphosis)

The Code

- The modern *International Code of Zoological Nomenclature* (The Code) is a complex document
- *Priority* is the basic principle of zoological nomenclature
- *Applied* to taxonomic units (taxa) of animals known to occur in nature, extant or extinct, and the fossilized animals (ichnotaxa), and names proposed before 1931
- *Excluded* are names proposed for taxa above the *family group*; names proposed after 1930 for extant animals
International Code of Botanical Nomenclature

- ICBN was changed to “international Code of Nomenclature for Algae, Fungi, and Plants” at the XVIII International Botanical Congress (IBC) in Melbourne, Australia in July 2011
- The mycologists viewed that the word “Botanical” was misleading and could imply that the Code covered only green plants and excluded algae an fungi
- Also, from 1 January 2012 the description and/or diagnosis must be in either English or Latin. Before that it must be in Latin only, and electronic publication for new names is acceptable in addition to publication in printed matter

Carolus Linnaeus or Carl von Linné
(March 23, 1707 - June 16, 1778)
Swedish Botanist
Established the System of Binomial Nomenclature

Johann Christian Fabricius
(January 7, 1745 - March 3, 1808)
Danish Entomologist
Established the Basis for Modern Insect Classification
Insect Classification

- Insects were classified in > 30 orders and > 700 families, and > 800,000 species have been described and ??? remain to be described
- Some insect orders:
  - Collembola (springtails)
  - Thysanura (silverfish)
  - Odonata (dragonflies and damselflies)
  - Orthoptera (locusts and grasshoppers)

Insect Classification

- Some insect orders:
  - Phasmatodea (stick insects)
  - Mantophasmatodea* (mantos, rock crawlers, gladiators)
  - Dermaptera (earwigs)
  - Isoptera (termites, white ants)
  - Mantodea (mantids)
  - Blattodea (cockroaches)

Insect Classification

- Some insect orders:
  - Hemiptera (true bugs, cicadas, hoppers, psyllids, whiteflies, aphids, scale insects, mealybugs)
  - Thysanoptera (thrips)
  - Coleoptera (beetles)
  - Neuroptera (lacewings, antlions)
Insect Classification

- Some insect orders:
  - Hymenoptera (sawflies, parasitic wasps, chalcids, ichneumonids, ants, wasps, bees)
  - Lepidoptera (butterflies and moths)
  - Strepsiptera (stylops, twisted-winged parasites)
  - Diptera (true flies)

Insect Classification

- The newest order is *Mantophasmatodea* (gladiators, rock crawlers, mantos) erected in 2001, with a prehistoric specimen in amber from the Baltic region and live specimens from Namibia, South Africa (*Mantophasma* spp.). Changed to Notoptera in 2006?

Typical Insect Classification System

- Kingdom: Animalia
- Phylum: Arthropoda
- Class: Insecta or Hexapoda
- Order: (> 30 orders)
- Superfamily: (under each order)
- Family: (under each superfamily)
- Genus: xxxx
- Species: xxxxxx (sometimes followed by author name and year)
- Common name: xxxx xxxx
Typical Insect Classification System

- Kingdom: Animalia
- Phylum: Arthropoda
- Class: Insecta or Hexapoda
- Order: Diptera
- Superfamily: Muscoidea
- Family: Muscidae
- Genus: Musca
- Species: domesticus Linnaeus 1758
- Common name: house fly

Insect Orders with Parasitoids

- Most parasitoids attacking insects are in the following orders:
  - Hymenoptera (parasitic wasps, ants, wasps and bees) with >115,000 spp. (including phytophagous spp. in suborder Symphyta)
  - Diptera (true flies) with >150,000 species (including non-parasitoid flies)

Insect Orders with Parasitoids

- Some parasitoids are also found in:
  - Strepsiptera (stylops, or stylopids, or twisted-wing insects) with about 550 species; all stylops are parasitoids
  - Some genera in few families of Coleoptera (beetles) and Lepidoptera (butterflies and moths)
Strepsiptera

Male and female styllops and stylopidized wasp

Parasitic Coleoptera
Meloidae

Meloidae (blister beetles, Spanishflies)
Larvae undergo hypermetamorphosis
Adult beetles release cantharidine
causing blisters on the skin

Parasitic Coleoptera
Meloidae

Blister beetles and blister on the neck
Hypermorphosis

Life cycle of blister beetle with triungulin larvae

Parasitic Meloidid Beetle

Female bee with triungulin larvae on her back

Parasitic Coleoptera

Ripiphoridae

Ripiphoridae (Rhipiphoridae)
Endoparasitoids of bees, wasps and cockroaches
Parasitic Lepidoptera

Epipyropidae (planthopper parasite moth)
Ectoparasitoids of fulgorids and other hemipterous insects

Parasitic Diptera

- Dipterous families containing parasitoids:
  - Acroceridae - spider flies
  - Nemestrinidae - tangle-veined flies
  - Bombyliidae* - bee flies
  - Pipunculidae* - big-headed flies
  - Conopidae - thick-headed flies
  - Cryptochaetidae* - cryptochaetid flies
  - Tachinidae* - tachinid flies

Parasitic Diptera
Acroceridae

Common names: spider fly, hunchback fly, small-headed fly
All are parasitoids of spiders
Parasitic Diptera
Nemestrinidae

Common name: tangle-veined fly
Endoparasitoids of grasshoppers and scarab beetles

Parasitic Diptera
Bombyliidae

Common name: bee fly
Parasitoid of slug caterpillars, hymenopterous larvae, grasshopper egg pods

Parasitic Diptera
Pipunculidae

Common name: big-headed fly
Parasitized leafhopper and adults of big-headed fly
Parasitoids of Hemiptera
Parasitic Diptera
Conopidae

Common name: thick-headed fly
Endoparasitoids of adult bumble bees and wasps

Parasitic Diptera
Cryptochaetidae

Cryptochaetum iceryae
Parasitoid of cottony cushion scale, Icerya purchasi

Parasitic Diptera
Tachinidae

Common name: tachinid fly
Most important dipterous parasitoids
Parasitic Hymenoptera

- Suborder Symphyta - sawflies
  (phytophagous except parasitoid Orussidae on larvae of buprestids and wood wasps)
- Suborder Apocrita - wasps, ants, bees, and parasitoids
  - Division Parasitica > 36 families
  - Division Aculeata - wasps, ants, bees

Useful Reference

Interactive key and information retrieval using Intkey (Windows)

- Intkey is easy to use, and has many features that will help you make accurate identifications, including:
  - Illustrations and notes to help you understand the characters
  - Advice on the best characters to use
  - Automatic recovery from errors
  - Easy ways to confirm or reject an identification
  - Illustrations and descriptions of taxa
Parasitic Hymenoptera
Suborder Symphyta: Orussidae

Orussus coronatus  Orussus terminalis

Parasitic wood wasps
Parasitic on buprestids, wood-boring Coleoptera, and hymenopterous larvae

Parasitic Hymenoptera
Suborder Apocrita: Parasitica

- Eight superfamilies:
  - Trigonalyoidea
  - Evanioidea
  - Cynipoidea
  - Chalcidoidea*
  - Proctotrupoidea*
  - Ceraphronoidea
  - Stephanoidea
  - Ichneumonoidea*

Apocrita: Parasitica:
Trigonalyoidea

Trigonalidae (Trigonalycidae) (trigonid wasp) (1/1 family)
Eggs laid on leaves and consumed by the host, larvae developed as parasitoids of hymenopterans and tachinids
Apocrita: Parasitica:
Evanoidea

*Evania appendigaster* (cosmopolitan sp.)

