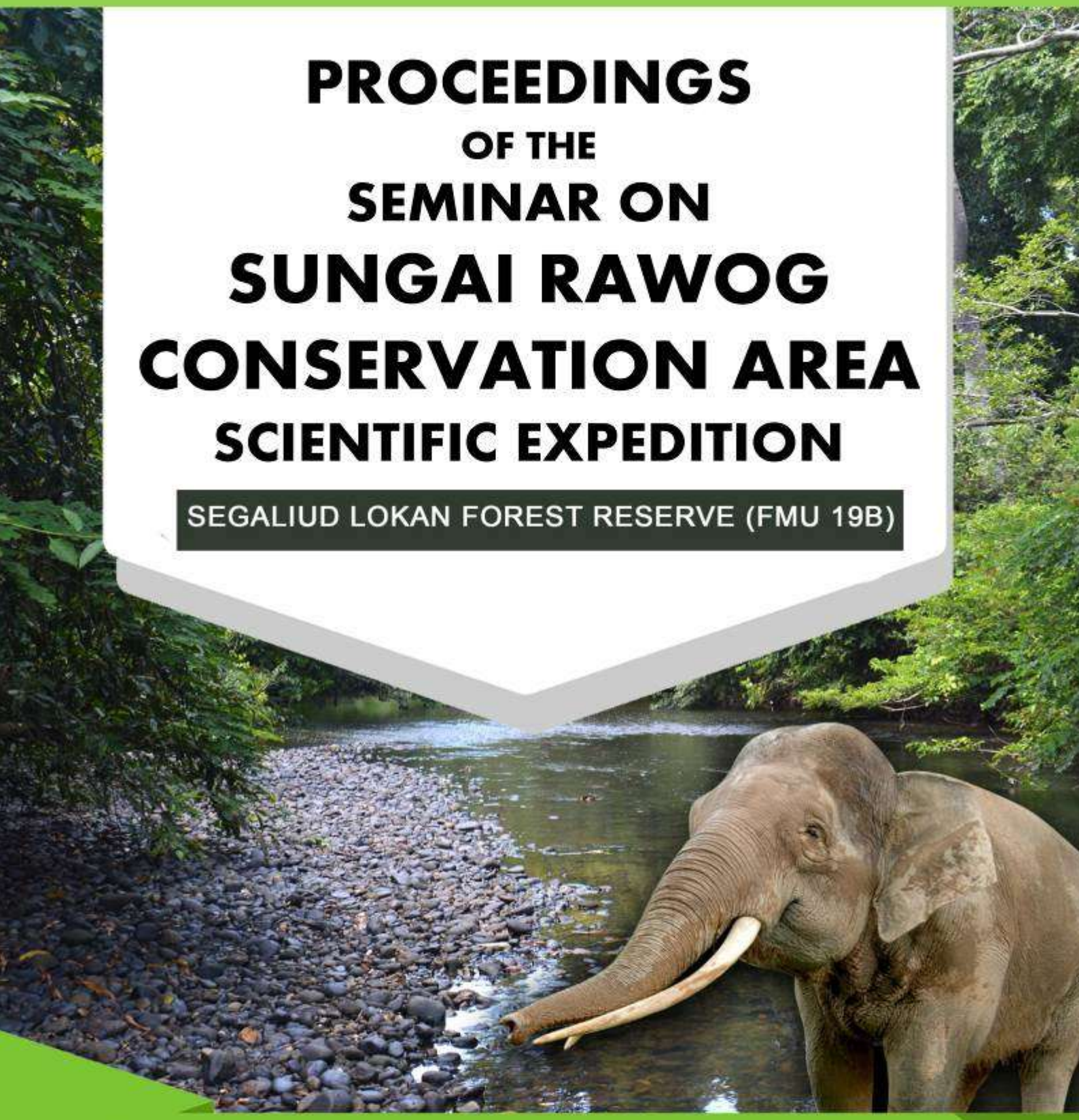
PROCEEDINGS
OF THE
SEMINAR ON
SUNGAI RAWOG CONSERVATION AREA
SCIENTIFIC EXPEDITION

SEGALIUD LOKAN FOREST RESERVE (FMU 19B)



21st February 2019
Le Meridien Hotel, Kota Kinabalu

Organizers:

KTS PLANTATION SDN BHD

Expedition Participating Agencies:

Universiti Malaysia Sabah

Wildlife Department Sabah

The Board of Trustees of the Sabah Parks

WWF

Participants of the Sg. Rawog Scientific Expedition in two batches from 8th to 18th of August, 2018.

PROCEEDINGS
of the
SEMINAR ON SUNGAI RAWOG CONSERVATION AREA SCIENTIFIC EXPEDITION

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Locked Bag No. 68,
90009 Sandakan,
Sabah, Malaysia

http://www.forest.sabah.gov.my/

and

Lot 32, Bandar Pasaraya Commercial Complex,
Mile 4, North Road, WDT 20,
90009 Sandakan,
Sabah, Malaysia

PROCEEDINGS OF THE SEMINAR ON SUNGAI RAWOG CONSERVATION AREA SCIENTIFIC EXPEDITION
21ST February 2019, Kota Kinabalu, Sabah

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FOREWORD

I'm glad to see that KTS Plantation Sdn. Bhd. is committed towards conserving the 3,118 ha along the Sungai Rawog valley in eastern Sabah. This conservation area also serves as a wildlife corridor connecting Deramakot Forest Reserve and adjacent oil palm plantations. It is part of the Segaliud Lokan Forest Reserve (SLFR) - Forest Management Unit No. 19(B). To be effective, forest conservation must come together with research and dissemination of information.

In line with the objective of the Heart of Borneo Initiative that focuses on biodiversity conservation, this seminar was held on 21st February 2019 to disseminate research findings from a scientific expedition conducted in August 2018. It was the first biodiversity documentation and dissemination of information for this conservation area. I am happy to know that some 200 participants from more than 20 agencies in Sabah attended the one-day seminar in Kota Kinabalu.

During the seminar, a keynote presentation and 18 oral papers as well as 19 research posters on Sg. Rawog forest ecosystems, physical sciences, plant and wildlife diversity, and tourism potentials were presented. This signifies a smart partnership between the state government through the Sabah Forestry Department and the private sector in sustainable forest management, working hand-in-hand with other agencies, as always advocated by the Right Honorable Chief Minister of Sabah.

I congratulate KTS Plantation Sdn. Bhd. for taking this initiative to organize the expedition and seminar together with Sabah Forestry Department. Within the department, I thank the Deputy Chief Conservator (Research & Development), Dr Robert Ong, Senior Assistant Chief Conservator, Indra Sunjoto and the Organizing Committee (both SFD & KTS) for excellent team work in planning and execution of the seminar. I also thank Dr Arthur Y.C. Chung and Nurul Aqidah Ibrahim for the publication of the proceedings. I was told that it is not the intention of the Committee to thoroughly edit the papers but merely to compile the information presented during the seminar, that contributes to the Forest Management Plan of Segaliud Lokan Forest Reserve.

Thank you.

Datuk Mashor Mohd. Jaini
Chief Conservator of Forests,
Sabah Forestry Department

PREFACE

First and foremost, I would like to express my sincere appreciation to the Chief Conservator of Forests, Yang Berbahagia Datuk Mashor Mohd. Jaini for his courteousness to attend and officiate the Sungai Rawog Scientific Expedition Seminar.

Special thank you to the Sabah Forestry Department, especially the Forest Research Centre headed by Dr. Robert Ong and team for great assistance provided to ensure that field work, the seminar and the subsequent publication of the Proceedings has achieved its intended objectives.

I was made to understand that the expedition was attended by 36 experts from various fields of studies representing Universiti Malaysia Sabah (UMS), Sabah Wildlife Department, Sabah Parks, Forest Research Centre (FRC) and World Wide Fund for Nature (WWF-Malaysia). Also, with an overwhelming response from 200 participants that represented more than 20 agencies during the Seminar, is an evidence of commitment from all parties to ensure that the conservation area which is an important wildlife corridor and habitat for Segaliud Lokan Forest Reserve is dully studied, documented and protected.

With such a great participation from various agencies, I believe that the main objective of the seminar which is to communicate the results of the Scientific Expedition to the various stakeholders and forest communities at large has been achieved. Similarly, with the publication of the Proceedings which compiled the various findings from the expedition will ensure that all important data are documented and made available for future references.

Among others, data from the expedition have indicated that Segaliud Lokan Forest Reserve has one of the highest population and species diversity of wildlife, comparable with other well-managed forests, such as Deramakot Forest Reserve. This is an endorsement for our prudent conservation strategy at landscape level and the conservative forest operational approach over the past 20 years has paid off.

The Scientific Expedition and the subsequent Seminar will not be so successful without the help and support of important agencies, such as the Sabah Forestry Department and Universiti Malaysia Sabah, to name a few. These two agencies have been our collaborative partners since 2015.

I can only be grateful for the voluntary willingness of various parties to engage in research collaboration with KTS Plantation. It is evident that such collaboration has contributed significantly to the industries and learning institutions alike. Looking forward, I can only foresee more significant contributions through various initiatives for the benefit of the industries, learning institutions and the community at large.

Last but not least, I would like to thank KTS Plantation team - though small in number but great in performance for making this collaboration project with various agencies a wonderful success.

Thank you.

Dato Henry Lau Lee Kong
Managing Director, KTS Group of Companies

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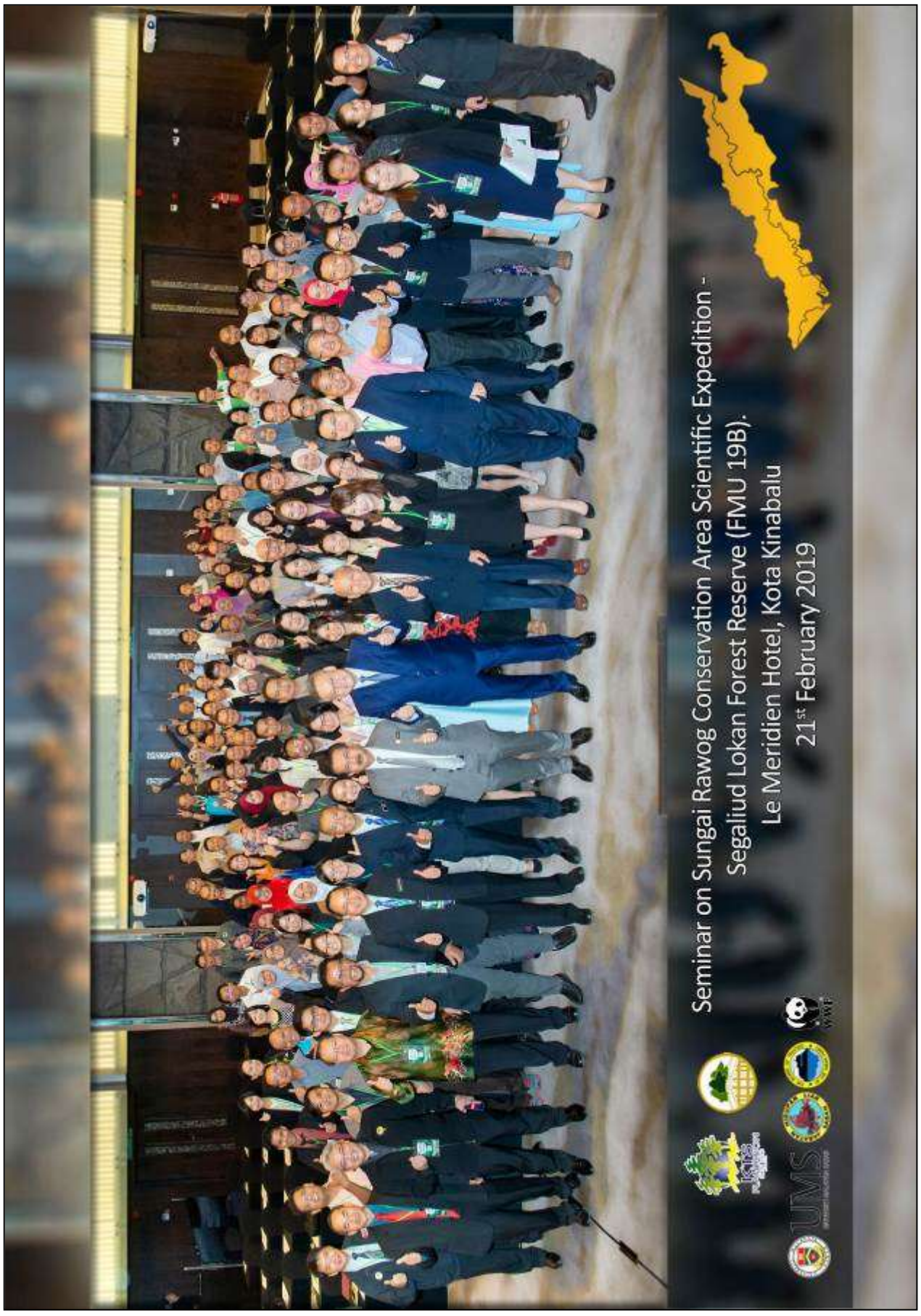

Seminar on Sungai Rawog Conservation Area Scientific Expedition -
Segaliud Lokan Forest Reserve (FMU 19B).
Le Meridien Hotel, Kota Kinabalu
21st February 2019
UMS

1.0 SEMINAR PROGRAMME

TIME	PROGRAMME
07:00 a.m.	Registration of Participants
08:30 a.m.	Arrival of Invited Guests
08:50 a.m.	Arrival of the Guest of Honour
09:00 a.m.	Welcoming Address by Director of KTS Holding Sdn. Bhd., Mr. Law Hui Kong
	Launching of the Seminar by the Guest of Honour (Chief Conservator of Forests, Datuk Mashor Mohd Jaini)
	Presentation of Souvenirs to the Guest of Honour & other participating agencies
	Group Photo
09:30 a.m.	Tour of the Exhibition
09:40 a.m.	Tea break
10:15 a.m.	Special Keynote Presentation by Sabah Forestry Department & KTS Plantation Sdn. Bhd.
10:30 a.m.	SESSION 1: FOREST ECOSYSTEMS, PHYSICAL SCIENCES & PLANT DIVERSITY
12:30 p.m.	Luncheon
01:30 p.m.	SESSION 2 : WILDLIFE DIVERSITY & TOURISM POTENTIALS
03:30 p.m.	Coffee break
04:00 p.m.	Closing Ceremony
	Remarks by Sabah Area Operation (SAO) Manager (Forests) of KTS Plantation Sdn. Bhd., Mr Collin Goh
	Remarks by the Deputy Chief Conservator of Forests (R & D), Sabah Forestry Department, Dr Robert Ong
	Presentation of Souvenir
04:30 p.m.	End of Seminar

SESSION 1: FOREST ECOSYSTEMS, PHYSICAL SCIENCES & PLANT DIVERSITY **Chairperson: Assoc. Prof. Dr. Monica Suleiman (UMS)**	
10:30 a.m.	Paper 1: Forest ecosystem assessment by Mohd. Aminur Faiz Suis (FRC, SFD)
10:40 a.m.	Paper 2: Diversity and conservation status of vascular plants by John Baptist Sugau (FRC, SFD)
10:50 a.m.	Paper 3: The mosses by Assoc. Prof. Dr. Monica Suleiman (ITBC,UMS)
11:00 a.m.	Paper 4: Species diversity of *Ficus* by Dr. Miyabi Nakabayashi (University of Ryukyus, Japan)
11:10 a.m.	Paper 5: Fungi by Assoc. Prof. Dr. Mahmud Sudin (FSSA, UMS)
11:20 a.m.	Paper 6: Medicinal plants by Assoc. Prof. Dr. Andy Mojiol (FSSA, UMS)
11:30 a.m.	Paper 7: Dipterocarps by Sandy Tsen Tze Lui (UMS/FRC)
11:40 a.m.	Paper 8: Preliminary survey of Araceae by Assoc. Prof. Dr. Kartini Saibeh (FSA, UMS Sandakan)
11:50 a.m.	Paper 9: Visitor impact on vegetation and soil along selected trails by Wilter Azwal Malandi (FSSA, UMS)
12:00 noon	Q&A Session

Session 2: WILDLIFE DIVERSITY & TOURISM POTENTIALS **Chairperson: Mr. Indra Sunjoto (SFD)**	
1:30 p.m.	Paper 1: An initial assessment on terrestrial mammal community by Assoc. Prof. Dr. Henry Bernard (ITBC, UMS)
1:40 p.m.	Paper 2: Human-wildlife conflict & coexistence by Hussien Muin (Sabah Wildlife Dept)
1:50 p.m.	Paper 3: Wildlife survey along the Rawog river by Dr. Jephte Sompud (FSSA, UMS)
2:00 p.m.	Paper 4: Rapid wildlife survey by Elyrice Alim (WWF- Malaysia)
2:10 p.m.	Paper 5: High tolerance to extreme environment – the case of a catfish by Prof. Dr. Abdul Hamid Ahmad (ITBC, UMS)
2:20 p.m.	Paper 6: Avifaunal survey by Hubert Petol (FRC, SFD)
2:30 p.m.	Paper 7: Insect diversity by Razy Japir (FRC, SFD)
2:40 p.m.	Paper 8: The land snails by Dr. Liew Thor Seng (ITBC, UMS)
2:50 p.m.	Paper 9:Potential ecotourism attractions by Jarry K.Lajanga (FRC,SFD)
3:00 p.m.	Q&A Session

POSTER PRESENTATIONS	
P01	Soil assessment by Esther Dyi Ka Mei (FRC, SFD)
P02	Distribution and abundance of Zingiberaceae by Dr. Walter Lintangah (FSSA, UMS)
P03	Distribution of *Etlingera coccinea* (Tuhau) Dr. Walter Lintangah (FSSA, UMS)
P04	Potential ornamental plants by Suzana Sabran (FRC, SFD)
P05	*Nepenthes* by Alviana Damit (FRC, SFD)
P06	Ferns & Lycophytes by Andi Maryani Andi Mustapeng (FRC, SFD)
P07	Preliminary study on fungus diversity by Viviannye Paul (FRC, SFD)
P08	Macrofungi diversity by Mohammad Hafiz Syukri bin Kassim (ITBC, UMS)
P09	The significant roles of salt licks on wildlife by Hennie Fitria (FSSA, UMS)
P10	Notes on bat diversity by Amirrah Amat (ITBC, UMS)
P11	Bat obligate ectoparasite diversity and its prevalence by Ummu Safiyyah Daud (ITBC, UMS)
P12	A brief glance on the ants by Dr. Bakhtiar Effendi Yahya (ITBC, UMS)
P13	Termite fauna by Assoc. Prof. Dr. Homathevi Rahman (ITBC, UMS)
P14	Dragonfly and damselfly fauna by Dayang Fazrinah Awg Damit (FRC, SFD)
P15	A checklist of the herpetofauna by Paul Imbun (Sabah Parks)
P16	A preliminary assessment of anuran diversity by Pg. Mohd Sahlan bin Salam (FRC, SFD)
P17	Diversity and distribution of ichthyofauna in selected rivers by Nur Syafiqah binti Shamsul Kamal (FRC, SFD)
P18	The status of parasites infestation among fishes by Hairul Hafiz bin Mahsol (ITBC, UMS)
P19	Preliminary assessment of avifauna in a recovering lowland forest by Alim Biun (Sabah Parks)

2.0 ORGANIZING COMMITTEE

Co-Chairman (SFD): Indra Sunjoto
Co-Chairman (KTS): Collin Goh

Main Committee Members: Dr Arthur Chung, John Sugau, Dr Reuben Nilus, Peter Tiong & Paul Liau

Secretariat: Suzana Sabran, Viviannye Paul, Alviana Damit, Fong Pek Yee & Darrysie Salapan

Master of Ceremony: Elne Betrece Johnlee

Rapporteus & Time keepers: Andi Maryani Andi Mustapeng, Esther Dyi Ka Mei, Mohd. Aminur Faiz Suis, Norlaila Ahmad & Marylyn Jonalius

Poster Setting-up: Razy Japir, Momin Binti & John Lee Yukang

ICT & Technical Services: Muhd. Nasrul Omar & Mohd. Adzwan Sapar

Cameramen: Nigel E. Balanjiu, Sanchez V. John & Dayang Fazrinah

Technicians: Pius Gubilil, Jemson Jumian, Markus Gumbilil & Postar@ Jaiwit Miun

Drivers: Saudi Bintang & Aloysius Laim

KTS Exhibition: Liaw Yi Chuang & Soliano Alfonso

Proceedings: Dr Arthur Chung & Nurul Aqidah Ibrahim

3.1 WELCOMING SPEECH BY MANAGING DIRECTOR, KTS GROUP OF COMPANIES, DATO HENRY LAU LEE KONG (Speech delivered by Director of KTS Holding Sdn. Bhd., Mr Kenny Law Hui Kong)

Yang Berbahagia Datuk Mashor Mohd. Jaini, Chief Conservator of Forests,
Yang Berusaha, all senior officials of Sabah Forestry Department,
All heads of government departments,
All heads of non-government organisations,
Senior managers of KTS group of companies,
Foresters, lecturers, students, ladies and gentlemen,

Welcome to the Seminar for Scientific Expedition on Sungai Rawog Conservation Area.

Please allow me to convey a deepest apology from Yang Berbahagia Dato' Henry Lau Lee Kong, the Managing Director of KTS Group of Companies, as he is not able to attend the function this morning due to an urgent matter need to be attended.

First and foremost, I would like to express my sincere appreciation to the Chief Conservator of Forests, Yang Berbahagia Datuk Mashor Mohd. Jaini for his courteousness to attend and officiate this seminar.

Special THANK YOU to the Sabah Forestry Department, especially the Forest Research Centre headed by Dr. Robert Ong and team for great assistance provided to ensure that field work and this seminar is a success as we see today. Thank you, Dr.

I was made to understand that the expedition was attended by 36 experts from various fields of studies representing Universiti Malaysia Sabah (UMS), Sabah Wildlife Department, Sabah Parks, Forest Research Centre (FRC) and World Wide Fund for Nature (WWF). Also, I would like to thank KTS Plantation team headed by Mr. Collin Goh –though small in number but great in performance. Mr. Collin Goh has informed me that the 2-week expedition in August last year was a huge success and I want to acknowledge and congratulate all those involved in the expedition, be it the organizer or the participants. For your kind information Datuk, the result from the expedition is used to improve our management of conservation areas in a holistic manner which is now being incorporated into our Forest Management Plan for the period of 2019-2028.

Ladies and gentlemen,

This seminar is organized to communicate the result of the Scientific Expedition to the various stakeholders and forest communities at large. Among others, data from the expedition have indicated that Segaliud Lokan Forest Reserve has one of the highest population and species diversity of wildlife as compared with other Forest Management Unit areas in Sabah. This is a testimony for our prudent conservation strategy at landscape level and the conservative forest operational approach over the past 20 years has paid off. As a layman, I am very encouraged by these findings. Congratulation, everyone!

Ladies and gentleman,

Over the past decade, we have seen that forest industry has evolved from a mere conventional industry into a complex one that has challenged the principle of Sustainable Forest Management. This is evidence in the declining of forest resources – both flora and fauna. Forest industry in developed countries, such as Canada and New Zealand shows that science has successfully navigated their forest industry through tough times and thereafter emerges as role model to other countries in the world in the aspect of sustainable forest management. For KTS Plantation, what is obvious must not be ignored. Lessons must be learned. Hence, as an acknowledgment of the importance of science in forest management, I would like to announce that KTS Plantation is going to establish a Field Research Station (FRS) at Segaliud Lokan Forest Reserve in the third quarter of this year. Among others, the Station will provide platform for foresters of brilliant mind to contribute to the industry through Research and Development collaboration. This will ensure Continuous Improvement of Practices according to the Principles of Sustainable Forest Management. And of course, the priority will be given to local scientists as advocated by the Chief Minister of Sabah, Yang Amat Berhormat Datuk Seri Panglima Haji Mohd. Shafie bin Haji Apdal.

Looking back, I can only be grateful for the voluntarily willingness of various parties to engage in research collaboration with KTS Plantation. It is evident that such collaboration has contributed significantly to the industries and learning institutions alike. We may not at where we are today without the help and support of important agencies, such as the Sabah Forestry Department and Universiti Malaysia Sabah, to name a few. These two agencies have been our collaborative partners since 2015. Though progress was occasionally slowed down by minor procedural glitch on our side, please bear with us as we learn the trade. Looking forward, I can only foresee more significant contribution through various initiatives for the benefit of the industries, learning institution and the community at large.

Ladies and gentlemen,

Once again I would like to express my greatest gratitude to Chief Conservator of Forests for his time. I would also like to express my sincere appreciation to all of you in making this event a success and thank you for joining us on this special occasion. Your gracious presence and support is greatly valued by us.

Thank you and have a wonderful seminar.

Dato Henry Lau Lee Kong
Managing Director, KTS Group of Companies

3.2 LAUNCHING SPEECH BY THE CHIEF CONSERVATOR OF FORESTS, DATUK MASHOR MOHD. JAINI

Mr Law Hui Kong, Director, KTS Holding Sdn. Bhd.,
Senior officials of KTS Plantation Sdn. Bhd. and Sabah Forestry Department,
Senior officials of government departments, NGOs and private sector,
Participants of the Seminar on Sg. Rawog Scientific Expedition,
Members of the Press,
Ladies & gentlemen,

Good morning and welcome to the Launching of the Seminar on Sg. Rawog Scientific Expedition, jointly organized by KTS Plantation Sdn. Bhd. and Sabah Forestry Department, with participation from Universiti Malaysia Sabah, Sabah Wildlife Department, Sabah Parks, WWF and other agencies in Sabah.

I'm glad to see that KTS Plantation is making much effort in biodiversity documentation and conservation. This seminar is held to present the research findings from the expedition organized in August 2018 in the Sg. Rawog Conservation Area within the Segaliud Lokan Forest Reserve in Sandakan. This is an activity that should be emulated by other FMU holders as well, in order to effectively manage the forest. The FMU is now managed based on the principles of sustainable forest management (SFM) and the requirements of the Sustainable Forest Management Licence Agreement (SFMLA) with the Sabah State Government. The main goal is to ensure that the timber resources will be maintained on a sustainable yield basis, with a commitment to protecting the natural resources and biological diversity of the natural forest.

Sg. Rawog is a conservation area covering 3,118 ha along the Sungai Rawog valley, serving as a wildlife corridor connecting Deramakot Forest Reserve & IOI Sdn. Bhd. It is located within the Segaliud Lokan Forest Reserve (SLFR) - Forest Management Unit No. 19(B), with a total area of 57,247 ha. This forest reserve is managed by KTS Plantation since 1993.

I was informed that the scientific expedition has been successfully organized and was given much publicity in the media, including TV1. Some 160 participants (in two batches) were involved, with participation from Universiti Malaysia Sabah (UMS), Sabah Wildlife Department (SWD), Sabah Parks (SP) and WWF-Malaysia. At least 31 groups of researchers from various disciplines conducted their surveys during the 11-day expedition. Collectively, the researchers have explored the 'unknowns' in Sg. Rawog Conservation Area from plants to wildlife and potentials in nature tourism. All these will be presented and showcased in this seminar. The data will be used as a guide to further enhance the conservation area and will definitely contribute towards the future plan of this area. This signifies the smart partnership between the state government through the Sabah Forestry Department and the private sector in sustainable forest management, working hand-in-hand with other agencies.

I am glad to know that KTS Plantation Sdn. Bhd. always strives to enhance its knowledge on sustainable forest management as the way forward. To enhance its conservation effort, a research collaboration has been established through a tripartite Memorandum of Understanding (MoU) signed between Sabah Forestry Department, Universiti Malaysia Sabah (UMS) and KTS Plantation in 2016. Among the programmes of collaboration were wildlife survey, forest camp and forest rehabilitation assessment, scientific expedition, and now this seminar for disseminating information and creating awareness on biodiversity conservation.

KTS Plantation adopts sustainable forest practices in managing Segaliud Lokan Forest Reserve, and the company is the first in Malaysia to attain the Programme for the Endorsement of Forest Certification (PEFC). The forest management practice in KTS Plantation has been endorsed by various certification schemes, such as Malaysian Criteria and Indicators for Forest Management Certification (Natural Forest) and EMS ISO14001.

Ladies & gentlemen, documentation of biodiversity in the Sg. Rawog Conservation Area is in line with the Heart of Borneo Initiative, which emphasizes on forest conservation and the establishment of wildlife connectivity. I was informed this is the first biodiversity documentation of this conservation area. Hence, the research findings will provide salient information to enhance the conservation effort of KTS in this reserve.

I understand that some 200 participants from about 20 agencies are taking part in this seminar. I wish all of you a fruitful and productive seminar. Once again, I congratulate such collaborative effort between KTS Plantation and Sabah Forestry Department towards conservation, with participation from various agencies. Keep up the good work! I also thank KTS Plantation for kindly sponsoring this seminar. With these remarks, I hereby officially launch the Seminar on Sg. Rawog Conservation Area Scientific Expedition.

Thank you very much.

Datuk Mashor Mohd. Jaini
Chief Conservator of Forests,
Sabah Forestry Department

KEYNOTE PRESENTATION

An overview of Sg. Rawog Conservation Area Scientific Expedition

A.Y.C. Chung[1*], C. Goh[2], J.B. Sugau[1], P. Tiong[2], R. Nilus[1] & P. Liau[2]

[1]Forest Research Centre, Sabah Forestry Department, P.O. Box 1407, 90715 Sandakan, Sabah, Malaysia
[2]KTS Plantation Sdn. Bhd., WDT 20, 90009 Sandakan, Sabah, Malaysia
**Author for correspondence. Email:Arthur.Chung@sabah.gov.my*

Abstract. The keynote presentation provides an overview of the scientific expedition, jointly organized by KTS Plantation Sdn. Bhd. and Sabah Forestry Department from the 8th to 18th of August, 2018, with participation from Universiti Malaysia Sabah, Sabah Wildlife Department, Sabah Parks and WWF Malaysia. Some 160 participants from at least 31 research groups were involved in this expedition. Research exploration included surveys on forest ecosystems, flora and fauna diversity, physical sciences and tourism potentials. This was the first biodiversity documentation of Sg. Rawog Conservation Area, covering an area of 3,118 ha within the Segaliud Lokan Forest Reserve, managed by KTS Plantation. The base camp was located in the middle of the conservation area in Compartment 56. Other study areas included Compartments 49 and 61. The various research activities during the 11-day expedition are highlighted in this presentation. It is hoped that all the data procured will enhance KTS Plantation's effort towards conserving this area, which is important as a wildlife corridor connecting Deramakot Forest Reserve and adjacent oil palm plantations. It also signifies the smart partnership in conservation management with relevant agencies.

INTRODUCTION

Much is not known about Sg. Rawog in central Sabah. It has been designated as a conservation area encompassing 3,118 ha and 23.4 km in length, within the Segaliud Lokan Forest Reserve. The reserve is also known as Forest Management Unit No. 19(B), covering an area of 57,247 ha, and has been managed by KTS Plantation Sdn. Bhd. since 1993 under the License Agreement with an effective period of 96 years. Sg. Rawog Conservation Area serves as a wildlife corridor connecting Deramakot Forest Reserve and adjacent oil palm plantations. Apart from routine monitoring, there have been no other activities in this area. As much is unknown about the biodiversity since 1993, KTS Plantation took the initiative to jointly organize a scientific expedition with Sabah Forestry Department (SFD) to explore Sg. Rawog's flora and fauna from 8th to 18th of August, 2018.

PARTICIPATION IN THE EXPEDITION

Some 160 participants (in two batches) were involved, with participation from Universiti Malaysia Sabah (UMS), Sabah Wildlife Department (SWD), Sabah Parks (SP) and WWF-Malaysia. On the first night at the camp, KTS Plantation Sabah Area Manager (Forestry), Mr Collin Goh, welcomed the participants to the scientific expedition.

At least 31 groups of researchers from various disciplines conducted their surveys during the 11-day expedition. Dr. Reuben Nilus, Mohd. Aminur Faiz and their ecology team of SFD studied the forest structure and composition of the conservation area. Climax vegetation comprises four forest ecosystems, namely late secondary forest, lowland mixed dipterocarp forest, kerangas forest and Kapur Merah forest. The lowland mixed dipterocarp and kerangas forest is rich in kapur trees (*Dryobalanops* spp.). This area harbours significant forest ecosystems and hence, long-term monitoring effort on its forest dynamics is highly recommended. A total of 11 permanent sampling plots were established to monitor the status of the area. Esther Dyi did the soil assessment during the expedition. The preliminary results showed two types of soil colour ranges from very dark brown to white (indicates heath forest) and reddish brown to yellowish red (lowland mixed dipterocarp forest). The soil texture ranged from sand to sandy clay loam.

Plant diversity survey and botanical collection were carried out by John Sugau and his team of the Sandakan Herbarium. Suzana Sabran worked on ornamental plants while Andi Maryani on ferns, Richard Majapun on dipterocarps, Alviana Damit on pitcher plants and Doris Seligin on medicinal plants. Some 40 dipterocarp species were recorded, with two endemic to Sabah, i.e. *Shorea symingtonii* and *S. waltonii*. Two pitcher plant species were sighted, namely *Nepenthes ampullaria* and *N. mirabilis*, with a hybrid, *N. x kuchingensis* (between *N. ampullaria* and *N. mirabilis*).

The researchers from Institute of Tropical Biology and Conservation (ITBC), UMS were led by Assoc. Prof. Monica Suleiman who studied mosses in the conservation area. Dr. Kartini Saibeh from Faculty of Sustainable Agriculture (FSA), UMS, conducted research on Araceae which is the family of taro. One undescribed species of Araceae from the genus *Homalomena* was recorded. Plant researchers from SP were headed by Rimi Repin, and they worked on Begonias and nickel hyper-accumulator plants. Rimi recorded three Begonia species, with two of them undetermined. Dr. Miyabi Nakabayashi of Ryukyus University, Japan in collaboration with SFD, was researching on figs, which are a source of food for frugivorous animals.

From Faculty of Science and Natural Resources (FSSA), UMS, Dr. Mohd. Sani Sarjadi and his team studied mineralogy. Assoc. Prof. Mahmud Sudin (FSSA) worked on the mushroom diversity within the area. Others who surveyed fungi were Viviannye Paul (SFD) and Dr. Jaya Seelan's student (ITBC, UMS). Dr. Walter Lintangah (FSSA) explored ginger diversity within the area.

Sabah Wildlife Department was represented by Hussien Muin, with his team surveying mammals, reptiles and birds. Sg. Rawog Conservation Area is known to have high abundance of orang utans and Bornean pygmy elephants, and the river itself is inhabited by crocodiles. Assoc. Prof. Dr Henry Bernard, Dr Jephte Sompud and their team from UMS as well as Elyrice Alim of WWF-Malaysia and Mohd. Aminur Faiz (SFD) were also researching

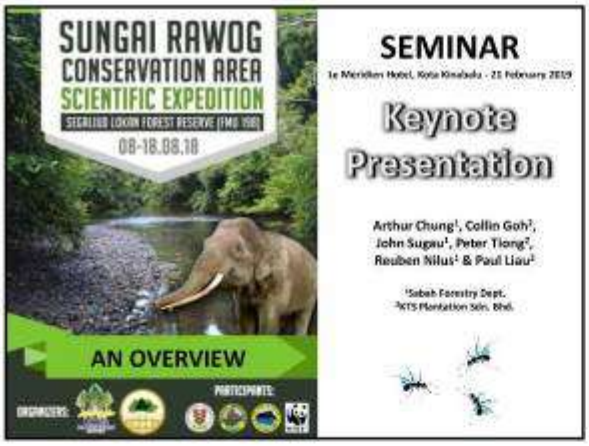
on wildlife. Among other mammals sighted were gibbons, grey-leaf monkey, bearded pig, Sambar deer, sun bear, tembadau, clouded leopard and the Sunda pangolin. Alim Biun (SP) and Hubert Petol (SFD) surveyed the avifauna. All the eight species of hornbills found in Borneo were sighted during the expedition. The presence of the great Argus pheasant was also recorded. Paul Imbun (SP) and Pg. Sahlan (SFD) conducted survey on frogs and toads. At least 18 species were recorded, with seven of them endemic to Borneo. Assoc. Prof. Abdul Hamid (ITBC, UMS) and Nur Syafiqah S. Kamal (SFD) did some work on the fishes of Sg. Rawog while Hairul Hafiz (ITBC, UMS) sampled parasites of fishes and bats. Students of Azniza Mahyudin (ITBC, UMS) did a survey on bats and their ectoparasites. Dr Liew Thor Seng (ITBC, UMS) surveyed land snails.

Dr Arthur Chung, Razy Japir and the Entomology team of SFD surveyed the insect fauna which included butterflies, moths, beetles and dragonflies. Nocturnal insect diversity as assessed through light-trapping was very high, with more than a hundred species enumerated on a meter square of the light-trapping cloth. For dragonflies and damselflies, more than 30 species were recorded within three days of sampling. At least nine Bornean endemic insect species were recorded and the iconic Malaysia national butterfly, Rajah Brooke's Birdwing was sighted at the riverine area of Sg. Rawog. Dr. Homathevi Rahman and Dr. Bakhtiar E. Yahya, both from ITBC, UMS, worked on termites and ants respectively.

Besides conservation, nature tourism is another aspect that was given emphasis in this expedition. Jarry Lajanga (SFD), Dr. Andy Russel Mojiol and Dr. Rosmalina (both from UMS) surveyed the potential sites and products for nature tourism. The natural garden of flask-shaped pitcher plants found in one of the heath forest site was spectacular and breathtaking. The presence of natural salt licks within the area can be used to promote wildlife watching.

Collectively, the researchers have explored the 'unknowns' in Sg. Rawog Conservation Area. Hence, such data would be very useful in enhancing the conservation efforts of this area.This also signifies a smart partnership between the state government through the Sabah Forestry Department and the private sector in sustainable forest management, working hand-in-hand with other agencies, as always advocated by the Chief Minister of Sabah.

Slide Presentation

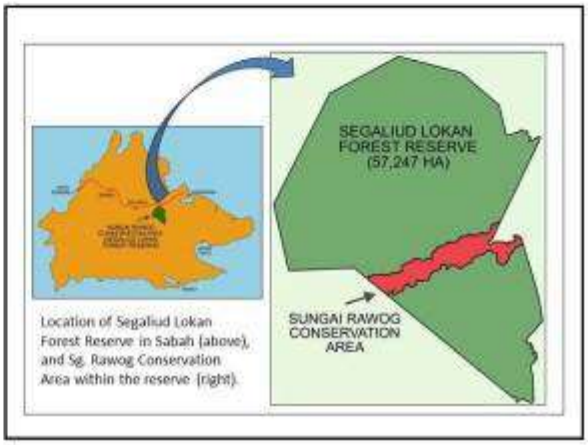


Sg. Rawog Conservation Area (SRCA) is located within the Segaliud Lokan Forest Reserve in Sandakan. The reserve (known as FMU 19(B)) is managed by KTS Plantation Sdn. Bhd. since 1993. SRCA covers an area of 3,118 ha, about 23.4 km in length along Sg. Rawog and was logged prior to 1993. The area is important as a wildlife corridor in line with the objective of the HoB Initiative.

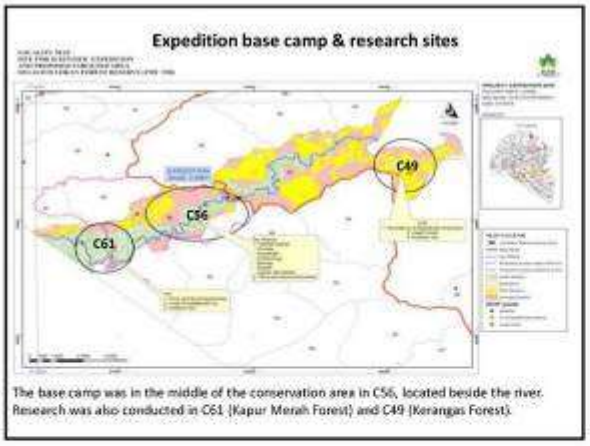
Main vegetation comprises four forest ecosystems, namely late secondary forest, lowland mixed dipterocarp forest, kerangas forest and Kapur Merah forest (*Dryobalanops beccarii*).

In the kerangas forest, the flask-shaped pitcher, *Nepenthes ampullaria*, is commonly seen. Other pitchers are *N. mirabilis* and a hybrid, *N. x kuchingensis*.

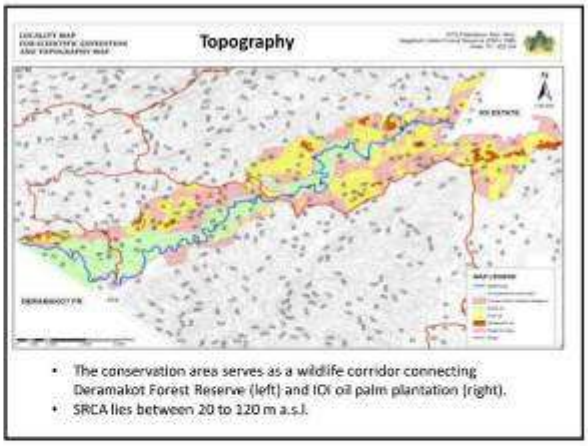
As much is not known about the biodiversity in SRCA, KTS Plantation took the initiative to jointly organize a scientific expedition with Sabah Forestry Department to explore Sg Rawog's biodiversity from 8th to 18th of August, 2018, with participation from UMS, Wildlife Dept., Sabah Parks & WWF M'sia.



Location of Segaliud Lokan Forest Reserve in Sabah (above), and Sg. Rawog Conservation Area within the reserve (right).



The base camp was in the middle of the conservation area in C56, located beside the river. Research was also conducted in C61 (Kapur Merah Forest) and C49 (Kerangas Forest).



- The conservation area serves as a wildlife corridor connecting Deramakot Forest Reserve (left) and IOI oil palm plantation (right).
- SRCA lies between 20 to 120 m a.s.l.

Expedition base camp site (N 05 27 41.9, N 117 33 58) at Sg. Rawog, Segaliud Lokan Forest Reserve (Drone Photo by M.A. Fui).

The 1st batch of the participants from 8th to 12th August, 2018.

The 2nd batch of the participants from 13th to 18th August, 2018.

At least 31 groups of researchers from various disciplines conducted their surveys during the 11-day expedition.

Dr. Reuben Nilus, Mohd. Aminur Faiz and their ecology team of SFD studied the forest structure and composition of the conservation area. A total of 11 permanent sampling plots were established to monitor the status of the area.

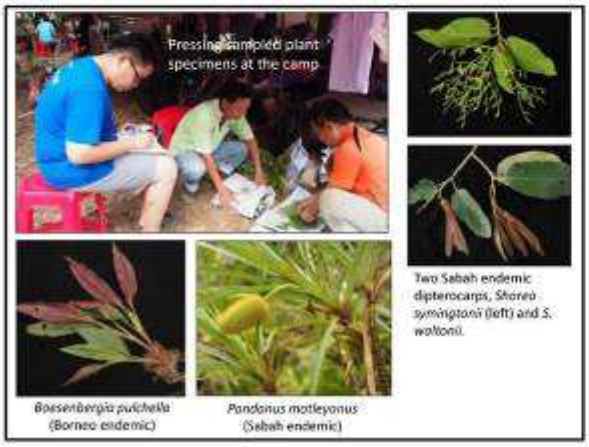
Lycophyte – Borneon endemic *Selaginella conjecta*

Aeginetia mirabilis

John Sugau

Plant diversity survey and botanical collection were carried out by **John Sugau** and his team of the Sandakan Herbarium. **Suzana Sabran** (ornamental plants), **Andi Maryani** (ferns & lycophytes), **Richard Majapun** (dipterocarps), **Alviana Damit** (pitcher plants), **Doris Seligin** (medicinal plants). 572 taxa recorded, with 124 taxa endemic Borneo and 11 endemic to Sabah.

Suzana Sabran | Alviana D. | Andi Maryani | Richard Majapun | Doris Seligin



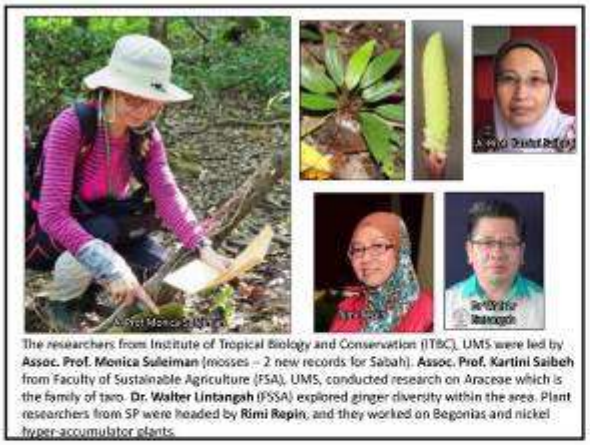
Two Sabah endemic dipterocarps, *Shorea symingtonii* (left) and *S. waltonii*.

Boesenbergia pulchella (Borneo endemic)

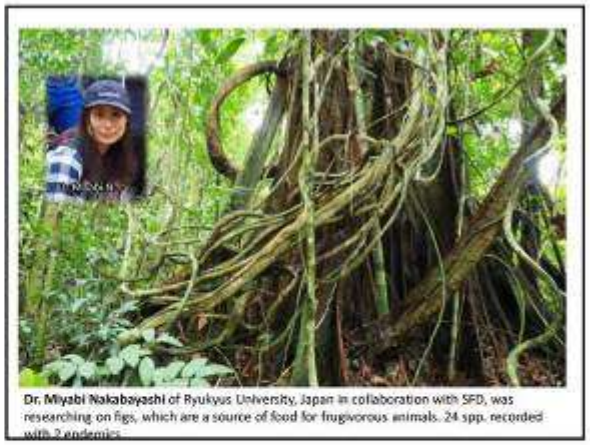
Pandanus motleyanus (Sabah endemic)

Gnetum cuspidatum (Gnetaceae) is one of the interesting plants sighted due to its abundant grape-like fruits on the stem and branches

Researchers at the Pitcher Plant Garden in the Kerangas forest



The researchers from Institute of Tropical Biology and Conservation (ITBC), UMS were led by **Assoc. Prof. Monica Suleiman** (mosses – 2 new records for Sabah). **Assoc. Prof. Kartini Saibeh** from Faculty of Sustainable Agriculture (FSA), UMS, conducted research on Araceae which is the family of taro. **Dr. Walter Lintangah** (FSSA) explored ginger diversity within the area. Plant researchers from SP were headed by **Rimi Repin**, and they worked on Begonias and nickel hyper-accumulator plants.



Dr. Miyabi Nakabayashi of Ryukyus University, Japan in collaboration with SFD, was researching on figs, which are a source of food for frugivorous animals. 24 spp. recorded with 2 endemics.

From Faculty of Science and Natural Resources (FSSA), UMS, **Dr. Mohd. Sani Sarjadi** & **Hennie Fibria** under **Prof. Baba Musta's** team studied minerals within the area. **Assoc. Prof. Mahmud Sudin** (FSSA) worked on the mushroom diversity within the area. Others who surveyed fungi were **Viviannye Paul** (SFD) and **Dr. Jaya Seelan's student** (ITBC, UMS).

Esther Dyi did the soil assessment. They are from Sook & Brantian Association. The results showed two types of soil colour ranges from very dark brown to white (indicates heath forest) and reddish brown to yellowish red (lowland mixed dipterocarp forest). More info is featured in the poster.

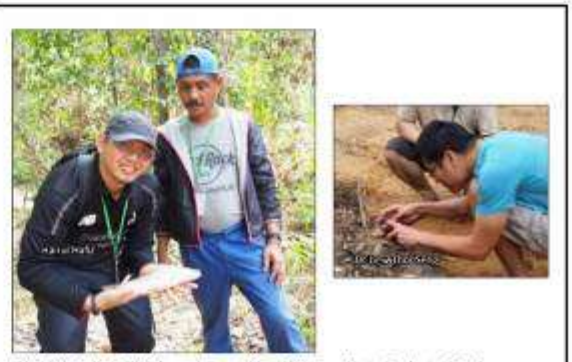
Sabah Wildlife Department was represented by **Hussien Muin**, with his team surveying mammals, reptiles and birds. Sg. Rawog Conservation Area is known to have high abundance of orang utans and Bornean pygmy elephants, and the river itself is inhabited by crocodiles.

Assoc. Prof. Dr Henry Bernard, Dr Jephte Sompud and their team from UMS as well as **Elyrice Alim** of WWF-Malaysia and **Mohd. Aminur Faiz** (SFD) were also researching on wildlife. Among the mammals sighted were gibbon, grey-leaf monkey, bearded pig, Sambar deer, sun bear, tembadau, clouded leopard and the Sunda pangolin. The extremely rare Flat-headed Cat was also photographed.

Alim Biun (SP) and **Hubert Petol** (SFD) surveyed the avifauna. Some 113 species were recorded. Shannon diversity index was very high (4.29). The presence of the great Argus pheasant was also recorded.

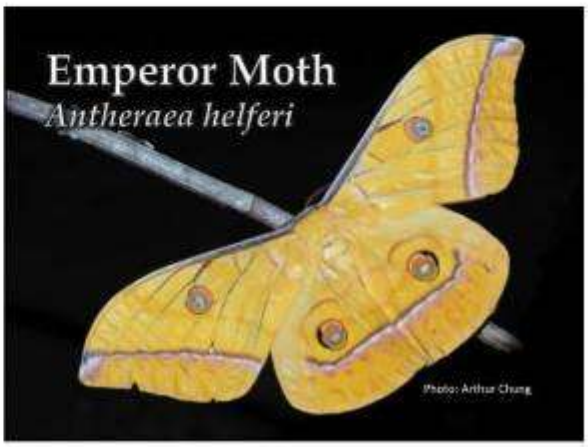
Paul Imbun (SP) and **Pg. Sahlan** (SFD) conducted survey on frogs and toads. At least 19 species were recorded, with eight of them endemic to Borneo. More info in the posters.

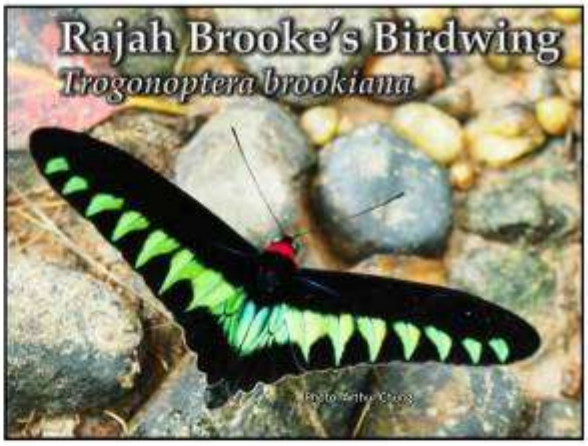
Prof. Abdul Hamid (ITBC, UMS) conducted research on the tolerance of a catfish species to extreme environment while **Nur Syafiqah S. Kamal** (SFD) did some work on fish diversity of Sg. Rawog Conservation Area.



Hairul Hafiz (ITBC, UMS) sampled parasites of fishes and bats. Students of **Azniza Mahyudin** (ITBC, UMS) did a survey on bats and their ectoparasites. **Dr Liew Thor Seng** (ITBC, UMS) surveyed land snails (21 spp.).

Dr Arthur Chung, Razy Japir and the Entomology team of SFD surveyed the insect fauna. Nocturnal insect diversity as assessed through light-trapping was very high. During daytime, butterflies, dragonflies and damselflies were documented. More info on Odonata fauna in the poster.





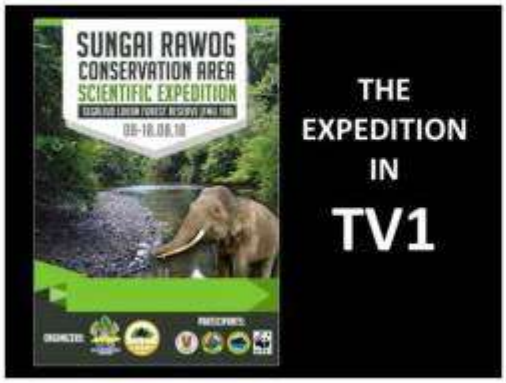
Assoc. Prof. Dr. Homathevi Rahman (ITBC, UMS) worked on termites and **Assoc. Prof. Dr. Bakhtiar E. Yahya** (ITBC, UMS) researched on ants. At least 60 litter ant species were recorded.

The presence of natural salt licks can be used to promote wildlife watching.

Besides conservation, nature tourism is another aspect that was given emphasis in this espedition. **Jarry Lajanga** (SFD), **Dr. Andy Russel Mojiol** and **Dr. Rosmalina** (both from UMS) surveyed the potential sites and products for nature tourism. **Wilter Azwal Malandi** (UMS) looked at the visitor impact on vegetation and soil along selected trails.

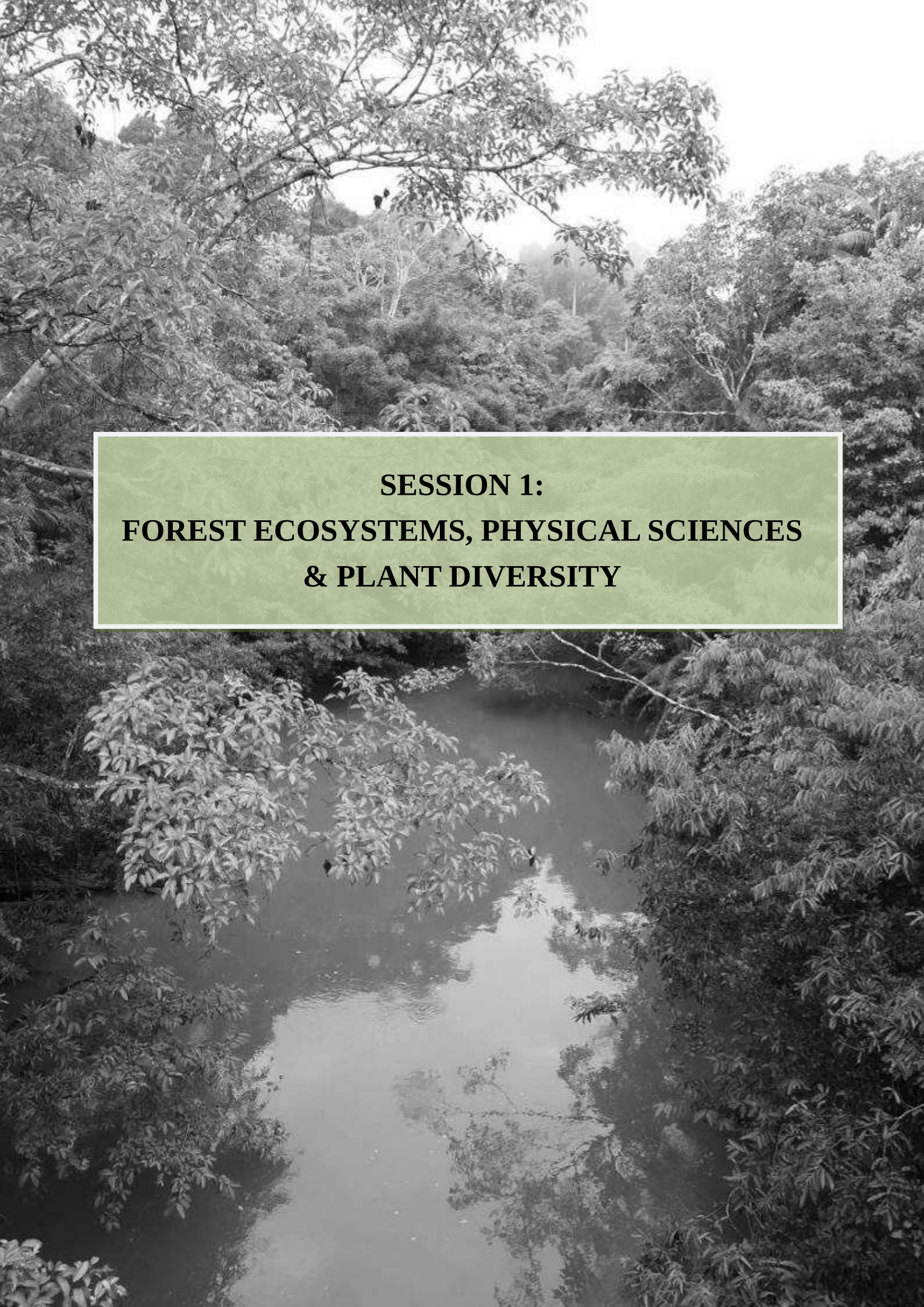
Conclusion

- Collectively, the researchers have explored the 'unknowns' in Sg. Rawog Conservation Area from plants to wildlife and potentials in nature tourism. These will be documented and published.
- The data will be used as a guide to further enhance the conservation effort in this area.
- Such basic information will contribute towards the future planning of this area, in setting-up a field station for researchers, special interest tourists and nature lovers.
- This signifies the smart partnership between the state government through the Sabah Forestry Department and the private sector in sustainable forest management, working hand-in-hand with other agencies, as advocated by the Chief Minister of Sabah.



Thank You!

KTS PLANTATION



SESSION 1:
FOREST ECOSYSTEMS, PHYSICAL SCIENCES & PLANT DIVERSITY

PAPER 1.1

Forest ecosystem assessment of Sungai Rawog Conservation Area in Segaliud Lokan Forest Reserve, Sabah

M.A.F. Suis, J.B. Sugau, E.K.M. Dyi & R. Nilus*

Forest Research Centre, Sabah Forestry Department, P.O. Box 1407, 90715 Sandakan, Sabah, Malaysia
**Author for correspondence. Email: reuben.nilus@sabah.gov.my*

Abstract. There were very few studies conducted in Sungai Rawog Conservation Area in Segaliud Lokan Forest Reserve. Hence, an ecological study was conducted during a scientific expedition to that area. This study aimed to elucidate the tree diversity, composition and structural aspects of forest ecosystems present in the conservation area. A total of eleven permanent sample plots were established and some statistical analyses were computed. The lowland mixed dipterocarp and kerangas forest of Sungai Rawog Conservation Area comprise another four sub-forest ecosystems, namely mixed dipterocarp, Kapur Merah forest, kerangas forest and a late secondary forest (previously on mixed dipterocarp forest). The forest structure, species composition, diversity indices and aboveground biomass of these forests are highly varied. Forest fires and poaching activities are the major threats to this conservation area. Sungai Rawog Conservation Area is undeniably a safe haven for a wide range of floral and faunal species. In accordance to the statewide biodiversity monitoring programme, the findings derived from this study support the long-term conservation commitments of protecting the integrity and functionality of forest ecosystems in SRCA.

Keywords: Borneo, permanent sample plot, diversity indices, aboveground biomass

INTRODUCTION

Segaliud Lokan Forest Reserve is a Class II Commercial Forest Reserve since 1984. In 1993, under the License Agreement for Timber Tree Plantation and Wood Processing Plant, the reserve is now managed by KTS Plantation Sdn. Bhd. for 96 years. KTS Plantation Sdn. Bhd. has designated 6,447 ha or approximately 11% of the reserve for conservation purposes.

Sungai Rawog Conservation Area (SRCA) is a part of the 11%. It comprises of four compartments: Compartment 49, 52, 56 and 61. Since SRCA is understudied, KTS Plantation Sdn. Bhd. collaborated with Sabah Forestry Department in organizing a scientific expedition from the 8th – 18th August 2018, to document the biodiversity of SRCA by facilitating various research groups from other government agencies and universities.

Objectives of study

The following are the objectives of this study conducted in SRCA:

1. To describe forest structure and composition.
2. To calculate diversity indices of the enumerated tree communities.
3. To estimate aboveground biomass (AGB) of the enumerated tree communities.

MATERIALS AND METHODS

Study site

SRCA is situated between longitude 117° 30' – 117° 38'E and latitude 05° 30' – 05° 25'N (Figure 1). This conservation area comprises of four compartments (i.e. Compartment 49, 52, 56 and 61) and is accessible from Sandakan-Telupid main road. Covering a total of 3,118 ha of land area, SRCA has been logged in the past.

In general, SRCA has a flat terrain where the altitude ranges from 30 to 120 m a.s.l. SRCA consists of two soil associations that are Brantian and Sook. There are no distinct dry periods recorded in this area. The mean annual temperature is 27°C. This area also serves as an important riparian buffer for the Rawog river that drains from Deramakot in the West and out to IOI Estate in the East.

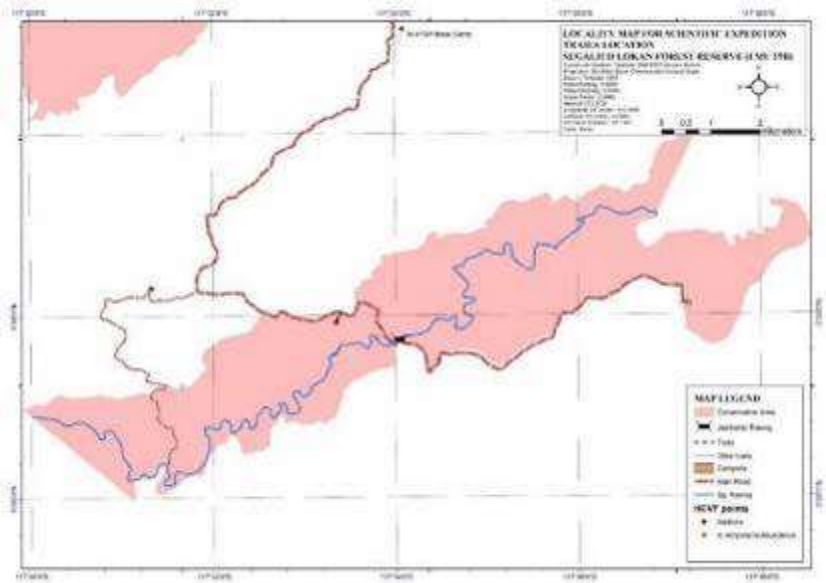


Figure 1. Map of Sungai Rawog Conservation Area in Segaliud Lokan Forest Reserve.

Sampling and tree enumeration

We established eleven permanent sample plots (PSPs) throughout the expedition. Location of each PSP was not randomly determined but based on accessibility, and the expedition's trails. These PSPs are circular in shape with a 20 m radius. The area covered by each plot was equivalent to 0.125 ha. We only enumerate trees with diameter at breast height (DBH) of ≥10 cm. We utilized standard field equipments for tree enumeration. Details of each PSP are shown in Table 1.

Table 1. Details of permanent sample plots established during the expedition.

Label	Latitude	Longitude	Elevation (m)	Soil Association	Remark
KTS 1	05°26'40.8"	117°31'39.1"	60	Sook	Logged over
KTS 2	05°26'46.3"	117°31'43.1"	65	Sook	Logged over
KTS 3	05°26'41.1"	117°31'48.8"	72	Sook	Logged over
KTS 4	05°27'30.8"	117°33'55.6"	44	Sook	Logged over
KTS 5	05°27'27.6"	117°33'47.5"	63	Sook	Logged over
KTS 6	05°27'40.2"	117°33'54.5"	41	Sook	Logged over
KTS 7	05°28'03.2"	117°37'23.5"	89	Brantian	Minimally disturbed
KTS 8	05°28'05.6"	117°37'21.6"	94	Brantian	Logged over
KTS 9	05°27'46.8"	117°34'01.9"	46	Sook	Secondary vegetation
KTS 10	05°27'41.3"	117°33'47.1"	53	Sook	Logged over
KTS 11	05°27'41.2"	117°33'44.2"	45	Sook	Logged over

Plant identification

The botanists identified most of the common trees on site by means of their distinctive field characteristics (e.g. leaf, flower, fruits, tree bark and resin). In case where their identity is uncertain, voucher specimens were collected for further identification process at the Sandakan Herbarium (SAN). The voucher specimens were identified to species-level by cross-referencing with existing authentic herbarium specimens.

Importance value index

We calculated the importance value index of each tree species and family enumerated from the PSPs. The importance value index of a tree species and family is defined as the average of relative tree density and relative basal area. The equation followed that of Brower & Zar (1977).

Diversity indices

We used three diversity indices, namely Simpson's Index, Menhinick's Index, and Hill's Evenness Index to quantify the species richness, diversity and evenness of tree communities in each PSP. This statistical analysis was computed using R vegan package version 2.5-2 (Oksanen *et al*., 2018).

Aboveground biomass and carbon stocks

We estimated the AGB of individual trees using two allometric regression equations. We chose generalized allometric equation developed by Brown (1997) and Roland & Lim (1999). The allometric equation based on Brown (1997) is suited for moist tropical forest. Meanwhile, the equation introduced by Roland & Lim (1999) is designed to calculate the AGB of individual trees in the kerangas forest.

We summed the individual tree biomass values to estimate the AGB of the PSPs. The AGB value is then multiplied by a standard value of carbon concentration to estimate the carbon stock. We followed Gibbs *et al*. (2007), of which 50% of the dry biomass is carbon.

