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UNIVERSITI MALAYSIA SARAWAK
UNIMAS

# 3rd International Southeast Asian Bat Conference

## PROGRAMME & ABSTRACTS

**14-17th AUGUST 2015**

**GRAND MARGHERITA, KUCHING, SARAWAK**

Supported by: SEABCRU, SARAWAK CONVENTION BUREAU, NSF

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# The 3rd International Southeast Asian Bat Conference (SEABCO) 2015

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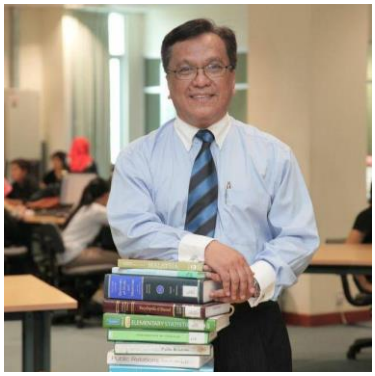
**MESSAGE FROM VICE CHANCELLOR**
**UNIVERSITI MALAYSIA SARAWAK**



Assalamualaikum, salam sejahtera and salam UNIMASku sayang to all participants of the 3rd International Southeast Asian Bat Conference 2015.

It gives me great pleasure to welcome you to the 3rd International Southeast Asian Bat Conference 2015. I thank the Organizing Committee for their commendable effort to bring together groups of talents from various fields of study on a mysterious creature, the bats. This conference is a remarkable to share their findings and expertise and hope that the exchange of ideas will lead to establishment of research and partnerships.

Malaysia, in particular Sarawak, the "Land of Hornbill", is endowed with rich biodiversity of flora and fauna. Borneo, as the third largest island in the world, is one of the world's twelve mega centres of biodiversity. The ecological significance and value of bats in Southeast Asia cannot be underestimated. Malaysia, in particular, is one of the world's most precious megadiverse countries. Unfortunately human activity has continued to inflict a dramatic and irreversible impact on the diverse ecosystem of the country and the region. Undeniably ecosystems change overtime, and changes are not always bad all the time, but quite rightly there has been growing concern about the breadth, depth and speed of change we are imposing on our surroundings. Universities play a crucial role in educating future generations about the importance of conservation and in ensuring that research has to continue to enable mankind to understand the nature and implications of human interventions on the global environment.

UNIMAS has developed research-extensive courses at undergraduate and postgraduate levels to address the challenges associated with wildlife management and monitoring in this region. We are fortunate in having been able to recruit outstanding experts in the areas of biodiversity and conservation management, taxonomy and systematics, evolutionary biology, ecology and ecosystem services, and conservation biology.

On a final note, I trust that the three-day interactions at the conference will witness an abundance of idea and knowledge dissemination, contributing to a better understanding on bats. Thank you for participating in the conference, and to advance the knowledge about bats.

**YBHG PROF DATO' DR MOHAMAD KADIM BIN SUAIDI**

**MESSAGE FROM THE DEAN**
**FACULTY OF RESOURCE SCIENCE AND TECNOLOGY, UNIMAS**

Assalamualaikum Wrh. Wbt. and salam sejahtera

I would like to express my warmest welcome and gratitude to all participants of the 3rd International Southeast Asian Bat Conference (SEABCO) 2015.

It all started when the first International Southeast Asian Bat Conference (SEABCO) was held in Phuket, Thailand (2007) and four years later in Bogor, Java (2011). Upon the success of these conferences, now the third SEABCO will be held in Grand Margherita Hotel, Kuching from 14th to 17th August 2015 and proudly hosted by Universiti Malaysia Sarawak (UNIMAS). Bats make a substantial contribution to the Southeast Asia biodiversity, comprising about 30% of mammal regions. Sadly, many bat species around Southeast Asia are vulnerable or endangered due to factors ranging from loss and fragmentation of habitat, diminished food supply, destruction of roosts, disease and hunting or killing of bats. Lack of knowledge is recognized as one of the major threats to the conservation of bats. Thus, SEABCO aspires to engage all the people interested in bat research and conservation to collaborate and evaluate knowledge gaps for bat conservation in the Southeast Asia, together identify several priority areas where new research is needed.

The conference will emphasise on different areas of bat research such as taxonomy and systematics, ecology and ecosystem services, evolutionary biology and zoonotic diseases. I appreciate your presence here in the conference and I am sure that we will be able to share current knowledge during the presentation and discussion, to better understand on the ecological and economic importance of bats in Southeast Asia, and to devise proper conservation plan for better future of bats. I am convinced that this 3rd International SEABCO is a good platform, as proven by the previous two conferences, for international and local researchers, conservation biologists, environmental academicians, and students to present their finding and ideas on bats research and conservation in Southeast Asia.

I take this opportunity to wish all participants enjoyable time and stay here in Kuching.

**ASSOCIATE PROFESSOR DR OTHMAN BOJO**

## MESSAGE FROM THE CHAIRMAN OF THE 3RD SEABCO ORGANIZING COMMITTEE, UNIMAS

Welcome to Kuching, Sarawak, we are happy to have all of you here, the Land of Hornbills. On behalf of the organizing committee, I would like extend our warm welcome to our invited guests, invited speakers and all the participants of 3rd International Southeast Asian Bat Conference 2015.

Historically, the first Southeast Asian Bats Conference was held at Phuket, Thailand in May 2007. A total of 125 participants joined the meeting. The second meeting was held at Bogor, Indonesia in June 2011 where a total of 88 participants joined the meeting. This every four years event has generate a lot of interest among researcher who work on bats especially in Southeast Asia to join the meeting and learned about what others working on the region. This year, the 3rd International Bats Conference 2015 (SEABCO2015) is held in Kuching Sarawak, and the Faculty of Resource Science and Technology (FRST), Universiti Malaysia Sarawak (UNIMAS) has taken the lead to host the meeting that is attended by 110 participants.

Broadly, we have four main agendas that we wish to accomplish during the conference: 1) To foster collaboration between researchers in Malaysia with researchers from countries in the region; 2) To provide a platform for researchers to exchange ideas thus form a network of research in the field of small mammals, especially bats; 3) To enable researchers and stakeholders to share/exchange information and experience to better implement conservation plans, and 4) To discuss the future direction of bat scientific research so that it is current, standardised across region and remain relevant.

On behalf of SEABCO2015 secretariat, I would like to thank the Vice-chancellor of UNIMAS and the Dean of FRST for their continuous support and encouragement. Not to forget, the continuous support from all the agencies in Malaysia that regulates biodiversity in Malaysia especially Sarawak Forestry Department (SFD), Sarawak Forestry Corporation (SFC), and Sarawak Biodiversity Council that work closely with UNIMAS on Biodiversity. We also thank our supporters and major funding agencies including UNIMAS, Southeast Asia Bats Conservation Research Unit (SEABCRU), National Science Foundation (NSF), Texas Tech University (TTU) and Sarawak Convention Bureau (SCB) for their advice and

support. I also would like to thank our sponsors and vendors who kindly participated and fund our meeting.

Last but not least, I would like to extend my appreciation to the organizing committee, support staff and students for their help, dedication and hard work to make this event a successful one. Hopefully this conference will create a good impact on all of us and I look forward to meet all of you again in the next meeting, four years from now.

*Keep supporting SEABCO to better manage our fascinating* **BATS!**

Thank you.

**DR FAISAL ALI ANWARALI KHAN**
**DEPARTMENT OF ZOOLOGY, FACULTY OF RESOURCES SCIENCE AND TECHNOLOGY, UNIMAS**
**SEABCRU STEERING COMMITTEE**

**MESSAGE FROM THE DIRECTOR OF THE SOUTHEAST ASIAN BAT CONSERVATION RESEARCH UNIT (SEABCRU)**

Ladies and gentlemen, it gives me great pleasure on behalf of the Southeast Asian Bat Conservation Research Unit (SEABCRU) to welcome you to SEABCO 2015, the 3rd International Southeast Asian Bat. I would like to begin with a heartfelt thank you to the UNIMAS organizing committee for hosting and organizing this exciting event.

The 1st International Southeast Asian Bat Conference grew out of discussions among bat researchers at the Southeast Asia Mammal Databank (SAMD) meetings in 2004 and 2005 which were part of the Global Mammal Assessment. At these meetings, several of us realized that bat research in SE Asia was on the cusp – there were several active researchers scattered across the region, but few were aware of each other's activities. What we needed was a conference! A chance to see what everyone was up to, to network, and encourage the expansion of bat research. So was born the 1st conference, hosted by the Prince of Songkla University, in Phuket, Thailand in 2007. The conference was a great success with over 120 participants from some 22 countries.

At the same time, we recognized the need for a regional network to connect researchers more regularly, grow in-country capacity and identify research directions that could support the conservation of the SE Asia's imperiled bat fauna. The SEABCRU was established in response to this need, supported by British American Tobacco (BAT) through Earthwatch Institute, and launched at the first conference in Thailand. During the conference, nearly 80 researchers came together in a workshop to identify the regional conservation research priorities that were to shape the SEABCRU activities for the coming ten years, with efforts focused on the conservation of flying foxes, cave-dependent bats, forest-dependent bats and taxonomy and systematics.

In 2011 the SEABCRU received support from the National Science Foundation of the USA to elevate the network with training activities centered on the four priorities, and to put together a regional database of bat localities. We began this new phase with the 2nd International Southeast Asian Bat Conference organized and hosted by the Indonesian Institute of Sciences (LIPI) in Bogor, Indonesia in 2011, which was another great success.

SEABCO 2015 is the third conference in our series, and presents many very exciting opportunities. First, it provides a wonderful chance to see how bat research has progressed over the 12 years since the first conference. Much of this research aligns with the SEABCRU research conservation priorities and is a great pleasure to see. Second, the conference affords an opportunity for the SEABCRU committee to report to our broader membership on activities of the past four years, present the SEABCRU protocols and guidelines developed, and to officially launch the SEABCRU database. Third, and just as importantly, we can meet together as we did in 2007 and discuss new priorities and directions to guide our research community through the next ten years. Embedded within the conference are workshops and forums and I cannot emphasize enough that these are **open to everyone.** Although guided by a steering committee, the SEABCRU is a network for all bat researchers in Southeast Asia.

Let me close by wishing you all a wonderful and productive conference and thanking you for your participation.

**DR TIGGA KINGSTON**
**TEXAS TECH UNIVERSITY**

# The 3rd International Southeast Asian Bat Conference (SEABCO) 2015

## Contents

# The 3rd International Southeast Asian Bat Conference (SEABCO) 2015

## Opening Ceremony

14 August, 2015 (Friday)
Asajaya Hall, 1st Floor, Grand Margherita Hotel, Kuching

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|---|---|
| 0830 | Arrival of invited guest |
| 0845 | Arrival of YBhg Prof Dato' Dr. Mohamad Kadim bin Suaidi,<br>Vice Chancellor of UNIMAS |
| 0850 | Arrival of YBhg Datu Dr. Hatta bin Solhi,<br>Chairman of the Board of Directors, UNIMAS |
| 0855 | Arrival of YB Datu Haji Len Talif Salleh,<br>Assistant Minister of Environment (Ministry of Resource Planning and Environment) and Assistant Minister at Chief Ministers Office (Promotion of Technical Education) |
| 0900 | National anthem |
| | Prayer recitation |
| | Conference address by Associate Professor Dr. Tigga Kingston,<br>Director of Southeast Asian Bat Conservation Research Unit |
| | Welcoming address by YBhg Prof Dato' Dr Mohamad Kadim bin Suaidi,<br>Vice Chancellor of UNIMAS |
| | Speech and opening ceremony by Chief Minister of Sarawak<br>YAB Datuk Patinggi Tan Sri (Dr) Haji Adenan bin Haji Satem,<br>represented by YB Datu Haji Len Talif Salleh, Assistant Minister of Environment (Ministry of Resource Planning and Environment) and Assistant Minister at Chief Ministers Office (Promotion of Technical Education) |
| | Presentation of souvenir |
| | End of opening ceremony |
| 1100 | Refreshment |

# The 3rd International Southeast Asian Bat Conference (SEABCO) 2015 Programme

## Venue: Asajaya Hall, 1st Floor, Grand Margherita Hotel, Kuching

| DAY 1: 14 August 2015 (Friday) | | |
|---|---|---|
| 0900 | **Official Opening Ceremony of 3rd International Southeast Asian Bat Conference (SEABCO 2015) by YB Datu Haji Len Talif Salleh, Assistant Minister of Environment (Ministry of Resource Planning and Environment) and Assistant Minister at Chief Ministers Office (Promotion of Technical Education)** | |
| 1100 | **Friday prayer/lunch/Press Conference** | |
| **Session 1: Community ecology and land use change<br>Chairperson: Dr. Dave Waldien** | | |
| 1430 | **Plenary Title: Role of Academic Institution in Bat Research in Malaysia**<br><br>Plenary Speaker **Prof. Dato' Dr. Mohd Tajuddin Abdullah** | |
| 1500 | **SEABCRU Priority: Forest bats – Spatial planning for the effects of climate and land-cover change on Borneo's bats and other mammals**<br><br>Invited Speaker **Dr. Mathew Struebig** | |
| 1520 | Joe Chun-Chia Huang | Understory Insectivorous Bats as Ecological Indicators of Vegetation Complexity in a Coffee-Forest Landscape of Sumatra |
| 1535 | Jimmy Lee | Bat Diversity Survey at Lower Kinabatangan River Valley Along a Disturbance Gradient |
| 1550 | M. Mathivanan | Bats in Ancient Temples: Influence of Micro Habitats and Landscape Features on Bat Occupancy and Abundance |
| 1605 | Jodi L. Sedlock | Bat Assemblages in Philippine Rice Fields |
| 1620 | Dai Fukui | Regional Patterns of Bat Community Assembly in the Japanese Archipelago |
| 1635 | Azuan Roslan | Ecomorphology, Verticle Segregation and Habitat Use of Bats in Kenyir Rainforest and Setiu Wetland |
| 1650 | Juliana Senawi | Beyond Wing Parameters – Body Mass Controls Flight Maneuverability in Malaysian Insectivorous Bats |
| 1705 | Benjamin Lee | The Effects of Major Roads on Bats in Singapore |
| 1720 | **Refreshment/Poster Session** | |

| DAY 2: 15 August 2015 (Saturday) | | |
|---|---|---|
| **Session 2: Bat-plant interactions and flying fox conservation<br>Chairperson: Dr. Vu Dinh Thong** | | |
| 0830 | **SEABCRU Priority: Flying Foxes – Ecosystem sevices and human-bat interactions**<br>Invited Speaker | **Dr. Sara Bumrungsri** |
| 0850 | Nor Zalipah Mohamed | Bat Pollination in Mangrove Habitats of Peninsular Malaysia |
| 0905 | Tuanjit Sritongchuay | Bat Roles in Pollination Network in Mixed Fruit Orchards, Southern Thailand |
| 0920 | Sheema Abdul Aziz | Is the Island Flying Fox in the Service of the King of Fruits? Camera-Trapping Reveals Further Clues About Durian Pollination Ecology |
| 0935 | **Coffeebreak/Poster Session** | |
| 1015 | Ibnu Maryanto | The Flower Visited by Fruit Bats at Lore Lindu National Park, Sulawesi, Indonesia |
| 1030 | Hoem Thavry | Diet of the Cave Nectar Bat *Eonycteris spelaea* in Cambodia |
| 1045 | Sheherazade Jayadi | The Role of Fruit Bats in Plant Community Changes in an Urban Forest in West Java, Indonesia |
| 1100 | Hul Vibol | Population Dynamics and Diet of Lyle's Flying Fox (*Pteropus lylei*) in Cambodia |
| 1115 | Tammy L. Mildenstein | Local People Count: Using Citizen Scientists to Monitor Flying Fox Populations |
| 1130 | Lisa J. Paguntalan | Conservation Status of the Palawan Flying Fox *Acerodon leucotis* in Calamian Group of Islands, Philippines |
| 1145 | Rajlakshmi Mishra | Status of Indian Flying Fox, *Pteropus giganteus*, Brunnich, 1782 in National Capital Territory of Delhi, India |
| 1200 | Marites Gatan-Balbas | Filipinos for Flying Foxes: Protecting the Last Roost Sites of Giant Fruit Bats in Northeast Luzon, Philippines |
| 1215 | Philip Godfrey C. Jakosalem | Creating Conservation Reserves for Philippine Flying foxes: Considerations and Implications |
| 1230 | **Lunch Break** | |
| 1400 | **Workshop for participants<br>Coordinator: Dr. Tigga Kingston** | |
| 1530 | **Refreshment/Poster Session** | |
| 1600 | **Fieldwork/Leave to Bau**<br>Coordinator: Ms. NurSyafiqah Shazali | |

| DAY 3: 16 August 2015 (Sunday) | | |
|---|---|---|
| **Session 3: Taxonomy, phylogeography, speciation and evolution**<br>**Chairperson: Dr. Juliana Senawi** | | |
| 0830 | **SEABCRU Priority: Taxonomy – Toward the Future of Southeast Asian Bat Taxonomy**<br>Invited Speaker **Dr. Pipat Soisook** | |
| 0850 | Faisal Ali Anwarali Khan | Species Delimitation and Biogeography of Southeast Asian *Hipposideros* |
| 0905 | Sultana Parvin Habeebur Rahman | Exploring Genetic and Echolocation Call Variations Within *Hipposideros galeritus* Species Complex (Cantor's Roundleaf bat) |
| 0920 | Nurul Farah Diyana Ahmad Tahir | Molecular Phylogeny of Rhinolophid Bats From Malaysia Based on Mitochondrial DNA (Cytochrome Oxidase I and Cytochrome b) |
| 0935 | **Coffeebreak/Poster Session** | |
| 1015 | Jayaraj Vijaya Kumaran | Phylogenetics and Taxonomy of Nectar Bats (Genus: *Macroglossus* spp.) in Malaysia |
| 1030 | Susan M. Tsang | Dispersal is a Significant Biogeographic Mechanism in *Pteropus* in the Indo-Australian Archipelago |
| 1045 | Vu Dinh Thong | Taxonomy of Flying Foxes and Free-Tailed Bats (Mammalia: Chiroptera) with an Investigation into Ecology of *Pteropus lylei* in Vietnam |
| 1100 | Rohit Chakravarty | Gene Flow in Species of Bats Differing in Ecology and Morphology: A Comparative Study from the Andaman Islands |
| 1115 | Stephen J Rossiter | A test of Non-Allopatric Divergence in Putative Island Endemic Sister Bat Species – A Case of Taiwanese *Murina* |
| 1130 | Kyle Armstrong | Genome-Wide SNP-Based Next Generation DNA Sequencing and 3D Geometric Morphometrics Helps to Resolve Long Standing Issues in Bat Taxonomy |
| 1145 | Isham Azhar | Host Specificity of Bat Flies (Diptera: Nycteribiidae and Streblidae) in Malaysia |
| 1200 | Majorie May Dixon | Convergence in eavesdropping behavior? Responses to frog mating calls by Old and New World bats |
| 1215 | Anna Nele Herdina | Correlative 3D Imaging of Bat Genital Micromorphology |
| 1230 | **Lunch Break** | |
| **Session 4: Cave-bat ecology and conservation**<br>**Chairperson: Dr. Jodi Sedlock** | | |
| 1400 | **SEABCRU Priority- Cave Bats - Can Wing Morphology Inform Conservation Priorities for Southeast Asian Cave Bats?**<br>Invited Speaker **Dr. Neil Furey** | |

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|---|---|---|
| 1420 | Krizler C. Tanalgo | Bat Cave Vulnerability Index (BCVI): A Tool for Equating Bat Caves for Conservation Prioritization and Protection |
| 1435 | Kendra L. Phelps | Prioritizing Caves to Conserve Bats: Identifying Factors that Influence Cave Use |
| 1450 | Nursyafiqah Shazali | Application of LiDAR Technology to Count Cave-Dwelling Bats Roost in Wind Cave Nature Reserve, Malaysian Borneo |
| 1505 | Teong Han Chew | Cataloguing Malaysian Caves using LiDAR: Bats Included |
| 1520 | Moe Moe Aung | Review of Bats of the Limestone Karst of Northern Chin State, Myanmar |
| 1535 | Lim Thona | Cave Selection and Reproductive Phenology of Insectivorous Bats in Southern Cambodian Karst and Their Conservation Implications |
| 1550 | **Refreshment/Poster Session** | |
| 1630 | **Group Workshop I: SEABCRU Database and Research Priority Setting**<br>**Coordinator: Dr. Tigga Kingston**<br>**Workshop is for ALL conference attendants** | |
| 1930 | **Dinner**<br>**Venue: Pelagus Room, 2nd Floor, Grand Margherita Hotel, Kuching** | |

| **DAY 4: 17 August 2015 (Monday)** | | |
|---|---|---|
| **Session 5: Integrated frameworks -disease, diet and ecology**<br>**Chairperson: Mr. Chun Chia Huang** | | |
| 0830 | **SEABCRU Priority: Disease Surveillance – Bat Viral Ecology in 2015: Moving From Pathogen Discovery to a More Integrated Ecological Framework**<br>Invited Speaker **Dr. Kelvin Olival** | |
| 0850 | Mei Ho Lee | Bat Viral Diversity in Different Anthropogenic Disturbance Gradients in Kinabatangan, Sabah, Malaysia |
| 0905 | Jessica L. Gamolo | Hematological Profile of Bats in Musuan, Bukidnon, Philippines |
| 0920 | Heidi C. Porquis | Blood Serum Glucose and Potassium Profiles of Frugivorous Bats (*Ptenochirus jagori* Peters) in Central Mindanao University, Bukidnon Philippines |
| 0935 | **Coffeebreak/Poster Session** | |
| 1015 | Nurul-Ain Elias | What`s On the Menu for Hungry Mums? Food Availability for Malaysian Insectivorous Bats |
| 1030 | Jin Sia Ting | Food habits of *Rhinolophus affinis, Emballonura monticola* and *Hipposiderus diadema* Roosting in an Agricultural Landscape at Kota Gelanggi, Malaysia |

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|---|---|---|
| 1045 | Nur Atiqah Abd Rahman | Comparison of Food Habits of the Lesser Asiatic Yellow Bat (*Scotophilus kuhlii*) in an Agricultural and Urban Landscape |
| 1100 | Roger Coles | Observations on the Ecology, Echolocation & Foraging Behaviour of the Emballonurid Bat, *Saccolaimus saccolaimus*, in Australia & Southeast Asia |
| 1115 | Swapnil Girade | Echolocation Calls and Diet Analysis of Michrochiropteran Species From Northern Western Ghats of Maharashtra |
| 1130 | Lee-Sim Lim | Roost Selection by Bats in the Anthropogenic Areas Along the West Coast of Peninsular Malaysia |
| 1145 | T. Ulmar Grafe | How a Pitcher Plant Facilitates Roosting of Mutualistic Woolly Bats (*Kerivoula hardwickii*) |
| | **Session 6: Acoustic techniques**<br>**Chairperson: Mr Benjamin Lee** | |
| 1200 | David A. Hill | Acoustic Lure Enhances Capture Rates of Echolocating Bats in Forest and Open Habitats in Australasia |
| 1215 | Ellen McArthur | Quantifying Bat Activity through Acoustic Sampling in a Riverine Forest at Gunung Mulu National Park, Malaysian Borneo |
| 1230 | **Lunch Break** | |
| | **Session 7: Bat conservation on the ground and on the map**<br>**Chairperson: Dr. Nina Ingle** | |
| 1415 | **Plenary Title:**<br>Plenary Speaker | **Conservation of Bats in Malaysia**<br>**Dr. Melvin Gumal** |
| 1445 | Md Nurul Islam | Operationalizing Bat Conservation Education Program in Bangladesh With a Special Focus of Nipah Encephalitis Outbreak |
| 1500 | D. Pilot Dovih | An Assessment Conservation Status of Bats in India and the Impacts of Bats on Public Health |
| 1515 | Rahul Prabhukhanolkar | Batting Trekkers – A Unique Citizen Science Initiative Documenting Bat Diversity and Roosts in Maharashtra, India |
| 1530 | Wing Chi Tsui | Ten Years at A Glance - An Overview of Bat Conservation in Hong Kong |
| 1545 | Marina Fisher-Phelps | Analysis of Spatial Clustering in Southeast Asian Bat Sampling Effort |
| 1600 | **Group Workshop II: SEABCRU Database and Research Priority Setting**<br>**Coordinator: Dr. Tigga Kingston**<br>**Workshop is for ALL conference attendants** | |
| 1630 | **Student Award Ceremoy/Closing Remark/Action Plan by Head of the group/UNIMAS/SEABCRU** | |
| 1700 | **Refreshment** | |

# Biography of Plenary Speakers

**Professor Dato' Dr. Mohd Tajuddin Abdullah** is from the Universiti Malaysia Terengganu where he is now the Director at Centre for Kenyir Ecosystems Research. As a pioneer zoologist and founding head of the Department of Zoology in UNIMAS from 1994 to 2013, he has successfully established UNIMAS mammalian research program. His research interest is on the fields of ecology, biodiversity, biogeography, evolution and protected area management. Some of his studies with postgraduate students have redefined the morphological species and genetic species within cryptic populations. Previously, between 1977 and 1993, he was leading a unit on research and management of the endangered Sumatran rhinoceros at the Department of Wildlife and National Parks, Kuala Lumpur and was a director of the Zoo Melaka in Malaysia. Internationally, he also serves as the member of the International Union for the Conservation of Nature and Natural Resources (IUCN), Species Survival Commission (SSC), Asian Rhinos Specialist Group and the World Commission on Protected Areas (WCPA). Base on this contribution, Prof. Tajuddin was elected and inducted as Fellow in the Academy of Science Malaysia on the 8 June 2013. In 2015 he is being invited as lead author for the Intergovernmental Panel on Biodiversity and Ecosystem Services. Now he is actively working on the establishment of Kenyir Geopark, research on canopy biology and sustainable livelihood of Orang Asli.