Evaniidae (ensign wasp) (1/3 families)
Parasitoid of cockroach attacking egg pod or ootheca

Apocrita: Parasitica:
Cynipoidea

Families:
- Ibaliidae - initially endoparasitoid of wood wasps but later becomes ectoparasitoid
- Figitidae - parasitoids of neuropterous larvae
- Eucoilidae - endoparasitoid of dipterous larvae
- Cynipidae - mainly gall-forming wasps
- Charipidae - hyperparasitoids of aphid parasitoids (aphidiids, aphelinids)

Cynipoidea

*Fig. 1: Photographs of representative species of Cynipoidea.*

- Ibaliidae
- Figitidae
- Eucoilidae
- Cynipidae
- Charipidae
Apocrita: Parasitica: Chalcidoidea

- One of the most important group in applied biological control

Families (>20):
- Chalcididae*, Eurytomidae, Torymidae, Ormyridae, Eucharitidae, Perilampidae, Pteromalidae*, Eupelmidae, Encyrtidae*, Signiphoridae, Aphelinidae* Elasmidae, Eulophidae*, Trichogrammatidae*, Mymaridae*
Chalcidoidea

Eupelmidae

Chalcidoidea

Encyrtidae

Chalcidoidea

Aphelinidae
Chalcidoidea

Elasmidae

Chalcidoidea

Eulophidae

Chalcidoidea

Trichogrammatidae
Egg parasitoids of Lepidoptera, Hemiptera, Coleoptera, Thysanoptera, Hymenoptera, Diptera, Neuroptera
Chalcidoidea

Mymaridae
Egg parasitoids

Apocrita: Parasitica:
Proctotrupoidea

Families (>10):
- Proctotrupidae
- Diapriidae
- Scelionidae*
- Platygasteridae

Proctotrupoidea

Proctotrupidae
Proctotrupoidea

Diapriidae

Proctotrupoidea

Scelionidae

Proctotrupoidea

Platygasteridae
Apocrita: Parasitica: Ceraphronoidea

Families (2):
- Ceraphronidae
- Megaspilidae

Ceraphronoidea

Ceraphronidae

Ceraphronoidea

Megaspilidae
Apocrita: Parasitica: Ichneumonoidea

- Adult ichneumonids are larger than other parasitic Hymenoptera

Families (2):
- Ichneumonidae
- Braconidae
Parasitic Hymenoptera
Suborder Apocrita: Aculeata

- Chrysoidea (7):
  - Dryinidae
  - Bethylidae
  - Chrysididae

Apocrita: Aculeata:
Chrysoidea

Dryinidae

Chrysoidea

Bethylidae
Chrysoidea

Chrysididae
Cuckoo wasps

That is it.
An introductory classification of
the parasitoids!

End of Part III
Classification of Parasitoids
Part IV
Biology and Ecology of Parasitoids

Insect Orders with Parasitoids

- Parasitoids are common among wasps (order Hymenoptera), less common among true flies (order Diptera), and few in beetles (order Coleoptera), moths and butterflies (order Lepidoptera), and lacewings (order Neuroptera)
- There are > 65,000 spp. of parasitic wasps in order Hymenoptera alone which are parasitoids, and many spp. have not been described

Parasitic Hymenoptera

- The largest and most common parasitoids belong to:
  - Superfamily Ichneumonoidea (Ichneumonidae and Braconidae),
  - Followed by Chalcidoidea (Chalcididae, Pteromalidae, Encyrtidae, Aphelinidae, Eulophidae, Trichogrammatidae, Mymaridae), and Proctotrupoidea (Proctotrupidae, Scelionidae, Platygasteridae)
Parasitic Hymenoptera

- Ichneumonidae
- Braconidae
- Eulophidae
- Trichogrammatidae
- Scelionidae

Mechanism of Reproduction

- Fertilization:
- Once mated, female parasitic wasps can control fertilization of their eggs during oviposition.
- Thus they can regulate the numbers of males (1n) and females (2n) according to whether eggs are fertilized.
- Males develop from unfertilized eggs (1n); females from fertilized eggs (2n).
- Females have an elongated tubular ovipositor; in some parasitoids it is even longer than the body.

Sex Determination

- Female hymenopterous parasitoids possess spermatheca (sperm sac) functioning as a sex-regulating mechanism.
- Sex is determined during oviposition: 1n = male; 2n = female.
- Parthenogenesis is common and characteristic of the entire Hymenoptera.
Female & Male Reproductive Organs

Parthenogenesis

- *Parthenogenesis* [Greek: parthenos = virgin; genesis = descent]: Reproduction without fertilization.
- Parthenogenesis is common and characteristic of the entire Hymenoptera
- It can be:
  - *Thelytoky*: all female offspring
  - *Deuterotoky*: normally thelytokous but with few male offspring
  - *Arrhenotoky*: pathenogenetically (1n) = male; zygogenetically (2n) = female offspring

Preoviposition Period

- No general rule
- Some reach adult stage with a complete compliment of ripe eggs, deposit them in a brief period and develop no other eggs (*Proovigenic*)
- Most continue to produce eggs through the adult stage (*Synovigenic*)
### Ovisorption

- For synovigenic females, the ripe eggs if not deposited will be absorbed.
- Sequence of egg production:
  - Cyclic:
    - Ovigenesis → Ovisorption → Ovigenesis
  - Linear:
    - Ovigenesis → Ovulation → Ovisorption

### Manner and Place of Oviposition

- **Oviposition on the host**
- **Oviposition in the host**
- **Oviposition apart from the host**

### Metamorphosis

- All parasitic wasps undergo "Complete metamorphosis" or "Holometamorphosis":
  - Egg → Larva → Pupa → Adult
- Some undergo "Hypermetamorphosis"
Complete Metamorphosis or Holometamorphosis

Developmental Stages of an Encyrtid

Immature life stages of Diaphorencyrtus aligarhensis

Immature Stages of the Mymarid

Immature stages of Pseudococcus schachtii. A. the egg; B. Anemic larva; C. immature larva. (From Bull. 15029, A)
Immature Stages of the Mymarid

- Immature stages of the Mymarid
  - A: first instar of Polyommatus cedrophilus
  - B: second instar of Polyommatus cedrophilus
  - C: third instar of Polyommatus cedrophilus
  - D: fourth instar of Polyommatus cedrophilus