RESULTS AND DISCUSSION

Description on forest structure and species composition

At a large scale, the natural forest ecosystem in SRCA is identified as lowland mixed dipterocarp and kerangas forest, and is divided into four sub-forest ecosystems, namely mixed dipterocarp forest, Kapur Merah forest, kerangas forest and a late secondary forest. All sub-forest ecosystems, except the late secondary forest, are in the advanced growth or regenerative stage, where most of the species composition and structure are contributed by climax tree species.

Anthropogenic signs (e.g. old skid trails and tree stumps) were seen in almost all sub-forest ecosystems. Nonetheless, disturbance signs were nearly absent in the kerangas forest. This suggests that the kerangas forest is minimally disturbed in the past, due to its low timber value. Newbery *et al*. (1986) also noted that the kerangas forest is often dominated by small trees (10-20 cm in DBH).

A. Lowland mixed dipterocarp and kerangas forest

i. Mixed dipterocarp forest

The mixed dipterocarp forest is represented by six PSPs, namely KTS 4, KTS 5, KTS 6, KTS 8, KTS 10 and KTS 11. This forest has large structures and high productivity. Its structure is largely contributed by dipterocarps and is associated with other important tree families. However, logging activities in the past have impacted the structures and floristic compositions of this forest, leaving various patches of vegetation in regenerative growth stages.

ii. Kapur Merah forest

The Kapur Merah forest is named after *Dryobalanops beccarii*, a dipterocarp which is considered as a mono-dominant species in this forest. This forest is unique as it has both ecological features of a kerangas forest and a mixed dipterocarp forest. Only three PSPs, namely KTS 1, KTS 2 and KTS 3 were established in the Kapur Merah forest.

iii. Kerangas forest

A pocket of kerangas forest in the eastern part of SRCA was also sampled. Represented by KTS 7, they occur on white-sand soils. Unusual abundance of *Nepenthes ampullaria* was observed in this nutrient-poor forest. The occurrence of *Nepenthes ampullaria* in a kerangas forest was also reported by Adam *et al*. (1991). The tree structures and species composition of a kerangas forest totally differ from its surrounding forests. This forest is dominated by tree family Myrsinaceae (Table 2). There were no dipterocarps found in KTS 7. Almost all trees in this forest are small in stature and have reddish-brown barks.

B. Secondary forest on previously mixed dipterocarp forest

KTS 9 was set up in the late secondary forest, close to the expedition's security post. This forest is common along unpaved road of SRCA. The late secondary forest is formed when a mixed dipterocarp forest was completely cleared and abandoned for a very long time. The late secondary forest is less diverse and is simple in structure. DBH of trees in this forest are roughly uniform, indicating that these trees grew simultaneously after the disturbance. KTS 9 is also devoid of dipterocarps.

A total of 200 taxa, comprising of 100 genera and 48 families were enumerated from eleven PSPs. Based on the estimation per hectare basis, kerangas forest attained the highest tree density, meanwhile the mixed dipterocarp forest was recorded with the lowest (Table 2). Total basal area of tree communities in the late secondary forest was estimated at 7.9 m^2ha^{-1} (Table 2). This is in concordance with a study conducted in Central Kalimantan by Brearly (2011), of which he reported that total basal area of trees in the secondary forests ranged between 3.28 – 24.0 m^2ha^{-1}.

Table 2. Ecological features of the four sub-forest ecosystems in Sungai Rawog Conservation Area.

Attribute	**Sub-forest Ecosystem**			
	Kerangas	**Kapur Merah**	**Late Secondary**	**Mixed Dipterocarp**
Estimated tree density (ha^{-1})	664	625	280	219
Estimated basal area (m^2ha^{-1})	16.7	33.3	7.9	13.8
Dominant family	Myrsinaceae	Dipterocarpaceae	Lamiaceae	Dipterocarpaceae
Dominant species	*Myrsine fluviatilis*	*Dryobalanops beccarii*	*Vitex pinnata*	*Dryobalanops beccarii*
Co-dominant species	-	-	-	*Shorea mecistopteryx*
Abundant species	*Myrsine fluviatilis*	*Dryobalanops beccarii*	*Vitex pinnata*	*Dryobalanops beccarii* *Pternandra* sp.

Three major forest canopy layers (i.e. main canopy, middle storey and understorey) were recorded in both Kapur Merah forest and mixed dipterocarp forest (Table 3). The main canopy layer comprised of large trees (DBH≥ 50 cm) and could reach up to 50-60 m in height. Whereas, the middle storey layer is made of trees with DBH ranging between 20-40 cm, which rarely exceeds 40 m in height. The understorey layer is dominated by small trees with 10-19 cm in DBH. The main canopy layer is not clearly visible in both kerangas forest and the late secondary forest.

Table 3. Common tree species that form the forest canopy layers of Sungai Rawog Conservation Area. (Notes: main canopy layer (MC); middle storey canopy layer (MS); and understorey canopy layer (US))

Sub-forest Ecosystem	Family	Species	MC	MS	US
Kerangas forest	Myrsinaceae	*Myrsine fluviatilis*			/
	Hypericaceae	*Cratoxylum arborescens*		/	/
	Myrtaceae	*Syzygium zeylanicum*			/
	Annonaceae	*Xylopia ferruginea*	/	/	/
	Tetrameristaceae	*Tetramerista glabra*		/	/
	Moraceae	*Ficus subgelderi*		/	
	Lauraceae	*Persea rimosa*		/	/
	Chrysobalanaceae	*Parastemon urophyllus*			/
	Lauraceae	*Litsea elliptica*			/
	Elaeocarpaceae	*Elaeocarpus clementis*			/
Kapur Merah forest	Dipterocarpaceae	*Dryobalanops beccarii*	/	/	/
	Lauraceae	*Litsea cylindrocarpa*	/	/	/
	Dipterocarpaceae	*Shorea macroptera*		/	/
	Sapotaceae	*Palaquium rostratum*	/		/
	Myrtaceae	*Syzygium incarnatum*			/
	Myrtaceae	*Syzygium pustulatum*	/		/
	Celastraceae	*Lophopetalum subovatum*	/	/	
	Rubiaceae	*Canarium* sp.		/	/
	Hypericaceae	*Cratoxylum arborescens*		/	/
	Chrysobalanaceae	*Parastemon* sp.		/	/
Late secondary forest	Lamiaceae	*Vitex pinnata*	/	/	/
	Elaeocarpaceae	*Elaeocarpus stipularis*		/	/
	Euphorbiaceae	*Macaranga conifera*		/	/
	Hypericaceae	*Cratoxylum cochinchinense*		/	/
	Myrtaceae	*Syzygium leptostemon*			/
	Annonaceae	*Xylopia elliptica*			/
	Hypericaceae	*Cratoxylum formosum*			/
	Apocynaceae	*Alstonia iwahigensis*			/
	Rhizophoraceae	*Carallia brachiata*			/
	Myrtaceae	*Syzygium* sp.			/
Mixed dipterocarp forest	Dipterocarpaceae	*Dryobalanops beccarii*	/	/	/
	Dipterocarpaceae	*Shorea mecistopteryx*	/	/	/
	Anacardiaceae	*Gluta wallichii*	/	/	/
	Melastomataceae	*Pternandra* sp.		/	/
	Euphorbiaceae	*Croton argyratus*		/	/
	Dipterocarpaceae	*Shorea argentifolia*	/	/	
	Dipterocarpaceae	*Shorea ovalis*	/	/	/
	Elaeocarpaceae	*Elaeocarpus stipularis*	/	/	
	Dipterocarpaceae	*Shorea parvifolia*	/	/	

Threats and mitigative measures

Secondary forests in SRCA are at risk of forest fires especially during prolonged drought seasons. For instance, discarded cigarette butts may inadvertently lead to forest fires. Secondary vegetations are more prone to forest fires than the advanced growth forest. Furthermore, tree mortality rates due to forest fires are even greater in tropical secondary forest than in pristine forests (Riswan & Yusuf, 1986).

The presence of natural saltlicks in Segaliud Lokan Forest Reserve, especially in SRCA, is known to many people. Even though wildlife benefitted from them, these natural saltlicks increase poaching risks. SRCA is not only accessible from the road but also through the river. There were no signs of poaching recorded during the expedition but the threat is still valid.

Thus, prevention measures are required to protect SRCA's ecosystem functionality from forest fires and poaching activities. Comprehensive forest fire prevention programme for SRCA should include fire prevention, detection, control and suppression mechanisms. Meanwhile, the patrolling strategies should be regularly revised to tackle poaching issues.

Species richness, evenness and heterogeneity

Both of the late secondary forest and kerangas forest were relatively low in species richness (Menhinick's Index) and species heterogeneity (Simpson's Index) (Table 4). This study suggests that the low species richness in kerangas forest is a result of its nutrient-deficient soil. The acidic soil of kerangas forest is also not favourable for many plant species. KTS 9 is devoid of climax trees and instead are dominated by pioneer species.

The Kapur Merah forest that is represented by KTS 3, recorded the highest values of species richness and species heterogeneity (Table 4). The cause has not been ascertained but the site (KTS 3) is seasonally inundated especially during the rainy seasons. Although KTS 3 is high in terms of species richness and species heterogeneity, the low Hill's Evenness value indicates that the tree species composition is not evenly distributed.

Table 4. Diversity indices of tree communities enumerated in each permanent sample plot.

Sub-forest Ecosystem	Permanent Sample Plot	Menhinick's Index	Simpson's Index	Hill's Evenness Index
Kapur Merah forest	KTS 1	3.074	0.904	0.085
	KTS 2	3.077	0.936	0.094
	KTS 3	5.620	0.970	0.057
Lowland mixed dipterocarp forest	KTS 4	4.854	0.928	0.070
	KTS 5	4.131	0.927	0.079
	KTS 6	4.111	0.940	0.098
	KTS 8	4.500	0.951	0.072
	KTS 10	3.983	0.921	0.087
	KTS 11	4.450	0.945	0.078
Late secondary forest	KTS 9	2.197	0.772	0.167
Kerangas forest	KTS 7	1.646	0.801	0.148

Aboveground biomass and carbon stock values

There are five pools of carbon, which are belowground biomass, litter, dead wood, soil organic carbon and AGB. The latter is known as the largest carbon pool and is most impacted by deforestation. The highest mean of AGB is recorded in the Kapur Merah forest at 360 tonne ha^{-1} (Table 5). On the contrary, the late secondary forest has the lowest mean for AGB (68.6 tonne ha^{-1}) (Table 5). It is clear that the mean AGB and mean carbon stock are positively correlated with the tree DBH and density.

Table 5. Estimated AGB and carbon stocks in different forest ecosystems.

Sub-forest Ecosystem	AGB ranges (tonne ha^{-1})	Mean AGB (tonne ha^{-1})	Carbon ranges (tonne ha^{-1})	Mean Carbon (tonne ha^{-1})
Kerangas forest	124	124	62	62
Kapur Merah forest	282 - 424	360	141 -212	180
Late secondary forest	68.6	68.6	34.3	34.3
Mixed dipterocarp forest	211.8 - 431.2	310.6	105.9 - 215.6	155.3

CONCLUSION

This study has shed light on the basic ecological features of forest ecosystems as well as diversity indices and AGB of tree communities in SRCA. Threats to the forest ecosystems and mitigation measures, has also been addressed. Forest ecosystems in SRCA are of high conservation value as they provide viable habitats for a wide range of faunal and floral species. In accordance to the statewide biodiversity monitoring programme, the PSPs could be incorporated in a long-term monitoring effort to conserve the integrity and functionality of forests in SRCA.

ACKNOWLEDGEMENTS

We would like to thank the Chief Conservator of Forests, Datuk Mashor Mohd Jaini, the Deputy Chief Conservator of Forests (Research & Development), Dr. Robert C. Ong and the Deputy Chief Conservator of Forests (Forest Sector Planning), Mr. Frederick Kugan for their overwhelming support. We thank KTS Plantation Sdn. Bhd. for their assistance throughout the expedition. We also would like to convey our appreciation to Mr. Md. Jumri Abd Hamid for his technical assistance in the remote sensing aspects. Mr. Postar Miun, Mr. Jemson Jumian, Mr. Markus Gubilil, Mr. Jeisin Jumian, Mr. Raisno Ibrahim, Mr. Dayren Dolusim, Mr. Juhar Aribin, Mr. Marius, Mr. Sharul and Mr. Johairul were also involved in this study.

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APPENDIX I Photo Gallery

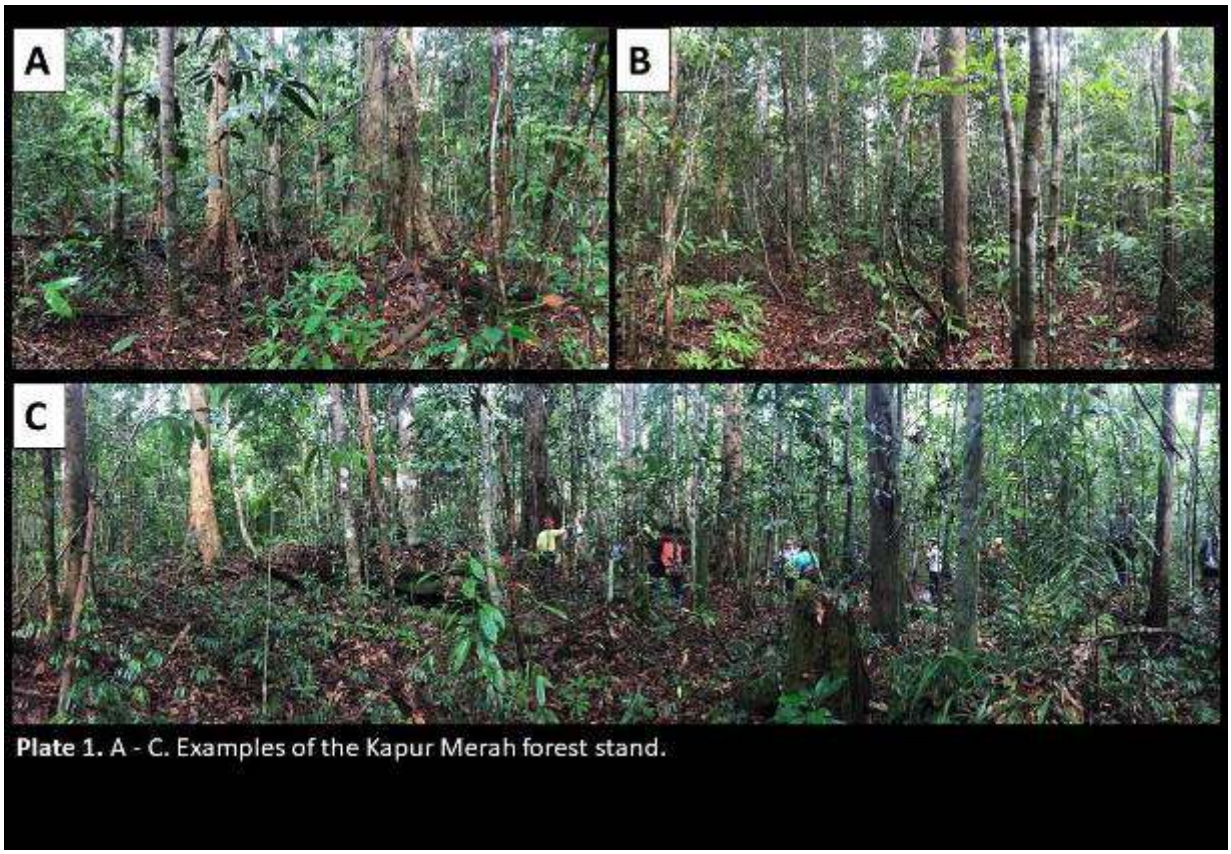


Plate 1. A - C. Examples of the Kapur Merah forest stand.

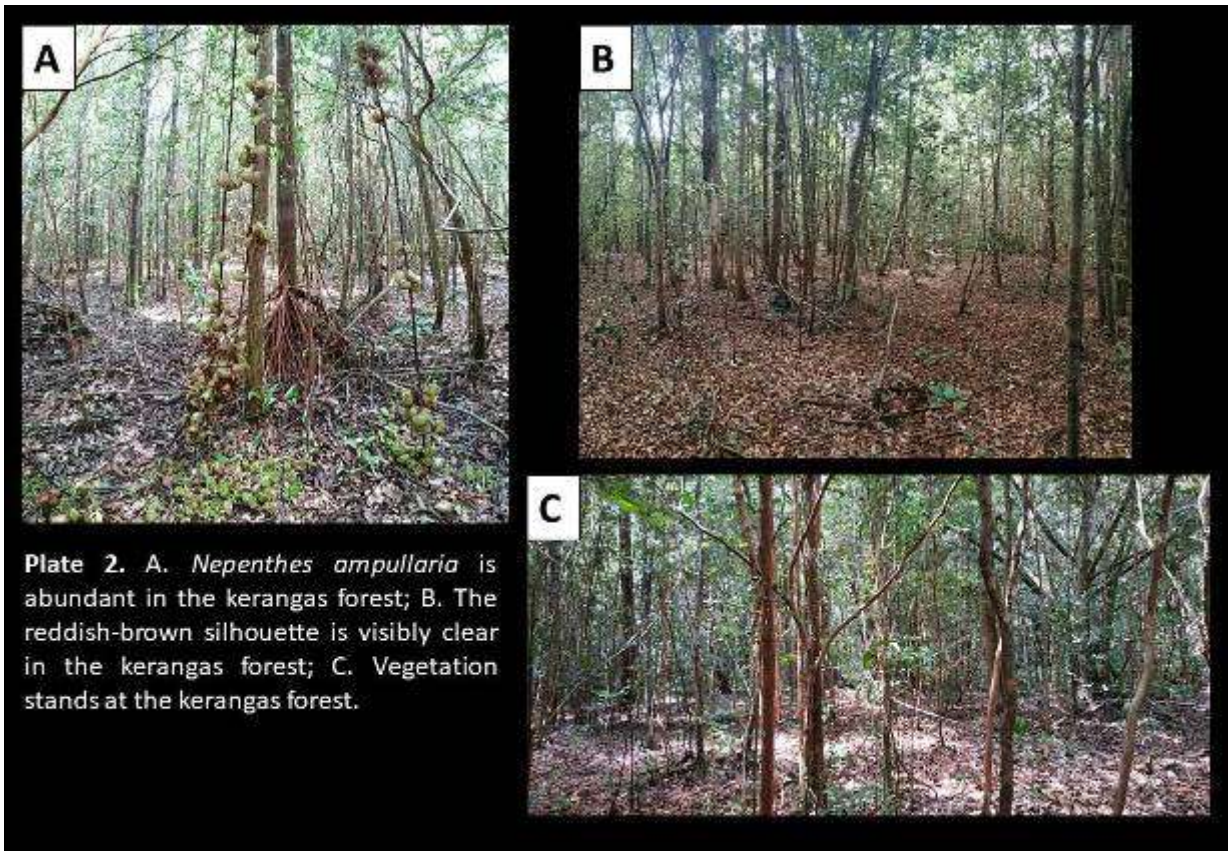
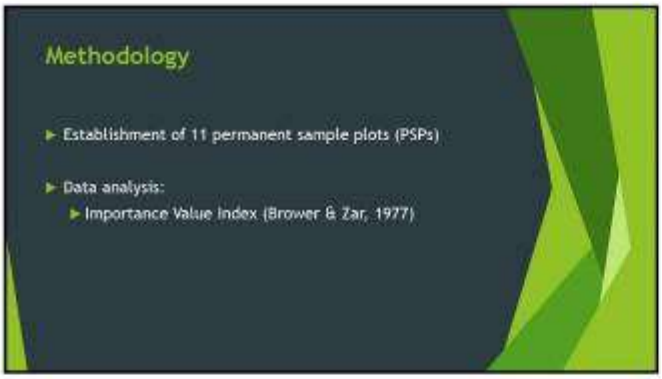


Plate 2. A. *Nepenthes ampullaria* is abundant in the kerangas forest; B. The reddish-brown silhouette is visibly clear in the kerangas forest; C. Vegetation stands at the kerangas forest.

Plate 3. A. A – B. Forest floor of the lowland mixed dipterocarp forest.

Plate 4. A. Forest floor of seasonally inundated site, near to KTS 3; B. Stand of trees in the late secondary forest.

Slide Presentation



Lowland Mixed Dipterocarp Forest (LMDF)

- Represented by KTS 4, KTS 5, KTS 6, KTS 8, KTS 10 & KTS 11
- Logged-over forest
- Dominated by Dipterocarpaceae (40.0% Relative Dominance (RD))
- Other families: Melastomataceae (7.1% RD), Anacardiaceae (5.4% RD),...
- Large total basal area
- Three forest canopy layers (i.e. main canopy, middle storey & understorey)

Late Secondary Forest

- Represented by KTS 9
- Previously on Lowland Mixed Dipterocarp Forest
- Dominated by Lamiaceae (42.9% RD)
- Other families: Elaeocarpaceae (19.6% RD), Euphorbiaceae (12.7% RD),...
- Less diverse & small-stature trees
- Trees rarely reached the main canopy layer

Kapur Merah Forest

- Represented by KTS 1, KTS 2 & KTS 3
- Named after Kapur Merah tree (*Dryobalanops beccarii*)
- Dominated by Dipterocarpaceae (33.1% RD)
- Other families: Lauraceae (10.3% RD), Myrtaceae (9.8% RD),...
- High total tree density and large total basal area
- All three forest canopy layers are easily detected

Kerangas Forest

- Represented by KTS 7
- Minimally disturbed
- Dominated by Myrsinaceae (30.0% RD)
- Other families: Myrtaceae (18.6% RD), Hypericaceae (18.2% RD),...
- Less diverse & has the tendency towards two-storey forest canopy layers
- Trees are small in stature and have reddish-brown bark

Drastic transition between LMDF (left) & kerangas forest (right)

Conclusion

- SRCA harbours various tropical forest ecosystems
- These forest ecosystems provide viable habitats for a wide range of floral and faunal species
- In accordance with the statewide biodiversity monitoring, the PSPs could be incorporated in a long-term monitoring programme to conserve the integrity and functionality of forest ecosystems.

PAPER 1.2

Diversity and conservation status of vascular plants in Sg. Rawog Conservation Area, Segaliud Lokan Forest Reserve, Sabah, Malaysia

J.B. Sugau[1*], S. Suzana[1], A. Damit[1], M.A.M. Andi[1], J. Seligi[1], R. Majapun[1], S.T.L. Tsen[2], R. Nilus[1] & M.A.F. Suis[1]

[1]Forest Research Centre, Sabah Forestry Department, P.O. Box 1407, 90715 Sandakan, Sabah, Malaysia
[2]Faculty of Science and Natural Resources, Universiti Malaysia Sabah, Jalan UMS, 88400 Kota Kinabalu, Sabah
**Author for Correspondence: Email: John.Sugau@sabah.gov.my*

Abstract. A study on diversity and conservation status of vascular plants was conducted in the Sg. Rawog Conservation Area (SRCA), which is located in Segaliud Lokan Forest Reserve, Sabah. The study aimed to document plant diversity and identify interesting, endemic, rare and threatened plant species which are considered high conservation value species. The study recorded 572 taxa from the reserve of which 124 taxa are endemic to Borneo, including 11 endemic to Sabah, thus indicating the forests in Sg. Rawog Conservation Area contain high conservation value plant species. Two high conservation value plant species, namely *Shorea symingtonii* and *S. waltonii* were selected as part of the key conservation targets for monitoring biodiversity integrity in SRCA. Adequate knowledge of plant diversity in the area is vital for the formulation of the SRCA management plan.

Keywords: Diversity, conservation status, vascular plants, Segaliud Lokan Forest Reserve

INTRODUCTION

Sg. Rawog conservation area (SRCA) is designated as Conservation area by the KTS Plantation Sdn Bhd. The forest management area is within the Segaliud Lokan Forest Reserve, a Class II Production Forest Reserve, which located in the middle part of Sabah (Figure 1). The area has experienced series of timber extraction activity in the past. In terms of botanical collection, there are more than 1,060 herbarium collections made from the Segaliud Lokan FR by the staff of Sandakan Herbarium during the period of 1947 to 2006 (Sandakan Herbarium Database). Imai *et al*., (2014) also established sixty 20 m-radius circular plots (1,257 m^2 in area) in Segaliud Lokan FR (some within the SRCA) for their study on the community composition of canopy tree species in the management unit. The objectives of this present survey were to obtain flora data, including plant diversity and their conservation status for the formulation of Forest Management Plan of the area (Sg. Rawog Conservation area).

STUDY SITE

Location

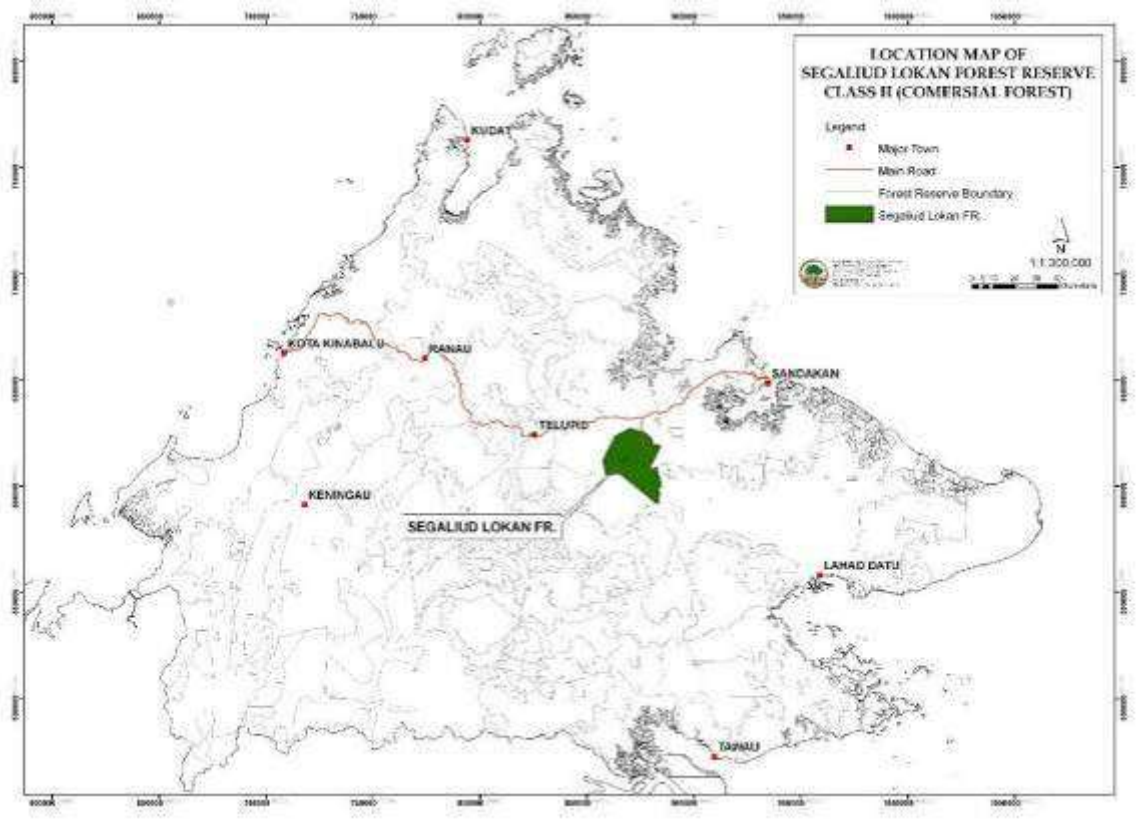


Figure 1. Location of Segaliud Lokan Forest Reserve in Sabah, marked with green colour.

The SRCA is within the Segaliud Lokan Forest Reserve and accessible by graveled and sealed road from Telupid-Sandakan highway. Sandakan is the nearest town where the key government administrative offices are located. Segaliud Lokan FR is surrounded with oil palm plantation estates, except in the southwest where it shares boundary with Deramakot Forest Reserve.

Topography & Drainage

As zoned by the management, the SRCA is allocated along the Rawog river. The Rawog river flows east and into Lokan river of which eventually drain into Kinabatangan River. The general terrain in Segaliud Lokan Forest Reserve is steeply undulated, with slopes and ridges of varying steepness. The topography around SRCA is mostly flat with some steep slopes.

Soils

The valley of Sg. Rawog is made up of old alluvial deposits. Gravel and stone beds are found along the river bank. The dominant soils, which belong to the Tanjong Lipat Family, are derived from a mixture (inter-bedded) of sandstone and mudstone/shale of mainly of the Sook Association. There are three main soil associations around SRCA, namely Lokan, Sook and Brantian associations (Acres *et al.*, 1975).

Vegetation

Originally, the natural vegetation of SRCA is made up of lowland mixed dipterocarp and kerangas forest formation or ecosystems. The forests were disturbed by logging activities in the past even some areas have been degraded into secondary forests and grassland.

METHODS

Sampling and plant identification

The field surveys were conducted from 9th to 17th of August, 2018. Prior to field survey, location map of the site and proposed study areas was provided by the KTS Plantation management. With the aid of satellite image (world map), the potential location of collection sites, which include the plant diversity assessment within 20 m-radius circular plots and general botanical collection surveys were identified within the study areas (Figure 2). Within the eleven circular plots that were established in various forest conditions, all plant species and trees ≥10 cm diameter at breast height (dbh) were recorded (Table 1). The common plant species were identified directly to species level in the field by means of their distinctive field characteristics. For those that could not be readily identified, voucher specimens were collected for subsequent determination at SAN.

Other botanical surveys include collecting fertile (flowering and fruiting) plant specimens and inventory of the dipterocarp species. The later focused on assessing the diversity of dipterocarp species and their distribution in SRCA. The other botanical survey focus on collecting fertile plant specimens under SAN numbering and later deposited at the Sandakan Herbarium (SAN). Voucher specimens of interesting plants were also collected, identified and included in the plant inventory list.

The collection and preservation of plant specimens are following Bridson *et al*., 1992. The voucher specimen collections were oven-dried to 55° C for several days before determining their species identities. All specimens were sorted according to morphospecies and attempted for identification to species level by cross-referencing with the existing specimens in the herbarium and related flora references (e.g., Soepadmo *et al*., 1995, 1996, 2000, 2002, 2004, 2007, 2011, 2014). Plant classification of the Angiosperm group is based on Stevens, P.F. (2001 onwards), and follows Christenhusz *et al.* (2011) with additional modification based on World of Ferns website, Hassler (2019). Relevant literature materials were also consulted to determine the conservation status of the plants listed.

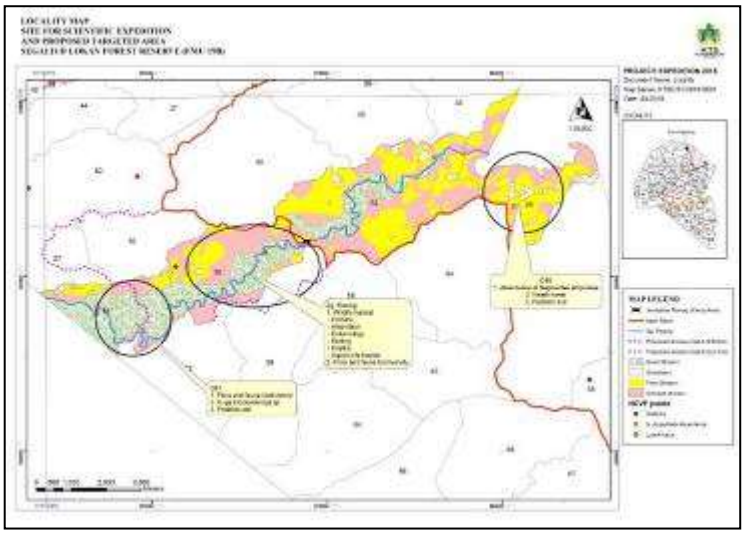


Figure 2. Location of the study areas (in circle) for plant collection within the SRCA in Segaliud Lokan FR.

Table 1. Location of plots in SRCA, Segaliud Lokan FR, Sabah.

Plot number	Latitude	Longitude	Elevation (m)	Forest Formation
KTS1	05°26'40.8"	117°31'39.1"	60	Disturbed Lowland Mixed Dipterocarp Forest
KTS2	05°26'46.3"	117°31'43.1"	65	Disturbed Lowland Mixed Dipterocarp Forest
KTS3	05°26'41.1"	117°31'48.8"	72	Disturbed Lowland Mixed Dipterocarp Forest
KTS4	05°27'30.8"	117°33'55.6"	44	Disturbed Lowland Mixed Dipterocarp Forest
KTS5	05°27'27.6"	117°33'47.5"	63	Disturbed Lowland Mixed Dipterocarp Forest
KTS6	05°27'40.2"	117°33'54.5"	41	Disturbed Lowland Mixed Dipterocarp Forest
KTS7	05°28'03.2"	117°37'23.5"	89	Kerangas Forest
KTS8	05°28'05.6"	117°37'21.6"	94	Disturbed Lowland Mixed Dipterocarp Forest
KTS9	05°27'46.8"	117°34'01.9"	46	Secondary Forests
KTS10	05°27'41.3"	117°33'47.1"	53	Disturbed Lowland Mixed Dipterocarp Forest
KTS11	05°27'41.2"	117°33'44.2"	45	Disturbed Lowland Mixed Dipterocarp Forest

RESULTS AND DISCUSSION

Plant diversity

Based on the tree enumeration, dipterocarp survey, herbarium and voucher specimens, a total of 572 taxa from 106 families were recorded from the study site (Appendix I). These are represented by the following families (values indicated in parenthesis) of various plant groups: lycophytes (2); ferns (13); Gymnosperm (1); Monocotyledon (13) and Dicotyledon (77) of the Angiosperms (Table 2). Some plant specimens could not be identified to species level due to the incomplete specimen.

Table 2. Number of taxa by plant groups from SRCA, Segaliud Lokan FR, Sabah, Malaysia.

Plant group	**No. of families**	**No. of taxa**
Lycopyhtes	2	4
Ferns	13	27
Gymnosperm	1	1
Angiosperm:		
Monocotyledon	13	55
Dicotyledon	77	485
Total	**106**	**572**

The ten most speciose families in decreasing order are the Dipterocarpaceae (45), Lauraceae (30), Annonaceae (34), Fabaceae (25), Myrtaceae (25), Myristicaceae (24), Phyllanthaceae (23), Malvaceae (22), Euphorbiaceae (21) and Rubiaceae (20) (Figure 3).

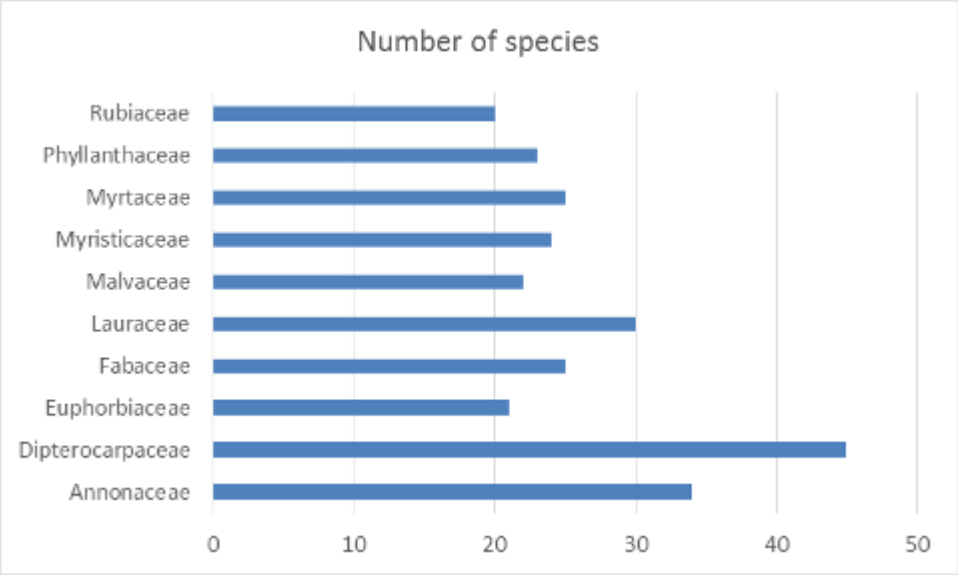


Figure 3. The ten most speciose plant families recorded in SRCA.

Ferns and Lycophytes

Ferns and lycophytes are green plants that lack flowers. They reproduce by microscopic spores, rather than by seeds as in flowering plants. Ferns can be distinguished from lycopytes by having highly divided fronds with branching veins and spore-bearing structures on the margins or undersides. While in lycophytes their sporangia are on the upper surface of small leaves with unbranched veins. There are 4 species of lycophytes and 27 species of ferns recorded in SRCA. Among interesting finding is an endemic lycophyte of Borneo, *Selaginella conferta*. This species was only recorded in Sabah and Kalimantan, Borneo.

Gymnosperms

Gymnosperms are vascular, seed bearing and non-flowering plant with seeds that are not protected by an ovule. Only one gymnosperm species was encountered during the survey, namely *Gnetum cuspidatum*.

Angiosperms

In terms of plant group, the flowering plants, also known as Angiospermae are the most diverse group in SRCA, with 540 number of species. The flowering plants are divided into two groups, monocotyledon and dicotyledon. The monocotyledons are a class of flowering plants, whose embryo (seed) store only one cotyledon. This includes all aroids, grasses, sedges, gingers, plams, orchids, etc. There are 55 species of monocotyledons recorded from SRCA. The dicotyledons are those plants with a pair of leaves, or cotyledons, in the embryo of the seed. This includes mostly all the trees, some herbs and shrubs. There are 485 species of dicotyledon recorded in SRCA, Segaliud Lokan FR.

Plant conservation

Endemism

Endemism is the ecological state of being unique to a defined geographic location, such as an island, nation or other defined zone, or habitat type; organisms that are indigenous to a place are not endemic to it if they are also found elsewhere. The extreme opposite of endemism is cosmopolitan distribution. Endemics can easily become endangered or extinct if

their restricted habitat changes, particularly but not only due to human actions, including the introduction of new organisms.

Of the 572 taxa that have been recorded, 124 taxa are endemic to Borneo, including 11 taxa endemic to Sabah (Appendix I). In terms of legal protection, 5 endemic plants (*Durio acutifolius, D. dulcis, D. lanceolatus, Shorea macrophylla and Shorea mecistopteryx*) are protected by the Sabah Forest Enactment 1968, 6 (*Amomum oliganthum, Amomum staminivum, Boesenbergia pulchela, Hornstedtia reticulata, Plagiostachys megacarpa and Zingiber vinosum*) by Sabah Wildlife Conservation Enactment 1997. All the Sabah endemic plants that were recorded from SRCA are also found in other places in Sabah.

The IUCN Red List and Malaysia Plant Red List

The IUCN Red List Categories and Criteria were designed for global taxon assessments. There may be difference between the Malaysian Plant Red List and the IUCN Red List, the Malaysian Red Data Book should always take precedence. Conservation status in parenthesis is based on Malaysian Red List. There are 9 plant species that are listed as Vulnerable (VU), 1 as Endangered (EN) and 12 as Critically Endangered (CR) from the Sg. Rawog conservation area (Appendix I). In terms of protection, of the 6 threatened species, *Aquilaria beccariana* (gaharu tree) is legally protected under Sabah Wildlife Conservation Enactment 1997, and *Baccaurea membranacea, Durio dulcis, Durio acutifolius, Eusideroxylon zwageri* and *Shorea macrophylla* are considered as prohibited species under Sabah Forestry Department.

Wildlife Conservation Enactment 1997, CITES and Sabah Forest Enactment

Sabah Wildlife Conservation Enactment 1997 (SWD, 1997), under part VI (Protection of Plants) listed plants that may not be harvested without a license. There were 23 plant taxa, comprised of 13 species of gingers, 5 orchids, 3 pitcher plants, 1 agarwood and 1 ramin that fall under Schedule 2, part II of the Protected Plant Species (Appendix I). There are 10 species listed under Appendix II CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) from the orchid and pitcher plants families (Appendix I). There are 35 plant species that are prohibited under Sabah Forest Enactment 1968, mostly of fruits trees and threatened tree species (Appendix I).

Other interesting plant species

Apart from the high conservation plant species, other interesting plant species were also encountered during the survey, such as those with ornamental and medicinal values. Plants with ornamental value are *Aeschynanthus tricolor*, *Bauhinia kockiana, Begonia* cf. *beryllae, Nepenthes ampullaria,* etc. Plants with medicinal value are *Labisia pumila, Eurycoma longifolia,* etc. (Plates 5: A, B, C, D, E & F).

ISSUES AND RECOMMENDATIONS

During the survey, there were no pressing issues or threats to both the forests and the high conservation value plants that were observed, since the forests in SRCA have already been put aside as a Conservation area. The next essential step is to formulate a management plan for the conservation area. The conservation area management plan is essential as a guideline to manage any forested area, such as SRCA in order to maintain the integrity of the area, including protection or conservation of plant species of high conservation value.

Plant species of high conservation value may include species that are locally endemic, threatened or important food source for wildlife. These high conservation value plants or plant conservation targets must be identified and monitored, including conducting population trend studies. However, most of the Sabah endemic plant species as well as the threatened plant species that are found in SRCA are widely distributed in Sabah, hence there are no urgent measures required. Nevertheless, we propose two species that are categorized as Sabah endemic trees, namely *Shorea symingtonii* (Plate 6) and *S. waltonii* (Plate 7) as conservation target plant species to be monitored. The justification for the selection of these species is they are easily recognized in the field. The *S. symingtonii* tree was recorded in PSP number 10, while *S. waltonii* tree was recorded in PSP number 6. Protection of the forest reserve as a whole, including from forest fire, illegal timber extraction and illegal encroachment must also be emphasized in the management plan.

CONCLUSION

The survey in SRCA has recorded 572 taxa of which 124 taxa are endemic to Borneo and 11 endemic to Sabah. The forests in Sg. Rawog Conservation area contain high conservation value plant species that require conservation attention.

ACKNOWLEDGEMENTS

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Photo Gallery

Plate 1. Ferns and Lycophytes. A. *Selaginella wallichii* (Selaginellaceae) **B.** *Taenitis blechnoides* (Pteridaceae) **C.** *Lygodium microphyllum* (Lygodiaceae) **D.** *Tectaria nayarii* (Tectariaceae) **E.** *Lindsaea ensifolia* (Lindsaeaceae) **F.** *Pronephrium nitidum* (Thelyteridaceae).

Plate 2. Gymnosperms. *Gnetum cuspidatum* (Gnetaceae). **A**. Fruits of the *Gnetum* hanging along the stems. **B**. Close-up of the fruits.

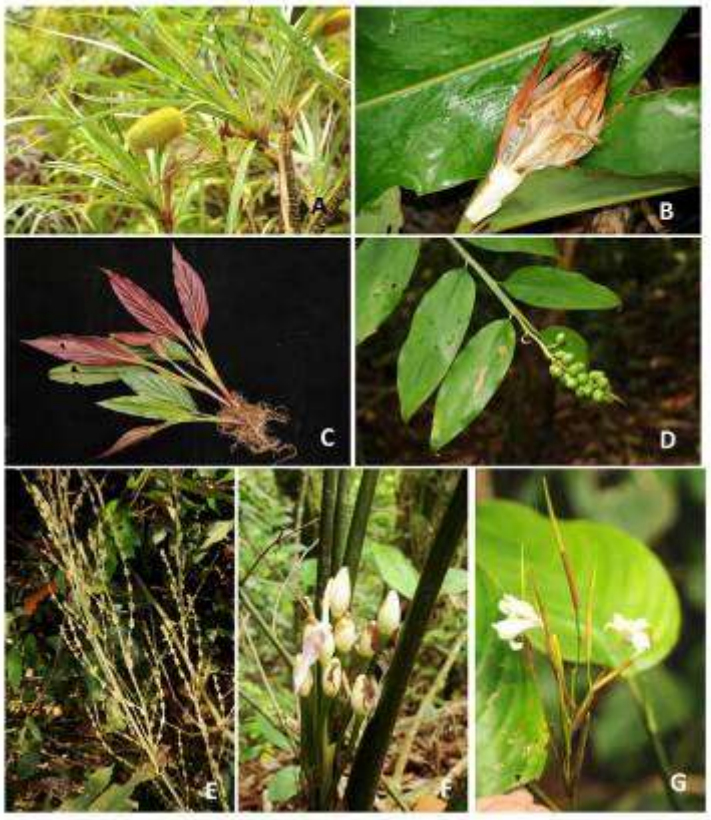


Plate 3. Angiosperms (Monocotyledon). A. *Pandanus motleyanus* (Pandanaceae); **B.** *Hornstedtia reticulate* (Zingiberaceae); **C.** *Boesenbergia pulchella* (Zingiberaceae); **D.** *Alpinia aquatic* (Zingiberaceae); **E**. *Dinochloa trichogona* (Poaceae); **F.** *Alocasia reginae* (Araceae); **G.** *Donax canniformis* (Marantaceae).

Plate 4. Angiosperms (Dicotyledon) A. *Saurauia agamae* (Actinidiaceae); **B.** *Ficus megaleia* (Moraceae); **C.** *Pternandra multiflora* (Melastomataceae); **D.** *Friesodielsia acuminate* (Annonaceae); **E.** *Ternstroemia citrina* (Pentaphylacaceae); **F.** *Schefflera obovatilimba* (Araliaceae); **G.** *Musaenda elmeri* (Rubiaceae); **H.** *Aglaia rivularis* (Meliaceae).

Plate 5. Angiosperms (Dicotyledon) with potential ornamental plants. A. *Bauhinia kockiana* var. *kockiana* (Fabaceae); **B.** *Begonia* cf. *beryllae* (Begoniaceae); **C.** *Nepenthes ampullaria* (Nepenthaceae); **D.** *Aeschynanthus tricolor* (Gesneriaceae); **E**. *Eurycoma longifolia* (Simaroubaceae). **F**. *Labisia pumila* (Primulaceae).

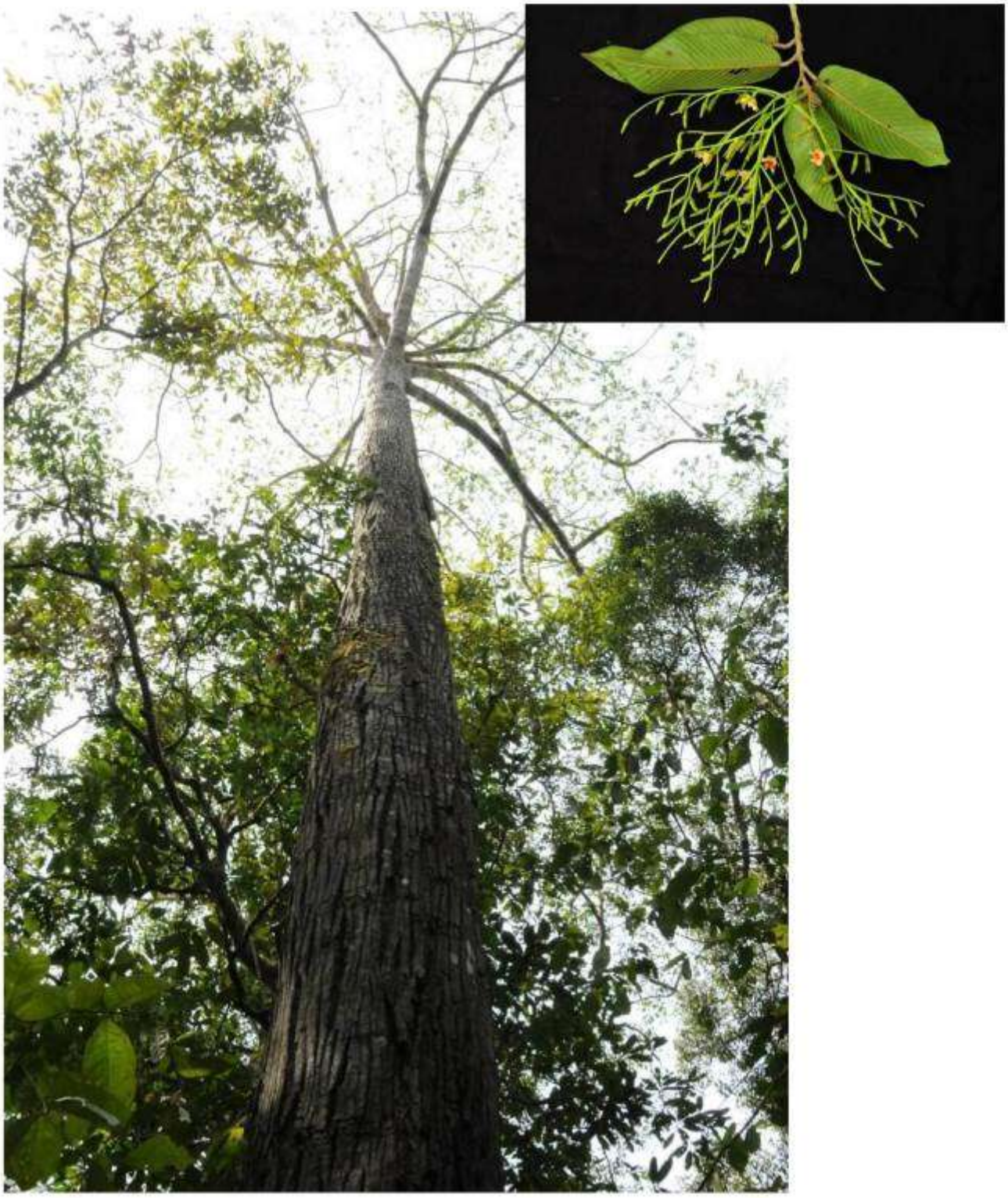


Plate 6: *Shorea symingtonii* (Dipterocarpaceae), the Melapi bunga/kuning is one of Sabah's endemic dipterocarps found in Sg. Rawog.

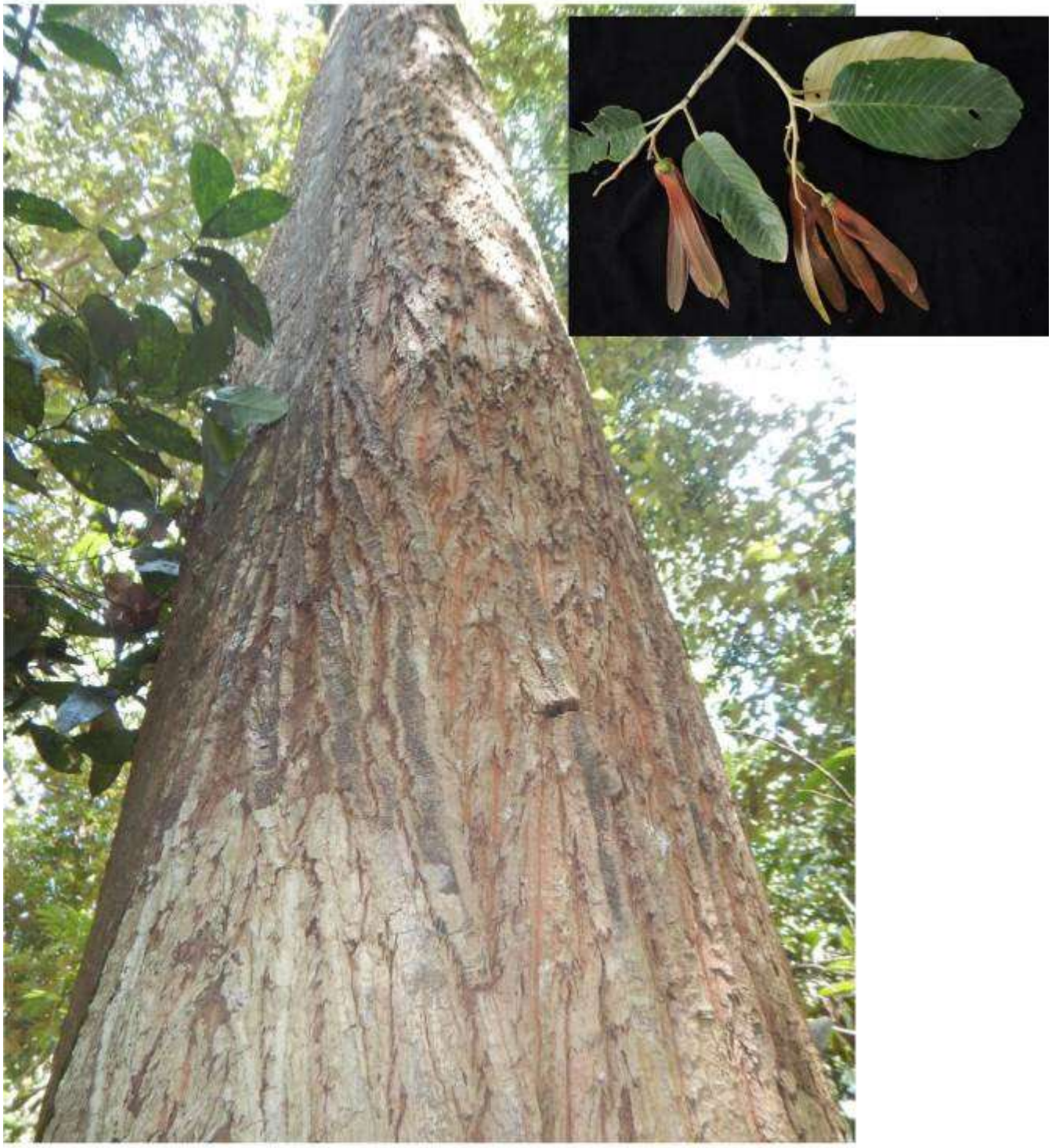


Plate 7: *Shorea waltonii* (Dipterocarpaceae), the Seraya kelabu is another Sabah's endemic dipterocarp found in Sg. Rawog.

Plate 8: *Dryobalanops beccarii* (Dipterocarpaceae). The 'Kapur merah' is very common in the flatter area in Sg. Rawog. **A**. The trunk with reddish brown bark. **B**. Flowering twig. **C**. The seedling.

Appendix I. List of vascular plant species recorded from Sg. Rawog Conservation Area, Segaliud Lokan FR. The species are arranged by family in alphabetical order.

Notes: **Malaysia Red List** (IUCN): CR=Critically endangered; EN=Endangered; VU=Vulnerable; NT=Near threatened; LC=Least concern; NE=Not Evaluated. **Plant Group** (G): Ad=Angiosperm (Dicotyledon); Am=Angiosperm (Monocotyledon); G=Gymnosperm; F=Fern; L=Lycophyte. **Habit** (H): t=tree; c=climber; sh=shrub; h=herb; g=grass; sd=sedge; f=fern; ep=epiphyte; l=lycophyte; pt=palm tree; sa= saprophytic; str=strangler. **Sabah Forestry Department prohibited species under Schedule I, Sabah Forest Rules 1969** (SFDpro). **Sabah Wildlife Conservation Enactment 1997** (SWCE). **Convention on International Trade in Endangered Species of Wild Fauna and Flora** (CITES). **Location** (IdLoc). KTS Plantation Sdn. Bhd.=KTS

Idloc	Species	Family	G	H	Ende-mism	IUCN	SFD pro	SWCE	CITES
SAN158595	Justicia gendarussa	Acanthaceae	Ad	sh	Not	NE	No	No	No
KTS5	*Hydnocarpus borneensis*	Achariaceae	Ad	t	Borneo	NE	No	No	No
KTS11/T39	*Hydnocarpus gracilis*	Achariaceae	Ad	t	Not	NE	No	No	No
KTS11	*Hydnocarpus* sp.	Achariaceae	Ad	t			No	No	No
KTS4;KTS10	*Hydnocarpus woodii*	Achariaceae	Ad	t	Not	NE	No	No	No
KTS10;KTS4/19; KTS6/8	*Ryparosa acuminata*	Achariaceae	Ad	t	Borneo	NE	No	No	No
KTS3	*Ryparosa hirsuta*	Achariaceae	Ad	t	Borneo	NE	No	No	No
KTS5	*Trichadenia philippenensis*	Achariaceae	Ad	t	Not	NE	No	No	No
SAN159082	*Saurauia agamae*	Actinidiaceae	Ad	t	Sabah	NE	No	No	No
SAN159101	*Saurauia oblancifolia*	Actinidiaceae	Ad	t	Borneo	NE	No	No	No
KTS5/28	*Androtium astylum*	Anacardiaeae	Ad	t	Not	NE	No	No	No
KTS10	*Dracontomelon dao*	Anacardiaeae	Ad	t	Not	NE	Yes	No	No
KTS8/14	*Gluta* cf. *macrocarpa*	Anacardiaeae	Ad	t			No	No	No
KTS6	*Gluta oba*	Anacardiaeae	Ad	t	Borneo	NE	No	No	No
KTS1:3;6;11	*Gluta sabahana*	Anacardiaeae	Ad	t	Sabah	NE	No	No	No
KTS4/T1;KTS5	*Gluta wallichii*	Anacardiaeae	Ad	t	Not	NE	No	No	No
KTS1/17	*Mangifera torquendra*	Anacardiaeae	Ad	t	Not	NE	Yes	No	No
KTS10/9	*Melanochyla angustifolia*	Anacardiaeae	Ad	t	Not	NE	No	No	No
KTS4/4; KTS10/16	*Melanochyla castaneifolia*	Anacardiaeae	Ad	t	Borneo	NE	No	No	No
KTS3/31	*Melanochyla tomentosa*	Anacardiaeae	Ad	t	Not	NE	No	No	No
SAN159099;KTS10/31 ; KTS11/24;KTS6/5;KTS 10/30	*Anaxagorea javanica*	Annonaceae	Ad	t	Not	NE	No	No	No
KTS4/18	*Artabotrys costatus*	Annonaceae	Ad	c	Not	NE	No	No	No
KTS4/16	*Artabotrys gracilis*	Annonaceae	Ad	c	Not	NE	No	No	No
KTS2/19	*Artabotrys* sp.	Annonaceae	Ad	c			No	No	No
KTS10/14;KTS2/20;KT S1/37; KTS9/19;KTS3/15	*Artabotrys suaveolens*	Annonaceae	Ad	c	Not	NE	No	No	No
KTS2/34	*Cyathocalyx* sp.	Annonaceae	Ad	t			No	No	No
SAN159100;KTS11/22	*Dasymaschalon clusiflorum*	Annonaceae	Ad	t	Not	NE	No	No	No
KTS9/12	*Desmos sinclairii*	Annonaceae	Ad	c	Not	NE	No	No	No
SAN158583	*Desmos* sp.	Annonaceae							

SAN159064	*Friesodielsia acuminata*	Annonaceae	Ad	c	Borneo	NE	No	No	No
KTS1/27;KTS5/21	*Friesodielsia affinis*	Annonaceae	Ad	c	Not	NE	No	No	No
KTS2/33;KTS2/33;KTS 1/33; KTS1/11;KTS2/17	*Friesodielsia fulgens*	Annonaceae	Ad	c	?	?	No	No	No
KTS9/17;KTS1/14;KTS 3/16; KTS2/36;KTS10/22	*Friesodielsia glauca*	Annonaceae	Ad	c	Not	NE	No	No	No
KTS10/19	*Friesodielsia grandifolia*	Annonaceae	Ad	c	Borneo	NE	No	No	No
KTS4/26	*Goniothalamus dolichocarpus*	Annonaceae	Ad	t	Sabah	NE	No	No	No
KTS5/29	*Goniothalamus woodii*	Annonaceae	Ad	t	Borneo	NE	No	No	No
KTS1;5	*Mezettia* sp.	Annonaceae	Ad	t			No	No	No
KTS1/T6;KTS5/T5	*Mezzettia parviflora*	Annonaceae	Ad	t	Not	NE	No	No	No
KTS8/5	*Orophea corymbosa*	Annonaceae	Ad	t	Not	NE	No	No	No
KTS5/25	*Polyalthia cauliflora*	Annonaceae	Ad	t	Not	NE	No	No	No
KTS5/14	*Polyalthia dolichopoda*	Annonaceae	Ad	t	Borneo	NE	No	No	No
SAN159071;KTS3/11; KTS1/28	*Polyalthia lateriflora*	Annonaceae	Ad	t	Not	NE	No	No	No
KTS9/T12;KTS4/21;KT S8/6; KTS9/13;KTS10/35	*Polyalthia rumphii*	Annonaceae	Ad	t	Not	NE	No	No	No
KTS11/T13	*Polyalthia* sp	Annonaceae	Ad	t			No	No	No
KTS5	*Polyalthia sumatrana*	Annonaceae	Ad	t	Not	NE	No	No	No
KTS5/20	*Popowia hirta*	Annonaceae	Ad	t	Not	NE	No	No	No
KTS6/T23	*Popowia odoardi*	Annonaceae	Ad	t	Borneo	NE	No	No	No
KTS6;KTS6/14	*Popowia pisocarpa*	Annonaceae	Ad	t	Not	NE	No	No	No
KTS2/T6;KTS2/12;KTS 7/4; KTS2/37;KTS1/38	*Sageraea sarawakensis*	Annonaceae	Ad	t	Borneo	NE	No	No	No
KTS9/7	*Uvaria littoralis*	Annonaceae	Ad	c	Not	NE	No	No	No
KTS8/21;KTS3/14;KTS 2/27; KTS5/17;KTS9/30;KTS 4/13; KTS6/15	*Uvaria* sp.	Annonaceae	Ad	c			No	No	No
KTS9/T14	*Xylopia elliptica*	Annonaceae	Ad	t	Not	LC	No	No	No
KTS7/T32	*Xylopia ferruginea*	Annonaceae	Ad	t	Not	NE	No	No	No
KTS10/10;KTS1/30	*Xylopia stenophylla*	Annonaceae	Ad	t	Not	NE	No	No	No
SAN158578	*Alstonia angustiloba*	Apocynaceae	Ad	t	Not	NE	No	No	No
KTS3/18;KTS10	*Alstonia iwahigensis*	Apocynaceae	Ad	t	Not	NE	No	No	No
KTS11/T10	*Alstonia spatulata*	Apocynaceae	Ad	t	Not	LC	No	No	No
KTS3/35	*Chilocarpus conspicuus*	Apocynaceae	Ad	t	Borneo	NE	No	No	No
KTS9/23	*Ichnocarpus frutescens*	Apocynaceae	Ad	t	Not	NE	No	No	No
KTS11/25; KTS10/23	*Kopsia dasyrachis*	Apocynaceae	Ad	t	Sabah	NE	No	No	No
KTS4/15; KTS6/11;SAN159097	*Kopsia pauciflora*	Apocynaceae	Ad	t	Not	NE	No	No	No
KTS11/32;KTS6/21; SAN159092	*Alocasia reginae*	Araceae	Am	h	Borneo	NE	No	No	No
SAN159126	*Homalomena pygmaea*	Araceae	Am	h	Not	NE	No	No	No
KTS1/02;KTS8/31	*Pothos atropurpurascens*	Araceae	Am	h	Borneo	NE	No	No	No