**Dr. Melvin Gumal** worked on flying foxes in Sarawak for his PhD. After successfully completing his studies, together with colleagues from Sarawak Forest Department, his PhD flying fox study site as well as other maternity roost sites recommended in his study has been made protected areas or is currently proposed for protection. Melvin is the Wildlife Conservation Society (WCS), Program Director for Malaysia. As the program director he also initiated other programmes and these are on orang-utans, tigers and elephants and apart from biological research, the work engages with locals and this includes conservation education and developing alternative livelihood sources. Noting his excellent work to conserve orang-utans in Sarawak, Dr. Melvin Gumal has been honoured with a 2014 Whitley Award. He is one of eight individuals to be awarded the prestigious international conservation prize.

**Dr. Lim Boo Liat** started his career as a lab assistant at the Institute of Medical Research (IMR) post World War II (WW II) in 1947. Later, based on his vast experience he was offered a Medical Research Council Fellowship (London) to pursue a Master of Science (MSc.) degree at the University of Aberdeen, Scotland without having a formal Bachelor (BSc.) degree. Dr. Lim obtained his PhD (Zoology) from Universiti Sains Malaysia in 1977. Since 1953 to date, he has authored 302 scientific papers on small animals, reptile and amphibian ecology, rodent control and bio-medical studies (zoonotic diseases) associated with terrestrial vertebrates and helminth parasitology in many national and international journals. He is currently an Honorary Advisor on Zoology for the Department of Wildlife and National Park (DWNP). In 2013, he was one of the Merdeka Award recipients for his contribution to the environment especially in the conservation of Malaysia biodiversity through scientific studies.

# ABSTRACTS OF

# INVITED SPEAKERS

# PRESENTATION

## Opening Session

# The Southeast Asian Bat Conservation Research Unit: A network approach to regional bat conservation

Tigga Kingston

Department of Biological Sciences, Texas Tech University, Lubbock, USA;
Corresponding author: tigga.kingston@ttu.edu

Regional networks provide for robust and resilient conservation efforts that promote consensus approaches to priority setting and action, as well as equitable distribution of management and leadership roles. The Southeast Asian Bat Conservation Research Unit (SEABCRU) was established in 2007 and is an open network of researchers, educators, and conservationists that seek to promote the conservation of Southeast Asia's bat fauna through research, capacity building and outreach. Bats are a diverse but vulnerable component of Southeast Asian biodiversity and perform critical ecosystem services. Rapid deforestation, disturbance at cave roosts and unregulated hunting for food and traditional medicine imperil many species, with a mere 18% of the region's 350+ species considered to have stable populations. Support from the National Science Foundation in 2011 enabled the SEABCRU to begin a 5-yr regional assessment of the distribution, abundance and status of Southeast Asian bats through research and training activities centered on four priority areas identified by group consensus: flying fox distributions and population ecology; taxonomy and systematics; cave bat diversity and conservation; response of forest-dependent bats to landscape change. Each priority is led by a multinational team of experienced biologists and graduate students, who identify key conservation needs with input solicited from the regional bat research community through workshops and online communication (www.seabcru.org, Facebook group). Workshops support a development cycle of priority setting (Indonesia 2011), expert opinion and protocol development (Thailand 2012), targeted capacity building in network gaps (Cambodia 2013, Myanmar and Vietnam 2014), and data synthesis and assessment (2015, 2016).

## SEABCRU Priority - Forest bats

# Spatial Planning for the Effects of Climate and Land-Cover Change on Borneo's Bats and Other Mammals

Matthew Struebig[1]*, Andreas Wilting[2], Erik Meijaard[3], David Gaveau[4], Bob Smith[1], Borneo Mammal Modelling Consortium, Manuela Fischer[2], Kristian Metcalfe[1,5], & Stephanie Kramer-Schadt[2]

[1]Durrell Institute of Conservation and Ecology (DICE), School of Anthropology and Conservation, University of Kent, Canterbury, CT2 7NR, UK; [2]Leibniz Institute for Zoo and Wildlife Research (IZW), Berlin, Germany; [3]Borneo Futures, People and Nature Consulting International, Jakarta, Indonesia; [4]Center for International Forestry Research (CIFOR), Bogor, Indonesia; [5]University of Exeter, Cornwall, UK;
*Corresponding author: m.j.struebig@kent.ac.uk

Habitat loss and climate change are major threats to many species, including bats. The extent to which species are affected by these processes is, however, poorly understood. This poses challenges for spatial conservation planning because species could shift, contract, expand, or maintain their range inside or outside protected areas. We address this problem in Borneo where we identify priority regions for mammal conservation under a 'climate-smart' spatial plan. We undertook spatial prioritization analyses based on a distribution dataset of 81 bat, primate and carnivore species. For each species we modelled the extent of suitable habitat under different climate and land-cover scenarios and used this information to select the most important areas for mammal conservation on Borneo this century. Combined climate and deforestation projections indicate that 30%–49% of Bornean mammal species will lose ≥30% of their habitat by 2080, and suitable conditions will shift upslope. This is less severe for bats than for other mammal groups, but could mean at least 11 bat species face an increased risk of extinction. Accommodating these distributional changes will require conserving land outside existing protected areas, mostly at mid-high elevation. Our results demonstrate the increasing importance of upland reserves and that relatively small additions (16,000–28,000 $km^2$) to current protected areas could provide benefits to biodiversity facing changes to land-cover and climate. On Borneo, this additional land is allocated for timber production (64%) or conversion (36%), warranting targeted partnerships with logging and plantation companies to better protect bats and other mammals.

## SEABCRU Priority- Taxonomy

# Toward the Future of Southeast Asian Bat Taxonomy

Pipat Soisook

Princess Maha Chakri Sirindhorn Natural History Museum, Prince of Songkla University, Hat Yai, Songkhla, Thailand 90110;
Corresponding author: pipat66@gmail.com

The number of bat taxa in Southeast Asia has been rapidly increasing over the last 10 years. With over 360 bat species currently known, Southeast Asia is the region that having highest bat diversity in the world. The discovery 'boom' of bats in the region during the last decade, with many led by local researchers, suggests we are in the golden-age of Southeast Asian bat taxonomy. This is an output of an intensive international network of collaborative taxonomic capacity building for Southeast Asian countries. The global network of taxonomists in several institutions around the world, for instance – the 'Harrison Institute' and 'SEABCRU', of course is one of the main drivers of this success. Nonetheless, the local, in-country networking should also be considered as a crucial key that support larger scale of international collaboration. A local network between researchers in academic institutions and governmental authorities, e.g. in Thailand, provided a lot of museum materials for further taxonomic studies and discoveries – many of which are astounding finds. By the way, the fact that we are in the age of extinction cannot be denied. As there are many more species out there expected to be found but at the same time they are being threatened by the loss of their natural habitats. It is an urgent task to describe them and proceed with conservation action. Therefore, strengthening the network, as well as expanding it, is essential to ensure that the network will be moving forward.

## SEABCRU Priority- Cave Bats

### Can Wing Morphology Inform Conservation Priorities for Southeast Asian Cave Bats?

Neil M. Furey[1]* & Paul A. Racey[2]

[1]Fauna & Flora International (Cambodia Programme), PO Box 1380, No. 19, Street 360, Boeng Keng Kang 1, Phnom Penh, Cambodia, 12000; [2]Centre for Ecology and Conservation, College of Life and Environmental Sciences, University of Exeter, Cornwall Campus, Treliever Road, Penryn TR10 9EZ, UK;
*Corresponding author: n.furey.ffi@gmail.com

Many bat species in Southeast Asia may be particularly susceptible to ongoing forest loss. However, ecomorphological analysis of Vietnamese bat assemblages challenges the hypothesis that, due to their greater vagility, cave-roosting bats are less vulnerable to habitat fragmentation than foliage-roosting species. Of the 13 most highly adapted forest-interior species in our study, eight were cave-roosting members of the Rhinolophidae and Hipposideridae and had wing morphologies closely resembling five foliage-roosting members of the Murininae and Kerivoulinae – species typically thought to have low vagility. Overall, both cave-roosting and foliage-roosting bats exhibited a wide range of flight indices. Consequently, where such variation occurs, cave-roosting bat ensembles are likely to include species with low vagility and similar sensitivity to habitat fragmentation. Since cave-roosting species in Myanmar also differ greatly in their vagility, such a pattern is likely to be more general than exceptional within the Asian tropics. This has important conservation implications as Asian karst formations support high cave densities and important bat diversity yet increasingly represent forest refugia in anthropogenic landscapes. We therefore advocate greater consideration of species vagility in determining conservation priorities for the region's bat fauna, together with) empirical studies of foraging preferences, home range sizes and dispersal abilities to improve understanding of the predictive limits of wing morphology analysis, ii) gradient-based studies across multiple sites to determine the relationship between vagility and sensitivity to fragmentation, and iii) studies of roost selection to establish differential roost dependencies and associated extinction risks for the many bat species for which such information is lacking.

## SEABCRU Priority- Disease Surveillance

# Bat Viral Ecology in 2015: Moving From Pathogen Discovery to a More Integrated Ecological Framework

Kevin J. Olival[1]*, Elizabeth H. Loh[1], Simon J. Anthony[1,2], Cristin C.W. Young[3], Jonathan H. Epstein[1], & Peter Daszak[1]

[1]EcoHealth Alliance, New York, NY, USA; [2]Center for Infection and Immunity, Columbia University, New York, NY USA; [3]University of California Davis, Davis, CA, USA;
*Corresponding author: olival@ecohealthalliance.org

Efforts to discover and describe viruses in bat population have increased dramatically over the past decade, including across Southeast Asia. This increase in research effort has been driven by the discovery that bats are important natural reservoirs for SARS-related coronaviruses, Marburg virus, Nipah virus, and other emerging human viral pathogens. For example over 100 bat viral discovery studies have been published in just the last half-decade, yet a rigorous synthesis of this literature is lacking. In this talk, we will first begin with an analysis of data published from nearly 100 viral discovery studies published since 2007, and identify trends in research and specific variables of importance to better target pathogen discovery efforts in bats. Next, we describe how the different goals and approaches between virologist and ecologist pose a challenge to integrated research. We highlight several viral ecology research projects ongoing at EcoHealth Alliance to show how bat virus research can be better integrated with an ecological framework. These include: 1) investigating the link between land-use change, bat communities, and viral diversity in the Brazilian Atlantic forest; 2) the ecology of Nipah virus and flying foxes in Bangladesh; 3) examination of the bat bushmeat trade and human behavioral practices in China to understand coronavirus ecology and spillover risk; and 4) the use of ecology/biodiversity statistics to understand viral diversity in bats. Through these various examples we hope to inspire the next generation of bat virologists to more completely integrate ecological theory and approaches into their research.

# ABSTRACTS OF

# ORAL PRESENTATION

## Understory Insectivorous Bats as Ecological Indicators of Vegetation Complexity in a Coffee-Forest Landscape of Sumatra

Joe Chun-Chia Huang [1]*, Elly L. Rustiati[2], Meyner Nusalawo[3], & Tigga Kingston[1]
[1]Department of Biological Sciences, Texas Tech University, Lubbock, USA; [2]Department of Biology, College of Mathematics and Natural Science, University of Lampung, Bandar Lampung, Indonesia; [3]Wildlife Conservation Society-Indonesia Program, Bogor, Indonesia; *Corresponding author: chun-chia.huang@ttu.edu

Recent studies demonstrate that the responses of understory bats to agriculture activities differ significantly among taxonomic and ecological groups in the Asian tropics. However, how vegetation simplification shapes bat diversity remains unclear, as does the strength of association between species or ensembles and specific habitats within agriculture landscapes. We investigated the correlation between vegetation complexity and insectivorous bat diversity along a gradient of coffee agricultural intensification. We also identified species indicative of specific land-uses. Bats were surveyed in forests, high-shade and low-shade coffee plantations of Sumatra, Indonesia, from 2011-2012. Seven vegetation measures, namely presence of shrubs, understory plants, canopy trees, emergent trees, big logs (diameter > 30 cm), and arboreal lianas, and shade cover were recorded. Species compositions of insectivorous bats varied significantly among land-uses due to the loss of plant-roosting species in the plantations. Bio-env analyses indicate that a model combining shade-cover level and the presence of big logs is the best predictor of variability in species compositions among sites, explaining 47.0 % of the overall variation. Plant-roosting specialists, mainly species in the subfamilies Kerivoulinae and Murininae, were generally associated with higher shade cover and presence of big logs, in comparison to roosting generalists and cave-roosting specialists. Indicator analyses suggest *Kerivoula hardwickii* and *Rhinolophus trifoliatus* have the strongest associations with forest in the study landscape. Since the distributions of both species overlap largely with the coffee cultivation in Southeast Asia, we highlight the potential use of these species as indicators for land management in coffee landscapes of the region.

## Bat Diversity Survey at Lower Kinabatangan River Valley along a Disturbance Gradient

Jimmy Lee[1]*, Tom Hughes[1], Mei Ho Lee[1], Carlos Zambrana-Torrelio[1], Kris Murray[1], Senthilvel Nathan[2], Benoit Goossens[2,3,4], Andrew Ginsos[5], Ray Clement[5], Ruhaizam Ruslan[5], Samsir Laimun[3,5], Marcelleno Anik[5], Siva Parasath Vijaya Kumar[5], Jonathan H. Epstein[1], & Peter Daszak[1]
[1]EcoHealth Alliance, New York, USA; [2]Sabah Wildlife Department, Kota Kinabalu, Sabah, Malaysia; [3]Danau Girang Field Centre, Kota Kinabalu, Sabah, Malaysia; [4]Organisms and Environment Division, School of Biosciences, Cardiff University, Cardiff, UK; [5]Wildlife Health Unit, Kota Kinabalu, Sabah, Malaysia; *Corresponding author: jimmy@ecohealthalliance.org

Anthropogenic environmental changes have influences on bat biodiversity, therefore understanding the species abundance and diversity is essential for conservation and land management. Here we report the first results of a study on bat species diversity and abundance along a disturbance gradient in the Lower Kinabatangan River Valley. Three levels of human disturbance were selected: high disturbance (HD), intermediate (ID) and low disturbance (LD). Three sampling sites (each 100 x 100 m) within each one of the disturbance levels were randomly chosen. Bats were captured by using different methodologies to maximize the capture rate with a total effort of 754 m2/30 hours per sampling season. Each sampling site was visited once per season (wet & dry). Species identification was done through morphological assessment and body measurements. LD sites presented the highest level of abundance and species richness (482 bats of 18 species), followed by the ID sites with 186 bats of 12 species and finally the HD sites with 65 bats of 11 species. A unique set of species were restricted to each disturbance level (LD: 8 species, ID: 3 species and HD: 4 species). Only five species of bats were found in all gradients suggesting high tolerance to disturbance. Z-test for proportions showed that low disturbance sites were significant higher than intermediate and high disturbance sites. Low disturbance habitats support 2.5 more bats and more species than disturbed habitats, highlighting the importance of preserving this type of habitats in order to protect ecologically important species.

## Bats in Ancient Temples: Influence of Micro Habitats and Landscape Features on Bat Occupancy and Abundance

M. Mathivanan[1]*, Moresmau Marie-Noëlle[2], A. Saravanan[1], & T. Ganesh[3]
[1]ATREE-Agasthyamalai Community-based Conservation Centre (ACCC), Tirunelveli, Tamil Nadu, India; [2]Agrocampus Ouest, Rennes, France; [3]Suriseghal Centre for Conservation Science and sustainability studies, Ashoka Trust for Research in Ecology and the Environment (ATREE), Bangalore, India; *Corresponding author: mathi@atree.org

Bats are known to use anthropogenic structures in temperate and tropical countries. Ancient Hindu temples in South India one such anthropogenic structure which serves roosting and breeding site for both mega chiropteran and micro chiropteran bats. We did a study on bat occurrence and abundance in temples and relate it to temple characteristics and landscape features around the temples. We sampled 58 temples spread all along the perennial river Tamiraparani basin a culturally and biodiversity rich region of south India. Roost count method was followed to count the bats. Six species of bats were recorded of which four were micro chiropteran and one (*Rousettus leschenaulti*) was a mega chiropteran. *Hipposideros speoris* is the most common species followed by *Taphozous melanopogon, Rousettus leschenaulti, Megaderma lyra* and *Tadarida aegyptiaca.* Bats occupied four micro habitats; tower, hall, abandoned room and pillars. About 65% of the species occupied tower and abandoned rooms in the temple while dark hall and pillars were also prefered by some species. Light levels and presense of trees in the temple had a negative effect on the occupancy of bats while dark corners and abandoned spaces had a strong positive influence on bat occupancy. Ten landscape elements were considered 1km. around the temple and the best model predicted availability of water had a negative effect on occupancy. We discuss these results in the context of species ecology and its conservation.

## Bat Assemblages in Philippine Rice Fields

Jodi L. Sedlock[1]*, James Alvarez[2], Phillip Alviola[2], Finbarr Hogan[3], Renee Lorica[3], Ari Rice[1], & Alexander Stuart[3]
[1]Lawrence University, Appleton, Wisconsin USA; [2]Museum of Natural History, University of the Philippines, Los Baños, Philippines; [3]International Rice Research Institute, Los Baños, Philippines; *Corresponding author: sedlockj@lawrence.edu

Rice fields cover over 35.8 million ha of land in Southeast Asia and serve as artificial wetlands and foraging habitat for bats. Despite the predominance of this habitat across the landscape, very few studies have attempted to describe bat assemblage structure or bats' response to a spatially and temporally dynamic prey, many of which may be harmful crop pests (e.g. stem borers, plant hoppers) or vectors of human disease (e.g. mosquitoes). Here, we present a theoretical framework for investigating assemblage structure and predator-prey interactions in a rice field ecosystem and present data from acoustic bat sampling and sweep netting in the experimental fields of the International Rice Research Institute, Los Baños, Philippines. Three bat guilds were present, each with different call structure and flight behavior. Pond bats (*Myotis* spp.) with short duration, broadband calls were present foraging low over rice fields, edge-space bats with longer duration calls with variable band width (e.g. *Miniopterus* spp., *Scotophilus kuhlii*), and high-flying open-space bats with low frequency, long-duration calls (e.g. molossids, *Taphozous melanopogon*). Simultaneous sampling of insects and bats along transects between rice paddies (in the vegetative growth stage) throughout the night (1730-0530 h) for four nights revealed a distinct activity pattern. Specifically, insects and bats exhibited a similar bimodal nightly activity pattern, with a peak in the early evening and a more abrupt peak just before dawn. A reliable call library is lacking; however, the majority of the bats detected were edge-space species with minimum frequencies between 35-45 kHz. These data provide evidence of bats' responsiveness to insect behavior and suggest that the rice field bat assemblage may be much richer than has been previously reported.

## Regional Patterns of Bat Community Assembly in the Japanese Archipelago

Dai Fukui[1]* & Toshihide Hirao[2]
[1]The University of Tokyo Hokkaido Forest, the University of Tokyo, Hokkaido, Japan; [2]The University of Tokyo Chichibu Forest, the University of Tokyo, Saitama, Japan; *Corresponding author: fukuidai@uf.a.u-tokyo.ac.jp

One of the most fundamental questions in mammal ecology is whether communities are composed randomly and what ecological processes determine the species composition of communities. Many concepts of assembly rules have been defined by previous studies. For example, non-random patterns of co-occurrence may be caused by biotic interactions, abiotic environmental factors and evolutionary histories, with none of those being mutually exclusive. However, few studies have examined how these rules can be applied to mammal assemblages. Revealing processes involved in community assembly is not just interesting in itself, but also valuable for gaining an understanding of how assemblages will respond to future environmental changes. Eco-morphology, especially wing morphology, has been used in the study of bat assemblages, as close relationships between morphology and ecology have been clearly demonstrated. In this study, we aimed to examine bat community assembly using an eco-morphological approach. To elucidate the mechanisms structuring bat assemblages, we analyzed variations in the size and structure of the eco-morphological space of bat assemblages at local and regional scales in the Japanese archipelago. Our results show that interspecific competition, as indicated by sympatric species sharing same eco-morphological niche, is not apparent in bat assemblages at either local or regional scales. We conclude that environmental filters may determine the structure of bat assemblages in the Japanese archipelago.

## Ecomorphology, Verticle Segregation and Habitat Use of Bats in Kenyir Rainforest and Setiu Wetland

Azuan Roslan[1]*, Mohd Tajuddin Abdullah[1,3], Faisal Ali Anwarali Khan[2], & Nor Zalipah Mohamed[3]
[1]Centre for Kenyir Ecosystems Reseach, Kenyir Research Institute, Universiti Malaysia Terengganu, 21300 Kuala Terengganu, Terengganu, Malaysia; [2]Faculty of Resource Science and Technology, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia.; [3]School of Marine and Environmental Sciences, Universiti Malaysia Terengganu, 21030 Kuala Terengganu, Terengganu, Malaysia; *Corresponding author: azuan.roslan@umt.edu.my

There are numerous bat studies being done at the understory level. However, there are not much that focus on the different forest stratification such as the canopy level. In this study, wing morphology is being chosen because of its great influence on bats true flight ability. Wings of bats have been studied extensively to investigate the bats flight behaviour and its relation to habitat usage. The wing loading and aspect ratio of bats will be studied to understand their habitat usage and how they forage upon different vegetative layers in the forest. The result of wing loading and aspect ratio will be identified to relate to their adaptation in habitat. This study will examine the habitat usage of bats from all species and their vertical segregation at forest from ground to the canopy level. The bats flight behaviour such as their maneuverability, agility, speeds and many more will be known upon completion of the project.