(From Rendle, 1960-1961)

Immature Stages of the Mymarid

- Larvae of the Mymarid
  - A: first instar of Polyommatus cedrophilus
  - B: second instar of Polyommatus cedrophilus
  - C: third instar of Polyommatus cedrophilus

(From Rendle, 1960)

Host-Parasitoid Relationships

- Parasitoids often develop on immature stages of host insects (eggs, larvae or pupae or nymphs) and occasionally and rarely adults

(From Rendle, 1960)
Host-Parasitoid Relationships

Parasitoids can be:
- *Idiobiont* parasitoids do not permit the host to grow beyond the stage attacked
- *Koinobiont* parasitoids allow their hosts to continue feeding and develop to the next stage

**Idiobiont Parasitoids**

- *Idiobiont* parasitoids do not permit the host to grow beyond the stage attacked
- According to types of hosts, they can be:
  - Egg parasitoids
  - Larval parasitoids
  - Pupal parasitoids
  - Nymphal parasitoids
  - Adult parasitoids

**Idiobiont Parasitoids**

- Egg parasitoid
- Larval parasitoid
- Pupal parasitoid
- Nymphal parasitoid
- Adult parasitoid
Nymphal Parasitoid of the Asian Citrus Psyllid, *Diaphorina citri*

*Diaphorencyrtus aligarhensis*
(Hymenoptera: Encyrtidae)

**Koniobiont Parasitoids**

- *Koinobiont* parasitoids allow their hosts to continue feeding and develop to the next stage

**Koniobiont Parasitoids**

- According to types of host stages, they can be:
  - Egg-larval parasitoids: oviposit in an egg stage but adults emerge from a larval stage
  - Egg-pupal parasitoids: oviposit in an egg stage but adults emerge from a pupal stage
  - Larval-pupal parasitoids: oviposit in a larval stage but adults emerge from a pupal stage
  - Nymphal-adult parasitoids: oviposit in a nymphal stage but adults emerge in an adult stage
Biological Behavior of Parasitoids

- Mode of action:
  - *Internal* or *endoparasitoids*: insert eggs into host and larvae and pupae develop internally to become adults
  - *External* or *ectoparasitoids*: lay eggs on the host and larvae and pupae develop externally to become adults

Endo- and Ecto-parasitoids

Endoparasitoids

Ectoparasitoids

Biological Behavior of Parasitoids

- In a particular food chain:
  - *Primary parasitoids*: Parasitoids of non-parasitoid host insects (herbivore host insects), *desirable* parasitoids
  - *Secondary parasitoids* or *Hyperparasitoids*: Parasitoids attacking other species of parasitoids, *undesirable* parasitoids
Parasitism

Parasitism can be *solitary* or *gregarious*

---

**Solitary Parasitism**

- *Solitary parasitism*: A parasitoid develops solitarily; one parasitoid larva utilizes an entire host to complete its development

---

**Gregarious Parasitism**

- *Gregarious parasitism*: Some parasitoids attack a host which is large enough to support the development of several larvae. It may be the result of:
  - Multiple eggs are laid on or in a single host individual, or
  - *Polyembryony*, a phenomenon of repeated division of a single egg into several larvae in a single host individual
Multiple Parasitism

- *Multiple parasitism*: The parasitism whereby a host receives eggs of *more than one parasitoid species*, i.e., when two or more species of parasitoids attack the same host individual.

Superparasitism

- *Superparasitism*: The parasitism when more eggs are deposited by *a single species* on or in a host.
- A host being attacked more than once by a single parasitoid individual (*self* superparasitism), or
- It may be the consequence of several parasitoids of the same species ovipositing on or in a single host (*conspecific* superparasitism).

Hyperparasitism

- *Hyperparasitism*: The parasitism when a parasitoid develops by feeding on other parasitoids.
- Most *hyperparasitoids* are *secondary* parasitoids, but *tertiary* and *quaternary* parasitism also occur facultatively.
Entomophagous Adults

- Adult parasitoids furnish morphological basis for taxonomy and identification of various groups of parasitoids.
- Adult female parasitoids are determinants of the efficiency of the species on:
  - Searching capacity
  - Host selection

Searching Capacity

- An effective parasitoid must have the ability to find hosts when the hosts are at low population densities.
- This ability is called "Searching capacity."
- Searching capacity depends on:
  - Its power of locomotion
  - Its power of perception of its host
  - Its power of survival
  - Its aggressiveness and persistence

Host Selection

- Behavioral sequence in host selection:
  - Ecological selection: Host habitat finding and host finding
  - Psychological selection: Host selection (host identification and discrimination) and host acceptance
  - Physiological selection: Host suitability
Phagocytosis

- *Phagocytosis*:
  - A cellular defense mechanism which destroys a small-sized microorganisms or foreign materials such as parasitoid eggs or larvae by the action of plasmatocytes (*phagocytes*)
  - The process by which parasitoid insect larvae inside are destroyed by their host

End of Part IV
Biology and Ecology of Parasitoids
Part V
Economic Importance of Parasitoids

Economic Overview of Hymenoptera

- The Hymenoptera, with more than 115,000 described species, includes as much as 10% of the species diversity of the planet
- Economically and ecologically, they are one of the most important groups of organisms
Economic Overview of Hymenoptera

- Various Hymenoptera are either:
- Severe economic pests threatening both the forest industry and agriculture (sawflies)
- Medical and noxious pests of urban landscapes (stinging wasps and ants)
- Pollinators (bees and others)

---

Economic Overview of Hymenoptera

- Defenders of our agricultural crops through their ability to parasitize and control pest insects (parasitic Apocrita)

---

Economic Role of Parasitoids

- Parasitoids, together with predators and pathogens, under natural condition are important natural enemies of insect pest of agriculture and forestry and insect vectors of medical and public health importance
- They are of high economic value but are not known nor recognized by man
- Their roles are not visible and their economic value is thus overlooked
Economic Role of Parasitoids

- Both parasitoids and predators have been used in biological control
- While pathogens (bacteria, fungi, viruses, protozoa and nematodes) have been used in microbial control

History of Biological Control

1200 - The weaver ant, Oecophylla smaragdina, was used to control litchi stink bug, Tessaratoma papillosa, in China

History of Biological Control

1602 - A braconid parasitoid Cotesia glomerata (= Apanteles glomeratus) was observed to parasitize cabbage butterfly larvae, Pieris rapae, in Europe
1883 - C. glomerata was shipped from UK to USA
The Legend of Vedalia Beetle

- In the 1880s citrus plantations in California was attacked by an insect invasive alien species (IAS) from Australia
- It was identified as the cottony cushion scale, *Icerya purchasi* (Hemiptera: Monophlebidae)

Cottony Cushion Scale

*Cottony cushion Scale, *Icerya purchasi*, an exotic destructive insect pest of citrus in California, USA in 1880s*

Management Strategy

- C.V. Riley, USDA entomologist in Washington, D.C., sent Albert Koebele to Los Angeles, CA and recruited D.W. Coquillett, a native of Illinois living in Anaheim, CA to help citrus growers control the cottony cushion scale
- Albert Koebele made an exploration for the natural enemies of *I. purchasi* in Australia (and New Zealand)
Exploratory Entomologist

Albert Koebele
(February 28, 1852 - December 28, 1924)

USDA Chief Entomologist

Charles Valentine Riley
(1843-1895)

Project Cost

- 1888 - The Vedalia beetle, *Rodolia cardinalis* (Coleoptera: Coccinellidae) [= *Vedalia cardinalis*) was shipped from Australia and New Zealand and released to control the cottony cushion scale, *Icerya purchasi*, in California, USA with fantastic success
- The cost of the project was about $1,500, equal to Koebele's salary for one year
- Enough fund was raised by the growers to present Albert Koebele with a gold watch, and Mrs. Koebele with a pair of diamond earrings
Rodolia cardinalis

Vedalia beetle

Introduced from Australia in 1888 to control the cottony cushion scale in California, USA with fantastic success!