KTS5/31	*Pothos borneensis*	Araceae	Am	h	Not	NE	No	No	No
KTS10/41;KTS6/20;KTS5/37	*Rhaphidophora maingayi*	Araceae	Am	h	Not	NE	No	No	No
KTS2/9;KTS11/36;KTS4/44	*Scindapsus rupestris*	Araceae	Am	h	Not	NE	No	No	No
SAN159065	*Arthrophyllum diversifolium*	Araliaceae	Ad	t	Not	NE	No	No	No
SAN159073	*Schefflera obovatilimba*	Araliaceae	Ad	c	Borneo	NE	No	No	No
KTS2/3	*Calamus muricatus*	Arecaceae	Am	c	Borneo	NE	No	No	No
KTS6/22;KTS10/44; KTS9/6;KTS5/38	*Korthalsia furtadoana*	Arececeae	Am	c	Borneo	NE	No	No	No
SAN159103	*Thottea triserialis*	Aristolochiaceae	Ad	sh	Borneo	NE	No	No	No
KTS4/48; KTS5/32	*Dracaena angustifolia*	Asparagaceae	Am	sh	Borneo	NE	No	No	No
KTS5/22	*Dracaena elliptica*	Asparagaceae	Am	sh	Borneo	NE	No	No	No
KTS8/29	*Asplenium affine*	Aspleniaceae	F	f	Not	NE	No	No	No
MAM Andi1303; 1329	*Asplenium* cf. *longissimum*	Aspleniaceae	F	f	Not	NE	No	No	No
MAM Andi1320	*Asplenium nitidum*	Aspleniaceae	F	f	Not	NE	No	No	No
MAM Andi 1330	*Asplenium pellucidum*	Aspleniaceae	F	f	Not	NE	No	No	No
Seen/Image	*Asplenium nidus*	Aspleniaceae	F	f	Not	NE	No	No	No
SAN159090	*Begonia* cf. *beryllae*	Begoniaceae	Ad	h			No	No	No
Seen/Image	*Blechnopsis orientalis*	Blechnaceae	F	f	Not	NE	No	No	No
KTS1;6;7;8; SAN158579	*Stenochlaena palustris*	Blechnaceae	F	f	Not	NE	No	No	No
KTS3/20	*Canarium apertum*	Burseraceae	Ad	t	Not	LC	No	No	No
KTS4; SAN159106	*Canarium denticulatum*	Burseraceae	Ad	t	Not	NE	No	No	No
KTS3/T27; KTS5/T37	*Dacryodes costata*	Burseraceae	Ad	t	Not	LC	Yes	No	No
KTS3/T8; KTS2/T26	*Dacryodes incurvata*	Burseraceae	Ad	t	Not	NE	Yes	No	No
KTS11/T25	*Dacryodes longifolia*	Burseraceae	Ad	t	Not	NE	Yes	No	No
KTS5/1;KTS5/T9	*Dacryodes rostrata*	Burseraceae	Ad	t	Not	LC	Yes	No	No
KTS11/T50;KTS5/23	*Dacryodes rugosa*	Burseraceae	Ad	t	Not	NE	Yes	No	No
KTS3/T50;2;5;11	*Dacryodes* sp.	Burseraceae	Ad	t			Yes	No	No
KTS2/24; KTS1/32	*Santiria laevigata*	Burseraceae	Ad	t	Not	LC	Yes	No	No
KTS3;1;2	*Mesua micrantha*	Calophyllaceae	Ad	t	Not	NE	No	No	No
KTS3;5;6;10	*Gironniera nervosa*	Cannabaceae	Ad	t	Not	NE	No	No	No
KTS5;10;11;SAN159114	*Gironniera subaequalis*	Cannabaceae	Ad	t	Not	NE	No	No	No
KTS5/T15	*Lophopetalum beccarianum*	Celastraceae	Ad	t	Not	NE	No	No	No
KTS11	*Lophopetalum* cf. *beccarianum*	Celastraceae	Ad	t			No	No	No
KTS11/T40;KTS1/18;KTS3/21	*Lophopetalum javanicum*	Celastraceae	Ad	t	Not	LC	No	No	No
KTS5	*Lophopetalum* sp	Celastraceae	Ad	t			No	No	No
KTS2;1;3	*Lophopetalum subovatum*	Celastraceae	Ad	t	Not	NE	No	No	No
KTS3;4	*Atuna racemosa*	Chrysobalanaceae	Ad	t	Not	NE	No	No	No
KTS11/T17; KTS8/T31;KTS10	*Maranthes corymbosa*	Chrysobalanaceae	Ad	t	Not	LC	No	No	No
KTS1/T78	*Parastemon grandifructus*	Chrysobalanaceae	Ad	t	Not	NE	No	No	No
KTS1;2	*Parastemon* sp.	Chrysobalanaceae	Ad	t			No	No	No

KTS7/T11	*Parastemon urophyllus*	Chrysobalanaceae	Ad	t	Not	NE	No	No	No
KTS3/T1	*Parinari canarioides*	Chrysobalanaceae	Ad	t	Not	NE	No	No	No
KTS10	*Parinari oblongifolia*	Chrysobalanaceae	Ad	t	Not	NE	No	No	No
KTS3;4	*Prunus* sp.	Chrysobalanaceae	Ad	t			No	No	No
KTS11/11	*Calophyllum gracilipes*	Clusiaceae	Ad	t	Not	NE	No	No	No
KTS3/30	*Calophyllum nodosum*	Clusiaceae	Ad	t	Not	NE	No	No	No
KTS1	*Garcinia* cf. *parvifolia*	Clusiaceae	Ad	t			No	No	No
KTS9/25	*Garcinia forbesi*	Clusiaceae	Ad	t	Not	NE	No	No	No
KTS1;2;3	*Garcinia gaudichaudi*	Clusiaceae	Ad	t	Not	NE	No	No	No
KTS2/T65	*Garcinia miquelii*	Clusiaceae	Ad	t	Borneo	NE	No	No	No
KTS1/T73; KTS3	*Garcinia parvifolia*	Clusiaceae	Ad	t	Not	NE	No	No	No
KTS9;10;11	*Combretum nigrescens*	Combretaceae	Ad	c	Not	NE	No	No	No
KTS6/T16	*Terminalia foetidissima*	Combretaceae	Ad	t	Not	NE	No	No	No
KTS6	*Terminalia* sp.	Combretaceae	Ad	t			No	No	No
KTS3/7	*Agelaea borneensis*	Connaraceae	Ad	c	Not	NE	No	No	No
KTS5/16KTS8/2	*Agelaea trinervis*	Connaraceae	Ad	c	Not	NE	No	No	No
KTS6/1	*Cnestis platantha*	Connaraceae	Ad	c	Not	NE	No	No	No
KTS5/5	*Connarus* sp.	Connaraceae	Ad	c			No	No	No
KTS4/24; KTS4/33;KTS4/9	*Connarus villosus*	Connaraceae	Ad	c	Not	NE	No	No	No
KTS1;2;10;KTS7/12	*Erycibe borneensis*	Convolvulaceae	Ad	t	Borneo	NE	No	No	No
KTS5/T11	*Alangium javanicum*	Cornaceae	Ad	t	Not	LC	No	No	No
KTS5/12	*Alangium javanicum* var. *tulela*	Cornaceae	Ad	t	Not	LC	No	No	No
KTS10/3	*Alangium sp.*	Cornaceae	Ad	t			No	No	No
KTS5	*Crypteronia griffithii*	Crypteroniaceae	Ad	t	Not	NE	No	No	No
KTS5/26	*Ctenolophon parvifolius*	Ctenolophonacea e	Ad	t	Not	NE	No	No	No
SAN 159088	*Cyperus digitatus*	Cyperaceae	Am	sd	Not	LC	No	No	No
KTS9/2	*Cyperus luzulae*	Cyperaceae	Am	sd	Not	NE	No	No	No
KTS4/39	*Mapania graminea*	Cyperaceae	Am	sd	Borneo	NE	No	No	No
KTS2/4	*Mapania palustris*	Cyperaceae	Am	sd	Not	NE	No	No	No
KTS4/42	*Mapania petiolata*	Cyperaceae	Am	sd	Not	NE	No	No	No
KTS9; SAN159111	*Scleria sumatrensis*	Cyperaceae	Am	sd	Not	NE	No	No	No
MAM Andi1328	*Davallia denticulata*	Davalliaceae	F	f	Not	NE	No	No	No
KTS4/34	*Dichapetalum* cf. *gelanioides ssp. Pilosum*	Dichapetalaceae	Ad	t			No	No	No
KTS8;9	*Dillenia indica*	Dilleniaceae	Ad	t	Not	NE	No	No	No
SAN158576	*Tetracera akara*	Dilleniaceae	Ad	t	Not	NE	No	No	No
KTS6/9;KTS5/2;KTS1/24; KTS3/13;KTS9/16; SAN158593	*Tetracera korthalsii*	Dilleniaceae	Ad	c	Not	NE	No	No	No
Dipt survey	*Dipterocarpus applanatus*	Dipterocarpaceae	Ad	t	Borneo	CR	No	No	No
Dipt survey	*Dipterocarpus caudiferus*	Dipterocarpaceae	Ad	t	Borneo	NT	No	No	No
KTS3;5; DS	*Dipterocarpus confertus*	Dipterocarpaceae	Ad	t	Borneo	NE	No	No	No
Dipt survey	*Dipterocarpus humeratus*	Dipterocarpaceae	Ad	t	Not	NE	No	No	No

KTS4;5;DS	*Dipterocarpus tempehes*	Dipterocarpaceae	Ad	t	Borneo	CR (VU)	No	No	No
Dipt survey	*Dipterocarpus validus*	Dipterocarpaceae	Ad	t	Not	CR	No	No	No
KTS1;2;3;4;5;6;8;10;DS	*Dryobalanops beccarii*	Dipterocarpaceae	Ad	t	Not	EN (LC)	No	No	No
KTS11;DS	*Dryobalanops keithii*	Dipterocarpaceae	Ad	t	Borneo	CR	No	No	No
KTS6;DS	*Dryobalanops lanceolata*	Dipterocarpaceae	Ad	t	Borneo	EN	No	No	No
KTS6/T12;DS	*Hopea cernua*	Dipterocarpaceae	Ad	t	Not	NE	No	No	No
KTS4/28; KTS5/27	*Hopea* cf. *wyatt smithii*	Dipterocarpaceae	Ad	t			No	No	No
KTS1/T56;3;DS	*Hopea dryobalanoides*	Dipterocarpaceae	Ad	t	Not	NE (LC)	No	No	No
KTS6;10;11;DS	*Hopea nervosa*	Dipterocarpaceae	Ad	t	Not	CR (LC)	No	No	No
KTS10;11;DS	*Parashorea malaanonan*	Dipterocarpaceae	Ad	t	Not	CR	No	No	No
KTS10;DS	*Parashorea tomentella*	Dipterocarpaceae	Ad	t	Borneo	NE	No	No	No
KTS4;5;DS	*Shorea acuminatissima*	Dipterocarpaceae	Ad	t	Borneo	CR	No	No	No
KTS3;5	*Shorea agamii*	Dipterocarpaceae	Ad	t	Borneo	EN	No	No	No
KTS5;DS	*Shorea almon*	Dipterocarpaceae	Ad	t	Not	CR	No	No	No
KTS5;10;11;DS	*Shorea argentifolia*	Dipterocarpaceae	Ad	t	Borneo	EN	No	No	No
KTS8/T57	*Shorea atrinervosa*	Dipterocarpaceae	Ad	t	Not	NE (LC)	No	No	No
DS	*Shorea beccariana*	Dipterocarpaceae	Ad	t	Borneo	NE	No	No	No
DS	*Shorea* cf. *patoensis*	Dipterocarpaceae	Ad	t			No	No	No
DS	*Shorea faguetiana*	Dipterocarpaceae	Ad	t	Not	EN (LC)	No	No	No
KTS8/T34	*Shorea fallax*	Dipterocarpaceae	Ad	t	Borneo	NE	No	No	No
DS	*Shorea havilandii*	Dipterocarpaceae	Ad	t	Borneo	LC	No	No	No
KTS11;DS	*Shorea inappendiculata*	Dipterocarpaceae	Ad	t	Not	CR (VU)	No	No	No
KTS6;11;DS	*Shorea johorensis*	Dipterocarpaceae	Ad	t	Not	CR (NT)	No	No	No
KTS6;DS	*Shorea leprosula*	Dipterocarpaceae	Ad	t	Not	EN (LC)	No	No	No
Dipt survey	*Shorea macrophylla*	Dipterocarpaceae	Ad	t	Borneo	VU	Yes	No	No
KTS1;3;5;10;11;DS	*Shorea macroptera*	Dipterocarpaceae	Ad	t	Borneo	NE	No	No	No
KTS4;DS	*Shorea mecistopteryx*	Dipterocarpaceae	Ad	t	Borneo	NE	Yes	No	No
KTS1;4;DS	*Shorea ovalis*	Dipterocarpaceae	Ad	t	Not	NE (NT)	No	No	No
KTS10;DS	*Shorea parvifolia*	Dipterocarpaceae	Ad	t	Not	NE (LC)	No	No	No
KTS8;DS	*Shorea parvistipulata*	Dipterocarpaceae	Ad	t	Borneo	NE	No	No	No
Dipt survey	*Shorea pauciflora*	Dipterocarpaceae	Ad	t	Not	EN (LC)	No	No	No
Dipt survey	*Shorea scrobiculata*	Dipterocarpaceae	Ad	t	Not	NE (LC)	No	No	No
Dipt survey	*Shorea seminis*	Dipterocarpaceae	Ad	t	Not	CR	No	No	No
KTS10;11;DS	*Shorea smithiana*	Dipterocarpaceae	Ad	t	Borneo	CR	No	No	No
KTS5/28	*Shorea* sp.	Dipterocarpaceae	Ad	t			No	No	No
Dipt survey	*Shorea superba*	Dipterocarpaceae	Ad	t	Borneo	CR	No	No	No
KTS10;DS	*Shorea symingtonii*	Dipterocarpaceae	Ad	t	Sabah	CR	No	No	No
KTS6;DS	*Shorea waltonii*	Dipterocarpaceae	Ad	t	Sabah	CR	No	No	No

KTS6;DS	*Shorea xanthophylla*	Dipterocarpaceae	Ad	t	Borneo	CR	No	No	No
KTS10/1;KTS11/18;KTS11/T45;DS	*Vatica havilandii*	Dipterocarpaceae	Ad	t	Not	CR (EN)	No	No	No
KTS3;4;8;DS	*Vatica oblongifolia*	Dipterocarpaceae	Ad	t	Borneo	NE	No	No	No
KTS7/T4	*Diospyros frutescens*	Ebenaceae	Ad	t	Not	NE	No	No	No
KTS11/T26	*Diospyros wallichii*	Ebenaceae	Ad	t	Not	NE	No	No	No
KTS2;1;3	*Elaeocarpus angustipes*	Elaeocarpaceae	Ad	t	Not	NE	No	No	No
SAN159069	*Elaeocarpus* cf. *euneurus*	Elaeocarpaceae	Ad	t			No	No	No
KTS8/23	*Elaeocarpus* cf. *nitidus*	Elaeocarpaceae	Ad	t			No	No	No
KTS2/29	*Elaeocarpus* cf. *pedunculatus*	Elaeocarpaceae	Ad	t			No	No	No
KTS4/T33; KTS7/T34; KTS3/T34	*Elaeocarpus clementis*	Elaeocarpaceae	Ad	t	Borneo	NE	No	No	No
KTS2/T32	*Elaeocarpus euneurus*	Elaeocarpaceae	Ad	t	Borneo	NE	No	No	No
KTS2	*Elaeocarpus pedunculatus*	Elaeocarpaceae	Ad	t	Not	NE	No	No	No
KTS9/15	*Elaeocarpus* sp.	Elaeocarpaceae	Ad	t			No	No	No
KTS4;6;8;SAN159110	*Elaeocarpus stipularis*	Elaeocarpaceae	Ad	t	Not	NE	No	No	No
KTS10/34	*Polyosma mutabilis*	Escalloniaceae	Ad	t	Not	NE	No	No	No
KTS5;6;11	*Croton argyratus*	Euphorbiaceae	Ad	t	Not	NE	No	No	No
SAN159060	*Croton oblongifolius*	Euphorbiaceae	Ad	t	Not	NE	No	No	No
KTS4/23; KTS5/3; KTS11/15	*Dimorphocalyx luzoniensis*	Euphorbiaceae	Ad	t	Not	NE	No	No	No
KTS3/6; KTS4/29;KTS5/13; KTS6/2;KTS11/5	*Koilodepas longifolium*	Euphorbiaceae	Ad	t	Not	NE	No	No	No
KTS11/23; KTS3/5; KTS1/22; KTS5/T20	*Macaranga brevipetiolata*	Euphorbiaceae	Ad	t	Borneo	NE	No	No	No
KTS3;9;11	*Macaranga conifera*	Euphorbiaceae	Ad	t	Not	NE	No	No	No
SAN159062	*Macaranga gigantea*	Euphorbiaceae	Ad	t	Not	NE	No	No	No
KTS3/T7	*Macaranga motleyana*	Euphorbiaceae	Ad	t	Borneo	NE	No	No	No
KTS3	*Macaranga* sp	Euphorbiaceae	Ad	t			No	No	No
SAN158584	*Macaranga triloba*	Euphorbiaceae	Ad	t	Not	NE	No	No	No
KTS8/10; KTS10/23	*Mallotus caudatus*	Euphorbiaceae	Ad	t	Borneo	NE	No	No	No
KTS3/T6	*Mallotus* cf. *tenuipes*	Euphorbiaceae	Ad	t			No	No	No
KTS6	*Mallotus miquelianus*	Euphorbiaceae	Ad	t	Not	NE	No	No	No
KTS4/31; KTS8/3; KTS3/40; KTS8/T21	*Mallotus penangensis*	Euphorbiaceae	Ad	t	Not	NE	No	No	No
KTS3	*Mallotus* sp.	Euphorbiaceae	Ad	t			No	No	No
KTS5/19	*Mallotus wrayii*	Euphorbiaceae	Ad	t	Not	NE	No	No	No
KTS11/31; KTS11/17	*Neoscortechinia angustifolia*	Euphorbiaceae	Ad	t	Borneo	NE	No	No	No
SAN159104	*Paracroton pendulus*	Euphorbiaceae	Ad	t	Not	NE	No	No	No
KTS3;2	*Pimelodendron griffithianum*	Euphorbiaceae	Ad	t	Not	NE	No	No	No
KTS5	*Ptychopyxis* sp.	Euphorbiaceae	Ad	t			No	No	No
KTS11/9	*Suregada multiflora*	Euphorbiaceae	Ad	t	Not	NE	No	No	No
KTS9/21	*Adenanthera pavonina*	Fabaceae	Ad	t	Not	NE	No	No	No

KTS8/T15; KTS8/T33	*Albizia* cf. *splendens*	Fabaceae	Ad	t			No	No	No
SAN159127	*Albizia splendens*	Fabaceae	Ad	t	Not	NE	No	No	No
KTS9/20	*Archidendron clypearia*	Fabaceae	Ad	c	Not	NE	No	No	No
KTS4; SAN158591	*Bauhinia diptera*	Fabaceae	Ad	c	Borneo	NE	No	No	No
KTS9	*Bauhinia kockiana*	Fabaceae	Ad	c	Not	NE	No	No	No
SAN159134	*Bauhinia kockiana* var. *kockiana*	Fabaceae	Ad	c	Not	NE	No	No	No
SAN159129	*Caesalpinia latisiliqua*	Fabaceae	Ad	c	Not	NE	No	No	No
KTS10/25	*Caesalpinia parviflora*	Fabaceae	Ad	c	Not	NE	No	No	No
KTS3/33;KTS4/10;KTS8/28	*Crudia reticulata*	Fabaceae	Ad	t	Borneo	NE	No	No	No
KTS2/39; SAN159075	*Dalbergia junghuhnii*	Fabaceae	Ad	c	Not	NE	No	No	No
KTS9/14;KTS11/6;KTS11/19	*Dalbergia pseudo-sisso*	Fabaceae	Ad	c	Not	NE	No	No	No
KTS1/6;KTS11/13	*Dalbergia* sp.	Fabaceae	Ad	c			No	No	No
KTS7/T52	*Dialium platysepalum*	Fabaceae	Ad	t	Not	NE	No	No	No
KTS9/24;KTS10/36	*Fordia filipes*	Fabaceae	Ad	t	Not	NE	No	No	No
KTS1;4;5;6;8;11	*Fordia splendidissima*	Fabaceae	Ad	t	Not	NE	No	No	No
KTS2/T14;2;3	*Koompassia malaccensis*	Fabaceae	Ad	t	Not	LC	Yes	No	No
KTS10;11	*Peltophorum racemosum*	Fabaceae	Ad	t	Borneo	NE	No	No	No
SAN159124	*Saraca declinata*	Fabaceae	Ad	t	Not	NE	No	No	No
KT3/T21; KTS8/T11	*Sindora iripicina*	Fabaceae	Ad	t	Bornoe	NE	No	No	No
KTS3	*Sindora* sp	Fabaceae	Ad	t			No	No	No
KTS10/29	*Spatholobus macropterus*	Fabaceae	Ad	c	Not	NE	No	No	No
KTS1/34	*Spatholobus* sp.	Fabaceae	Ad	c			No	No	No
KTS10/40	*Spatholobus* sp.2	Fabaceae	Ad	c			No	No	No
KTS4/20	*Spatholobus viridis*	Fabaceae	Ad	c	Borneo	NE	No	No	No
KTS1	*Castanopsis motleyana*	Fagaceae	Ad	t	Not	NE	Yes	No	No
KTS10/T53; KTS10/T19	*Lithocarpus clementianus*	Fagaceae	Ad	t	Not	NE	Yes	No	No
KTS3/26; KTS3/37;KTS11/21	*Lithocarpus leptogyne*	Fagaceae	Ad	t	Not	NE	Yes	No	No
SAN159105	*Lithocarpus meijeri*	Fagaceae	Ad	t	Not	NE	Yes	No	No
KTS8/T10; T12; KTS4/25; SAN159053	*Lithocarpus niewenhuisii*	Fagaceae	Ad	t	Not	NE	Yes	No	No
KTS10	*Lithocarpus* sp	Fagaceae	Ad	t			Yes	No	No
KTS11/35	*Flagellaria indica*	Flagellariaceae	Am	c	Not	NE	No	No	No
SAN159063	*Fagraea cuspidata*	Gentianaceae	Ad	t	Not	NE	No	No	No
KTS11;SAN159059	*Fagraea spicata*	Gentianaceae	Ad	t	Not	NE	No	No	No
KTS2/23;SAN159055	*Aeschynanthus tricolor*	Gesneriaceae	Ad	ep	Borneo	NE	No	No	No
KTS9	*Dicranopteris linearis*	Gleicheniaceae	F	f	Not	LC	No	No	No
KTS2/31; KTS7/4;SAN159121; SAN158597	*Gnetum cuspidatum*	Gnetaceae	Ad	c	Not	NE	No	No	No
KTS3/4	*Hanguana major*	Hanguanaceae	Am	sh	Borneo	NE	No	No	No
MAM Andi1318	*Crepidomanes maximum*	Hymenophyllaceae	F	f	Not	LC	No	No	No
KTS9/T1	*Cratoxylum*	Hypericaceae	Ad	t	Not	LC	No	No	No

	cochinchinensis								
KTS11	*Cratoxylum formosum*	Hypericaceae	Ad	t	Not	LC	No	No	No
KTS9/T	*Cratoxylum sumatranum*	Hypericaceae	Ad	t	Not	NE	No	No	No
KTS10/43;KTS11/34; SAN159083;SAN158574	*Curculigo latifolia*	Hypoxidaceae	Am	h	Not	NE	No	No	No
KTS9;10;SAN159074	*Vitex pinnata*	Lamiaceae	Ad	t	Not	NE	No	No	No
KTS1;2;3	*Actinodaphne borneensis*	Lauraceae	Ad	t	Borneo	NE	No	No	No
KTS9;SAN159108	*Actinodaphne glomerata*	Lauraceae	Ad	t	Not	NE	No	No	No
KTS11/28	*Actinodaphne kinabaluensis*	Lauraceae	Ad	t	Sabah	NE	No	No	No
KTS6/16; KTS4/2	*Actinodaphne venosa*	Lauraceae	Ad	t	Borneo	NE	No	No	No
KTS8	*Alseodaphne insignis*	Lauraceae	Ad	t	Not	NE	No	No	No
KTS5/T17	*Beilschmeidia geminiflora*	Lauraceae	Ad	t	Not	NE	No	No	No
KTS3/T28	*Beilschmeidia lucidula*	Lauraceae	Ad	t	Not	NE	No	No	No
KTS3;5	*Beilschmeidia* sp	Lauraceae	Ad	t			No	No	No
KTS5/4;KTS10/7;KTS9/18	*Cinnamomum iners*	Lauraceae	Ad	t	Not	NE	No	No	No
KTS10/38;KTS8/16;KTS8/7	*Cryptocarya ferrea*	Lauraceae	Ad	t	Not	NE	No	No	No
KTS4/17	*Cryptocarya griffithiana*	Lauraceae	Ad	t	Not	NE	No	No	No
KTS11/3	*Cryptocarya nitens*	Lauraceae	Ad	t	Not	NE	No	No	No
KTS5/30	*Dehaasia incrassata*	Lauraceae	Ad	t	Not	NE	No	No	No
KTS4;5;6;10;11	*Eusideroxylon zwageri*	Lauraceae	Ad	t	Not	VU	Yes	No	No
KTS1	*Litsea caulocarpa*	Lauraceae	Ad	t	Not	NE	No	No	No
KTS6/T7	*Litsea* cf. *accedens*	Lauraceae	Ad	t			No	No	No
KTS7/T11 (T5)	*Litsea* cf. *cylindrocarpa*	Lauraceae	Ad	t			No	No	No
KTS11/T51	*Litsea* cf. *suboppostifolia*	Lauraceae	Ad	t			No	No	No
KTS1;2;3;8	*Litsea cylindrocarpa*	Lauraceae	Ad	t	Not	NE	No	No	No
KTS7/10;KTS8/12	*Litsea elliptica*	Lauraceae	Ad	t	Not	NE	No	No	No
KTS8/18;KTS3/42	*Litsea fulva*	Lauraceae	Ad	t	Not	NE	No	No	No
KTS1	*Litsea insignis*	Lauraceae	Ad	t	Not	NE	No	No	No
KTS8/T13	*Litsea machilifolia*	Lauraceae	Ad	t	Not	NE	No	No	No
KTS11	*Litsea oppsitifolia*	Lauraceae	Ad	t	Borneo	NE	No	No	No
KTS6	*Litsea* sp.	Lauraceae	Ad	t			No	No	No
KTS8/T9	*Litsea* sp.2	Lauraceae	Ad	t			No	No	No
KTS6	*Nothaphoebe* sp.	Lauraceae	Ad	t			No	No	No
KTS7/T27	*Persea rimosa*	Lauraceae	Ad	t	Not	NE	No	No	No
KTS3/T53	*Phoebe grandis*	Lauraceae	Ad	t	Not	NE	No	No	No
KTS6/T5	*Phoebe* sp.	Lauraceae	Ad	t			No	No	No
KTS4	*Barringtonia lanceolata*	Lecythidaceae	Ad	t	Borneo	NE	No	No	No
KTS5/T16;KTS3/12	*Barringtonia macrostachya*	Lecythidaceae	Ad	t	Not	NE	No	No	No
KTS5	*Barringtonia sarcostachys*	Lecythidaceae	Ad	t	Borneo	NE	No	No	No
KTS7/5;SAN159072	*Indorouchera griffithiana*	Linaceae	Ad	t	Not	NE	No	No	No
MAM Andi1324	*Lindsaea doryphora*	Lindsaeaceae	F	f	Not	NE	No	No	No
KTS9; MAM Andi1326	*Lindsaea ensifolia*	Lindsaeaceae	F	f	Not	NE	No	No	No

KTS4/T11;KTS4	*Norrisia malaccensis*	Loganiaceae	Ad	t	Not	NE	No	No	No
KTS3/9	*Strychnos ignatii*	Loganiaceae	Ad	c	Not	NE	No	No	No
SAN159057	*Dendrophthoe constricta*	Loranthaceae	Ad	ep	Not	NE	No	No	No
SAN158570; MAM Andi1300	*Palhinhaea cernua*	Lycopodiaceae	L	l	Not	NE	No	No	No
KTS1	*Phlegmariurus phlegmaria*	Lycopodiaceae	L	l	Not	NE	No	No	No
KTS4;5;6;9	*Lygodium circinnatum*	Lygodiaceae	F	f	Not	NE	No	No	No
MAM Andi1313	*Lygodium flexuosum*	Lygodiaceae	F	f	Not	NE	No	No	No
KTS9	*Lygodium microphyllum*	Lygodiaceae	F	f	Not	LC	No	No	No
KTS1/35	*Magnolia candolii* var. *obovata*	Magnoliaceae	Ad	t	Not	NE	No	No	No
KTS6	*Brownlowia peltata*	Malvaceae	Ad	t	Not	NE	No	No	No
KTS6/3	*Byttneria reinwardtii*	Malvaceae	Ad	t	Not	NE	No	No	No
KTS3/T3;KTS3/T33;KTS8/T35; KTS3/19;KTS8/01	*Durio acutifolius*	Malvaceae	Ad	t	Borneo	VU	Yes	No	No
KTS3	*Durio* cf. *lanceolatus*	Malvaceae	Ad	t			Yes	No	No
KTS10/T41	*Durio dulcis*	Malvaceae	Ad	t	Borneo	VU	Yes	No	No
KTS10	*Durio lanceolatus*	Malvaceae	Ad	t	Borneo	NE	Yes	No	No
KTS4	*Durio oxleyanus*	Malvaceae	Ad	t	Not	NE	Yes	No	No
KTS3	*Durio* sp	Malvaceae	Ad	t			Yes	No	No
KTS9/31	*Grewia laevigata*	Malvaceae	Ad	t	Not	NE	No	No	No
KTS3;4;5;11	*Heriteria sumatrana*	Malvaceae	Ad	t	Not	NE	No	No	No
KTS10/24;KTS11/7	*Microcos antidesmifolia*	Malvaceae	Ad	t	Not	NE	No	No	No
KTS1	*Microcos* cf. *reticulata*	Malvaceae	Ad	t			No	No	No
KTS11	*Microcos crassifolia*	Malvaceae	Ad	t	Borneo	NE	No	No	No
KTS4;5;KTS1/T78;KTS9/11	*Microcos reticulata*	Malvaceae	Ad	t	Not	NE	No	No	No
KTS11	*Neesia synandra*	Malvaceae	Ad	t	Not	NE	No	No	No
KTS1;3;5;10;11	*Pentace borneensis*	Malvaceae	Ad	t	Borneo	NE	No	No	No
KTS11/T1	*Pentace chartacea*	Malvaceae	Ad	t	Borneo	NE	No	No	No
KTS6	*Pentace laxiflora*	Malvaceae	Ad	t	Borneo	NE	No	No	No
KTS3	*Scaphium* cf. *macropodum*	Malvaceae	Ad	t			No	No	No
KTS11	*Scaphium longipetiolatum*	Malvaceae	Ad	t	Borneo	NE	No	No	No
KTS4	*Scaphium macropodum*	Malvaceae	Ad	t	Not	LC	No	No	No
KTS10/T39	*Sterculia rubiginosa*	Malvaceae	Ad	t	Not	NE	No	No	No
SAN159093	*Donax canniformis*	Marantaceae	Am	sh	Not	NE	No	No	No
KTS8/35	*Phyrnium* cf. *hirtum*	Marantaceae	Am	sh			No	No	No
KTS11; SAN158571	*Clidemia hirta*	Melastomataceae	Ad	sh	Not	NE	No	No	No
SAN159061	*Diplectria divericata*	Melastomataceae	Ad	c	Not	NE	No	No	No
SAN159066;159118	*Medinilla constricta*	Melastomataceae	Ad	sh	Not	NE	No	No	No
KTS9; SAN1598572	*Melastoma malabathricum*	Melastomataceae	Ad	sh	Not	NE	No	No	No
KTS3/10	*Memecylon laevigatum*	Melastomataceae	Ad	t	Not	NE	No	No	No
KTS6/17	*Memecylon scolopacium*	Melastomataceae	Ad	t	Borneo	NE	No	No	No

KTS8;10; KTS1/T79;11	*Pternandra coerolescens*	Melastomataceae	Ad	t	Not	NE	No	No	No
SAN159056	*Pternandra multiflora*	Melastomataceae	Ad	t	Borneo	NE	No	No	No
KTS1/21;KTS2/25;KTS 4/5; KTS5/11;KTS4/T23	*Pternandra rostrata*	Melastomataceae	Ad	t	Not	NE	No	No	No
KTS1;4;5	*Pternandra* sp1	Melastomataceae	Ad	t			No	No	No
KTS3	*Aglaia* cf. *macrophylla*	Meliaceae	Ad	t			No	No	No
KTS6/T9	*Aglaia elliptica* subsp *clementis*	Meliaceae	Ad	t	Not	LC	No	No	No
KTS5/7	*Aglaia faveolata*	Meliaceae	Ad	t	Not	NT	No	No	No
KTS4/T14	*Aglaia meliosmoides*	Meliaceae	Ad	t	Not	NE	No	No	No
SAN159125	*Aglaia rivularis*	Meliaceae	Ad	t	Borneo	VU	No	No	No
KTS4;6	*Aglaia* sp	Meliaceae	Ad	t			No	No	No
KTS4	*Azadirachta excelsa*	Meliaceae	Ad	t	Not	NE	No	No	No
KTS4	*Chisocheton* sp.	Meliaceae	Ad	t			No	No	No
KTS4/T43	*Dysoxylum alliaceum*	Meliaceae	Ad	t	Not	NE	No	No	No
KTS10/39;KTS10/T52	*Reinwardtiodendron humile*	Meliaceae	Ad	t	Not	NE	No	No	No
KTS10	*Reinwartiodendron* sp.	Meliaceae	Ad	t			No	No	No
KTS6	*Sandoricum koejapti*	Meliaceae	Ad	t	Not	NE	No	No	No
KTS2;3	*Artocarpus kemando*	Moraceae	Ad	t	Not	NE	No	No	No
KTS2/22	*Ficus depressa*	Moraceae	Ad	t	Not	NE	No	No	No
KTS5/T22	*Ficus glandulifera*	Moraceae	Ad	t	Not	NE	No	No	No
SAN159089	*Ficus megaleia*	Moraceae	Ad	t	Borneo	NE	No	No	No
KTS7/T31	*Ficus subgelderi*	Moraceae	Ad	t	Not	NE	No	No	No
SAN159087	*Ficus treubii*	Moraceae	Ad	t	Borneo	NE	No	No	No
KTS3/28	*Parartocarpus bracteatus*	Moraceae	Ad	t	Not	NE	No	No	No
KTS5	*Paratocarpus* sp	Moraceae	Ad	t			No	No	No
KTS2	*Gymancranthera* sp.	Myristicaceae	Ad	t			No	No	No
KTS4/T29	*Gymnacranthera contracta*	Myristicaceae	Ad	t	Borneo	NE	No	No	No
KTS4/T20	*Horsfieldia brachiata*	Myristicaceae	Ad	t	Not	NE	No	No	No
SAN159119	*Horsfieldia crassifolia*	Myristicaceae	Ad	t	Not	NT	No	No	No
KTS2/T39	*Horsfieldia glabra*	Myristicaceae	Ad	t	Not	NE	No	No	No
KTS2/18	*Horsfieldia pallidicaula*	Myristicaceae	Ad	t	Bornoe	NE	No	No	No
KTS8/T4	*Horsfieldia polyspherula*	Myristicaceae	Ad	t	Not	NE	No	No	No
KTS10/21	*Knema* cf. *kortalsii*	Myristicaceae	Ad	t			No	No	No
KTS3	*Knema* cf. *latericia*	Myristicaceae	Ad	t			No	No	No
KTS3/27;KTS5/10;KTS 10/T1	*Knema cinerea*	Myristicaceae	Ad	t	Not	NE	No	No	No
KTS2/T69;KTS7/T60	*Knema conferta*	Myristicaceae	Ad	t	Not	LC	No	No	No
KTS8;KTS3/T15	*Knema latericia*	Myristicaceae	Ad	t	Not	NE	No	No	No
KTS4/14;KTS8/09	*Knema laurina*	Myristicaceae	Ad	t	Not	NE	No	No	No
KTS5/18	*Knema membranifolia*	Myristicaceae	Ad	t	Borneo	NE	No	No	No
KTS4/T15	*Knema oblongata*	Myristicaceae	Ad	t	Borneo	NE	No	No	No
KTS4;10	*Knema* sp	Myristicaceae	Ad	t			No	No	No

KTS4	*Myristica* cf. *villosa*	Myristicaceae	Ad	t			No	No	No
KTS3;8;KTS3/T16	*Myristica cinnamomea*	Myristicaceae	Ad	t	Not	LC	No	No	No
KTS2;5	*Myristica* sp	Myristicaceae	Ad	t			No	No	No
KTS3	*Myristica* sp.	Myristicaceae	Ad	t			No	No	No
KTS4	*Myristica* sp3	Myristicaceae	Ad	t			No	No	No
KTS4	*Myristica* sp4	Myristicaceae	Ad	t			No	No	No
KTS4/T18	*Myristica villosa*	Myristicaceae	Ad	t	Borneo	NE	No	No	No
KTS8/T18;KTS8/T60;KTS11/T7; KTS2/16;KTS10/13	*Syzygium acuminatissimum*	Myrtaceae	Ad	t	Not	NE	No	No	No
KTS1/T86;KTS10/T38; KTS8/28	*Syzygium castaneum*	Myrtaceae	Ad	t	Not	NE	No	No	No
KTS1;3;8	*Syzygium caudatilimbum*	Myrtaceae	Ad	t	Not	NE	No	No	No
KTS4/T30;KTS5/9	*Syzygium cephalantha??*	Myrtaceae	Ad	t			No	No	No
KTS1/T22;KTS2/T22	*Syzygium* cf. *claviflorum*	Myrtaceae	Ad	t			No	No	No
KTS9/8	*Syzygium* cf. *pustulatum*	Myrtaceae	Ad	t			No	No	No
KTS2/11;KTS1/12;KTS7/11; KTS2/T57;KTS7/T7	*Syzygium claviflorum*	Myrtaceae	Ad	t	Sabah	NE	No	No	No
KTS4/T48	*Syzygium fastigiatum*	Myrtaceae	Ad	t	Not	NE	No	No	No
KTS8;SAN159109	*Syzygium hirtum*	Myrtaceae	Ad	t	Not	NE	No	No	No
KTS2/T4;KTS1/T35	*Syzygium incarnatum*	Myrtaceae	Ad	t	Not	NE	No	No	No
KTS1/26	*Syzygium kalahiense*	Myrtaceae	Ad	t	Borneo	NE	No	No	No
KTS1/31;KTS2/38;KTS8/15	*Syzygium kunstleri*	Myrtaceae	Ad	t	Not	NE	No	No	No
KTS9/T4;KTS9/9;KTS2	*Syzygium leptostemon*	Myrtaceae	Ad	t	Not	NE	No	No	No
KTS1/T84;KTS3/41	*Syzygium longiflorum*	Myrtaceae	Ad	t	Not	NE	No	No	No
KTS3/T2	*Syzygium pustulatum*	Myrtaceae	Ad	t	Not	NE	No	No	No
KTS4	*Syzygium* sp	Myrtaceae	Ad	t			No	No	No
KTS1;4	*Syzygium* sp1	Myrtaceae	Ad	t			No	No	No
KTS1;2	*Syzygium* sp2	Myrtaceae	Ad	t			No	No	No
KTS1;2	*Syzygium* sp3	Myrtaceae	Ad	t			No	No	No
KTS1;2;3	*Syzygium* sp4	Myrtaceae	Ad	t			No	No	No
KTS1	*Syzygium* sp5	Myrtaceae	Ad	t			No	No	No
KTS2	*Syzygium* sp7	Myrtaceae	Ad	t			No	No	No
KTS3	*Syzygium* sp8	Myrtaceae	Ad	t			No	No	No
KTS1/19;KTS2/13;KTS2/30;KTS7/1; KTS8/22;KTS1/T38;KTS2/T2;KTS7/T24	*Syzygium zeylanicum*	Myrtaceae	Ad	t	Not	NE	No	No	No
KTS4;10;11	*Syzygium*sp.	Myrtaceae	Ad	t			No	No	No
SAN159120	*Nepenthes ampullaria*	Nepenthaceae	Ad	sh	Not	LC	No	Yes	Yes
SAN159069; SAN158580	*Nepenthes mirabilis*	Nepenthaceae	Ad	sh	Not	LC	No	Yes	Yes
SAN159113	*Nepenthes* x *kuchingensis*	Nepenthaceae	Ad	sh	Not	NE	No	Yes	Yes
KTS9	*Nephrolepis biserrata*	Nephrolepidaceae	F	f	Not	NE	No	No	No
KTS4;KTS10	*Gomphia serrata*	Ochnaceae	Ad	t	Not	LC	No	No	No
KTS4;5;10	*Ochanostachys amentacea*	Olacaceae	Ad	t	Not	DD	No	No	No

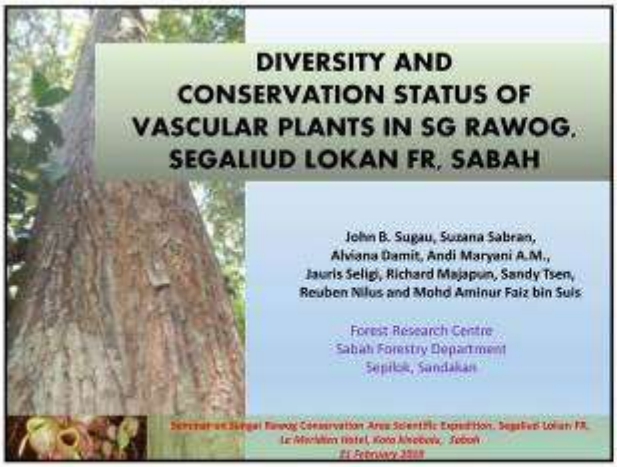
KTS10	*Scorodocarpus borneensis*	Olacaceae	Ad	t	Not	NE	No	No	No
KTS2/T15	*Chionanthus laxiflorus*	Oleaceae	Ad	t	Not	NE	No	No	No
KTS4/T9	*Chionanthus lucens*	Oleaceae	Ad	t	Not	NE	No	No	No
KTS2;4	*Chionathus* sp	Oleaceae	Ad	t			No	No	No
MAM Andi1298	*Ophioderma pendulum*	Ophioglossaceae	F	f	Not	NE	No	No	No
KTS7/14	*Appendecula* sp.	Orchidaceae	Am	h			No	Yes	Yes
KTS8/32;KTS2/5	*Bulbophyllum* sp.	Orchidaceae	Am	h			No	Yes	Yes
KTS1/03	*Dipodium* cf. *scandens*	Orchidaceae	Am	h			No	Yes	Yes
KTS2/23	*Eria* sp.	Orchidaceae	Am	h			No	Yes	Yes
KTS3/1;KTS2/7	*Neuwedia* sp.	Orchidaceae	Am	h			No	Yes	Yes
KTS1;3;7	*Sarcotheca diversifolia*	Oxalidaceae	Ad	t	Not	NE	No	No	No
KTS1/16	*Galeria* sp.	Pandaceae	Ad	t			No	No	No
KTS2/6;KTS3/3	*Benstonea pumila*	Pandanaceae	Am	sh	Borneo	NE	No	No	No
KTS1/01; KTS10/42	*Benstonea rustica*	Pandanaceae	Am	sh	Borneo	NE	No	No	No
KTS4/38	*Freycinetia biloba*	Pandanaceae	Am	sh	Borneo	NE	No	No	No
SAN159068	*Pandanus motleyanus*	Pandanaceae	Am	sh	Sabah	NE	No	No	No
SAN159067	*Ternstroemia citrina*	Pentaphylacaceae	Ad	t	Borneo	NE	No	No	No
KTS1;KTS1/T7	*Chaetocarpus castanocarpus*	Peraceae	Ad	t	Not	NE	No	No	No
KTS6/T37	*Trigonopleura* sp	Peraceae	Ad	t			No	No	No
KTS6/12;KTS10/6;KTS 11/12	*Antidesma banguensis* var. *banguensis*	Phyllanthaceae	Ad	t	Not	NE	No	No	No
KTS8/17	*Antidesma stipulare*	Phyllanthaceae	Ad	t	Not	NE	No	No	No
KTS4/27;KTS6/4	*Aporosa elmeri*	Phyllanthaceae	Ad	t	Borneo	NE	No	No	No
KTS6	*Aporosa lucida*	Phyllanthaceae	Ad	t	Not	NE	No	No	No
KTS8/24	*Aporosa lunata*	Phyllanthaceae	Ad	t	Not	NE	No	No	No
KTS8/28;KTS10/28	*Aporosa nigricans*	Phyllanthaceae	Ad	t	Not	NE	No	No	No
KTS4/32;KTS6/6;KTS8 /08; KTS6/T32;KTS10/T31	*Aporosa prainiana*	Phyllanthaceae	Ad	t	Not	NE	No	No	No
KTS10	*Aporosa* sp.	Phyllanthaceae	Ad	t			No	No	No
KTS2	*Baccaurea* cf. *macrocarpa*	Phyllanthaceae	Ad	t			Yes	No	No
KTS3/T23;KTS7/6	*Baccaurea macrocarpa*	Phyllanthaceae	Ad	t	Not	NE	Yes	No	No
KTS5/24	*Baccaurea membranacea*	Phyllanthaceae	Ad	t	Not	VU	Yes	No	No
KTS3/T38;SAN159116	*Baccaurea nanihua*	Phyllanthaceae	Ad	t	Not	NE	Yes	No	No
KTS5/T43;KTS8/T42	*Baccaurea sumatrana*	Phyllanthaceae	Ad	t	Not	NE	No	No	No
KTS3/T52	*Baccaurea trigonocarpa*	Phyllanthaceae	Ad	t	Borneo	NE	No	No	No
KTS11	*Bridelia insulana*	Phyllanthaceae	Ad	t	Not	NE	No	No	No
KTS5/T32	*Cleistanthus* cf. *baramicus*	Phyllanthaceae	Ad	t			No	No	No
KTS3/38	*Cleistanthus* cf. *paxii*	Phyllanthaceae	Ad	t			No	No	No
KTS1/15;KTS3/34;KTS 8/11;KTS1/T60	*Cleistanthus rufescens*	Phyllanthaceae	Ad	t	Not	NE	No	No	No
KTS1;5	*Cleistanthus* sp.	Phyllanthaceae	Ad	t			No	No	No
KTS9/26	*Glochidion andersonii*	Phyllanthaceae	Ad	t	Bornoe	NE	No	No	No
SAN159128	*Glochidion macrostigma*	Phyllanthaceae	Ad	t	Not	NE	No	No	No
KTS9/29	*Glochidion philippicum*	Phyllanthaceae	Ad	t	Not	NE	No	No	No

SAN159079	*Glochidion rubrum*	Phyllanthaceae	Ad	t	Not	NE	No	No	No
KTS10/45	*Centotheca lappacea*	Poaceae	Am	g	Not	NE	No	No	No
KTS8/36; KTS5/35; KTS4/50; KTS6/18; KTS10/37; KTS9/3; SAN158573	*Dinochloa prunifera*	Poaceae	Am	g	Borneo	EN	No	No	No
KTS4/45	*Dinochloa scabrida*	Poaceae	Am	g	Borneo	NE	No	No	No
KTS9/4; KTS4/7;SAN159098	*Dinochloa trichogona*	Poaceae	Am	g	Borneo	NE	No	No	No
SAN158589	*Imperata cylindrica*	Poaceae	Am	g	Not	NE	No	No	No
KTS6	*Xanthophyllum adenotus*	Polygalaceae	Ad	t	Not	NE	No	No	No
KTS6;10;KTS6/T15;KTS10/T42	*Xanthophyllum flavescens*	Polygalaceae	Ad	t	Not	NE	No	No	No
KTS3/T47;KTS5/T31	*Xanthophyllum obscurum*	Polygalaceae	Ad	t	Not	NE	No	No	No
KTS4/T41	*Xanthophyllum pachycarpon*	Polygalaceae	Ad	t	Borneo	NE	No	No	No
KTS3/32;KTS4/30;KTS5/8; KTS11/29	*Xanthophyllum purpureum*	Polygalaceae	Ad	t	Borneo	NE	No	No	No
KTS5	*Xanthophyllum rufum*	Polygalaceae	Ad	t	Not	NE	No	No	No
KTS3;4;5	*Xanthophyllum* sp	Polygalaceae	Ad	t			No	No	No
KTS3;KTS11/8	*Xanthophyllum stipitatum*	Polygalaceae	Ad	t	Not	NE	No	No	No
MAM Andi1302	*Goniophlebium percussum*	Polypodiaceae	F	f	Not	NE	No	No	No
KTS4/22	*Ardisia forbesii*	Primulaceae	Ad	t	Not	NE	No	No	No
KTS7/8;KTS8/04	*Ardisia lamponga*	Primulaceae	Ad	t	Not	NE	No	No	No
KTS10/14;KTS11/30	*Ardisia macrocalyx*	Primulaceae	Ad	t	Borneo	NE	No	No	No
KTS1;2;7;SAN159070; SAN158596	*Labisia pumila*	Primulaceae	Ad	h	Not	NE	No	No	No
KTS8/20	*Myrsine aralioides*	Primulaceae	Ad	t	Not	NE	No	No	No
KTS1/29;KTS2/26;KTS7/9;KTS7/T2	*Myrsine fluviatilis*	Primulaceae	Ad	t	Not	NE	No	No	No
KTS2/T35;KTS2/T64	*Myrsine porteriana*	Primulaceae	Ad	t	Not	NE	No	No	No
KTS2	*Myrsine* sp	Primulaceae	Ad	t			No	No	No
KTS6/T6	*Helicia robusta*	Proteaceae	Ad	t	Not	NE	No	No	No
KTS6	*Helicia* sp.	Proteaceae	Ad	t			No	No	No
KTS2/8;KTS7; MAM Andi1301	*Haplopteris ensiformis*	Pteridaceae	F	f	Not	NE	No	No	No
KTS4/49	*Haplopteris scolopendrina*	Pteridaceae	F	f	Not	NE	No	No	No
MAM Andi1327	*Syngramma alismifolia*	Pteridaceae	F	f	Not	NE	No	No	No
KTS2;4;5;9; MAM Andi1299	*Taenitis blechnoides*	Pteridaceae	F	f	Not	NE	No	No	No
KTS8; MAM Andi1325	*Vittaria elongata*	Pteridaceae	F	f	Not	NE	No	No	No
KTS10/18	*Drypetes* cf. *eriocarpa*	Putranjivaceae	Ad	t			No	No	No
KTS6/7;KTS11/16	*Drypetes eriocarpa*	Putranjivaceae	Ad	t	Borneo	NE	No	No	No
KTS6	*Drypetes longifolia*	Putranjivaceae	Ad	t	Not	NE	No	No	No
SAN159131	*Naravelia laurifolia*	Ranunculaceae	Ad	c	Not	NE	No	No	No
KTS8;10;KTS6/10	*Ventilago dichotoma*	Rhamnaceae	Ad	c	Not	NE	No	No	No
KTS10	*Ziziphus angustifolia*	Rhamnaceae	Ad	c	Not	NE	No	No	No
KTS4;9	*Ziziphus borneensis*	Rhamnaceae	Ad	t	Borneo	NE	No	No	No

KT9/T19;KTS11/10	*Carallia brachiata*	Rhizophoraceae	Ad	t	Not	NE	No	No	No
KTS4/T10; KTS3/T64	*Prunus arborea*	Rosaceae	Ad	t	Not	LC	No	No	No
SAN159076; SAN158577	*Rubus moluccanus*	Rosaceae	Ad	c	Not	NE	No	No	No
KTS2/T5	*Canthium confertum*	Rubiaceae	Ad	t	Not	NE	No	No	No
KTS2	*Canthium* sp.	Rubiaceae	Ad	t			No	No	No
SAN159102	*Chassalia curviflora*	Rubiaceae	Ad	t	Not	NE	No	No	No
SAN159051	*Gaertnera junghuhniana*	Rubiaceae	Ad	t	Not	NE	No	No	No
SAN159054	*Hedyotis rigida*	Rubiaceae	Ad	t	Not	NE	No	No	No
SAN159112	*Musaenda elmeri*	Rubiaceae	Ad	t	Borneo	NE	No	No	No
SAN159123	*Myrmeconauclea strigosa*	Rubiaceae	Ad	sh	Not	NE	No	No	No
KTS5	*Nauclea* sp.	Rubiaceae	Ad	t			No	No	No
KTS5/T21	*Nauclea subdita*	Rubiaceae	Ad	t	Not	NE	No	No	No
SAN158592	*Neolamarckia cadamba*	Rubiaceae	Ad	t	Not	NE	No	No	No
SAN159091	*Pavetta* cf. *sarawakensis*	Rubiaceae	Ad	t			No	No	No
KTS5;11;KTS5/T34	*Pleiocrapidia paniculata*	Rubiaceae	Ad	t	Borneo	NE	No	No	No
KTS5	*Praravinia molis*	Rubiaceae	Ad	t	Borneo	NE	No	No	No
SAN159117;SAN159095	*Psychotria* sp.	Rubiaceae	Ad	t			No	No	No
KTS4/T21	*Timonius palawanensis*	Rubiaceae	Ad	t	Not	NE	No	No	No
SAN158581	*Uncaria longifolia*	Rubiaceae	Ad	c	Not	NE	No	No	No
SAN159081	*Uncaria ferrea*	Rubiaceae	Ad	t	Not	NE	No	No	No
SAN159094	*Urophyllum glabrum*	Rubiaceae	Ad	t	Not	NE	No	No	No
SAN159086	*Urophyllum woodii*	Rubiaceae	Ad	t	Borneo	NE	No	No	No
SAN159085	*Xanthophytum fruticulosum*	Rubiaceae	Ad	sh	Not	NE	No	No	No
SAN158588	*Clausena excavata*	Rutaceae	Ad	t	Not	NE	No	No	No
SAN159133	*Homalium caryophyllaceum*	Salicaceae	Ad	t	Not	NE	No	No	No
KTS1	*Guioa pleuropteris*	Sapindaceae	Ad	t	Not	NE	No	No	No
KTS10	*Guioa* sp.	Sapindaceae	Ad	t			No	No	No
KTS5;10	*Mischocarpus* sp.	Sapindaceae	Ad	t			No	No	No
KTS10	*Nephelium lappaceum*	Sapindaceae	Ad	t	Not	LC	Yes	No	No
KTS10	*Nephelium ramboutan-ake*	Sapindaceae	Ad	t	Not	NE	Yes	No	No
KTS3;10	*Nephelium* sp	Sapindaceae	Ad	t			Yes	No	No
KTS1;8	*Nephelium uncinatum*	Sapindaceae	Ad	t	Not	NE	Yes	No	No
KTS6	*Paranepehelium xestophyllum*	Sapindaceae	Ad	t	Not	NE	No	No	No
KTS10	*Pometia pinnata*	Sapindaceae	Ad	t	Not	NE	No	No	No
KTS1;2;3	*Madhuca* cf. *pallida*	Sapotaceae	Ad	t			No	No	No
KTS1	*Madhuca pallida*	Sapotaceae	Ad	t	Not	NE	No	No	No
KTS4	*Madhuca sarawakensis*	Sapotaceae	Ad	t	Borneo	NE	No	No	No
KTS1;10;11	*Madhuca* sp	Sapotaceae	Ad	t			No	No	No
KTS3	*Palaquium calophyllum*	Sapotaceae	Ad	t	Not	NE	No	No	No
KTS1;2;3	*Palaquium rostratum*	Sapotaceae	Ad	t	Not	NE	No	No	No
MAM Andi1314	*Selaginella conferta*	Selaginellaceae	L	l	Borneo	NE	No	No	No

KTS5/33	*Selaginella wallichii*	Selaginellaceae	L	l	Not	NE	No	No	No
KTS1;3;8;11; SAN158585	*Eurycoma longifolia*	Simaroubaceae	Ad	t	Not	NE	No	No	No
KTS9	*Smilax borneensis*	Smilacaceae	Am	c	Sabah	NE	No	No	No
SAN158582	*Smilax gigantea*	Smilacaceae	Am	c	Borneo	NE	No	No	No
KTS5	*Stemonurus malaccensis*	Stemonuraceae	Ad	t	Not	NE	No	No	No
KTS11	*Symplocos fasciculata*	Symplocaceae	Ad	t	Not	NE	No	No	No
MAM Andi1316	*Tectaria borneensis*	Tectariaceae	F	f	Not	NE	No	No	No
MAM Andi1317	*Tectaria nayarii*	Tectariaceae	F	f	Not	NE	No	No	No
KTS2;7	*Tetramerista glabra*	Tetrameristaceae	Ad	t	Not	NE	No	No	No
MAM Andi1319	*Pneumatopteris michaelis*	Thelypteridaceae	F	f	Not	NE	No	No	No
Seen/Image	*Pronephrium nitidum*	Thelypteridaceae	F	f	Not	NE	No	No	No
KTS8	*Aquilaria beccariana*	Thymelaeaceae	Ad	t	Not	VU	Yes	Yes	Yes
KTS1;2;3	*Gonystylus* cf. *keithii*	Thymelaeaceae	Ad	t			Yes	Yes	Yes
KTS3/23;KTS10	*Trigoiastrum hypoleucum*	Trigoniaceae	Ad	t	Not	NE	No	No	No
SAN159132	*Poikilospermum cordifolium*	Urticaceae	Ad	c	Not	NE	No	No	No
SAN159130	*Cayratia trifolia (not in Borneo)*	Vitaceae	Ad	c	Not	NE	No	No	No
SAN159077; SAN158590	*Leea indica*	Vitaceae	Ad	t	Not	NE	No	No	No
KTS9/5;SAN159058; 159078	*Alpinia aquatica*	Zingiberaceae	Am	h	Not	NE	No	Yes	No
KTS6/24	*Amomum oliganthum*	Zingiberaceae	Am	h	Borneo	NE	No	Yes	No
KTS3/2	*Amomum* sp.	Zingiberaceae	Am	h			No	Yes	No
KTS4/40	*Amomum staminidvum*	Zingiberaceae	Am	h	Borneo	NE	No	Yes	No
SAN159107	*Boesenbergia pulchella*	Zingiberaceae	Am	h	Borneo	NE	No	Yes	No
KTS4/36;KTS6/19;KTS 10/46	*Elettariopsis* sp.	Zingiberaceae	Am	h			No	Yes	No
SAN159115	*Globba pendula*	Zingiberaceae	Am	h	Not	NE	No	Yes	No
SAN159084	*Hornstedtia reticulata*	Zingiberaceae	Am	h	Borneo	NE	No	Yes	No
KTS4/14	*Hornstedtia* sp.	Zingiberaceae	Am	h			No	Yes	No
SAN159080	*Plagiostachys albiflora*	Zingiberaceae	Am	h	Not	NE	No	Yes	No
SAN158596	*Plagiostachys megacarpa*	Zingiberaceae	Am	h	Borneo	NE	No	Yes	No
KTS6/23	*Zingiber* sp.	Zingiberaceae	Am	h			No	Yes	No
KTS9/1;KTS4/37	*Zingiber vinosum*	Zingiberaceae	Am	h	Sabah	NE	No	Yes	No

Slide Presentation



Introduction

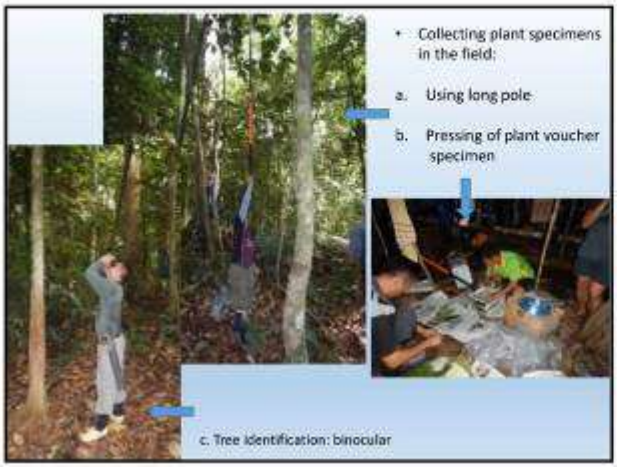
- In terms of flora, there has been no comprehensive study on plant diversity in Sg Rawog Conservation Area (SRCA).
- There are more than 1060 herbarium collections made from the Segaliud Lokan FR by the staff of Sandakan Herbarium during the period of 1947 and 2006 (Sandakan Herbarium Database).
- Imai *et al*., (2014) also established fifty 20 m-radius circular plots (1257 m^2 in area) in Segaliud Lokan FR (some within the SRCA) for their study on tree community composition as an indicator in biodiversity monitoring of REDD+

Objectives

- To determine plant diversity.
- To identify conservation status of plant species and high conservation value plants.
- To provide flora data/recommendations for the formulation of Sg Rawog Conservation Area Management Plan.

Methods

- 11 Circular plots (20 m r)
- Enumeration of trees, ≥ 10 cm diameter at breast height.
- All vascular plants in the plots were also collected/enumerated.
- General collection using SAN number
- Dipterocarp survey
- Plant identification in situ and at SAN
- All taxa.



Conservation status and legal protection of plant

- IUCN Red list (2019) and Malaysia Red List (2010).
- Sabah Forest Enactment 1968/Forest Rules 1969.
- Sabah Wildlife Conservation Enactment 1997 (SWCE)
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)

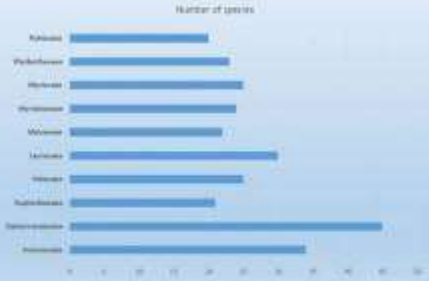
Results and Discussion

- Plant diversity.

Plant group	No. of families	No. of taxa
Lycopyhtes	2	4
Ferns	13	21
Gymnosperm	1	1
Angiosperms:		
Monocotyledon	13	55
Dicotyledon	77	485
Total	106	572

Results and Discussion

- The ten most speciose plant families



Results and Discussion

Diversity of Dipterocarp

- 45 taxa recorded from the current survey in Sg Rawog (24.7%);
  [182 spp in Sabah (Ashton, 2004); Borneo 267 spp]
- 2 spp. Sabah endemic, *Shorea symingtonii* and *S. waltonii*

Results and Discussion

- Endemism.

Results and Discussion

- Threatened Species.

Threat category	Number of species
Critically Endangered	12
Endangered	1
Vulnerable	9
Total	**22**

Results and Discussion

- Protected species

- SFD: Sabah Forest Enactment, 1968
- SWCE: Sabah Wildlife Conservation Enactment, 1997
- CITES: Convention on International Trade in Endangered Wild Fauna and Flora.

Legal protection	Number of species
SFD	35
SWCE	23
CITES	10
Total	**68**

Recommendations

Monitoring of high conservation value plant species:

-*Shorea symingtonii* (Dipterocarpaceae)

-*Shorea waltonii* (Dipterocarpaceae)

Recommendations

- *Shorea symingtonii* (Dipterocarpaceae)
- Melapi bunga/kuning
- Endemic to Sabah; CR

Recommendations

- *Shorea waltonii* (Dipterocarpaceae)
- Seraya kelabu
- Sabah Endemic; CR

Recommendations

- Protection of the forest reserve from:
  poaching/illegal harvest of plants,
  illegal encroachment

Aquilaria beccariana (Thymelaeaceae)

Conclusion

- 572 plant taxa recorded from SRCA
- Forests in Sg Rawog contain High Conservation Value Plant Species (Endemic, Threatened and legally protected).

Acknowlegdements

- KTS Plantation Sdn Bhd
- Chief Conservator of Forests and Deputy Chief Conservator of Forests (R&D and FSP) of the Sabah Forestry Dept.
- The survey team members.

PAPER 1.3

The Mosses of Sungai Rawog Conservation Area, Segaliud Lokan Forest Reserve, Sabah, Malaysia

M. Suleiman[1]* N. J. Rajian[1], A. Irmah[1] & M.A.M. Andi[2]

[1]Institute for Tropical Biology and Conservation, Universiti Malaysia Sabah, Jalan UMS, 88400 Kota Kinabalu, Sabah.
[2]Forest Research Centre, Sabah Forestry Department, P.O. Box 1407, 90715 Sandakan, Sabah.
**Author for correspondence. Email: monicas@ums.edu.my*

Abstract. A total of 50 species, in 26 genera and 13 families, of mosses were collected from Sungai Rawog Conservation Area within the Segaliud Lokan Forest Reserve. This represents ca. 8% of the taxa of mosses reported for Sabah and ca. 7% of the taxa reported for Borneo. The largest family of mosses collected was Calymperaceae with 17 species, followed by Pylaisiadelphaceae with seven species. These families of mosses are typically common in lowland tropical rain forests. It is worth to note that two of the species collected, *Leucobryum candidum* (Brid. ex P. Beauv.) Wilson. and *Wijkia polymorpha* (Dixon) H.A. Crum., are new records for Sabah. This shows that this area is an important habitat for lowland species of mosses in Sabah.

Keywords: Bryoflora, lowland, new records, Sg. Rawog

INTRODUCTION

Sungai Rawog Conservation Area (3,118 ha) is located within the Segaliud Lokan Forest Reserve in Sandakan District, eastern part of Sabah which is managed by KTS Plantation Sdn Bhd (KTS). It is part of a conservation area set aside by KTS within the forest reserve. A scientific expedition along the valley of Rawog River was jointly organized by KTS and Sabah Forestry Department in August 2018 partly to explore the biodiversity and tourism potential of the area. The expedition site is a lowland area of less than 100 m a.s.l.

Lowland areas in Sabah have received less attention from bryologists due to the low diversity of bryophytes as compared to highland areas. Despite the low species richness, inventories of mosses in lowland areas in Sabah had contributed significantly to new records both for the state of Sabah and the island of Borneo (Suleiman *et al*. 2003; Suleiman *et al*. 2009; Suleiman & Rimi 2016). Thus, the objective of this study is to carry out an inventory of mosses in Sungai Rawog Conservation Area. This will provide the baseline data for future research related to bryophytes and to contribute to bryological knowledge of lowland areas in Sabah.