## Beyond Wing Parameters – Body Mass Controls Flight Maneuverability in Malaysian Insectivorous Bats

Juliana Senawi[1,2]* & Tigga Kingston[2]
[1]Institute for Environment & Development (LESTARI), Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia;
[2]Department of Biological Sciences, Texas Tech University, Lubbock, Texas, USA;
*Corresponding author: juliana.senawi@gmail.com

It is predicted that differences in wing morphology will reflect differences in foraging strategies of bats. Several studies have experimentally tested this prediction, typically assessing the relationship between aspects of wing morphology and maneuverability through an obstacle course. However, studies have lacked measures of flight ability true scores, which may confound interpretation of ability across the range of presented tasks. Here, we used a collision-avoidance experiment to determine the relationships among flight performance, wing morphology and foraging strategy in 15 forest interior insectivorous bat species from Malaysia. The flight performance scores were quantified based on individual responses of each species to 11 different obstacle arrangements (four banks of vertical strings 10 - 60 cm apart). The tasks employed for the collision-avoidance experiment were reliable and valid, even though Rasch analysis suggested that the experiment was too easy to discriminate completely among the 15 species. We found negative significant correlation between flight ability and body mass, wingspan and wing area but a positive significant correlation with wingtip area ratio. However, using stepwise multiple regression analysis, a significant model emerged with body mass as the only significant predictor for flight ability. Moreover, none of the size-independent wing parameters (relative wing loading, aspect ratio, and wingtip shape index) correlated with flight ability. We also found an isometric relationship between wing area and body mass (scaling coefficient of 0.643), and conclude that differences in maneuverability among species in this ensemble do not reflect differences in wing shape, but instead are governed by size.

## The Effects of Major Roads on Bats in Singapore

Benjamin P. Y. H. Lee[1,2]*, Zoe G. Davies[1], & Matthew J. Struebig[1]
[1]Durrell Institute of Conservation and Ecology, School of Anthropology and Conservation, University of Kent, United Kingdom; [2]National Parks Board, Singapore; *Corresponding author: chiroptera.sg@gmail.com

Roads and vehicular traffic pose many challenges to the conservation of wildlife, which includes habitat loss, road-kills, and severing of commuting routes in natural areas. A growing number of studies have examined the effects of roads on different species in recent years but the majority was conducted in temperate regions. This study based in tropical Singapore examined if bat activity and diversity correlated with distance form major roads. We investigated the effects of three major roads on bat activity and diversity in Singapore. During September 2013 to February 2014, bio-acoustic surveys of bats using a portable full-spectrum bat detector were conducted in both forest and urban environments along 800-metre transects perpendicular to the major roads. We recorded bat activity at ten recording points along each transect at a standardised duration post sunset. We examined the influences of environmental variables (e.g. light levels, noise, micro-climate) on activity of bats and compared the results with those in temperate regions. Finally, we assessed the role of a wildlife overpass in mitigating the barrier effects of the Bukit Timah Expressway in relation to bats.

## Bat Pollination in Mangrove Habitats of Peninsular Malaysia

Nor Zalipah Mohamed[1,2]*, Shahrul Anuar Mohd Sah[3], & Gareth Jones[1]
[1]University of Bristol, School of Life Sciences, Life Sciences Building, 24 Tyndall Avenue, Bristol BS8 1TQ, UK; [2]Pusat PengajianSains Marin dan Sekitaran, Universiti Malaysia Terengganu, 21030 Kuala Terengganu, Terengganu, Malaysia;
[3]Pusat Pengajian Sains Kajihayat, Universiti Sains Malaysia, Pulau Pinang, Malaysia;
*Corresponding author: zalipah@umt.edu.my

Bats are believed to be the major pollinators of mangrove trees in the genus *Sonneratia* that are widespread and important for stabilising coastal habitats. Bats however, visit numerous plant species in a night, resulting in mixed pollen loads on their bodies that can potentially affect their role as effective pollinators. We investigated the potential for bats to be effective pollinators from the number of pollen grains they carried and transferred to stigmas while visiting flowers from two *Sonneratia* species (*Sonneratia caseolaris* and *S. alba*), and from their visitation rates. Despite carrying several pollen types, conspecific *Sonneratia* pollen grains were the major pollen grain types carried by *Eonycteris spelaea*, and hence they are likely to be important pollinators for the two mangrove species in the study area. Over 75% of pollen grains recorded after single-visit deposition following visits by bats to *S. caseolaris* were conspecific pollen, suggesting that the bats are highly effective pollinators of this species. After a full flowering night, *S. caseolaris* stigmas received relatively more heterospecific pollen grains presumably as a consequence of multiple visits by pollinators. Reduced pollinator efficiency during multiple visits may not reduce reproductive success of the trees however, as conspecific pollen grains usually adhere strongly to the stigmatic surface for germination. Lower visitation rates to the *S. alba* flowers, and relatively low amounts of conspecific pollen deposited after single visits by bats may be related to the low number of ovules present; hence *S. alba* may attract bats relatively infrequently to ensure effective fertilisation.

## Bat Roles in Pollination Network in Mixed Fruit Orchards, Southern Thailand

Tuanjit Sritongchuay* & Sara Bumrungsri
Department of Biology, Faculty of Science, Prince of Songkla University, Hat Yai, Thailand, 90112;
*Corresponding author: t.sritongchuay@gmail.com

Since in last decade, reproductive biology and pollination ecology of only one plant species have been intensively considered, understand the mutualistic interactions in whole community also need to be highlighted. Pollination of economic crops such as rambutan, mango, longan, and santol depend on insects, however, there are some economic plant whose pollination relies on both bats and insects, namely durian, parkia, and banana. Thus in this study we investigated the role of bat in pollination network from 20 mixed fruit orchards. We found eight species of fruit bat visit to 6 species of plant in pollination network, including specialist plant, *Oroxylum indicum* and generalist plant, *Musa*. Bats play the important role in pollination network because support the pollination for specialist plants which tend to be the rarest species, appear at greatest risk of real-world extinction. Moreover, bats provide the complementary pollination for generalist plant when the insects decline.

## Is the Island Flying Fox in the Service of the King of Fruits? Camera-Trapping Reveals Further Clues about Durian Pollination Ecology

Sheema Abdul Aziz[1,2,3]*, Gopalasamy Reuben Clements[1,4,5], Tuanjit Sritongchuay[6], Kim McConkey[3], Saifful Pathil[7], Muhammad NurHafizi Abu Yazid[7], Ahimsa Campos-Arceiz[3], Pierre-Michel Forget[2], & Sara Bumrungsri[6]

[1]Rimba, Bandar Baru Bangi, Selangor, Malaysia; [2]Muséum National d'Histoire Naturelle, Département Écologie et Gestion de la Biodiversité, UMR 7179 CNRS-MNHN, Paris, France; [3]School of Geography, University of Nottingham Malaysia Campus, Semenyih, Selangor, Malaysia; [4]Kenyir Research Institute, Universiti Malaysia Terengganu, Terengganu, Malaysia; [5]Centre for Tropical Environmental & Sustainability Science, James Cook University, Cairns, Queensland, Australia; [6]Department of Biology, Prince of Songkla University, Hat Yai, Songkhla, Thailand; [7]Tree Climbers Malaysia, Shah Alam, Selangor; *Corresponding author: sheema@myrimba.org

Fruit bats (Pteropodidae) are known to provide valuable ecosystem services to humans. The pollination services of nectarivorous bats such as *Eonycteris spelaea*, particularly for commercially important trees such as durian (*Durio zibethinus*) are now well documented. However, the pollination roles of larger fruit bats such as flying foxes (*Pteropus* spp., *Acerodon* spp.) are still poorly understood, and require further elucidation. Flying foxes are said to be necessary to maintain the health of tropical forests, particularly on islands. Yet in Malaysia they are frequently hunted, persecuted and even legally killed as pests. Efforts to improve their protection in Malaysia have been hampered by a lack of basic quantitative information on their role as ecosystem service providers. Here, we investigate the role of *Pteropus hypomelanus* in the pollination ecology of durian trees on Tioman Island, Peninsular Malaysia. At four individual flowering trees in a durian orchard, we deployed 19 stations of paired infra-red camera and video traps across varying heights in the lower, middle and upper levels. The traps were aimed at large durian inflorescences to document the animal visitors and their feeding behaviour. Our preliminary results indicate at least seven species of animal visitors, including *P. hypomelanus*. Most importantly, we now have the first known video footage of *P. hypomelanus* feeding on nectar of durian flowers. This has important implications for the role of flying foxes in pollinating durian.

## The Flower Visited by Fruit Bats at Lore Lindu National Park, Sulawesi, Indonesia

Ibnu Maryanto* & Irawati

RC for. Biology-Indonesian Institute of Science; *Corresponding author: ibnumaryanto@gmail.com

The bat fauna of the Sulawesi Island is characterized by high endemism. Tragically, bat biodiversity in the region is threatened by fast habitat loss and high hunting activity. Loss of endemic fruit bat species may also bring a loss of pollination services they provided, and consequently, loss of endemic plant species in the region. However, knowledge of pollen use in fruit bats, and how species segregate their diets are unclear. We study pollen diets and resource partitioning of a fruit bat ensembles at Lore Lindu National Park on Central Sulawesi, Indonesia. Pollen samples were collected from stomach of 124 individuals of 13 bat species were analyzed, namely *Boneiabidens, Chironax melanocephalus, Cynopterus luzoniensis, C. minutus, Dobsonia exoleta, Eonycteris spelaea, Harpyonicteris celebensis, Macroglosus minimus, Nyctemene cephalotes, Rousettus celebensis, Styloctenia wallacei, Thoopteru snigrescens*, and *T. suhaeniahi*. Plant species of the pollens were identified with a microscope at 400 magnifications, and the existence of pollen genera/family were identified. Pollens were found in the diets of all species, except *C. luzoniensis*, and 30 genera (12 families) that were *Myristica subifera* (Myristicaceae), *Trema* sp., *Celtis* sp. 1, *Celtis* sp. 2, *Ulmus* sp. (Ulmaceae), *Ficus* sp., *Ficus* sp. 2, *Arthocarpus* sp., (Moraceae), *Castanopsis* sp., *Lithocarpus* sp., (Fagaceae), *Casuarina sumatrana* (Casuarinaceae), *Eugenia* sp. (Myrtaceae), *Cinnamomum champora, Litsea* sp. (Lauraceae), Aceraceae *A, Acer* sp. 1, *Acer* sp. 2 (Aceraceae), *Emilia* sp., (Compositae), *Engelhardtia chrysolepis, Juglandaceae_B* (Juglandaceae), *Mastixia* sp.(Cornaceae), *Macadamia hildelbrandri* (Proteaceae), *Heliconia* sp., *Musa* sp. 1, *Musa* sp. 2 (Musaceae), *Urtica* sp. 1, *Urtica* sp. 2, *Urticaceae*_C (Urticaceae), *Dyospiros* sp. (Ebenaceae), and *Gentiana* sp. (Gentianaceae). A principle component analysis on the existence of the pollen data were known three groups similarity of fruit bats to choose of the flower. There were group 1 that was consist of *Macroglossus minimus* and *Thoopterus suhaeniahi*; group 2 were *C. minutus, E. spelaea, N. cephalotes, H. celebensis, T. nigrescens*, and *R. celebensis*; and group 3 were *C. melanocephalus, B. bidens, S. wallacei* and *D. exoleta*.

## Diet and Reproductive Phenology of the cave nectar bat *Eonycteris spelaea* in Cambodia

Hoem Thavry[1,2]*, Julien Cappelle[2,4], Lim Thona[1], Hul Vibol[3]& Neil M. Furey[1,5]
[1]Centre for Biodiversity Conservation, Room 415, Department of Biology, Faculty of Science, Royal University of Phnom Penh, Confederation of Russia Boulevard, Phnom Penh, Cambodia; [2]Institut Pasteur du Cambodge, Epidemiology Unit, BP983, Phnom Penh, Cambodia; [3]Institut Pasteur du Cambodge, Virology Unit, BP983, Phnom Penh, Cambodia; [4]Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD), UR Animal et Gestion Intégrée des Risques (AGIRs), F-34398, Montpellier, France; [5]Fauna & Flora International (Cambodia Programme), PO Box 1380, No. 19, Street 360, Boeng Keng Kong 1, Phnom Penh, Cambodia; *Corresponding author: thavry_h@yahoo.com

The cave nectar bat *E. spelaea* is an important pollinator of several economically significant plants in SE Asia. As information on the diet of the species is currently limited to Thailand and Malaysia, we undertook dietary studies on an *E. spelaea* colony in Kampot province of Southern Cambodia. Sampling was conducted from February 2014 to January 2015 and comprised ten days of faecal sample collection from the cave each month to identify plant species consumed by the bats by their pollen. The diet of *E. spelaea* in Southern Cambodia includes at least 24 plant species, a broader diet compared to southern Thailand (11 species). *Sonneratia alba* (26.4%) and *Musa truncata* (16.9%) had the highest percentage frequency, followed by *Bombax valentonii* (11.2%), *Parkia speciosa* (9.8%) and *Ceiba pentandra* (6%). *Sonneratia*, *Musa*, *Bombax* and *Parkia* were present in the diet nearly every month, whereas the presence and contributions of other species varied seasonally. *Durio* spp. are variably important components of the diet in January-March (11.8–32.4%).Reproductive data suggest that *E. spelaea* mainly gives birth in January and May-June in Southern Cambodia (10°N), in contrast to North Vietnam (22°N) where birth peaks mainly occur in March–April and August–September. Colonies of the species in Southern Cambodia are heavily threatened by hunting and cave disturbance and these threats worsen each year during April, the Khmer new-year period.

## The Role of Fruit Bats in Plant Community Changes in an Urban Forest in West Java, Indonesia

Sheherazade Jayadi[1]*, Susan M. Tsang[2,3], Yasman[1], & Dimas Haryo Pradana[1]
[1]Department of Biology, Universitas Indonesia, Depok, West Java, Indonesia; [2]Department of Biology, City College and the Graduate Center, The City University of New York, New York, New York, USA; [3]Department of Mammalogy, American Museum of Natural History, New York, New York, USA; *Corresponding author: sheherazade.jayadi@gmail.com

Urban forests act as important vegetative buffers and carbon sinks for one of the most densely populated cities in Southeast Asia, Jakarta. Since the artificial planting of 19 species of angiosperms on the campus of Universitas Indonesia (UI) for the greening program started three decades ago, the urban forest has grown to over 100 species, covering approximately half of the campus' total area. Frugivorous bats, especially long-distance foragers, are suspected to be the cause of the urban forest's success. To investigate how fruit bats affect plant communities in urban forests, a host plant association study was conducted from December 2013 to March 2014. Additional observations were conducted during the day to identify bat guano and ejecta with seeds. The results showed that fruit bats (*Cynopterus brachyotis, C. horsfieldii, C. minutus, C. sphinx, C. titthaecheilus, Macroglossus minimus, M. sobrinus,* and *Rousettus amplexicaudatus*) consumed fruit, pollen, or nectar from 26 plants. A significant association among bat and plant species preference was found, though bat species were differentially associated to each plant species. Plants from the greening program were found outside the introduction area. A quarter of the plants consumed were *Ficus*, which were never deliberately planted, suggesting that fruit bats introduced them to the urban forest. *Cecropia* were found in UI, but was only planted in Bogor Botanical Garden. By acting as seed dispersers and pollinators, fruit bats are not only increasing plant diversity, but also are connecting plant populations that have been isolated by human development.

## Population Dynamics and Diet of Lyle's Flying Fox (*Pteropus lylei*) in Cambodia

Hul Vibol[1]*, Huk Visal[2], Neil M. Furey[2,3], & Julien Cappelle[1,4]
[1]Institut Pasteur du Cambodge, 5 Monivong Boulevard, BP 983, Phnom Penh, Cambodia; [2] Centre for Biodiversity Conservation, Room 415, Department of Biology, Faculty of Science, Royal University of Phnom Penh, Confederation of Russia Boulevard, Phnom Penh, Cambodia; [3]Fauna & Flora International (Cambodia Programme), PO Box 1380, No. 19, Street 360, BoengKeng Kong 1, Phnom Penh, Cambodia, 12000; [4]Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD), UR Animal et Gestion Intégrée des Risques (AGIRs), F-34398, Montpellier, France; *Corresponding author: hvibol@pasteur-kh.org

Three flying fox species are thought to occur in Cambodia: large flying fox *Pteropus vampyrus*, Lyle's flying fox *P. lylei* and island flying fox *P. hypomelanus*. All three are listed in Appendix II of CITES, but almost nothing is known about their conservation status, diet or population dynamics nationally. We conducted field surveys between June 2013 and August 2014 to assess all of the known or suspected *Pteropus* colonies in the country. We also conducted monthly surveys at one roost in Kandal province between December 2012 and December 2014 to determine reproductive phenology and population dynamics. Flying fox diets were assessed through analysis of feces collected monthly at the Kandal roost from December 2013 to June 2014. A total of 13 roost sites were assessed nationally and despite a measure of protection being provided by certain roost locations (where roosts were near a religious or government building), hunting was commonly reported. At the Kandal roost, monthly observations indicate that mating occurs in November and parturition in April and also suggest that an immigration phase occurs before mating and an emigration phase prior to parturition. Seven different plant species including mango and sapodilla were identified in fecal samples from the Kandal roost. Additional ecological data, including demographic data are needed to design effective conservation plans for *Pteropus* species in Cambodia and Southeast Asia.

## Local People Count: Using Citizen Scientists to Monitor Flying Fox Populations

Tammy L. Mildenstein[1,2]*, L. Scott Mills[3], & Dave Patterson[4]
[1]Bat Count Philippines, [2]Department of Biology, Cornell College, Mount Vernon, IA 52314 USA; [3]Department of Forestry and Environmental Resources, North Carolina State University, Raleigh, NC, USA; [4]Department of Mathematical Sciences, University of Montana, Missoula, MT USA; *Corresponding author: tammy.mildenstein@gmail.com

Three quarters (143/196) of the world's megabats (Old World fruit bats; Pteropodidae) are found on islands, where they are ecological keystones as seed dispersers and pollinators. Although nearly half of the species are considered threatened, the conservation status of most Pteropodids remains largely unknown because of the lack of researchers on remote islands. We studied how local community members could be engaged as citizen scientists to monitor and detect trends in populations. We conducted fruit bat exit counts across the Mariana Islands and the Philippines to measure sampling error due to differing levels of counting experience and to demonstrate the impact of observer error on trend detection. As expected, field experience was inversely correlated with observer error; average error was 70% among observers with no field experience, 11% among fieldworkers, and 5% among experienced counters. However, even the largest error (from inexperienced observers) did not greatly compromise trend estimation. In a projection model incorporating observer error from our field data, we found estimates of exponential trend to be robust to the measured levels of observer error. There were no misidentifications of trend direction after 20 years of counting even for amateur counters and few misidentifications after only 5 years of counting. Fruit bat conservation in Oceania and insular Southeast Asia is dependent on regular monitoring of populations of concern. Our modeled success in trend estimation suggests that community-based fruit bat monitoring programs may be scientifically valid in addition to being cost-effective, sustainable, and locally-relevant.

## Conservation Status of the Palawan Flying Fox *Acerodon leucotis* in Calamian Group of Islands, Philippines

Lisa J. Paguntalan* & Irish Bacuel
Philippines Biodiversity Conservation Foundation Inc. c/o Negros Forest Ecological Foundation Inc. South Capitol Road, Bacolod City 6100, Philippines; *Corresponding author: lisamariep10@gmail.com

The Calamianes groups of Islands were surveyed last 3-20 March 2010, 3-15 May 2010, 15-19 October 2013, 28-31 August 2014 and from 21 – 30 March 2015 in search of the threatened endemic Palawan flying fox *Acerodon leucotis*. Mist-netting, informal interviews and verifying reports of roosting colonies of flying foxes were conducted during the surveys. A total of 24 species of bats were identified including the poorly known Palawan flying fox. Of the 24 species, 11 were new records for Busuanga, 20 additional records for Culion and one new country record. A total of 12 sites in Calamian Islands were surveyed for the Palawan flying fox. Only five of the 12 sites positively recorded the presence of this species: two were in private island resorts and one is within marine protected area. All remaining forests patches in the three islands are vulnerable to threats, such as habitat conversion into cattle farms, timber poaching, hunting targeted species for wildlife trade, game and food as well as intentional burning of remaining forests patches. On-going conservation initiatives conducted in collaboration with local organizations, local communities and the local government will also be presented.

## Status of Indian Flying Fox*, Pteropus giganteus,* Brunnich, 1782 in National Capital Territory of Delhi, India

Rajlakshmi Mishra*, Sumit Dookia, & Prodyut Bhattacharya
University School of Environment Management, Guru Gobind Singh Indraprastha University, Sector 16-C, Dwarka, New Delhi-110078, India; *Corresponding author: rajlakshmi.jha@gmail.com

The forest cover alone constitutes 11.91 per cent of the total 1483.01 sq. km. geographical area and comprises 6.76 sq. km. very dense forest, 49.84 sq. km. moderately dense forest and 119.98 sq. km. open forest, making Delhi one of the greenest capitals in the world. The avenue plantations of Lutyens' Delhi have variety of tree species which provide for both roosting and foraging of *Pteropus giganteus*. Opportunistic surveys were undertaken to check the status of the species in the area and also to ascertain whether the process of large scale urbanization was displacing traditional roosts resulting in the fragmentation of the original population. The major threat to bat roosts is the destruction of habitat and tree roosts. 'Direct Roost Count' method was followed in the survey. In Delhi, roost trees included *Ficus* species, *Terminalia arjuna, Neolamarckia kadamba, Polyalthia longifolia, Artocarpus heterophyllus* and *Tamarindus indicus*. Maximum roosting sites were found in LBZ (Lutyens' Bungalow Zone) area, a high security zone. If properly monitored it has huge potential to be converted into a 'Conserved Roosting site' of the Indian Flying Fox. It supports dense population of many tree species favored for roosting and foraging. These include both native trees and species planted in the British regime more than 100 years ago. It could be seen that instead of a very large roost on a single tree, they were scattered on several trees in the area, thereby indicating that the number of smaller roosts are increasing and that of traditional roosts decreasing.

## Filipinos for Flying Foxes: Protecting the Last Roost Sites of Giant Fruit Bats in Northeast Luzon, Philippines

Marites Gatan-Balbas[1]*[#], Joni T. Acay[1#], Edmund D. Jose[1], Dorina R. Soler[1], Leonalyn C. Tumaliuan[2], Chic Mabell T. Batarao[2], Myrna C. Cureg[1,2], Tammy Mildenstein[3], Merlijn van Weerd[1,4], & Rens Vogel[4]

[1]Mabuwaya Foundation, Inc., CCVPED Bldg, Isabela State University Campus, Garita Heights, Cabagan, 3328 Isabela, Philippines; [2]Department of Development Communication and Languages, College of Development Communication and Arts & Sciences, Isabela State University, Cabagan, 3328 Isabela, Philippines; [3]Biology Department, Cornell College, Mount Vernon, IA 52314 USA; [4]Institute of Environmental Sciences, Leiden University, Leiden, the Netherlands;
*Corresponding author: mikaela_tess@yahoo.com; [#]Co-authorship

Giant fruit bats or flying foxes have become rare throughout the Philippines as a result of hunting, disturbance of their roost sites and disappearance of their forest habitat. With support from the IUCN's Save Our Species Fund, the Mabuwaya Foundation is implementing the Filipinos for Flying Foxes Project in Luzon. The project is focused on three species found in the Northern Sierra Madre Mountains in northeast Luzon: two endemic species, the Mottle-winged Flying Fox *Desmalopex leucopterus* and the endangered Golden-crowned Flying Fox *Acerodon jubatus*, and the non-endemic near-threatened Large Flying Fox *Pteropus vampyrus.* To support conservation of these species, Mabuwaya is undertaking bat count surveys and social surveys to determine Flying Fox distribution and population size, perceptions of bats and hunting pressure. Communication, Education and Public Awareness campaigns are implemented and local governments are assisted to protect flying foxes and their roost sites. As a result, mixed-species roosting sites were confirmed in the municipalities of Baggao (Cagayan Province) and Divilacan (Isabela Province), with exit counts of at least 35,500 and 34,000 bats, respectively. Hunting and disturbance have led to the disappearance of roost sites elsewhere, and remain a threat to the existing roost sites as well. Communication campaigns help in generating support for Flying Fox conservation by both communities and local governments. This presentation will show the results of bat counts and social studies, and will outline the conservation strategy for Flying Foxes in northeast Luzon.