A Mysterious Parasitic Fly

- In collaboration with Frazer Crawford, Australian entomologist, W.G. Klee, state entomologist in San Mateo was also able to obtain [sneaked in] a parasitic fly, Cryptochaetum iceryae (Diptera: Cryptochaetidae) from Australia in 1886 and released them in 1888 to control Icerya purchasi in San Mateo south of San Francisco, California, USA with success
- In California today the parasitic fly, C. iceryae, is more common on the cottony cushion scale, I. purchasi, than the vedalia beetle, R. cardinalis

Cryptochaetum iceryae

Cryptochaetum iceryae
Parasitoid of cottony cushion scale, Icerya purchasi
Banana skipper, *Pelopidas thrax*

Parasitoids from Thailand

- 1973 - A braconid parasitoid, *Cotesia (Apanteles) erionotae*, was introduced from Thailand to control the banana skipper, *Pelopidas (Erionota) thrax*, in Hawaii with success and additional introductions from Hawaii to Guam and Papua New Guinea, also with success
- Save banana industry in Hawaii, Guam, and Papua New Guinea (PNG)
- The project cost Thailand less than $1,000

Parasitoids of Banana Skipper

- Egg parasitoid *Ooencyrtus erionotae* (Encyrtidae)
- Larval parasitoid *Cotesia erionotae* (Braconidae)
Insect Orders with Parasitoids

- Most parasitoids are in Hymenoptera (all parasitic wasps)
- Diptera contains some parasitoids (pipunculids or big-headed flies, tachinid flies)
- All species of Strepsiptera are parasitoids (stylops or stylopids or twisted-wings insects)
- Few parasitoids are found in Coleoptera (blister beetles, rhipiphorids) and Lepidoptera (epipyropids or planthopper parasite moths)

Economic Importance of Hymenoptera

- Species of Hymenoptera make food for us, pollinate our crops, and destroy countless insect pests, and only a small proportion are crop pests
- Hymenoptera can be grouped as:
  - Pestiferous Hymenoptera
  - Beneficial Hymenoptera

Pestiferous Hymenoptera

- Pestiferous Hymenoptera are:
  - Forest and agricultural pests, e.g., sawflies, and wood wasps
  - Medical, public health and household pests, e.g., vespid wasps, hornets, bees, and ants)
Beneficial Hymenoptera

- Beneficial Hymenoptera are:
  - Pollinators, e.g., bees, bumble bees, fig wasps, etc.
  - Providers of commercial products, e.g., honey, bee pollens, royal jelly, bee wax
  - Predators of insect pests
  - Parasitoids of insect pests

Hymenoptera as Natural Enemies

- Both predatory and parasitic Hymenoptera are “Natural enemies” of most, if not all, insect species and insect pests in forestry and agriculture and insect vectors of medical importance
- They are widely utilized in “Biological control” of noxious insect species

Natural Enemies of Insect Pests

- Predators, Parasitoids and Pathogens are collectively known as “Natural enemies” of noxious insects and are colloquially called “3Ps”
- Under natural conditions they are responsible for “Natural control” of insect populations under the phenomenon of “Naturally-occurring biological control” or “Natural biological control”
Diversity of Insects on Earth

- Species composition of living organisms (after Strong, Lawton and Southwood, 1982. Insects on plants: Community patterns and mechanisms)
  - Green plants 308,000
  - Phytophagous insects 361,000
  - Saprophagous, predaceous & parasitic insects 431,000
  - Other invertebrates 213,000
  - Invertebrates 54,000
  - Protozoa 30,000
  - Total insects 792,000
  - Total 1,097,000

Diversity of Insects on Earth

- Of about 1 million insect species known, most are general and beneficial insects, predators and parasitoids, and few are pest species
- No more than 0.5% or 5,000 insect species are known to be noxious insect pests
- Commonwealth Agricultural Bureau Intl (CABI) in UK began compiling Distribution Maps of Plant Pests since 1951 to 2010 totaling 60 years, there are only 738 plant pest species from all over the world which are of economic importance
- The remaining is kept unharmed by natural enemies

Utilization of Natural Enemies

- Natural enemies are utilized as one of the pest control strategies called “Biological control”
- They are used for the suppression of the populations of insect pests to the harmless, non-damaging, and uneconomic levels
- Achievements in biological control of insect pests can be partial, substantial, or complete
What is Biological Control?

- Biological control is "The study and utilization of parasites, predators, and pathogens for the regulation of host population densities" (Paul DeBach, 1964)
- Fields of biological control are:
  - Basic study
  - Importation of natural enemies
  - Augmentation of natural enemies
  - Conservation of natural enemies
Biological Control Methods

- Biological control methods may be:
  - Naturally-occurring biological control, or
    - Natural biological control
  - Classical biological control
  - Augmentative biological control
  - Conservation biological control

Naturally-occurring Biological Control

- It is an on-going natural phenomenon in the regulation of insect populations brought about by both abiotic and biotic factors
- Abiotic factors are physical factors such as temperature, moisture and unfavorable climatic condition, etc.
- Biotic factors are mainly the predators, parasitoids and pathogens (3Ps) and other biological competitors, etc.

Classical Biological Control

- It is mainly used for controlling *invasive alien species* (IAS) or *exotic* pest species
- It is carried out by exploration and searching for effective natural enemies in the native habitat of the pests in foreign countries and *introducing or importing* them to control the IAS and/or exotic pests in the country where they become serious pests
Classical Biological Control

- Most parasitoids used in classical biological control involving importation or introduction are in the order Hymenoptera and, to a lesser degree, Diptera.
- The most frequently used groups are: Braconidae, Ichneumonidae, Eulophidae, Pteromalidae, Encyrtidae and Aphelinidae in the Hymenoptera; and Tachinidae in the Diptera.