MATERIALS & METHODS

Opportunistic sampling of mosses was carried out along the trails established by the organizers during the Sungai Rawog Conservation Area Scientific Expedition 2018 from 9th to 11th August 2018 (Table 1). Excursion of 5–10 m besides the trails was also carried out. All common substrates of mosses were intensively surveyed, including tree trunks, rotten logs, tree stumps, rocks, soils and fallen branches or twigs. The specimens were identified at the BORNEENSIS Herbarium (BORH) of the Institute for Tropical Biology and Conservation, Universiti Malaysia Sabah. The specimens were deposited at BORH and a set of duplicates was sent to the Sabah Forestry Department Herbarium (SAN).

Table 1. Collection details of mosses collected from Sungai Rawog Conservation Area.

Collection No.	Collection detail
MS 6386-6408	Trail 1, 3 and 3A; N 5°33'5.8", E 117°10'32.6"& N 5°26' 44.1", E117°31'37.7", 9 August 2018.
MS 6409-6440	Trail 7, 8 and 11; N 5°27'32", E 117°33'54.4" & N 5°27'38.7", E 117°34'14.2", 10 August 2018.
MS 6441-6457; MAM Andi *s.n.*	Kerangas forest; N 5°28'4", E 117°37'16.2", 11 August 2018.

Note: MS - M. Suleiman; MAM Andi - Andi Maryani AM

RESULTS & DISCUSSION

During the short survey, a total of 73 moss specimens were collected and out of these there were 50 species in 26 genera and 13 families of mosses identified to species level (Appendix 1). This number represents ca. 8% of the 651 taxa of mosses reported for Sabah and ca. 7% of the 767 species reported for Borneo (Akiyama 2012, Akiyama & Suleiman 2015, Andi & Suleiman 2005, Andi *et al*. 2015, Chua & Suleiman 2015, Ellis *et al*. 2010, Ellis *et al*. 2016a, Ellis 2016, Higuchi *et al*. 2008, Ho *et al*., 2010, Jia & He 2016, Mohamed *et al*. 2010, Suleiman *et al*. 2006, Suleiman & Akiyama 2007, Suleiman *et al*. 2009, Suleiman *et al*. 2011a, Suleiman *et al*. 2011b, Suleiman & Jotan 2015, Suleiman *et al*. 2017a, 2017b). Calymperaceae has the highest diversity with 17 species in six genera, followed by Pylaisiadelphaceae with seven species in five genera (Table 2). These two families are known to have a high species richness in lowland tropical rain forests.

Table 2. Summary of the mosses collected from Sungai Rawog Conservation Area.

No.	Families	Genera	Species
1	Calymperaceae	6	17
2	Pylaisiadelphaceae	5	7
3	Fissidentaceae	1	5
4	Orthotrichaceae	1	4
5	Sematophyllaceae	4	4
6	Leucobryaceae	1	4
7	Hypnaceae	1	2
8	Neckearaceae	2	2
9	Symphyodontaceae	1	1
10	Meteoriaceae	1	1
11	Ptychomniaceae	1	1
12	Rhizogoniaceae	1	1
13	Thuidiaceae	1	1
	Total	**26**	**50**

Among the 50 species of mosses collected, two species are new records for Sabah, *Leucobryum candidum* (Brid. ex P. Beauv.) Wilson. and *Wijkia polymorpha* (Dixon) H.A. Crum. The former species was previously reported from Sabah by Johnson (1964) but it was excluded by Yamaguchi (1993) in his treatment of the *Leucobryum* of Asia. The presence of this species in the Sungai Rawog Conservation Area confirmed its occurrence in Sabah. This species is abundant in the Kerangas forest, preferring acidic and wet substrates. It was also found submerged in water, a unique character for this genus.

Wijkia polymorpha was found in similar habitats with *Leucobryum candidum*, preferring wet peat and also submerged in acidic water. This species was described by Dixon (1924) from Myanmar as *Acanthocladium polymorphum* Dixon. and was recorded several times from Pahang, Peninsular Malaysia (Yong *et al*. 2013). There was only one record of this species in Borneo which was from Marudi of Sarawak in 1932, collected from Kerangas forest below 300 m a.s.l. (Dixon, 1935), indicating that this species is rare in this island. The forest type and substrate of both localities in Borneo are similar. This species seems to have a restricted distribution as it has not been recorded in other neighboring islands.

There are also two noteworthy species collected from the conservation area, *Wijkia hornschuchii* (Dozy & Molk.) H.A. Crum. and *Fissidens laxitextus* Broth. ex Gangulee (Figure 3). The former species, formally known as *Hageniella hattoriana* B.C. Tan, was only collected once in Borneo based on its type specimen from Mount Kinabalu in 1986 (Tan, 1990). This is the second record of this species in Borneo and it is interesting to find it from a lowland habitat in Sabah. This species is also recorded in China, Japan, Peninsular Malaysia, the Philippines, Java and New Guinea (Tan & Jia 1999).

Fissidens laxitextus was recently reported as a new record to Borneo (Chua and Suleiman, 2015). Sungai Rawog is the third locality of this tiny moss in this island. Interestingly, it was also collected from the same substrate as in the previous localities, which is on termite mount. This species has a disjunctive pattern of distribution; apart from Borneo, it is only recorded in Japan and India.

CONCLUSION

The short survey in Sungai Rawog Conservation Area has contributed significantly to the bryoflora of Sabah. The two new records and rare species collected show how important this conservation area is for lowland plants, including bryophytes. Further exploration in other parts of the Segaliud Lokan Forest Reserve will undoubtedly enrich our knowledge of lowland species of mosses in Sabah.

ACKNOWLEDGEMENTS

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Appendix 1 – Checklist of mosses of Sungai Rawog Conservation Area

Species marked with an asterisk (*) are new to Sabah. The arrangement of families follows that of Buck & Goffinet (2010). MS denotes for M. Suleiman.

Calymperaceae

Arthrocormus schimperi (Dozy & Molk.) Dozy & Molk.
On rotten stump and tree trunks, 100 m, MS 6392a, 6396, 6397, 6425.

Calymperes afzelii Sw.
On rotten logs by rivers, 100 m, MS 6420.

Calymperes moluccense Schwägr.
On tree trunks in an open area, 100 m, MS 6403.

Calymperes porrectum Mitt.
On rocks, 100 m, MS 6410.

Exostratum blumei (Nees ex Hampe) L.T. Ellis.
On tree trunks, 100 m, MS 6413.

Leucophanes angustifolium Renauld & Cardot.
On climber by rivers, 100 m, MS 6423.

Leucophanes octoblepharioides Brid.
On leaves, tree and shrub trunks, 100 m, MS 6394, 6421; Andi Maryani AM *s.n*.

Mitthyridium fasciculatum (Hook. & Grev.) H. Rob. subsp. *fasciculatum*
On rotten logs, 100 m, MS 6402.

Mitthyridium flavum (Müll. Hal.) H. Rob.
On tree trunks, by rivers, 100 m, MS 6406, 6430, 6434.

Mitthyridium luteum (Müll. Hal.) H. Rob.
On tree trunks by rivers, 100 m, MS 6424.

Mitthyridium subluteum (Müll. Hal.) H.K. Nowak.
On climbers by pond, 100 m, MS 6455.

Mitthyridium undulatum (Dozy & Molk.) H. Rob.
On climbers in secondary forest, 100 m, MS 6390.

Syrrhopodon albovaginatus Schwägr.
On rotten logs by stream, 100 m, MS 6427.

Syrrhopodon confertus Sande Lac.
On tree trunks in secondary forest, 100 m, MS 6436.

Syrrhopodon croceus Mitt.
On tree trunks in secondary forest, 100 m, MS 6391.

Syrrhopodon muelleri (Dozy & Molk.) Sande Lac.

On tree trunks by river, 100 m, MS 6428.

Syrrhopodon spiculosus Hook. & Grev.
On rotten logs and stumps in open areas of secondary forest, 100 m, MS 6386, 6388, 6392b, 6408.

Fissidentaceae

Fissidens crispulus Brid.
On rocks, by stream and river, 100 m, MS 6415, 6416, 6422.

Fissidens javanicus Dozy & Molk.
On rocks, 100 m, MS 6409.

Fissidens laxitextus Broth. ex Gangulee.
On termite mounts, 100 m, MS 6440, 6442.

Fissidens pellucidus Hornsch.
On tree trunks in secondary forest, 100 m, MS 6414.

Fissidens zollingeri Mont.
On tree roots, secondary forest, 100 m, MS 6412.

Hypnaceae

Vesicularia miquelii (Sande Lac.) M. Fleisch.
On rotten logs, 100 m, MS 6433.

Vesicularia reticulata (Dozy & Molk.) Broth.
On rocks in secondary forest, 100 m, MS 6411.

Leucobryaceae

Leucobryum aduncum var. *scalare* (Müll. Hal. ex M. Fleisch.) A. Eddy
On rotten log in Kerangas forest, 100 m, MS 6451.

**Leucobryum candidum* (Brid. ex P. Beauv.) Wilson. (Figure 1)
On rotten logs, peat and humus, wet to submerged in acidic water in Kerangas forest, 100 m, MS 6444, 6446, 6452, 6454.

The leaves of this species is mostly in 5 ranks and the abaxial surface of leaves is undulate to spinose-prorate. It can be confused with *L. aduncum* Dozy & Molk. var. *aduncum* but the latter is commonly much smaller and leaves are not clearly ranked.

Leucobryum javense (Brid.) Mitt. var. *javense*
On peat, 100 m, MS 6453.

Leucobryum sanctum (Nees ex Schwägr.) Hampe.
On tree trunks and rotten stumps, 100 m, MS 6389, 6457.

Meteoriaceae

Aerobryopsis wallichii (Brid.) M. Fleisch.
On tree trunks, Kerangas forest, 100 m, MS 6400, 6437. 6447.

Neckeraceae

Himantocladium cyclophyllum (Müll. Hal.) M. Fleisch.
On tree trunks by river, 100 m, MS 6426.

Pinnatella mucronata (Bosch & Sande Lac.) M. Fleisch.
On tree trunks, 100 m, MS 6401.

Orthotrichaceae

Desmotheca apiculata (Dozy & Molk.) Lindb. ex Cardot.
On fallen branches, 100 m, MS 6435.

Ptychomniaceae

Garovaglia compressa Mitt.
On tree trunks in an open area, secondary forest, 100 m, MS 6399.

Pylaisiadelphaceae

Isocladiella surcularis (Dixon) B.C. Tan & Mohamed.
On tree trunks by river, 100 m, MS 6431.

Isopterygium minutirameum (Müll. Hal.) A. Jaeger.
On rotten branch by river, 100 m, MS 6418.

Mastopoma armitii (Broth. & Geh.) Broth.
On rotten logs in an open area, 100 m, MS 6407.

Taxithelium instratum (Brid.) Broth.
On roots, by river, 100 m, MS 6417.

Taxithelium kerianum (Broth.) Broth.
On rotten logs and tree trunks, 100 m, MS 6439, 6441.

Wijkia hornschuchii (Dozy & Molk.) H.A. Crum.
On rotten stump in secondary forest, 100 m, MS 6387.

This species has ovate-oblong stem leaves but the specimen from Sungai Rawog has slightly different leaf shapes which is triangular-ovate.

**Wijkia polymorpha* (Dixon) H.A. Crum. (Figure 2)
Commonly on wet or submerged peat, seldom on shrub trunks, by acidic pond, in Kerangas forest, 100 m, MS 6404, 6405, 6448, 6449, 6450, 6456.

This species has highly polymorphic leaves, particularly the branch leaves. The stem leaves are broadly-ovate with abruptly piliferous apices, while the branch leaves are from ovate to ovate-oblong with gradually short to acuminate apices. This species could be confused with *Rhaphidostichum* in the field due to its long piliferous stem leaves. The serrate margin and unipapillose lamina cells of branch leaves will immediately separate it from the latter genus. In addition, the stem leaves apices of *Wijkia polymorpha* are plane and not strongly recurved as in *Rhaphidostichum*.

Rhizogoniaceae

Pyrrhobryum latifolium (Bosch & Sande Lac.) Mitt.
On humus and rotten stumps, 100 m, MS 6395, 6445.

Sematophyllaceae

Acanthorrhynchium papillatum (Harv.) M. Fleisch.
On rotten climbers in secondary forest and tree trunks, by river, 100 m, MS 6393, 6429.

Papillidiopsis bruchii (Dozy & Molk.) W.R. Buck & B.C. Tan.
On shrub trunks, in secondary forest, 100 m, MS 6398.

Piloecium pseudorufescens (Hampe) Müll. Hal.
On tree trunks in secondary forest, 100 m, MS 6438.

Trichosteleum stigmosum Mitt.
On tree trunks, 100 m, MS 6443.

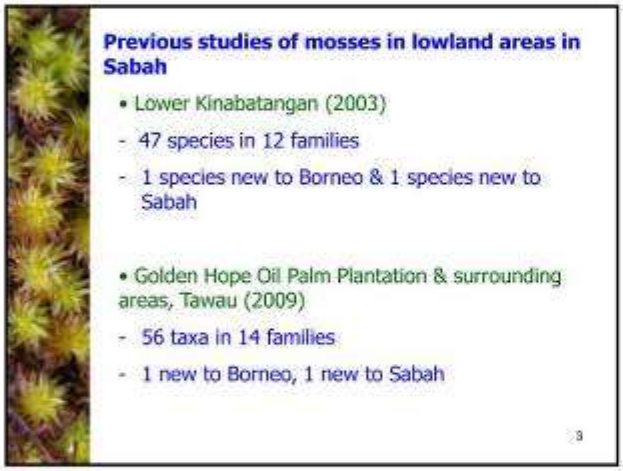
Symphyodontaceae

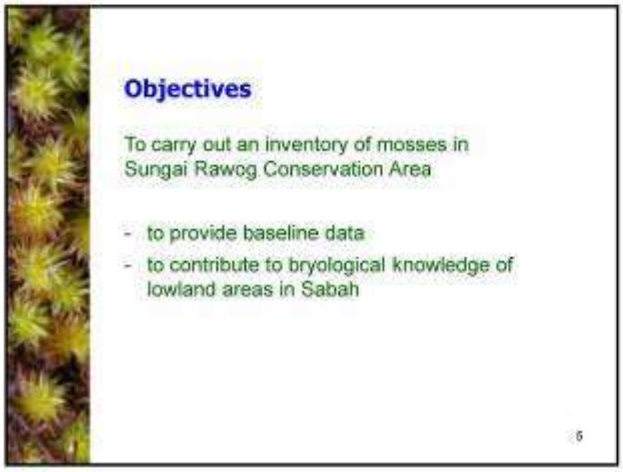
Chaetomitrium orthorrhynchum (Dozy & Molk.) Bosch & Sande Lac.
On shrub trunks, by stream, 100 m, MS 6432.

Thuidiaceae

Pelekium velatum Mitt.
On tree trunk by river, 100 m, MS 6419.

Slide Presentation





Collection details

Coll. No.	Date	Locality
6386-6408	9 Aug 2018	Trail 1, 3 & 3A
6409-6440	10 Aug 2018	Trail 7,8 &11
6441-6457	11 Aug 2018	Kerangas forest


Habitats

- opportunistic
- along trails & excursion
- all substrates

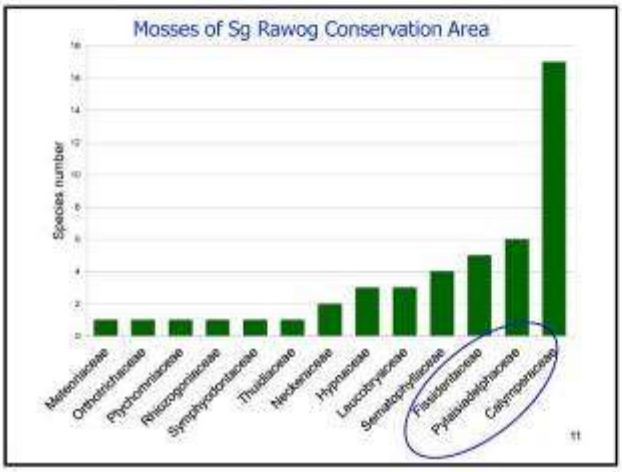
Results & discussion

9

1. Species richness

- 73 specimens of mosses (3 days)
- 46 species - 25 genera & 13 families

10



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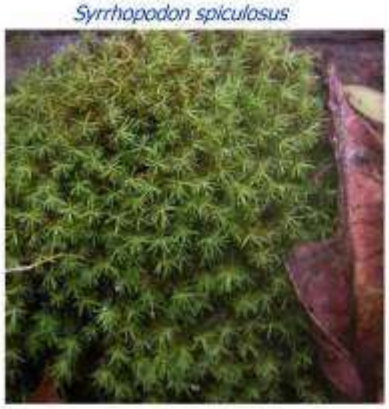
2. Common species

i. Calymperaceae - 17 species

Arthrocormus schimperi

Syrrhopodon spiculosus



13

Leucophanes octoblepharioides

14

Mitthyridium luteum

ii. Pylaisiadelphaceae - 6 species

Wijkia polymorpha

16

Taxithelium instratum

17

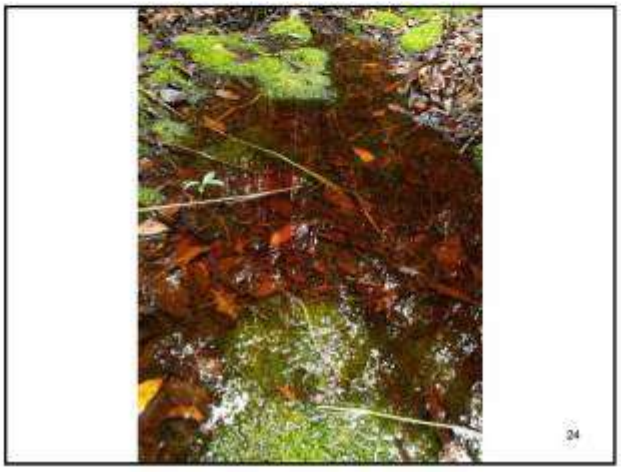
iii. Fissidentaceae - 5 species

Fissidens javanicus

18


Fissidens crispulus


3. New records
i. Leucobryum candidum


24

- previously reported from Sabah by Johnson (1964)
- but excluded by Yamaguchi in his treatment of the *Leucobryum* of Asia (1993)
- new to Asia?

25

ii. Wijkia polymorpha

Noteworthy species

i. Wijkia hornschuchii

- only collected once in Borneo based on its type specimen from Mount Kinabalu (1986)
- 2nd record in Borneo

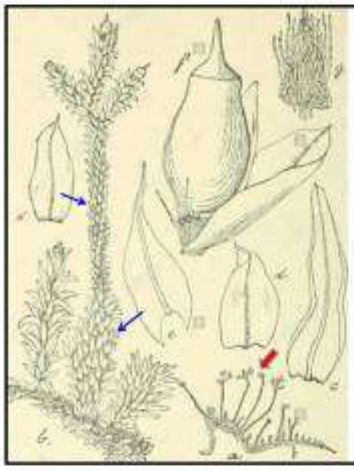
30

ii. *Fissidens laxitextus*

- Reported new to Borneo in 2015
- 3rd locality in Borneo
- on termite mounts

31

iii. *Desmotheca apiculata*



- Strongly dimorphic branch leaves
- with erect fertile branches (unique character of the genus)

33

Conclusion

34

- 46 species of mosses

- 7% of the 651 mosses reported for Sabah
- 5% of the 767 mosses reported for Borneo
- similar species richness to Kinabatangan WS

- 2 new records for Sabah
- lowland habitats - contribute to the richness of mosses in Sabah
- the study area is an important habitat for lowland species of mosses in Sabah

35

Acknowledgements

KTS

UMS
UNIVERSITI MALAYSIA SABAH

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PAPER 1.4

Species diversity of *Ficus* in the Sungai Rawog Conservation Area

M. Nakabayashi[1*] & P. Jumian[2]

[1]Faculty of Science, University of the Ryukyus, Sembaru 1, Nishihara, Okinawa, 903-0213, Japan
[2]Sabah Forestry Department, Forest Research Centre, P. O. Box 1407, 90715, Sandakan, Sabah, Malaysia
** Corresponding author. Email: miyabi.nakabayashi@gmail.com*

Abstract. Despite the ecological importance of *Ficus* in forest communities, relatively little attention has been given to the basic information of this genus, especially in Sabah over 50 years. In this report, we listed *Ficus* species found during three survey days in the Sungai Rawog Conservation Area in Sabah. In total, we found 24 *Ficus* species including two endemics. These species are classified into four growth forms; hemi-epiphyte (17 spp.), climber (3 spp.), tree (3 spp.), shrub (1 sp.). Hemi-epiphytes constitute over 70% of all the detected species. In the study area, *Ficus virens*, a hemi-epiphytic species was the commonest species. Although this data is based on only three survey days, *Ficus* community in the study area is not peculiar compared to other lowland forests in Sabah, e.g. Imbak Canyon Conservation Area except for the high density of *F. virens*. *Ficus* are important plants through the perspective of ecology, restoration, and conservation. Any basic information could contribute to understanding this genus and also the surrounding environment. More details on ecology of species or at least subgenus level and long-term studies are needed to make intra- and inter-community comparisons within Borneo and also among the tropical regions.

INTRODUCTION

"In all works on Natural History, we constantly find details of the marvellous adaptation of animals to their food, their habits, and the localities in which they are found."- Alfred Russel Wallace

A renowned naturalist and evolutionary biologist of the 19th century, Alfred Russel Wallace left this word. However, not only animals show adaptations, but plants also exhibit marvellous and brilliant adaptations. One good example is the genus *Ficus*. *Ficus* is one of the most species rich ca. 750 species (Berg & Corner 2005) and having most diverse life forms; hemi-epiphyte, epiphyte, climber, tree, shrub, creeper, in all the woody plants (Ashton 2014). *Ficus* is pan-tropically distributed, but Asian-Australasian region includes by far the largest species number ca. 360 compared to the other tropical region; ca. 120 in America, ca. 105 in Africa (Berg & Corner 2005). Amongst Asian-Australasian region, Borneo has the largest number of species ca. 150, and northern Borneo is regarded as a hot spot (Berg & Corner 2005). High species and life form diversity indicates that Ficus species have adapted to various environments, e.g. riparian area: *Ficus racemose*, *F. francisci*, lower canopy: *F. xylophylla* (Laman 1996a), upper canopy: *F. stupenda* (Laman 1996a), open-canopy area such as forest edge: *F. septica*, *F. callosa*.

In addition to the species diversity of *Ficus* itself, this genus also contributes to high diversity of animals in tropical rainforests. All *Ficus* species have coevolved with the obligate, and generally, species-specific pollinating fig wasps (Agaoninae) (Weiblen 2002, Machado *et al.* 2005). There are also non-pollinating fig wasps such as parasitoids and predators (Weiblen 2002). *Ficus*'s speciousness is generated and sustained by fig wasps, and *vice versa*. *Ficus* is also known as keystone food resources in tropical rainforests. The obligate pollination mutualism makes most *Ficus* species reproduce ripe fig fruits/syconia continuously to maintain population of pollinating fig wasps (Wiebes 1979). Therefore, there always exist individuals producing figs, providing food resources for many animals year-roundly. Over 1000 animal species in the world feed on figs, especially as fallback foods (Shanahan *et al.* 2001). Hemi-epiphytic species may also contribute to plant community. The main cause of mortality of this type is host tree-fall (Harrison 2006), generating forest gaps and may be promoting forest regeneration. Due to these ecological characteristics, recently *Ficus* receives attention as an important forest restoration agent (Kuaraksa & Elliott 2013, Cottee-Jones *et al.* 2016).

Despite the ecological importance of *Ficus* in forest communities, relatively little attention has been paid to the basic information of this genus especially in Sabah, an ecological hot spot of this genus, over 50 years (Corner 1964). To find "details of the marvellous adaptation" of plants, basic information such as species local distribution is inevitable. In this report, we listed all *Ficus* species found during the expedition conducted in the Sungai Rawog Conservation Area in Sabah, Malaysian Borneo.

MATERIALS AND METHODS

Study site

This study was conducted in the Sungai Rawog Conservation Area, part of protection areas in the Segaliud Lokan Forest Reserve between 9 and 11th August 2018. We surveyed three compartments; Sg. Rawog, C49, and C61 with the FRC herbarium team. On the first day, we surveyed on trail number 1 and 3, and also walked along the gravel road about 500 m, located in the border of compartment 49, 56 and 61. On the second day, we walked on trail number 7, 8, and 11 in compartment 56. On the last day, we surveyed on a trail in compartment 49 and riverside vegetation riding on a boat from the campsite.

Survey methods

We searched *Ficus* individuals along the three prepared trails and also along the river from a boat. When we detect each individual, we recorded species and habitat. The nomenclature of species, growth form, and taxonomic rank followed Berg and Corner (2005).

RESULTS AND DISCUSSION

In total, we found 24 *Ficus* species including two endemics during the three survey days (Table 1). These species are classified into four growth forms; hemi-epiphyte (17 spp.), climber (3 spp.), tree (3 spp.), shrub (1 sp.). Hemi-epiphytes constitute over 70% of all the detected species, corroborating the general pattern that they account for one third to over half the fig species in any particular locality (Harrison *et al.* 2003). In the study area, *Ficus virens*, a hemi-epiphytic species was the commonest species.

Hemi-epiphytic figs germinate and establish in the canopy of host trees (Holbrook & Putz 1996). Therefore, their effective seed disperses are confined to volant and arboreal animals. Seeds of large syconia are surrounded by thick and hard flesh (inflorescence), therefore only animals that swallow whole figs will disperse their seeds and small animals usually remain seeds untouched (Shanahan 2016, M Nakabayashi pers. obs.). From these perspectives, syconia size can be an indicator of animal diversity and also environmental quality of forests. In Sabah, *F. virens* is widely distributed and often found in remnant forest patches within urban and countryside landscapes. In other lowland mixed dipterocarp forests in Sabah (Imbak Canyon Conservation Area and Maliau Basin Conservation Area), *F. virens* is not common as the surveyed area of this study (Nakabayashi unpubl. data). Though successful seed dispersal of hemi-epiphytic figs in Bornean rainforests is quite low (Laman 1995, 1996b), it will increase with an increase in opportunities of seed dispersal. The syconia of this species is relatively small ca. 0.5-0.8 cm (M Nakabayashi unpub. data), and therefore almost all animals including small birds can disperse its seeds. The other possibility for high density of *F. virens* in the study area is growth condition of this species. Successful seed germination of *F. virens* are strongly inhibited by water stress (Ji *et al* 2018) as hemi-epiphytic figs generally require consistently moist conditions with low light level for germination in the canopy (Laman 1995, Swagel *et al.* 1997). Once they establish, high light becomes advantage for their growth (Hao et al. 2013). Given that establishment canopy height differs among species (Laman 1996b), suitable condition for germination and establishment may also differ subtly. The microenvironments in the study area might match requirements of *F. virens* although we need to prove geological peculiarity in the area. The exact reason of high density of *F. virens* in the study area remains unclear, but the fig size is one of the factors facilitating its wide distribution and high density in the study area.

CONCLUSION

Ficus community in the study area is not peculiar compared to other Bornean forests (Table 2, Nakabayashi unpubl. data) except for the high density of *F. virens*. One of the important characteristics of the *Ficus* community of Borneo is the high speciosity in climber and hemi-epiphytes (Berg & Corner 2005). These forms need host trees for the sustention of their body. They colonise relatively large hosts in a given environment (Nakabayashi unpubl. data), and 40% of host trees of hemi-epiphytes was Dipterocarps in a lowland forest in Sarawak (Harrison *et al.* 2003). High opportunities of seed dispersal by animals and exitance of suitable hosts in their habitats might help diversify host-dependant *Ficus* on Borneo. The striking features of Bornean forests such as tall and developed canopy strata (Ashton & Hall 1992) may also enable these forms diversify and coexist as some closely related hemi-epiphytic species occupy different heights of establishment (Laman 1996b).

Ficus is important plants through the perspective of ecology, restoration, and conservation. Any basic information could contribute to understanding this genus and also the surrounding environment. More details on ecology of species or at least subgenus level and long-term studies are needed to make intra- and inter-community comparisons within Borneo and also among the tropical regions.

ACKNOWLEDGEMENT

We thank Sabah Forestry Department and KTS Plantation Sdn Bhd for granting us permission to conduct this research and for inviting us to participate in the expedition. We are very grateful to staffs of Sabah Forestry Department for preparing the transportation, study place, foods, and accommodation space during the expedition. We also thank all participants in the expedition for the friendship and the interesting information on various taxa surveyed in this area.

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Table 1. List of *Ficus* species detected during the survey.

subgenus section subsection	*Ficus* species*	life form[1]	number of individuals	trail number
Sycidium				
Palaeomorphe	*tinctoria* var *gibbosa*	H	1	8
Sycomorus				
Sycocarpus				
Sycocarpus	*malayana*	S	3	11
	*treubii**	T	1	3
Sycomorus				
Sycomorus	*racemosa*	T	3	riverside
Neomorphe	*variegata*	T	1	riverside
Synoecia				
Kissosycea	*barba-jovis**	C	4	riverside
	punctata	C	1	roadside
	sagitatta	C	3	11
Urostigma				
Urostigma				
Conosycea	*annulata*	H	3	riverside
	consociata	H	1	3
	crassiramea	H	2	12
	delosyce	H	1	12
	dubia	H	1	3
	forstenii	H	2	roadside,12
	globosa	H	1	riverside
	kerkhovenii	H	1	riverside
	kochummeniana	H	1	11
	microcarpa	H	1	riverside
	pellucidopunctata	H	1	riverside
	stricta	H	1	riverside
	stupenda	H	1	riverside
	subgelderii	H	1	12
	sundaica	H	1	11
Urostigma	*virens*	H	6	roadside,3,7,8

* Borneo endemic
[1] H: hemi-epiphyte, S: shrub, T: tree, C: climber

Table 2. *Ficus* species richness in six sites in Borneo. GP, Gunung Palung National Park; KP, Kutai National Park; MK, Mount Kinabalu National Park; LH, Lambir Hills National Park. Data from Laman & Weiblen (1998), Nakabayashi M. (unpubl. data).

subgenus and section (N species on Borneo)	GP	KP	MK	LH	Batu Timbang	Sg. Rawog
survey effort	1996 & 1997	-	3.5 months	120 ha	6 days 20.7 ha	3 days
Urostigma						
Urostigma (5)	1	2	2	1	2	1
Conosycea (36)	27	23	16	19	16	15
Malvanthera (1)	0	0	0	0	0	0
Pharmacosycea						
Oreosycea (5)	0	1	0	0	0	0
Sycomorus						
Sycomorus (3)	0	1	0	0	1	1
Ficus	28	25	60	34	8	7
Total	56	52	78	54	27	24

Slide Presentation

Species diversity of *Ficus* at the Sungai Rawog Conservation Area

Miyabi Nakabayashi
Japan Society for the Promotion of Science
post-doctoral research fellow
univ. of the Ryukyus, Japan

FRC herbarium team

Why figs?

- genus Ficus (Moraceae)
- pantropical ada di seluruh tropika
- species rich pelbagai species
  c. 735 species
  120 **America (Neotropic)**
  106 **Africa (Afrotropic)**
  510 **Asia-Australasia**
  367 in Malesia (Berg & Corner 2005)

Keystone species
fallback food

obligate mutualism
fig-fig pollinating wasps

Hidup bersama
Fig wasp = membawa debunga ara
Fig = tempat bertelur & membiak

©Nicolle R. Fuller / Science Photo Library

all-year round
bear figs = food resource

sentiasa ada fig di dalam hutan

growth forms and reproductive system
Bentuk Pertembuhan dan Sistem Pembiakan

perhaps the most diverse in form of all the woody plants (Gibbon 2014)

Hemi-epiphyte (strangler)	Climber	Tree	Shrub
e.g. *Ficus microcarpa*	e.g. *Ficus punctata*	e.g. *Ficus racemosa*	e.g. *Ficus septica*
monoecious	dioecious	dioecious racemosa=monoecious	dioecious

What is special about Borneo?

the largest number ca. 150
centre of host-dependant fig species

growth form	hemi-epiphyte	tree	shrub	climber	hemi-epiphyte climber	tree	
subgenus	Urostigma	Pharmacosycea	Ficus	Synoecia	Sycidium	Sycomorus	Total
Borneo	38	4	20	25	26	25	138
Peninsula	43	4	13	15	10	14	99
Sumatra	32	5	13	14	16	14	94
Java	28	5	7	11	15	8	74
Philippines	25	5	8	13	20	16	87
Sulawesi	16	7	9	6	22	16	76
New Guinea	18	14	2	24	29	51	139

We need more basic study
taxonomy, ecology

9 - 11 August 2018 (3 days)
ad-libitum sampling
following the FRC botany team
sg. Rawog, C49, C56, and C61

Please refer to FRC herbarium
teams' presentation

sg. Rawog

during 3 survey days
24 sp.
2 Borneo endemics
(*F. treubii*, *F. barba-jovis*)

	sg. Rawog 3 days	Imbak 6 days
hemi-epiphyte	17	18
climber	3	5
tree	3	2
shrub	1	1

Comparison of fig species richness on Borneo

subgenus and section (N species on Borneo)	Gunung Palung	Kutai	Mount Kinabalu	Lambir Hills	Batu Tinbang	Sg. Rawog
survey effort	1996 & 1997	-	3.5 months	120 ha	6 days 20.7 ha	3 days
Urostigma						
Urostigma (5)	1	2	2	1	2	1
Conosycea (36)	27	23	16	19	16	15
Pharmacosycea (5)	0	1	0	0	0	0
Sycomorus (3)	0	1	0	0	1	1
Ficus (23)	28?	25?	60?	34?	8	7
Total	56	52	78	54	27	24

Data from Laman and Weiblen (1998), Nakabayashi et al. in subm.

Ficus virens

most frequently encountered fig species
6 individuals

Thank you very much for listening

I sincerely thank

Sabah Forestry Department
KTS plantation Sdn Bhd
member of FRC herbarium
All participants

Gila kah orang yang minat tembuhan macam *Eugenia*
Apa lagi yang minat *Ficus*

"Are all botanists crazy?
I began to think that anyone who would bother with
such a genus as Eugenia must be a bit off;
to say nothing of those who like to play with Ficus."
(from a letter of Merrill to Lam, 23 August 1949) Berg & Corner 2005)

Strangler figs

rumah hantu

"Kijimunah" in Okinawa, Japan

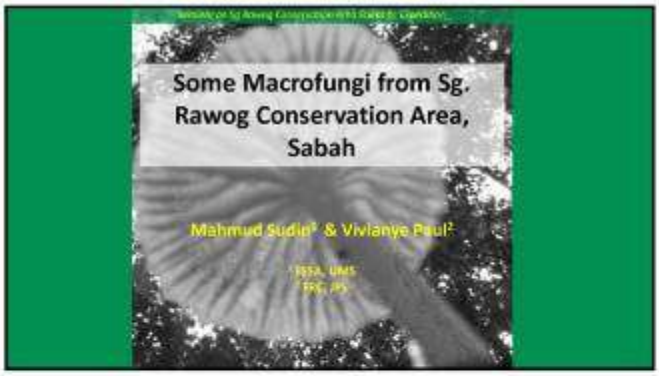
"Kemmun" in Amami, Japan

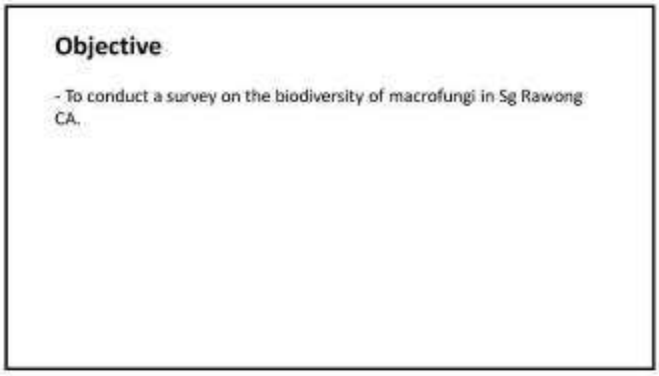
Hemi-epiphytic/strangler figs

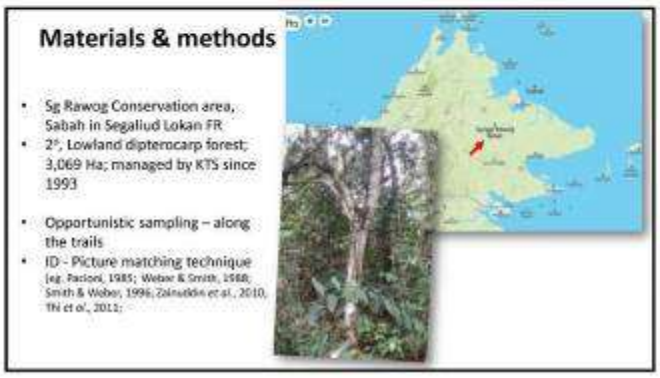
40-60/150-220 species on Borneo
30-50% of fig species (Harrison et al. 2003)

PAPER 1.5 (Slide Presentation)

Fungi by Assoc. Prof. Dr. M. Sudin & V. Paul

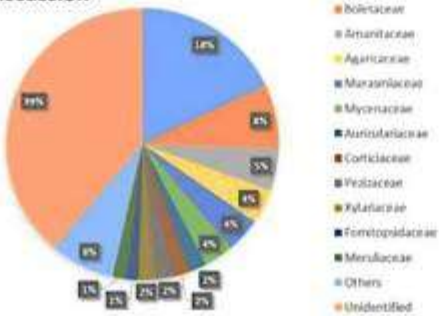






Results & Discussion

- 36 Genera
- 21 Family



Conclusion

- Some important data on biodiversity of forest microflora was documented.

Acknowledgement

- Jabatan Perhutanan Sabah
- UMS
- Expedition grant by the KTS
- Azwal Aziz,Roxidie, Kee Tse Lue, Staff of FRC.


6(3) : Calocybe sp.


6(4) : Marasmius sp.


6(5) : Marasmius sp.


6(6) : Boletus sp.


6(7) : Crepidotus sp.


6(8) : Sarcoscypha sp.


6(9) : Polyporus sp.


6(10) : Marasmius sp.


6(11) : Schizophyllum sp


6(12) : Pleurotus sp.
6(13) : ? sp.


6(14) : Mycena sp


6(15) : Marasmius sp.


6(16) Boletus sp


Amanita sp.


6(17) : Lepiota sp.


Rhodotus manipularis


Gymnopilus sp.


6(18) : Macrolepiota sp.


6(19) : Mycena sp.


6(20) : Amanita sp.


6(21) : Dacrymyces sp.


6(22) : Clavania sp.


6(23) : Fomitopsis sp.


6(24) : Termitomyces sp.


6 (25) Marasmius sp.


Credopitus sp.
Cantharellula sp.
Acknowledgment: Andi Mariani (Trail 1)

PAPER 1.6

Medicinal Plants of Sg. Rawog Conservation Area, Segaliud Lokan Forest Reserve, Sandakan, Sabah

A.R. Mojiol[1*], J.D. Salegin[2], W. Lintangah[1], S.V. John[3] & M. Patrick[3]

[1]Faculty of Science and Natural Resources, Universiti Malaysia Sabah, 88400, Kota Kinabalu
[2]Forest Research Centre, Sabah Forestry Department, 90175 Sandakan, Sabah
[3]KTS Plantation Sdn Bhd, Lot 32, Bandar Pasaraya Commercial Complex, Mile 4, North Road, W.D.T. 20, 90009 Sandakan, Sabah
**Author for correspondence. Email: andy@ums.edu.my*

Abstract. The aim of the study was to determine plants that have medicinal value found in Sg. Rawog Conservation Area, Segaliud Lokan Forest Reserve in Sandakan, Sabah. The survey and data collection were conducted in selected expedition trails, namely Trail 1, 2, 3, 3A, 4 and 5. A total of 27 species of medicinal plants were recorded and categorized under six different categories. The most prominent species include Laran (*Neolamarckia cadamba*), Kangkawit (*Uncaria lanosa*), Keladi hutan (*Alocasia sarawakensis*), Ampalas (*Tetracera scandens*), Pulai (*Alstonia angustiloba*), Tongkat Ali (*Eurycoma longifolia*), Kacip Fatimah (*Labisia pumila*) and Wadan (*Dinochloa trichogana*). It was found that the categories of medicinal plants are mainly from climbers (26%), followed by woody plants (22%), herbs (19%), shrubs (15%), and ferns (11%). Other categories belong to grasses, palms & bamboos (8%).

Keywords: Medicinal plants, categories, Sg. Rawog Conservation Area, Segaliud Lokan Forest Reserve

INTRODUCTION

Malaysia is one of the 12 Mega Biodiversity countries in the world. According to World Health Organization (2018), "People depend on biodiversity in their daily lives, and human health ultimately depends upon ecosystem products and services (such as availability of fresh water, food and medicinal product) which are requisite for good human health and productive livelihoods." Around 20,000 species of medicinal plants are used in herbal medicine today, and nearly 80% of people in the developing world or 60% of the human race relies on traditional medicine based largely on the use of plants (Ong, 2006). However, habitats are being destroyed almost every day, and many medicinally valuable plants will be gone before scientists can investigate them.

Certain plants like herbs and shrubs are used as a natural medicine to cure sickness. Over 40% of medicines now prescribed in the United States contain chemicals derived from plants (Wee, 1992). This practice has existed since prehistoric times. There are two ways in which plants have been found useful in medicine. First, they may be directly consumable or in other extracted forms. Second, they may be used as agents in the synthesis of drugs.

Knowledge about the use of medicinal plants exists in the form of local folklore (Fasihuddin & Hasmah, 1991). Certain knowledge about medicinal plants and how to use them is handed down from generation to generation.

In this study, survey and data collection were conducted during the scientific expedition in Sg. Rawog Conservation Area, Segaliud Lokan Forest Reserve on August 8-18, 2018. The objective of this research was to determine and record the types of herbs and plants that have medicinal value in the Sg. Rawog, Segaliud Lokan Forest Reserve.

METHOD

Plant collection was conducted from 8th to 18th August, 2018. Specimens were collected randomly from 500 m to 1 km long trail that was established at Sg. Rawog Conservation Area. The location of trails located at compartment 61 is listed in Table 1 below. The collected samples were pressed for herbarium specimens and deposited at SAN Herbarium, FRC Sandakan. The study involved an extensive information search of existing medicinal plant records in supporting the reliability of indigenous traditional knowledge.

Table 1. Location of study trails (Compartment 61), Sg. Rawog Conservation Area.

No.	Study trails	Coordinates		Distance (m)
1	1	N5º26’57.1”	E117º31’24.1”	500
2	2	N5º26’46.2”	E117º31’33.4”	630
3	3	N5º26’47.7”	E117º31’27.8”	1000
4	3A	N5º26’36.2”	E117º31’12.5”	290
5	4	N5º26’34.8”	E117º31’35.8”	350
6	5	N5º26’33.9”	E117º31’35.7”	565

RESULTS & DISCUSSION

There were 27 types of medicinal plant species found in the study areas as shown in Table 2. The most prominent species are Laran (*Neolamarckia cadamba*), Kangkawit (*Uncaria lanosa*), Keladi hutan (*Alocasia sarawakensis*), Ampalas (*Tetracera scandens*), Pulai (*Alstonia angustiloba*), Tongkat Ali (*Eurycoma longifolia*), Kacip Fatimah (*Labisia pumila*) and Wadan (*Dinochloa trichogana*).

Table 2. List of medicinal plants found in Sg. Rawog Conservation Area, Sabah.

No.	Local Name	Botanical Name	Family	Uses
1.	Senduduk Hitam	*Clidemia hirta*	Melastomataceae	Stop bleeding wound, cut, natural soap.
2.	Senduduk	*Melastoma malabathricum*	Melastomataceae	Stop bleeding wound, cut; diarrhoea, haemorrhoid.

3.	Wadan	*Dinochloa trichogana*	Poaceae	Dissipate the opacity of the cornea; asthma.
4.	Lamba	*Curculigo latifolia*	Hypoxidaceae	Ripe fruit can be eaten to improve appetite.
5.	Keladi Hutan	*Alocasia sarawakensis*	Araceae	Treating snake bite, insect sting.
6.	Ampalas	*Tetracera scandens*	Dilleniaceae	Treatment of dysentery, diarrhoea; other use as sandpaper.
7.	Rubus	*Rubus moluccanus*	Rosaceae	Astringent; emmenagogue and to treat abdominal pain; bath.
8.	Pulai, Tembirog	*Alstonia angustiloba*	Apocynaceae	Anti-malaria, fever; drink.
9.	Lembiding	*Stenochlaena palustris*	Blechnaceae	Improve blood circulation; food.
10.	Periuk Kera	*Nepenthes mirabilis*	Nepenthaceae	Skin itchiness; rub.
11.	Kakawit	*Uncaria lanosa*	Rubiaceae	Treating cough, and water from vines can drink.
12.	Hungkung	*Smilax borneensis*	Smilacaceae	To prevent and treat Cancer; drink.
13.	Halia Liar	*Costus speciosus*	Costaceae	To treat fever, rash, asthma, bronchitis, treat kidney and other urinary problems.
14.	Makaranga	*Macaranga hypoleuca*	Euphorbiaceae	Bleeding gums, mouth ulcer; gargle.
15.	Tongkat Ali	*Eurycoma longifolia*	Simaroubaceae	Anti-malaria, aphrodisiac and improve blood circulation; drink.
16.	Kacip Fatimah	*Labisia pumila*	Primulaceae	Maintain a healthy female reproductive system, postpartum; drink.
17.	Kari Liar	*Clausena excavata*	Rutaceae	Astringent, bitter, emmenagogue and tonic, treating stomach aches.
18.	Lalang	*Imperata cylindrica*	Poaceae	Treating small pox and cough for

				children; bath.
19.	Mali-Mali	*Leea indica*	Vitaceae	Cool fever, young shoots are chewed to relieve severe cough.
20	Akar pepanjat	*Bauhinia* sp.	Leguminoseae	Improve blood circulation, treat kidney problems and other urinary problems.
21.	Laran	*Neolamarckia cadamba*	Rubiaceae	Bark is boiled and drunk to prevent and treat cancer.
22.	Ampalas / Pampad	*Tetracera korthalsii*	Dilleniaceae	Treatment of dysentery, diarrhoea, paralysis and dead veins.
23.	Gandarusa	*Justicia gendarussa*	Acanthaceae	Treating cold in infants and children.
24.	Tepus	*Etlingera brevilabrum*	Zingerberaceae	Treating swelling due to sprain.
25.	Gogor	*Palhinhaea cernua*	Lycopodiaceae	Treating back pain and high blood pressure.
26.	Netum	*Gnetum cuspidatum*	Gnetaceae	Seeds in the fruit are eaten for treating bone pain.
27.	Kantan	*Etlingera eliator*	Zingirberaceae	Appetizer; food.

Sources / info on the uses;

Traditional knowledge
de Guzman-Ladion (1999)
Kulip et al. (2005)
Kodoh et al. (2017)
Mashitah M. Y. (2002)
Mojiol et al. (2010)
Useful Tropical Plants (2014)
http://tropical.theferns.info/viewtropical.php?id

These results show that medicinal plants found in Sg. Rawog Conservation Area are numerous and very diverse in the type of uses. There are 22 families of medicinal plants found at Sg. Rawog. The families with more than one species found were Melostamaceae, Poaceae, Rubiaceae, Dilleniaceae and Zingerberaceae. According to Mohd. Joffry *et al*., (2012), *Melastoma malabathricum* (Melastomataceae) is a species found in the Southeast Asian region, including Malaysia considered as native to tropical and temperate Asia and the Pacific Islands. This commonly found small shrub has gained herbal status in the Malay folklore belief as well as the Indian, Chinese, and Indonesian folk medicines.

Ethno-pharmacologically, the leaves, shoots, bark, seeds, and roots of *M. malabathricum* have been used to treat diarrhoea, dysentery, hemorrhoids, cuts and wounds, toothache, and stomachache. Scientific findings also revealed the wide pharmacological actions of various parts of *M. malabthricum*, such as antinociceptive, anti-inflammatory, wound healing, antidiarrheal, cytotoxic, and antioxidant activities. While the Zingerberaceae family especially *Etlingera eliator* (Kantan) has been widely used in traditional Kadazan-dusun food. It is believed that Kantan is commonly used as an appetizer in food (Lintangah, pers. com., 2019).

From the analysis of medicinal plants categories, it can be divided into six main categories. They are from Climbers (26%) followed by Woody trees (22%), Herbs (19%), Shrubs (15%), and Ferns (11%). Lastly, the remaining category belonged to Grasses, Palms & Bamboos (7%) (see Figure 1). According to Patel (2014), he stated that most medicinal plants differ in their presence according to sites which caused by climatic and soil conditions. A climber plant includes tendrils and creepers having adventitious roots on nodular part of the stem helpful for their climbing and creeping on any substratum. While woody trees usually require most of its energy from the sunlight.

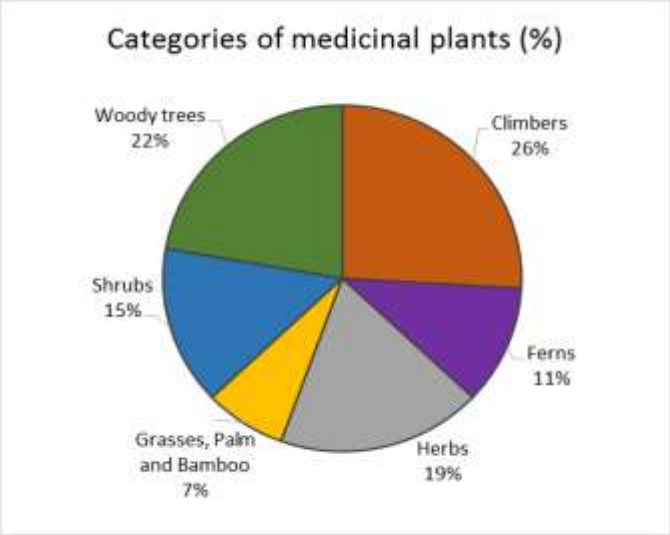


Figure 1. Categories of the medicinal plants in Sg. Rawog Conservation Area.

According to Kulip (2007), traditional medicine is practised in almost all cultures. Most of the knowledge of traditional medicinal plants have been learnt or passed down orally through older people. Thus, there is a need to carry out further study on the biological and chemical contents of the medicinal plants. As a recommendation, further study of medicinal plants in this Segaliud Lokan Forest Reserve is necessary in the future.

CONCLUSION & RECOMMENDATIONS

The survey during the expedition produced an important listing of species of the medicinal plants found in the area. There were 27 species of plants documented in this survey under 22 families of medicinal plants. The families with more than one species are Melastomaceae, Poaceae, Rubiaceae, Dilleniaceae and Zingerberaceae. The medicinal plants can be categorized into six groups. The highest number of species in this study belongs to the categories of Climbers (26%) followed by Woody trees (22%), Herbs (19%), Shrubs (15%), and Ferns (11%). The other species are under the category of Grasses and Palm & Bamboo (7%). Medicinal plants found in Sg. Rawog Conservation Area are numerous with a diverse form of uses. The biological and chemical content of the plants should be further studied for potential commercialization and enhanced products. This will also ensure the preservation of traditional knowledge and the optimum benefit to the people of Sabah.

ACKNOWLEDGEMENTS

The authors would like to express their great appreciation to the Sabah Forestry Department, Forest Research Centre Sepilok, KTS Plantation Sdn. Bhd for permission and generous support in conducting this study. Many thanks also go to Mr. Paul Liau, Mr. Colin Goh from KTS Plantation and Botany Section, FRC for their help in plant identification.

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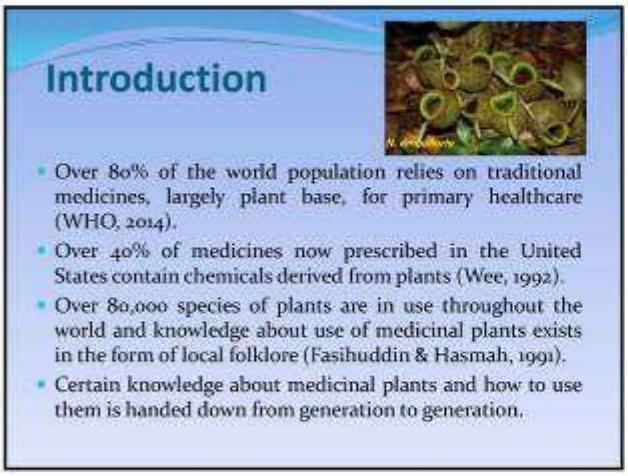
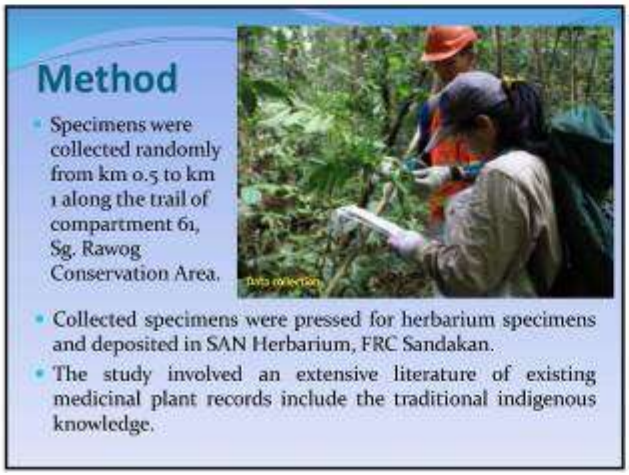
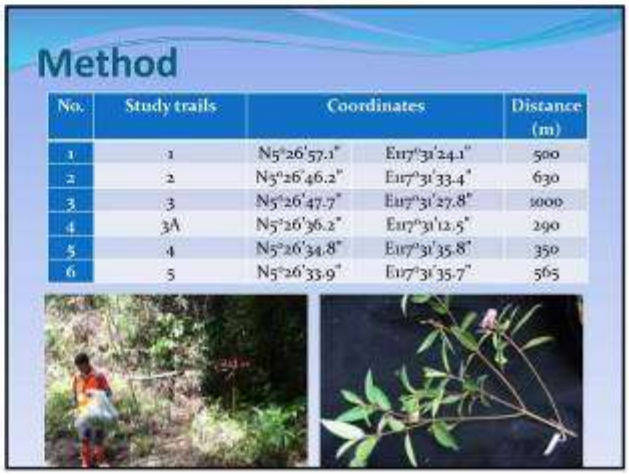






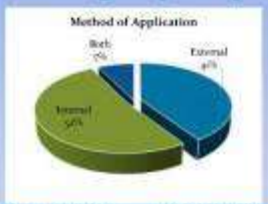
Result and Discussion

- 27 species of medicinal plant from 22 family were found in the study.
- Melostamaceae, Poaceae, Rubiaceae, Dilleniaceae and Zingiberacea are family with more than one species found.
- The most prominent species are Laran (*Neolamarckia cadamba*), Kangkawit (*Uncaria lanosa*), Keladi hutan (*Alocasia sarawakensis*), Ampalas (*Tetracera scandens*), Pulai (*Alstonia angustiloba*), Tongkat Ali (*Eurycoma longifolia*), Kacip Fatimah (*Labisia pumila*) and Wadan (*Dinochloa trichogana*).

Result and Discussion

No.	Local Name	Botanical Name	Family
1.	Senduduk Hitam	*Clidemia hirta*	Melastomataceae
2.	Senduduk	*Melastoma malabathricum*	Melastomataceae
3.	Midan	*Dinochloa trichogana*	Poaceae
4.	Lambu	*Coccoloba latifolia*	Hypoxidaceae
5.	Keladi Hutan	*Alocasia sarawakensis*	Araceae
6.	Ampalas	*Tetracera scandens*	Dilleniaceae
7.	Rubus	*Rubus moluccanus*	Rosaceae
8.	Pulai, Tembeng	*Alstonia angustiloba*	Apocynaceae
9.	Lembiding	*Centochloa palmata*	Bischoraceae
10.	Perlok Kera	*Nyctanthes arcuata*	Nyctanthaceae
11.	Kalawit	*Uncaria lanosa*	Rubiaceae
12.	Hangkang	*Strobilanthes*	Strobilanthaceae
13.	Halia Liar	*Costus speciosus*	Costaceae
14.	Makaranga	*Macaranga hypoleuca*	Euphorbiaceae
15.	Tongkat Ali	*Eurycoma longifolia*	Simaroubaceae
16.	Kacip Fatimah	*Labisia pumila*	Primulaceae
17.	Kuli Lisi	*Clinostemon excavata*	Rutaceae
18.	Lalang	*Imperata cylindrica*	Poaceae
19.	Mali Mali	*Leea indica*	Vitaceae
20.	Akar pepanjat	*Bauhinia* sp.	Leguminosae
21.	Laran	*Neolamarckia cadamba*	Rubiaceae
22.	Ampalas/Pampod	*Tetracera hordwickii*	Dilleniaceae
23.	Gendarusa	*Justicia gendarussa*	Acanthaceae
24.	Tepus	*Etlingera foveolata*	Zingiberaceae
25.	Gegar	*Palhinhanea cernua*	Lycopodiaceae
26.	Notum	*Gnetum cuspidatum*	Gnetaceae
27.	Kantan	*Etlingera elatior*	Zingiberaceae

Category of plant uses



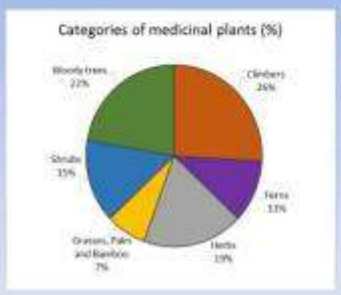
- Method of application
  - External use
  - Internal use
  - Both
- Example;

No.	Local Name	Botanical Name	Family	Uses
1.	Senduduk Hitam	*Clidemia hirta*	Melastomataceae	Stop bleeding wound, cut, natural soap
2.	Senduduk	*Melastoma malabathricum*	Melastomataceae	Stop bleeding wound, cut, diarrhoea, hemorrhoid
3.	Midan	*Dinochloa trichogana*	Poaceae	Used to eliminate the opacity of the cornea; Asthma
4.	Lambu	*Coccoloba latifolia*	Hypoxidaceae	Ripe fruit can be eaten to improve appetite
5.	Keladi Hutan	*Alocasia sarawakensis*	Araceae	Treating Snake bite; insect sting
6.	Ampalas	*Tetracera scandens*	Dilleniaceae	Treatment of dysentery, diarrhoea; other use as sandpaper

Category of Ailments

- 9 categories of ailments based on uses.
- Skin diseases (22%)
- Bowel cleanser (22%)

Analysis of plants categories



- Divided into six (6) main categories.
  - Climbers (26%)
  - Woody trees (22%),
  - Herbs (19%)
  - Shrubs (15%)
  - Ferns (11%)
  - Grasses, Palm & Bamboo (7%).
- Most medicinal plants differ in their presence according to sites which caused by climatic and soils conditions (Patel, 2014).

Macaranga hypoleuca (Euphorbiaceae)

Medicinal uses

- Bleeding gums.
- Mouth ulcer;
- Plants skin boiled and gargle when warm.

Sources:

Alocasia sarawakensis
(Araceae)

Medicinal uses

- Treating from snake bite – latex from plant use to rub the bitten area.
- Insect sting.

Alstonia angustiloba
(Apocynaceae)

Medicinal uses

- Traditional knowledge to treat fever and Malaria.
- Part uses; plant skin boiled and drink in a cup for 3 times a day.

Curculigo latifolia
(Hypoxidaceae)

Medicinal uses

- Ripe fruit can be eaten to improve appetite; as alternative sweetener.
- root is used as alternative treatment for diuretic and urinary problems.

Nepenthes mirabilis
(Nepenthaceae)

Medicinal uses

- To treat Skin itchiness

Stenochlaena palustris
(Blechnaceae)

Medicinal uses

- Root – Improve blood circulation.
- High blood pressure
- Healthy food

Melastoma malabathricum
(Melastomataceae)

Medicinal uses

- To treat diarrhoea, dysentery, haemorrhoids, and toothache, and stomachache.
- Stop bleeding wound, cut.
- Flower – Skin care (mask).
- Root – Improve blood circulation.

Smilax borneensis (Smilacaceae)

Medicinal uses

- To prevent and treat Cancer

Sources:

Labisia pumila (Primulaceae)

Medicinal uses

- Maintain healthy female reproductive system.
- Postpartum drink.
- Improve blood circulation and muscle.
- "cleansing blood" for female

Sources:

Eurycoma longifolia (Simaroubaceae)

Medicinal uses

- Anti-malaria
- Aphrodisiac (Sexual).
- Improve blood circulation.
- High blood pressure.
- "tenaga batin" for male

Sources:

Tetracera scandens (Dilleniaceae)

Medicinal uses

- Treatment of dysentery, diarrhoea.
- Treating paralysis and dead veins.
- other use as sandpaper.

Imperata cylindrical (Poaceae)

Medicinal uses

- Treating fever, measles and cough for children.
- The roots are boiled and drunk once for the baby and made a bath.

Dinochloa trichogana (Poaceae)

Medicinal uses

- To treat asthma
- Used to dissipate the opacity of the cornea
- Food - Vegetables

Palhinhaea cernua (Lycopodiaceae)

Medicinal uses

- Back pain and high blood pressure.
- Whole parts are boiled and drunk twice daily (glass).

Sources:

Rubus moluccanus (Rosaceae)

Medicinal uses

- Root - boiled and taken twice a day for postpartum women.
- Increase blood circulation.
- Mixed with other herbs and used for postpartum women's baths.

Sources:

Etlingera brevilabrum (Zingirberaceae)

Medicinal uses

- Traditional knowledge, plant was use to treat for "Lontong"

Conclusion

- There were 27 species of plants documented in this survey under 22 families of medicinal plants.
- The families with more than one species are Melostamaceae, Poaceae, Rubiaceae, Dilleniaceae and Zingiberacea.
- The medicinal plants can be categorized into six groups. Climbers (26%), Woody trees (22%), Herbs (19%), Shrubs (15%), and Ferns (11%). The others species are under the category of Grasses and Palm & Bamboo (7%).
- Medicinal plants found in Sg. Rawog Conservation Area is numerous with a diverse form of uses.
- The biological and chemical content of the plants should be further studied for potential commercialization and enhanced products. This will also ensure the preservation of traditional knowledge and the optimum benefit to the people of Sabah.

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Acknowledgement

- Many thanks to the management of Sabah Forestry Department, KTSP, and Universiti Malaysia Sabah in making this expedition a successful one.

GOOD TIMES COME AND GO, BUT THE MEMORIES WILL LAST FOREVER.

PAPER 1.7

Dipterocarps in Sungai Rawog Conservation Area, Segaliud Lokan Forest Reserve, Sandakan

S.T.L. Tsen[2], R.J. Majapun[1], Y.L. Lee[2], J. Runcin[1], A.J.S. Abdullah[3], J. Jumian[1], J.B. Sugau[1], C.R. Maycock[2] & E. Khoo[1]

[1]*Forest Research Centre, Sabah Forestry Department, Sandakan, Sabah.*
[2]*FSSA, Universiti Malaysia Sabah, Kota Kinabalu*
[3]*KTS Plantation Sdn. Bhd.*

Abstract. Based on past herbarium records from the 1960's until 1990's, a total of 26 dipterocarp species were recorded for the Segaliud Lokan area. However, in the recent Species Distribution Modeling (SDMs) performed, it was suspected that given much of the area is of Lowland Mixed Dipterocarp Forest, there is a possibility that species diversity for this family could be higher than previously recorded. Therefore, surveys were conducted to collect species occurrence data for the area. The surveys were carried out over various topography and soil associations, the team recorded a total of 40 dipterocarp species from 6 genera. Aside from coming across species that was previously recorded, another additional 26 species are found to occur in the area as well. Of the species listed, there were two Sabah endemics (*Shorea symingtonii* and *Shorea waltoni*) and 19 Bornean endemics. As of current, 50% of the species recorded in this survey are currently listed under the Threatened category in the Global IUCN Red List. It is hope that the results obtained will contribute towards the setting up of management measures for the area, while the updated occurrence data will be used in the ongoing State level IUCN Red List Assessment for Dipterocarps.

Keywords: Dipterocarps, conservation, IUCN Red List, endemism

INTRODUCTION

The Dipterocarpaceae family is one of the well studied plant groups in Borneo due to its ecological significance and commercial importance in the timber industry (Sugau *et al.*, 2016; Kettle, 2010; and Ashton, 2004). Much effort has been made by the department in updating species distribution across the various forest reserves within the State since 2009, in which Segaliud Lokan Forest Reserve was listed as one of the priority areas to be surveyed. The interest is because based on past herbarium records from the 1960's until 1990's, a total of 26 Dipterocarp species were recorded for the Segaliud Lokan area, however a recent ensemble of Dipterocarp Species Distribution Model (SDMs) (Lee *et al.*, 2018) has suggested that species diversity for the area should be much higher than what has been recorded. Therefore, the survey was carried out to document the occurrence data of the Dipterocarp species within the area and subsequently to utilize the occurrence data for IUCN Red List conservation status assessment of Dipterocarps at the State level. The surveyed area was in Sungai Rawog Valley that encompasses an area of 3,118 ha (Figure 1). Forest types within

the area are categorized as Lowland Mixed Dipterocarp and Heath Forest. Locality of the base camp was beside Sg. Rawog in compartment 56 (N5.46194, E117.56657).