## Creating Conservation Reserves for Philippine Flying foxes: Considerations and Implications

Philip Godfrey C. Jakosalem[1]*, Lisa J. Paguntalan[1], Ronald Allan G. Cesante[2], & Tammy Mildenstein[3]

[1]Philippines Biodiversity Conservation Foundation, Inc. NFEFI Compound, South Capitol Road, Bacolod City, Philippines; [2]Municipal Mayor Municipality of Dalaguete, Dalaguete, Philippines; [3]Cornell College, Mount Vernon, Iowa, USA;
*Corresponding author: godo.jakosalem@pbcfi.org.ph

Flying fox species in a small isolated forest fragments face demographic threats to their existence. These concerns can be addressed by creating flying fox conservation reserves in which the threatened species are protected. Here, we present some strategies to ensure the long term viability of the species and ecosystems on which they depend, which are economically acceptable to the local government units and the local communities adjacent to the flying fox colonies. Using legislation at the national and local level, we have been able to create conservation reserves for threatened flying fox species. One approach that has gained popularity in last few years is the local conservation area (LCA), which attempts to link conservation to the local government agenda. The LCA initiatives provide the local government units and local communities with a voice in the shared decision-making authority, as well as employment and often revenue sharing. This paper describes different modalities and strategies for conserving flying fox roosting colonies in different landscapes and with different stakeholders.

## Species Delimitation and Biogeography of Southeast Asian *Hipposideros*

Faisal Ali Anwarali Khan[1, 2]*, Caleb D. Phillips[1], Mohd Tajuddin Abdullah[2], Ibnu Maryanto[3], Jacob A. Esselstyn[4], Jodi L. Sedlock[5], & Robert J. Baker[1]

[1]Department of Biological Sciences and the Museum, Texas Tech University, Lubbock, Texas, USA; [2]Department of Zoology, Faculty of Resource Science and Technology, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia; [3]Museum ZoologicumBogoriense, Research Center for Biology, Indonesian Institute of Sciences (LIPI), Indonesia; [4]Museum of Natural Science, Louisiana State University, 119 Foster Hall, Baton Rouge, LA 70803, USA; [5]Biology Department, Lawrence University, 711 E Boldt Way, Appleton, WI 54911, USA; *Corresponding author: fanwaral@gmail.com

The Round-leaf bats, genus *Hipposideros* are an exemplar lineage, being understudied, broadly distributed throughout the biodiversity hotspots of Southeast Asia, and cryptic genetic diversity has previously been identified through mitochondrial sequence analysis. The taxonomic description of biodiversity is essential for conservation decisions, yet this description invariably relies on the acceptance of divergence thresholds, which are strengthened by corroboration from different forms of biological data. To provide a robust dataset for informed biodiversity assignment we used a combination of echolocation data, mitochondrial cytochrome-*b* and NADH dehydrogenase subunit-2 sequence data, nuclear AFLPs, and a combination of phylogenetic and biogeographic tools. Together these data were used to characterize *Hipposideros* biodiversity and to explore the utility of coalescent stochastic modeling in identifying "species level lineages" as compared to those identified following proposed mammalian percent divergence thresholds. The nuclear DNA phylogeny identified a total of 27 lineages out of the 34 lineages with > 5% divergence in mtDNA. Echolocation data supported mitochondrial clades for which maternal and nuclear phylogenies were discordant; these phylogenetic contrasts describe recent gene flow among islands during the last glacial maximum. Biogeographic reconstructions of *Hipposideros* suggest the Southeast Asian lineage studied here originated on the Sunda Shelf ~19.2 mya and subsequently diversified into adjacent regions. Species identification using coalescent stochastic modeling and the proposed mammalian percent divergence threshold of > 5% were concordant. The combined information from these decision-making criteria and data types employed indicates the number of unrecognized species in Southeast Asian *Hipposideros* is about half of that currently described.

## Exploring Genetic and Echolocation Call Variations within *Hipposideros galeritus* Species Complex (Cantor's Roundleaf Bat)

Sultana Parvin Habeebur Rahman[1]*, Tan Jo Ann[1], A.R. Mohd Ridwan[2], V.K. Jayaraj[3], S. Badiozaman[1], Mohd Tajuddin Abdullah[4], & Faisal Ali Anwarali Khan[1]

[1]Department of Zoology, Faculty of Resource Science and Technology, [2]Centre for Pre University Studies, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia; [3]Faculty of Earth Science, Universiti Malaysia Kelantan, 16100 Kota Bharu, Kelantan, Malaysia; [4]Center of Kenyir Ecosystems, Institute of Kenyir Research, Universiti Malaysia Terengganu, 21030 Kuala Terengganu, Terengganu, Malaysia; *Corresponding author: habeebursultana@gmail.com

The taxonomy status of *Hipposideros galeritus* remains to be exposed, as earlier finding suggest that currently recognized species may represent a composite species. Recent molecular studies showed that *H. galeritus* was paraphyletic with *H. cervinus* and high intra-specific divergence were found between currently recognized *H. galeritus* lineages. Thus, the objective of our study is to evaluate the taxonomy of *H. galeritus* species using genetics, morphometric and echolocation datasets. Phylogenetic analyses revealed deep genetic variations between different biogeographic regions (5.0-14.0% for cytochrome-band, 2.9-18.4% for cytochrome oxidase-I). Discriminant Function Analysis was carried out on samples from Sarawak and Sabah using external and craniodental datasets. This morphometric analyses indicate that distance between cochleae and second molar tooth crown length as the best resolving characters, but no significant clusters were formed to discriminate the assigned groups. Echolocation call analysis suggests that *H. galeritus* from several localities in northern and southern Sarawak exhibit a range of call frequencies from 100-115 kHz, contrast to Peninsular Malaysia (Kelantan) samples as the call recorded were in the range of 90-95 kHz. The combination of genetic, morphometric and echolocation data from this study provide a better understanding on the cryptic lineages within currently recognised *H. galeritus* and provide support to elevate *H. galeritus labuanensis* to specific rank (*H. labuanensis*). Interestingly, we also present preliminary data suggesting that population from Southwestern Borneo may represent a separate species from those in Sabah. Our finding emphasise the importance of past biogeographic event in shaping the species diversity in Southeast Asia.

## Molecular Phylogeny of Rhinolophid Bats from Malaysia Based on Mitochondrial DNA (Cytochrome Oxidase I and Cytochrome *b*)

Nurul Farah Diyana Ahmad Tahir[1]*, Charlie J. Laman[1] and Jayaraj Vijaya Kumaran[2], Rosli Hashim[3], Roberta Chaya Tawie Tingga[4], Mohd Ridwan Abd Rahman[4], Mohd Tajuddin Abdullah[5], & Faisal Ali Anwarali Khan[1]

[1]Department of Zoology, Faculty of Resource Science and Technology, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak; [2]Faculty of Earth Sciences, University Malaysia Kelantan, 17600 Jeli, Kelantan; [3]Institute of Biological Sciences, Faculty of Science, University of Malaya, 50603 Kuala Lumpur; [4]Centre of Pre-University, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak; [5]Centre for Kenyir Ecosystem Research, Universiti Malaysia Terengganu, 21030 Kuala Terengganu, Terengganu; *Corresponding author: farahdiyanatahir@gmail.com

Horseshoe bats (Rhinolophidae) are among the most widely distributed and ecologically diverse group of insectivorous bats in the Old World. Genus *Rhinolophus* is a monotypic genus in the family Rhinolophidae that consist of at least 71 species in the Old World region. The lack of phylogenetics data of family Rhinolophidae in Malaysia has encouraged us to study the phylogeny of this family. The phylogenetic relationship among 10 species from Borneo and Peninsular Malaysia were inferred from two mitochondrial (mtDNA) genes; full cytochrome (cyt *b*) - 1140 bp and cytochrome oxidase I (COI) – 687 bp. The phylogenetic trees were constructed using neighbor-joining (NJ), unweighted maximum parsimony (MP) and maximum likelihood (ML) methods. From this phylogenetic study, it has adding new information regarding family Rhinolophidae. Further study for this family can add other genes especially the nuclear gene.

## Phylogenetics and Taxonomy of Nectar Bats (Genus: *Macroglossus* spp.) in Malaysia

Jayaraj Vijaya Kumaran[1,2]*, Faisal Ali Anwarali Khan[3], Siti Hajjar Mohd Daud[4], Joshua Anantham[2], & Seri Intan Mokhtar[4]

[1]Faculty of Earth Science, Universiti Malaysia Kelantan, UMK Jeli Campus, 17600 Jeli, Kelantan, Malaysia; [2]School of Biological Science, UniversitiSains Malaysia, 11800 Minden, Penang; [3]Department of Zoology, Faculty of Resource Science and Technology, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia; [4]Faculty of Agro Based Industry, Universiti Malaysia Kelantan UMK Jeli Campus, 17600 Jeli, Kelantan, Malaysia;
*Corresponding author: jayaraj@umk.edu.my

The taxonomic status of nectar bats of the genus *Macroglossus* in Malaysia is debatable as previous assignment of *Macroglossus* representatives from Peninsular Malaysia and Borneo were based on inconclusive evidence and this warrants taxonomic revision. Thus the aim of this study was to infer the phylogenetic relationships and review the taxonomic status of *Macroglossus* in Malaysia. Morphometric analysis using 28 characters and phylogenetic analysis using DNA sequences of partial cytochrome *b* gene were performed and our findings indicate that *M. sobrinus* and *M. minimus lagochillus* may probably be conspecifics, with variations previously described were morphological variations that exist between populations. However, our findings suggest that *M. minimus minimus* (Bornean form) was divergent and should be elevated to a species. The results are useful for zoologists, conservationists and taxonomists that manage and conserve this important bio-resource in Malaysia.

## Dispersal is a Significant Biogeographic Mechanism in *Pteropus* in the Indo-Australian Archipelago

Susan M. Tsang[1,2]*, Sigit Wiantoro[3], Maria Josefa S. Veluz[4], Norimasa Sugita[5], Nancy B. Simmons[2], & David J. Lohman[1]

[1]Department of Biology, City College and the Graduate Center, The City University of New York, New York, USA; [2]Department of Mammalogy, American Museum of Natural History, New York, USA; [3] Museum Zoologicum Bogoriense, Indonesian Institute of Sciences (LIPI), Cibinong, Indonesia; [4] Mammalogy Section, National Museum of the Philippines, Manila, Philippines; [5] Department of Zoology, National Museum of Nature and Science, Tokyo, Japan; *Corresponding author: susan.m.tsang@gmail.com

*Pteropus* is a highly mobile genus native to the islands of the Indo-Australian Archipelago (IAA). Islands provide opportunities for isolation from sister taxa, promoting speciation. However, most of the landmasses in the IAA are oceanic in origin, and the ability of organisms to disperse to these islands varies. For volant taxa in the IAA, dispersal and founder-event speciation should then be the observed dominant biogeographic forces instead of vicariance. To empirically test this hypothesis, a multilocus species tree was reconstructed using *BEAST for *Pteropus* with representative species from each biogeographic region. We implemented the DEC and DEC+J model in BioGeoBears and the BBM model in RASP 3.0 to determine what biogeographic forces shaped the genus *Pteropus*. Wallacea was found to be the origin of the genus, with dispersal as the most common scenario through which lineages diverged. Founder-event speciation was the mechanism for expansion of *Pteropus* into Micronesia and Africa. The estimated rate of dispersal for *Pteropus* is an order of magnitude higher than any other volant taxa, highlighting the significant role of dispersal. The degree and potential for colonization of islands or subsequent *in situ* speciation are generally dependent on island area, age, and distance from mainland, but *Pteropus* do not seem to act as models predicted. The data presented here have shown dispersal to be a powerful mechanism that should be considered of greater importance than vicariance when studying the biogeography of volant taxa in the IAA.

## Taxonomy of Flying Foxes and Free-Tailed Bats (Mammalia: Chiroptera) with an Investigation into Ecology of *Pteropus lylei* in Vietnam

Vu Dinh Thong

Institute of Ecology and Biological Resources, Vietnam Academy of Science and Technology 18 Hoang Quoc Viet road, Cau Giay district, Hanoi, Vietnam; Corresponding author: vietnambat@gmail.com

Flying foxes (Pteropodidae) and free-tailed bats (Molossidae) have been known from Vietnam for almost 100 years. However, their taxonomy and ecology are poorly studied. Between 2013 and 2014, the author examined all specimen collections of flying foxes and free-tailed bats in the country and investigated the ecology of flying foxes. Vietnamese Flying foxes comprise three distinct taxa (*Pteropus* cf. *hypomelanus*, *P. lylei* and *P. vampyrus*), whereas results of taxonomic assessments confirm one genus and one species of free-tailed bats new to Vietnam. *Pteropus lylei* daily forages distances of over 40 km from the roost; feeds on at least five plant species: Tropical almond (*Terminalia catappa*), Brown-woolly Fig (*Ficus drupacea*), Calabur tree (*Muntingia calabura*) and Sacred Fig (*Ficus religiosa*); and mates in August and gives birth in April. The current range of flying foxes in Vietnam is limited to five provinces within the Mekong Delta region. Only two permanent roosting sites exist: Can Gio Biosphere Reserve of Ho Chi Minh city and Soc Trang city of Soc Trang province. Colony size in Soc Trang varies monthly and seasonally with a total number of individuals ranging between 453 individuals in April and 1,753 individuals in February. Vietnamese flying foxes are critically threatened by illegal hunting, habitat loss and other factors. In the absence of conservation actions throughout southern Vietnam, they face extinction in the wild. This presentation concludes with recommendations for research and conservation of bats in Vietnam.

## Gene Flow in Species of Bats Differing in Ecology and Morphology: A Comparative Study from the Andaman Islands

Rohit Chakravarty [1,2]*, Balaji Chattopadhyay[1], & Arjun Sivasundar[1]
[1]National Centre for Biological Sciences, GKVK Campus, Bangalore- 560 065, India; [2]Wildlife Conservation Society- India Program, Centre for Wildlife Studies, Bangalore, India; *Corresponding author: rohit.chakravarty77@gmail.com

Gene flow is the transfer of genetic material between separate populations and is one of the driving forces of evolution. While the capability to move among populations is an essential pre-requisite for gene flow, there is growing evidence that it may be more strongly determined by ecological traits (such as mating systems, diet, habitat preference and ability to tolerate disturbance). We compared genetic and morphometric differentiation in four species of bats — *Eonycteris spelaea*, *Cynopterus sphinx*, *Rhinolophus yunanensis* and *Hipposideros pomona* —which differ in their flight capability and roosting requirement to understand their effects in shaping genetic structure. Hypervariable region I of the mitochondrial control region was amplified from 40 *E. spelaea*, 28 *C. sphinx*, 45 *R. yunanensis* and 57 *H. pomona* sampled from locations spread across the Andaman archipelago. We found that populations of *E. spelaea* were nearly panmictic; *R. yunanensis* were differentiated into two groups, and *H. pomona* were differentiated into three groups. Consistent genetic and morphometric clusters were obtained for *C. sphinx* and the genetic break for *C. sphinx* occurs between Middle and South Andaman Islands, coinciding with the Jarawa Tribal Reserve. In conclusion, the lowest-dispersing, cave-roosting species shows highest population structure, but when flight capability is very well-developed, the effect of disjunct roost availability is offset. The genetic structure of *C. sphinx* for which panmixia was expected, is possibly confounded by the colonization history of its two genetic lineages and its habitat use which may prevent significant gene flow between the two lineages.

## A Test of Non-Allopatric Divergence in Putative Island Endemic Sister Bat Species – A Case of Taiwanese *Murina*

Hao-Chih Kuo[1], Shiang-Fan Chen[2], Yin-Ping Fang[3], James Cotton [4], Joe Parker[5], Gábor Csorba[6], Burton Lim[7], Chia-Hong Chen[8], Cheng-Han Chou[9], & Stephen J Rossiter[1]*
[1]School of Biological and Chemical Sciences, Queen Mary University of London, London E1 4NS, UK; [2]Center for General Education, National Taipei University, New Taipei City 23741, Taiwan; [3]Department of Biological Resources, National Chiayi University, Chiayi City 60004, Taiwan; [4]Wellcome Trust Sanger Institute, Wellcome Trust Genome Campus, Cambridgeshire CB10 1SA, UK; [5]Department of Zoology, Hungarian Natural History Museum, 1083 Budapest, Hungary; [6]Department of Natural History, Royal Ontario Museum, Toronto, ON M5S 2C6, Canada; [7]Shei-Pa National Park Headquarters, Miaoli County 36443, Taiwan; [8]Division of Zoology, Endemic Species Research Institute, Nantou County 552, Taiwan; *Corresponding author: s.j.rossiter@qmul.ac.uk

Cases of geographically restricted sister taxa are rare and may suggest potential non-allopatric divergence. *Murina gracilis* and *M. recondita* are both endemic to Taiwan and, based on morphology and mtDNA evidence, have been proposed as sister species. To test for non-allopatric divergence and gene flow in these taxa, we generated sequences using Sanger and Next Generation Sequencing, and combined these with microsatellite data for coalescent-based analyses. MtDNA phylogenies unambiguously supported the reciprocally monophyletic sister relationship between *M. gracilis* and *M. recondita*, however, clustering of microsatellite genotypes indicated several individuals with signatures of species admixture suggesting possible introgression. Sequencing of microsatellite flankers revealed that apparent admixture stemmed from microsatellite allele size homoplasy, and also uncovered an unexpected sister relationship between *M. recondita* and the continental species *M. eleryi*, to the exclusion of *M. gracilis*. To investigate these conflicts between ncDNA and mtDNA, we analysed sequences from 10 anonymous ncDNA loci with *BEAST and isolation-with-migration (IM) and found two distinct clades of *M. eleryi*, one of which was sister to *M. recondita*. We conclude that Taiwan was probably colonized by the ancestor of *M. gracilis* first, followed by the ancestor of *M. recondita* after a period of allopatric divergence between these two taxa. After colonization, the mitochondrial genome of *M. recondita* has been replaced by that of the resident *M. gracilis* via introgressive hybridization. Apparent signatures of sympatric divergence can thus arise from complex histories of allopatric divergence, colonization and hybridization, highlighting the need for rigorous analyses to distinguish among such scenarios.

## Genome-Wide SNP-Based Next Generation DNA Sequencing and 3D Geometric Morphometrics Helps to Resolve Long Standing Issues in Bat Taxonomy

Kyle N. Armstrong[1,2]*, Bastien Llamas[3]*, Terry B. Reardon[2], & Stephen C. Donnellan[1,2]*
[1]Department of Genetics and Evolution, The University of Adelaide, South Australia; [2]South Australian Museum, Adelaide, South Australia; [3]Australian Centre for Ancient DNA, The University of Adelaide, South Australia;
*Corresponding authors: kyle.armstrong@adelaide.edu.au, bastien.llamas@adelaide.edu.au, steve.donnellan@samuseum.sa.gov.au

Taxonomic ambiguities persist in certain bat groups because earlier studies were either limited by the available technology or sampling extent. The application of new genetic methods based on next generation DNA sequencing can provide the necessary power to resolve species boundaries, especially in combination with morphological datasets incorporating information on both size and shape. Preliminary observations are available for two cave-roosting taxa in arid northern Australia, which have remained taxonomically problematic despite studies over more than 20 years. In the case of an isolated southern population *Rhinonicteris aurantia*, which has been investigated previously using mitochondrial, microsatellite and traditional morphometric analyses, there is now sufficient information to make a decision about the taxonomy below the species level based on SNPs from a standardised gene capture probe set comprising hundreds of exon fragments. The presence of reproductive isolation between two cryptic sister taxa of *Taphozous* over a 1000 km long zone of potential sympatry and hybridisation was established using a second technique—Restriction site associated DNA markers (RADSeq). Three-dimensional geometric morphometrics based on microCT scans of skulls was useful for defining differences in cranial morphology between the two taxa. The cost of these investigations was only slightly higher than the older standard approach of sequencing one or more markers, and relegates capillary sequencing to a supporting role in DNA barcoding to confirm field-based identifications of groups where species boundaries have been resolved with genome screens.

## Host Specificity of Bat Flies (Diptera: Nycteribiidae and Streblidae) in Malaysia

Isham Azhar[1,2]*, Norwahidah Ismail[1], Faisal Ali Anwarali Khan[1], & Mohd Tajuddin Abdullah[2]
[1]Department of Zoology, Faculty of Resource Science and Technology, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak; [2]Centre for Kenyir Ecosystems, Kenyir Research Institute, Universiti Malaysia Terengganu, 20130 Kuala Terengganu, Terengganu, Malaysia; *Corresponding author: ishamzhar@gmail.com

Host specificity is a common trait in host and parasite association. The level of specificity exist at different levels, from the one that parasitise a particular host to the one that can be found on a range of hosts. A survey was conducted at different localities throughout Malaysia to investigate the host specificity of the bat flies. The survey had resulted in a total of 984 individuals of bat flies comprising of 15 species collected from 24 species of bats. The results showed that eight species of bat flies have monoxenous association with their hosts. Moreover, there were three species of bat flies having stenoxenous association while the rest were more of generalists. The results also confirmed that majority of the bat flies were highly specialised. Information on bat flies is very scarce in Malaysia and the findings from this study are crucial to add to the knowledge for these understudied taxa.

## Convergence in Eavesdropping Behavior? Responses to Frog Mating Calls by Old and New World Bats

Majorie May Dixon[1,2]*, Rachel A. Page[2], & Jodi L. Sedlock[3]
[1]Department of Integrative Biology, University of Texas at Austin, Texas, USA; [2]Smithsonian Tropical Research Institute, Gamboa, Panama; [3]Department of Biology, Lawrence University, Appleton, Wisconsin, USA;
*Corresponding author: m.m.dixon@utexas.edu

When animals call for mates, they also betray their location to potential predators. Eavesdropping on prey sexual advertisement signals is a widespread strategy across taxa, including for many species of hunting bats. Males advertising to attract mates experience opposing selection pressures acting on different components of fitness. To attract females, males must produce conspicuous advertisement signals, but to avoid predation they must evade notice by eavesdropping predators. Only one species of bat is currently known to capture frogs using their mating calls: *Trachops cirrhosus*, a phyllostomid bat occurring from Mexico through Brazil. The investigation of *T. cirrhosus* and its sexually advertising prey is a rich system that has been informative to both the study of sexual signal evolution and to the understanding of the influence of foraging strategy on behavior and cognition. Because this is the only species currently documented with this behavior, however, it is difficult to generalize results to other systems. The lesser false vampire bat, *Megaderma spasma*, is known to use prey-generated sounds to hunt (Tyrell, 1990), and frogs have been documented in its diet (Davison and Zubaid, 1992). Recent studies also suggest that *M. spasma* can use katydid calling song to approach prey (Raghuram *et al*., 2015), but it is currently unknown whether or not *M. spasma* approaches frog mating calls. I propose to test whether Philippine *M. spasma* use frog and insect calling song to capture prey, and whether this foraging strategy has resulted in behavioral and cognitive convergence between *T. cirrhosus* and *M. spasma*.