Most Frequently Used Families (Hymenoptera)
- Braconidae
- Ichneumonidae
- Eulophidae
- Pteromalidae
- Encyrtidae
- Aphelinidae

Most Frequently Used Families (Diptera)

Trichopoda pennipes
(Diptera: Tachinidae)
Classical Biological Control

- Up to 2000, > 390 species in 194 genera of parasitoids have been used in classical biological control projects of > 2,740 species of insect pests in > 860 occasions worldwide resulting in > 215 effective control cases
- This is in addition to the use of predatory insects

Augmentative Biological Control

- It is the utilization of resident or native natural enemies to control the insect pest species
- It is undertaken by rearing natural enemies in large quantity and release them in the fields where there is no such natural enemies or where their populations are low and not adequate to control the pests
- Field releases can be inoculative or inundative depending on the number of natural enemies reared and available in the laboratories

Conservation Biological Control

- It is the manipulation of the environment to minimize any adverse environmental effects to suit certain needs of the natural enemies
- It is carried out in order to render them more suitable and conducive for the survival and persistence of the natural enemies
- Avoidance of using agrochemicals in the area is a good example
Other Biological Control Methods

- There are several other pest control methods claimed, misunderstood, and mistaken to be biological control methods because they are “non-chemical” and as such they are also “biocontrol” or “biological control”
- They are all “pseudo-biological control” and are not be classified as “true” biological control, but rather be classified as:
  - Para-biological control
  - “Me-too” biological control

Para-biological Control

- *Para-biological control* is “biological control” involving other methods which are non-chemical but are biologically-based such as:
  - Sterile insect technique (SIT)
  - Insect growth regulators (AGR)
  - Semiochemicals such as pheromone
  - Botanical insecticides such as pyrethrum
  - Resistant plant varieties
  - Genetically modified (GM) crops resistant to insects such as Bt cotton, Bt soybean and Bt corn

“Me-Too” Biological Control

- “Me-too” biological control is any “belief-based” not “science-based” non-chemical control strategy employed for insect pest control such as the uses of plant extracts, the so-called effective microorganisms (EM), plant and animal concoctions, etc.
- It may be considered “friendly”, “beneficial” and “green” to the environment because it avoids the use of synthetic and chemical insecticides
End of Part V
Economic Importance of Parasitoids
Part VI
Collecting and Preserving Parasitoids

Study of Hymenoptera

- General techniques in:
  - Collecting
  - Rearing
  - Preservation and storage
  - Individual experience

Insect Collecting

- One of the best ways to study insects is to go out and collect them, handling them, preparing and preserving the specimens, and collections
- You will develop much more interest in insects by collecting and handling them than by merely looking at pictures or preserved specimens
- Insects can be found practically everywhere and usually in considerable numbers
- The more kinds of places in which you look for them, the greater the variety you will be able to collect them
Collecting Equipment

- Insect net, killing jar
- Pillboxes, envelopes or paper for making envelopes, plastic boxes
- Vials, empty and filled with preservative
- Pocket knife, hand lens, magnifying glass
- Tweezers, forceps, camel-hair brushes
- Aspirators, sucking machines, vacuum machines
- Traps, yellow pan traps, light traps, etc

Collecting Parasitoids

- Collecting adult Hymenoptera:
  - Flying species
  - Non-flying species

Collecting Flying Species

- Sweeping for general collection and small species; smaller species can be removed by aspirator, the larger species transferred directly to alcohol
- Hand netting for large species; transfer to killing jar
- Trapping by yellow-pan trap or Malaise trap for large, general samples
Insect Sweep Nets

Aspirators and D-Vac Machine

Figure 1. Killing Jar
Collecting Flying Species

- Malaise trap is a tent-like structure, somewhat similar to a mosquito net; invented by Rene Malaise, Swedish entomologist and there are several designs
- Yellow-pan trap is a shallow tray painted bright yellow on the inside, black on the outside; laid on the ground surface, filled with water

Malaise Traps

René Edmond Malaise
Inventor of Malaise Trap

René Malaise (1892-1978)
René Malaise Who is she?
Malaise Traps

Yellow-pan Traps

Collecting Flying Species

- Others:
  - Light traps
  - Use of pyrethrum sprays
  - Pitfall traps for crawling insects
Light Traps

Pitfall Traps

Collecting Non-flying Species

- Collecting by hand, forceps, or aspirators
- Extracting specimens from various substrates using Berlese funnel invented by Antonio Berlese, Italian entomologist pioneering acarology (study of ticks and mites) as a scientific discipline
Berlese Funnels

Antonio Berlese (1863-1927)
Inventor of Berlese trap

Modified Berlese Funnel

Insect Rearing

- Rearing for biological study/adult specimens for identification
- Necessary data: Date and place of collection, habitat, host plant, stages of host insect
- When an adult emerges it should be allowed enough time to harden off before killing and emergence date noted
- Fore gregarious parasitoids, count brood size
- Specimens preserved with individual larval/pupal remains
Insect Rearing Cages & Containers

Rearing for Adult Specimens

- Adult specimens preserved with larval/pupal remains
- Host remain and cocoons are best preserved dry in gelatin capsules

Preservation and Storage

- Specimens collected in the field or reared are to be preserved prior to being prepared for examination or identification
- Freshly collected large specimens may be preserved dry or in 70-95% ethyl alcohol or mounted later if desired
- Small and minute specimens are preferably preserved wet in 70-95% ethyl alcohol and mounted on microscopic slides
Preservation and Storage

- To avoid damage, dry specimens are to be relaxed prior to mounting by leaving the specimens for 12-24 hrs in an airtight plastic box containing some cotton wool moistened with a few drops of water or glacial acetic acid.
- Specimens may be mounted by direct pinning, or indirect pinning, or card pointing, or card rectangles.

Pinning Insect Specimens

Figure 4. Placement of the pin.

Figure 5. Mounting wood insects.

Pinning Insect Specimens

Wrong
Correct
Wrong
Wrong
Wrong
Preservation and Storage

- Labeling
- Data labels should be reasonably small, neat and legible, and logically arranged

Specimen Labeling

Insect Mounting Media

- Canada Balsam: thick balsam is diluted with xylool (xylene)
  - A general permanent mounting medium for dehydrated whole specimens
  - Specimen must be dehydrated in alcohol/xylene series
- Hoyer’s Medium: Dissolve 30g of pulverized gum Arabic in 50ml of water; add 20ml glycerin; add and dissolve 12.5g of chloral hydrate; add 2g of iodine crystals; add 1g of potassium iodide; filter thru cotton wool
- PVA Medium (Bioquip)
  - Clearing and semipermanent medium for small arthropods, insect larvae, mites and spiders (substitute for Hoyer’s medium)
Insect Collections

End of Part VI
Collecting and Preserving Parasitoids

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- Kyay tzu tin-pa-te (Myanmar)
- Salamat po (Philippines)
- Xie xie (Singapore)
- Khob khun (Thailand)
- Ca’m on (Vietnam)

That’s All, Folks!
Predators

— Ireneo Lit
Identification of Major Groups of Predatory Insects

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Insect Orders that Include Predatory Species