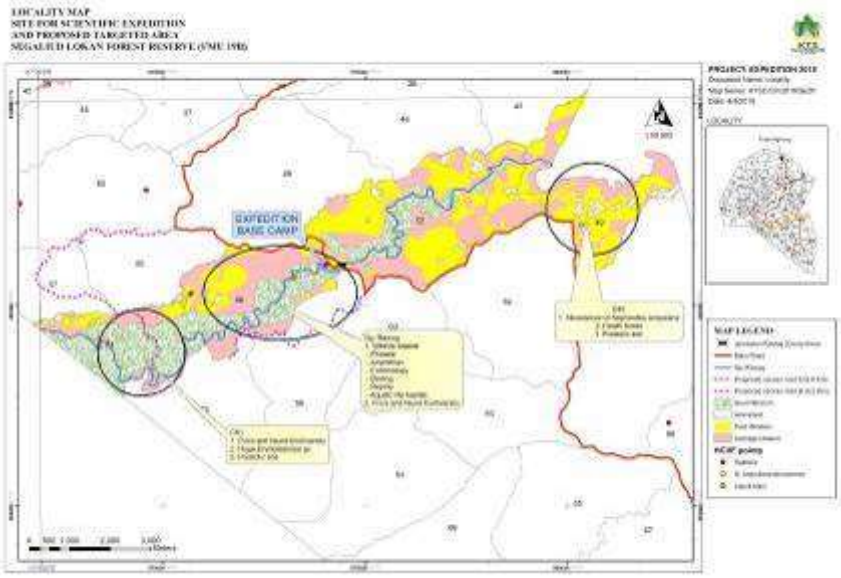

Figure 1. Scientific expedition area.

MATERIALS AND METHODS

During the survey, 20 m width transects were set up whereby species occurrence were recorded and GPS with Garmin GPSmap 62st. Species were generally identified on site, with voucher specimens collected for further verification at the Forest Research Centre's Herbarium in Sandakan. Map of species distribution is generated with the QGIS programme and the species' conservation status was listed according to Global IUCN Red List online database (2018).

Figure 2. Discussion of the findings in the field.

RESULTS & DISCUSSION

Dipterocarps recorded

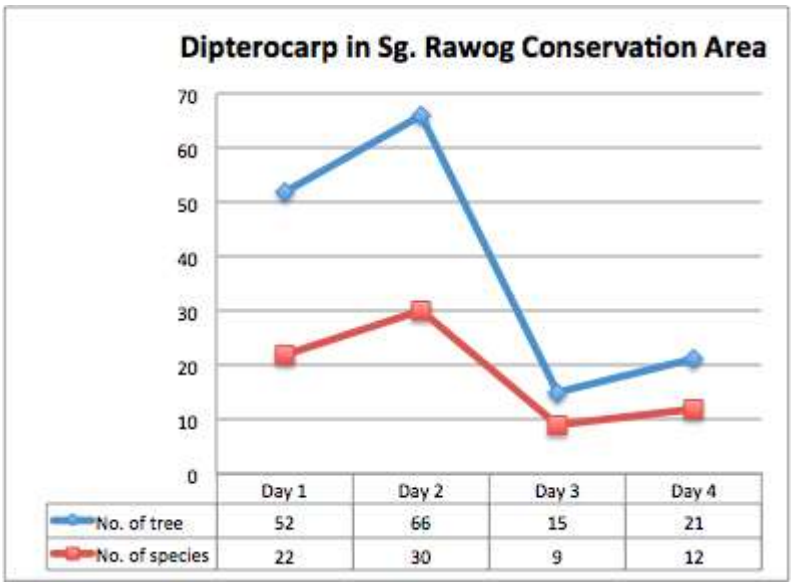

Figure 3. Number of individuals and species recorded.

A total of 40 dipterocarp species from 6 genera, namely *Dipterocarpus, Dryobalanops, Hopea, Parashorea, Shorea* and *Vatica* were recorded from Rawog Valley. The recorded species represent 21.9% of the total species found in Sabah. According to the species listing, *Shorea* is the most diverse genus with a record of 23 species, followed by *Dipterocarpus* (6 species). As for the other genera only 2 to 3 species were recorded. In terms of endemism, there are 2 Sabah endemics, 19 Borneo endemics and 19 widespread species. Of the 40 species recorded, 26 species are an addition to the previous dipterocarp listing for the area. Therefore, giving rise the number of species that can be found in the area to be 52 rather than 26, which is more diverse than previously thought. Based on Figure 3, it is seen that the number of species and individuals recorded in the first two days was much higher, this is the result of the difference in distance covered (Table 2).

Table 1. Species recorded from the past based on the herbarium records in comparison to the recent records obtained during the Rawog Expedition.

PAST RECORD	
Anisoptera costata	*Dipterocarpus pachyphyllus*
Hopea bracteata	*Hopea rudiformis*
Hopea sangal	*Shorea fallax*
Shorea ferruginea	*Shorea isoptera*
Shorea mujongensis	*Vatica chartacea*
Shorea agamii	*Shorea superba*

Dipterocarpus caudiferus	*Shorea leprosula*
Dryobalanops lanceolata	*Shorea parvifolia*
Parashorea malaanonan	*Shorea pauciflora*
Parashorea tomentella	*Shorea macroptera*
Shorea acuminatissima	*Shorea waltoni*
Shorea almon	*Shorea xanthophylla*
Shorea johorensis	*Vatica oblongifolia*
NEW RECORD	
Dipterocarpus applanatus	*Shorea havilandii*
Dipterocarpus confertus	*Shorea inappendiculata*
Dipterocarpus humeratus	*Shorea macrophylla*
Dipterocarpus tempehes	*Shorea mecistopteryx*
Dipterocarpus validus	*Shorea ovalis*
Dryobalanops beccarii	*Shorea parvistipulata*
Dryobalanops keithii	*Shorea scrobiculata*
Hopea cernua	*Shorea seminis*
Hopea dryobalanoides	*Shorea smithiana*
Hopea nervosa	*Shorea superba*
Shorea argentifolia	*Shorea symingtonii*
Shorea beccariana	*Vatica havilandii*
Shorea faguetiana	*Vatica rassak*

*Highlighted in blue are species that were previously recorded and recorded again during the Rawog Expedition.

Table 2. Information on the survey conducted in Rawog Valley.

Field survey	Date	Survey site	Distance covered (km)	Elevation (m)
Day 1	14/8/2018	Trail 2, 3, and road survey	4.8	0-100
Day 2	15/8/2018	Trail 7, 8, and 10	3.0	0-100
Day 3	16/8/2018	Trail 12	1.0	0-100
Day 4	17/8/2018	Trail 11	1.3	0-100

Assessment on different soil associations

The surveys conducted have covered three different soil associations namely Brantian, Lokan and Sook. Both Brantian and Sook are within the alluvium group, while Lokan is associated with mudstone and sandstone. More than 50% of the species recorded was from the Sook soil association (Figure 4). Given the time frame, much of the transects were in the Sook area (Figure 5), therefore the results generated from this part of the study is still at its preliminary stage. This does not necessarily indicates that Sook soil has richer diversity, further assessments would need to be conducted in the other soil associations. From the preliminary results, *Parashorea malaanonan*, *Shorea leprosula*, *Shorea mecistopteryx* and *Shorea ovalis* were recorded from all three soils association, while the other species were recorded from one or two of the soil association present (Figure 5).

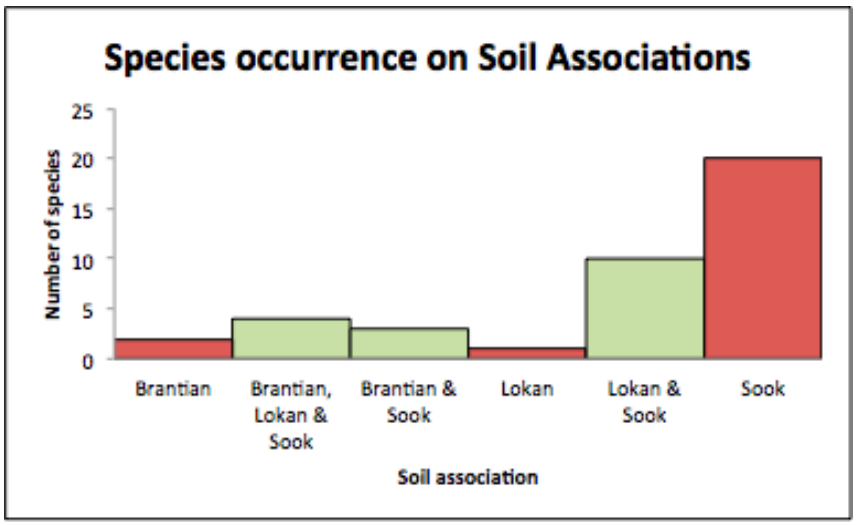

Figure 4. Species occurrence on different soil associations.

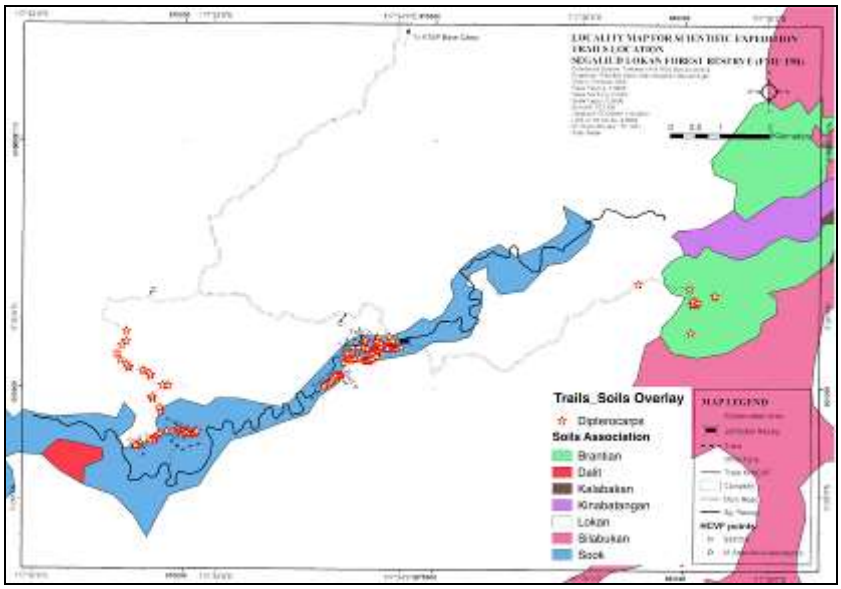

Figure 5. Dipterocarp occurrences and transects conducted.

IUCN Red Listing

The International Union for Conservation of Nature (IUCN) has come out with a set of criteria to evaluate the extinction risks of species as a guide to their current status. Based on the Global IUCN Red List assessment, out of the 40 species recorded, 23 species are listed under threatened categories, 2 near threatened, 7 least concern and 8 species has not has their status assessed (Figure 6).

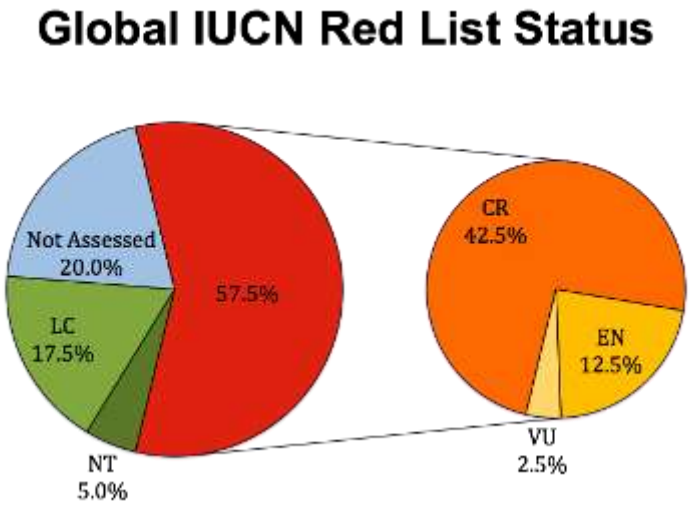

Figure 6. Summary of IUCN Red List Status of Dipterocarps found in Rawog Valley.

Both of the Sabah endemic are listed as critically endangered due to habitat conversion and degradation (Ashton, 1998). From the list of species recorded, one species is of particular interest to the team, *Vatica havilandii*. Although this species can be found in Borneo and Peninsular Malaysia but based on our records, its distribution range seems to have confined to south eastern side of Sabah and is considered rare and threatened (Ashton, 2004), due to the rarity of encountering this species.

CONCLUSION

With the new addition of 26 species, this suggest that Segaliud Lokan is potentially a suitable habitat for at least 52 dipterocarp species. The inability to record another 12 of the previously recorded species listed in the herbarium records could be due to (1) duration of survey conducted; (2) area covered; as mentioned earlier most of the transects were conducted on the Sook soil association, therefore there is a potential for further research at different soil associations in the conservation area. The baseline information generated can be used towards the setting up of management measures for the area, at the same time the updated occurrence data will be used in the ongoing IUCN Red List Assessment for Dipterocarps to obtain the conservation status of the timber trees at the State level.

ACKNOWLEDGEMENT

We would like to thank KTS Plantation Sdn. Bhd. and Sabah Forestry Department for organizing and arranging the expedition. Special thanks to our guide throughout the expedition, Mr. Abdul Jalal Sampurai Abdullah and Mr. Sahrul bin Sangkala.

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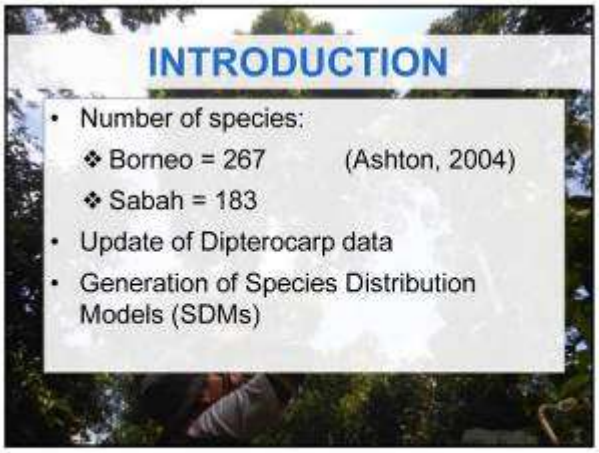
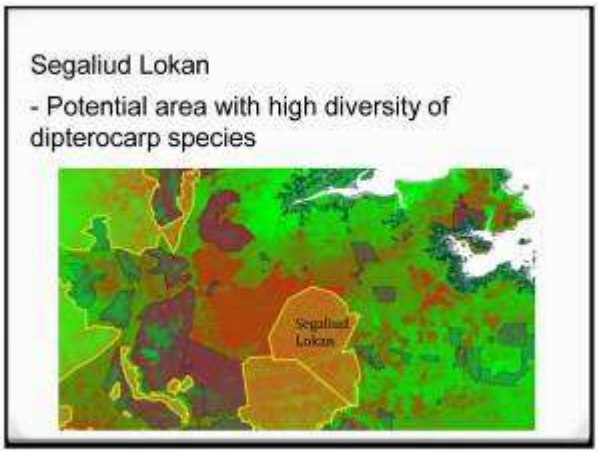
Appendix: Dipterocarp listing

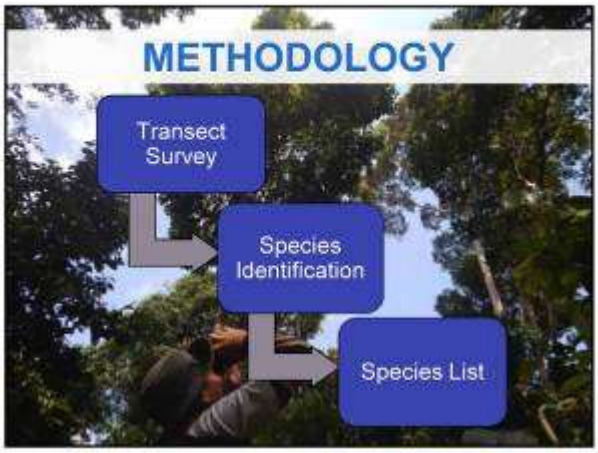
IUCN 2017: CR-Critically Endangered, EN-Endangered, VU-Vulnerable, NT-Near Threatened, LC-Least Concern, NA-Not Assessed

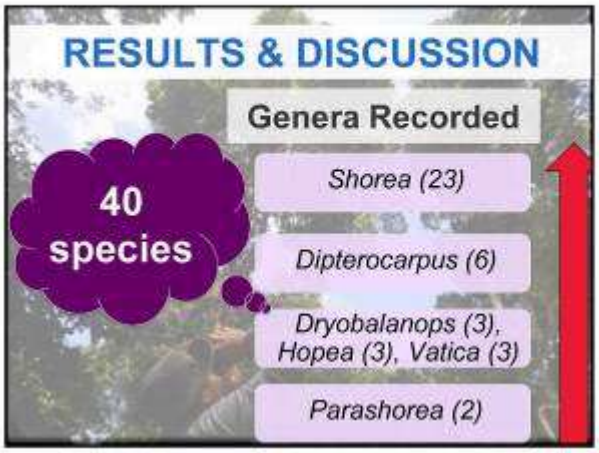
No	Species recorded	Day 1	Day 2	Day 3	Day 4	Endemism			IUCN 2017					
						Borneo	Sabah	Not Endemic	CR	EN	VU	NT	LC	NA
1	*Dipterocarpus applanatus*	2	1			1			1					
2	*Dipterocarpus caudiferus*	3	1		1	1						1		
3	*Dipterocarpus confertus*		1			1								1
4	*Dipterocarpus humeratus*		2					1						1
5	*Dipterocarpus tempehes*		1			1			1					
6	*Dipterocarpus validus*		1					1	1					
7	*Dryobalanops beccarii*	6	6	2				1		1				
8	*Dryobalanops keithii*		1		1	1			1					
9	*Dryobalanops lanceolata*	2	3		1	1				1				
10	*Hopea cernua*		2					1						1
11	*Hopea dryobalanoides*	1						1					1	
12	*Hopea nervosa*		3					1	1					
13	*Parashorea malaanonan*	4	6	2	1			1	1					
14	*Parashorea tomentella*	2	2		1	1							1	
15	*Shorea acuminatissima*	2	1		3	1			1					
16	*Shorea almon*			1				1	1					
17	*Shorea argentifolia*	2	2	2		1				1				
18	*Shorea beccariana*	1				1								1
19	*Shorea faguetiana*	1						1		1				
20	*Shorea havilandii*	2				1							1	
21	*Shorea inappendiculata*	1	1					1	1					
22	*Shorea johorensis*		2		3			1	1					
23	*Shorea leprosula*	2	4	1	2			1				1		
24	*Shorea macrophylla*	3			2	1					1			
25	*Shorea macroptera*	3	4		1	1							1	
26	*Shorea mecistopteryx*	5		1	2	1								1
27	*Shorea ovalis*	3	2	1				1					1	
28	*Shorea parvifolia*	1	5					1					1	
29	*Shorea parvistipulata*		1			1								1
30	*Shorea pauciflora*			2				1		1				
31	*Shorea scrobiculata*		1					1						1
32	*Shorea seminis*		1					1	1					
33	*Shorea smithiana*	2	3	3	3	1			1					
34	*Shorea superba*	2	1			1			1					
35	*Shorea symingtonii*						1		1					
36	*Shorea waltonii*		1				1		1					
37	*Shorea xanthophylla*	2	4			1			1					
38	*Vatica havilandii*		1					1	1					
39	*Vatica oblongifolia*		2			1								1
40	*Vatica rassak*							1					1	
	Number of species	22	30	9	12	19	2	19	17	5	1	2	7	8
	Number of individuals	52	66	15	21									

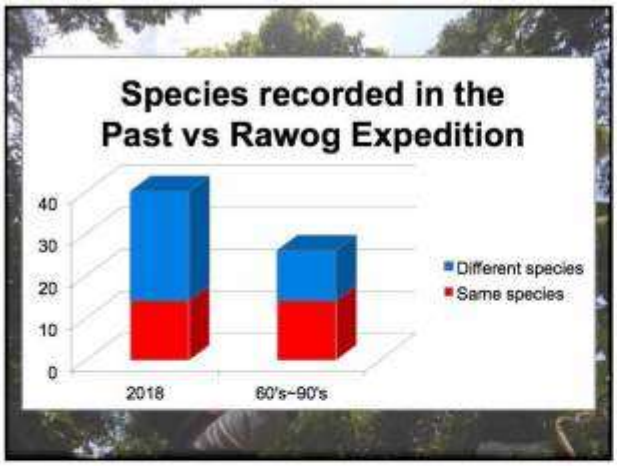
Slide Presentation

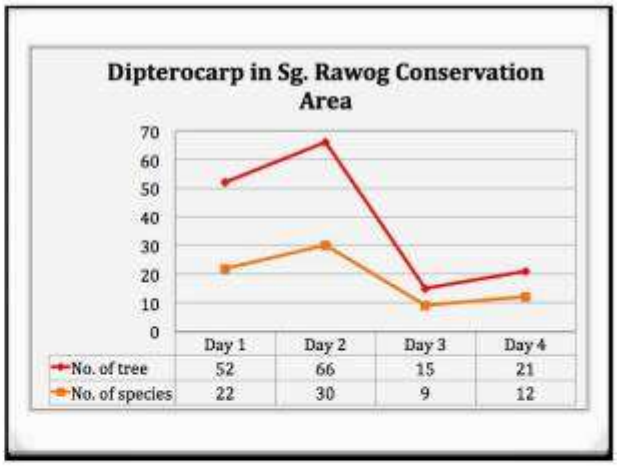






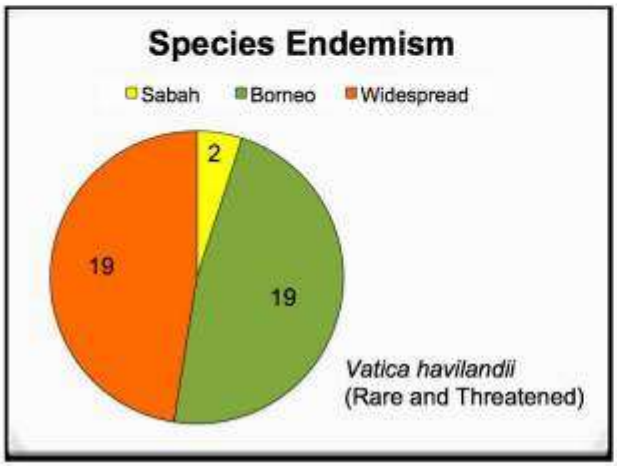


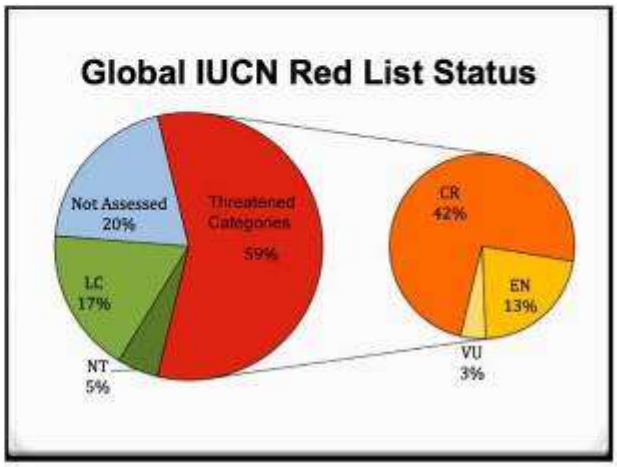

Species recorded in the Past vs Rawog Expedition
40
30
20
10
0
2018
60's~90's
Different species
Same species

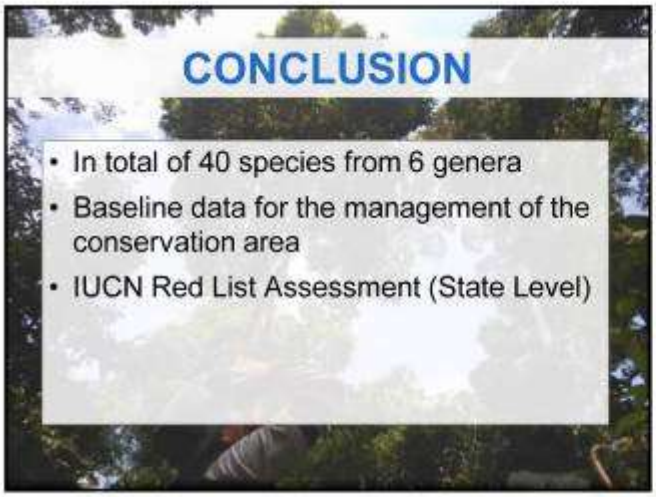

Dipterocarp in Sg. Rawog Conservation Area
70
60
50
40
30
20
10
0
Day 1 Day 2 Day 3 Day 4
No. of tree 52 66 15 21
No. of species 22 30 9 12


Shorea waltoni
Photo by Sandakan Herbarium


Shorea symingtonii
Photo by Sandakan Herbarium


Species Endemism
Sabah
Borneo
Widespread
2
19
19
Vatica havilandii
(Rare and Threatened)


Global IUCN Red List Status
Not Assessed 20%
Threatened Categories 59%
LC 17%
NT 5%
CR 42%
EN 13%
VU 3%



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PAPER 1.8

Preliminary survey of Araceae of Sg. Rawog Conservation Area, Segaliud Lokan Forest Researve (FMU 19B)

K. Saibeh* & S. Salleh

Faculty of Sustainable Agriculture, Universiti Malaysia Sabah, Sandakan
**Author for correspondence. Email: k_saibeh@ums.edu.my*

Abstract. Considering that Sg. Rawog Conservation Area has been logged, it was thus with considerable surprise that the author encountered *Rhaphidophora fluminea* Ridl. along the river bank of Sg. Rawog since its first collection in 1897 from Bonggaya. *Homalomena gempal* Kartini, P.C Boyce and W.S Yeng was found growing on the sandstone of the river bank. Two interesting species of *Schismatoglottis* belong to the Trifiscata Complex were found not far from river bank of Trail 11. *Alocasia princeps* W. Bull and *A. sarawakensis* M. Hotta were found inside the forest at all trails except in the heath forest (Trail C49). Aroids climbers, namely *Amydrium medium* (Zoll. & Moritzi) Nicolson, *Pothos* sp., *Rhaphidophora lativeginata* M. Hotta, *Scindapsus pictus* Hassk. and *Scindapsus* sp. were found scattered in the inner area of the forest. In conclusion, the area around the river bank of Sg. Rawog represented aroid species found in pristine forest.

INTRODUCTION

Araceae or commonly known as aroids, the fourth largest family of monocotyledons after the orchids, grasses and sedges, is one of the most important mesophytic plant families in tropical Asia. The Araceae, comprising seven subfamilies, 121 genera and 6000 species, is mainly tropical and distributed worldwide (Cusimano *et al*., 2011).

The family is defined by having minute sessile flowers on spadix and covered by a spathe. The spadix may bear either unisexual or bisexual flowers. Most of the climbers have bisexual type of flowers while others have unisexual flowers (Mayo *et al*, 1997). Ecologically, aroids can be found in streams, ponds and canals, terrestrial habitats, tidal mud, swamps and wasteland, forest floor, climbers, epiphytes and rheophytes (Mashhor *et al*., 2012).

The aroids of Borneo currently stand at 575 species, of which 433 are formally described (Wong, 2016). Most Bornean terrestrial aroids show marked local endemism, often to a very high degree, and frequently associated with geological obligation. Fieldtrips in Sabah has resulted in numerous undeterminable species of aroids which on subsequent flowering in cultivation have proven to be taxonomic novelties (Kartini *et al*., 2017).

MATERIALS & METHODS

Ground survey was conducted from 8th to 10th August 2018. The first and second days we went to Trail 6, 7, 8, 9, 10 and 11 which were walking distance from the basecamp. On the third day we went to Trail 2, 3, 4, 5 and C49 (heath forest) which was about 30 minutes' drive from basecamp. Morphological and habitat of the specimens were noted. Living specimens were collected and planted in the nursery at FSA, UMS Sandakan for observation. Identification was based on Wong (2016), Boyce (2004), Boyce *et al.* (2001), Mayo *et al.* (1997), and Hay (1996a & b).

RESULTS & DISCUSSION

Three subfamilies and seven genera with 11 species of Araceae were recorded in Sg. Rawog Conservation Area (Table 1). Rheophytic climber *Rhaphidophora fluminea* (the first collection was in 1897 from Bongaya) was found in several populations along the river bank of Sg. Rawog. The narrow leaf blade shape adapted to the strong water current of the river. The seedling also strongly adhered to the substrate of the riverbank. *Homalomena gempal* found abundant at the sandstone area of the river bank. Two species of *Schismatoglottis trifasciata* Complex were found in Trail 11. Present knowledge of Borneo aroids, is that *Schismatoglottis* and *Homalomena,* the largest genera, alone probably comprise more than 300 species each (Low *et al*., 2018).

Alocasia sarawakensis found in saturated mud in open sunny area; the typical habitat. In *A. sarawakensis*, the leaf's abaxial surface is hairy with very prominent veins. Aroids climbers namely *Amydrium medium*, *Pothos* sp., *Rhaphidophora lativeginata* and *Scindapsus pictus* and *Scindapsus* sp. were found scattered in the inner area of the forest.

The lowest number of Araceae was recorded in the heath forest of C49. The restriction to heath forest is a well-reported phenomenon in plants, thus Araceae show similar levels of restrictive distributions associated with a wide range of different geologies (Mayo *et al.*, 1997).

Table 1. List of Araceae found in Sg. Rawog Conservation Area.

Subfamily	Genus and Species	Trail 6,7,8,9,10,11	Trail 1,2,3,4,5,6	C49
Pothoideae	*Pothos* sp.	-	+	+
Monsteroideae	*Amydrium medium*	-	+	-
	Rhaphidophora fluminea	+	+	-
	Rhaphidophora latevaginata	+	+	-
	Scindapsus pictus	+	+	-
	Scindapsus sp.	+	+	+

Aroideae	*Homalomena gempal*	+	+	-
	Schismatoglottis trifasciata Complex 1	+	-	-
	Schismatoglottis trifasciata Complex 2	+	-	-
	Alocasia sarawakensis	+	+	-
	Alocasia princeps	+	+	-

CONCLUSION

Sg. Rawog is less rich in aroids. However, the geological formation of sandstone and mudstone around the river bank of Sg. Rawog represented special populations of aroid species found in pristine forest.

ACKNOWLEDGEMENTS

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Slide Presentation

Preliminary survey of Araceae of Sg Rawog Conservation Area, Segaliud Lokan Forest Researve

By
KARTINI SAIBEH
FACULTY OF SUSTAINABLE AGRICULTURE
UMS, SANDAKAN

Introduction

- The Araceae or commonly known as aroids, the fourth largest family of monocotyledons after the orchids, grasses and sedges, is one of the most important mesophytic plant families in tropical Asia.
- The Araceae of Borneo currently stands at 575 species, of which 433 are formally described.
- Currently Sabah has 20 genera (one endemic – *Tawaia sabahensis*) and 84 described species, of which 38 are endemic.
- Most Bornean terrestrial aroids show marked local endemism, often to a very high degree, and frequently associated with geological obligation

Materials & Methods

- On ground survey were done from 8th - 10th August 2018
- First and second days we went to Trail 6, 7, 8, 9, 10 and 11 – walking distance from the basecamp.
- Third day we went to Trail 2, 3, 4, 5 and C49 – about 30 minutes' drive from basecamp
- Morphological and habitat were noted.
- Living specimens were collected and planted in the nursery at FSA, UMS Sandakan for observation.

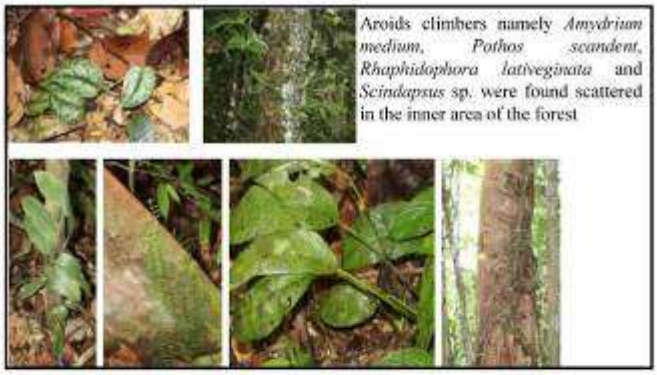
Results and Discussion

Rhaphidophora fluminea Ridl. at the river bank of Sg Rawog.
(the first collection was in 1897 from Bonggaya)

Homalomena gempal Kartini, P.C Boyce and W.S Yeng growing on the sandstone of the river bank
(Described in 2017; Type specimen from Galas Waterfall, Tawau Hill Parks)

Schismatoglottis Trifasciata Group (sterile specimen) found near the river bank

Living specimen flowered in nursery



Aroids climbers namely *Amydrium medium*, *Pothos scandent*, *Rhaphidophora lativeginata* and *Scindapsus* sp. were found scattered in the inner area of the forest

Alocasia princeps W. Bull

Alocasia sarawakensis M. Hotta found in saturated mud in open sunny area; the typical habitat.

In *A. sarawakensis*, the leaf's abaxial surface is hairy with very prominent veins.

Present knowledge of Borneo aroids, is that *Schismatoglottis* and *Homalomena,* the largest genera, alone probably comprise more than 300 species each.

It is wholly probable that Borneo has in excess of 1000 species of aroid.

Endemism is about 90% for the terrestrial aroid flora of Borneo.

Sabah's intricate mosaic of geologies can result in high levels of locally-restricted species abundance in remarkably small areas.

Conclusion

Sg Rawog is less rich in aroids.

However, the geological formation of sandstone and mudstone around the river bank of Sg Rawog proved to be habitat of special populations of aroids found in pristine forest.

PAPER 1.9

Visitor impact on vegetation and soil along selected trails in Sg. Rawog, Sandakan, Sabah: preliminary assessment and monitoring

W.A. Malandi, S.R.M. Hashim & R. Hassan

Faculty of Science and Natural Resources, Universiti Malaysia Sabah, Kota Kinabalu
**Author for correspondence. Email: wilaz@ums.edu.my*

Abstract. Preliminary assessment of visitor impact along selected trails in Sg. Rawog has been conducted through species composition, vegetation cover, and soil compaction. The data collected would become a baseline data for future monitoring impact. Study results showed that there was no statistical difference between disturbed and undisturbed plots in terms of vegetation with proximity to the trail, suggesting weak linearity between amount of usage and impact. It indicated the level of trampling impact still under the threshold of diminishing species diversity and it is rather a form of external pressure on vegetation. Besides, the results also showed insignificant difference in terms of soil compaction. However, the results demonstrated that moderate human trampling near camping area over long periods can have devastating impacts on the condition of the soil. A good management plan that emphasizes on the balance between recreational use and environmental protection and taking into consideration the visitor trampling impacts could help in maintaining long-term conservation goals.

Slide Presentation

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Visitor Impact on Vegetation and Soil Compaction along Selected trails in Sg. Rawog, KTS, sabah malaysia: Preliminary monitoring

Wilter Azwal MALANDI
Faculty of Science and Natural Resources, University Malaysia Sabah, MALAYSIA,
wilaz@ums.edu.my

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Topics to be Covered

- Introduction
- Human and Nature
- Visitor impact
- Problems and Aims
- Rawog
- Methodology and field procedures
- Result and Conclusions
- Aknowledgement

Introduction

- "One touch of nature makes the whole world kin."
  William Shakespeare (Palmer 1982)
- Nature echoes in the psycho-religious themes in human society in all parts of the world.
- Nature - central to the affairs of human life and the birth and continuance of the human civilization.
- Humans heavily depend on natural resources at all ages of the human history

Human and Nature

The grandeur of Nature still remains, and although parts of the natural environment might have been altered or destroyed by human technology, there still remain large tracks of natural wilderness in the world that might be of interest to what are known as "NATURE-LOVERS".

"ECOTOURISM"

"NATURE-BASED TOURISM"

THEN "OUTDOOR RECREATION"....

Visitor impact

- In order to fulfill the needs and requirements of each natural area tourism activity, visitors have to physically move closer to the exact location of the specific resources
- The increased number of visitors would bring about parallel increase in recreational activities and environmental changes

Visitor impact

- Hiking, Birding and unique species

Visitor impact

- Camping, Swimming & Climbing


Visitor impact

- Fauna's – reason for visitor activities

Plant Diversity & soil compaction

- In forest area, most plant diversity occurs in the ground layer (or the undergrowth), thus it is specifically important to sample this community (Johnson *et. al.* 2006). This is the approach adopted in this study.
- The basic assumption of measuring diversity is that it describes the relationship of individuals of varying categories within a community such as soil compaction

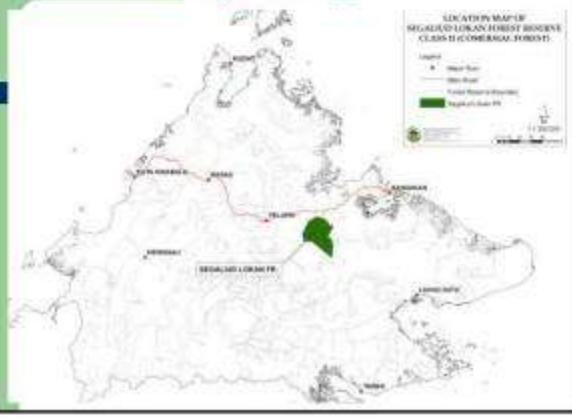
Plant Diversity

- In this study, the vegetation biodiversity index is considered as very essential information that indicates the relationship of recreational use of trail with ecological impacts.
- Logically, different conditions of vegetation would vary in tolerance to the ecological impacts. Generally, as often observed, some types of ground vegetation would grow intensively under heavy destruction due to high intensity of light as a result of more exposed condition.

Problems and Aims

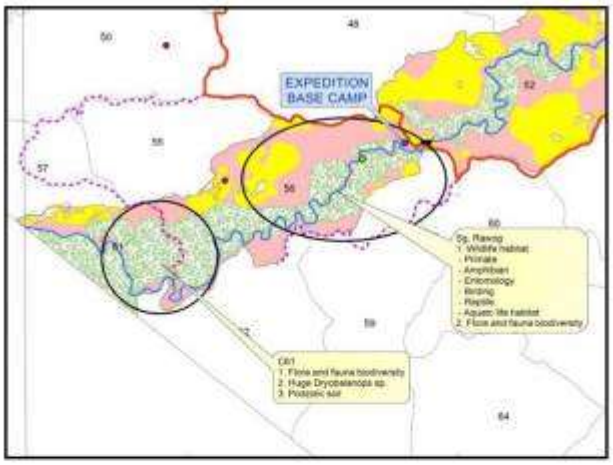
- Problems
  - Outdoor recreation is becoming increasingly popular and as such it has inevitably resulted in greater and wider spread of impacts on the natural ecosystems particularly plants
  - However, less study in Rain-forest
- **Aims**
  - **Preliminary assessment and monitoring of visitor impacts on plant diversity as well as soil compaction along permanent trails in Rawog protected area**

Sg. Rawog



Why Rawog??

- Since little such study has been conducted considering that Rawog is one of the remote conservation areas in Sabah.
- Rawog is a protected forest area located near to accessability.
- Gazetted as Class one Forest Area??
- Preliminary and base line data



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Result vegetation

Trail	Species richness	Total of Individual	Diversity index Shannon-Wiener	Similarity index
Trail 6	26	288	2.135	0.663
Trail 3	34	307	2.457	0.691

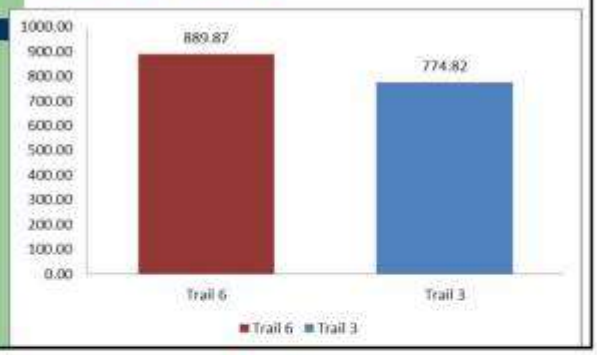
Result Vegetation

Trail	Plot	Species richness	Individual	Diversity index Shannon-Wiener	Similarity index
Trail 6	On trail	7	58	1.506	0.774
	<5m from trail	12	156	1.828	0.712
	> 5m from trail	26	330	2.259	0.764
Trail 3	On trail	13	43	2.197	0.857
	<5m from trail	22	150	2.886	0.675
	> 5m from trail	23	314	2.414	0.77

ANOVA - species richness

	SS	df	MS	F	P
Within group	881125.544	3	440562.772	2.524	.143
Between group	16998531.536	97	175252.902		
Total	17880657.080	99			

Soil compaction



Result

	SS	df	MS	F	P
Within group	881125.544	3	440562.772	2.524	.088
Between group	16998531.536	97	175252.902		
Total	17880657.080	99			

Conclusion

- Human or visitor activities impact on plant ecology and soil along trails exist in long term usage
- However, There is no significant different of species richness between disturb and undisturbed area
- trampling near camping area over long periods can have devastating impacts on the condition of the soil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Acknowledgement
Special Thanks for allowing me to attend this Expedition and Seminar to:
1. University Malaysia Sabah
2. Sabah Forestry Department
3. KTS Plantation

QUESTION & ANSWER SESSION

Session 1: Forest Ecosystems, Physical Sciences & Plant Diversity

Name: Dr. Benedict Topin
(Agency: Kadazandusun Cultural Association Sabah)
Question: Why is the area named Segaliud or Sg. Rawog?

Indra P. Sujonto: Segaliud is named after the Segaliud River.

Name: Dr. Benedict Topin
(Agency: Kadazandusun Cultural Association Sabah)
Question: Could you comment or elaborate on their use of medicinal plants?

Assoc. Prof. Dr. Andy Mojiol: Medicinal plants have been known since the olden times and act as alternative to cure many sicknesses. Further studies on the medicinal plant's chemical content is needed first to ensure its effectiveness in treating illnesses.

Name: Dr. Benedict Topin
(Agency: Kadazandusun Cultural Association Sabah)
Question: How to differentiate between the male and female ficus tree?

Dr. Miyabi Nakabayashi: It can be differentiated by halving the fruits of the figs. Female figs have seeds in their fruits. Male figs have fig wasps in their fruits.

Name: Dr. Robert Francis Peters
(Agency: Universiti Malaysia Sabah)
Question: Are there any studies that focus on the distribution of *Selaginella conferta* and its role as an environmental indicator?

Wilter Azwal Malandi: The assessment was a general one for all lower plants, trampling and human impacts to plants and soil compaction.

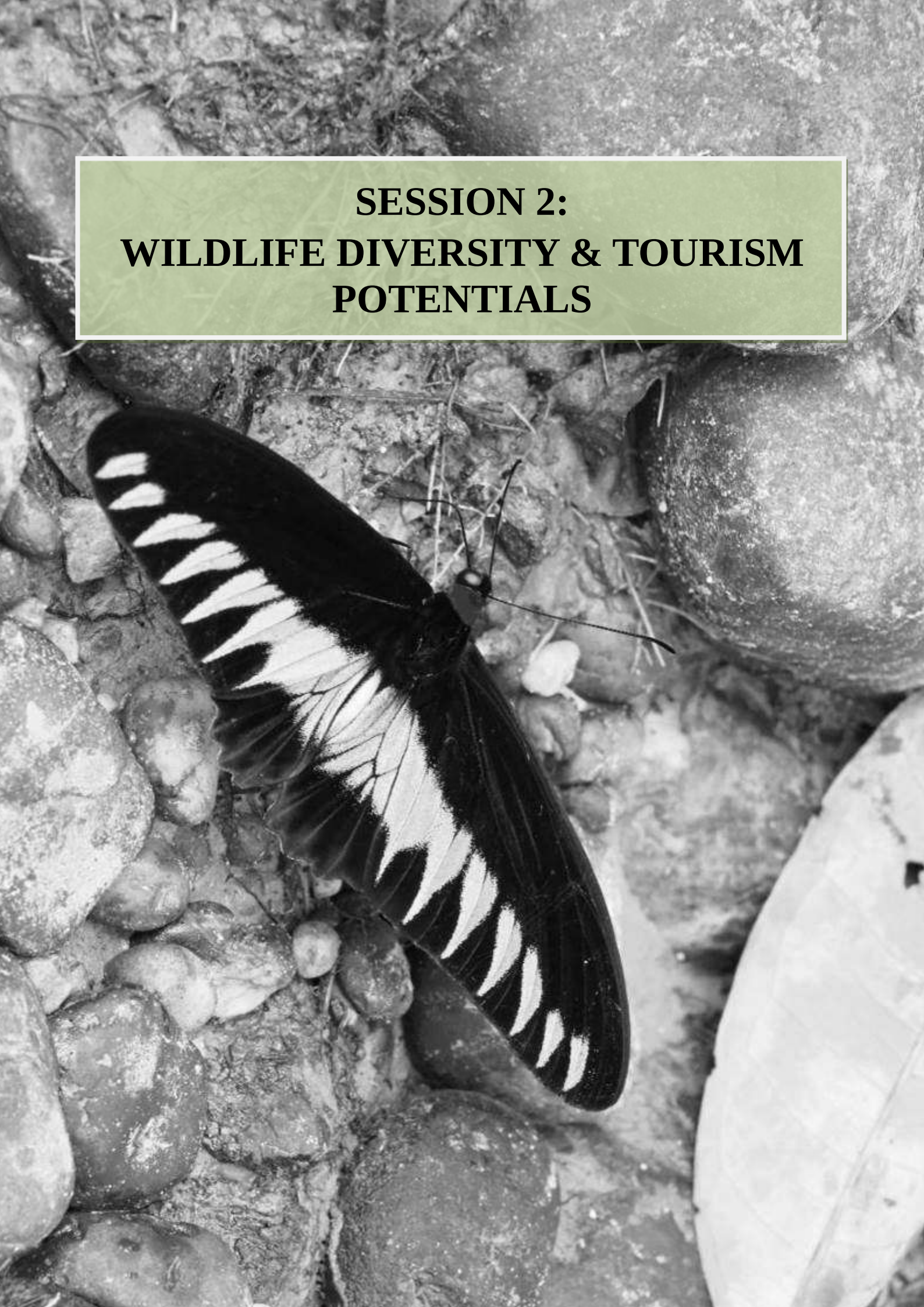
Andi Maryani Andi Mustapeng: I mentioned *Selaginella conferta* in my findings. *Selaginella conferta* (Selaginellaceae) is endemic to Borneo, which is only reported from Sabah, Sarawak, and Kalimantan so far. Species was first collected from Mount Kinabalu in 1859. No study on impact for this species was conducted, but what I can say, the population in Sg. Rawog Conservation Area is low, only 2 populations found along the Sungai Rawog. Species is considered rare and it is important to conserve this area.

Name: Prof. Dr. Abdul Hamid Ahmad
(Agency: Universiti Malaysia Sabah)
Comment: I stood up to appreciate the habitats within the Sungai Rawog Conservation Area. It has been logged but was allowed to regenerate. As a result, the area has achieved emergence of various levels. I also invited the audience to pay close attention in the afternoon session and appreciate the connections between the habitats and the faunal diversity.

Name: Mr. Jutom Ongkosing
(Agency: Sabah Agricultural Department)
Question: What can be done to conserve the easily erodible soil condition in Sg. Rawog Conservation Area?

Mohd. Aminur Faiz Suis: A tree planting project could improve the soil condition.

Paul Liau: The area is fully conserved and protected of which no active harvesting operations are allowed. Tree planting activities are also conducted in this area.



SESSION 2:
WILDLIFE DIVERSITY & TOURISM POTENTIALS

PAPER 2.1

An assessment of the terrestrial mammal community in and around Sungai Rawog Conservation Area, Sabah, Malaysia

H. Bernard[1]*, N. Joseph[1], A. H. Ahmad[1], S.-L. Kee[2], J. Sompud[2], M. Nakabayashi[3,4], R. Nilus[5], M.A.F. Suis[5], J. Miun[5], H. Miun[6], R. Jaikim[6], A. Md. Yakub[6], A. Jamali[6], M. Anson[6], E. Alim[7], P. Liau[8] & C. Goh[8]

[1]*Institute for Tropical Biology and Conservation, Universiti Malaysia Sabah, Jalan UMS, 88400 Kota Kinabalu, Sabah, Malaysia*
[2]*Faculty of Science and Natural Resources, Universiti Malaysia Sabah, Jalan UMS, 88400 Kota Kinabalu, Sabah, Malaysia*
[3]*Faculty of Science, University of the Ryukyus, Nishihara, Okinawa, Japan*
[4]*Graduate School for International Development and Cooperation, Hiroshima University, Hiroshima, Japan*
[5]*Forest Research Centre, Sabah Forestry Department, P.O. Box 1407, 90715 Sandakan, Sabah, Malaysia*
[6]*Sabah Wildlife Department, Sandakan, Sabah, Malaysia*
[7]*WWF Malaysia, Kota Kinabalu, Sabah, Malaysia*
[8]*KTS Plantation, Sandakan, Sabah, Malaysia*
**Author for correspondence: hbtiandun@gmail.com or hbernard@ums.edu.my*

Abstract. Sungai Rawog Conservation Area (SRCA), located within the Segaluid Lokan Forest Reserve, is one of the largest wildlife conservation areas set aside in an active production forest reserve in Sabah, Malaysian Borneo. However, much remains unknown about its animal communities. We conducted a mammal survey in and around the SRCA to gather baseline data on animal community structure and to inform conservation management strategies for this area in general. Between July 2018 and February 2019, we used camera traps (total camera trapping effort: 855 camera trap-days), in addition to day transect surveys, night roadside spot light surveys and other incidental sightings, which led to the detection of 32 mammal species from 8 orders. These included common and rare species, as well as species of high conservation value, such as bearded pig (*Sus barbatus*), sambar deer (*Rusa unicolor*), banteng (*Bos javanicus*), Asian elephant (*Elephas maximus*), orang-utan (*Pongo pygmaeus morio)*, Sunda clouded leopard (*Neofelis diardi*), flat-headed cat (*Prionailurus planiceps*) and Malayan pangolin (*Manis javanica*). Photographs captured of the flat-headed cat from our study may likely be the first photographs of this species taken from the SRCA, hence confirming the presence of this extremely rare wild cat species in Segaliud Lokan FR. Despite the highly disturbed nature of the forests due to past logging activities, the surveyed sites in and around the SRCA serve as important habitats and provide a functional protected conservation area for many important animal species. We conclude that the conservation of the SRCA is vital for the continued survival of the animal communities in this region of Sabah and suggest the need for long-term protection, research and monitoring programmes of the habitats and animal communities.

Keywords: Mammals, camera trap, Sungai Rawog Conservation Area, Segaliud Lokan Forest Reserve, Sabah, Borneo

INTRODUCTION

Bornean tropical rainforests are one of the most species rich terrestrial ecosystems in the world (Myers *et al*., 2000), yet much of these forests are rapidly disappearing as land is cleared, mainly for logging and for oil palm (Gaveau *et al*., 2014). The Malaysian state of Sabah (*ca.* 73,600 km^2), which occupies less than 10% of the northern part of Borneo, is no different. Much of Sabah's forests were selectively logged between the 1970s through 1990s (Marsh & Greer, 1992), and although by regional standards, Sabah still contain some of the largest contiguous tracts of forested land (51%), extensive areas of these forests have been, and will continue to be disturbed (Reynolds *et al*., 2011). Biodiversity-rich areas of primary lowland forest only cover less than 5% of the total land area (Reynolds *et al*., 2011).

Borneo harbours 247 species of land mammals including charismatic species (Phillipps & Phillipps, 2016), and many species that are threatened with extinction (IUCN. 2019). Many mammals also fill key ecological roles in the tropical forest ecosystems, such as seed predators and dispersers, and without them the stability and sustainability of the tropical forest ecosystems would be compromised (Meijaard *et al*., 2005; Nakashima *et al*., 2010; Corlett, 2017). Mammal conservation is therefore, of paramount importance. However, given the current trend of habitat loss and disturbance in Borneo (Gaveau *et al*., 2014), relying conservation of wildlife solely in primary forests is not practical and selectively logged forests may still contain a significant proportion of their original wildlife community (e.g. Granados *et al*., 2016; Bernard *et al*., 2016; Wearn *et al*., 2016; Jati *et al*., 2018). Even so, we still lack knowledge of animal species richness and community composition in degraded forests (Bernard *et al*., 2013), and hence the relative value of human-modified habitats for animal conservation, particularly over the long-term, is not fully understood (e.g. Prosser *et al*., 2016; Chapman *et al*., 2018). Research on the presence of animal species in degraded habitats is essential for land-use planning and conservation management strategies, so that suitable habitats can be identified, conserved, and even rehabilitated, wherever they still exist. One of such areas in Sabah is the Segaliud Lokan Forest Reserve (SLFR).

Several Sabah-state wide surveys have been conducted in the past on the Asian elephant and orang-utan populations that also included the SLFR (e.g. Ancrenaz *et al*., 2004; Alfred, 2009; Alfred *et al*., 2011). A broad based inventory survey of wildlife using camera trappings and other methods was conducted in 2010 by Wilting & Mohamed (2010). The study covered the northern part of Segaliud Lokan and formed part of the larger research project of Mohamed *et al*. (2013). Another study by Kee *et al*. (2018), also in the northern part of Segaliud Lokan, described the nocturnal terrestrial mammal community composition using the night spotlight survey methods. Both studies revealed a high richness of the animal communities in the surveyed areas. Nevertheless, as far as can be determined, no mammal inventory studies have been conducted in the southern parts of SLFR, including in and around the Sungai Rawog Conservation Area (SRCA). Hence, despite this area being set aside for wildlife protection and conservation in Segaliud Lokan (Mohamed, 2013), the detail information about the mammalian fauna at this area remains generally unknown.

Camera trapping is an increasingly popular method for determining the presence of animal species (Ancrenaz *et al*., 2012). Though camera traps based near the ground are known to be bias in favour of detecting mainly medium- to large-bodied terrestrial animals (Wilting *et al*., 2010; Bernard *et al*., 2013), camera traps are now widely used especially where long-term study via direct observation or live-trapping are logistically difficult, such as in remote dense forests (e.g. Mohd-Azlan, 2006; Jati et al., 2018).

The present study was aimed at documenting records of mammalian fauna in and around the SRCA primarily using camera trappings and other methods. This study is part of the research activities of "SRCA Scientific Expedition 2018" conducted at the area from 8th-18th August 2018, though mammal sampling also included beyond those periods to increase sample size. We describe generally the disturbance level of the forest habitats and provide an inventory list of mammals from the sampling sites. We also quantify some aspects of animal community structure based on camera trapping data. Lastly, we provide some suggestions that are pivotal for the landscape management and long term conservation of the animal communities in this region of Sabah.

MATERIALS & METHODS

Study site

The SRCA, within the SLFR, is situated in the district of Sandakan in central Sabah, Malaysian Borneo (Figure 1). A private company known as the KTS Plantation Sdn. Bhd. manages the SLFR since 1993 under the License Agreement by the State Government of Sabah (Mohamed, 2013). Located between longitudes 117º23'–39'E and latitudes 5º20'–27'N, SLFR covers an area of approximately 570 km^2 of lowland mixed dipterocarp forest with vegetation composition belonging to the *Parashorea tomentella*/*Eusideroxylon zwageri* type (KTS plantation, 2008). Except for areas along the south-western boundary where the SLFR is bordered by Deramakot FR, all other boundaries in the northern and eastern parts of SLFR are located adjacent to private oil palm plantations. For management purposes, SLFR is divided into 70 compartments with 11 compartments, covering an area of 64 km^2, have been set aside for wildlife protection and conservation (Mohamed, 2013). Four of these compartments (C49, C52, C56, and C61) are located along the river valley of Sungai Rawog bisecting the south-central part of SLFR. These compartments, approximately 23 km long and 30 km^2 in size, formed the SRCA. Due to selective logging activities conducted prior to 1995, the vegetation in the conservation area consists of a mixture of variously degraded lowland mixed dipterocarp forest. Areas in the vicinity of SRCA are dotted by several sodium-rich natural spring salt-licks. The topography of the conservation area is gently undulating with elevations ranging between 70–120 m above sea level. Annual precipitation for this region ranges between 3000–3500 mm. Daily temperature can range from 21^{o}C to 36 ^{o}C (Mohamed, 2013).

Vegetation survey

We assessed the level of habitat disturbance at 10 points selected at random within each of three sampling sites (C49, C56 and C61) in which we conducted the mammal surveys. Distance between sampling points within a sampling site was approximately 50 m. At each point, we measured or estimated four aspects of vertical forest structure variables within a 20 m radius: (1) Canopy height, m (the height of the lowest canopy from the ground measured using a laser range finder); (2) Percentage of canopy closure (all above ground vegetation cover >2 m, measured using a spherical densitometer), (3) Percentage of understorey vegetation (a visual estimation of the vegetation coverage between 2–5 m from the ground) and (4) Percentage of vegetation cover (or shrub cover) on the ground –estimated by eye.

Mammal sampling

We used several non-invasive survey methods to identify the presence of mammal species in SRCA: (1) Camera trapping; (2) Day transect surveys; and (3) Night roadside spotlight surveys. We also included other incidental sightings.

Camera trapping

From 28th July 2018 – 8th February 2019, we used Reconyx remote infrared digital cameras (HD Trophy Cam model 119537) to estimate animal detections. In all, we established a total of 10 camera-trap stations, across an elevational range of 40 to 105 m above sea level. Camera stations were at least 1 km apart, mainly at three compartments within the conservation area: C49 (2 stations), C56 (3 stations) and C61(2 stations). We established three other camera-trap stations outside of the conservation area (< 2km), of which two were located at the natural spring salt-licks (Figure 1). Except for cameras placed near salt-licks where the forest canopy was generally more open, we positioned all other camera stations inside the forest under the canopy at places where we suspected animal activities to be high i.e. along old and inactive logging roads and skid trails, animal trails, under fruiting trees, trees with cavities (both standing or fallen) and places near little streams, ponds or wallows (Tobler *et al*., 2008; Bernard *et al*., 2013). We placed only one camera at each camera station. All cameras were fixed to the base of trees close to the ground, usually <0.4 m. We set all cameras at "high" trigger sensitivity and programmed them to take three photographs at rapid-fire succession during every trigger. There was no time delay between triggers. No baits or other lures were used. All cameras were active 24 hours daily and used infrared flash at night.

Day transect surveys

We conducted the day transect surveys only during fine weather by walking quietly (in a group of 3 persons), at a speed of approximately 1–1.5km/hour, along man-made trails (trails 4, 5, 6, 6A, 6B, 7 and 10, Figure 1; each of which was approximately 0.2 – 1.0 km in length), including old and inactive logging roads inside the forest in the conservation area, usually between 8:00 to 11:30 am, for three days from 9th -11th August 2018. We surveyed each trail only once. During the transect surveys, we searched for arboreal as well as

terrestrial species. Species were identified via direct and indirect sightings i.e. based on their track marks on soft soil, droppings or dungs and other signs of activity or presence e.g. old or newly constructed nests (orang-utan) and calls (gibbon).

Night spotlight survey

We performed the night spotlight surveys using a bright spotlight from the back of a pick-up car, moving at a speed of approximately 8-20 km/hour, in search of mammals on the ground and in the trees at the forest edge by the road side along the main gravel road within or in the vicinity (< 2 km) of the conservation area. We conducted the night spotlight surveys during fine weather, between 8:00–11:30 pm, on the 9th–11th August 2018 and on the 14th and 16th August 2018.

Data Analysis

We used the IUCN Red list (IUCN, 2019) for the taxonomic names of all mammals identified in our study. We determined the global and regional conservation status of each species based on the IUCN Red List criteria (IUCN, 2019), and their local protection status based on Sabah's Wildlife Conservation Enactment 1997 Protected Species lists (WCE, 1997). We provided an overall summary of the inventory list of all mammals detected based on the combined survey methods used in our study. Additionally, to allow for comparisons of results based on the camera trapping method, we analyzed and presented separately all photographic data of mammals obtained from this survey method. H. Bernard identified the taxonomic identities of all mammals from the photographs captured. Some mammal photographs were verified by an external mammal expert (Andrew Hearn, Wildlife Conservation Research Unit, University of Oxford, U.K.).

To reduce temporal autocorrelation of photo-capture events, we treated multiple photos of the same species recorded from the same camera station <1 hour apart as a single record (Bernard *et al*., 2013) and considered them to be"independent photo-capture events", or "independent photographs", of different individual animals in the surveyed sites. We excluded all other photographs, including non-target species such as birds and other unidentified species (mainly small mammals and bats) from analysis. We treated the two mouse-deer species i.e. lesser mouse-deer, *Tragulus kanchil*, and greater mouse-deer, *T. napu*, as a single genus (*T.* spp.), because of difficulties in distinguishing between species. We calculated the camera detection rate (or trap success rate) for each individual mammal species, as well as for all species combined, by dividing the number of independent photographs captured of a species (or all species pooled) by100 camera trap-days.

We assessed the camera trapping sampling adequacy by calculating the sampling completeness ratio i.e. calculated as observed/estimated species number; where the estimated species number was taken as the mean value of four commonly used sample-based species richness estimators (AEC, CHAO1, JACK1, and Bootstrap) derived from EstimateS version 9.1.0 (Colwell, 2013). We assumed sampling to be sufficient when this proportion approached the value of one indicating that all species present were observed. In addition, we used the species accumulation curve of the cumulative number of the observed species as a function of the camera trapping effort to determine the sampling efficiency of the camera

trapping survey. The observed species accumulation curve was constructed using EstimateS based on the sample-based rarefaction approach with 100 random iterations. We plotted abundance, represented by the number of independent photographs, as a measure of sampling effort. We also extrapolated the sampling effort by a factor of five to determine the approximate sampling saturation point.

We assessed the relative abundance of mammals at each camera station by plotting the number of independent photographs against the number of samples, where each sample consisted of the pooled data of every 5 consecutive camera trap-days. All abundance plots were constructed from the outputs in EstimateS.

RESULTS

Habitat characteristics

Canopy height, canopy closure, understorey vegetation and ground cover vegetation, were typical of highly disturbed forest due to past logging activities with generally more open canopy and highly irregular understorey, and dense ground cover vegetation in logged areas (Figure 2). These features were most prominent at C56, suggesting that this site had probably suffered more logging damage than sites C61 and C49. The tallest forest canopy on average was recorded at C61, indicating the presence of many tall trees at this site. Canopy height was lowest at C49. This site (C49) included a small patch of *kerangas* forest, or tropical heath forest, where large trees are naturally rare due to the nutrient-poor soil in this forest formation. Outside of the vegetation plots, we also noted several large areas of compacted soils by the roadside near C49 that are devoid of any trees and no forest regeneration seems to be taking place.

Overall mammal survey results

In all, we recorded a total of 32 different mammal species in 8 orders across all survey methods (Table 1). We detected 21of these species using the camera trapping method (855 camera trap-days), accounting for 66% of the overall number of mammal species recorded in this study. Additionally we detected a total of 15 species (46%) by the day transect survey method (total distance walked: 7.6 km) and 5 species (16%) by the night roadside spotlight survey method (total distance travelled by car: 25 km). Two species (6%) were detected based on opportunistic sightings. The species recorded in our study were both common and rare species, as well as species of high conservation concerned, including 13 species that are listed on the IUCN Red List that are classed as threatened by extinction (i.e. Vulnerable, Endangered or Critically Endangered; e.g. orang-utan, *Pongo pygmaeus morio*; Malayan pangolin, *Manis javanica*; Sunda clouded leopard, *Neofelis diardi*; flat-headed cat, *Prionailurus planiceps*; Asian elephant, *Elephas maximus*; and banteng, *Bos javanicus*). Sixteen species are listed as not threatened (Least Concern and Near Threatened) and 3 species are not evaluated (IUCN, 2019). A total of 26 species are additionally listed under Schedule 1, Schedule 2 or Schedule 3 of the Sabah Wildlife Conservation Enactment (WCE, 1997), which make them protected locally by law in Sabah.