## Correlative 3D Imaging of Bat Genital Micromorphology

Anna Nele Herdina[1]*, Hanns Plenk Jr.[2], & Brian D. Metscher[1]
[1]Department of Theoretical Biology, Faculty of Life Sciences, University of Vienna, Vienna, Austria; [2]Bone and Biomaterials Research, Institute of Histology and Embryology, Medical University of Vienna, Vienna, Austria;
*Corresponding author: annanele.herdina@univie.ac.at

This ongoing study provides new insights into the 2D and 3D micromorphology of the *Pipistrellus pipistrellus* penis, as a foundation for further functional research. Histomorphological details can be studied non-destructively by x-ray microtomography (microCT) imaging, which is especially valuable after destructive evaluation of very few specimens by light microscopy of ground sections. Thus, quantitative and comparative studies of valuable or rare museum specimens are possible. Serial, surface-stained, undecalcified ground sections of the penes of 3 *P. pipistrellus* (1 sub-adult) were compared with microCT images of the bacula of *P. pipistrellus* (n=42, 3 sub-adult), *P. pygmaeus* (n=24), *P. hanaki* (n=9), and *P. nathusii* (n=11). The baculum in these species consists of a proximal base with two club-shaped branches, a long, slender shaft, and a small, forked distal tip. The baculum consists of lamellar bone around a central marrow canal, surrounded by woven bone. Entheses connect the distal ends of the corpora cavernosa to the proximal ends of the baculum. The urethra, surrounded by the corpus spongiosum, lies ventral of the corpora cavernosa and the baculum. The dorsal half of the urethral meatus is encased by the forked distal tip of the baculum. In the sub-adult bats, the baculum appeared not to be fully developed. The proximal branches of the baculum where shorter and did not contain a marrow cavity, while distal tip seemed to be fully developed. The combination with histomorphological techniques enabled a more precise interpretation of the histological structures shown in microCT images from all four *Pipistrellus* species.

## Bat Cave Vulnerability Index (BCVI): A Tool for Equating Bat Caves for Conservation Prioritization and Protection

Krizler C. Tanalgo[1]*, Alice Catherine Hughes[2], & John Aries G. Tabora[1]
[1]Department of Biological Sciences, College of Arts and Sciences, University of Southern Mindanao, Kabacan, Cotabato, Philippines; [2]Center for Integrative Conservation, Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences, Menglun, Yunnan, People's Republic of China; *Corresponding author: tkrizler@gmail.com

Identification of key habitat for wildlife is an essential step to plan and promote strategies for long-term conservation. Caves are an often overlooked habitat which harbour large numbers of ecologically important species and which require serious attention to protect effectively. These species include a wide suite of taxa, which are adapted to cave environments, but within cave systems bats are key providers of energy for other cave dependant species. In the Philippines about 78 species of bats are currently known and at least 30 of these depend on caves for their life history and survival. The Bat Cave Vulnerability Index (BCVI= $P_bP_g$) attempts to create a standard index for evaluating bat caves for conservation based on two criteria, the biological ($P_b$) and geophysical ($P_g$) potential of caves. The biological potential is represented by cave bat's community attributes such as population sizes, richness, endemicity, conservation status, species-site commonness. On the other hand, the geophysical potential is represented by the bat cave's physical and geographical features (accessibility of the cave, cave openings, effort of exploration, tourism potential, presence and intensity of cave internal and external disturbances). Pilot testing in the Philippines revealed that the index has effectively suggested bat caves for conservation priorities. Furthermore, the use of BCVI in bat cave assessment could be valuable rapid assessment tool in cave conservation with special concern to bats and cave geological features. We are now trying to apply and adapt the index to evaluate cave vulnerability more widely and develop appropriate protection and management strategies.

## Prioritizing Caves to Conserve Bats: Identifying Factors that Influence Cave Use

Kendra L. Phelps[1]*, Reizl Jose[2], Marina Labonite[2], & Tigga Kingston[1]
[1]Department of Biological Sciences, Texas Tech University, Lubbock, Texas USA; [2]Research & Development, Bohol Island State University, Bilar, Philippines; *Corresponding author: kendra.phelps@ttu.edu

Caves represent critical roosting sites for many bat species, housing some of the largest and most diverse aggregations of bat species in the world. However, cave-dependent bat populations are declining globally, with cave disturbance identified as the leading cause of these declines. In the Philippines, caves are protected under the National Cave Act, yet implementation of the Act is hindered by a lack of information to identify caves to protect. Thus, to prioritize caves to conserve cave bat assemblages, it is vital to identify factors that influence bat diversity in caves. No studies to date have explicitly quantified factors, both anthropogenic and environmental, that may shape assemblages of cave-dependent bats in the Philippines. Anthropogenic (visitation rate, hunting intensity, mining, etc.) and environmental (cave dimensions, microclimate, roost area) factors were assessed at 60 caves on Bohol Island in the central Philippines, and compared with species diversity and composition of bat assemblages documented over two consecutive nights at each cave. Between July 2011 and June 2013, we captured 7,419 individuals comprising 24 bat species. Using non-metric multidimensional scaling and generalized linear modeling, we elucidated the primary drivers that shape cave bat diversity and composition. Results are used to evaluate the significance of individual caves for maintaining viable populations of cave-dependent bats, a priority under the National Cave Act.

## Application of LiDAR Technology to Count Cave-Dwelling Bats Roost in Wind Cave Nature Reserve, Malaysian Borneo

Nursyafiqah Shazali[1]*, Teong Han Chew[2], Mohd Ridwan Abd Rahman[3], Mohd Shahir Shamsir[2], Roberta Chaya Tawie Tingga[3], & Faisal Ali Anwarali Khan[1]

[1]Department of Zoology, Faculty of Resource Science and Technology, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia; [2]Department of Biological Sciences, Faculty of Bioscience and Bioengineering, Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malaysia; [3]Centre for Pre-University Studies, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia; *Corresponding author: shazalisyafiqah@gmail.com

Introduction of LiDAR (Light Detection and Ranging) scanning system, an optical remote sensing technology into biological scientific purposes have open many conceivable research especially on cave wildlife surveys. Information on bats' roost inside a cave is an example of such surveys and essential for conservation management and practice. Conventionally, bats roost count is potentially a disruptive, repetitive method and are time consuming. To this end, terrestrial LiDAR able to generate images of high resolution, precise and yet accurate three dimensional (3D) features of roosting bats together with their spatial distribution pattern and topological structure of the cave. We utilize this technology to census bats that roost inside the cave which include direct roost count for species that roost individually and estimated based on laser return intensity value from the LiDAR images for bats in larger clusters. LiDAR data were analyzed to identify colony size of bat population, and determine surface area of their roosts. The group of bats that roosts in large clusters, *Penthetor lucasi* were determined by automated counting using connected components labelling. For bats' that roost separately from other individual, automated direct count was performed by differentiating bats and cave surfaces based on the reflectance values. We successfully count 979 individuals of *P. lucasi* and 1907 individual of insect bats of nine species from four families. Terrestrial LiDAR provided a novel way to survey cave bats population that is precise and accurate, for less amount of time.

## Cataloguing Malaysian Caves using LiDAR: Bats Included

Teong Han Chew[1]*, Nursyafiqah Shazali[2], Faisal Ali Anwarali Khan[2], Liz Price[3], Wan Juliana Wan Ahmad[4], & Mohd Shahir Shamsir[1]

[1]Bioinformatics Research Group, Faculty of Biosciences and Medical Engineering, Universiti Teknologi Malaysia, 81300 UTM Skudai, Johor, Malaysia; [2] Department of Zoology, Faculty of Resource Science and Technology, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia; [3] International Union of Speleology; [4] School of Environmental and Natural Resource Sciences, Faculty of Science and Technology, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia; *Corresponding author: teonghan@gmail.com

Conventional cave surveying methods involve extensive manual measurements and sketches that can only produce two-dimensional (2D) images. Although these 2D images can be converted into three-dimensional (3D) maps, the resulting output is only good as an estimation (extrapolation, interpolation) given that this manual measurements are done only at certain intervals. Light Detection and Ranging (LiDAR) technique can be applied to cave surveying, producing a true 3D model without the intermediate 2D maps. Since LiDAR operates based on the principle of light, the device (known as a laser scanner) is able to capture any surface that has the ability to reflect light (typically laser). Apart from capturing the cave structure and morphology, LiDAR can be utilized to show cave fauna within range (notably bats and swiftlets). Interactive data visualization can then be converted from the raw point clouds and hosted online for reaching a bigger audience and raising awareness as well as interest. We have applied this methodology to study several cave complexes in Peninsular Malaysia. We aim to show that LiDAR is versatile in representing caves in various formats for various purposes (high resolutions for accurate measurement, low resolutions for overview and online interactive maps for observation). Temporal cave mapping is also possible as we show in our case study. Most importantly, the accuracy of LiDAR eliminated the need for revisiting the cave in order to do any further relevant data analysis.

## Review of Bats of the Limestone Karst of Northern Chin State, Myanmar

Moe Moe Aung[1,3]*, Soe Soe Tun[2], Khin Aung Myint[3], Van Neih Mang[3], & Lal Duat Lian[3]
[1,3]Department of Zoology,Yangon University, Yangon,Myanmar; [2]Department of Zoology, Yadanarpon University, Mandalay, Myanmar; [3] Department of Zoology, Kalay University, Kalay, Myanmar;
*Corresponding author: moeaung189@gmail.com

Although systematic research of bats in Myanmar has been conducted since 1863, very few studies were conducted in Chin state. A total of 97 species of bats has been recorded in Myanmar. It includes the results of a recent bat survey in Northern Chin State during which 11 species of bats were collected. Taxonomic approach based on the external characters, morphology of skull, teeth, baculum characters and echolocation call frequency have been applied to confirm the specific and generic status. Morphometric characters of all species of skull and teeth and seven species of baculum were examined. Echolocation call frequency of the species of *Taphozous melanopogon, Rhinolophus affinis, Rhinolophus thomasi, Rhinolophus luctus, Hipposideros pomona and Hipposideros armiger* were recorded. Among the collected species, *Rhinolophus luctus* and *Hipposideros armiger* were found over 90 years ago in Chin hills. Therefore all the bat species were collected as the first time record for Chin State. Ecology, distribution and conservation status were also studied.

## Cave Selection and Reproductive Phenology of Insectivorous Bats in Southern Cambodian Karst and their Conservation Implications

Lim Thona[1]*, Julien Cappelle[2], Hoem Thavry[1], Hul Vibol[3], & Neil M. Furey[4]
[1]Centre for Biodiversity Conservation, Room 415, Department of Biology, Faculty of Science, Royal University of Phnom Penh, Confederation of Russia Boulevard, Phnom Penh, Cambodia; [2]Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD), UR Animal et Gestion Intégrée des Risques (AGIRs), F-34398, Montpellier, France; [3]Institut Pasteur du Cambodge, Virology Unit, BP983, Phnom Penh, Cambodia; [4]Fauna & Flora International (Cambodia Programme), PO Box 1380, No. 19, Street 360, BoengKeng Kong 1, Phnom Penh, Cambodia, 12000;
*Corresponding author: lim.thona@yahoo.com

The ecology and conservation status of cave-dwelling bats is almost unknown in Cambodia. We evaluated cave selection, reproductive phenology and conservation threats to insectivorous bat species inhabiting three limestone caves (Bat Khteas, Vihear-Tuk Bonn and Trai Lak) in Kampot province, southern Cambodia. Caves were compared in terms of their internal dimensions and sampled monthly for variation in species composition and flight maneuverability from February to July 2014.Bat reproductive phenology was investigated by live-trapping and threats were identified from direct observation, interviews with guano collectors and cave visitor data. Bat Khteas cave had higher bat species richness (nine species) and larger populations than the Vihear Tuk-Bonn and Trai Lak caves (five species apiece) due to its greater size and complexity providing a wider range of environmental niches for different bat species. Reproductive data from 735 bats of two insectivorous species (*Taphozous melanopogon* and *Hipposideros larvatus*) suggest that birth peaks largely occur in April-May and lactation from April-July, the beginning of the wet season. As this period of heightened vulnerability coincides with the Khmer new year (April) when cave visitation is greatest, this is likely to affect bat population recruitment. Hunting of bats for bush meat, opportunistic recreation and unregulated guano collection also threaten the local bat fauna. Improved law enforcement, public education and promotion of sustainable guano collection techniques are needed to conserve the cave bats of southern Cambodia.

## Bat Viral Diversity in Different Anthropogenic Disturbance Gradients in Kinabatangan, Sabah, Malaysia

Mei Ho Lee[1]*, Tom Hughes[1], Jimmy Lee[1], Simon J. Anthony[1], Kris Murray[2], Carlos Zambrana-Torrelio[1], Elizabeth Loh[1], Senthilvel Nathan[3], Benoit Goossens[3,4,5], Jonathan H. Epstein[1], & Peter Daszak[1]

[1]EcoHealth Alliance, New York, USA; [2]Faculty of Natural Sciences, The Grantham Institute For Climate Change, Imperial College London, London, UK; [3]Sabah Wildlife Department, Kota Kinabalu, Sabah, Malaysia; [4]Danau Girang Field Centre, Kota Kinabalu, Sabah, Malaysia; [5]Organisms and Environment Division, School of Biosciences, Cardiff University, Cardiff, UK; *Corresponding author: lee@ecohealthalliance.org

Bats are reservoirs of many viral zoonoses. Anthropogenic changes can have major influences on emerging zoonoses through changes in bat ecology. We conducted viral surveillance as part of the USAID PREDICT Deep Forest project. Three sites at three levels of human disturbance (disturbed, intermediate and pristine) along the Kinabatangan River were chosen. Each site was sampled once per season (wet, dry) for 5 nights. Swabs and blood were collected prior to the bats release. Samples were screened at the Sabah Wildlife Department, Wildlife Health, Genetics and Forensics Laboratory, and the Centre for Infection and Immunity, Columbia University, New York using PCRs and were confirmed by sequencing. In disturbed sites (n=65 bats), viral DNA was detected in 12.30% of sampled bats – one coronavirus, two adenoviruses, one astrovirus and three herpesviruses. In intermediate sites (n=186 bats), we found one astrovirus, three adenoviruses and 7 herpesviruses, totaling 5.88% of sampled bats. In pristine sites (n=482 bats),we found two coronaviruses including one related to severe acute respiratory syndrome coronavirus (SARS-CoV), two paramyxoviruses, one adenovirus and one herpesvirus, totaling 2.01% of sampled bats. Z-test for proportions showed pristine sites results are significantly different from the other two, while intermediate and disturbed sites results are not significantly different from each other. Lower number of viruses from pristine site bats might indicate healthier environments due to less human disturbance. The SARS-CoV-related strain from a pristine site further support the importance of protected habitats as buffer zones to reduce human-bat contact and therefore reducing disease transmission risk.

## Hematological Profile of Bats in Musuan, Bukidnon, Philippines

Jessica L. Gamolo*, Heidi C. Porquis, Reggie Y. Dela Cruz, Florfe M. Acma, Alma B. Mohagan, & Lorelei Gloria A. Samaniego

Department of Biology, College of Arts and Sciences, Central Mindanao University, University Town, Musuan, 8710, Bukidnon, Philippines; *Corresponding authors: 40ppy.essie@gmail.com

This study focused on the profiling of hematocrit, hemoglobin, total white blood cell and differential white blood cell counts. Blood samples were from one hundred fifty (150) bat individuals captured between August to September, 2014 through mist netting. Bats were marked after sampling. Individual bats were given sugar syrup before release. A total of nine species belonging to family Pteropodidae, Vespertilionidae and Megadermatidae were recorded in the present study. Among the nine species, three are endemic to the Philippines; *Eonycteris robusta* is listed as nearly threatened by the IUCN Red List; and *Megaderma spasma* appears as a new record in Musuan, Bukidnon, Philippines. Hematological values were 39-51% for hematocrit, 13-17 % for hemoglobin, 3,450-11,150 $mm^3$for total white blood cell, 32-76% for neutrophils, 21-68% for lymphocytes, 0-5% for both eosinophil and monocyte, and 0% for basophil. A weak positive correlation was noted between eosinophil and monocytes and a strong positive correlation between Hct and Hb. A weak negative correlation between TWBC and eosinophils and a strong negative association between lymphocytes and neutrophils were observed. Other hematological values were found to have no association. Hematological values among species with respect to age and sex variations did not exhibit any difference.

## Blood Serum Glucose and Potassium Profiles of Frugivorous Bats (*Ptenochirus jagori* Peters) in Central Mindanao University, Bukidnon Philippines

Enjyl Jay A. Soriano, Alma B. Mohagan, Zeus S. Elumba, & Heidi C. Porquis*
Department of Biology, College of Arts and Sciences, Central Mindanao University, University Town, Musuan, 8710, Bukidnon, Philippines; *Corresponding author: dingbiocmu@yahoo.com

A profile of blood serum glucose and potassium in frugivorous bats, *Ptenochirus jagori* Peters, 1861 was done on 45 individuals captured through mist netting after prior permission. The colorimetric and ion selective electrolyte methods were used respectively to get the profiles. The relationship between these values to each other and with age and sex was determined. The 45 bat samples included 77.8% males (M) and 22.2% females (F); 35.6% juveniles (J) and 64.4% adults (A). Mean values (in mmol/l) were,J (3.67), A ( 3.62), F ( 6.36), and M (6.32) for glucose, and J (4.38), A ( 4.50); F (4.40), M (4.47) for potassium. Pearson's correlation coefficient (r= - 0.180) for glucose and potassium is not significant. Furthermore, results show that variation in blood serum glucose and potassium levels is not linked to their age and sex.

## What's on the Menu for Hungry Mums? Food Availability for Malaysian Insectivorous Bats

Nurul-Ain Elias[1,2]*, Rosli Hashim[3], & Tigga Kingston[1]
[1]Department of Biological Sciences, Texas Tech University, Lubbock, Texas, USA; [2]School of Biological Sciences, UniversitiSains Malaysia, Penang, Malaysia; [3]Institute of Biological Sciences, Faculty of Science, Universiti Malaya, Kuala Lumpur, Malaysia; *Corresponding author: ain.elias@ttu.edu

Patterns of insect availability in tropical and subtropical forests are not as distinct as those of flower and fruit resources. However, previous studies report that many tropical insectivorous bat species exhibit a seasonal pattern in their annual reproduction, although few studies have related the timing of reproduction to the availability of insect resources. We hypothesized that peaks in annual bat reproduction will reflect the availability of species-specific dietary resources, and predicted that insectivorous bats from Krau Wildlife Reserve, Malaysia would synchronize their breeding season with the fluctuation of certain insect Orders. To test this prediction, we tracked reproductive phenology of nine insectivorous bat species simultaneously with nine dominant insect Orders and local weather variables (temperature and rainfall) for 21 months. All insect Orders differed in their peak of abundance except Orthoptera. While Coleoptera, Homoptera, and Blattodea were highly abundant from March-May, Isoptera recorded its highest peak from October-November. Lepidoptera, Hymenoptera, Hemiptera and Diptera were at their highest abundances during the dry season. Most lactating bats were recorded April – June. Hymenoptera and Homoptera were positively correlated with lactation in a single species, *Kerivoula pellucida* and *Rhinolophus lepidus,* respectively. Peak abundance of Isoptera was associated with lactating *K. intermedia* and *K. papillosa*. Only Hemiptera abundance correlated with lactation in the cave bat species *Hipposideros cervinus, H. bicolor* 142 kHz, *R. stheno* and *R. lepidus*. Overall, insectivorous bats matched their critical stage in reproduction with the maximum availability of certain insect Orders.

## Food Habits of *Rhinolophus affinis, Emballonura monticola* and *Hipposideros diadema* roosting in an Agricultural Landscape at Kota Gelanggi, Malaysia

Jin Sia Ting*, Yong Foo Ng, & Akbar Zubaid
School of Environmental and Natural Resources, Faculty of Science and Technology, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia; *Corresponding author: jinsia87@yahoo.com

Insectivorous bats are major consumers of nocturnal insects, many of which are economically important pests. Despite Malaysia being the centre of Old-World bat diversity little is known about the diets of most of these species. Faecal analysis gives us an insight into the feeding ecology and food preferences of bats. Diets of three species of insectivorous bats, namely *Rhinolophus affinis*, *Emballonura monticola* and *Hipposideros diadema* were analysed based on faecal pellets. Two hundred fifty faecal pellets for *R. affinis* and *H. diadema*, and 200 pellets for *E. monticola* were collected from two caves in the Kota Gelanggi Limestone complex, Pahang from April to August 2014. The percentage of occurrence of prey for each species was calculated. The diet of *R. affinis* consisted of 36.0% Lepidoptera, 32.8% Coleoptera, 15.2% Isoptera, 8.0% Hymenoptera, 4.4% Hemiptera, and 3.6% Diptera which suggests it preyed both on soft-bodied and hard-bodied insects. For *E. monticola*, the diet consisted of 59.5% Hymenoptera, 8.0% Isoptera, 4.0% Coleoptera and 3.5 % Hemiptera which suggests a preference for small and soft-bodied insects. The diet of *H. diadema*, consisted of 43.6% Isoptera, 24.8% Coleoptera, 6.0% Hemiptera, 3.2% Lepidoptera and 0.4% Diptera which showed a preference for insects with a hard and thick exoskeleton but switched opportunistically to termites during the swarming season. The dietary profile of these bats suggest that they may play an important role as biological control agents in the agroecosystem.

## Comparison of Food Habits of the Lesser Asiatic Yellow Bat (*Scotophilus kuhlii*) in an Agricultural and Urban landscape

Nur Atiqah Abd Rahman*, Ng Yong Foo, & Akbar Zubaid
School of Environmental Science and Natural Resources, Faculty of Science and Technology, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia; *Corresponding author: nursyiqa@gmail.com

*Scotophilus kuhlii* is a widespread species frequently associated with human habitation and can be found roosting in large colonies but little is known of its food preferences. This dietary study was conducted in 2 different landscapes: an agricultural landscape in the Tasik Chini catchment and an urban landscape in Universiti Kebangsaan Malaysia (UKM). Six hundred faecal samples from 120 individuals were examined over six months. Seven insect orders were recorded in the diet namely, Coleoptera, Hemiptera, Isoptera, Lepidoptera, Hymenoptera, Diptera and Orthoptera. The diet expressed as percent volume, consisted largely of Coleoptera in Tasik Chini and UKM followed by Hemiptera, while Diptera formed the lowest percentage in both areas. Chi-square tests showed that there were no significant differences in diet preferences between males and females in each locality. We also found no significant differences in the diet of *Scotophilus kuhlii* between Tasik Chini and UKM. Cluster analysis showed 69.9% similarity of food items selected between Tasik Chini and UKM. The results suggest that although there were landscapes differences between Tasik Chini and UKM, prey selection by the bats showed a high degree of similarity.

## Observations on the Ecology, Echolocation & Foraging Behaviour of the Emballonurid bat, *Saccolaimus saccolaimus,* in Australia & Southeast Asia

Roger Coles[1,2]*, Richard Meutstege[3], Chris Clague[4], David Lane[5], & Hugh Spencer[3]
[1]School of Biomedical Sciences, The University of Queensland, Brisbane, QLD 4072, Australia; [2] School of Earth, Environmental & Biological Sciences, QUT, Brisbane QLD 4000; [3]Cape Tribulation Tropical Research Station, Cape Tribulation, QLD 4873, Australia; [4]PO Box 901, Edmonton, QLD 4865, Australia; [5]Dept. of Biology, Faculty of Science, Universiti Brunei Darussalam, Brunei; *Corresponding author: r.coles@uq.edu.au

The Bare-rumped sheath tail bat *Saccolaimus saccolaimus* is centrally distributed in SE Asia but it has a wide range extending from India and as far eastwards as the Solomon Is. Extralimitally, it inhabits the northern tropical regions of Australia with two populations separated geographically on either side of the Gulf of Carpentaria: they have morphological variation (pelage) but are genetically almost identical. Over most of its range *S. saccolaimus* is considered a common species but relatively few records exist although. Few roosts are known but it is a colonial species living in trees and will occupy buildings. Preferred habitat can be considered tropical rainforest although Australian records extend to adjacent savannah woodlands. In Australia we have recently made the first detailed observations of foraging behavior in *S. saccolaimus.* It is a large open foraging emballonurid species and so far in Australia it has not been live captured whilst foraging. Therefore we have relied on a species-specific duplet or triplet frequency alternating calling pattern (most energy in the 11- 25 kHz band, see Coles *et al.*(2012 Aust. Bat Soc. Newsletter 38:35-36) to identify individuals foraging at night. It has been possible to visually observe *S. saccolaimus* commuting at dusk and dawn in the Cape Tribulation area of north Queensland. A roosting area has been located in lowland tropical rainforest, near the top of a ridge about 150m above sea level and only 1km inland from the coastline. Individual bats from this roost area have been found to be foraging along a narrow coastal strip just above canopy height along a 2km section of mangrove and littoral forest immediately adjacent to the beach. Bats have been tracked in another 10 locations between Cape Tribulation, and the Daintree River, and up to 15km inland. Ultrasound detectors (*Nanobat*) on a pole above canopy height in the foraging areas, have recorded detailed echolocation calling behaviour for this species, including all phases of prey capture. By monitoring the alternating call to initially track individuals, considerable flexibility was noted in the temporal patterning and changes in pulse structure during flight and foraging. Social interactions and calling between individuals was observed and a very peculiar 'flight song' has been identified. Further studies of *S. saccolaimus* in Southeast Asia (Indonesia, East Malaysia, Brunei and Singapore) show that there are variations for this unusual alternating call pattern compared to the Australian population. Individuals have been captured from a breeding colony in the roof of a house in Brunei to examine morphology and genetics and echolocation behaviour.