- Coleoptera
- Dermaptera
- Hymenoptera
- Neuroptera
- Diptera
- Mantodea

- Beetles
- Earwigs
- Ants, bees, wasps
- Antlions, lacewings
- Predatory flies
- Preying/Praying mantises

Insect Orders that Include Predatory Species

- Hemiptera
- Orthoptera
- Odonata
- Lepidoptera
- Thyrsiptera
- Ephemeroptera
- Plecoptera

- Predatory bugs
- Predatory crickets, katydids
- Dragonflies, damselflies
- Pred. caterpillars
- Pred. thrips
- Mayfly naïads
- Stonefly nymphs
Other Predatory Arthropods
- Araneae
- Acari
- Chilopoda
- Scorpionida
- Cheloniorthida
- Uropygi
- Amblypygi

Order Coleoptera
Families of Predatory Beetles
- Coccinellidae
- Staphylinidae
- Carabidae
- Cionididae
- Lampyridae

Family Coccinellidae
- Common name: ladybird beetles
- Identification: body nearly spherical and convex, usually brightly colored, red, orange, yellow, with black markings.
Family Coccinellidae

- Common species: Cheilomenes sexmaculatus

Family Carabidae

- Common name: Ground beetles
- Identification:
  - Prominent mouthparts projecting forward
  - Forewing usually striate
  - Possess antennae cleaning organ on the fore tibiae

Family Cicindelidae

- Sometimes considered as subfamily within Carabidae
- Common name: Tiger beetles
- Identification:
  - Deflexed head with large labrum and large protruding eyes
  - Long slender legs
Family Cicindelidae

Family Staphylinidae
- Common name: rove beetles
- Identification:
  - Usually elongate, slender
  - Forewings short, leaving more than half of abdomen exposed

Family Staphylinidae
- Faederus sp.
Order Dermaptera

- Common name
  - Earwig
- Identification
  - Forceps-like cerci and short forewings

Order Dermaptera

- Includes the following predatory Families:
  - Forficulidae - common earwigs
  - Chelisochidae - brown or black earwigs
  - Labiduridae - longhorn earwigs, handsome earwigs
  - Labiidae - little earwigs
  - Pygidicranidae - large earwigs

Order Dermaptera

- [Image: Proceius simulans]
Order Hymenoptera - Families that Include Predatory species

- Formicidae
- Sphingidae
  (incl. subfamilies)
- Vespidae
  (incl. subfamilies)
- Scoliidae
- Pomphilidae
- Apidae

- Ants
- Thread-waisted wasps
- Vespid wasps, yellow-jackets
- Scoliids
- Spider wasps
- Bees (esp. some carpenter bees etc.)

Family Formicidae

- Common name
  - Ants
- Identification
  - With a node-like petiole (first abdominal segments)

Example: crazy ant - Anoplolepis gracilipes
Family Sphecidae

- **Common name**
  - Thread-waisted wasps
- **Identification**
  - Pronotum more or less freely articulating with mesothorax.
  - The abdomen is stalked at the base (Subfamily Sphecoidea).

Family Vespidae

- **Common name**
  - Vespid wasps, Yellowjackets, Hornets, Paper wasps
- **Identification**
  - Circular thorax
  - Forewing with longitudinal fold
  - Pronotum reaching tegula

Family Scoliidae

- **Common name**
  - Scoliid wasps
- **Identification**
  - Usually large bodied and densely haired for fossorial habit
  - Wings with numerous longitudinal wrinkles
Family Pompilidae

- Common name
  - Spider wasps
- Identification
  - Legs are long and slender, equipped with prominent tibial spur
  - Wing are not folded longitudinally when at rest

Order Neuroptera
Families with Predatory Species

- Chrysopidae- green lacewings
- Hemerobiidae- brown lacewings
- Myrmeleontidae- antlions
- Mantispidae- mantidflies

Family Chrysopidae

- Common name
  - Green lacewings
- Identification
  - Usually green and delicate lacewings and usually with clear wings
  - Their larvae cover themselves with debris
Family Myrmelontidae

- **Common name**
  - Ant lions

- **Identification**
  - Abdomen long and slender
  - Wings long, extending beyond abdomen when folded
  - Antennae short and thickened apically
  - Larvae are ground dwelling and some make pits to trap prey

Family Mantispidae

- **Common name**
  - Mantidflies

- **Identification**
  - Mantid-like lace wings with raptorial forelegs
  - Wings membranous, narrow and has a clear pterostigma

Order Diptera

- **Families of Predatory Flies**
  - Syrphidae
  - Dolichopodidae
  - Asilidae
  - Ceratopogonidae, Cecidomyiidae, Muscidae
Family Syrphidae

- **Common name**
  - Hover flies

- **Identification**
  - Most species have characteristic yellow markings on the body
  - Some mimic bees, muscoid flies and wasps

*Example:* *Fechnia scutellaris*

---

Family Dolichopodidae

- **Common name**
  - Long-legged flies

- **Identification**
  - Body usually metallic green, blue or coppery; slender in built
  - Antennae with long fine aristae

---

Family Dolichopodidae
Family Asilidae

- Common name: Robber flies
- Identification:
  - Head bristled (with "moustache")
  - Abdomen long, stout and tapering

Order Mantodea

- Common name: Praying mantis
- Identification:
  - Forelegs are raptorial with large movable coxa
  - The forewings modified into hard tegmina (leathery), some wingless
  - Antennae usually filiform

Order Mantodea

- Family: Phasmatidae
- Common name: Stick insects
- Identification:
  - Body covered with hard scales
  - Legs adapted for burrowing or climbing

Order Mantodea

- Family: Mantidae
- Common name: Mantises
- Identification:
  - Long slender body
  - Large compound eyes
  - Front legs modified for抓住 and killing prey

Order Mantodea

- Family: Tettigoniidae
- Common name: Grasshoppers
- Identification:
  - Large hind legs
  - Short antennae
  - Broad wing base

Order Mantodea

- Family: Romaleidae
- Common name: Summer cicadas
- Identification:
  - Large brown body
  - Short antennae
  - Broad wing base

Order Mantodea

- Family: Cercopidae
- Common name: Treehoppers
- Identification:
  - Small body
  - Short antennae
  - Broad wing base
Order Mantodea

Some Families

- Mantidae
- Hymenopodidae
- Amorphoscelidae
- Empusidae
- Erenniaphilidae
- Metallyctidae

Order Mantodea


Order Hemiptera

- Common name
  - True bugs (Suborder Heteroptera)
- Identification
  - With piercing-sucking mouthparts
  - Forewings partly membranous and partly thickened (Homelytra)
  - Prominent scutum
Order Hemiptera
Some Families of Predatory Bugs
- Reduviidae - Assassin bugs
- Miridae - Mirid bugs
- Lygaeidae - Lygaeid bugs
- Pentatomidae - Soldier bugs (esp. subfamily Asopinae)
- Corixidae - Water boatmen
- Anthocoridae - Flower bugs
- Belostomatidae - Waterbugs
- Nabidae