Results from camera trapping survey

The total camera trapping efforts of 855 camera trap-days, recorded from all 10 camera trap stations combined, has resulted in a total of 1,079 animal photos of which 854 were independent mammal photo-capture events (Table 2). The average camera trapping effort at the individual camera trap stations was 86 camera trap-days (range: 36-298 camera trap-days per camera trap station). The overall photo-capture rate of all 21 mammal species detected via the camera trapping method was 99.88 independent photographs/100 camera trap-days. The most frequently photo-captured species were ungulate taxa: sambar deer, *Rusa unicolor* (45.85 independent photos/100 camera trap-days) and bearded pig, *Sus barbatus*, (19.65 independent photos/100 camera trap-days) and mouse-deer, *Tragulus* spp., (19.42 independent photos/100 camera trap-days). These three species were also detected across a wider spatial distribution as they were captured in at least 8 of our 10 camera stations. Five species were photo-captured only once (flat-headed cat, *Prionailurus planiceps*; banded palm civet, *Hemigalus derbyanus*; banded lisang, *Prionodon lisang*; short-tailed mongoose, *Herpestes brachyurus*; and long-tailed porcupine, *Trichys fasciculata*), and were thus the least widespread species from the camera trap data.

Estimate of species richness and sampling efficiency based on camera trapping method

The mean estimated species number computed with EstimateS was 25.68 (ACE = 24.70; CHAO 1 = 24.33; JACK 1 = 29.10; Bootstrap = 24.58) compared to the observed species number of 21 species, resulting in a sampling completeness ratio of 0.82. Although all species richness estimators, especially JACK 1, indicated that some species were still missing from our samples, the accumulation curve of the observed mammal species in general appeared to be approaching an asymptote (Figure 3). Based on extrapolated data the species accumulation curve appeared to level off at about 30 species, i.e. after about 4000 independent photographs have been captured (Figure 3).

Relative abundance of mammals at each camera trap station

The highest mammal density was recorded at two camera trap stations located at the natural spring salt-lick sites (Figure 4). Most (>95%) detections here consisted of two ungulate species; sambar deer and bearded pigs, both of which are generalist and/or group living animals. Seven other species were also recorded to visit the salt-licks including the banteng, Asian elephant and orang-utan. Animals visited the salt-licks during day and night time.

DISCUSSION

Past logging activities using conventional logging methods in and around the SRCA have modified the structure of the forest significantly, although forest structure damage was not uniform across the entire logged forests. For example, some patches of primary forest persist within the logged-over areas, such as on steep slopes near ridges and along river margins. However, there were also open areas that are devoid of any trees. On a large spatial scale, these have created a highly heterogeneous landscape of disturbed habitats in the

logged-over forest. In spite of this forest condition, the overall mammal species richness recorded in our survey (32 species) was relatively high and included small-, medium- and large-bodied terrestrial mammals. Many common and rare species, as well as species of high conservation value regionally or globally were recorded. In addition, many of the identified animals are species of high conservation importance locally. The mammalian fauna of Borneo in general seems to have considerable resilience to logging (e.g. Bernard *et al*., 2016; Granados *et al*., 2016; Wearn *et al*., 2016; Jati *et al*., 2018) and our study suggests that heavily degraded forests of SRCA still hold a significant value for the conservation of terrestrial mammals.

Our camera trapping survey yielded a lower mammal species number (21 species) compared with the camera trapping survey conducted by Wilting & Mohamed (2010) in the northern part of SLFR in 2010 (total: 34 species). Our cameras registered only 65% of the species recorded by Wilting & Mohamed (2010). The higher species richness recorded by Wilting & Mohamed (2010) may be due to the greater camera trapping efforts (5731 camera trap-days; 53 camera trap stations) and larger sampling area (114 km^2) relative to our study. Thus, future camera trapping surveys in SRCA should include increased sampling effort while also allocating more camera traps to cover larger sampling areas. In addition, we recommend that all habitats available are surveyed in the vicinity of the Rawog river. Indeed, our extrapolated camera trap data suggest that more species could be sampled with greater sampling effort.

Though we did not control for differences in sampling efforts, compared to both day transects walk and night spotlight surveys, a higher number of mammal species were detected by camera traps, including many species that were detected exclusively with this survey method; this suggests that camera trapping is effective to provide baseline data of the mammalian community in Sungai Rawog, particularly medium- to large-bodied terrestrial mammals. However, if a complete inventory list of terrestrial mammals is required, we recommend complementing the use of camera traps with a combination of other survey methods, including the day transect walk and night spotlight surveys that are particularly useful for detecting canopy mammals, such as both the diurnal and nocturnal primates, as demonstrated in our study. Live trappings using wire-mesh cage traps will be necessary for sampling the non-volant small mammals (e.g. Bernard *et al*., 2009). Whereas, the volant mammals (bats) can only be sampled efficiently using mist-nets and/or harp-traps (e.g. Struebig *et al*., 2013).

The most species rich order detected in our study, with a total of 10 species, belongs to the order Carnivora. Three species were felids including the flat-headed cat photo-captured at night (7:56 pm) in wetland area at C61, located <50 m from the Rawog river. Photographs of the flat-headed cat may likely be the first photographs of this species taken from the SRCA, confirming the presence of this endangered wild cat species in SLFR. Being strictly a wetland specialist, the flat-headed cat was predicted to be more common in forest areas that are associated with swamps or lowland forests with many lakes or other water bodies including rivers and streams (Wilting & Mohamed, 2010; Wilting *et al*., 2010; Cheyne & McDonald, 2011; Phillips & Phillips, 2016; Wilting *et al*., 2016). This suggests that available habitats for the flat-headed cat in SRCA are rather limited. Moreover, given that it was photo-captured on only one occasion over the six months period of our camera trapping survey, our

findings indicate that the flat-headed cat may exists at very low abundance. Therefore, the SRCA should be considered as a high priority conservation area for the flat-headed cat.

Other wild cat species recorded in the SRCA include the Sunda clouded leopard. An adult male, was spotted walking along the gravel road at around 7:30 pm in disturbed forest. It appeared undeterred by passing vehicle or humans, indicating that at least for the adult males, human activities and the presence of active roads in the conservation area are not posing any ecological barriers to the movement of this animal across the modified habitats in Sungai Rawog. Observations of the clouded leopard utilizing active logging roads are not uncommon elsewhere (e.g. Rabinowitz *et al*., 1987; Gordon & Stewart, 2007; Bernard *et al*., 2013a; Wearn *et al*., 2013; Nakabayashi *et al*., 2014). Nevertheless, while these observations could suggest that clouded leopards are able to use modified habitats, the full effects of anthropogenic disturbance on its abundance and distribution remain unclear (Hearn *et al*., 2016). Local abundance of Sunda clouded leopard was found to be lower in logged forest than in unlogged forest sites (Brodie *et al*., 2015), suggesting that this species may thrives better in pristine forest than in disturbed forest.

The leopard cat was among the most commonly detected species in camera trap surveys and seems to show preference for disturbed areas (Rajaratnam *et al*., 2007; Mohamed *et al*., 2013; Bernard *et al*., 2014). Surprisingly, the leopard cat was recorded only once from our camera traps. Leopard cats were detected more frequently from the night spotlight surveys conducted along gravel roads. Leopard cat association with logging roads has been documented by Mohamed *et al*. (2013) and Kee *et al*. (2018) in SLFR. Mohamed *et al*. (2013) placed most of their cameras on logging roads, whereas Kee *et al*. (2018) conducted wildlife survey using the night spotlight survey method, also along logging roads. In contrast to their studies, most of our cameras were positioned inside the forest, under the forest canopy. Therefore, the low trapping success of leopard cat in our study may be an artefact of the placements of our cameras inside the forest. Samejima *et al*. (2012) who conducted long-term camera trapping surveys in Deramakot FR where they placed most of their cameras inside the forest also revealed similar results as our study i.e. less detection of leopard cats in camera traps located inside the forest than in open areas on logging roads. In addition to facilitation of movement and likely higher 'catchability" of murid prey in more open habitats (Rajaratnam *et al*., 2007; Mohamed *et al*., 2013), the leopard cat associations with logging road could be related to their biological needs, such as olfactory communication. Some species of carnivores, for example the common palm civet, *Paradoxurus hermaphroditus*, may deposit their faeces or scats along gravel road as scent-marking for purposes of olfactory communication (Nakabayashi *et al*., 2014).

Other wild cat species that have been observed elsewhere in SLFR and the neighbouring Tangkulap dan Deramakot FR, i.e. the marbled cat, *Pardofelis marmorata*, and bay cat, *Pardofelis badia* (Mohamed, 2013; Wilting & Mohamed, 2010; Kee *et al*., 2018), were not recorded in the Sungai Rawog area. Both species are probably extremely rare in the SRCA. Additionally, marbled cats are arboreal (Phlillipps & Phillipps, 2016), and therefore do not appear frequently in camera trap data using cameras located near ground level. Other camera trapping studies also showed generally similar trend as our study with regard to the community composition and relative abundance of wild cat species (Brodie & Giordano, 2011; Bernard *et al*., 2013; Wearn *et al*., 2013).

Frugivorous carnivores frequently detected in our study, such as the Malay civet, *Viverra tangalunga*, and Common palm civet, showed a comparable trend to the results of the study by Wilting & Mohamed (2010) and Mohamed (2013) in terms of photo-capture rates at SLFR. All other frugivorous carnivores were rare.

Six species of the order Artiodactyla were recorded in our survey and this was the second richest animal group. We detected only one muntjac species i.e. the Bornean yellow muntjac. The red muntjac was never recorded. Both species may co-occur, though red muntjac is more common in highland areas ((Phillipps & Phillips, 2016). Hence, the red muntjac is likely naturally rare in the lowland areas in the vicinity of Sungai Rawog. The sambar deer and bearded pig frequented the spring salt-licks, both during the day and night time, suggesting that this habitat feature is a useful resource for large herbivorous mammals. Large herbivorous mammals regularly visit natural salt-licks for mineral supplementing as their diet is deficient in mineral content, particularly sodium (Matsubayashi & Lagan, 2014; Matsuda *et al*., 2015). Payne & Davis (1987) even suggested that the distribution of large Bornean mammals may be more linked to the distribution of natural salt-licks than to forest type or degradation. Other animals, such as the Sunda clouded leopard, may also indirectly benefit from the presence of salt-licks, as the abundance of their major prey species i.e., bearded pigs and sambar deer presence (Hearn *et al*., 2016), may correlate with the abundance of salt-licks. A total of 28 species of medium- to large-bodied mammals were previously recorded at or in the vicinity of four natural spring salt-licks sites in Deramakot FR, including short-tailed mongoose, leopard cat and Malay civet, *Viverra tangalunga* (Matsubayashi & Lagan, 2014). As with the Sunda clouded leopard, these species are probably associated with the salt-licks to prey for other animals. Indeed, the salt-licks are hot spots of species diversity (Matsubayashi & Lagan, 2014). In this regard, identifying the locations and providing protection to all natural salt-licks in SRCA, and SLFR overall, would be management aspects that are pivotal for the conservation of terrestrial mammal species in the area in general.

It is interesting to note that the camera trap success rate for bearded pigs was recorded to be very low (<1.0 photos/100 camera trap-days) in 2010 in the northern part of SLFR (Mohamed, 2013). In contrast, we recorded bearded pigs frequently in the Sungai Rawog area (ca. 20 photos/100 camera trap-days). Hence, Mohamed's (2013) finding for the bearded pigs was rather surprising because bearded pigs are a widespread forest generalist and they are well known to be resilient to habitat disturbance and conversion (e.g. oil palm) (Bernard *et al*., 2013; Love *et al*., 2018). It is possible that uncontrolled illegal hunting may suppress, or even extirpate, a game animal to local extinction, such as the case with the bearded pigs in Lambir Hills in Sarawak (Mohd-Azlan & Lading, 2006). Illegal hunting pressure of game animals in SLFR is consistently present especially from the human settlement areas in and around the nearby oil palm plantations or elsewhere. However, none of our camera traps detected illegal hunters inside the conservation area, though one of our cameras was stolen (at C49), most likely by illegal hunters. Furthermore, we did not detect any other evidences or signs indicating humans' encroachment inside the SRCA during our study. We therefore presume that hunting pressure in SLFR is low in general compared to other sites in Borneo (e.g. see Brodie *et al*., 2014). On the other hand, it is also possible that bearded pigs migrate between preferred habitats in search of food at different areas of the forests at different

seasons. For example, the bearded pig was found to respond to masting via movement and increased reproduction, although their response may be attenuated by habitat disturbance (Granados *et al*., 2019). Hence, the distribution of bearded pigs in the forest may not be uniform at different times of the year due to the spatial differences in forest productivity (e.g. fruit productions).

We recorded old and new signs of activities (track marks and dungs) of both elephant and banteng suggesting long-term use of the SRCA. We also photographed single individuals (bulls) of elephant and banteng at our camera trapping sites in the forests and at the salt-licks, though only infrequently. In addition to food resources, the availability of water resources, habitat loss or degradation and fragmentation may also influence the home range of these animals (Alfred *et al*., 2011; Sabah Wildlife Department, 2019). The elephant is known to have large ranging area, e.g. 400 – 700 km^2, with greater range in fragmented habitats because they may travel further in search of food which could increase human-elephant contacts and conflicts (Alfred et al., 2012). The SRCA may act as an important continuous wildlife corridor for animals' movements within the SLFR or between neighbouring forest reserves, including for both elephant and banteng, though not much is known of the long-term ranging behaviour of banteng. Bantengs probably only use closed-canopy forest to pass through, or for resting, as food resources for this species (grasses and small shrubs) are scarce under such forest condition. Nonetheless, with sufficient food and water supplies, banteng may prefer to stay around the same sites with little migration between different sites (Hoogerwerf, 1970; and Bowman & Panton, 1991; cited in Olson, 2002). Elephants generally avoid steep slopes during migration (Alfred *et al*., 2011). So, the low lying areas with gently undulating terrain in SRCA are more convenient for elephant to move i.e. along the flat river margin under the forest canopy that may also provide suitable cover or secluded places to retreat from the high temperature in open areas during the day. Open areas by the river banks may also provide suitable food resources (e.g. tall grasses) for feeding during night time (Alfred *et al*., 2011). In general the SLFR has been identified as part of the North Kinabatangan Elephant Range with an estimated density of 1.41 elephant/km^2 in 2011 (Alfred *et al*., 2011), hence making this area an important habitat for elephant. Likewise for the banteng, with a minimum number alive estimated to be 46 animals based on surveys conducted between 2011–2016, the SLFR was identified as one of the important strongholds for this species in Sabah (Sabah Wildlife Department, 2019).

The primates in the SRCA were represented by five species, the most prominent of which is the orang-utan, *Pongo pygmaeus morio*, which was detected on the forest floor by our camera traps, including at the salt-licks, where a large flanged male was photographed. Although primarily an arboreal primate, terrestrial locomotion among Bornean orang-utan is a common phenomenon in primary forests or in heavily degraded habitats (Ancrenaz *et al.*, 2014). However, most of the detections of orang-utans in our study were made through indirect observations of old and newly constructed nests in the trees, suggesting previous and recent use of the conservation area by orang-utans. The SLFR in general has been identified as one of the strongholds of orang-utan populations in Sabah with an estimated population size of 692 individuals (CI: 255-1874) (Ancrenaz *et al*., 2005). The most frequently and most widespread primate species recorded from our camera traps was the pig-tailed macaque, *Macaca nemestrina*. The long-tailed macaque, *Macaca fascicularis*, was rarely detected, probably due to the species being more arboreal than the pig-tailed macaque (Phillipps &

Phillips, 2016). The greater slow loris, *Nycticebus caucang*, was only detected by incidental sightings at night in the trees at low heights, and Bornean gibbon, *Hylobates muelleri*, was detected via their loud calls in the morning.

Smaller mammals, i.e. the rodents, and three porcupine species, i.e. Malayan porcupine, *Hystrix brachyura*, Thick-spined porcupine, *Thecurus crassispinis*, and Long-tailed porcupine, *Trichys fasciculata* were infrequently detected in SRCA.

Management Implications

Our survey, using primarily camera trapping method and substantiated by other survey methods, has successfully documented the mammalian fauna of SRCA, although our data analysis also suggested that more mammal species would be recorded with greater sampling effort. In spite of the highly disturbed nature of the logged forests at our study sites, our survey revealed that the SRCA is an important area providing functional protected conservation habitats for many mammal species, including common and rare species, and many species that are of high conservation value. The natural spring salt-licks were found to be important for terrestrial mammals in general, particularly for the ungulates. Our survey provided some evidence suggesting that SRCA is an important wildlife corridor for animals to move within the conservation area or as a migration route between adjacent forest reserves for large ranging mammals such as the elephant and banteng. Hunting threats are present in SRCA, though presumed to be low.

Based on our findings from this survey we recommend a strategy to enhance the conservation management of wildlife resources in SRCA, as well as the greater SLFR area in general. The approaches are to improve the long-term protection, increase the number of high quality priority research projects and monitoring programmes of the habitats and animal communities. We suggest the following activities to achieve these goals: (1) maintain the protection status and the contiguity of the forests within SRCA and between this area with other adjacent forests outside of SLFR, particularly Deramakot FR in the west and oil palm plantations in the east; (2) prohibit further logging activity of forest within the SRCA and, where appropriate, to rehabilitate patches of open areas that are devoid of any trees, though bearing in mind that open grassland areas may also be useful as feeding sites for banteng and other ruminants; (3) form a dedicated wildlife research and monitoring unit within the KTS plantation management structure in SLFR; (4) establish a systematic long-term monitoring programme of the richness and diversity of animals in SRCA, preferably using camera trapping techniques, to monitor changes in the richness and diversity patterns of animals through time; information derived from such long-term monitoring exercise would feed useful data/information for managing the animals effectively, e.g. relative abundance of game animals such as bearded pig, sambar deer and mouse-deer due to changes in the habitats and/or other anthropogenic factors (e.g. illegal hunting); (5) study plant community succession over long term periods to determine how this might affect the dynamics of animal communities, including individual animal species; the effects of forest regeneration due to logging may change over time (e.g. Chapman *et al*., 2018; Gadner *et al*., 2018); (6) to identify and map out the locations of all natural salt-licks in and around the SRCA, and the SLFR overall, and provide protection to this important habitat feature; note that unprotected salt-licks sites may attract illegal hunters; (7) conduct research on the distribution patterns of

large herbivorous animals, including elephant, banteng, sambar deer, and bearded pig (as well as orang-utan and other animal species red-listed by the IUCN), in relation to the distribution of salt-licks and human activities e.g. oil palm plantation, active road and settlement areas; note that all suggested research could be done in collaboration with local/international research institutions that should also in-cooperate training components to local students; (8) intensify systematic surveillance or law enforcement activities particularly along the forest-oil palm plantation boundaries in the east of SRCA and other parts in SLFR in general, where hunting threats are consistently present, and at major entry points into the forest reserve; including setting up of a joint wildlife management and monitoring, and environmental awareness education, committee consisting of the KTS plantation management, Sabah Forestry Department, Sabah Wildlife Department, personnel from the management of all oil palm plantation companies bordering with the SLFR and other relevant stakeholders.

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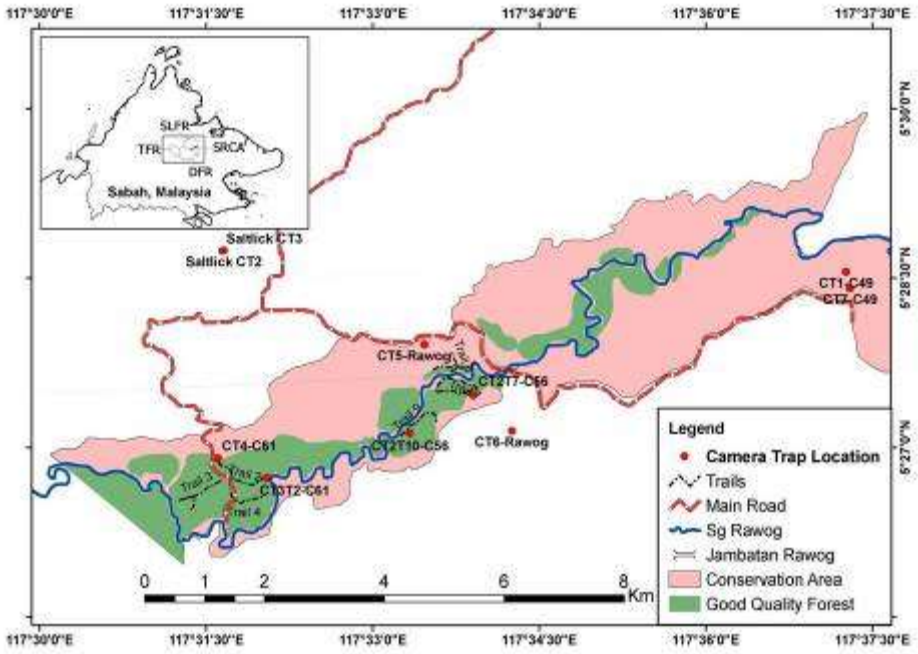


Figure 1. Sungai Rawog Conservation Area (SRCA), within Segaliud Lokan Forest Reserve (SLFR), and in relation to Deramakot Forest Reserve (DFR) and Tangkulap Forest Reserve (TFR) in central Sabah, Malaysia (inset). Larger map of SRCA shows camera trap locations, forest trails and gravel road where the terrestrial mammal surveys were conducted.

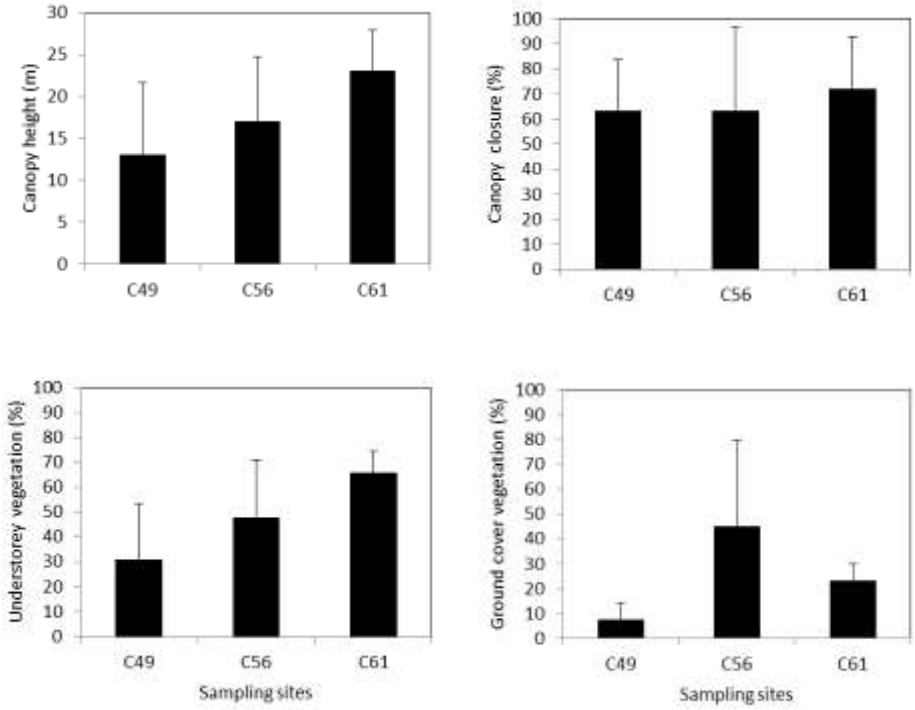


Figure 2. Vertical forest structure variables (mean ± s.d.) at three sampling sites (C49, C56, C61) in Sungai Rawog Conservation Area; (Top Left) Canopy height; (Top Right) Canopy closure; (Bottom Left) Understorey vegetation; and (Bottom Right) Ground cover vegetation.

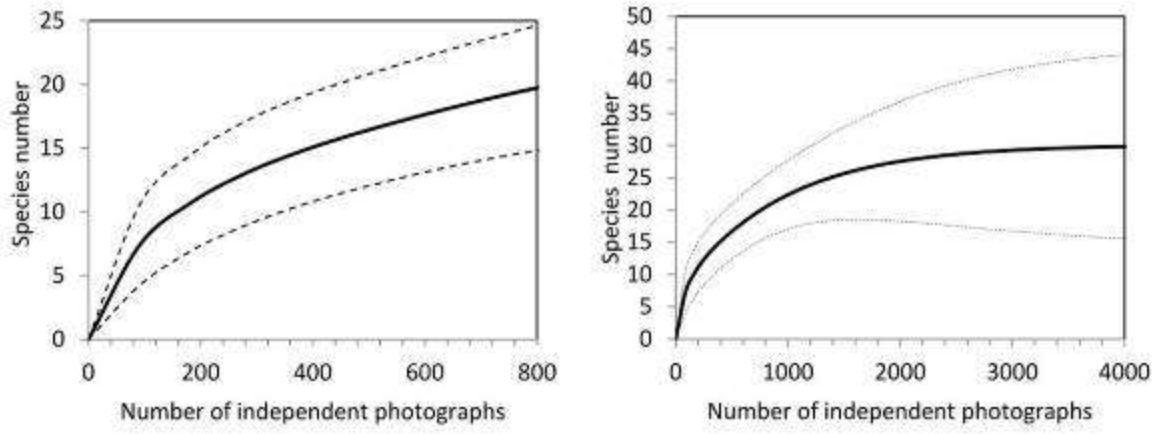


Figure 3. Species accumulation curves (solid line) of mammals and their 95% Confidence Intervals (dashed line) from camera trapping data; (Left) based on the observed data of 854 individual photographs; and (Right) based on extrapolated data of 4270 individual photographs. Analysis was conducted using individual-based abundance samples with 100 randomization runs using EstimateS (Colwell *et al*., 2013).

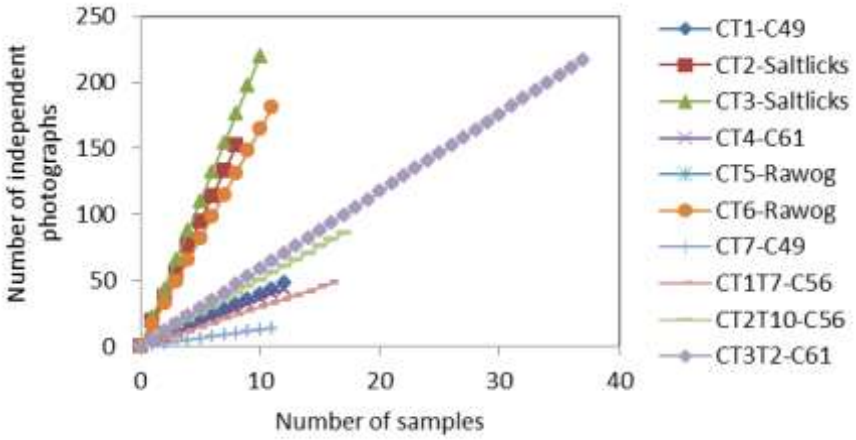


Figure 4. Mammal species density (i.e. number of independent photographs per sample) calculated using sample-based data (i.e. grouped as 5 consecutives camera-days per sample) at 10 camera trap stations. Analysis was conducted using EstimateS (Colwell *et al*., 2013).

Table 1. Summary of all mammal species recorded during the survey at Sungai Rawog Conservation Area (SRCA) in Segaliud Lokan Forest Reserve (SLFR), Sandakan, Sabah.

Scientific name	Order/Common name	Detection methods	IUCN	Protection in Sabah
	Carnivora			
Neofelis diardi	Sunda clouded leopard	OBV	VU	Schedule 1
Prionailuruss planiceps	Flat-headed cat	CT, OBV	EN	Schedule 2
Prionailurus bengalensis	Leopard cat	SOP	LC	Schedule 2
Viverra tangalunga	Malay civet	CT, SOP	VU	Schedule 2
Paradoxurus hermaphroditus	Common palm civet	CT, SOP	LC	Schedule 2
Hemigalus derbyanus	Banded palm civet	CT	NT	Schedule 2
Prionodon lisang	Banded lisang	CT	Na	Schedule 2
Mydaus javanensis	Sunda stink-badger	CT, LT	LC	Schedule 2
Herpestes brachyurus	Short-tailed mongoose	CT, LT	LC	Schedule 2
Helarctos malayanus	Malayan sun bear	CT	VU	Schedule 1
	Rodentia			
Hystrix brachyura	Malayan porcupine	CT	LC	Schedule 3
Hystrix crassispinis	Thick-spined porcupine	CT	LC	Schedule 2
Trichys fasciculata	Long-tailed porcupine	CT	LC	Schedule 2
Calosciurus notatus	Plantain squirrel	LT	LC	Not listed
Sundasciurus lowi	Low's squirrel	LT	Na	Not listed
Exillisciurus exilis	Bornean pigmy squirrel	LT	Na	Not listed
	Primates			
Nycticebus caucang	Greater slow loris	SOP	VU	Schedule 2
Macaca nemestrina	Pig-tailed macaque	CT	VU	Schedule 2
Macaca fascicularis	Long-tailed macaque	CT	LC	Schedule 2
Hylobates muelleri	Bornean gibbon	LT	EN	Schedule 1
Pongo pygmaeus morio	Orang-utan	CT, LT	CR	Schedule 1
	Artiodactyla			
Sus barbatus	Bearded pig	CT, LT	VU	Schedule 3
Rusa unicolor	Sambar deer	CT, LT	VU	Schedule 3
Muntiacus atherodes	Bornean yellow muntjac	LT	LC	Schedule 3
Tragulus napu	Greater mouse-deer	CT, LT	LC	Schedule 3
Tragulus kanchil	Lesser mouse-deer	CT, LT	LC	Schedule 3
Bos javanicus	Banteng	CT, LT	EN	Schedule 1
	Insectivora			

Echinosorex gymnura	Moonrat	CT	LC	Not listed
	Scandentia			
Tupaia longipes	Common treeshrew	LT	LC	Not listed
Tupaia minor	Lesser treeshrew	LT	LC	Not listed
	Pholidota			
Manis javanica	Malayan pangolin	CT	CR	Schedule 2
	Proboscidae			
Elephas maximus	Asian elephant	CT, SOP	EN	Schedule 2

Note:
IUCN, Red list of globally threatened species status, CR=critically endangered, EN=endangered, VU=vulnerable, NT=near threatened, LC=least concern. Protection in Sabah refers to the protection status of animals based on the Sabah Wildlife Conservation Enactment (1997), Schedule 1= totally protected animals, Schedule 2=protected animals, Schedule 3=game animals. CT- detected via camera trapping surveys, LT – detected via day line transect surveys, SOP – detected via night spotlight surveys, OBV – detected via opportunistic observations during the day or night time.

Table 2. Number of independent photographs of mammals recorded in Sungai Rawog Conservation Area based on camera-trapping method. Number in parenthesis shows the camera detection rate or trap success rate (number of independent photographs/100 camera trap-days).

	Camera trapping station										
Species	Ct-1-C49	Ct-2-Saltlick	Ct-3-Saltlick	Ct-4-C 61	Ct-5-Rawog	Ct-6-Rawog	Ct-7-C49	Ct1t7-C56	Ct2t10-C56	Ct3t2-C61	Total
Prionailurus planiceps										1 (0.34)	1 (0.12)
Viverra tangalunga			3 (6.25)	1 (1.72)		2 (3.70)		2 (1.92)	11 (13.92)	3 (1.01)	22 (2.57)
Paradoxurus hermaphroditus						11 (20.37)					11(1.29)
Hemigalus derbyanus									1 (1.27)		1 (0.12)
Prionodon linsang										1 (0.34)	1 (0.12)
Mydaus javanensis								3 (2.88)			3 (0.35)
Hespestes brachyurus										1 (0.34)	1 (0.12)
Helarctos malayanus						1 (1.85)			1 (1.27)		2 (0.23)
Hystrix brachyura										7 (2.45)	7 (0.82)
Hystrix crassispinis								2 (1.92)		7 (2.35)	9 (1.05)
Trichys fasciculata								1 (0.96)			1 (0.12)
Macaca nemestrina	4 (6.67)		3 (6.25)			17 (31.48)	1 (1.69)	2 (1.92)	5 (6.33)	6 (2.01)	38 (4.44)
Macaca fascicularis									2 (2.53)		2 (0.23)
Pongo pygmaeus morio	1 (1.67)		1 (2.08)			2 (3.70)		1 (0.96)	2 (2.53)		7 (0.82)
Sus barbatus	1 (1.67)	25 (69.44)	21 (43.75)	27 (46.55)	2 (3.39)	23 (42.59)	5 (8.47)	9 (8.65)	5 (6.33)	50 (16.78)	168 (19.65)
Rusa unicolor	15 (25.00)	123 (341.67)	188 (391.67)	5 (8.62)	26 (44.07)	10 (18.52)	5 (8.47)	1 (0.96)	5 (6.33)	14 (4.70)	392 (45.85)
Tragulus spp.	24 (40.00)	2 (5.56)		9 (15.52)		7 (12.96)	3 (5.08)	9 (8.65)	10 (12.66)	102 (34.23)	166 (19.42)
Bos javanicus		1 (2.78)	2 (4.17)		2 (3.39)	2 (3.70)					7 (0.82)
Echinosorex gymnurus	3 (5.00)									3 (1.01)	6 (0.70)
Manis javanica			1 (2.08)							2 (0.67)	3 (0.35)
Elephas maximus		1 (2.78)	1 (2.08)		2 (3.39)				1 (1.27)	1 (0.34)	6 (0.70)
Total	48 (80.00)	152 (422.22)	220 (458.33)	42 (72.41)	32 (54.24)	75 (138.89)	14 (23.73)	30 (28.85)	43 (54.43)	198 (66.44)	854 (99.88)
Number of camera trap-days	60	36	48	58	59	54	59	104	79	298	855

Note:
We did not distinguish between the greater mouse-deer (*Tragulus napu*) and lesser mouse-deer (*T. kanchil*) as the two species were not always easily distinguishable from the photographs captured, though we confirm that both mouse-deer species were present during the camera trapping surveys.

Slide Presentation

An initial assessment on terrestrial mammal community in and around Sungai Rawog Conservation Area, Sandakan, Sabah

Henry Bernard, Jephte Sompud, Kee Sze Lue and **Abdul Hamid Ahmad**
Institute for Tropical Biology and Conservation, Universiti Malaysia Sabah, Kota Kinabalu, Sabah

Ruben Nilus, Mohd Aminur Faiz and **Jabanus Muin**
Forest Research Centre, Forestry Department of Sabah, Sandakan, Sabah

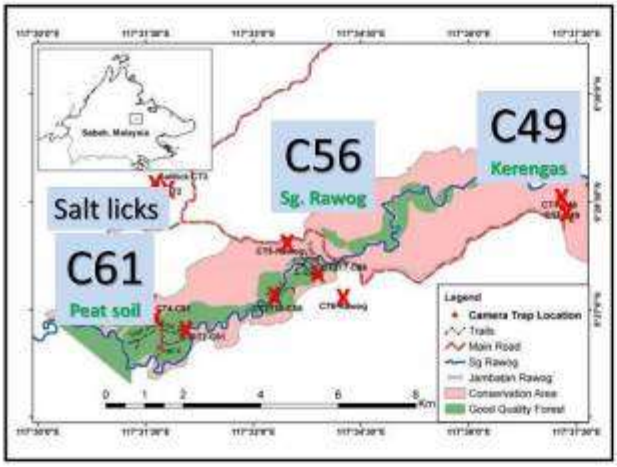
Hussien Misin, Richard Jaikim, Asnandy Md. Yakub, Awang Basri, Aldde Jamail, Muin Anson and **Jimat Sakok**
Sabah Wildlife Department, Sandakan, Sabah

Elyrice Alim
WWF Malaysia, Kota Kinabalu, Sabah

Dies Justin, Jefli and **Widly**
KTS Plantation Sabah, Sandakan

Methods

1) Camera trapping survey (Primary method)
2) Line transect survey
3) Night roadside spotlight survey
4) Other opportunistic observation
5) Habitat structure to assess disturbance levels



Overall results

- Sampling period: July 2018-February 2019.
- Thirty two (32) mammal species, 10 orders.
- Thirteen (13) species are threatened with extinction (IUCN 2019).
- Two (2) – CR.
- All species are TP or P under the SWCE (1997)

New Record for SLFR?

- Flat-headed cat, *Prionailurus planiceps*.
- May likely be the first photograph taken from SRCA/SLFR(?).

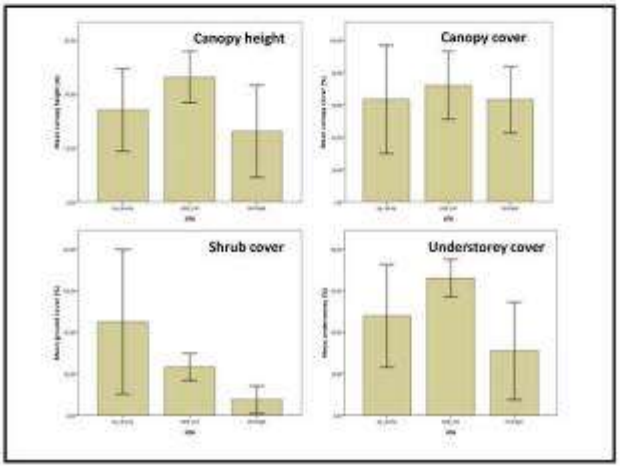
- Photo-captured from Compartment 61.

Camera trapping data – natural spring salt licks

Species	C1-1-C49	C1-2-saltlick	C1-3-saltlick	C1-4-C 61	C1-5-Rawog	C1-6-Rawog	C1-7-C 49	ct1t7_c56	ct2t10_c56	Grand Total
Rusa unicolor	15	123	188	5	26	6	5	1	5	374
Muntiacus atherodes	0	0	0	0	0	4	0	0	0	4
Lophura ignita	0	0	0	2	0	107	0	4	20	133
Sus barbatus	1	25	21	27	2	23	5	9	5	118
Tragulus spp.	24	2	0	9	0	7	3	9	10	64
Macaca nemestrina	4	0	3	0	0	17	1	2	5	32
Arborophila chantleri	0	0	0	0	0	0	0	1	20	21
Viverra tangalunga	0	0	3	1	0	2	0	2	11	19
Argusianus argus	0	0	0	0	0	0	0	15	3	18
Paradoxurus hermaphroditus	0	0	0	0	0	11	0	0	0	11
Bos javanicus	0	1	2	0	2	2	0	0	0	7
Pongo pygmaeus	1	0	1	0	0	2	0	1	2	7
Elephas maximus	0	1	1	0	2	0	0	0	1	5
Echinosorex gymnurus	3	0	0	0	0	0	0	0	0	3
Mydaus javanensis	0	0	0	0	0	0	0	3	0	3
Helarctos malayanus	0	0	0	0	0	1	0	0	1	2
Macaca fascicularis	0	0	0	0	0	0	0	0	2	2
Thecurus crassispinis	0	0	0	0	0	0	0	2	0	2
Hemigalus derbyanus	0	0	0	0	0	0	0	0	1	1
Manis javanica	0	0	1	0	0	0	0	0	0	1
Trichys fasciculata	0	0	0	0	0	0	0	1	0	1
Grand Total	**48**	**152**	**220**	**44**	**32**	**182**	**14**	**50**	**86**	**828**

Camera trapping data – natural spring salt licks

Camera trapping data – natural spring salt licks


Canopy height
Canopy cover
Shrub cover
Understorey cover

Encroachment into the SRCA

- Camera trap stolen.
- Compartment 49 (Kerengas forest).

Conclusion/Management Implications

1) In spite of the disturbed nature of the habitats, SRCA contains a high species richness of mammals.
2) Incl. both common and rare species, and species of high conservation concern – Flat headed cat (new record?)
3) It is important to continue the protection status of SRCA.
4) Maintain the continuity of the forests.
5) Maintain and protect useful habitat features e.g. the natural salt licks.

Conclusion/Management Implications

7) Law enforcement activities needs to be enhanced.
8) It is important to study the effects of habitat disturbance and forest regeneration over time on the mammal community.

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- Sabah Forestry Department, KTS Plantation Sabah, Sabah Wildlife Department
- Institute for Tropical Biology and Conservation UMS
- Dr. Arthur Chung, Dr. Ruben Nilus,
- Mohd. Aminur Faiz, Jabanus Miun
- Ms. Darrysie
- Thank you!

PAPER 2.2

Human-Wildlife conflict and co-existence

H. Muin, R. Jaikim, A. Jamali, A. Mohd. Yaakub, M. Anson, A. Basri & J. Suko

Level 6, State Administrative Building, W.D.T. No. 200, Sabah Wildlife Department, Sandakan, Sabah
**Author for correspondence. Email: hussien.muin@sabah.gov.my*

Abstract. The Segaliud-Lokan Commercial Forest used to be classified as North Kinabatangan MER (Managed Elephant Ranges), but now it is included into Central Sabah MER. Central Forest MER is holding the largest elephant population in Sabah which is estimated around 1,000 elephants. The highest elephant activity recorded is concentrated at the southern Segaliud-Lokan Commercial Forest Reserve, eastern part of Deramakot Forest Reserve and Tangkulap Forest Reserve. The challenges lie ahead is to maintain the connection with other forest reserves. Furthermore, the Pan Borneo Project and the conversion of secondary forests to human activities in other parts of central forest MER will give much pressure to the elephant populations and will force them to venture out towards other people's land. Meanwhile, there are also opportunities to promote these areas as "co-existence" area for the people and elephants.

Slide Presentation

SUNGAI RAWOG CONSERVATION AREA SCIENTIFIC EXPEDITION

08 – 18/08/2018

ELEPHANT

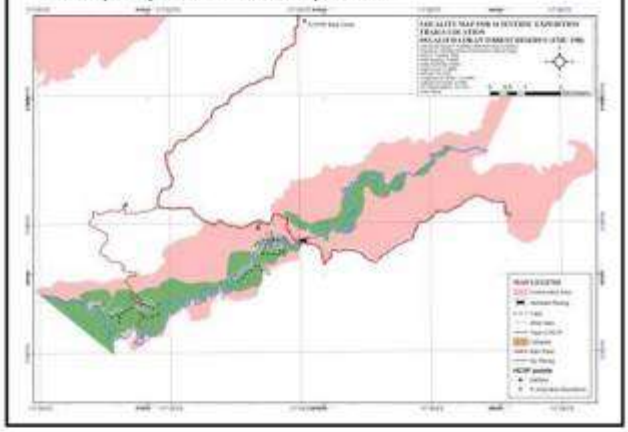
Human- Wildlife Conflict & Co-existence

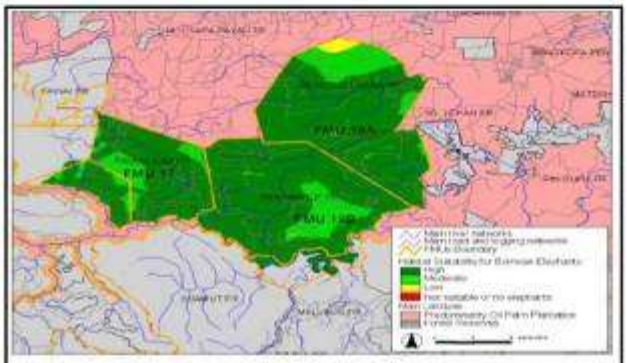
KTS WWF

Sabah Wildlife Department Team

1. Hussien Muin
2. Richard Jaikim
3. Aiddie Jamali
4. Aznandy Mohd. Yaakub
5. Muin Anson
6. Awang Basri
7. Jumat Suko

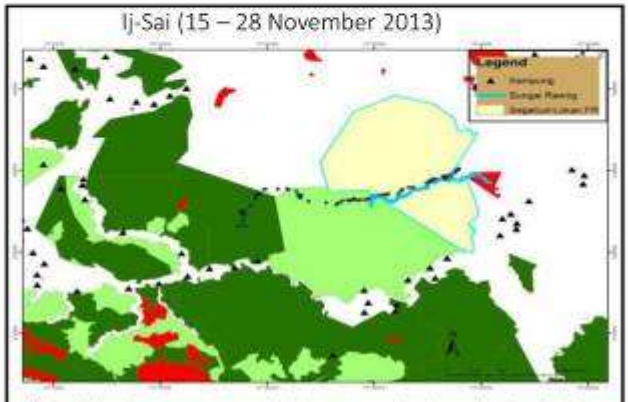
Locality Map For Scientific Expedition





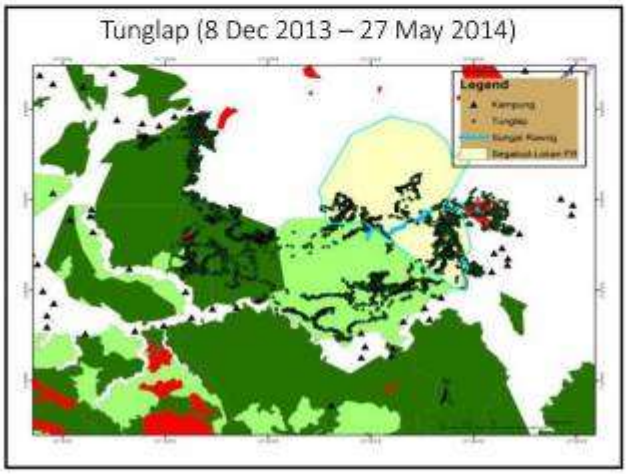
- The Segaliud-Lokan Commercial Forest used to be classified as North Kinabatangan MER, but now it is included into Central Sabah MER (*Managed Elephant Ranges*)
- Central Forest MER is holding the largest elephant population in Sabah which is estimated around 1,000 elephants.

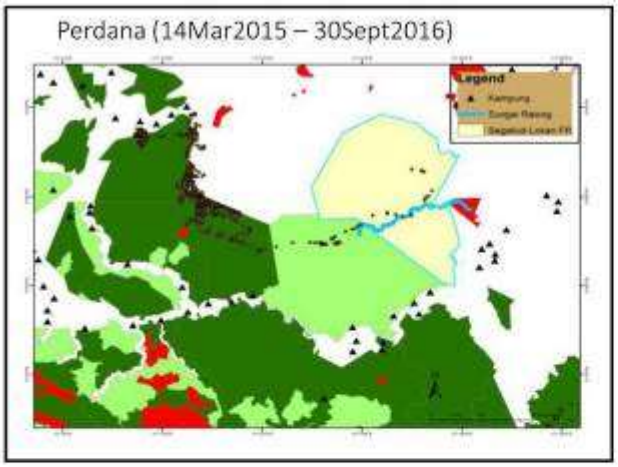
Ij-Sai (15 – 28 November 2013)



- The highest elephant activity recorded is concentrated at the southern Segaliud-Lokan Commercial Forest Reserve, eastern part of Deramakot Forest Reserve and Tangkulap Forest Reserve.

Tunglap (8 Dec 2013 – 27 May 2014)




Perdana (14Mar2015 – 30Sept2016)
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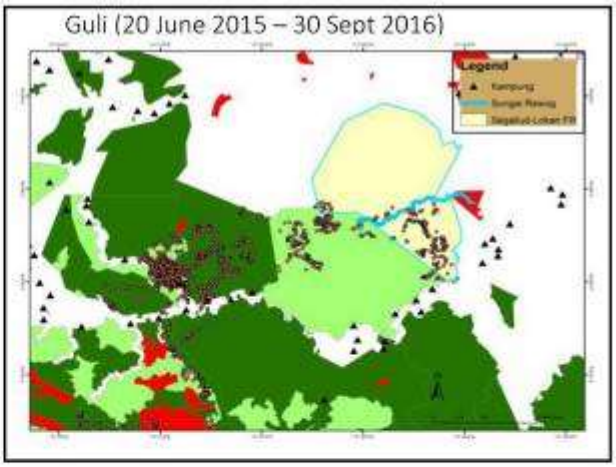
Guli (20 June 2015 – 30 Sept 2016)
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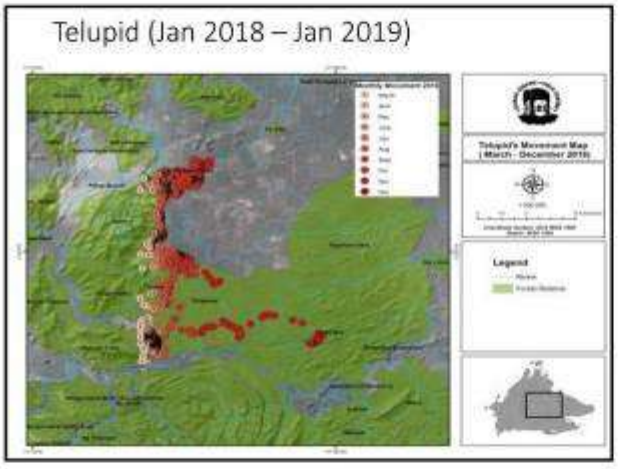
Telupid (Jan 2018 – Jan 2019)
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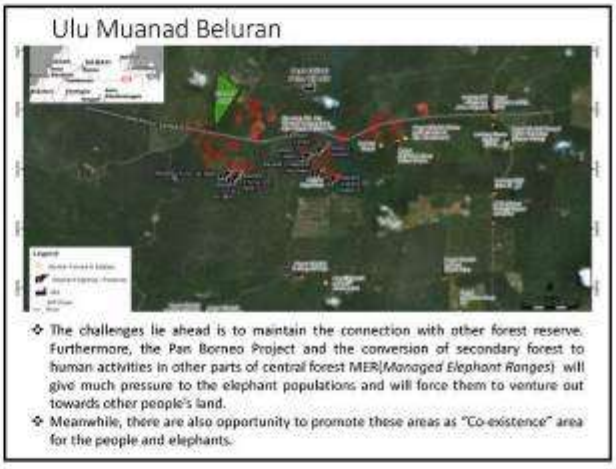
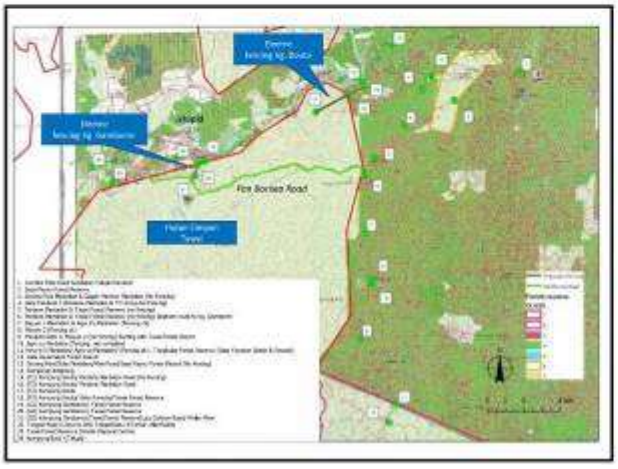
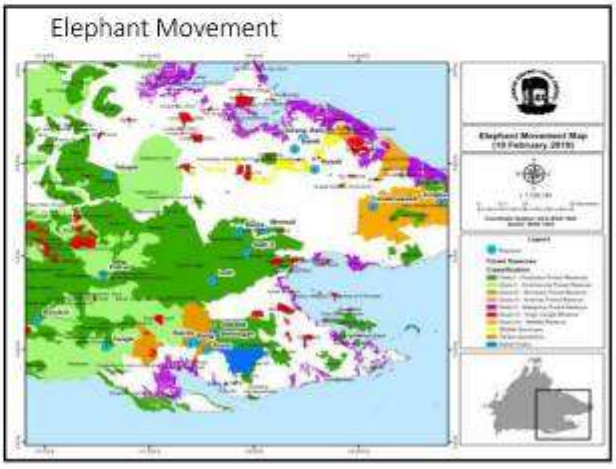

Ulu Muanad Beluran
The challenges lie ahead is to maintain the connection with other forest reserve. Furthermore, the Pan Borneo Project and the conversion of secondary forest to human activities in other parts of central forest MER(Managed Elephant Ranges) will give much pressure to the elephant populations and will force them to venture out towards other people's land.
Meanwhile, there are also opportunity to promote these areas as "Co-existence" area for the people and elephants.


Pan Borneo Road


Elephant Movement

PAPER 2.3

Wildlife survey along the Rawog River Conservation Area, Segaliud Lokan Forest Reserve

J. Sompud[1]*, A. Ambrose[1], E. A. Gilbert[1], A. J. Embug[1], S. Gasinin[2], N. Muroi[3] & K. Kos[3]

[1]Faculty of Science and Natural Resources, Universiti Malaysia Sabah, UMS Road, 88400 Kota Kinabalu, Sabah, Malaysia
[2]Center for Strategic Management and Corporate Communications, Universiti Malaysia Sabah
**Author for correspondence. Email: jephte@ums.edu.my*

Abstract. The Rawog river that stretched along the Rawog Conservation Area is one of the two rivers within the Segaliud Lokan Forest Reserve. Nonetheless, there is still scarce studies that document the wildlife that inhabit along this river. As such, limited information is available to describe the qualities of the Rawog river as part of the protected area. Therefore, this study was conducted during the Rawog Scientific Expedition with the aim to document and update the wildlife that includes birds, terrestrial mammals and crocodile that can be found along that river. Opportunistic observation survey was conducted for both morning and night sessions during the 4 days of expedition. A total of 61 individuals from 31 species and 24 families of wildlife were recorded. Interestingly, there were Endangered species of bird namely the Storm's Stork (*Ciconia stormi*) and one species with Vulnerable status that is Greater Green Leafbird (*Chloropsis sonnerati*) sighted during the survey. Meanwhile, for terrestrial mammals, there one Endangered species namely the Flat-headed cat (*Prionailurus planiceps*) and one Near-Threatened species of amphibian of which, is the Greater Swamp Frog (*Limnonectes ingeri*) were also able to be recorded even though there were no crocodile spotted during the survey. The result from this preliminary survey showed that the Rawog river play an important role in supporting diverse species of wildlife and worth to be retained as the fully protected area inside the Segaliud Lokan Forest Reserve.

Keywords: bird, Borneo, conservation, forest reserve, terrestrial mammals

INTRODUCTION

The Rawog Valley Conservation Area is one the 10 compartments within the Segaliud Lokan Forest Reserve (SFLR) that has been classified as the protected areas by the KTS Plantation management. These protected areas have been set-aside from any activities such as replanting and harvesting not only for the purpose of conserving the biodiversity of the forest but also serve as safeguarding the wildlife corridor that is connected to the Deramakot Forest Reserve.

To date, there is still limited studies that have been done documenting the wildlife population in Rawog valley conservation area. The latest wildlife study was conducted by (Wilting & Mohamed, 2010) in SFLR. However, this research was not focused at the Rawog Conservation Area. Therefore, little is known on the qualities of this conservation area, of which, has become one of the constraints faced by the plantation management especially in terms of enhancing their management prescription of this area that comply with the certification of High Conservation Value Forest (HCVF) management. Hence, this expedition was conducted in order to document and update the fauna population at the Rawog valley conservation area. We conducted a riverine survey along the Rawog river to document the wildlife that are extant there.

MATERIALS & METHODS

Study Sites

The Rawog Valley Conservation Area comprises four compartments, namely Compartment 49, 52, 56 and 61 (Figure 1). Apart from that, this conservation area also has a river with the length of 23.4 km that flows in from the Deramakot Forest Reserve in the northern part and flows out to the nearby Malbumi Oil Palm Estate at the southern part. The survey was conducted at the Rawog river from 9th to 11th August 2018.

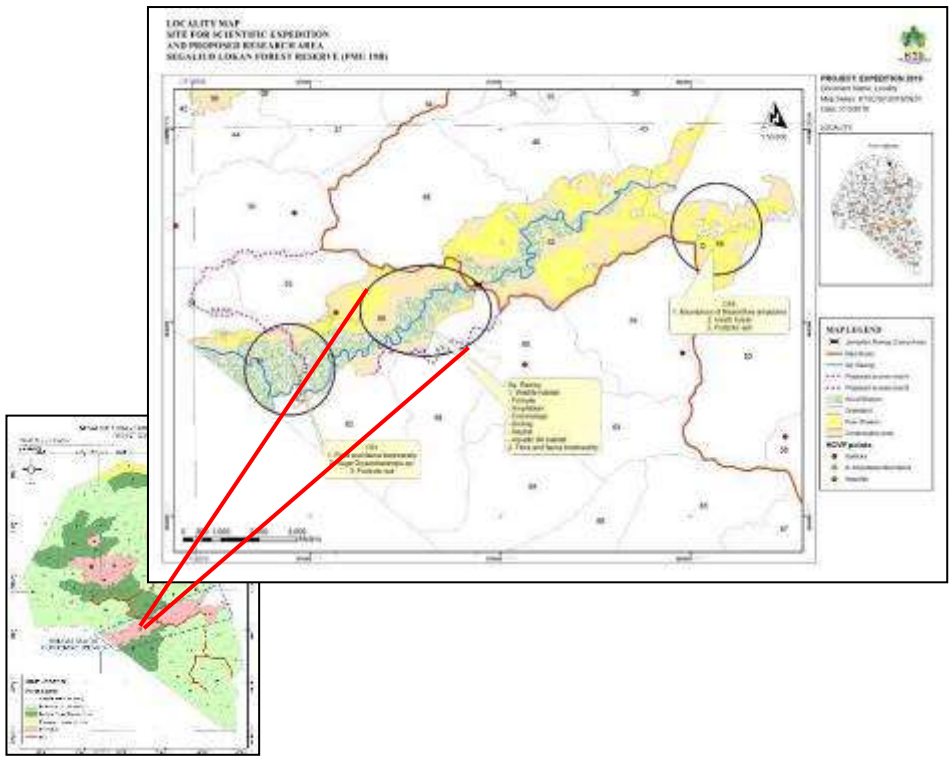


Figure 1. Map of Rawog river within the conservation area of Segaliud Lokan Forest Reserve (KTS Plantation Sdn. Bhd., 2018).

Wildlife Survey

The preliminary survey was conducted by using a standard line transect survey method adopted from (Rabinowitz, 1993) along the Rawog river. The opportunistic observation survey was conducted in two sessions namely morning and night session for each day by using a binocular with 10x40 magnification. In the morning, the survey was conducted as early as 6.30am until 11.30am. Meanwhile, at night the survey was started at 7pm until 10pm. The "Birds of Borneo" (Phillips & Phillips, 2011) and "Mammals of Borneo" (Payne *et al*., 1985) field guide books were being used for the identification of the observed wildlife. Apart from that, photos of the wildlife were taken in order to help in reconfirming the recorded species. The GPS location of observed species along the Rawog river was also recorded.

RESULTS

A total of 68 sightings comprises from 31 species and 24 families of wildlife were recorded for both morning and night surveys on 9th until 12th August 2018 at Rawog river including the 7 individuals of unidentified species. The number of sightings, species and family based on morning and night survey are shown in Figure 2. The findings from morning survey showed a total of 43 sightings from 25 species and 15 families of wildlife that were recorded. Meanwhile, there were 25 sightings from 12 species and 9 families recorded during the night survey.

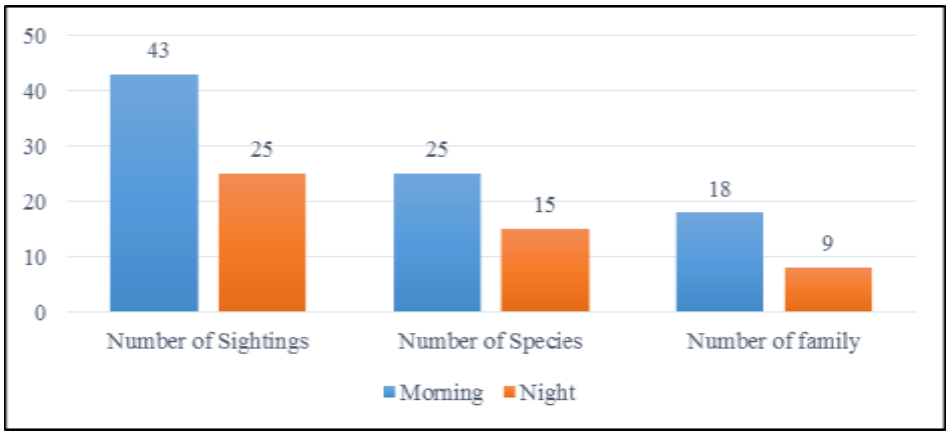


Figure 2. Total number of sightings, species and families based on morning and night surveys.

The result of this expedition showed that there were 41 sightings of birds (shown in Table 1) and 3 sightings of mammals (referred to Table 2) including the unidentified species that were able to be recorded during the morning survey. The Whiskered treeswift (*Hemiprocne comate*) and Black-winged flycatcher shrike (*Hemipus hirundinaceus*) recorded the highest number with 4 individuals. This was then followed by several species of birds such as Darter (*Anhinga melanogaster*), Raffles's malkoha (*Phaenicophaeus chlorophaeus*), Blue-throated bee-eater (*Merops viridis*) and Red-eyed bulbul (*Pycnonotus brunneus*) with 3

individuals recorded each. Meanwhile, there were only 2 mammals recorded namely the Prevost squirrel (*Callosciurus prevostii*) and unidentified treeshrew.

Table 1. Species of birds recorded at morning survey.

Family/Species	Observation	Conservation status (IUCN)
Aegithinidae		
Green Iora (*Aegithina viridissima*)	2	Near-threatened
Alcedinidae		
Blue-eared kingfisher (*Alcedo meninting*)	1	Least concern
Stork-billed kingfisher (*Pelargopsis capensis*)	1	Least concern
Anhingidae		
Darter (*Anhinga melanogaster*)	3	Near-threatened
Bucerotidae		
Oriental pied hornbill (*Anthracoceros albirostris*)	1	Least concern
Chloropseidae		
Greater green leafbird (*Chloropsis sonnerati*)	1	Vulnerable
Ciconiidae		
Storm's Stork (*Ciconia stormi*)	1	Endangered
Cuculidae		
Raffles's malkoha (*Phaenicophaeus chlorophaeus*)	3	Least concern
Red-billed malkoha (*Phaenicophaeus javanicus*)	2	Least concern
Dicaeidae		
Orange-bellied flowerpecker (*Dicaeum trigonostigma*)	1	Least concern
Eurylaimidae		
Black-and-Yellow broadbill (*Eurylaimus ochromalus*)	1	Near-threatened
Hemiprocnidae		
Whiskered treeswift (*Hemiprocne comata*)	4	Least concern
Hirundinidae		
Pacific swallow (*Hirundo tahitica*)	1	Least concern
Meropidae		
Blue-throated bee-eater (*Merops viridis*)	3	Least concern
Red-bearded bee-eater (*Nyctyornis amictus*)	1	Least concern
Monarchidae		
Black-naped monarch (*Hypothymis azurea*)	1	Least concern
Muscicapidae		
Malaysian blue flycatcher (*Cyornis turcosus*)	2	Near-threatened
Nectariniidae		

Eastern crimson sunbird (*Aethopyga siparaja*)	1	Least concern
Pycnonotidae		
Red-eyed bulbul (*Pycnonotus brunneus*)	3	Least concern
Vangidae		
Black-winged flycatcher shrike (*Hemipus hirundinaceus*)	4	Least concern
Unidentified	4	

Table 2. Species of mammals recorded at morning survey.

Family/Species	Observation	Conservation status (IUCN)
Sciuridae		
Prevost squirrel (*Callosciurus prevostii*)	1	Least concern
Long tailed macaque	1	Least concern

During the night survey, there were 6 species of birds (as shown in Table 3), 7 species of amphibians, one species of reptile and one species of mammal shown in Table 4 including the unidentified species that were able to be recorded. The Black-and-red broadbill (*Cymbirhynchus macrorhynchos*) and White-chested babbler (*Trichastoma rostratum*) recorded the highest with 3 individuals each. Apart from that, the Greater Swamp Frog (*Limnonectes ingeri*) was recorded the highest abundance with 3 individuals during the survey.

Table 3. Species of birds recorded during night survey.

Family/Species	Observation	Conservation status (IUCN)
Alcedinidae		
Blue-eared kingfisher (*Alcedo meninting*)	2	Least concern
Stork-billed kingfisher (*Pelargopsis capensis*)	1	Least concern
Eurylaimidae		
Black-and-red broadbill (*Cymbirhynchus macrorhynchos*)	3	Least concern
Muscicapidae		
Malaysian blue flycatcher (*Cyornis turcosus*)	2	Near-threatened
Pellorneidae		
White-chested babbler (*Trichastoma rostratum*)	3	Near-threatened
Unidentified	1	

Table 4. Species of amphibians, reptiles and mammals recorded during night survey.

Family/Species	Observation	Conservation status (IUCN)
Bufonidae		
River toad (*phrynoidis asper*)	2	Least concern
Dicroglossidae		
Giant river toad (*Limnonectes leporinus*)	1	Least concern
Greater Swamp Frog (*Limnonectes ingeri*)	3	Near threatened
Colubridae		
Grey-tailed racer (*Gonyosoma oxycephalum*)	1	Least concern
Felidae		
Flat-headed cat (*Prionailurus planiceps*)	1	Endangered
Ranidae		
Copper-cheeked frog (*Hylarana ranicep*)	2	Least concern
Poisonous rock frog (*Odorrana hosii*)	1	Least concern
Rough-sided frog (*Hylarana glandulosa*)	1	Least concern
Unidentified	1	

The result in Figure 3 shows that there is an increasing pattern in terms of species accumulation as the asymptote curve has not reach the optimum point. This indicates that there is more species of wildlife that have not been documented at the Rawog River. Apart from that, the graph also showed 38 species of wildlife were able to be recorded within four days of survey. Hence, this suggests that there are diverse species of wildlife that were able to be observed even within a short period of time of the survey.