## Echolocation Calls and Diet Analysis of Michrochiropteran Species from Northern Western Ghats of Maharashtra

Kranti Yardi & Swapnil Girade*
Institute of Environment Education and Research Bharati Vidyapeeth University, Pune, India;
*Corresponding author: swapnilgirade88@gmail.com

The NorthernWestern Ghats of Maharashtra are a part of the globally recognized biodiversity hotspot. They are characterized by elevated mountain peaks, plateaus, semi evergreen forest, forts, old temples, large crevices and caves. For many species of bats these sites provide excellent roosting conditions in these areas. At the preliminary phase of the study, distribution of Michrochiropteran species was investigated. Preliminary study identified 20 sites for different bat species in the area. Further study consisted of collection of morphological data, fecal samples, and echolocation calls for selected species. The time expanded echolocation calls were recorded using Peterson "D240X" detector and analyzed using "Bat Sound" software. Discriminant function analysis was applied to classify and describes the echolocation calls. This paper presents the echolocation calls for *R. beddomei, R. rouxii, R. lepidus, M. lyra, M. spasma, H. speoris, H. fulvus, P. javanicus*, and *P. tenieus* from Northern Western Ghats of Maharashtra. Dietary analysis was performed for *H. speoris*, and *R. beddomei* by examining prey items in fecal pellets using methods described in Whitaker (1988) and the prey taxa were identified to order level. Percent volume and percent frequency occupied by each prey order in the pellets of *R. beddomei* shows, Coleoptera (34 % by volume), Lepidoptera (7%), Diptera (18%) as major prey composition while *H. speoris* shows Lepidoptera: 65 %, Coleoptera: 9 %, Diptera: 6.28 % as major prey items and other prey items in trace amounts during the dietary analysis.

## Roost Selection by Bats in the Anthropogenic Areas along the West Coast of Peninsular Malaysia

Lee-Sim Lim[1]*, Syarafina Ramli[2], Mohd Rani Ismail Hashim[1], Sheema Abdul Aziz[3,4,5], Christine Fletcher[6], Jin Sia Ting[2], Nur Atiqah Abdul Rahman[2], Nur Izzati Abdullah[1], Shahrul Anuar Mohd Sah[7], & Akbar Zubaid[2]

[1]School of Distance Education, Universiti Sains Malaysia, 11800 Penang, Malaysia; [2]School of Environmental Science and Natural Resources, Faculty of Science and Technology, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia; [3]Rimba, 4 Jalan 1/9D, 43650 Bandar Baru Bangi, Selangor, Malaysia; [4]Muséum National d'Histoire Naturelle (MNHN), Paris, France; [5]University of Nottingham Malaysia Campus (UNMC), Malaysia; [6]Forest Research Institute Malaysia, 52109 Kepong, Selangor, Malaysia; [7]School of Biological Sciences, Universiti Sains Malaysia, 11800 Penang, Malaysia;
*Corresponding author: leesim.lim@usm.my

Intense developments in Peninsular Malaysia in the last few decades have caused rapid loss of natural habitat in the country. Wildlife need to either immediately adapt to their shrinking habitat or to live in the anthropocene in order to survive. Bats have a long history in sharing habitat with human, especially frugivorous bats and open-space bats. Here, we report bat species detected to live in anthropogenic areas and describe their roosts. In the last three years, we focused our survey along the west coast of Peninsular Malaysia, which is the most developed and highest populated zone in Malaysia. Each of the detected sites was visited once every fortnight for a minimum period of two months to confirm that it is a permanent bat roost. Physical and micro climatic measurements of the roost were recorded. At least four species of insectivorous bats (*Taphozous melanopogon*, *T. longimanus*, *Hypsugo macrotis*, and *Scotophilus kuhlii*) and three species of frugivorous/nectar bats (*Cynopterus brachyotis*, *C. horsfieldii* and *Eonycteris spelaea*) were identified to permanently roost in the man-made structures; the basement of high-rise building, historic school building and abandoned wooden houses. Some of these bat species are known to be forest-dependent. Detailed conditions of the detected roosts will be discussed. This preliminary study shed light on the roosting ecology and diversity of bats in the Malaysian anthropocene landscape which would allow us to further assess the adaptability of bats towards habitat change and facilitate future research on bat-human mutual co-existence.

## How a Pitcher Plant Facilitates Roosting of Mutualistic Woolly Bats (*Kerivoula hardwickii*)

T. Ulmar Grafe[1]*, Yen Shan Lim[1], Caroline R. Schöner[2], Michael G. Schöner[2], & Gerald Kerth[2]

[1]Faculty of Science and Institute for Biodiversity and Environmental Research, Universiti Brunei Darussalam, Tungku Link, Gadong 1410, Brunei Darussalam; [2]Zoological Institute and Museum, Greifswald University, J.-S.-Bach-Str. 11 / 12, D-17489 Greifswald, Germany; *Corresponding author: ulmar.grafe@ubd.edu.bn

Mutualistic interactions between animals and plants play a key role in the organization of ecological communities. The strength of mutual dependencies between interacting species will depend, in part, on the physical fit between the two partners that is the result of evolutionary, ecological, and functional specialization. This study investigates how small morphological changes in pitcher structure of the carnivorous pitcher plant *Nepenthes hemsleyana* facilitates the roosting of the woolly bats *Kerivoula hardwickii* that in turn use the pitchers as toilets and provide the plants with valuable nitrogen. Field observations in Brunei Darussalam, Borneo showed that numerous morphological traits of *N. hemsleyana* set it apart from its close relative *Nepenthes rafflesiana* that is not visited by bats. Aerial pitchers of *N. hemsleyana* were more elongate, cylindrical, and strongly tapered. Furthermore, digestive fluid levels and fluid volume were lower increasing the habitable space within the pitcher. The bats' body length and body width were well matched to the length and diameter of *N. hemsleyana* aerial pitchers. Pitchers wider at fluid level than the largest bat were never occupied. Our study demonstrates that several key features of the *N. hemsleyana* aerial pitchers facilitate bat roosting and suggest that *Nepenthes* nitrogen-acquisition strategies have evolved by modifying and prioritizing different pitcher structures. We discuss how using pitchers as roosts has allowed *K. hardwickii* to exploit habitats that offer few roosting sites to other species of bats.

## Acoustic Lure Enhances Capture Rates of Echolocating Bats in Forest and Open Habitats in Australia

David A. Hill[1,2]*, Paul A. Barden[3], & Kyle N. Armstrong[4,5]
[1]Primate Research Institute, Kyoto University, Inuyama, Aichi, 484-8506, Japan; [2]Wildlife Research Center, Kyoto University, Sakyo-ku, Kyoto, 606-8203, Japan.; [3]Ecological Management Services, Coolum Beach, Queensland 4573, Australia; [4]School of Earth and Environmental Sciences, The University of Adelaide, Adelaide, South Australia 5005, Australia.; [5]South Australian Museum, Adelaide, South Australia 5000, Australia; *Corresponding author: hill.david.2u@kyoto-u.ac.jp

Capture is an essential part of field research and surveys for echolocating bats where acoustic monitoring alone is not sufficient. While some species can be captured fairly readily, others are much more elusive, even at sites where they are abundant. The Autobat acoustic lure has greatly increased both numbers and diversity of bats captured in a variety of forest and woodland habitats in U.K., Japan and Malaysia. Here we report preliminary assessments of the effectiveness of this technique in various habitats in Australia, including tropical, subtropical and warm temperate forests, as well as a more open landscape (the Mulga zone, S.W. Queensland). Capture rates in harp traps with lures were significantly higher than in control traps in all habitat types. The lure was particularly effective for three species of *Nyctophilus*, which typically fly in forest interiors, but also attracted large numbers of two species of *Miniopterus*, which most frequently fly in open spaces and along edges. Smaller numbers of several other edge and open habitat species (including *Chalinolobus* spp., *Falsistrellus tasmaniensis*, *Saccolaimus saccolaimus* and *Mormopterus petersi*) were also captured more frequently, or exclusively, in traps with lures. Our results indicate that the Autobat acoustic lure has great potential for improving capture efficiency (both numbers and diversity) of echolocating bats in Australia. Promising areas for further investigation include targeting the lesser known species of *Nyctophilus*, which include several Critically Endangered and Data Deficient species, and the development of more effective stimuli for attracting open-sky bats.

## Quantifying Bat Activity through Acoustic Sampling in a Riverine Forest at Gunung Mulu National Park, Malaysian Borneo

Ellen McArthur[1]*, M. T. Abdullah[2], & Faisal Ali Anwarali Khan[1]
[1]Department of Zoology, Faculty of Resource Science and Technology, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia; [2]Center For Kenyir Ecosystems Research, Kenyir Research Institute, Universiti Malaysia Terengganu, 21030, Kuala Terengganu, Terengganu; *Corresponding author: ellenmcarthur@gmail.com

Habitat loss and fragmentation have been identified as the major factors contributing to the decline of bat populations in the tropical forests of Southeast Asia. Therefore, there is an urgent need to improve the efficiency of surveys to document the diversity, distribution and habitat requirements of bats in both protected and disturbed areas. In Gunung Mulu National Park, a tropical karst landscape, with high diversity and large populations of bat species, passive acoustic sampling with a SM2Bat detector is being conducted at rivers, trails and gaps in riverine forest. Recordings from 36 nights have been analysed and compared to the reference echolocation calls recorded for 22 species that were previously captured from the same area. Preliminary results suggest that insectivorous bat activity, measured by the number of passes, is highest in forest gaps, followed by rivers and trails. However, higher diversity of species and call types have been detected at rivers. The most frequently detected species was *Miniopterus australis* followed by *Rhinolophus creaghi*, *Hipposideros galeritus*, *H. cervinus*, a *Myotis* species and an unidentified call type similar to *M. australis* but lower in frequency. Evidence of foraging activity, in the form of feeding buzzes was detected at both gaps and rivers. Acoustic sampling is currently emerging as an essential component in a variety of sampling methods used to provide crucial information on the conservation needs of bats in the threatened forests of this region.

## Operationalizing Bat Conservation Education Program in Bangladesh with a Special Focus of Nipah Encephalitis Outbreak

M. N. Islam[1]*, A. H. Shaikat[2], S. A. Khan[2], Ariful Islam[3], M. M. Hassan[2], & M. A. Hoque[2]
[1]One Health Fellow, Massey University, New Zealand; [2]Chittagong Veterinary and Animal Sciences University, Khulshi, Chittagong-4202, Bangladesh; [3]Eco Health Alliance, NY, USA; *Corresponding author: nurul.dvm@gmail.com

Bats are fascinating mammals group plays role in pollination, seed dispersal and control of insect pests. Unfortunately, they are considered as natural reservoirs of public health zoonotic diseases such as Nipah encephalitis, Hendra, SARS, Rabies etc. Due to recent and rapid destruction of their natural habitats bats are more often coming in close contact with humans who pose serious public health threats to transmit zoonotic diseases. Nipah encephalitis is a highly fatal zoonotic disease causing human mortality up to 100%. Bangladesh has been experiencing outbreaks of Nipah encephalitis since 2001 resulted in several human deaths. Date palm sap contamination by bat feces and urine has been identified as an important risk factor for transmission of Nipah infection in human. Very specifically the Nipah outbreak in 2014 drew high media attention and government intervention. Therefore, selling and consumption of date palm sap has been banned to prevent the Nipah problem in this country. Nipah associated with bats and different myths and misconception about bats in this country have created some negative impressions on bats which is threatening bat conservation attempt. Therefore, a bat conservation education program was urgently needed to change the attitude of peoples in Bangladesh. We are conducting conservation education program with focusing on prevention method of Nipah and informing positive role of bats to the nature. The method of conservation education program applied under the study along with some important findings will be presented in the conference. The method can implicate in bat education program of other disease outbreak country in the world.

## An Assessment Conservation Status of Bats in India and the Impacts of Bats on Public Health

D. Pilot Dovih[1]*, Reeta S. Mani[2], M. A. Ashwini[2], Balaji Chattopadhyay[3], Kritika Garg[3], Uma Ramakrishnan[1], & S. N. Madhusudana[2]
[1]Department of Ecology and Evolution, National Centre for Biological Sciences, Bangalore, India; [2]Department of Neurovirology, WHO Collaborating Centre for Reference and Research on Rabies, National Institute of Mental Health and Neurosciences, Bangalore, India; [3]National University of Singapore, Singapore; *Corresponding author: pilot@ncbs.res.in

Bats are critical elements in maintaining the ecosystem. However of late, bats are recognized as important reservoirs for many viruses. Nagaland, a north-eastern state in India, falls in the Indo-Myanmar biodiversity hotspot. Every year thousands of cave-dwelling bats are harvested for consumption in villages as a tradition in Nagaland. One-third of the emerging human infectious diseases are zoonotic. Studies on different species of bats in China and Thailand have given important insights into zoonotic diversity of viruses in this region. But there is a dearth of credible reports from India, not due to the lack of infectious pathogens in Indian bats, but probably reflecting the absence of systematic surveillance studies. We collected 250 tissue samples of three species from the harvested bats to determine potential population decline using molecular techniques. We found signature of population decline, suggesting hunting pressure might be driving the trend. As a preliminary study, we examined brain samples of 110 harvested bats for the presence of rabies viral RNA by molecular methods and blood (serum) samples from 65 bats for presence of neutralizing antibodies against rabies virus. None of the 110 brain samples were positive for rabies viral RNA suggesting the absence of an active rabies infection. However 5/65 (7.6%) serum samples had evidence of rabies virus specific neutralizing antibodies, suggestive of recent exposure to rabies virus. This indicates the necessity of extensive surveillance studies in bats for presence of rabies virus as well as other pathogens that may impact public health.

## Batting Trekkers – A Unique Citizen Science Initiative Documenting Bat Diversity and Roosts in Maharashtra, India

Rahul Prabhukhanolkar[1,2]*, Saili Palande-Datar[3,4], Anvith K.S.[1,2], & Avishkar Munje[1]
[1]Indian Bat Conservation Research Unit, H.No 762, 1st cross Bhagyanagar, Belgaum -590006, India, Belgaum; [2]Mhadei Research Centre, c/o Rachana Infotech, 1st floor, mahalaxmi Plaza, PRD corner, Tilakwadi, Belgaum- 590006, India; [3]Malabar Nature Conservation Club, Village Amboli, Sawantwadi, Dist.Sindhudurg, Mharashtra; [4]Samvidya Institute of Cultural Studies, c/o Ambarish V. Khare, Khunya Murlidhar Temple, Sadashiv Peth, Pune 411030, India;
*Corresponding author: pkrahul85@gmail.com, info@ibcru.org

The state of Maharashtra in India possesses a unique landscape of historical significance. Due to the vast coastline on the western side, along with the parallel Western Ghats mountain range, the region has always been of strategic importance for colonialists, traders and rulers. Rulers of different rulers and religious communities throughout the history have built infrastructure like forts, fortress, buildings, caves (manmade and natural), temples, tunnels, water tanks etc. Many of these abandoned structures, spread across landscape, now provide roosting sites for several species of bats and simultaneously attract a large trekking community (formal and informal –regional groups). Since trekkers frequently visit these historical sites, we decided to channelize their enthusiasm into an opportunity to document roosts of bats in the state by conducting regional workshops. Trekkers were explained the basics of bat ecology, diversity and the functioning of an internet based application to share their observations, photographs of the roosts, bat colonies, site details, etc. This is helping us create a large state-wide database on the bat roosts. Out of an estimated >80,000 trekkers in the state, > 400 members in different regions have started sharing information and building the roost site database. Spatial data on over 150 bat roosting sites (occupied/abandoned) are now available through these 'batting trekkers'. This network is slowly growing to different parts in the state and will cover diverse landscapes across region.

## Ten Years at A Glance - An Overview of Bat Conservation in Hong Kong

Wing Chi, Tsui
Agriculture, Fisheries and Conservation Department, The Government of the Hong Kong Special Administrative Region;
Corresponding author: wing_wc_tsui@afcd.gov.hk

Hong Kong is mostly known as a metropolitan city full of hustle and bustle. Little do people realise that it also has large stretches of countryside and a rich biodiversity. Since 2002, the Agriculture, Fisheries and Conservation Department (AFCD) of the Hong Kong Special Administrative Region Government has been conducting regular ecological surveys to take inventory and update the status of local biodiversity in order to better understand the natural assets in Hong Kong, and hence facilitate nature conservation work. The Mammal Working Group under AFCD has been monitoring the bat populations in Hong Kong through conducting various surveys across the territory, with the use of mist nets, harp traps, acoustic devices or by direct observation since then. Advanced technologies including DNA barcoding technique and radio-tracking are used to supplement survey findings. To date, 27 species of bats have been recorded within the territory. This overview looks into the work carried out so far and the results of different surveys which help identify challenges and opportunities lying ahead of bat conservation in Hong Kong.

# Analysis of Spatial Clustering in Southeast Asian Bat Sampling Effort

Marina Fisher-Phelps* & Tigga Kingston
Department of Biological Sciences, Texas Tech University, Lubbock, Texas 79409;
*Corresponding author: m.fisher-phelps@ttu.edu

Species distribution models are widely used in species conservation, but model effectiveness depends on data biases and model uncertainty. When data are spatially biased, for example if they are clustered or overly dispersed, the true distribution of a species is not represented. Spatial cluster detection is assessed using density estimators and local statistics, which describe how count data spatially vary across an area of interest. The most common spatial bias in occurrence data is an over-sampling of easy-access sites such as protected areas, urban areas, and sites near roads. Our objective was to identify clusters in Southeast Asian bat sampling effort. We identified spatial clusters using kernel density estimation and two local statics: Getis-Ord G and Local Moran's I. Point data were aggregated to equal-sized polygons to avoid aggregation biases related to size differences in province-level aggregation. The local statistics were able to identify both clusters of low values (polygons with few sampling localities) and clusters of high values (polygons with many sampling localities). The Getis-Ord G and Moran's I statistics identified similar high value clusters but cluster extent differed between method thus it is important to utilize multiple cluster detection methods during analysis. Clustering and bias can increase uncertainty in species distributions models for Southeast Asian bats, thus steps should be taken to remove data clustering and bias through a *priori* or a *posteriori* methods.

# ABSTRACTS OF

# POSTER PRESENTATION

## Bat Souvenir Trade in Ho Chi Minh City, Vietnam

Nguyen Dang Hoang Vu[1]*, Nguyen Ngoc Tuan[1], Nguyen Tran Vy[1], & Joe Chun-Chia Huang[2,3]
[1]Department of Biological Resources, Institute Tropical of Biology, Viet Nam Academy Science and Technology, Ho Chi Minh City, Vietnam; [2]Department of Biological Sciences, Texas Tech University, Lubbock, USA; [3]Southeast Asia Bat Conservation and Research Unit, Lubbock, USA; *Corresponding author: nguyendanghoangvu888@gmail.com

With the 125 species recorded, Vietnam represents one of the countries with highest bat richness among the world. Tragically, bat fauna in Vietnam is currently threatened by various anthropogenic activities, including bat souvenirs trade that recently reported by Lee *et al.* (2015) on *Oryx*. To further understand bat souvenir trade in the country, we surveyed souvenir shops at five localities in Ho Chi Minh City, southern Vietnam, from December 2014 to April 2015. Bat souvenirs were found in four of which, namely Ben Thanh Market, Ben Thanh Night Market, Nguyen An Ninh Street, and Nguyen Hue Street. At least four species, including the woolly painted bat (*Kerivoula picta*), a small tube-nosed bat (*Murina* sp.), a small whisker bat (*Myotis* sp.), and a small Pteropodidae species, were found. A bat pup of the family Vespertilionidae was also recorded. Bat souvenirs were made as dry skin specimens preserved in woody boxes with nametags, usually two bats or a single bat mixed with large arthropod specimens per set. The prices of bat souvenirs per set ranged from 20 to 37 USD. Noteworthy, these shops were all located in the core tourism area in the city, and some of the owners reported that they have sold the product for more than ten years. Moreover, although not documented yet, all bat specimens were reported originally from nearby regions. We urgent that local authorities should immediately react to the bat souvenir trading and associated hunting activities for mitigating impacts to the target species in Vietnam.

## BatCode: Integrating Education and Biodiversity Research Through DNA Barcoding in Bats Across Southeast Asia

Susan M. Tsang[1,2]* & Stephen Harris[1]
[1]Department of Biology, City College and the Graduate Center, The City University of New York, New York, USA;
[2]Department of Mammalogy, American Museum of Natural History, New York, USA;
*Corresponding author: susan.m.tsang@gmail.com

DNA barcoding is increasingly used as a teaching tool for molecular biology at the secondary and post-secondary level in the Americas. Through a combination of teaching theoretical background knowledge and practical skills necessary to carry out a barcoding project, we have successfully guided students in New York City and Belize to develop research questions to investigate their local biodiversity. We have spent several years developing a portable DNA barcoding lab that functions in tropical climates and requires no refrigeration. We aim to improve on this model for biodiversity education by creating a unifying pipeline from education to long-term research objectives. We will accomplish this by providing a taxonomic and regional framework—bats in Southeast Asia—an ecologically important but taxonomically understudied group. The benefit of BatCode is that it will provide opportunities for capacity building to local students, but also generate preliminary data for local researchers to stimulate more in-depth taxonomic research. By bringing in a local expert, we aim to increase project accountability and continuity since they too will be able to benefit from the project. These data can also be repurposed for addressing questions related to biodiversity, conservation, wildlife crimes, and more. Additionally, this project will allow for collection of assessment data to determine the effectiveness of conservation education.

## Guidelines for Describing the Structure of Echolocation Calls from Southeast Asia Bats

Joe Chun-Chia Huang[1,2]*, Benjamin P. Y-H. Lee[2,3,4], Matthew Struebig[2,3], & Tigga Kingston[1,2]
[1]Department of Biological Sciences, Texas Tech University, Lubbock, USA; [2]Southeast Asia Bat Conservation and Research Unit, Lubbock; USA; [3]Durrell Institute of Conservation and Ecology, School of Anthropology and Conservation, University of Kent, Canterbury, UK.; [4]National Parks Board, Singapore; *Corresponding author: chun-chia.huang@ttu.edu

Acoustic techniques are a powerful tool for assessing spatio-temporal patterns of echolocating bat diversity, responses to disturbance, behavioural interactions between individuals, and resolving evolutionary relationships among closely-related species. One of the basic requirements to achieve those goals is to describe echolocation calls adequately for estimating within-species plasticity and between-species differentiation. This is challenging for Southeast Asia's bat biologists because the diversity of echolocation calls is among the highest in the world. Moreover, current descriptions of echolocation calls come mainly from the Hipposideridae and Rhinolophidae, with broader species coverage from only a handful of localities within the region or/and with small sample sizes. Even within these limited studies, call parameters and structures vary within and among studies of the same species. Furthermore, reviews of the existing studies reveal two issues that can substantially mislead researchers in cross-study comparisons, namely: 1) lack of standard definitions of call descriptions and measurements; 2) data presented without sufficient information of within-species variability (e.g. mean with standard deviations; failure to report distinct phonic types). Moving forward, it is essential that researchers in the region describe calls and present measurements in a consistent way for future comparisons. Here we present guidelines for classifying call types and phonic types, defining call parameters, and describing intra-specific variation. Lastly, we demonstrate how changes in the size of Fast Fourier Transformation, a setting in time-expansion analysis, affect some common quantitative measurements and phonic type assignment. A more detailed and complete guidelines will be provided in a workshop during the conference.