Order Odonata
- Common name
  - Damselflies and Dragonflies
- Identification
  - Large head connected to a flexible neck
  - Antennae minute and noodle like
  - Long slender abdomen
  - Pair of membranous wings are equal or subequal

Order Odonata
Suborder Zygoptera - Damselflies
- The pair of wings are similar in shape and venation
- Immobile (naiads) are usually slender and have 3 caudal gills

Suborder Anisoptera - Dragonflies
- The pair of wings have different shape and venation
- Naiads usually stout
Order Orthoptera
Families that Include Predatory Species

- Tettigoniidae – Katydid (esp. subfamily Listroscelinae)
- Grylidae – Crickets (esp. group of Metioche)

Order Lepidoptera
Families that Include Species with Predatory Larvae

- Lycaenidae – example: Malelinae, Spalaginae (mealybug predator Spalgis epius)
- Pyralidae – example: aphid predators Cryptoblabes aphidiavora, Thiaella sp.
- Tortricidae – example: some predators of giant scales

Other Predatory Arthropods

- Araneae
- Acari
- Chilopoda
- Scorpionida
- Chelonethida
- Uropygi
- Amblypygi

- Spiders
- Predatory mites
- Centipedes
- Scorpions
- Pseudoscorpions
- Whip scorpions
- Whip spiders
Class Arachnida
- Order Araneae
  - Spiders
- Identification
  - 4 pairs of legs
  - 2 major body regions: Cephalothorax and Abdomen

Order Araneae
Some Common Families
- Araneidae- Orb weavers
- Lycosidae- Wolf spiders
- Oxyopidae- Lynx spiders
- Salticidae- Jumping spiders
- Tetragnathidae- Long-jawed spiders
- Sparassidae- Huntsman spiders
- Ctenidae- Wandering spiders
- Theraphosidae- Tarantulas

Order Araneae
Class Arachnida

- Subclass Acari
  - Mites
- Identification
  - Body consists of a single segment along where the 4 pairs of legs and the mouthparts are attached

Subclass Acari
Some Common Predatory Families

- Phytoseiidae
- Cheyletidae
- Cunaxidae
- Ascoidea
- Bdellidae
- Trombiculidae

Class Chilopoda

Centipedes

- Scutigeridae
- Scolopendridae
- Geophilidae
Addenda
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<th>Name</th>
<th>Job title/Organization</th>
<th>Contact Details</th>
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<td>1</td>
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<td>Haji Shahrin</td>
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<td>Brunei Darussalam</td>
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EXTENDED TAXONOMIC CAPACITY BUILDING FOR SUSTAINABLE USE OF BIODIVERSITY: BRYOPHYTES, PTERIDOPHYTES AND ECONOMICALLY IMPORTANT INSECTS (PREDATORS & PARASITOIDS)

Haji Huda & Phonevilay

collections

6 x ORTHOPTERA
9 x HYMENOPTERA
3 x COLEOPTERA
4 x DIPTERA
11 x HEMiptera
1 x BLATTODEA
5 x ARANAEAE
4 x ODONATA
1 x MILLIPEDE

44 SPECIES
# Results of identification

**Predators and Parasitoids**

Mr. Anupap Tosuwan  
Ms. Khin Thuza Kyaw

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Place: QS8G  
Time: 9.00 – 11.00 AM, September 4, 2014  
Collector: Mr. Anupap Tosuwan & Ms. Khin Thuza Kyaw
Activity Report “Extended Taxonomic Capacity Building for Sustainable Use of Biociversity: Bryophytes, Pteridophytes and Economically Important Insects”
01-05, September 2014, QSBG, Chiang Mai, Thailand

Tanyalak Somboonchai - Thailand
Ben Golosino - Philippines

Activities include:

a. Lecture
b. Field Work/ Specimen Collection
c. Processing
Lecture:

- Mr. Carl Callangan - ACB taxonomy Information Management
- Dr. Banpot Napompeth - Taxonomy of Economically important Insects (Predators and Parasitoids)
- Dr. Ireneo Lit, Jr. - Identification of Major groups of Predatory Insects

b. Field Work/ Specimen Collection

- Materials:
  - Catching net
  - Vials (with 85% Ethyl Alcohol)
  - Folded Paper/plastic container
  - Killing jar
Method of Collection

- Swinging of net for flying insects
- Handpick
- Sucking

Processing

- Sorting/Identification
Mounting of Specimens

Labelling
Our group collected a total of 59 species belonging to 10 different orders such as:

- Hymenoptera: 21
- Odonata: 3
- Coleoptera: 4
- Lepidoptera: 2
- Diptera: 3
- Hemiptera: 8
- Spider: 14
- Mantodea: 1
- Orthoptera: 2
- Blattodea: 1
Output:

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Observations:

- In collecting, do not focus only to flying insects, some insects can be found in the branch, leaves, stem of the tree as well as in the ground;
- Not all insects needs to be dip in the alcohol like damselflies and butterflies;
- Identifying and handling of specimens may be more challenging than collecting
- Extra precaution is required in handling insects to avoid accident
Insects We Killed In The Name Of Science

Coleoptera
Hymenoptera

Hemiptera
Odonata

Zygoptera

Our Insects

Going To The 9.30pm Cabaret!!
Khop Khun Khrap
Capacity Building for Taxonomy of Economically Important Insects (Predators and Parasitoid)
Queen Sirikit Botanic Garden
Mae Rim, Chiang Mai, Thailand
September 1 – 5, 2014

Presentation of results of identification

GROUP Members
- Ma. Vivian Obligar-Soriano – Philippines
- Paula Jade L. Matias – Philippines
- Trang Quynh Troung - Vietnam
Field Collection

Malaise Trap & Pitfall Trap Demo
Laboratory processing and identification

Predatory Insects identification

Order Odonata: Family Zygoptera – Damselfly
Odonata - extremely large eyes (in proportion to its head) and a long, slender abdomen.
Order Odonata: Family Zygoptera - Damselfly
Predatory Insects identification

Order Odonata: Family Anisoptera - Dragonfly
Insects identification

Order Hemiptera: True bug
(with piercing sucking mouthparts & forewings partly membranous)

Insects identification

Order Diptera: True fly
(Known to have two wings although they only have one pair of functional wings. The second pair of wings are known as halteres)
Order Coleoptera: Beetle
(with hard wings that serve as protective covers for the membranous hind wings)

Order Hymenoptera: Cuckoo wasp
(have membranous wings and are joined together as one by the hamuli)
Order Hymenoptera: Ants

Order Araneae: Spiders
(with 2 pairs of body regions - cephalothorax & abdomen & 4 pairs of legs)
Order Phasmatodea: Stick Insect, not a predator insect (phasma=apparition/phantom); many species resembles sticks and insect making them extremely difficult to spot.

Preserve & mounted species

14 insects collected
7 orders of insects
Members

Salamat po!
MARUT & lily
Voodoo 101
DEDICATION!!!