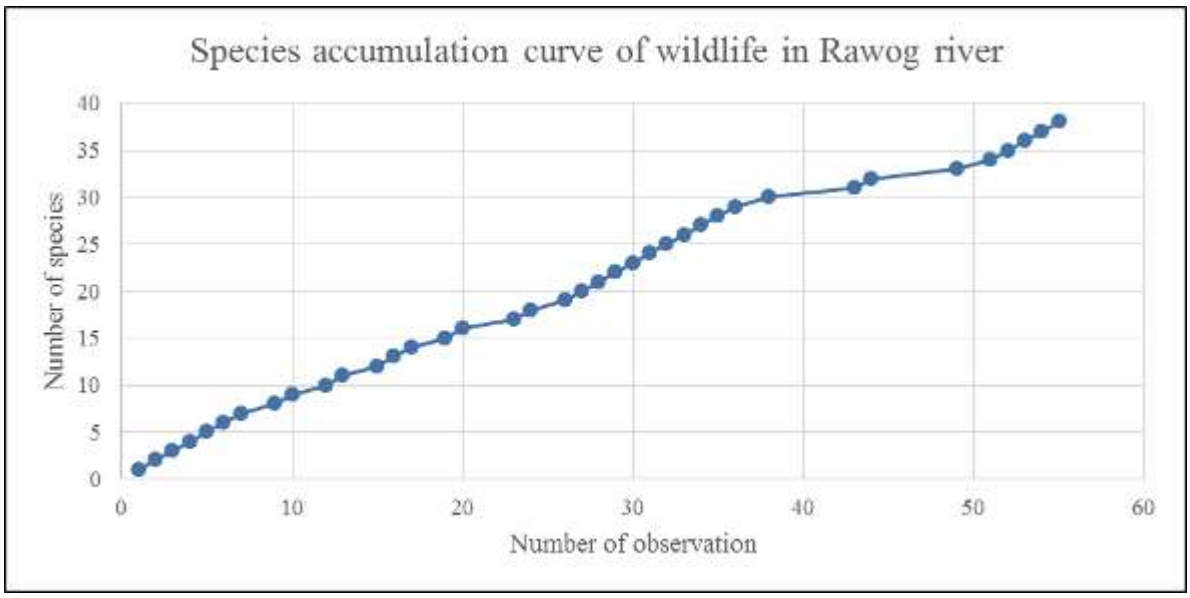


Figure 3. Species accumulation curve of wildlife in Rawog River.

DISCUSSION

The results from this survey have provided insights on the wildlife population inhabit along the beautiful Rawog River. The diverse species of wildlife that were recorded throughout the expedition comprises of birds, mammals, reptile and amphibians. The availability of food resource can influence the species composition of wildlife (White, 1978). Hence, this indicates that the Rawog river does provide sufficient food resource for the wildlife.

Interestingly, the Storm's Stork (*Ciconia stormi*) that is classified as Endangered species under the International Union for the Conservation of Nature Redlist (IUCN, 2018) was recorded in Rawog river. This species was also recorded at the Kinabatangan river in Sukau, Sabah (Ali *et al*., 2018). Phillips & Phillips (2011) stated that the Storm's Stork (*Ciconia stormi*) is also a scarce local resident in Borneo. Meanwhile, according to the International Union for the Conservation of Nature Redlist (IUCN, 2018) there were also one Vulnerable and 5 Near-Threatened species of bird namely Greater Green Leafbird (*Chloropsis sonnerati*), Green Iora (*Aegithina viridissima*), Darter (*Anhinga melanogaster*), Black-and-Yellow Broadbill (*Eurylaimus ochromalus*), Malaysian Blue Flycatcher (*Cyornis turcosus*) and White-chested Babbler (*Trichastoma rostratum*) that were able to be recorded during the survey. The study done by (Lee *et al*., 2018) also recorded this species in plantation compartments of Segaliud Lokan Forest Reserve. Hence, it reconfirms the existence of this species within this forest reserve. Meanwhile, study done by (Lee *et* al., 2018) also recorded this species in plantation compartments of Segaliud Lokan Forest Reserve. Hence, it reconfirms the existence of this species. Past study done by (Bing *et al*., 2013) also recorded the White-chested Babbler (*Trichastoma rostratum*) at the logged dipterocarp forest at Berkelah Forest Reserve, Pahang. The presence of the Endangered, Vulnerable and Near-Threatened species of birds showed that the habitat structure of Rawog river plays a significant role in supporting the survival of these species of birds. This is because habitat quality and resources can affect the species composition of birds (Muniale *et al*., 2014) in that area.

The result of this survey also showed that the Greater Swamp Frog (*Limnonectes ingeri*) was able to be recorded among the 7 other species of amphibians in Rawog river. According to the International Union for the Conservation of Nature Redlist (IUCN, 2018), this species is categorized as Near-Threatened species. In addition, this species was also similarly found by (Haas et al., 2018) at the Maliau Basin Conservation Area, Sabah. Amphibians are vulnerable to the changes of their environment of which, made them suitable to be one of the biological indicators (Sewell & Griffiths, 2009; Gardner, 2001) to determine the health of the forest ecosystem. The Flat-headed cat (*Prionailurus planiceps*) was also spotted during the survey at the Rawog river. According to (Wilting & Mohamed, 2010), this species was suspected to be found in Segaliud Lokan Forest Reserve eventhough it was able to be recorded during their camera trap survey in this forest reserve. Interestingly, this species was also recorded by (Hearn *et al.,* 2010) at the Lower Kinabatangan Wildlife Sanctuary. This species was classified as one of fully protected species under the Sabah Wildlife Conservation Enactment (1997) joining other iconic animals such as Bornean orangutan (*Pongo pygmaeus*) and Sun Bear (*Helarctos malayanus*). Moreover, this species is also a protected species under the Sarawak Wild Life Protection Ordinance (1998) and the

Appendix of the Government of Republic of Indonesia Regulation No. 7 (1999). Hence, it indicates the drastic declination of the population of this species in Borneo. Therefore, this highlights that the conservation of the Rawog River is very important in order to ensure the survival of this species.

Species accumulation graph was established based on the data recorded during the survey. The finding from this graph showed that diverse species of wildlife were able to be found even within a short period of survey. Hence, it suggests that the Rawog river has high diversity of wildlife. Apart from that, the increasing pattern of the species accumulation curve indicates that there is still more species of wildlife that have yet to be documented in Rawog river. Therefore, there is an urgent need to continue this study in the future at a longer period in order to obtain rigid data of wildlife population for the benefit of KTSP management in monitoring and executing proper conservation management plan for this conservation area.

CONCLUSION

The findings from this survey showed the Rawog River support diverse species of wildlife of which includes the species that are classified as the Endangered, Vulnerable and Near-Threatened status. This indicates that the river acts as an important habitat for the wildlife and it is crucial that this conservation area being remained as a fully protected area in Segaliud Lokan Forest Reserve. Apart from that, further study still need to be conducted in the Rawog River in order to obtain holistic data that can be incorporated by the KTSP management inside their management plan to enhance their conservation management work in this conservation area.

ACKNOWLEDGEMENT

We would like to acknowledge KTS Plantation Sdn. Bhd. and Forestry Department of Sabah for providing our research team the accommodation and assistance throughout the expedition at Rawog Conservation area. Our appreciation also goes to Pg. Mohd Sahlan bin Salam from Forest Research Centre (FRC) Sandakan for assisting our team in the identification of the frog species.

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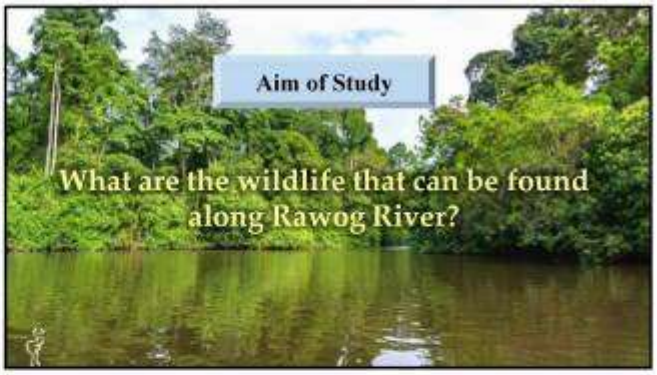
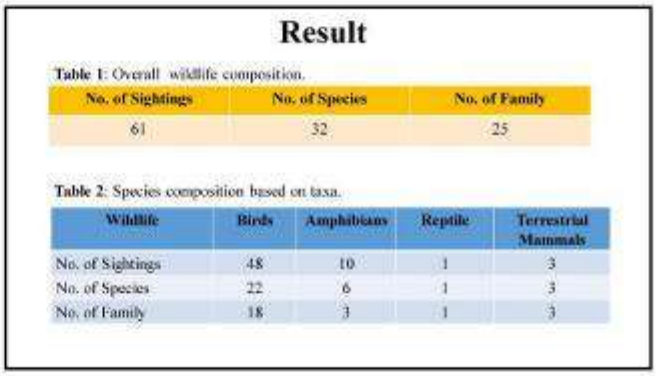
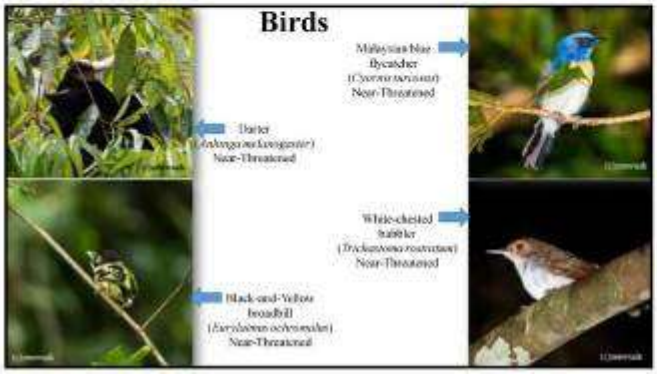
Slide Presentation







Discussions

- Lee *et al*. (2018) SLFR = 55 birds species.
- Lee et al., (unpublished data, 2019) = 120 bird species in SLFR. Inclusive → The White–chested babbler
- Wilting & Mohamed (2010) → suspects the existence of the Flat-headed cat. (*Prionailurus planiceps*).
- White (1978) → Availability of food resource influences wildlife composition.

Conclusion

The Conservation Area should remain as a fully protected status in Segaliud Lokan Forest Reserve.

Acknowledgements

KTS PLANTATION SDN BHD

Thank You

PAPER 2.4

Rapid wildlife survey in Sg. Rawog

E. Alim*, M. Kapis, T. Tindok & Z. Rahman

WWF-Sabah, Suite 1-6-W11 6th Floor, CPS Tower, Centre Point Complex, No. 1, Lrg. Centre Point, Pusat Bandar, 88000 Kota Kinabalu, Sabah
**Author for correspondence. Email: ealim@wwf.org.my*

Abstract. The survey team established a 2 km transect cut at right-angles to the access road, with a starting point at 50 m from the nearest access road, and then marking every 100 m. During the 2-day survey, nine (9) species of mammals and twenty-eight (28) species of birds were recorded. The team discovered signs of endangered species such as Orangutan, the Asian Elephant and Sun Bear. One group of gibbons was identified within the immediate area. One wildlife pathway was found, suggesting that the area is functioning as a corridor. It is recommended that more transects are to be established for long-term fauna biodiversity monitoring and management.

INTRODUCTION

The transect method for wildlife survey is used to identify presence and locations of wildlife. It is most suitable for rapid wildlife surveys due to efficiency and ease of replication. The concession is known to host rich fauna diversity including 75 species of mammals, 220 species of birds and over 100 species of reptiles, amphibians and fish (Sabah Forestry Department, 1995). The Sg. Rawog area was set aside as a conservation area in consideration for wildlife movement from Segaliud Lokan Forest Reserve (managed by KTS Plantation Sdn. Bhd.) to the adjacent Deramakot Forest Reserve, although species habitat is not restricted to the conservation area. The transect area is a generally flat swamp area with muddy ditches, shrubs and sparse riverine trees.

METHOD

During the 2-day survey, the team applied a recently developed WWF-Malaysia General Wildlife Survey method. The survey team established a 2 km transect cut at right-angles to the access road, with the starting point 50 m from the road edge on the first day at a location near Trail 1. The start and end points were marked at 5.44792 N, 117.52687 E and 5.44856 N, 117.54488 E respectively. Marking tapes were left at 100 m intervals. This resulted an east-to-west line with the end point almost reaching one of Sg. Rawog bend as demonstrated in Figure 1. The location was selected as guided by the indication of good forest stratum in the expedition map. The survey team conducted 2 km walk starting at 06:00

to record direct sightings, footprints, nests and calls of wildlife. Directions of gibbon calls were estimated using compass which was later used to triangulate gibbon group location(s).

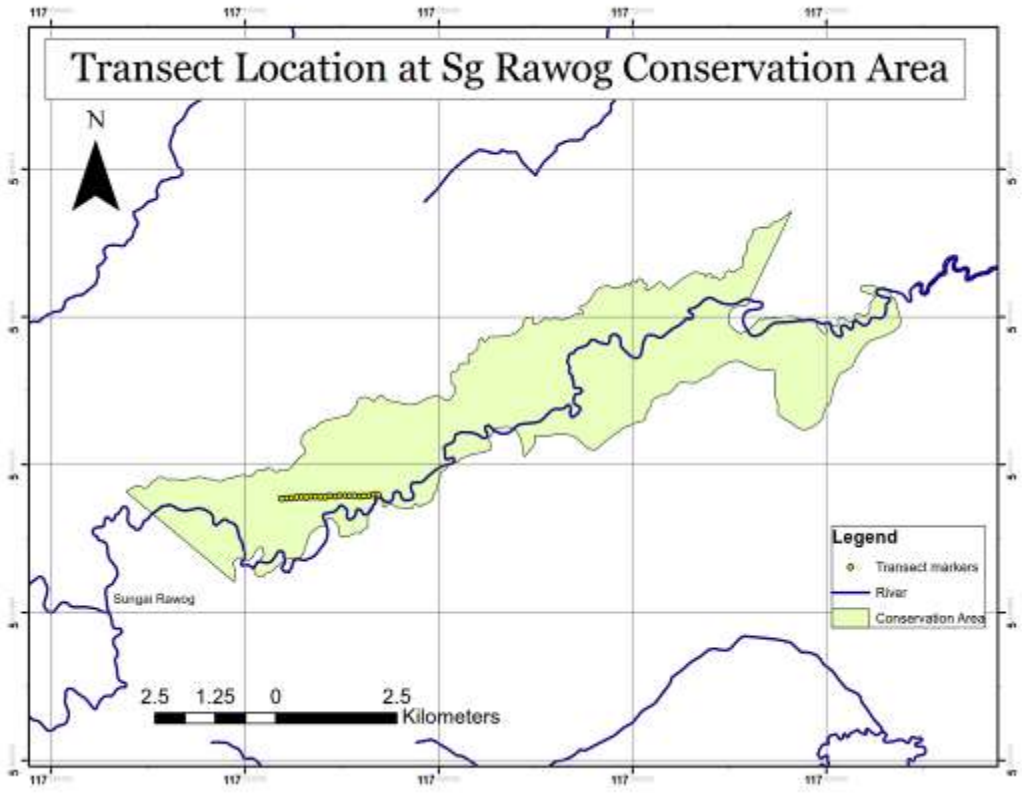


Figure 1. Location of survey transect.

RESULTS

Throughout the 2-day survey, nine (9) species of mammals and twenty-eight (28) species of birds were recorded. Birds were almost entirely identified by calls. Indirect observation such as footprints, wallows and wildlife clearing contributed to most of mammal's record. Direct sightings of gibbons, grey-leaf monkey and a Horseshoe bat highlighted the 2-day survey. The team found signs of iconic species such as the Asian Elephant, Sun Bear and Orangutan without any direct observation of these species. Full list of species with reference to common species range in Borneo (Phillips & Phillips, 2014, 2018) are tabulated in the following Table 1 and Table 2.

Table 1. List of mammals.

No	Common name	Scientific name
1	Trefoil Horseshoe Bat	*Rhinolophus trifoliatus*
2	Bearded Pigs	*Sus barbatus*
3	Asian Elephant	*Elephas maximus*
4	Bornean Gibbon	*Hylobates funereus*

5	Grey Leaf Monkey	*Presbytis sabana*
6	Orangutan	*Pongo pygmaeus*
7	Sambar Deer	*Cervus unicolor*
8	Sun Bear	*Helarctos malayanus*
9	Ground Squirrel	*Lariscus* sp.

Table 2. List of birds.

No	Common name	Scientific name	No	Common name	Scientific name
1	Asian Black Hornbill	*Anthracoceros malayanus*	15	Green Imperial Pigeon	*Ducula aenea*
2	Barbet	*Megalaima* sp.	16	Helmeted Hornbill	*Buceros vigil*
3	Black-naped Monarch	*Hypothymis azurea*	17	Hill Myna	*Gracula religiosa*
4	Blue-eared Barbet	*Megalaima australis*	18	Jungle Crow	*Corvus macrorhynchos*
5	Blue-breasted Quail	*Coturnix chinensis*	19	Kingfisher	*Alcedo* sp.
6	Bulbul	*Pycnonotus* sp.	20	Little Spider Hunter	*Arachnothera longirostra*
7	Chestnut-winged Babbler	*Stachyris erythroptera*	21	Oriental Magpie Robin	*Copsychus saularis adamsi*
8	Chestnut-naped Forktail	*Enicurus ruficapillus*	22	Parrot	*Loriculus galgulus*
9	Common Iora	*Aegithina tiphia*	23	Pitta	*Pitta* sp.
10	Cream-vented Bulbul	*Pycnonotus simplex*	24	Rhinoceros Hornbill	*Buceros rhinoceros*
11	Crested Jay	*Platylophus galericulatus*	25	Thick-billed Spiderhunter	*Arachnothera flavigaster*
12	Cinereous Bulbul	*Hemixos cinereous*	26	White-crowned Forktail	*Enicurus borneensis*
13	Great Argus	*Argusianus argus*	27	White-crowned Shama	*Copsychus stricklandi*
14	Greater Coucal	*Centropus sinensis*	28	Yellow-rumped Flowerpecker	*Prionochilus xanthopygius*

DISCUSSION

The team discovered consistent early morning gibbon calls near the starting point (transect length 0-300m). This suggests that there is at least one group of gibbons within the immediate surrounding. The group location could not be determined as the calls were no longer consistently heard at other points of the transect. Sg. Rawog is also an orangutan

habitat; relatively old Class 3 and Class 4 nests were found sporadically along the transect. No signs of tembadau, known to roam in the concession, was found along the transect.

A well-used wildlife pathway was found at 1100 m containing multiple-species footprints including elephant. Considering that it is only about 2.5 km from Deramakot Forest Reserve boundary, the wildlife corridor function of the Sg. Rawog Conservation Area might be demonstrated with a long-term wildlife monitoring plan here.

The transect method used was designed for rapid survey. The data obtained is too small to be further analyzed. However, if utilized in the long term, it could produce more useful pattern of wildlife changes for management purposes-in combination with other methods such as camera trapping in forested area and night drive along the access road. It is also recommended that the management select key species indicators for long term High Conservation Value (HCV) monitoring and management for the Sg. Rawog Conservation Area.

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Slide Presentation

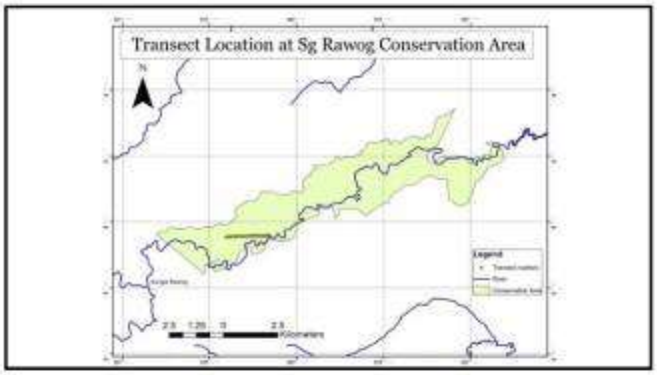
RAPID WILDLIFE SURVEY
SG RAWOG SCIENTIFIC EXPEDITION
8-12 AUGUST 2018

WWF-MALAYSIA
Elyrice Alim
Middleseen Kapis
Tinrus Tindok
Zuraimi Rahman

Method

WWF-Malaysia General Wildlife Survey method

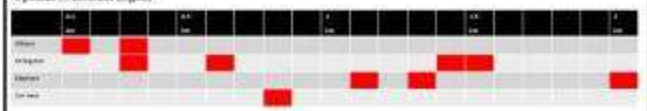
- 2 km transect cut at right-angles to the access road
- Starting point 50 m from the access road
- Marking tapes at 100 m intervals
- 2 km walk starting at 06:00 to record direct sightings, footprints, nests and sounds of wildlife.



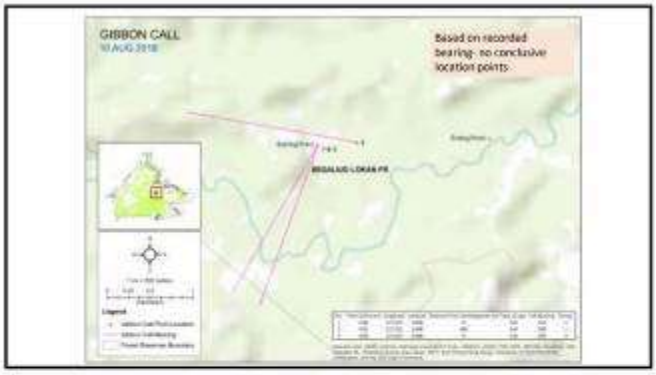
Findings

No sign of poaching.

Species of interest (signs)



Total observation (calls+signs+direct observation)



List of mammals

No	Common name	Scientific name
1	Trifoil Horseshoe Bat	*Rhinolophus trifoliatus*
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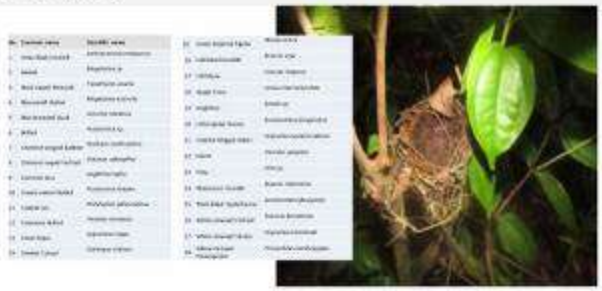
7	Sambar deer	*Cervus unicolor*
8	Sun Bear	*Helarctos malayanus*
9	Ground Squirrel	*Lariscus sp.*

List of birds



Discussion + Recommendation

- Data too small for further analysis
- Method suitable for rapid survey. However, strategic application in the long term monitoring will produce more useful pattern of wildlife changes for management purposes. This may complement other methods i.e. camera trapping.
- Select wildlife monitoring indicator for biodiversity High Conservation Value monitoring. (e.g gibbon group or orangutan nest count in Conservation Area)
- Prioritize iconic/endangered species.
- Consistent method+ good indicator +defined area+ long term effort = Good monitoring.

Thank You

PAPER 2.5

High tolerance to extreme environment: the case of a catfish in Rawog

A. H. Ahmad & H. H. Mahsol

Institute for Tropical Biology and Conservation, Universiti Malaysia Sabah
Authors for correspondence. Email: abdulhamidahmad.sabah@gmail.com & hairulha@ums.edu.my

Abstract. Some of tropical freshwater fish are able to tolerate very low dissolved oxygen and over a range of acidity. Natural habitats provide a wide range of ecological settings allowing for specialists that could live in the different microhabitats, hence reducing competition. Sluggish and small waterways and stagnant ponds in around the Sg. Rawog Conservation Area were examined for the presence of freshwater fishes. The values for acidity and dissolved oxygen from each station were recorded. We report here the different levels of tolerance of freshwater fish species against acidity and dissolved oxygen, with a species of catfish being the only species found in the stagnant black water ponds.

INTRODUCTION

Studies on Bornean fresh water fishes began during the Dutch East Indies (Indonesia) administration beginning in 1800, with the major work published by Bleeker from 1850 to 1860 (see Roberts, 1986). Although Inger and his co-workers made collection in Sarawak prior to his similar collection and ichthyological work in eastern North Borneo, only the second collection was published (Inger, 1962). There are indeed newer work after 1962, but the current knowledge on the freshwater fishes of Borneo demands much more input.

After several field trips involving undergraduates from Universiti Malaysia Sabah (UMS), we have developed some interests in looking at inland fishes, in particular fishes occupying sluggish water bodies including in freshwater swamps and peatlands. These habitats are usually isolated and certainly difficult to reach, and our team intends to respond to any opportunity working in such areas. This is our first report from the work carried out in Sungai Rawog Conservation Area (SRCA) within the Segaliud Lokan FMU19 Forest Reserve. Our objective was to match species of freshwater fishes to their immediate surrounding characteristics, in particular the pH and dissolved oxygen.

MATERIALS AND METHODS

Our team visited SRCA during the SRCA Scientific Expedition held from 8th t0 18th of August 2018. We spent three days carrying out work in freshwater fishes. Small streams, little creeks and black water ponds were searched for fishes. The majority of the samples

were collected using electro-fishing assisted with the use of hand held nets and bare hands. On many occasions, streams were too small, reduced to very small puddles and trickling waters, on which the use of methods other than electro-fishing were not feasible. Physical parameters were recorded, which were the pH and the values of dissolved oxygen. Because of the limitation in the volume, size and the physico-chemical characteristics of water bodies we worked on, the effort yielded a low number or species, although the was the usual marked density of selected species.

RESULTS

A total of 8 species of freshwater fishes were collected, and expectedly low in species diversity against the possibly high number of species living in all freshwater systems in SRCA. Out of this number, three species (38%) are known as the air-breathing fishes – species of fish capable of living in water bodies with low dissolved oxygen. These were the betta, catfish, snakehead, which accounted. It was also of note that some species, which are usually found inhabiting flowing clear water with better physical parameters were also present in some of the samples, which were similarly obtained from waters with low DO and pH. These were *Puntius sealei, Nematabramis* sp, *Rasbora* sp and the loach, *Nemachilus* sp.

Our data recorded DO ranging from as low as 2.97 to 7.6 mg/mL and pH from 3.4 to 7.5, demonstrating the distinct differences to otherwise fast flowing and clear water in the undisturbed rainforest. It also showed that most of the streams in the sampling area within SRCA were slow moving with intermittent ponding within the forests.

Table 1 shows the distribution of species following the pH and DO gradient. Species diversity gradually reduced with decreasing pH and DO, with one species of catfish being the only species living in the most acidic and with lowest DO – the stagnant black water peat ponds.

Table 1. The species list and their distribution along the physical parameters of their habitats.

DO (mg/mL) pH	7.6 7.5	6.5 6.9	4.8 6.5	3.9 4.2	2.9 3.4
Clarias sp.		+	+	+	+
Channa melasoma	+		+	+	
Betta sp.		+	+	+	
Nemachilus sp.	+	+			
Puntius sealei	+	+			
Nematabramis sp.	+	+			
Rasbora sp.	+				
Dermogenys sp.	+				

DISCUSSION

The presence of three species of air-breathing fish was a reflection of the freshwater habitats within SRCA which contains water bodies that are slow moving, disallowing rapid movement of water, hence low DO. Low DO is also associated with the types of substrate in the water bodies. Those with mud and decomposing organic matter tend to be acidic and contain less oxygen. The values of the DO and pH for the black water ponds within SRCA are consistent with the findings in peatland areas in Sarawak (Rosli *et al*., 2010).

The black water ponds are located on a higher plateux with small creeks flowing down from the area. This was rather interesting because the catfish was the only species occupying the ponds. The invasion of the ponds, apart from overland movement, which most catfish are capable of, could happen as a result of severe flooding. After the such floods, although the ponds were initially habituated by several more species, most die out due to the shrinking of the pond size alongside the increase of acidity and decreasing DO.

Borneo is one of the centre of speciation of the catfish from the genus *Clarias*. Because of Sg. Rawog is a tributary of Sg. Lokan, which eventually joins the Kinabatangan and empties to the east coast of Sabah, the ichthyofaunal from this area should be viewed with interest as many of the easterly flowing rivers in Sabah might not have been connected to the Great Sunda River in the west, hence the possibility of having a different fish assemblage.

ACKNOWLEDGEMENTS

We thank Sabah Forestry Department and KTS Plantation Sdn. Bhd. for the invitation to join the expedition and the opportunity given for the stay and sampling. Rangers from KTS Plantation helped in the field. We are grateful to the assistance both in the field and the base camp, during which the stay was comfortable. Universiti Malaysia Sabah provided transportation and the time away from office, which we appreciate.

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Slide Presentation

High tolerance to extreme environment – the case of a catfish at Rawog

Abdul Hamid Ahmad[1] and Hairul Hafiz Mahssi[2]
Institute for Tropical Biology and Conservation
Universiti Malaysia Sabah
[1]abdulhamidahmad.sabah@gmail.com; [2]hairulhs@ums.edu.my

"Air breathing fishes"

- Modified air sacs, usually under skull bones
- Adaptation in low DO habitats
- Lungfish, catfish, snakehead, climbing perch, gourami, fighting fish, eels

Specializations lead to invasions of extreme conditions – speciation – new species (Yay!)

Sluggish streams, ponds

Electroshocking

How many species?

- We found 8, possibly 9 species
- Low diversity – as expected
- There are many/extensive peatland, kerangas and low-quality soils within SRCA – there are still a lot of opportunities in ichthyology and taxonomic work!

Snakehead
Channa melasoma

Catfish
Clarias sp

Catfish
Clarias sp

Fighting fish
Betta sp

Cyprinid
Puntius sealei

Loach
Nemachilus sp

Halfbeak
Dermogenys sp

Rasbora
Rasbora sp

Fish distribution following pH and DO gradient

DO (mg/mL) pH	7.6 7.5	6.5 6.9	4.8 6.5	3.9 4.2	2.9 3.4
Clarias sp		+	+	+	+
Channa melasoma	+		+	+	
Betta sp		+	+	+	
Nemachilus sp	+	+			
Puntius sealei	+	+			
Nematabramis sp	+	+			
Rasbora sp	+				
Dermogenys sp	+				

Acknowledgements:

Sabah Forestry Department, KTS Plantations Sdn Bhd, UMS, Sabah Wildlife Department, Sabah Parks, WWF Malaysia

Friends, former students, rangers, drivers, Security personnel, cooks.

Kaaamurang jugalah!

PAPER 2.6

Avifaunal survey of Sungai Rawog Conservation Area, Segaliud Lokan Forest Reserve

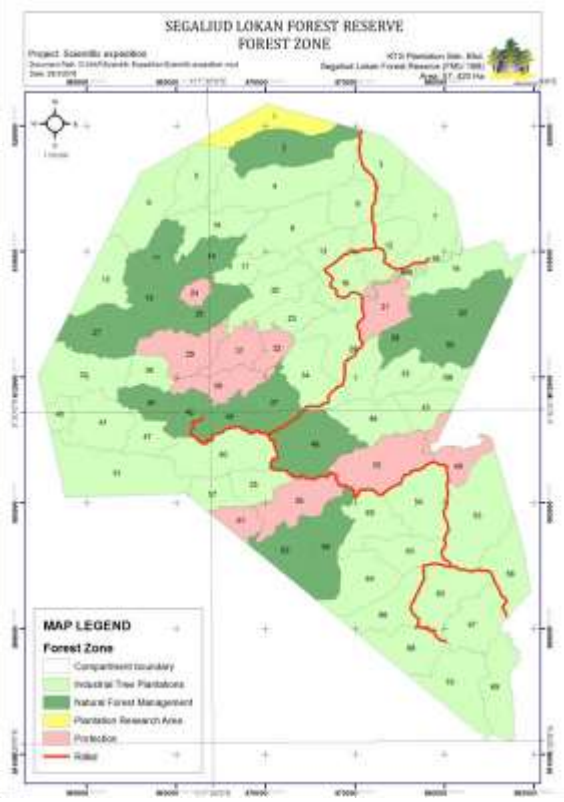
G. H. Petol[1*] & V. Rudolf[2]

[1] Rainforest Discovery Centre, Forest Research Centre, Sepilok
[2] Menara Kayangan, Mt. Silam, Lahad Datu District Forestry Office
**Author for correspondence. Email: Hubert.Petol@sabah.gov.my*

INTRODUCTION

Birds are important indicators of forest health and have been included when surveying biodiversity. This reports documents the outcomes of a brief bird survey conducted during the Sungai Rawog Conservation Area Scientific Expedition on the 8th-18th August 2018. The expedition was co-organized by KTS Plantations Sdn. Bhd. and the Sabah Forestry Department.

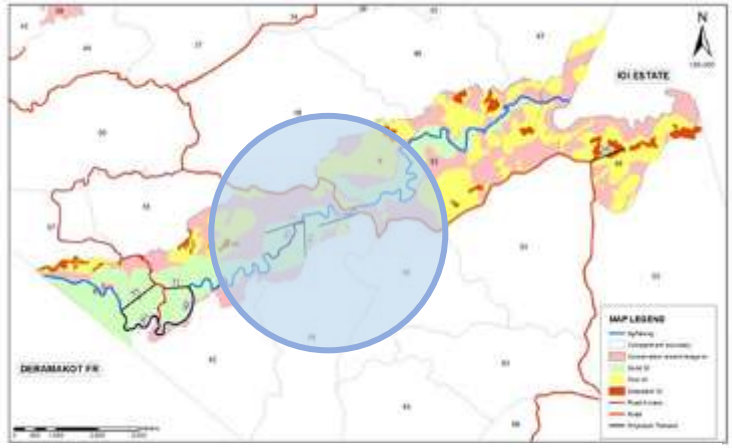
The main objective of this survey is to provide a list of bird species present in the forest reserve to support future forest management initiatives. Surveys, using the MacKinnon List method, were conducted during the 2nd phase of the expedition (13th-18th August) at 3 sites close to the expedition base camp. Three volunteers from Universiti Malaysia Sabah assisted the main authors.



Map 1. Segaliud Lokan FR forest zonation.

The Sungai Rawog Conservation Area (SRCA) Scientific Expedition was held within the Segaliud Lokan Forest Reserve (SLFR) (see Map 1). The Conservation Area along the Rawog river valley covers an area of 3,118 *ha*, about 11 % of the forest reserve. The forest reserve forms part of the FMU 19, which also includes Deramakot Forest Reserve, designated as FMU 19a with SLFR designated as FMU 19b. Since 1993, KTS Plantation Sdn. Bhd. managed SLFR under the License Agreement for Timber Tree Plantation and Wood Processing Plant, which has an effective period of 96 years.

The bird survey was conducted in Compartment 56 (trail system) and 52 (gravel road). In terms of forest structure, the



Map 2. Map of forest strata in Sg. Rawog Conservation Area. Blue circle showing the main survey area, the centre being the expedition base camp.

secondary forests in the Compartment 56 were categorized as good and average forest. The average forest along the main graveled road that cuts through the SRCA was categorized as average forest (see Map 2).

METHODOLOGY

The purpose of this survey was mainly to produce a preliminary bird list and to determine species richness and relative abundance of the SRCA, with the hope of identifying iconic species that can be used to support future management strategies and initiatives.

For this survey, a MacKinnon List (ML) method (MacKinnon & Phillips, 1993) was used. This rapid assessment method has been gaining popularity in the past 10 years or so as a very cost-effective method of conducting bird surveys in the tropics. It is very well suited for those who have limited time for surveys, for *e.g.* government agencies, NGOs, citizen scientists, forest concessionaires, *etc*. The ML method also accounts for differences in effort, observer experience and knowledge, and weather (Poulsen *et al*., 1997). It has also been used in other countries for rapid surveys of other animal species.

In this survey, 15-species MacKinnon lists were employed. Both auditory and visual observations were grouped into consecutive lists of 15 species, and a species accumulation curve was generated from the addition of those species not recorded on any of the previous lists to the total species number, which is then plotted as a function of the list number. Because the method relates species richness to the number of observations rather than to time, area or walking speed, this method allows for comparison of data obtained by different observers or under varying field conditions (Herzog *et al*., 2002).

In addition to the MacKinnon lists, for every species observed and recorded, the number of individuals seen or heard was also recorded. Care was taken not to have intra-list and inter-list double-counts of individuals. This additional data was used to compliment the data from the ML method and to calculate the Shannon Diversity Index (H) and Evenness (or equitability). The total number of species for the site was estimated using the SuperDuplicates® online application (https://chao.shinyapps.io/SuperDuplicates/). Developed by Chao *et al*. (2017), it applies the Good-Turing frequency formula to estimate species richness using only unique observations and a species list. See Appendix 2 for sample data of the MacKinnon list and the additional information.

The survey team consisted of the authors from SFD, assisted by 3 volunteers from Universiti Malaysia Sabah, Kota Kinabalu. Prior to the expedition, the volunteers were

trained in bird identifications and conducting bird surveys using the MacKinnon List Method while interning at the Rainforest Discovery Centre, Sepilok. Every observer had a pair of binoculars (mostly 8 x 42s). The reference field guide of choice was the 'Phillips' Field Guide to the Birds of Borneo', 3rd Ed., 2009. Audio playback equipment (an mp3 player connected to a small, battery-powered loudspeaker) was used to verify the species of the birds heard. Surveys were conducted for 4-5 hours during the mornings, beginning at 7:00-7:30 am, and again for 2-3 hours in the afternoons from 4 pm onwards. All survey durations were dependent on the weather. On Day 3 of the survey, the evening survey was extended to 8 pm to observe nocturnal species.

During the expedition, researchers used temporary trails prepared by rangers from KTS Plantation Sdn, Bhd. As such, the surveys were conducted along narrow trails and shared with other expedition members. Thus, walking speed and time spent in an area were not taken into account for the analyses. All observations were recorded by a designated person. As most species were recorded by their calls/vocalizations, individuals were not recorded again in subsequent lists unless the observers were certain that they were different individuals, for *e.g.* the calls originated from a different direction and/or there are more than one call heard from a similar direction of the previously recorded individual.

Table 1: Timetable of bird surveys during the expedition.

Date	Survey site	Observation times	Observation hours	No. of 15-species lists
14th August 2018	Trail 6A, 6B, 8: Forest	7:00 am – 11:30 am, 2:00 – 4:30 pm	8	7
15th August 2018	Trail 10 & 11: Forest	7:30 am – 12:00 pm, 4:00 – 6:30 pm	7	7
16th August 2018	Roadside, river: Secondary & riverine forest	7:30 am – 11:30 am, 4:00 – 7:30 pm	7.5	11
17th August 2018	Roadside	7:00 am – 11:00 am	4	6

RESULTS AND DISCUSSION

1. Species richness and relative abundance

Table 2: Top 20 relative abundance ranking of bird species in SRCA (ML method data).

Rank	Species	Relative Abundance
1	Bold-striped Tit-babbler	0.656
2	White-crowned Shama	0.594
3	Ashy Tailorbird	0.469
4	Blue-eared Barbet	0.469
5	Little Spiderhunter	0.469
6	Blue-crowned Hanging Parrot	0.406
7	Sooty-capped Babbler	0.375
8	Cream-vented Bulbul	0.313
9	Ferruginous Babbler	0.313
10	White-chested Babbler	0.313
11	Bornean-necklaced Partridge	0.281
12	Orange-bellied Flowerpecker	0.281
13	Red-eyed Bulbul	0.281
14	Black-and-yellow Broadbill	0.250
15	Chestnut-winged Babbler	0.250
16	Green Iora	0.250
17	Purple-naped Sunbird	0.250
18	Slender-billed Crow	0.250
19	Hairy-backed Bulbul	0.219
20	Black-and-Crimson Pitta	0.188

Using the ML method, the 4-day survey at SRCA recorded a total of 31 lists and 465 observed individuals. The total number of species recorded was 113 from 42 families. Using additional 'Number of individuals' data within the modified MacKinnon lists, a total of 659 individuals were observed, with 367 individuals (55.7 %) detected by their calls.

The bulbul and babbler families (Pycnonotidae and Pellorneidae respectively) had the highest number of species, *i.e.* 11 and 9 species respectively, while the sunbird/spiderhunter and cuckoo families (Nectariniidae and Cuculidae respectively) each had 8 species. The hornbill family was well represented by 5 species, *i.e.*

the Asian Black Hornbill, Oriental Pied Hornbill, Rhinoceros Hornbill, Wreathed Hornbill and the Wrinkled Hornbill. About 10 individuals of the Wreathed Hornbill were observed on a tree during an evening survey by boat along Sg. Rawog on Day 3. The 3 pittas observed, *i.e*. Blue-headed Pitta, Black-and-crimson Pitta and Hooded Pitta, were commonly heard along the expedition trails near the campsite.

Table 3: Top 20 relative abundance ranking of bird species in SRCA (additional data).

Rank	Species	Relative Abundance
1	White-crowned Shama	0.058
2	Bold-striped Tit-Babbler	0.044
3	Ashy Tailorbird	0.035
4	Blue-eared Barbet	0.033
5	Slender-billed crow	0.030
6	Little Spiderhunter	0.027
7	Sooty-capped Babbler	0.026
8	Bornean-necklaced Partridge	0.024
9	Green Iora	0.024
10	Blue-crowned Hanging Parrot	0.023
11	Dark-necked Tailorbird	0.023
12	Orange-bellied Flowerpecker	0.020
13	Chestnut-winged Babbler	0.018
14	Cream-vented Bulbul	0.018
15	Ferruginous Babbler	0.018
16	Red-eyed Bulbul	0.018
17	Wreathed Hornbill	0.018
18	Hairy-backed Bulbul	0.017
19	Little Green Pigeon	0.017
20	White-chested Babbler	0.017

The species relative abundance was calculated using two methods: one using the main data from the 31 MacKinnon lists, and the other using the additional data as mentioned in the Methodology section. Using the first method, the species with the highest relative abundance value was the Bold-striped Tit-babbler (0.656) followed by the White-crowned Shama (0.594) and the Ashy Tailorbird (0.469) (see Table 2). Using the second method, the White-crowned Shama (0.058) was ranked 1st, followed by the Bold-striped Tit-babbler (0.044) and the Ashy Tailorbird (0.035) (see Table 3).

The differences in the species ranking order between the two methods was due to the inherent nature of the ML method of data collection which does not account for detectability of birds. For *e.g*., although White-chested Babbler was ranked higher than the Orange-bellied Flowerpecker in Table 2, it cannot be assumed that it is easier to detect the latter. In Table 3, the Orange-bellied Flowerpecker was ranked higher than the White-chested Babbler, *i.e.* it is easier to detect then the latter, which is true from the authors' experience.

Similarly, the Black-and-yellow Broadbill and the Slender-billed Crow was ranked 14th and 18th respectively in Table 2. In Table 3, the latter ranked 5th but the former did not make it into the list (it was ranked 21st). Thus, Table 3 is more reflective of the experience of the authors during the survey.

The Bornean-necklaced Partridge, normally uncommon elsewhere, was observed to be more commonly heard than the ubiquitous Black-and-yellow Broadbill. This was mainly due to the former calling consistently in the early mornings during the expedition, in the forest surrounding the expedition base camp. Although the babblers were well represented by 9 species, the common Brown Fulvetta was not seen nor heard during the survey.

During the expedition, the Wildlife Monitoring Unit from the Forest Research Centre had also made a checklist of bird species they had observed. Out of the 71 species they recorded, the following 10 species were not in our list: Chestnut Munia, Common Iora, Bornean Crested Fireback, Dollarbird, Dusky Broadbill, Maroon Woodpecker, Storm's Stork, White-bellied Woodpecker, White-breasted Waterhen and the Black-winged Scimitar Babbler. If these were taken into account, the total species observed during the expedition

would be 123 species from 43 families. However, this additional data was not included in any of the other analyses.

Nine (9) species of Bornean endemics were observed, namely the Bornean Black Magpie, Yellow-rumped Flowerpecker, Dusky Munia, Bornean Brown Barbet, White-crowned Shama, Bornean Necklaced Partridge, Blue-headed Pitta, Black-and-crimson Pitta and the Bornean Crested Fireback, the last being included from the Wildlife Monitoring Unit's bird list.

Based on the survey data, the avifaunal diversity for SRCA was relatively good for logged-over lowland mixed dipterocarp forest. Strictly forest species were present and the apparent lack of specialists open area species (such as munias, Eurasian Tree Sparrows, Asian Glossy Starlings, *etc*.) may reflect the relatively intact ecological functions of the forest, at least in terms of avifaunal survivability and sustainability.

2. Diversity and evenness

Table 4: Shannon Diversity Index and Evenness for Sg Rawog, Segaliud-Lokan Forest Reserve.

Shannon Diversity Index	Evenness
4.29	0.661

As mentioned above, in addition to recording the species within a 15-species list (MacKinnon List method), the number of individuals of the species observed were also recorded. Data from the species lists, with the total number of observations per species, were used to calculate a Shannon diversity index and evenness for Sg. Rawog Conservation Area (see Table 4). With a total of 113 spp. and a Shannon Diversity Index value of **4.29**, the Sg. Rawog CA can be considered as an area with a high diversity of bird species. The Evenness value of **0.661** implies that most species have close to similar number of individuals.

3. Species accumulation curve

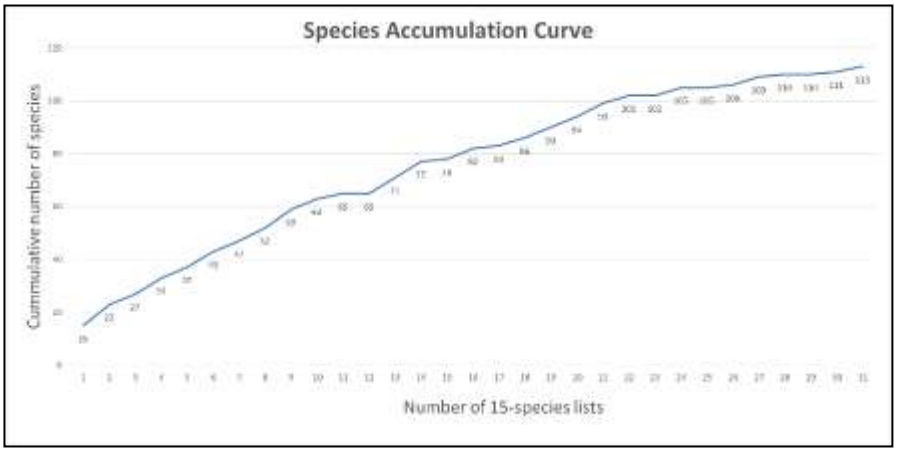


Figure 1. Species Accumulation Curve.

For the ML method, 15-species lists were used. A species accumulation curve was generated from the addition of those species not recorded on any of the previous lists to the total species number, which was then plotted as a function of the list number. In Figure 1, a total of 113 species were observed after 31 lists. The species accumulation curve did not reach a plateau, indicating that we had not a point where we had detected most of the species present in survey sites. This was expected as the survey was conducted for only 4 days and for a total of 26.5 observation hours.

Thus, to accurately estimate the species richness of the area, the authors used the SuperDuplicates® online calculator developed by Chao *et. al*. Based on the Good-Turing frequency formula used in World War II, the calculator requires only the total number of species observed (113 species) and the number of uniques/species observed only once (30 species). For further information, see Chao *et. al.* (2017). As can be seen in Table 5, the SuperDuplicates® online calculator estimated that the true species richness is about 142 species, with an upper and lower threshold of about 164 and 130 species respectively, at 95% confidence interval. It also estimated that about 29 species were undetected, *i.e.* the survey managed to observe about 79 % of the total species found in the area.

Table 5: Estimation of true species richness using SuperDuplicates online calculator.

Sobs	Q1
113	30

Q2.est	Chao2.est	SE	95% C.I. lower	95% C.I. upper	Undetected # species	Undetected percentage (%)
14.85	142.32	8.41	129.89	163.88	29.32	20.60

Sobs: Number of species observed.
Q1: Number of species observed ONLY once.
Q2.est: The estimated number of duplicates (species recorded in exactly two sampling units or sessions). This estimate is needed to obtain the species richness estimate.
Chao2.est: Estimated number of species (species richness) for incidence data, including species present but not detected (Chao 1987).
SE: Standard error (sampling uncertainty) of the Chao2 estimator. This number is used to compute a plausible range (95% confidence interval) of species richness.
95% C.I. lower: Lower bound of the estimated 95% confidence interval (C.I.) of species richness.
95% C.I. upper: Upper bound of the estimated 95% confidence interval (C.I.) of species richness.
Undetected # species: The estimated number of species present but not (yet) seen.
Undetected percentage: The percentage of species present but not (yet) seen.

4. Habitat types and feeding guilds

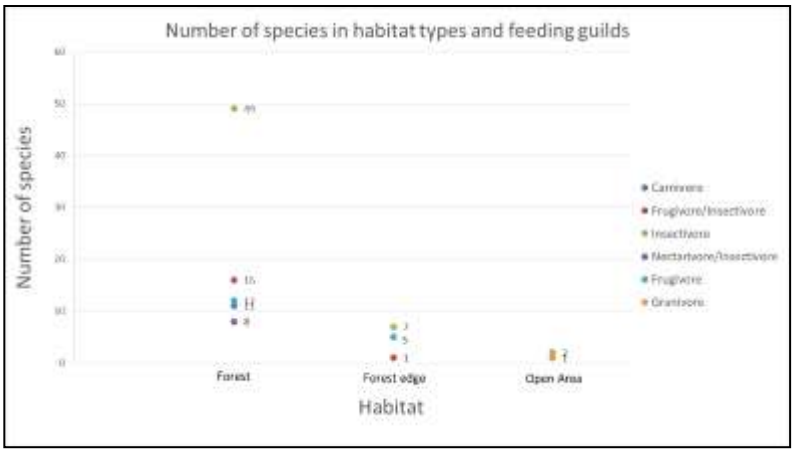


Figure 2. Number of species in habitat types and feeding guilds.

The species were divided according to their respective feeding guilds (and possible combinations) and preferred habitat (*i.e.* forest, forest edges, open area). From the total of 113 species observed, 96 spp. (85 %) were forest birds, 13 spp. (11.5 %) were birds of forest edges and 4 spp. (3.5 %) were species that are commonly found in open areas (see Figure 2).

Insectivores were the most dominant dietary guild. All insectivorous species comprised 84 species (74 % of the total species observed) from 25 families while strict insectivores comprised 58 spp. from 16 families. The dominance of insectivorous (strict or otherwise) bird species in Sg. Rawog Conservation Area indicated that presence of plentiful food resources. This may be related to the initial results of the survey by the Entomology Section of FRC which showed that the insect diversity of the area was very high compared to other lowland forests in Sabah. All frugivorous species comprised 35 species (about 20 % of the total species) from 13 families, with strict frugivorous comprising 17 species from 4 families.

CONCLUSION

During the 4-day bird survey using the MacKinnon List method, the survey team managed to acquire a preliminary insight on the diversity of bird species in Sg. Rawog Conservation Area. The survey recorded a total of 113 species from 42 families. The bulbul and babbler families (Pycnonotidae and Pellorneidae respectively) had the highest number of species, *i.e.* 11 and 9 species respectively, while the sunbird/spiderhunter and cuckoo families (Nectariniidae and Cuculidae respectively) each had 8 species. Six (6) species of Bornean endemics were observed, namely the Blue-banded Pitta, White-crowned Shama, Bornean Falconet, Yellow-rumped Flowerpecker, Bornean Black Magpie and the Bornean Brown Barbet. Additional data from the Wildlife Monitoring Unit also detected another endemic, the Bornean Crested Fireback, and a further 9 species. Thus, the total number of species recorded during the expedition was 123 species.

The forests of SLFR (including SRCA) were logged-over many years before KTS Plantations Sdn. Bhd. took over its management. According to the 2nd Forest Management Plan for Forest Management Plan No. 19 prepared by the Sabah Forestry Department, the total number of bird species was about 220 species. This figure is comparable to other undisturbed forest reserves in Sabah, such as Tawau Hills Park (180 species) and Tabin Wildlife Reserve (182 species), but lower than the Kabili-Sepilok Forest Reserve (308 species), Danum Valley (275 species) and Maliau Basin (280 species).

However, it has to be stressed here that the abovementioned also included the number of species from Deramakot FR, as FMU 19 comprises Deramakot FR (FMU 19a) and Segaliud-Lokan FR (FMU 19b). Deramakot FR has a significantly better forest structure and years of reliable bird data from numerous ornithologists compared to SLFR. Thus, it is highly unlikely that the number of bird species (220 species) from the FMP reflects the true number in SLFR or SRCA.

Thus, it is more reliable to use the estimated true species richness (from the SuperDuplicates® online calculator) of 142 species for SRCA (see Table 5 above). It also

estimated that about 29 species were undetected. Thus, with a total of 123 species (including the 10 species observed by the Wildlife Monitoring Unit of SFD), the 4-day survey yielded about 87 % of the total estimated number of species in SRCA. The management of KTS Plantations Sdn. Bhd. could compare this estimation with data from long-term ornithological studies conducted in SRCA by graduate students from Universiti Malaysia Sabah.

The structure of the bird feeding guilds indicated that the forest was ecologically balanced with insectivores and frugivores making up about 90 % of the total bird species, while the remaining 10 % were carnivores and nectarivores.

ACKNOWLEDGEMENTS

The authors would like to thank our volunteers Jennifer Andrew, Leadora Mikal and Suriyani Sulaiman for their valuable assistance during the 4-day survey. Our appreciation also goes to the management of KTS Plantation Sdn. Bhd. for organising the expedition, especially to Paul Liau and his remarkable expedition team, for providing all the necessary infrastructure and manpower for the success of the Sg. Rawog Conservation Area Scientific Expedition. Many thanks goes to fellow researchers and staff of the Forest Research Centre, Sepilok, for sharing their scientific knowledge and experiences, and their joys and laughter during the successful Sg. Rawog Conservation Area Scientific Expedition.

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Appendix 1

Common names of bird species observed in Sg. Rawog Conservation Area, Segaliud Lokan Forest Reserve during the Sg. Rawog Conservation Area Scientific Expedition.

No.	Species	Family
1	Crested Serpeant Eagle	Accipitridae
2	Jerdon's Baza	Accipitridae
3	Green Iora	Aegithinidae
4	Blue-banded Kingfisher	Alcedinidae
5	Blue-eared Kingfisher	Alcedinidae
6	Rufous-backed Kingfisher	Alcedinidae
7	Stork-billed Kingfisher	Alcedinidae
8	Oriental Darter	Anhingidae
9	Glossy Swiftlet	Apodidae
10	Mossy Nest Swiftlet	Apodidae
11	Silver-rumped Spinetail	Apodidae
12	Asian Black Hornbill	Bucerotidae
13	Oriental Pied Hornbill	Bucerotidae
14	Rhinoceros Hornbill	Bucerotidae
15	Wreathed Hornbill	Bucerotidae
16	Wrinkled Hornbill	Bucerotidae
17	Lesser Green Leafbird	Chloropsidae
18	Ashy Tailorbird	Cisticolidae
19	Dark-necked Tailorbird	Cisticolidae
20	Rufous-tailed Tailorbird	Cisticolidae
21	Yellow-bellied Prinia	Cisticolidae
22	Emerald Dove	Columbidae
23	Green Imperial Pigeon	Columbidae
24	Little Green Pigeon	Columbidae
25	Bornean Black Magpie	Corvidae
26	Crested Jay	Corvidae
27	Slender-billed Crow	Corvidae
28	Banded Bay Cuckoo	Cuculidae
29	Black-bellied Malkoha	Cuculidae
30	Chestnut-bellied Malkoha	Cuculidae
31	Chestnut-breasted Malkoha	Cuculidae
32	Greater Coucal	Cuculidae
33	Moustached Hawk-cuckoo	Cuculidae
34	Raffles's Malkoha	Cuculidae
35	Red-billed Malkoha	Cuculidae
36	Orange-bellied Flowerpecker	Dicaeidae
37	Yellow-breasted Flowerpecker	Dicaeidae
38	Yellow-rumped Flowerpecker	Dicaeidae
39	Bronze Drongo	Dicruridae
40	Greater Racquet-tailed Drongo	Dicruridae
41	Dusky Munia	Estrildidae
42	Banded Broadbill	Eurylaimidae

No.	Species	Family
43	Black-and-Red Broadbill	Eurylaimidae
44	Black-and-Yellow Broadbill	Eurylaimidae
45	Green Broadbill	Eurylaimidae
46	Grey-rumped Treeswift	Hemiprocnidae
47	Whiskered Treeswift	Hemiprocnidae
48	Pacific Swallow	Hirundinidae
49	Asian Fairy-bluebird	Irenidae
50	Blue-eared Barbet	Megalaimidae
51	Bornean Brown Barbet	Megalaimidae
52	Red-throated Barbet	Megalaimidae
53	Blue-throated Bee-eater	Meropidae
54	Red-bearded Bee-eater	Meropidae
55	Asian Paradise Flycatcher	Monarchidae
56	Black-naped Monarch	Monarchidae
57	Rufous-chested Flycatcher	Muscicapidae
58	Rufous-tailed Shama	Muscicapidae
59	White-crowned Forktail	Muscicapidae
60	White-crowned Shama	Muscicapidae
61	Brown-throated Sunbird	Nectariniidae
62	Crimson Sunbird	Nectariniidae
63	Little Spiderhunter	Nectariniidae
64	Long-billed Spiderhunter	Nectariniidae
65	Plain Sunbird	Nectariniidae
66	Purple-naped Sunbird	Nectariniidae
67	Thick-billed Spiderhunter	Nectariniidae
68	Yellow-eared Spiderhunter	Nectariniidae
69	Dark-throated Oriole	Oriolidae
70	Black-capped Babbler	Pellorneidae
71	Ferruginous Babbler	Pellorneidae
72	Horsfield's Babbler	Pellorneidae
73	Moustached Babbler	Pellorneidae
74	Rufous-crowned Babbler	Pellorneidae
75	Scally-crowned Babbler	Pellorneidae
76	Short-tailed Babbler	Pellorneidae
77	Sooty-capped Babbler	Pellorneidae
78	White-chested Babbler	Pellorneidae
79	Bornean-necklaced Partridge	Phasianidae
80	Great Argus	Phasianidae
81	Buff-rumped Woodpecker	Picidae
82	Grey-and-Buff Woodpecker	Picidae
83	Orange-backed Woodpecker	Picidae
84	Rufous Piculet	Picidae

No.	Species	Family
85	Black-and-Crimson Pitta	Pittidae
86	Blue-headed Pitta	Pittidae
87	Hooded Pitta	Pittidae
88	Large Frogmouth	Podargidae
89	Blue-crowned Hanging Parrot	Psittacidae
90	Blue-rumped Parrot	Psittaculidae
91	Black-headed Bulbul	Pycnonotidae
92	Buff-vented Bulbul	Pycnonotidae
93	Cream-vented Bulbul	Pycnonotidae
94	Grey-cheeked Bulbul	Pycnonotidae
95	Hairy-backed Bulbul	Pycnonotidae
96	Olive-winged Bulbul	Pycnonotidae
97	Puff-backed Bulbul	Pycnonotidae
98	Red-eyed Bulbul	Pycnonotidae
99	Streaked Bulbul	Pycnonotidae

No.	Species	Family
100	Yellow-bellied Bulbul	Pycnonotidae
101	Yellow-vented Bulbul	Pycnonotidae
102	Sunda Pied Fantail	Rhipiduridae
103	Boobook	Strigidae
104	Common Hill Myna	Sturnidae
105	Pink-necked Green Pigeon	Theronidae
106	Bold-striped Tit-Babbler	Timaliidae
107	Chestnut-winged Babbler	Timaliidae
108	Fluffy-backed Tit-Babbler	Timaliidae
109	Diard's Trogon	Trogonidae
110	Scarlet-rumped Trogon	Trogonidae
111	Bar-winged Flycatcher-Shrike	Vangidae
112	Black-winged Flycatcher Shrike	Vangidae
113	Rufous-winged Philentoma	Vangidae

Appendix 2:

Example of a MacKinnon list, including the additional number of individuals observed

List 1[1]	No. of individuals[2]
Sooty-caped Babbler (A)[3]	2
Ferruginous Babbler (A)	1
White-crowned Shama (A)	2
Bornean Brown Barbet (A)	1
Pied Fantail (A)	1
Rhinoceros Hornbill (A)	1
Horsfield's Babbler	1
Bornean-necklaced Partridge (A)	1
Chestnut-winged Babbler (A)	2
Bornean Black Magpie (A)	5
Moustached Babbler (A)	1
Asian Black Hornbill (A)	1
Yellow-bellied Bulbul	1
Ashy Tailorbird (A)	2
Hooded Pitta (A)	1

[1] *List number. Each list contains 15 unique species.*
[2] *Originally not in the MacKinnon List method but is added for additional analyses. Care was taken not to have intra-list and inter-list double-counts.*
[3] *The letter A denotes birds observed by their calls/vocalizations.*

Slide Presentation

AVIFAUNAL SURVEY OF Sg. Rawog Conservation Area

G. Hubert Petol
Forest Research Centre
Sabah Forestry Department

CONTENTS

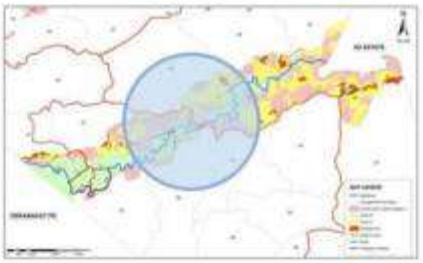
Sg Rawog Conservation Area survey sites
Bird survey methodology
A note on the MacKinnon List method
Results & discussions

BIRD SURVEY SITES (Sg. Rawog Conservation Area)

Sg. Rawog Conservation Area (Compartment 56)

- Logged-over forest close to river
- Categorised as good and average forests
- Relatively flat terrain
- Broken canopy layer
- Surveyed for 4 days on 4 different trails/sites

SG RAWOG CONSERVATION AREA



SURVEY METHODOLOGY

Main purpose:

- Bird list
- Species richness
- Abundance index
- Shannon's diversity index (H)
- Evenness
- Predict total species richness of the area (using Superduplicates[2])

SURVEY METHODOLOGY

- Using a modified MacKinnon List Method
- Main researchers: Vivian Rudolf & G Hubert Petol
- Assistants: 3 interns from RDC (UMS undergrads)
- Assistants were trained for 2-3 months in bird ID and survey at the RDC prior to the expedition

SURVEY METHODOLOGY

- Survey days: 4 days (6 hours/day)
- Raw data entered into Excel files, edited for spelling mistakes and analysed.
- Main reference: 'Phillipps' Field Guide to the Birds of Borneo', 3rd Ed., 2009.
- Equipment: Binoculars (8 x 42), audio playback equipment (to verify species)

SURVEY SCHEDULE

Date	Survey site	Observation times	Observation hours	No. of 15-species lists
14th August 2018	Trail 6A, 6B, 8: Forest	7:00 am – 11:30 am, 2:00 – 4:30 pm	8	7
15th August 2018	Trail 10 & 11: Forest	7:30 am – 12:00 pm, 4:00 – 6:30 pm	7	7
16th August 2018	Roadside, river: Secondary & riverine forest	7:30 am – 11:30 am, 4:00 – 7:30 pm	7.5	11
17th August 2018	Roadside	7:00 am – 11:00 am	4	6

SURVEY METHODOLOGY

- Bird detection: Visual & audio (bird call/vocalisation)
- Observations were recorded by **one** assistant daily
- Care was taken to prevent double counting
- Observations conducted along predetermined paths/trails
- *Not taken into account in analyses:*
  - *walking speed*
  - *distance travelled*
  - *distance to observed species*

A Note On The MacKinnon List Method

- ✓ A rapid assessment method developed MacKinnon & Phillips (1993)
- ✓ Very cost-effective and practical method.
- ✓ Well suited for those who have limited time for surveys (for *e.g.* government agencies, NGOs, citizen scientists, forest concessionaires, *etc.*)
- ✓ Accounts for differences in effort, observer experience and knowledge, and weather (Poulsen *et al.*, 1997).
- ✓ Also used elsewhere for rapid surveys of other animal species.

A Note On The MacKinnon List Method

- 15-species MacKinnon lists were employed, *i.e.* 1 list contains 15 different species.
- Both auditory and visual observations were grouped into consecutive lists of 15 species.
- Then a species accumulation curve was generated from the addition of those species not recorded on any of the previous lists to the total species number, which is then plotted as a function of the list number.
- Because the method relates species richness to the number of observations rather than to time, area or walking speed, this method allows for comparison of data obtained by different observers or under varying field conditions (Herzog et al., 2002).