## Use and Characteristics of Plant Roosts of *Cynopterus* Bats in a Sumatran Coffee Agriculture Landscape, Indonesia

Eka Sulpin Ariyanti[1]*, Elly L. Rustiati[1], Meyner Nusalawo[2], & Joe Chun-Chia Huang[3]
[1]Department of Biology, College of Mathematics and Natural Sciences University of Lampung, Indonesia; [2]Wildlife Conservation Society Indonesia Program, Indonesia; [3]Department of Biological Sciences, Texas Tech University, USA; *Corresponding author: ekasulpina@yahoo.com

Roosts play critical roles for bats' survival and reproduction. Understanding of roosting ecology is essential, especially for species in human-modified landscapes. We studied the use and characteristics of plant roosts of fruit bats in coffee plantations of Bukit Barisan Selatan Landscape, Sumatra, Indonesia, in June - October 2012. Roosts were searched with a walking transect line design. We assigned roost types by the utilization time (day, night), roost plant species, and canopy cover, diameter at breast height (DBH), canopy height, height of the first main branch, and the distance to the nearest trail. One hundred and twenty-two roosts of 21 plant species were found, including 110 night roosts and 12 day roosts. All bats found in the roosts were belonging to genus *Cynopterus*. Campaka trees (*Magnolia campaca*) were most common for night roosts (n = 42) and coconut trees (*Cocos nucifera*) (n = 8) for day roosts. Day roosts had higher canopies (10.9 ± 4.1 m) and first main branches (7.6 ± 3.9 m), larger DBH (34.0 ± 11.3 cm), and shorter distances to trails (9.9 ± 15.8 m) than night roosts (8.1 ± 2.7 m for canopy height, 3.7±2.3 m for first main branch, 19.0 ± 10.0 cm for DBH, 26.3 ± 25.7 m for distance to trail) but similar in canopy cover (87.7% for day roosts and 96.0 % for night roosts). Since all roost plant species were grown by farmers, we conclude that high floral diversity cultivation is a win-win management strategy for local people and fruit bats.

## Roosting Behaviour of Lesser Dog-Faced Fruit Bats (*Cynopterus brachyotis*) in Relation to Height and Surface Shade for Man-Made Structures

Zong Xian Lim*, W. M. Linn, Y. J. Chong, Rachel C. Y. Lim, & Kenneth Y. S. Kua
Faculty of Life Science, National University of Singapore, Singapore; *Corresponding author: zongxlim@gmail.com

There have been many studies done to investigate the roosting behaviours and site selection by bats in the wild. Some of the common parameters considered are height, size of roost openings and the surrounding environment of the roost site. However studies of roosting behaviours of fruit bats in urban and manmade structures are still relatively scarce. We report on the roosting behaviour of *Cynopterus brachyotis* observed at the Singapore Zoo. Data was collected to investigate the effect of height and surface shade in the choice of bat roost selection. Bats were found to be roosting singly, in harems and extremely large clusters. Using binary logistical regression analysis, it is found that height plays a significant role in roost selection and whereas surface shade did not. The bats were found to concentrate at heights of 3.5 m and 5.0 m whereas no association with surface shade. Harems make up the majority of the sampled bat population and were found mainly at 3.5 m and 5.0 m. A particular large roost was observed at the orang utan enclosure, numbering at 136 bats with a height of 6.3 m. Infrastructure in the Singapore Zoo at heights of 3.5 m and 5.0 m are probably ideal for the establishment of harems. This study can perhaps help to inform the design and encouragement of fruit bat roosts away from urban areas, so as to reduce human-wildlife conflict.

## Present Status and Conservation Issues of the Daito Flying Fox, a Subspecies of the Ryukyu Flying Fox, Endemic to Small Oceanic Islands

Masako Izawa* & Atsushi Nakamoto
Faculty of Science, University of the Ryukyus, Senbaru 1, Nishihara, Okinawa 903-0213, Japan;
*Corresponding author: izawa@sci.u-ryukyu.ac.jp

The Daito flying fox (*Pteropus dasymallus daitoensis*) is one of the two endangered subspecies of the Ryukyu flying fox (*P. dasymallus*) that is distributed in the Ryukyu Islands, Taiwan, and Philippines and has 5–6 subspecies. It is listed as Critically Endangered (CR) in the Red List (RL) of Japan (2012), and the Ryukyu flying fox is listed as Near Threatened (NT) in the IUCN RL (2008). The population status of the Ryukyu flying fox varies among the islands. The Daito flying fox is endemic to two small islands (total area, 42.5 $km^2$) of the Daito Islands, which have a unique history of human activity. These islands had been inhabited since 1900, and almost all the natural forests were cut and converted to farmlands, which caused many native animals, including endemic species, to become extinct due to habitat loss. However, the flying foxes survived by utilizing the remaining forests, partly because of the lack of native predators and food from the artificially planted trees. A recent survey showed that the population size was 300–400 individuals, which seems to be a stable range for the past 10 years. The only natural threat to the population of the Daito flying fox is the direct and indirect effects of typhoon. To further ensure stable population numbers, some artificial threats such as decrease of natural habitats, predation by introduced animals, and accidental death by introduced palms must be eliminated.

## Economic Value and Challenges of Harvesting Guano Fertilizer from Bat Houses in the MeKong Delta, Vietnam

Nguyen Dang Hoang Vu[1]*, Nguyen Ngoc Tuan[1], Nguyen Tran Vy[1], Joe Chun-Chia Huang[2,3], & Tigga Kingston[2,3]

[1]Department of Biological Resources, Institute Tropical of Biology, Viet Nam Academy Science and Technology, Ho Chi Minh City, Vietnam; [2]Department of Biological Sciences, Texas Tech University, Lubbock, USA; [3]Southeast Asia Bat Conservation and Research Unit, Lubbock; USA; *Corresponding author: nguyendanghoangvu888@gmail.com

Recent conservation efforts suggest large artificial roosts, such as "bat houses", may not only serve as alternative sources of guano fertilizer but also provide opportunities to re-establish bat populations and associated ecological services in disturbed landscapes. To achieve this goal, it is essential to evaluate the economic benefits of harvesting guano fertilizer from the artificial roosts and the costs of managing the roosts. In our pilot study, we surveyed bat houses in the Mekong Delta region of southern Vietnam in April 2015. We recorded construction materials and dimensions of the houses and bat species in the roosts. We also interviewed householders about the costs of roost construction, the yield of guano, and the income from selling guano fertilizer. To date, we have surveyed seven bat houses in the region. All houses were made of dry leaves of sugar palm (*Borassus flabellifer*) placed in traditional thatched roof at a height of 6-7 m above the ground. The lesser yellow house bat (*Scotophilus kuhlii*) was the only bat species observed in the roosts. The construction of one bat house cost 400 – 450 USD. On average, every householder collected 1–3kg of guano/day/house and sold it for 2 USD/kg, which brought a monthly income of 50 USD/householder. Noteworthy, threats of *in situ* hunting activities for bush meat, population declines, and male-biased mortality were reported by householders. Our next step is to seek solutions to prevent hunters from accessing the houses and find other possible causes of the population declines.

## Do Anthropogenic Disturbances of Habitats Promote the Transmission Risk for Viruses?

Seltmann Anne[1]*, Struebig Matthew[2,3], Czirjak Gábor A.[4], Dehnhard Martin[5], Kingston Tigga[6], Bernard Henry[7], Drosten Christian[8], Kurth Andreas[9], & Voigt Christian C.[1]

[1]Leibniz Institute for Zoo and Wildlife Research, Dept. of Evolutionary Ecology, Alfred-Kowalke-Straße 17, 10315 Berlin, Germany; [2]University of Kent, Durrell Institute of Conservation and Ecology, School of Anthropology and Conservation, University Road, CT27NR Canterbury, UK; [3]Queen Mary University of London, School of Biological & Chemical Sciences, E14NS London, UK; [4]Leibniz Institute for Zoo and Wildlife Research, Dept. of Wildlife Diseases, Alfred-Kowalke-Straße 17, 10315 Berlin, Germany; [5]Leibniz Institute for Zoo and Wildlife Research, Dept. of Reproduction Biology, Alfred-Kowalke-Straße 17, 10315 Berlin, Germany; [6]Texas Tech University, Dept. of Biological Sciences, 2500 Broadway, TX 79409 Lubbock, USA; [7]Universiti Malaysia Sabah, Institute of Tropical Biology & Conservation, Jalan UMS, 88400 Kota Kinabalu, Malaysia; [8]University of Bonn, Institute for Virology, Sigmund-Freud-Straße 25, 53127 Bonn, Germany; [9]Biosafety Level 4 Laboratory, Robert-Koch Institute, Nordufer 20, 13353 Berlin, Germany; *Corresponding author: Seltmann@izw-berlin.de

Bats are pivotal partners in many plant-animal interactions and make up a large portion of the mammalian biodiversity in Asian tropical forests. Yet, they may also carry pathogens and it is so far poorly understood what factors may facilitate the transmission of bat-mediated pathogens. Here, we ask if habitat disturbance causes stress-induced immune-suppression and increased virus prevalence in bats according to their roosting habit and sociality. We work at the Stability of Altered Forest Ecosystems project in Sabah, Malaysia, and sample old growth, selectively logged forests as well as locations of future fragments before, during and after logging. We use a comparative approach in congeneric bat species (*Rhinolophus*, *Hipposideros* and *Kerivoula*), where species differ either in roost choice (caves versus plant structures) or sociality (group versus solitary living). Bats are captured in harp traps to collect blood, faecal and urine samples as well as throat swabs. This study will elucidate the role of physiological drivers in promoting the spill-over of viral diseases, and will contribute to a better understanding of the bat fauna in Sabah in particular and Southeast Asia in general.

## Pollination Partners on Chiropterophilous-Like *Mucuna macrocarpa*

Shun Kobayashi[1,2]*, Tetsuo Denda[3], Chi-Cheng Liao[4], Yu-Hsiu Lin[5], Atsushi Nakamoto[3], & Masako Izawa[3]

[1]Graduate School of Engineering and Science, University of the Ryukyus, 1 Senbaru, Nishihara, Okinawa 903-0213, Japan; [2]Research Fellow of Japan Society for the Promotion of Science; [3]Faculty of Science, University of the Ryukyus, 1 Senbaru, Nishihara, Okinawa 903-0213, Japan; [4]Department of Life Science, Chinese Culture University, 55 Hwa-Kang Road, Yang-Ming-Shan, Taipei 11114, Taiwan; [5]Endemic Species Research Institute, Taiwan, 1 Ming-Shen East Road, Chichi, Nantou 552, Taiwan; *Corresponding author: cheirotonus.jambar@gmail.com

*Mucuna* flowers follow explosive opening mechanism in the first step of pollination. This process exposes the stamens and pistil from the hard carina and is entirely dependent on animals (explosive openers), because it cannot be initiated by plants. Explosive openers are considered as pollinators because a large amount of pollen attaches to them when flowers open. Most *Mucuna* species have specific openers, such as fruit bats. We investigated whether *Mucuna macrocarpa*, distributed from Southeast Asia to Japan, specifically adapts to fruit bats. This study was conducted in three regions: Okinawa-jima with living population of fruit bat; Kyushu with no recorded population of fruit bats; and Taiwan where fruit bats are restricted only to small islands at present. The explosive opener in Okinawa-jima is the Ryukyu flying-fox (*Pteropus dasymallus*), and those in Kyushu and Taiwan are the Japanese macaque (*Macac afuscata*) and red-bellied squirrel (*Callosciurus erythraeus*), respectively. The manner in which the squirrels caused the explosive opening of flowers was similar to that by the flying-foxes, but varied from that by the macaques. Furthermore, macaques and squirrels conducted diurnal visits, while flying-foxes did nocturnal visits. The proportion of explosively opened inflorescence was lower in Kyushu than in the other two regions. These results indicate that *M. macrocarpa* is possibly not chiropterophilic but mammal pollinated, because it depends not only on fruit bats, which occurs only in the tropical and subtropical zone, but also on other mammals. This flexibility can enable further widespread distribution of *M. macrocarpa*, even to temperate zones.

## Capturing Records of Old Aged Individuals of the Ryukyu Flying Fox *Pteropus dasymallus*

Atsushi Nakamoto[1]*, Kazumitsu Kinjo[2], & Masako Izawa[1]

[1]Faculty of Science, University of the Ryukyus, Senbaru 1, Nishihara, Okinawa 903-0213, Japan; [2]Faculty of Law, Okinawa International University, Ginowan 2-6-1, Ginowan, Okinawa 901-2701, Japan;
*Corresponding author: dasymallus@gmail.com

The lifespan of the target species constitutes critical information when planning a conservation strategy for an endangered bat species. However, it is difficult to determine ecological longevity in the wild because most chiropteran species generally have a long lifespan and low recovery rate in capture-recapture surveys. The Ryukyu flying fox, *Pteropus dasymallus*, is a medium sized fruit bat (BW = 450 g, FAL = 140 mm) that inhabits small islands in the Philippines, Taiwan, and the Ryukyu archipelago of Japan, and is listed in the IUCN Red List as a Near Threatened species. We analysed 290 capture/collection records from long-term capture-recapture surveys with microchip identification, which were conducted between 1995 and 2009, and obtained records for the maximum ecological longevity of this species; the ages of two long-lived individuals were estimated at 7.5 and at least 12 years, respectively. We discussed the ecological longevity of this species based on the tooth-wearing patterns of captured individuals, maximum longevity records for captive individuals, and information from the literature. We also confirmed that the degree of tooth wear is useful for estimating approximate age in this species.

## Elevation Gradients in Bat Diversity along the Southern Cross-Island Highway in Yushan National Park, Taiwan

Ying-Yi Ho*, Chiung-Chen Cheng, Ya-Li Huang, Ming-Hung Hsu, Chi-Yu Huang, Shih-Yu Liang, Jia-Ming Tsao,Hsien-Chung Lee, Hung-Yu Wang, Sin-Han Chen, & Hsueh-Wen Chang
Department of Biological Sciences, National Sun Yat-Sen University, Kaohsiung, Taiwan;
*Corresponding author: yho@staff.nsysu.edu.tw

Understanding the elevational gradient of variation in bat diversity is crucial for conservation action in montane ecosystems. However, the patterns and underlying mechanisms were not well understood so far. We compared patterns of species richness, relative abundance and distribution range of bats and their presumably insect prey, Lepidoptera and Coleoptera, along the Southern Cross-Island Highway in Yushan national park in Taiwan. From May to November in 2013, we used harp trapping, mist netting, roost checking and sound recording to survey the bat fauna along a 1000-2700 m a.s.l altitudinal gradient. Insects were also surveyed by hand net and light trap at ten sites. In total, we recorded 12 species of bats (Hipposideridae, Rhinolophidae and Vespertilionidae), 178 Lepidopteran species (21 families), and 24 Coleopteran species (15 families). Both bat and insect species richness and abundance peaked at intermediate altitude. *Rhinolophus formosae, Pipistrellus montanus* and *Miniopterus schreibersii fuliginosus* occurred at all elevational gradients and seasons, while some species were restricted to the high or low altitude, or specific season. The results by harp trap and sound recording were inconsistent. Most bat species were recorded by acoustic monitoring while Murininae and Kerivoulinae were only documented by harp trap, suggesting the necessary of the implementation of multi-approach for bat survey. Our results indicated an apparent elevational variation in the geographical distribution of bats, and the high diversity of bats and insects may reflect the intact and various montane forest habitats along the southern cross-island highway.

## Systematics and Phylogeny of SE Asian Bats and Their Viruses – An Introduction to Our Research Program

Tamás Görföl[1,2], Gábor Kemenesi[3], Ferenc Jakab[3], Péter Estók[4], & Gábor Csorba[1]*
[1]Department of Zoology, Hungarian Natural History Museum, Budapest, Hungary; [2]Institute for Veterinary Medical Research, Centre for Agricultural Research, Hungarian Academy of Sciences, Budapest, Hungary; [3]Virological Research Group, JánosSzentágothai Research Center, University of Pécs, Pécs, Hungary; [4]Department of Zoology, EszterházyKároly College, Eger, Hungary; *Corresponding author: csorba@nhmus.hu

The exploration of tropical areas that are most heavily impacted by the biodiversity crisis is one of the most urgent and most important basic research areas of our times. For several reasons, mammals generate remarkable attention and bat taxonomy and systematics is one of the most important research fields. One aim of our program is the systematic and phylogenetic investigation of tropical Vespertilionids. This taxon is characterized by a high number of cryptic species and methods of multi-variate statistics and molecular biology provide the necessary grounds for applied research such as physiology, parasitology, virology and conservation biology. The other main asset of our program is the virological analysis of bat samples. During the past decade, several groups of viruses with human health hazard or interesting evolutionary relevance turned out to originate from bat hosts (Hepadnaviridae, Orthomyxoviridae, Coronaviridae, Astroviridae, Caliciviridae etc.). There are three directions of our virological examinations: PCR and real-time PCR screening of samples; virus isolation procedure on multiple cell lines in appropriate biosafety level conditions; metagenomic analyses on multiple sequencing platforms. Besides detecting and characterizing novel viruses, our another important objective is the examination of local bat associated virological problems affecting the local human and bat populations (i.e. Nipah virus).As knowledge distribution is an important task of our program and we cannot be successful without the cooperation of local researchers, colleagues working in SE Asia are welcome for collaboration.

## Roost Characteristics and Group Composition of the Woolly bat (*Kerivoula titania*) in Central Taiwan

Chia-Wei Hsu[1]*, Cheng-Han Chou[2], Hsi-Chi Cheng[2], & Jian-Nan Liu[1]
[1]Department of Forestry and Natural Resource, National Chiayi University, Chiayi, Taiwan; [2]Endemic Species Research Institute, Nanton, Taiwan; *Corresponding author: s1030105@mail.ncyu.edu.tw

The woolly bat, *Kerivoula titania*, was first discovered in Taiwan in 1998. It was considered to roost inside bamboos. Recently, woolly bats have been recorded in several occasions to roost in small groups inside the furled leaves of plantains. In this study, we investigated the roost characteristics and group composition of woolly bats in central Taiwan. From July 2014 to May 2015, with the aid of a thermal imager, we found 105 out of 1,275 plantain leaf tubes used by woolly bats as day roosts. The average height of plantain trees used by bats was 4.3±1.6 m and the average diameter size of the leaf tube opening was 14.0±7.0 cm. We captured and banded 67 individuals, including 30 adult females, 15 adult males, 11 juvenile females and 11 juvenile males. By using a capture-recapture model (CARE-2), the population size was estimated about 79 individuals in our study area during the period of July-November 2014. The group size in each leaf tube varied between 1 to 13 individuals, with an average of 4.0±2.6. The group composition varied among months.

## Study of Georgian Bats on Reemerging Lyssavirus by DFA testing

Lela Urushadze[1,3], Tamar Kutateladze[1]*, Tsiuri Tushishvili[1], Magda Dgebuadze[1], IosebNatradze[3],Lillian Orciari[2], & A. Velasco-Villa[2]
[1] NCDC Lugar Center, Georgia; [2] CDC Atlanta, USA; [3]Ilia State University, Georgia;
*Corresponding author: tamar_kutateladze@yahoo.com

Bats are increasingly recognized as reservoirs of emerging zoonotic pathogens, such as *Lyssaviruses, Coronaviruses, Filoviruses*. Decade ago, the West Caucasian Bat Virus was isolated from an insectivorous bat (*Miniopterus schreibersii*), in ~300 km from the Georgian border. Commercially available rabies biologics do not provide protection against WCBV. Rabies virus is a genus of *Lyssavirus* and is listed as a priority pathogen by the Georgian ministries of Health and Agriculture.Our goal was implementation of DFA testing methodology in Georgian Lugar Center for detection different type of Lyssaviruses in Georgian bats. Bat Surveillance was conducted in five regions of Georgia in June, 2012 and June 2014. 336 bats of 8 species were sampled. The BSL2+ facility at NCDC Lugar Center provided possibility for the *Lyssavirus* DFA study in Georgian Bats. The most common diagnostic method used for rabies diagnosis is serological method such as the direct fluorescent antibody (DFA) test. Brains from 336 bats were tested on presence of *Lyssavirus* antigen by DFA. Samples were prepared, fixed in cold acetone, and stained with florescent isothiocyanate (FITC)-conjugated anti-rabies monoclonal antibodies and examined under a fluorescent microscope for *Lyssavirus* antigen. Study was supported by ISTC G-2101 project and Atlanta, CDC collaborators stuff. None of the studied bats had detectable antigen consistent with an active infection of rabies or a related *Lyssavirus*. Current study and correct interpretation of test results, implementation of new diagnostic methods will improve surveillance system, control and response measures for emerging pathogens in Georgia.

## Epidemiological Overview of Rabies in Georgia

Ts.Tushishvili[1]*, T.Kutateladze[1], L. Urushadze[1,3], P. Imnadze[1], & A. Velasco-Villa[2]
[1]NCDC Lugar Center, Georgia,; [2]CDC Atlanta, USA; [3]Ilia State University, Georgia;
*Corresponding author: c.tushishvili@ncdc.ge

Rabies is among the urgent notifiable diseases in Georgia. Rabies data have been registered since 1930. Until 2011, rabies diagnosis in humans was based only on clinical symptoms. From 2011 saliva samples from 8 human rabies cases were tested and laboratory confirmed by conventional PCR. Annually ~ 40, 000 people receive rabies post-exposure prophylaxis (PEP). Approximately 7-10 human rabies cases are documented in Georgia every year. In 2005 – 2014 years were registered 59 cases of Rabies. Among reported cases 76.3% (45 cases) were caused by bites of stray dogs, by cat, wolf, fox -3.4% (2 cases) each, 1.7% (1 case) jackal and in 11.8% ( 7 cases) source is unknown. Epidemiological for roosting investigation is conducted for all reported cases. Seven unrecognized cases involved resulted in fatalities, as PEP was not administered. Rabies is caused not only by RABV, but also other Lyssavirus. Decades ago West Caucasian Bat Virus (WCBV) was isolated from an insectivorous bat (*Miniopterus schreibersii*) in ~ 300 km from the Georgian border. Commercially available rabies biologics do not provide protection against WCBV. These and other bat Lyssaviruses may be present in Georgia, with the opportunity for spillover infections to humans, domestic animals and wild carnivores. Bats in Georgia use a variety of places for roosting including house roofs. There is suspicion that unknown cases may be caused from bats exposure. Under ongoing project supported by ISTC and CDC Atlanta we investigate bats collected during 2014 survey in various regions of Georgia. Study information is needed to develop Lyssavirus prevention and control strategies for epidemiologists in future.

## Population Dynamics of Black Bearded Tomb Bat *Taphozous melanopogon* at Samaesarn Islands, Thailand

Kasidit Rison & Thongchai Ngamprasertwong*
Department of Biology, Faculty of Science, Chulalongkorn University, Thailand;
*Corresponding author: thongchai.n@chula.ac.th

This study aims to monitor population dynamics of Black bearded tomb bat *Taphozous melanopogon* in caves at Kham and Changkleua islets which located at Samaesarn islands, eastern Thailand, between May 2014 and May 2015. Emergence count indicated that the population size of *T. melanopogon* in both caves were quite stable throughout the year. The number of bats in caves at Kham and Changkleua islets ranged between 230-315 individuals and 126-178 individuals, respectively. Both male and female resided together in caves all year round. The beard character can be found all year round in male. Females gave birth once a year between April and May and reared their offspring during May to July. Flyable juveniles were found only in July. Few recapture rate indicated high mobility of roosting bats in this area.