~~ THANK you~~
INTRODUCTION

This field work is part of the ACB training program to provide hands-on experience in collecting and processing insect specimens, mainly predatory and parasitic insects for taxonomic work.

Objectives

1. To collect insect specimens and process them for preservation and taxonomic work;
2. To classify insect specimens up to Order level and categorize them accordingly to their habit (predatory or parasitic)
**METHOD**

Method:
- Active searching along the trail;
- Insects were caught by using sweep net, pooter & beating net;
- Insects collected were grouped accordingly to the order;
- Insect identification by referring to Training Notes and Lecturers; and
- Specimen were preserved into two ways: dry specimen (pinned) & wet specimen (85% ethanol)

**COLLECTION INFORMATION**

*Locality:* Queen Sirikit Botanical Garden (QSBG), Chiang Mai  
*Altitude:* 660m above sea level  
*Date:* 2014.09.04  
*Time:* 0830-0930; 1030-1130  
*Weather:* Cloudy, raining  
*Habitat:* garden, road site, bushes, small stream areas  
*Collected by:* Tan & Jeremy

**FINDINGS**

Insects collected on 4 September 2014 at QSBG

<table>
<thead>
<tr>
<th>No.</th>
<th>Order</th>
<th>Collected individuals</th>
<th>Specimen (individuals)</th>
<th>Habitat (individuals)</th>
<th>Predatory</th>
<th>Parasitoid</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hymenoptera</td>
<td>12</td>
<td>1</td>
<td>11</td>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>Diptera</td>
<td>9</td>
<td>2</td>
<td>7</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>Hemiptera</td>
<td>6</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>Odonata</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>Coleoptera</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>Lepidoptera</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>Dermaptera</td>
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<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>Neuroptera</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>Araneae</td>
<td>5</td>
<td>0</td>
<td>5</td>
<td>5</td>
<td>0</td>
</tr>
</tbody>
</table>

**Total**  
43  
16  
27  
32  
3
FINDINGS

Order HYMENOPTERA

- Formicidae
  - Predator
- Parasitoid
- Predator
- Vespidae
  - Predator

FINDINGS

Order DIPTERA

- Dolichopodidae
  - Predator
- Parasitoid
FINDINGS

Order HEMIPTERA  Order ODONATA

Reduviidae  Reduviidae  Anisoptera  Zygoptera
Predator    Predator    Predator    Predator

FINDINGS

Order COLEOPTERA  Order MANTODEA

Cicindelidae  Predator
Predator
FINDINGS

Order DERMAPTERA
Forficulidae
Predator

Order NEOROPTERA
Hemerobiidae
Predator

THANK YOU
Extended Taxonomic Capacity Building for Sustainable Use of Biodiversity: Economically Important Insects

Ms. KHIN MAR MYINT (MYANMAR) & Mr. HONG QUAN MAI (VIETNAM)

Collected Insect Specimens:
- Odonata: 6 SPM
- Lepidoptera: 6 SPM
- Hymenoptera: 3 SPM
- Hemiptera: 2 SPM
- Mantodea: 1 SPM
- Diptere: 1 SPM
- Mantodea: 6 specimens (SPM)
Introduction to the Key

- The key is adapted from and provides a first step towards identifying an insect specimen.
- However, due to the range of variation within many insect Orders, it is impossible to cover all contingencies and the key will not track down unusual and difficult species.
- For these we will need to consult a reference book of entomology or scan through the listing and descriptions of insect Orders on this site.

Insect Order Identification

- Hind legs long, modified for jumping
- Forewings hardened, leathery, spread in flight, covering membranous hindwings at rest
- Cerci (appendages at tip of abdomen) unsegmented
- Pronotum usually with large descending lobes on sides
- Hind coxae small and well-separated
- Hind tibiae with two dorsal rows of teeth
Hymenoptera

- Bees, wasps and ants; insects feared by many people because of their stings.
- However, these make up only a small proportion of the order. The Hymenoptera also includes Ichneumons and other parasitic "wasps" and Sawflies.
- Hymenoptera characteristically have two pairs of wings, a large fore pair and a smaller hind pair.
- These wings are held together by a series of hooks (called a frenulum) and may appear like a single pair to the naked eye.
- Hymenoptera also tend to have prominent antennae, generally with nine or more segments and biting mouthparts.

ODONATA

- Many characteristics distinguish Odonata from other groups of insects -
  - minute antennae, extremely large eyes, two pairs of transparent membranous wings with many small veins, a long slender abdomen
- While both dragonflies and damselflies belong to the Odonata and share many common features, then are a number of noticeable differences as well.
**ODONATA**

- Includes some of the most ancient and beautiful insects that ever roamed Earth, as well as some of the largest flying invertebrates ever to have lived.

- This order is very diverse with about 5000 species, and its members are easy to observe.

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**Classification of Order**

- Latin
- hemi (half)
- ptera (wings)

- **Morphological characteristics**
  - Mouthparts modified into beak which extends from the front of head.
  - Forewing with basal half thickened and leather-like; the apical half is membranous (hemelytron).
  - Wings, when at rest, held flat over body and overlap each other.
  - Some wingless.
LEPIDOPTERA

Kingdom - Animalia (Animals)
Phylum - Arthropoda (Arthropods)
Subphylum - Hexapoda (Hexapods)
Class - Insecta (Insects)
Order - Lepidoptera (Butterflies and Moths)

Order Lepidoptera: key features

- Holometabolous.
- Mouth forms a long tube suited to sucking nectar from flowers.
- When not in use, the tube is coiled in a spiral beneath the head.
- Wings: Two pairs of wings; membranous flight wings.
- The wings are covered with tiny colored scales, visible under a dissecting microscope.
- Without the microscope, the wings appear fuzzy or powdery.
- Antennae: Long. In many moths, the antennae are comb-shaped; in butterflies they are simple but have a bulb at the end.
THANKS FOR YOUR ATTENTION!
Taxonomic Capacity Building for Sustainable Use of Biodiversity: Predators and Parasitoids

Haji Shahrin (Brunei)
&
Ong Su Ping (Malaysia)

Methodology

- Sampling were conducted along forest trails and streams in QSBG from 8.30 am to 11.30 am
- Flying insects were collected using a sweep net while insects hidden among shrubs were collected using a beating net
- Spiders were collected from the ground using a pair of forceps
- Insects and spiders were preserved in tubes filled with 85% ethanol
- Dragonflies and damselflies were kept in envelopes and later placed into a killing jar
The specimens were sorted into Orders in the laboratory using the notes provided

Results

A total of 7 insect orders with 23 individuals were collected during the field trip.
Order Odonata

Suborder Anisoptera

1 species of dragonfly

Suborder Zygoptera

1 species of damselfly
Order Hymenoptera

6 species of ants

Order Hemiptera

2 species of true bugs
Order Coleoptera

1 species - tiger beetle

Order Orthoptera

2 species - grasshopper, cricket
Order Diptera and Order Araneae

- 2 species flies
- 6 species of spiders
- Preserved in ethanol

Thank you