## Morphological Analysis of Spotted-winged Fruit Bat (Pteropodidae: *Balionycteris maculata*) in Malaysia

Nur Mukminah Naharuddin[1]*, Mohd Tajuddin Abdullah[4], Faisal Ali Anwarali Khan[2], Mohd Zacaery Khalik[2], Roberta Chaya Tawie Tingga[3] & Mohd Ridwan Abd. Rahman[3]*
[1]Institute of Biodiversity and Environmental Conservation, [2]Department of Zoology, Faculty Resource Science and Technology, [3]Centre for Pre University Studies, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia; [4]Centre for Kenyir Ecosystems, Kenyir Research Institute, University Malaysia Terengganu, 21030 Kuala Terengganu, Malaysia; *Corresponding authors: nurmukminah@gmail.com; ridwanrahman2@gmail.com

The spotted-winged fruit bat, *Balionycteris maculata*, is among the smallest fruit bats that inhabit Southeast Asia. Currently, two subspecies of *B. maculata* is recognised. *Balionycteris maculata maculate* is restricted to Borneo, whereas *B. maculata seimundi* are distributed in Peninsular Malaysia, Sumatra, and adjacent Indonesian Islands. Although genetic data support high genetic divergence between Peninsular Malaysia and Bornean samples, data on morphological variation between these localities are still lacking. To further test on this subspecific rank status, samples of *B. maculate* from Sarawak (N=16), Sabah (N=7) and Peninsular Malaysia (N=7) were subjected to analysed using 14 external and 18 craniodental characters. Discriminant function analysis (DFA) was performed on external and craniodental characters separately. Three clusters corresponding to their geographic origin were able to be recovered in canonical discriminant plot for craniodental characters but not for external characters. The third digit metacarpal length (D3MCL) for the external character and dentary length (DL) for the craniodental characters were chosen as the predictors to differentiate between the *B. maculata* group studied here. This finding shows that the morphological variation exist among the different population of *B. maculata* in Malaysia, thus support the recognition of separate lineages as recognised through the high mitochondrial genetic variation between Peninsular Malaysia and Borneo.

## Roost Site Preferences for Cave-Dwelling Bats in Wind Cave Nature Reserve, Bau, Sarawak

Muhd Amsyari Morni[1]*, Qhairil Shyamri Rosli[1], Julius William Dee[1], Mohd Tajuddin Abdullah[2], Roberta Chaya Tawie Tingga[3], Faisal Ali Anwarali Khan[1], & Mohd Ridwan Abdul Rahman[3]
[1]Department of Zoology, Faculty of Resource Science and Technology, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia; [2]Kenyir Research Institute, Universiti Malaysia Terengganu, 21030, Kuala Terengganu, Terengganu; [3]Center for Pre-University, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia;
*Corresponding author: amsyari.morni92@gmail.com

Cave roost plays a major role in supporting complex diversity of bats. Roosting sites in general provides protection to the bats from their predator, unfavourable weather condition and a place to enter into torpor and hibernation as the environment change for a long period of time. Studies on roost ecology provide important knowledge on how bats partition their roost specifically cave microhabitat among different species. To understand the role of cave microhabitat, we have conducted roost preferences studies in Wind Cave Nature Reserve (WCNR), Bau, Sarawak. The parameters that were recorded include roost temperature and humidity, distance of the roosting site from the nearest cave entrance, light intensity at the roosting site and sound intensity at the bat's roost site. HOBO data logger was used for taking temperature and humidity reading, Leica Disto D3 range finder was used to measure the roost distance, light intensity were determined by the level of brightness observed by researcher and sound intensity were recorded by using Decibel Meter Version 1.6 application. There were 10 species of bats from five families that were found roosting in WCNR. Our study revealed that there were preferences between bat species based on these five parameters that dictate where these bats roost in the cave. Knowing these parameters provide better understanding of cave dwelling bats roost selection, thus enable us to monitor these parameters for the conservation of the bats in WCNR.

## Bats Assemblage in Wind Cave Nature Reserve

Julius William Dee[1]*, Muhd Amsyari Morni[1], Qhairil Shyamri Rosli[1], Mohd Tajuddin Abdullah[2], Roberta Chaya Tawie Tingga[3], Faisal Ali Anwarali Khan[1], & Mohd Ridwan Abdul Rahman[3]

[1]Department of Zoology, Faculty of Resource Science and Technology, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia; [2]Kenyir Research Institute, Universiti Malaysia Terengganu, 21030, Kuala Terengganu, Terengganu; [3]Center for Pre-University, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia; *Corresponding author: julius9214@yahoo.com

Limestone areas in Borneo have been the main attraction for researchers to study the diversity of bats as they support a large colony of bats. Information on what species is presence in an area is crucial for developing conservation plan and management and also helps in promoting ecotourism in Wind Cave Nature Reserve. Thus, a species diversity study of chiropteran was conducted at the limestone cave of WCNR using harp traps, mist nets and hand-net. The study was conducted starting from September 2013 to March 2014. A total of 296 individuals from 22 species and six families were recorded in this study. The most abundance species recorded was *Penthetor lucasi*, with 138 individuals followed by *Hipposideros cervinus* (49 individuals). *P. lucasi* and *H. cervinus* comprised 46% and 16% of the total individuals caught respectively. *Megaderma spasma* was caught using hand-net while roosting in the cave. Five species of bats, *H. bicolor, K. papillosa, K. pellucida, M. montivagus,* and *N. tragata*, were caught as singletons. New record for WCNR, namely *Kerivoula papillosa*, *Myotis montivagus*, *Myotis ater*, *Nycteris tragata, M. spasma, H. ater,* and *H. bicolor* making it 26 species known inhabited WCNR.

## Roost Site Mapping of Cave-Dwelling Bats in Wind Cave Nature Reserve, Bau, Sarawak, Malaysia

Qhairil Shyamri Rosli[1]*, MuhdAmsyari Morni[1], Julius William Dee[1], Mohd Tajuddin Abdullah[2], Roberta Chaya Tawie Tingga[3], Faisal Ali Anwarali Khan[1], & Mohd Ridwan Abd Rahman[3]

[1]Department of Zoology, Faculty of Resource Science and Technology, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia; [2]Kenyir Research Institute, Universiti Malaysia Terengganu, 21030, Kuala Terengganu, Terengganu; [3]Center for Pre-University, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia; Terengganu, Malaysia; *Corresponding author: qhairilshyamri@yahoo.com

A roost survey of cave-dwelling bats in Wind Cave Nature Reserve (WCNR) was conducted for 11 days from July 2013 until April 2014. This study aims to locate and describes the roosting ecology of cave-dwelling bats. The null hypothesis being tested was there is no association between roosting ecology and bats assemblages. Observation of bats roost was conducted during the day between 0900 until 1400 hours using transect method. EM3+ dial bat detector was used to record bats echolocation calls for species identification. Roosting ecology parameter was recorded for each roost comprises of colony sizes, spatial arrangement of bats, roost posture and also position of roost. A total of 462 observations were made and recorded five families of bats comprising of 11 species of bats. This species includes *Penthetor lucasi, Megaderma spasma, Myotis horsfieldii, Rhinolophus borneensis, R. affinis, Hipposideros ater, H. diadema, H. larvatus, H. cervinus, H. coxi* and *H. galeritus.* The most abundant species observed was *P. lucasi,* most roost observations was *M. horsfieldii* with 136 observations and Hipposideridae with the highest number of species with 6 species. Chi-square test obtained p=<0.05 shows association exist between roost behaviour with bats assemblages. Finally, a location map was produced based on the data obtained showing the range of roosting bats for each bats assemblages.

## Preliminary Study on Population Genetic of Spotted-Winged Fruit Bat (Pteropodidae: *Balionycteris maculata*) in Sarawak

Rafik Murni[1]*, M. T. Abdullah[2], Faisal Ali Anwarali Khan[3], Mohd Ridwan Abdul Rahman[4], Mohd Zacaery Khalik[3], & Roberta Chaya Tawie Tingga[4]

[1]Institute of Biodiversity and Environmental Conservation, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia; [2]Kenyir Research Institute, Universiti Malaysia Terengganu, 21030, Kuala Terengganu; [3]Department of Zoology, Faculty of Resource Science and Technology, [4]Centre for Pre University Studies, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia; *Corresponding author: rafikmurni@gmail.com

The study of population genetic of *Balionycteris maculata* in Sarawak was conducted from 14 April 2012 until 12 May 2013. The aims of this study were to investigate the intraspecific relationship of *B. maculata* populations using the partial mitochondrial DNA cytochrome *b* (cyt*b*) gene sequence and to examine the population structure of *B. maculata* populations in Sarawak. A total of 25 individuals were examined and were grouped into three populations in Sarawak namely north, middle and south Sarawak. From the phylogenetic analyses and minimum spanning network, there were no major cluster within the species and suggest that this species underwent a recent population expansion. The $H_o$ is accepted where there are no significant differences in genetic variations of *B. maculata* from three populations in Sarawak.This suggest that all samples from Sarawak represent single lineage.

## Identifying bats in an unknown acoustic realm using a semi-automated approach to the analysis of large scale full spectrum datasets

Kyle N. Armstrong[1]* & Ken P. Aplin[2]*

[1]Specialised Zoological; Department of Genetics and Evolution, The University of Adelaide, South Australia; South Australian Museum, Adelaide, South Australia; [2]Ken Aplin Fauna Studies Pty Ltd; Smithsonian Institution;
*Corresponding authors: kyle.n.armstrong@gmail.com, aplin.ken@gmail.com

Identifying bat species from acoustic recordings of echolocation made on environmental impact assessments in Papua New Guinea (PNG) is the "perfect storm" of challenges, but brings the opportunity to overcome some obstacles common to acoustic surveys in poorly surveyed areas. Prior to several recent development projects, the acoustic realm of the PNG bat fauna was almost completely undocumented. Adding to the challenge, recent models of autonomous ultrasonic acoustic recorders provide information-rich full spectrum data, though in considerable amounts, which precludes analysis by manual inspection on all but the smallest projects. There are various commercial software options for analysing such data, but some underlying analysis systems are not available for developing protocols for new assemblages, and feedback outputs for verification or further analysis can be disappointingly limited. Alongside a steadily growing reference call collection and understanding of echolocation call types in PNG, we developed a semi-automated approach using a combination of commercially available software, custom R language scripts and statistical analysis to allow expedient analysis of massive datasets, efficient manual checking of all identifications and the means to completely avoid spurious outputs representing false positive identifications. The approach is adapted readily to new geographic regions and bat assemblages, takes advantage of a new classification nomenclature for bat call types in undocumented faunas and provides complete transparency and control over the analysis process. By reducing the effort required for acoustic analysis, the approach eradicates any associated encumbrance that would limit site replication, which is fundamental in inventory surveys striving for completeness, and provides more power for community-level analysis in combination with other site, phylogenetic and trait data.

## A Global Online Bat Call Database: Updates and Progress

Simon K.A. Robson[1]*, Kyle N. Armstrong[2]*, & Jeremy Vanderwal[1,3]*
[1]Centre for Tropical Biodiversity and Climate Change, College of Marine and Environmental Science, James Cook University; [2]Department of Genetics and Evolution, The University of Adelaide, South Australia; South Australian Museum, Adelaide, South Australia; [3]eResearch, College of Marine and Environmental Science, James Cook University;
*Corresponding authors: simon.robson@jcu.edu.au, kyle.armstrong@adelaide.edu.au, jeremy.vanderwal@jcu.edu.au

The ability to access and contribute to an online reference library of bat echolocation calls represents a tremendous opportunity for scientists, government, industry and NGO's, capitalising on the value of remote sensing combined with big data and new data analytical techniques. The Atlas of Living Australia and CSIRO, in collaboration with the Australasian Bat Society, have taken the first key steps and collated a call library of over 1.5 million files in a prototype database. A new WWW portal providing access to this database is currently under construction at James Cook University and will be maintained by the Centre for Tropical Biodiversity and Climate Change and eResearch. The database will allow not only for both uploading and downloading of example reference and representative calls, but also the curation of bulk raw recordings. The latter category can accommodate data collected as part of environmental impact studies, and also long term research projects that collect data continuously, such as at the Daintree Rainforest Observatory in Queensland and a planned project in Sabah, Malaysia. The existence of a global database is providing exciting opportunities for large-scale collaborations and echolocation recording networks, and we are in the process of inviting colleagues to beta-test and provide feedback on this system.

## Using Metabolic and Thermal Profiles to Assess Climate Change Vulnerability in an Arboreal Tropical Bat: Does Heterothermy Provide a Pre-adaptive Advantage?

Shaun Welman[1]*, Andrew Alex Tuen[2] , & Barry G. Lovegrove[1]
[1]School of Life Sciences, University of KwaZulu-Natal, Pietermaritzburg, South Africa; [2]Institute of Biodiversity and Environmental Conservation, Universiti Malaysia, Sarawak, Malaysia;
*Corresponding author:shaun.welman@gmail.com

Given that recent climate change models suggest an unprecedented rate at which the average global temperature ($T_a$) will increase, establishing a robust pragmatic approach to evaluating species thermoregulatory capabilities and tolerances is paramount. Although predictions indicate that the tropics will experience less severe $T_a$ increases, many tropical endotherms are already exposed to $T_a$s close to their body temperatures ($T_b$s). Of these, arboreal species are potentially most vulnerable to heat stress. We investigated the concurrent effect of $T_a$ (22°C – 36°C) on metabolism and core $T_b$ in an arboreal tropical bat species, using wild caught lesser dog-faced fruit bats (*Cynopterus brachyotis*). Bats typically entered into torpor at $T_a$s below 30°C and maintained a $T_b$-$T_a$ gradient of *ca*. 4-6°C while torpid. At higher $T_a$s, an abrupt increase in metabolism at 33°C, suggested 32°C as the upper critical limit of thermoneutrality ($T_{uc}$), above which bats maintained a $T_b$-$T_a$ gradient of < 2°C. Thermal conductance remained relatively low and stable at $T_a$s below 34°C, where after a massive increase was observed, indicating the possible onset of heat stress. However, the low $T_b$-$T_a$ gradients observed at $T_a$s above $T_{uc}$, in combination with a $Q_{10}$ value of < 2 between $T_{uc}$ and 36°C, suggests that bats were be able to respond to the heat stress by entering into a hypometabolic state or "hyperthermic torpor". The potential of these bats (and possibly other heterotherms) to down-regulate metabolism at high $T_a$s would retard increases in $T_b$ and may aid them in better coping with global warming.

## Mitochondrial DNA Structure of Lyles's Flying Fox *Pteropus lylei*

Thongchai Ngamprasertwong[1]*, Vibol Hul[2], Julien Cappelle[3,4], & Somsak Panha[1]
[1]Department of Biology, Faculty of Science, Chulalongkorn University, Bangkok, Thailand; [2]Institut Pasteur du Cambodge, Virolgy Unit, Phnom Penh, Cambodia; [3]CIRAD, AGIRs, Montpellier, F-34398, France; [4]Institut Pasteur du Cambodge, Epidemiology and Public Health Unit, Phnom Penh, Cambodia; *Corresponding author: thongchai.n@chula.ac.th

Lyle's flying fox *Pteropus lylei* is one of the major reservoirs for Nipah virus in Southeast Asia. Several outbreaks of this virus occurred in many areas of South East Asian and South Asia in the last decade. More than 200 people in those areas have died due to this viral infection since 1998. An accurate understanding of the potential for epidemiology spread and disease risk requires an understanding of population ecology and population genetic structure of the primary host. This study investigated the spatial distribution of mitochondrial DNA diversity among Lyle's flying fox populations in order to clarify their population genetic structure and characterize the potential epidemiology spread of Nipah virus among bat populations. The current mitochondrial DNA survey suggested the genetic homogeneity of mtDNA among Lyle's flying fox populations in Thailand and Cambodia.

## Values of Forest Patches in Conserving Bat Diversity on Penang Island, Malaysia

Nur Izzati Abdullah[1], Joe Chun-Chia Huang[2], Faisal Ali Anwarali Khan[3], Mohd Abdul Muin Md Akil[4], Shahrul Anuar Mohd Sah[4], & Lee-Sim Lim[1]*
[1]School of Distance Education, Universiti Sains Malaysia, 11800, Penang, Malaysia; [2]Department of Biological Sciences, Texas Tech University, Lubbock, Texas, USA; [3]Department of Zoology, Faculty of Resource Science and Technology, Universiti Malaysia Sarawak, Kota Samarahan, Sarawak, Malaysia; [4]School of Biological Sciences, Universiti Sains Malaysia, 11800, Penang, Malaysia; *Corresponding author: leesim.lim@usm.my

The natural habitats on Penang Island has been largely transformed for urban and industry developments over the past century. Only few relative large forests are remained as reserves and the other forest patches are usually small and discontinuously distributed within agricultural and urban landscapes. The values of these forest patches and forest-like habitats (e.g. orchard) in conserving the island's bat diversity are understudied. We surveyed bat diversity with harp traps and mist nets at five forest sites and two orchard sites in continuous forest, agriculture, and urban landscapes from November 2014 to May 2015. A total of 398 individuals from 22 bat species of six families were recorded. *Cynopterus brachyotis* was the most abundant species across sites, followed by *Rhinolophus affinis*. The two sites in agriculture landscapes, regardless habitat types, had higher values of Simpson Index (0.16 for the forest site and 0.37 for the orchard site) than sites in forest landscapes (0.41-0.46, n = 3) and urban landscapes (0.46 and 0.50, n = 2). The results suggest that species compositions in agriculture landscapes were more even than other landscapes. With an estimate of over 60 species, we suggest that the small sample size in our study may underestimate the overall species diversity for Penang Island. We will include more sample sites to justify the patterns reported here and more comparisons of bat assemblage structure in forest patches among the three study landscapes. The values of forest patches within each landscape on conserving Penang's forest bats will be discussed.

## Species Abundance and Body Size Relationship of Volant Mammal (Chiroptera) in Western Sarawak

Noorshazlin M. Samsudin, Ahmad F. Aziz, & Charlie J. Laman*
Department of Zoology, Faculty of Resource Science and Technology, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia; *Corresponding author: cjlaman@frst.unimas.my

Data for body size abundance relationship came from two sources; primary and secondary sources. The sampling was conducted at Permai Rainforest Resort on 2nd of November until 6th of November. The study area was divided into two different sites, Site A (1°45.415' N and 110°19.032' E) and Site B (1°45.491' N and 110°18.967' E). Meanwhile, secondary data were retrieved from published and unpublished data. The secondary data consists of data from sampling done at Damai Golf and Country Club, Sarawak Golf Club, Gunung Gading National Park, Mount Jagoi, Mount Singai and Wind Cave Nature Reserve. Regression analysis was used as statistical technique for modelling the relationship between a dependent variable and one or more independent variables were analysed using *SPSS* version 21.0. A total of 1024 individuals consist of 35 bat species from six families were recorded. The most dominant species was Dusky Fruit Bat (*Penthetor lucasii*) with total of 410 individuals. All the localities show positive relationship which means the abundance of bats increases as the body mass increases. The results shown were opposite to the one proposed by Energetic Equivalence Rule.

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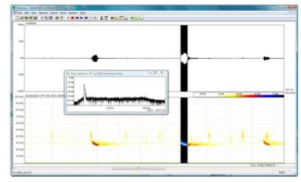
## BatSound sound analysis software



## D500X Bat Detector/recorder

The D 500X is an ultrasound CF card recording unit intended for long-term, unattended recording of bat calls.

- Built-in electret microphone and jack for external microphone
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- Timer to turn the unit on/off at desired intervals
- Weather-protected housing
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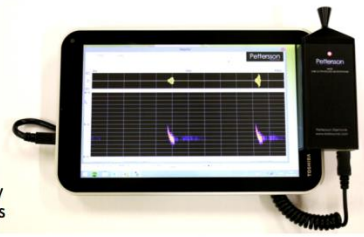

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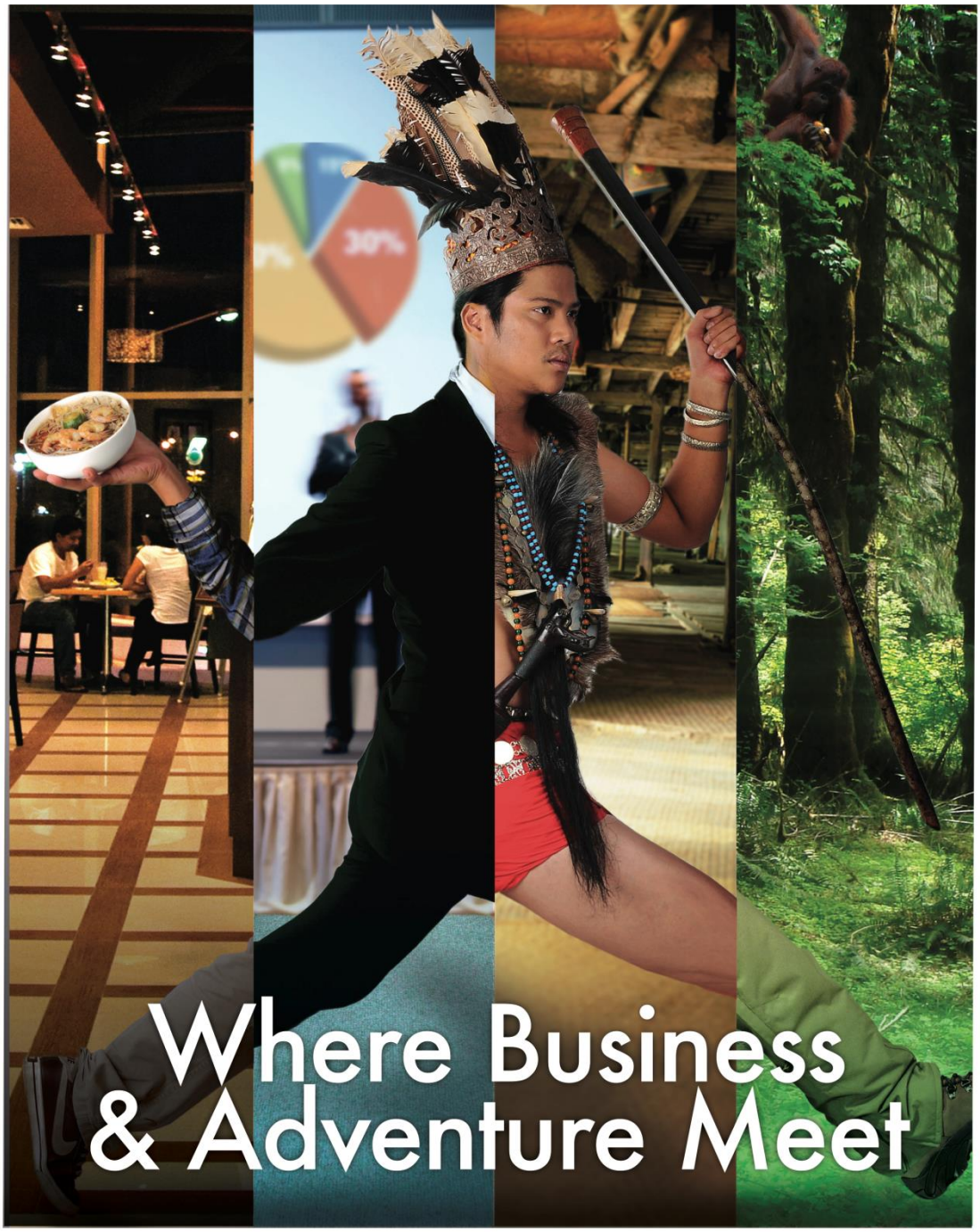


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Department of Zoology
Faculty of Resource Science and Technology
Universiti Malaysia Sarawak
94300 Kota Samarahan, Sarawak, Malaysia

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