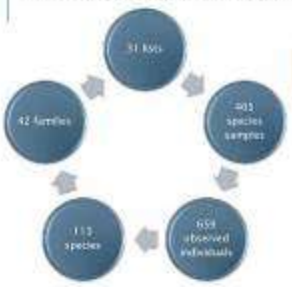
Example of the 15-species lists (Standard)

1	2	3	4	5
Great Argus (A)	Banded Broadbill (A)	Banded Bay Cuckoo (A)	White-crowned Shama	Fraser's Eagle-Owl (A)
Indian Cuckoo (A)	Little Spiderhunter (A)	Asian Paradise Flycatcher	Rufous-winged Philentoma (A)	Gold-whiskered Barbet (A)
Red-eared Bulbul	Red-bearded Bee-eater (A)	Chestnut-winged Babbler (A)	Blue-eared Barbet (A)	Hill Myna (A)
Yellow-bellied Prinia	Grey-chested Jungle Flycatcher (A)	Dark-throated Oriole (A)	Black-naped Monarch (A)	Brown Fulvetta (A)
Chestnut Munia	Black-capped Babbler (A)	Short-tailed Babbler (A)	Yellow-crowned Barbet (A)	Dark-throated Oriole (A)
Yellow-vented Bulbul	Grey-cheeked Bulbul	Blue-eared Barbet (A)	Chestnut-backed Scimitar Babbler (A)	White-crowned Forktail
Ashy Tailorbird	Bornean Brown Barbet	Brown Fulvetta (A)	Dark-necked Tailorbird (A)	Bornean Black Magpie (A)
Rufous-tailed Shama (A)	Greater Green Leafbird	Gold-whiskered Barbet (A)	Ashy Tailorbird (A)	Black-and-yellow Broadbill (A)
Chestnut Tropic (A)	Asian Fairy Bluebird	Raffles Malkoha	Crested Jay (A)	Grey-rumped Treeswift
Orange-bellied Flowerpecker	Red-throated Barbet	Little Spiderhunter (A)	Grey-cheeked Bulbul	Yellow-bellied Prinia (A)
Blue-eared Barbet (A)	Scarlet Minivet (A)	Black-headed Bulbul (A)	Dark-throated Oriole (A)	Red-eared Bulbul (A)
Gold-whiskered Barbet (A)	Scaly-breasted Bulbul (A)	Asian Fairy Bluebird	Grey-chested Jungle Flycatcher (A)	Plain Sunbird
Bold-striped Tit-babbler	Great Argus (A)	Chestnut Tropic	Gold-whiskered Barbet (A)	Asian Glossy Starling
Hill Myna (A)	Scaly-crowned Babbler	Changeable Hawk-Eagle (A)	Bornean Brown Barbet (A)	Orange-bellied Flowerpecker
Grey-rumped Treeswift	Gold-whiskered Barbet (A)	Chestnut-Collared Needletail	Red-throated Barbet (A)	Barn Swallow

15-species lists

Example of 15-species lists (modified MLM)

RESULTS: SUMMARY



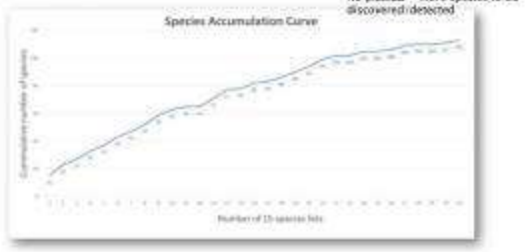
Shannon Diversity Index	Evenness
4.29	0.661

With additional data from the Wildlife Monitoring Unit:

- 123 species from 43 families

RESULTS: Species accumulation curve

No plateau – more species to be discovered/detected



RESULTS: Estimation of species richness

- SuperDuplicates© online calculator developed by Chao *et. al.* was used.
- Using the Good-Turing frequency formula, Chao *et. al.* developed a method to estimate true species richness, including undetected species.
- Requires ONLY the total number of species observed (113 species) and the number of species observed only once (30 species).

RESULTS: Estimation of species richness

Total species observed: 113
Species observed **ONLY** once: 30

Q2.est	Chao2.est	Standard error	95% C.I. (lower)	95% C.I. (upper)	Number of undetected species	Undetected percentage (%)
14.85	142.32	8.41	129.89	163.88	29.32	20.60

RESULTS: Top 4 most common families

Family	Common name	Number of species
Pycnonotidae	Bulbuls	11
Pellorneidae	Babblers	9
Nectariniidae	Sunbirds/Spiderhunters	8
Cuculidae	Cuckoos	8

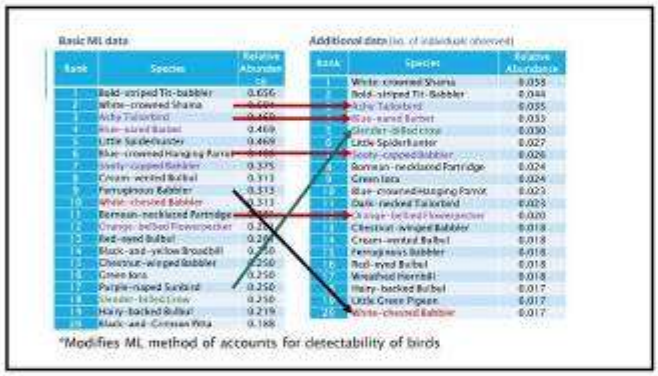
RESULTS: Top 20 relative abundances

Basic ML data

Rank	Species	Relative Abundance
1	Bold-striped Tit-babbler	0.656
2	White-crowned Shama	0.594
3	Ashy Tailorbird	0.469
4	Blue-eared Barbet	0.469
5	Little Spiderhunter	0.469
6	Blue-crowned Hanging Parrot	0.406
7	Sooty-capped Babbler	0.375
8	Cream-vented Bulbul	0.313
9	Ferruginous Babbler	0.313
10	White-chested Babbler	0.313
11	Bornean-necklaced Partridge	0.281
12	Orange-bellied Flowerpecker	0.281
13	Red-eyed Bulbul	0.281
14	Black-and-yellow Broadbill	0.250
15	Chestnut-winged Babbler	0.250
16	Green Iora	0.250
17	Purple-naped Sunbird	0.250

Additional data

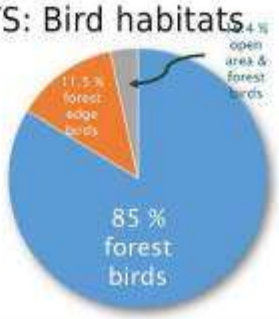
Rank	Species	Relative Abundance
1	White-crowned Shama	0.058
2	Bold-striped Tit-Babbler	0.044
3	Ashy Tailorbird	0.035
4	Blue-eared Barbet	0.033
5	Slender-billed crow	0.030
6	Little Spiderhunter	0.027
7	Sooty-capped Babbler	0.026
8	Bornean-necklaced Partridge	0.024
9	Green Iora	0.024
10	Blue-crowned Hanging Parrot	0.023
11	Dark-necked Tailorbird	0.023
12	Orange-bellied Flowerpecker	0.020
13	Chestnut-winged Babbler	0.018
14	Cream-vented Bulbul	0.018
15	Ferruginous Babbler	0.018
16	Red-eyed Bulbul	0.018
17	Wreathed Hornbill	0.018



RESULTS: 9 bornean endemics (incl. WMU data)

RESULTS: HABITAT TYPES AND FEEDING GUILDS

RESULTS: Bird habitats



SRCA is a **GOOD** forested area for birds.

CONCLUSION

Future rapid surveys by KTS (for monitoring purposes):

- 4-day survey yielded 113 species from 42 families.
- Species richness is estimated to be about 143 ± 8 species. This can be compared with results from studies on bird populations by UMS undergraduate projects in Sg. Rawog CA.
- It is possible that 7-9 days of survey (using MLM) may yield 90% of the total bird species in Sg. Rawog CA.
- The modified MacKinnon List Method is recommended.

CONCLUSION

Sg Rawog can be developed as a tourist destination:

- ✓ A field centre concept is probably the best option to start with (research + tourism)
- ✓ Advantages:
  - Presence of wildlife (from sightings and camera traps)
  - Easy sightings of certain trophy bird species
  - Field staff who worked with UMS undergraduates on birds/wildlife
  - Proximity to a clear, rocky river

I HAVE SHARED ABOUT:

Bird survey sites
Bird survey methodology
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AVIFAUNAL SURVEY OF Sg. Rawog Conservation Area

G. Hubert Petol
Forest Research Centre
Sabah Forestry Department

PAPER 2.7

Insect diversity of Sg. Rawog Conservation Area in Segaliud Lokan Forest Reserve, Sabah

A.Y.C. Chung[1*], R. Japir[1], A.D. Dg. Fazrinah[1], J.L. Yukang[1], B.E. Yahya[2] & R. Homathevi[2]

[1]Forest Research Centre, Sabah Forestry Department, P.O. Box 1407, 90715 Sandakan, Sabah
[2]Institute of Tropical Biology & Conservation, Universiti Malaysia Sabah
**Author for correspondence. Email: arthur.chung@sabah.gov.my*

Abstract. Nocturnal insect diversity was assessed through light-trapping while diurnal insects were documented through sweep nets and forceps. A mean 104 species of nocturnal insects was recorded from a one-square-metre of the light-trapping cloth, with an average of 128 individuals. The mean Shannon Index was 4.52 while Simpson Index was 173.6 and Fisher Alpha Index was 266.7. When the nocturnal insect richness was compared with 24 other forest reserves in Sabah, it is interesting to note that Sg. Rawog insect richness appears to be the third highest after Crocker Range and Bukit Hampuan FRs. In terms of nocturnal insect diversity as reflected by Shannon Index, it is the second highest after Crocker Range FR. One undescribed moth species (*Plutodes* sp., Geometridae) and at least 13 Bornean endemic species were recorded during the survey. The endemics and other insect species recorded during the survey provide significant information to enhance the conservation of Sg. Rawog area. Continuous monitoring and enforcement at strategic locations within the conservation area are important to minimize the threats and adverse issues. This will ensure that the forest quality would be improved in order to maintain the interesting biodiversity, including insects. On-going cooperation with the relevant authorities, such as Sabah Forestry Department and Sabah Wildlife Department, will enhance effort in conservation and curb future incidences of encroachment. Further biodiversity research with academic institutions, such as Universiti Malaysia Sabah as well as Forest Research Centre, Sepilok, is also encouraged. In view of the high wildlife diversity, Sg. Rawog is potentially important for nature tourism.

INTRODUCTION

The Sg. Rawog Conservation Area covers an area of 3,118 ha and 23.4 km in length, within the Segaliud Lokan Forest Reserve. The reserve is also known as Forest Management Unit No. 19(B), covering an area of 57,247 ha, and has been managed by KTS Plantation Sdn. Bhd. since 1993 under the License Agreement with an effective period of 96 years. Sg. Rawog Conservation Area serves as a wildlife corridor connecting Deramakot Forest Reserve and adjacent oil palm plantations. Apart from routine monitoring, there have been no other activities in this area. Climax vegetation comprises two forest ecosystems, namely lowland mixed dipterocarp forest, and lowland mixed dipterocarp together with kerangas forest. The

lowland mixed dipterocarp and kerangas forest is rich in kapur trees (*Dryobalanops* spp.). There are two types of soil colour ranges from very dark brown to white (indicates heath forest) and reddish brown to yellowish red (lowland mixed dipterocarp forest). The soil texture ranged from sand to sandy clay loam.

The insect survey was conducted from 8th to 12th of August, 2018, based beside Sg. Rawog (N 05°27'42.3", E 117°33'58.3" at 34 m a.s.l.). The objectives of this study were to document the insect fauna of Sg. Rawog Conservation Area, and to investigate the threats affecting insect diversity, as well as to provide recommendations that would contribute towards biodiversity conservation of the study area.

MATERIALS & METHODS

Light trap was used to sample nocturnal insects while sweep nets and forceps were used to sample diurnal insects.

Light-trapping

Light trap was used to sample nocturnal insects. The trap consists of a vertical white sheet (2 X 2 m) illuminated by a 250W mercury-lithium bulb. It was powered by a portable Yamaha generator. The trap was set up in an open area facing the forest reserve, from 7:00 to 9:00 p.m. A GPS (Model: Garmin GPSMAP 60CSx) was used to determine the coordinates of each sampling site. Temperature and humidity were taken with a digital hygrometer from Extech Instruments (model no. 445702).

To evaluate diversity of the sampling area, insect species and individuals (≥ 5 mm) within the 1 X 1 m square of the white cloth were enumerated from 8:30 to 9:00 pm. This is a rapid biodiversity assessment method because by the end of the sampling time, species and individual numbers can be obtained, and the data can be used to calculate diversity indices, i.e. Shannon Wiener, Simpson and Fisher Alpha, using the Species Diversity & Richness version IV (SDR 2006). This method is simple, fast and can be carried out by non-insect specialist. To avoid compounding human error, the same staff was assigned to count the species and individual numbers throughout the sampling period, and also for other sampling sites.

Table 1. Light-trapping sites in Sg. Rawog Conservation Area.

Sampling site	Coordinates	Elevation (m)	Temp. (°C)	Humidity (%)	Sampling date	Remarks
A	N 05°27’44.3” E 117°34’02.3”	32	25	88	09 August	Clear sky with a few stars
B	N 05°27’47.7” E 117°34’00.5”	27	26	88	10 August	Clear sky
C	N 05°27’45.9” E 117°34’01.6”	33	n.a.	n.a.	11 August	Heavy downpour at 7:30 pm. Hence, light-trapping was cancelled.

Sweep net and manual collection

Sweep nets were used to collect flying insects while other insects were sampled using fine forceps. Butterflies were put in triangle papers while other specimens were put in vials with 75% ethanol solution. Sampling was conducted along the trails established for the expedition.

Insect specimens and identification

In this survey, focus was given to certain insect groups, i.e., butterflies, moths, beetles, dragonflies and damselflies. Only selected insects for further research work were sampled, as to minimize the workload at the laboratory in preparing the specimens for identification. Photographs were taken to facilitate identification. Common insects were not sampled but photographs were taken for record purposes.

Selected specimens were dry-mounted and sorted to family and some to the genus and species level. Some of the identifications are still tentative while others will be identified later. The specimens sampled from this study are deposited at the Forest Research Centre, Sepilok, Sabah. Dry-mounted specimens were identified based on the FRC Entomology Collection and various reference materials, e.g. Otsuka (1988 & 2001) for butterflies; Holloway (1983, 1985, 1986, 1988, 1989, 1993, 1996, 1997, 1998a & b, 1999, 2001, 2003, 2005, 2008, 2009 & 2011) and Robinson *et al.* (1994) for moths; Fujita (2010), Makihara (1999) and Tung (1983) for beetles; Seow-Choen (2016) for stick insects; Orr (2003) and Tang *et al*. (2010) for dragonflies and damselflies. Some other insects were identified based on Hill and Abang (2005).

Diversity indices

The diversity indices, namely Shannon Wiener, Simpson and Fisher Alpha were calculated through a diversity analysis software by Henderson & Seaby (1998), based on Magurran (2004), and Southwood and Henderson (2000).

Shannon Wiener Index (H')

This index is calculated in the following way:

$$H' = -\sum p_i \ln p_i$$

where p_i is the proportion of individuals found in species i. For a well-sampled community, we can estimate this proportion as $p_i = n_i/N$, where n_i is the number of individuals in species i and N is the total number of individuals in the community. Since by definition the p_is will all be between zero and one, the natural log makes all of the terms of the summation negative, which is why we take the inverse of the sum. Typical values are generally between 1.5 and 3.5 in most ecological studies, and the index is rarely greater than 4. The Shannon index increases as both the richness and the evenness of the community increase.

Simpson Index (D)

This index is based on the probability of any two individuals drawn at random from an infinitely large community belonging to the same species:

$$D_s = \sum p_i^2$$

where again p_i is the proportion of individuals found in species i. For a finite community, this is

$$D = \sum n_i(n_i - 1)/N(N - 1)$$

D is a measure of dominance, so as D increases, diversity (in the sense of evenness) decreases. Thus, Simpson's index is usually reported as its complement 1-D (or sometimes 1/D or –lnD). In Seaby and Henderson (2007), it is reported as 1/D, which is also known as Simpson's Reciprocal Index. It is heavily weighted towards the most abundant species in the sample while less sensitive to species richness (Magurran 1988). Hence, the value will be low if there is a very abundant species.

Fisher Alpha Index (S)

This is a parametric index of diversity that assumes that the abundance of species follows the log series distribution:

$$\alpha x, \alpha x^2/2, \alpha x^3/3, \ldots \alpha x^n/n$$

where each term gives the number of species predicted to have 1,2,3,....n individuals in the sample. The index is the alpha parameter. This is a useful index, which has been widely used. It is estimated by an iterative procedure that may take an appreciable amount of time with large data sets.

RESULTS & DISCUSSION

Nocturnal insect diversity as assessed through light-trapping

The nocturnal insect diversity is shown in Table 2. Data were not available for Site C because of the heavy downpour before the enumeration could be conducted. A mean 104 species of nocturnal insects was recorded from a one-square-metre of the light-trapping cloth, with an average of 128 individuals. The mean Shannon Index was 4.52 while Simpson Index was 173.6 and Fisher Alpha Index was 266.7.

During light-trapping, the temperature was 25^0C - 26^0C with humidity reaching 88% (Table 1). The distribution of insect species from the light-trapping sites is reflected in the species-rank abundance curves in Figure 1. Simpson's Index shows lower value in Site A because of a more dominant species with 8 individuals, compared to Site B. This is also reflected in the higher staggered slope of the species-rank abundance curve of Site A.

Table 2. Insect diversity within a one-square-metre, as sampled through light-trapping in Sg. Rawog Conservation Area.

No.	Sampling site	Species	Ind.	Shannon	Simpson	Fisher Alpha
1.	A	103	129	4.48	139.9	237.1
2.	B	105	126	4.55	207.2	296.4
3.	C	-	-	-	-	-
	Mean	104±1	128±2	4.52±0.05	173.6±47.6	266.7±41.9

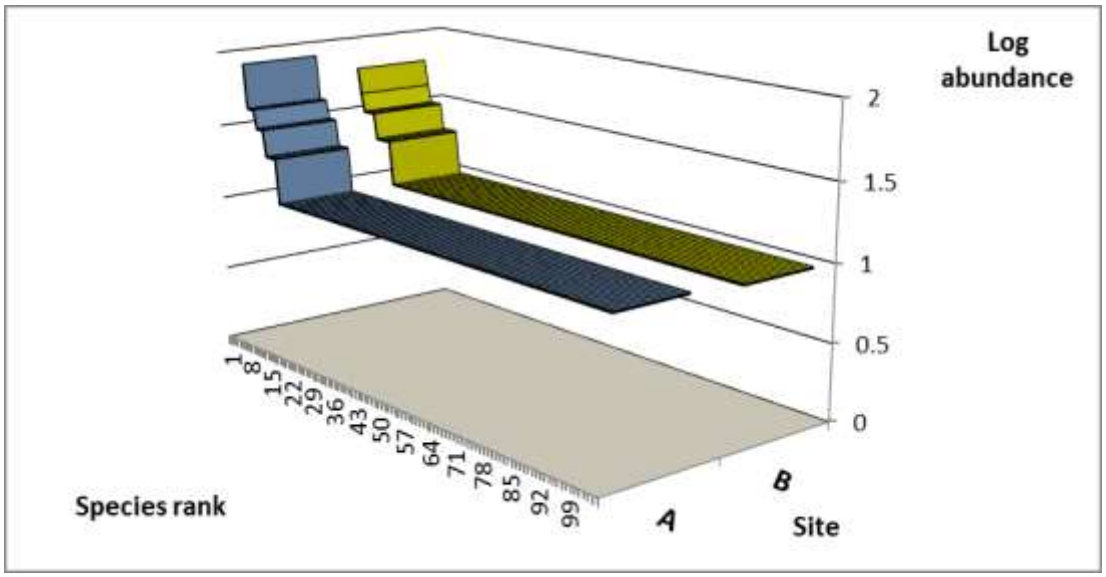

Figure 1. Species-rank abundance curves of the light-trapping in Sg. Rawog Conservation Area.

When the nocturnal insect richness is compared with 24 other forest reserves in Sabah, it is interesting to note that Sg. Rawog insect richness appears to be the third highest after Crocker Range and Bukit Hampuan FRs, as shown in Figure 2. In terms of nocturnal insect diversity as reflected by Shannon Index, it is the second highest after Crocker Range FR (Figure 3).

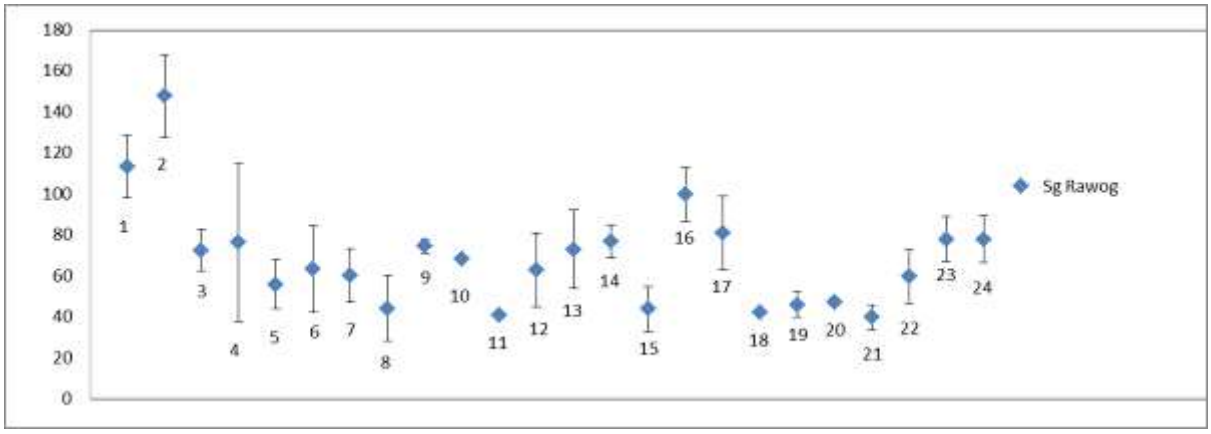

Figure 2. Species number (±standard deviation) within one square metre as assessed through light-trapping in various forest reserves in Sabah (1 = Bkt Hampuan, 2 = Crocker Range, 3 = Rafflesia, 4 = Gn. Lumaku, 5 = Gunong Lumaku, 6 = Milian Labau, 7 = Kawag, USM Office, 8 = Sg. Kapur, 9 = Sg. Siliawan, 10 = Nurod Urod, 11 = Punggol & Sansiang, 12 = Gg Tinkar, 13 = Sg. Imbak 2a&2b, 14 = Tim-Bot, 15 = T. Bohangin, 16 = Sg. Imbak 2c&2d, 17 = Kungkular, 18 = Pensiangan, 19 = Nuluhon Trusmadi, 20 = Batu Timbang, 21 = Tambulanan, 22 = Trusan Sugut, 23 = IJM SG & 24 = Ulu Kalang).

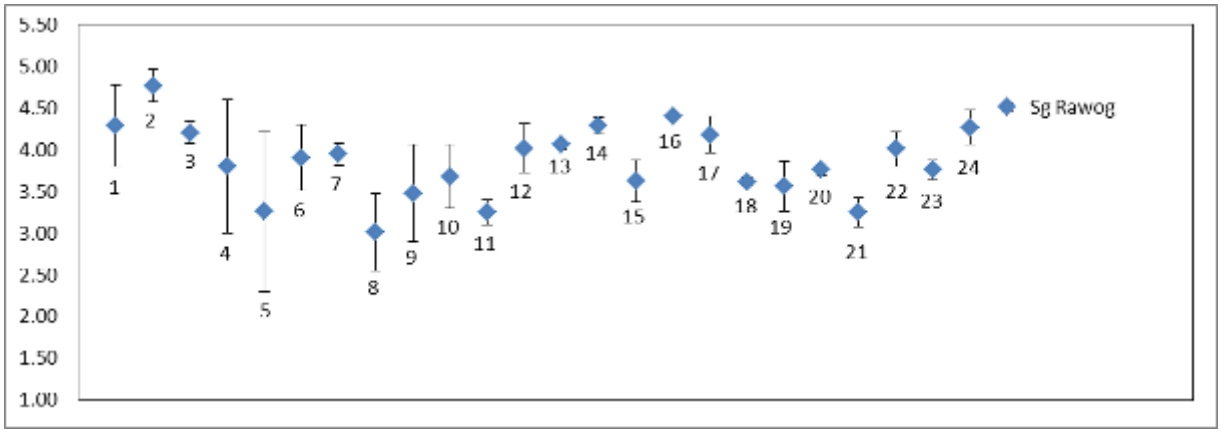

Figure 3. Shannon Index (±standard deviation) within one square metre as assessed through light-trapping in various forest reserves in Sabah (For sites1-24, refer to details in Figure 10a).

Bornean endemic insect species from the survey

One undescribed moth species and at least 13 Bornean endemic species were recorded during the survey, as listed in Table 3. This information provides input towards recommendations on high conservation values (HCV) of the area, based on HCV 1 as stipulated in HCVRN (2013).

Table 3. Bornean endemic insect species recorded from Sg. Rawog Conservation Area.

No.	Species	Author	Order	Family	Photo code
1	*Eulichas fasciolata*	Fairmaire	Coleoptera	Elateridae	KTSP0223
2	*Cyclommatus martini*	Hirschkafer	Coleoptera	Lucanidae	KTSP0433/KTSP0434
3	*Pyrops siderea*	Distant	Homoptera	Fulgoridae	KTSP0316/KTSP0317
4	*Pyrops whiteheadi*	Distant	Homoptera	Fulgoridae	RAZ_1707
5	*Cyana maiae*	Holloway	Lepidoptera	Erebidae	RAZ_1974
6	*Cyana saulia*	Swinhoe	Lepidoptera	Erebidae	KTSP0201
7	*Plutodes* sp. (undescribed)		Lepidoptera	Geometridae	KTSP0209
8	*Glyphodes militaris*	Munroe	Lepidoptera	Crambidae	KTSP0447
9	*Eupanacra psaltria*	Rothschild	Lepidoptera	Sphingidae	KTSP0430
10	*Rhinagrion elopurae*	McLachlan	Odonata	Megapodagrionidae	KTSP0132
11	*Coeliccia nigrohamata*	Liadlaw	Odonata	Platycnemididae	RAZ_1920
12	*Prodasineura hyperythra*	Selys	Odonata	Protoneuridae	KTSP0121
13	*Marmessoidea vinosa*	Serville	Phasmida	Diapheromeridae	RAZ_2044
14	*Hermagoras cultratolobatus*	Brunner	Phasmida	Phasmatidae	KTSP0341

The undescribed moth species is from the genus *Plutodes* of the family Geometridae. It did not match any of the species featured in Holloway (1993), and Roger Kendrick (pers. comm.) suggested that it is a species that is close to *Plutodes cyclaria*. Unfortunately, the specimen was not collected and only photograph was taken.

At least four Bornean endemic moth species were recorded in this expedition, namely two Tiger Moths (*Cyana maiae* and *Cyana saulia*), a wasp-like Micro Moth (*Glyphodes militaris*) and a Hawk Moth (*Eupanacra psaltria*). For beetles, two Bornean endemic species were recorded. *Eulichas fasciolata* is a Forest Stream Beetle which was attracted to the light trap. Although it is endemic, this species is locally common. The other beetle is *Cyclommatus martini*. It is brown Stag Beetle, which can be easily confused with *C. cannaliculatus*. The whole body of *C. martini* is reddish in colour while *C. cyclommatus* has two light black stripes. (Steven Bosuang, pers. comm.). Two species of Bornean endemic Lantern Bugs were sighted. *Pyrops whiteheadi* was sighted by Forestry Entomology team while the other species, *Pyrops siderea* was spotted by the KTS guide, Felix J. Gedullah. For damselflies, three Bornean endemic species were recorded. All were very delicate and difficult to be spotted. *Rhinagrion elopurae* is listed as a near threatened species under the IUCN Red List. At least two Bornean endemic stick insects were recorded, namely *Marmessoidea vinosa* and *Hermagoras cultratolobatus.* Both were spotted during day time while trekking along the trail.

The insect fauna (non-endemic) of Sg. Rawog Conservation Area

During the expedition, the main insect groups that were documented are butterflies, moths, beetles, dragonflies and the rest are grouped as other insects.

Butterflies

A total of 17 butterfly species were recorded (Appendix 1). Interesting butterflies sighted during the expedition were the Rajah Brooke's Birdwing (*Trogonoptera brookiana*) and the Golden Birdwing (*Troides amphrysus*). The former is Malaysia's national butterfly while the latter is an iconic species which is often featured in Sabah's nature tourism promotion. Both are protected species under Schedule 2 of Sabah's Wildlife Conservation Enactment 1997. The male Rajah Brooke's Birdwing was spotted a number of times feeding on the minerals at the riverbank of Sg. Rawog, adjacent to the base camp. Another butterfly that was commonly sighted feeding on the damp river bank was the Cruiser, *Vindula erota*.

Moths

At least 56 moth species were documented from this expedition (Appendix1). The most interesting moth sighted was the Emperor Moth, *Antheraea helferi* (Saturniidae), because of its striking yellow colour and its size with a wing span of about 16 cm. Other large moth species included the Hawk Moths (Sphingidae), with six species recorded, and the black and white Swallowtail Moth, *Lyssa menoetius* (Uraniidae). From the family Cossidae, *Xyleutes strix* was the largest goat moth recorded, with a body length (including wings) up to 6 cm and wing span of 12 cm.

Beetles

Six macro beetle species were recorded during the survey (Appendix 1). *Oxynopterus audouini* was the largest beetle recorded through light trap, with a body length of about 7 cm. It is also the largest Click Beetle in Borneo. Other large beetles recorded included the Long-

horned Beetle, *Cyriopalus wallacei*, which is also known as 'Lubang Pusing' because of the damage caused to the timber trees. The Rhinoceros Beetle, *Oryctes rhinoceros*, was also sighted during light-trapping. It is a pest in oil palm plantation, feeding on the young leaves and shoots.

Dragonflies and damselflies

At least 31 Odonata species were sighted in Sg. Rawog Conservation Area during the survey (Appendix 1). Sixteen of them were dragonflies while the remaining were damselflies. The number of species recorded is considered very high, considering that sampling was only conducted for three working days. The survey was carried out along the riverine area of Sg. Rawog and some ponds adjacent to the base camp. It is also interesting to note that the Pixie, *Brachygonia oculata*, was found in abundance in the stagnant water within the mixed dipterocarp and heath forest floor in Compartment 61.

Other insects

At least 26 species of other insects were recorded (Appendix 1). It is interesting to note that eight species of praying mantises were sighted during the expedition. Of these, the most awesome species was the alien-like Bark Horned Mantis, *Ceratocrania macra*. It has a long 'horn' on its head that suggests its common name. A beautiful Lantern Bug, *Aphaena chionaema*, with its striking red-patterned wings and profuse wax on its abdomen, was spotted. This species is found only in Sumatra and Borneo. A leaf-mimicking Grasshopper, *Chorotypus* sp. was found attracted to the light trap. Processional termite of the genus *Hospitalitermes* was seen trapped in the Flask-shaped Pitcher Plant, *Nepenthes ampullaria*, in Compartment 49.

Insect diversity in contributing towards conservation

This is the first assessment on insect diversity in Sg. Rawog Conservation Area. It was a logged-over forest when KTS Plantation took over in 1993. The short survey has indicated that nocturnal insect diversity was extremely high in this area, which was the second highest after the Crocker Range Forest Reserve, in comparison with 24 forest reserves throughout Sabah. The dragonfly and damselfly fauna was also very high in terms of species richness. Hence, from the perspective of insect diversity, this conservation area should continue to be protected and conserved.

Like many other forests, the threats and issues that indirectly affect insect diversity include forest fire, forest fragmentation, changes in land-use and encroachment. KTS Plantation has set aside this area for conservation purposes. It is hoped that the management will continue their effort in monitoring as well as to carry out activities that can enrich biodiversity of the area. The Sg. Rawog Conservation Area is known to be a wildlife corridor connecting the adjacent oil palm plantations and Deramakot Forest Reserve. The high diversity of insects in this area also justifies and supports the importance of Sg. Rawog not only for the bigger wildlife species but also for the small inhabitants too.

Research findings from the expedition can be used to promote nature tourism in the conservation area. Interesting insect species, such as the Rajah Brooke's Birdwing, Golden Birdwing, giant Click Beetle as well as other large insects, can attract nature lovers. Hence, interesting insects can be incorporated within the package with other interesting flora and fauna to promote this area for recreational and tourism purposes in future. A video clip, featuring interesting insects of Sg. Rawog, sighted during the expedition, was prepared and it was featured in social media, through email, facebook and whatsapp to promote the importance of conservation in this area from the perspective of insects. Sg. Rawog was also given much publicity after the expedition in the local newspapers and TV1 in promoting its rich biodiversity and KTS Plantation's effort in conservation.

CONCLUSION

The data procured from the expedition serve as baseline information as there was no insect diversity survey in this area in the past. Research findings have revealed that the nocturnal insect diversity was very high, second after the Crocker Range F.R., in comparison with 24 other sites in Sabah. Hence, from the insect diversity perspective, this area is utmost important. The Bornean endemic insect species recorded provide salient information to enhance the conservation of Sg. Rawog Conservation Area.

Continuous monitoring and enforcement at strategic locations within the reserve are important to minimize the threats and adverse issues. This will ensure that the forest quality would be improved in order to maintain the interesting biodiversity, including insects. On-going cooperation with the relevant authorities, such as Sabah Forestry Department and Sabah Wildlife Department, will curb future incidences of encroachment into the conservation area. Further biodiversity research with Universiti Malaysia Sabah and Forest Research Centre, Sepilok is also encouraged.

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Appendix 1. List of insects documented during the Sg. Rawog Scientific Expedition in 2018.

Butterflies

No.	Species	Author	Family	Photo no.	Remarks
1	*Jamides* sp.		Lycaenidae	RAZ_1665	
2	*Euploea diocletianus lowii*	Butler	Nymphalidae	RAZ_1929	
3	*Euploea* sp.		Nymphalidae	KTSP0549	
4	*Hypolimnas anomala anomala*	Wallace	Nymphalidae	KTSP0528	
5	*Moduza procris agnata*	Fruhstorfer	Nymphalidae	KTSP0548	
6	*Mycalesis anapita fucentia*	Fruhstorfer	Nymphalidae	RAZ_2057	
7	*Mycalesis fasciata fasciata*	Hewitson	Nymphalidae	RAZ_1751	
8	*Mycalesis fusca adustata*	Fruhstorfer	Nymphalidae	RAZ_2056	
9	*Parthenos sylvia borneensis*	Staudinger	Nymphalidae	KTSP0577	
10	*Vindula erota montana*	Fruhstorfer	Nymphalidae	KTSP0364/KTSP0369	
11	*Ypthima baldus selinuntius*	Fruhstorfer	Nymphalidae	KTSP0530	
12	*Ypthima pandocus sertorius*	Fruhstorfer	Nymphalidae	KTSP0529	
13	*Graphium doson evemonides*	Horrath	Papilionidae	KTSP0330	
14	*Graphium evemon orthia*	Jordan	Papilionidae	RAZ_1930/RAZ_2050	
15	*Trogonoptera brookiana brookiana*	Wallace	Papilionidae	KTSP0356/KTSP0367	
16	*Troides amphrysus flavicollis*	Druce	Papilionidae	KTSP0541	
17	*Paralaxita telesia ines*	Fruhstorfer	Riodinidae	RAZ_1753/RAZ_1756	

Moths

No.	Species	Author	Family	Photo no.	Remarks
1	*Xyleutes ceramica*	Barlow	Cossidae	RAZ_1872	
2	*Xyleutes mineus*	Cramer	Cossidae	RAZ_1958	
3	*Xyleutes strix*	Linneaus	Cossidae	RAZ_2000	
4	*?Cotachena* sp.		Crambidae	RAZ_1798	
5	*Aetholix* sp.		Crambidae	RAZ_1805	
6	*Dausara amethysta*	Butler	Crambidae	RAZ_1794	
7	*Endocrosis flavibasalis*	Moore	Crambidae	RAZ_1819	
8	*Heterocnephes lymphatalis*	Swinhoe	Crambidae	RAZ_1843	
9	*Omiodes noctescens*	Moore	Crambidae	RAZ_1811	
10	*Pachynoa* sp.		Crambidae	KTSP0438	
11	*Parotis marginata*	Hampson	Crambidae	RAZ_1795	
12	*Pitama hermesalis*	Walker	Crambidae	RAZ_1808	
13	*Rhimpalea astrigalis*	Hampson	Crambidae	RAZ_1837	
14	To be identified later		Crambidae	KTSP0207	
15	*Xanthomelaena schematias*	Meyrick	Crambidae	RAZ_1844/RAZ_KTSP0187	
16	*Callidrepana pulcherrima*	Hampson	Drepanidae	KTSP0206	
17	To be identified later		Drepanidae	KTSP0236	
18	*Amata prepuncta*	Holloway	Erebidae	RAZ_1833	
19	*Amerila omissa*	Rothschild	Erebidae	KTSP0198	
20	*Asota heliconia*	Linneaus	Erebidae	RAZ_1830	
21	*Cyana costifimbria*	Walker	Erebidae	RAZ_1884/RAZ_1886	
22	*Cyana maiae*	Holloway	Erebidae	RAZ_1974	Endemic to Borneo
23	*Cyana malayanensis*	Hampson	Erebidae	RAZ_1961	
24	*Cyana perornata*	Walker	Erebidae	RAZ_1786	
25	*Cyana saulia*	Swinhoe	Erebidae	KTSP0201	Endemic to Borneo
26	*Cyana* sp.		Erebidae	RAZ_1992	
27	*Nyctemera muelleri*	Vollenhoven	Erebidae	RAZ_1803/KTSP0210	

Moths (continued)

28	*Bracca georgiata*	Guenee	Geometridae	RAZ_1854	
29	*Cassyma sciticinta*	Walker	Geometridae	RAZ_1871	
30	*Celerena signata*	Warren	Geometridae	RAZ_1873	
31	*Cleora alienaria*	Walker	Geometridae	KTSP0208	
32	*Heterostegane urbica*	Holloway	Geometridae	RAZ_1824	
33	*Hypochrosis binexata*	Walker	Geometridae	RAZ_1789/KTSP0186	
34	*Hypochrosis pyrrhophaeata*	Walker	Geometridae	RAZ_1790	
35	*Ornithospila cincta*	Walker	Geometridae	RAZ_1870	
36	*Pingasa ruginaria*	Holloway	Geometridae	RAZ_1820	
37	*Pingasa tapungkanana*	Strand	Geometridae	RAZ_1849	
38	*Plutodes* sp.		Geometridae	KTSP0209	Undescribed
39	*Tanorhinus rafflesii*	Moore	Geometridae	KTSP0205	
40	*?Bhima* nr *borneana*		Lasiocampidae	RAZ_1802	
41	*Lebeda cognata*	Grunberg	Lasiocampidae	RAZ_1947/RAZ_1964	
42	*Paralebeda lucifuga*	Swinhoe	Lasiocampidae	RAZ_1827	
43	To be identified later		Lasiocampidae	RAZ_1823	
44	*Chloroplaga nygmia*	Swinhoe	Nolidae	RAZ_1842	
45	To be identified later		Nolidae	RAZ_1864/RAZ_1866	
46	To be identified later		Nolidae	RAZ_1869	
47	*Glyphodes militaris*		Crambidae	KTSP0447	Endemic to Borneo
48	*Antheraea helferi*	Moore	Saturniidae	RAZ_2001/RAZ_2002	
49	*Ambulyx canescens*	Walker	Sphingidae	RAZ_1980/RAZ_1967	
50	*Cechenena helops*	Walker	Sphingidae	RAZ_1991	
51	*Eupanacra psaltria*	Rothschild	Sphingidae	RAZ_1968/RAZ_1990	
52	*Megacorma obliqua*	Walker	Sphingidae	KTSP0419	
53	*Rhagastis* nr *castor*	Walker	Sphingidae	RAZ_1975/RAZ_1989	
54	*Theretra latreillei*	Macleay	Sphingidae	RAZ_1976	
55	*Theretra suffusa*	Walker	Sphingidae	RAZ_1787	

Beetles

No.	Species	Author	Family	Subfamily	Photo no.	Remarks
1	*Cyriopalus wallacei*	Pascoe	Cerambycidae		KTSP0443/KTSP0445	
2	*Cryptoalaus* sp.		Elateridae		KTSP0215	
3	*Eulichas fasciolata*	Fairmaire	Elateridae		KTSP0223	Endemic to Borneo
4	*Oxynopterus audouini*	Hope	Elateridae		KTSP0189/KTSP0196	
5	*Cyclommatus martini*	Hirschkafer	Lucanidae		KTSP0433/KTSP0434	Endemic to Borneo
6	*Oryctes rhinoceros*	Linneaus	Scarabaeidae		KTSP0343/KTSP0344	

Dragonflies & damselflies

No.	Species	Author	Family	IUCN Redlist	Remarks	Pic. No.
1	*Vestalis* sp.	Selys, 1853	Calopterygidae	LC		RAZ_1778
2	*Libellago semiopaca*	Selys, 1873	Chlorocyphidae			DSCN9197, DSCN9232
3	*Archibasis viola*	Lieftinck, 1948	Coenagrionidae	LC		RAZ1912
4	*Ceriagrion cerinorubellum*	Brauer, 1865	Coenagrionidae	LC		KTSP0607
5	*Teinobasis cryptica*	Rambur,1842	Coenagrionidae	LC	Female	KTSP0296
6	*Pseudagrion microcephalum*	Rambur,1842	Coenagrionidae	LC		KTSP9209
7	*Teinobasis liadlawi*	Kimmins, 1936	Coenagrionidae			KTSP0097
8	*Agriocnemis alcyone*	Liadlaw, 1931	Coenagrionidae			DSCN9213
9	*Dysphaea dimidiata*	Selys, 1853	Euphaeidae	LC		DSCN9223
10	*Ictinogomphus decoratus melaenops*	Selys, 1858	Gomphidae			DSCN9206
11	*Tyriobapta torrida*	Kirby, 1889	Libellulidae	LC		KTSP0615
12	*Diplacodes trivalis*	Rambur,1842	Libellulidae			RAZ_2157
13	*Neurothemis fluctuans*	Fabricius, 1793	Libellulidae	LC		RAZ_2159
14	*Neurothemis ramburii*	Brauer, 1866	Libellulidae	LC	HW 28mm	KTSP0591
15	*Tetrathemis irregularis hyalina*	Kirby, 1889	Libellulidae			KTSP0597
16	*Cratilla lineata*	Brauer, 1878	Libellulidae	LC		KTSP0258
17	*Rhyothemis triangularis*	Kirby, 1889	Libellulidae	LC		DSCN9203
18	*Barchygonia ocuolata*	Brauer, 1878	Libellulidae			RAZ_1909

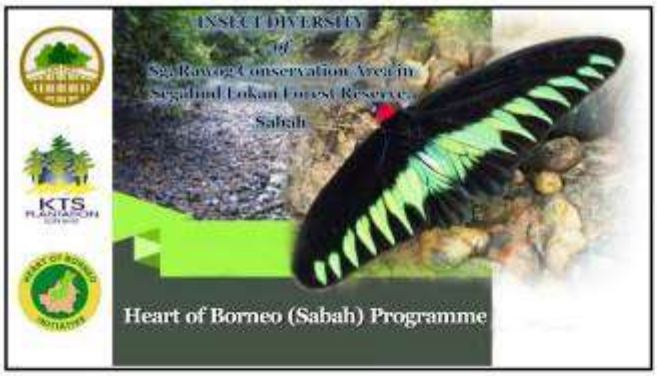
Dragonflies & damselflies (continued)

19	*Trithemis aurora*	Brurmeister, 1839	Libellulidae			RAZ_1909
20	*Lyriothemis biappendiculata*	Selys, 1878	Libellulidae	LC		KTSP0076
21	*Agrionoptera ignisis*	Rambur,1842	Libellulidae			DSCN9184
22	*Orthetrum pruinosum*	Forster, 1903	Libellulidae	LC		Spotted
23	*Orthetrum chrysis*	Selys, 1891	Libellulidae	LC		Spotted
24	*Orthetrum testaceum*	Burmeister, 1839	Libellulidae	LC		Spotted
25	*Tyriobapta liadlawi*	Ris, 1919	Libellulidae		HW 24mm; BL 31mm	KTSP0301
26	*Rhinagrion elopurae*	McLachlan, 1886	Megapodagrionidae	NT	Endemic	KTSP0132
27	*Coeliccia nigrohamata*	Liadlaw, 1918	Platycnemididae		Endemic	RAZ_1920
28	*Copera vittata*	Selys, 1863	Platycnemididae	LC		RAZ_1684
29	*Prodasineura verticalis*	Selys, 1860	Protoneuridae	LC		RAZ_2087
30	*Prodasineura hyperythra*	Selys, 1886	Protoneuridae		Endemic	KTSP0121
31	No ID		Coenagrionidae		Female	RAZ_2066

Other insects

No.	Species	Author	Order	Family	Photo no.	Remarks
1	*Hospitalitermes* sp.		Blattodea	Termitidae	RAZ_2032/RAZ_2033	
2	*Gerris* sp.		Hemiptera	Gerridae	KTSP0492/KTSP0495	
3	*Aphaena chionaema*	Butler	Homoptera	Fulgoridae	ALV_0568	
4	*Pyrops siderea*	Distant	Homoptera	Fulgoridae	KTSP0316/KTSP0317	Endemic to Borneo
5	*Pyrops whiteheadi*	Distant	Homoptera	Fulgoridae	RAZ_1712/RAZ_1713	Endemic to Borneo
6	To be identified later		Homoptera		KTSP0211	
7	To be identified later		Homoptera		RAZ_1793	
8	*Polyrhachis ypsilon*	Emery	Hymenoptera	Formicidae	RAZ_1738/RAZ_1740	
9	Unidentified		Hymenoptera	Ichneumonidae	RAZ_1876	
10	Unidentified		Hymenoptera	Ichneumonidae	RAZ_1876	
11	*Phimenes flavopictus*		Hymenoptera	Vespidae	KTSP0579/KTSP0580	
12	*Euchomenella matilei*		Mantodea	Mantidae	KTSP0243/KTSP0245	
13	*Humbertiella ocularis*	Saussure	Mantodea	Mantidae	KTSP0151	
13	*Pachymantis bicingulata*	Giglio-Tos	Mantodea	Mantidae	KTSP0454/KTSP0456	
14	*Psychomantis* nr *borneensis*	Haan	Mantodea	Mantidae	KTSP0217/0218	
15	*Theopompa* sp.		Mantodea	Mantidae	KTSP0442/KTSP0446	
16	To be identified later		Mantodea	Mantidae	KTSP0204	
17	To be identified later		Mantodea	Mantidae	KTSP0228/KTSP0230	
18	*Ceratocrania macra*		Mantodea	Mantidae	KTSP0161/KTSP0164	
19	*Sagittalata* sp.		Neuroptera	Mantispidae	RAZ_1812	
20	*Hybris* sp.		Neuroptera		RAZ_1861	
21	*Chorotypus* sp.		Orthoptera	Chorotypidae	KTSP0214	
22	Unidentified		Orthoptera		KTSP0032	
23	*Acacus sarawacus*	Westwood	Phasmida	Diapteromeridae	KTSP0157/RAZ_1943	
24	*Marmessoidea vinosa*	Serville	Phasmida	Diapteromeridae	RAZ_2044/KTSP0526	Endemic to Borneo
25	*Hermagoras cultratolobatus*	Brumer	Phasmida	Phasmatidae	KTSP0338/KTSP0340	Endemic to Borneo
26	Unidentified		Plecoptera	Perlidae	RAZ_2096	

Slide Presentation



No.	Sampling site	Species	Ind.	Shannon	Simpson	Fisher Alpha
1.	A	103	129	4.48	139.9	237.1
2.	B	105	126	4.55	207.2	296.4
3.	C	-	-	-	-	-
	Mean	104±1	128±2	4.52±0.05	173.6±47.6	266.7±41.9

Table 1: Insect diversity within a one-square-metre, as sampled through light-trapping in Sg. Rawog Conservation Area

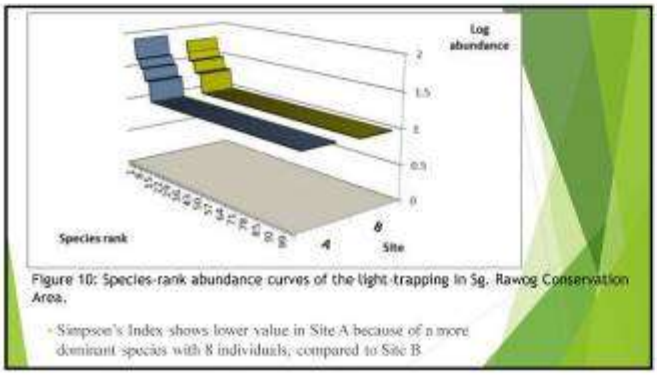


Figure 10: Species-rank abundance curves of the light-trapping in Sg. Rawog Conservation Area.

- Simpson's Index shows lower value in Site A because of a more dominant species with 8 individuals, compared to Site B

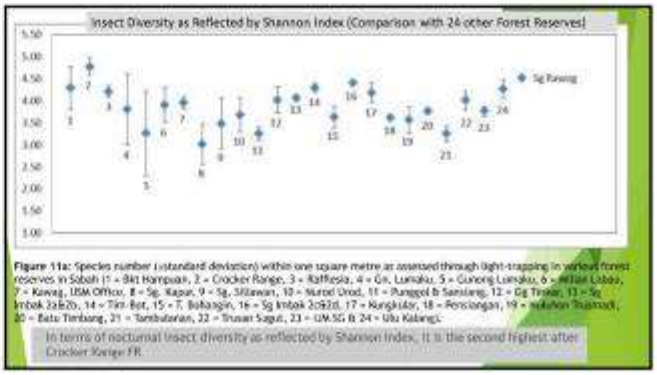


Figure 11a: Species number (±standard deviation) within one square metre as assessed through light-trapping in various forest reserves in Sabah (1 = Bkt Hampuan, 2 = Crocker Range, 3 = Rafflesia, 4 = Gn. Lumaku, 5 = Gunong Lumaku, 6 = Melalap Lobou, 7 = Kawag, UMS Office, 8 = Sg. Kapur, 9 = Sg. Silliawan, 10 = Nurod Urod, 11 = Punggol B Sansiang, 12 = Gg Tinkar, 13 = Sg Imbak 2a&2b, 14 = Tim Bot, 15 = T. Bohangin, 16 = Sg Imbak 2c&2d, 17 = Kungkular, 18 = Pensiangan, 19 = Kalabon Tsamadi, 20 = Batu Timbang, 21 = Tambatuman, 22 = Trusan Sagut, 23 = UM.SG B, 24 = Ulu Kalang).

In terms of nocturnal insect diversity as reflected by Shannon Index, it is the second highest after Crocker Range FR


BORNEAN ENDEMIC INSECTS


Eulichas fasciolata (Coleoptera: Eulichadidae)


Cyclommatus martini (Coleoptera: Lucanidae)


Pyrops siderea


Pyrops whiteheadi


A praying mantis was devouring a Bornean endemic tiger moth, Cyana maie


Tiger Moth
Cyana saulia (Lepidoptera: Erebidae)
Photo: Arthur Chung


Plutodes sp.(Lepidoptera: Geometridae)
Identified by Roger Kendrick
Photo: Arthur Chung


Hawk Moth
Photo: Arthur Chung


Wasp-like Moth
Glyphodes militaris (Lepidoptera: Crambidae)
Photo: Arthur Chung


Rhinagrion elapurae (Odonata: Philosinidae)
Photo: Arthur Chung


Caeliccia nigrahamata (Odonata: Platycnemididae)
Photo: Roy Tapir

CONCLUSION

- The nocturnal insect diversity was very high, second after the Crocker Range F.R., in comparison with 24 other sites in Sabah (as shown in Shanon index). Hence, the area is utmost important.
- The Bornean endemic insect species recorded provide salient information to enhance the conservation of Sg. Rawog Conservation Area.
- Continuous monitoring and enforcement at strategic locations within the reserve are important to minimize the threats and adverse issues.

PAPER 2.8

The land snails of Sungai Rawog Conservation Area, Telupid, Sabah, Malaysia

T.S. Liew* & Z.Y. Chang

Institute for Tropical Biology and Conservation, Universiti Malaysia Sabah, Jalan UMS, 88400 Kota Kinabalu, Sabah, Malaysia.
**Author for correspondence. Email: thorsengliew@gmail.com*

Abstract. This paper presents the first checklist of land snails of Sungai Rawog Conservation Area (SRCA). The specimens of land snails were collected from 12 standard sampling plots and several random locations in the SRCA between 9th and 11th August 2018. A total of 101 specimens were collected that consists of 21 species from ten Families. The number of species various among plots of different trails. The number of species of the five plots that located around Trail No. 6, 7, 8 and 9 range between seven and ten species. On the other hand, each of the six plots that located around Trail No. 1, 2, 3, and 11 has no more than 2 species, with exception of Plot 7 at Trail No. 11 with 10 species. The plots with low number of species are also have relatively low land snail abundance and missing of many micro-snail species (< 5mm) as compare to the plot with high number of species. Overall, the species assemblage and diversity are similar to the previous sampling done in other non-limestone forest reserves in the east coast of Sabah.

Keywords: Gastropoda, molluscs, Segaliud Lokan Forest Reserve, non-limestone forest

INTRODUCTION

Mollusca is the second most speciose animal Phylum after Arthropoda. Currently, there are around one thousand land snail species recorded in Malaysia, which 400 species can be found in Sabah. In Sabah, land snail abundance is higher in limestone habitats than in non-limestone habitat while the species richness is similar between the two different habitats (Schilthuizen *et al*., 2003; Liew *et al*., 2008). To date, there is no systematic sampling of land snails in between lower Kinabatangan and Imbak Crayon Conservation Area, except a few species recorded from Demarakot Forest Reserve (Figure 1). To close the gap, this study presents the results of the land snail biodiversity assessment during the Sg. Rawog Conservation Area Scientific Expedition.

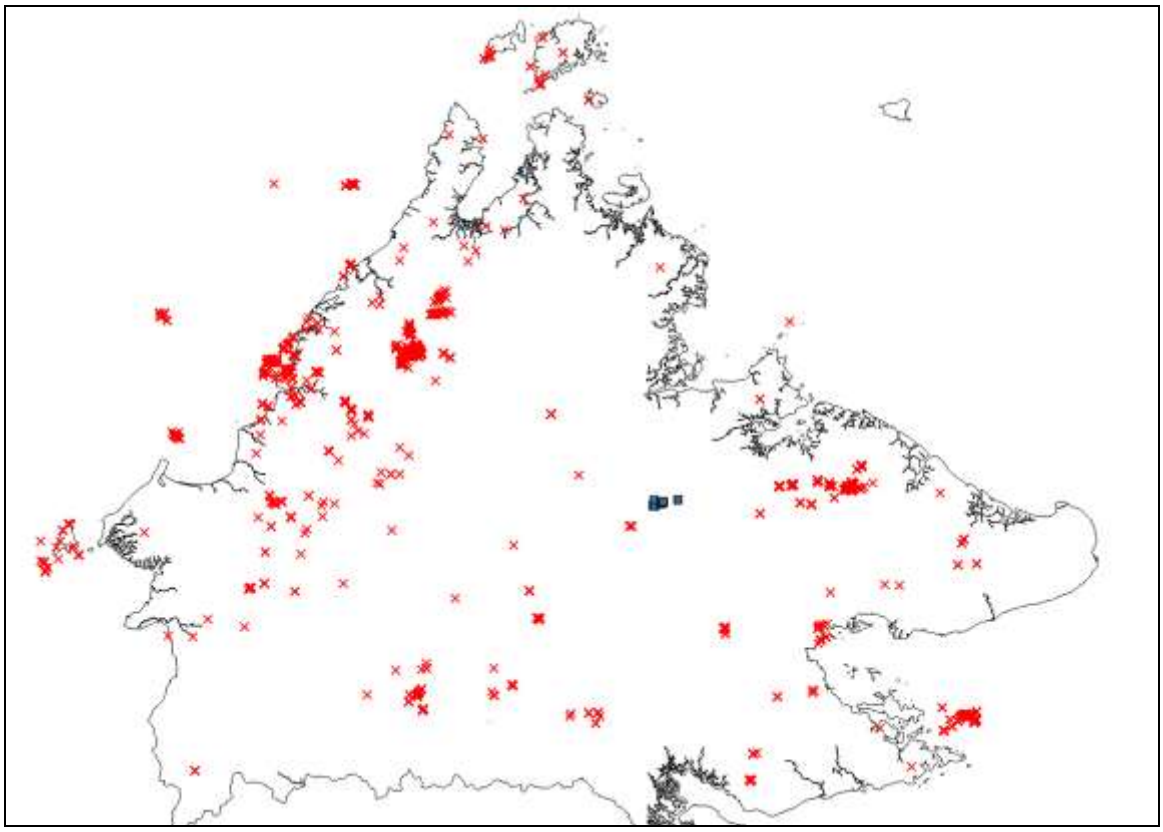


Figure 1. Current known land snail records deposited at BORNEENSIS collection. Red colour cross symbols indicate land snails collected prior to this study; Blue colour square symbols indicate land snail collected in this study.

MATERIALS AND METHODS

This sampling was conducted in the compartment No. C49, 52, 56 and 61 along Rawog river in Segaliud Lokan Forest Reserve (SLFR) which is also known as Forest Management Unit No. 19(B), between 9th and 11th August 2018. We performed two man-hours search for snails in twelve standard plots (20m x 20m) along the trails that established for expedition (Table 1). In addition to the standard sampling plots, snails encountered opportunistically outside of the plots were also collected. Each specimen was identified until species level based on shell morphology by referring to manuscript of *Field Guide to Land Snails of Sabah* (Vermeulen & Liew, in prep.), Vermeulen *et al*. (2015) and the *BORNEENSIS* Mollusca collection in Universiti Malaysia Sabah. The specimens were catalogued into database and deposited in the BORNEENSIS collection at the Institute Tropical Biology and Conservation, Universiti Malaysia Sabah (Collection No. BOR/MOL 13943 - BOR/MOL 14038).

Table 1. List of coordinates for each sampling locations.

Sampling point	Coordinates (decimal degree)		Location Description
	Latitude	Longitude	
Plot 1	5.44583	117.52611	Standard sampling Plot 1. Trail 2 (40m).
Plot 2	5.44583	117.53056	Standard sampling Plot 2. Trail 2 (630m).
Plot 3	5.44861	117.52389	Standard sampling Plot 3. Trail 1 (380m).
Plot 4	5.44500	117.52333	Standard sampling Plot 4. Trail 3 (200m).
Plot 5	5.46997	117.61964	Standard sampling Plot 5. Trail 11 (160m).
Plot 6	5.44583	117.52611	Standard sampling Plot 6. Trail 11 (110m).
Plot 7	5.47098	117.61943	Standard sampling Plot 7. Trail 11 (40m).
Plot 8	5.46250	117.56125	Standard sampling Plot 8. Trail 6 (40m).
Plot 9	5.46036	117.56258	Standard sampling Plot 9. To trail 7 and 8 (780 m from Rawog bridge).
Plot 10	5.45486	117.55646	Standard sampling Plot 10. Trail 9 (1.56 km from basecamp)
Plot 11	5.45869	117.55794	Standard sampling Plot 11. Trail 7 (900 m from basecamp)
Plot 12	5.45892	117.56169	Standard sampling Plot 12. Trail 7 (500 m from basecamp)
Compartment 50.	5.47023	117.52919	Random sampling. Compartment 50.
Basecamp	5.46225	117.56319	Random sampling. Expedition Basecamp
Trail 8.	5.46000	117.56000	Random sampling. Trail 8.
Trail 9.	5.45472	117.55667	Random sampling. Trail 9.

RESULTS AND DISCUSSION

A total of 101 shell or snails were collected which belongs to 21 species of 10 Families (Table 2). The number of species of the five plots that located around Trail No. 6, 7, 8 and 9 ranges between seven and ten species. On the other hand, each of the six plots that located around Trail No. 1, 2, 3, and 11 has no more than two species, with exception of Plot 7 at Trail No. 11 with 10 species. All the species found in this study are common lowland land snail in the East Coast of Sabah. The species number of each of the plots around Trail No. 6, 7, 8 and 9 are similar to the species number for standard plots in other non-limestone forest, such as in Danum Valley, Tabin Wildlife Reserve, Mount Kinabalu, and Mount Tambuyukon (Liew *et al*., 2008).

The plots with low number of species are also have relatively low land snail abundance. In addition, the same plots also lack many micro-snail species (< 5mm) as compare to the plot with high species number, for instances, *Microcystina* spp., *Philalanka* spp., *Charopa argos*, *Diplommatina rubicunda*, and *Allopeas gracile*. The low abundance may indicate low pH of the forest leaves litters.

Table 2. Species list and number of individuals collected from each sampling points.

Species	Random				Standard Plots												Total individuals for each species
	Compartment 50	Basecamp	Trail 8	Trail 9	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	Plot 9	Plot 10	Plot 11	Plot 12	
Ariophantidae																	
Hemiplecta humphreysiana (Lea, 1841)			1						1								2
Microcystina microrhynchus Vermeulen, Liew & Schilthuizen, 2015										1	2	4		2	5	2	16
Microcystina muscorum (Benthem Jutting, 1959)											3		2				5
Microcystina physotrochus Vermeulen, Liew & Schilthuizen, 2015								1				1					2
Camaenidae																	
Amphidromus martensi (Boettger, 1894)				1										1			2
Charopidae																	
Charopa argos Vermeulen, Schilthuizen & Liew, 2007											2	1	1	1		2	7
Cyclophoridae																	
Japonia sp.															1		1
Leptopoma sericatum (Pfeiffer, 1851)												1		1	1		3
Opisthoporus iris (Godwin Austen, 1889)											1			1		1	3
Pterocyclos sp.					1	3					2	1	1	2			10
Diplommatinidae																	
Arinia sp.															1		1
Diplommatina rubicunda (von Martens, 1864)							5				4	1	1				11
Dyakiidae																	
Dyakia hugonis (Pfeiffer, 1863)						5	1										6
Everettia sp.												1					1
Everettia jucundior Liew, Schilthuizen & Vermeulen, 2009					1						1	1		1			4
Everettia subconsul (Smith, 1887)										3	4		1		1	1	10
Endodontidae																	
Philalanka kusana (Aldrich, 1889)											1						1
Philalanka thienemani Rensch, 1932													2	1	2	1	6
Euconulidae																	
Kaliella calculosa (Gould, 1852)												1					1
Kaliella eurytrochus (Vermeulen, Liew & Schilthuizen, 2015)															1	1	2
Subulinidae																	
Allopeas gracile (Hutton, 1834)		1									1	1	1	1		1	6
Trochomorphidae																	
Bertia brookei (Adams & Reeve, 1848)	1																1
Total individuals per plot	**1**	**1**	**1**	**1**	**2**	**8**	**6**	**1**	**1**	**4**	**21**	**13**	**9**	**11**	**12**	**9**	**101**

ACKNOWLEDGEMENT

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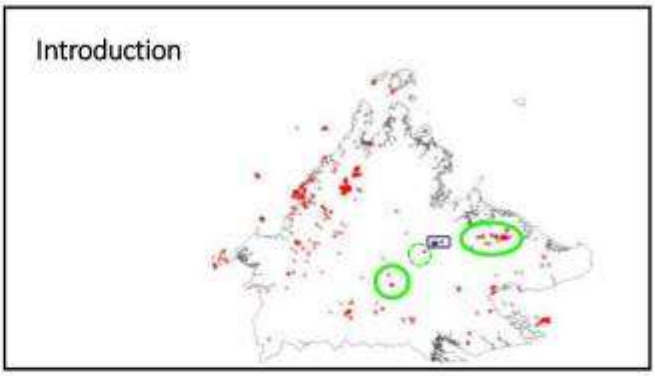
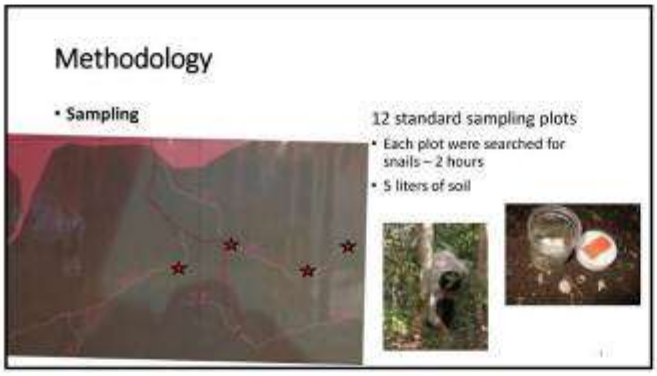
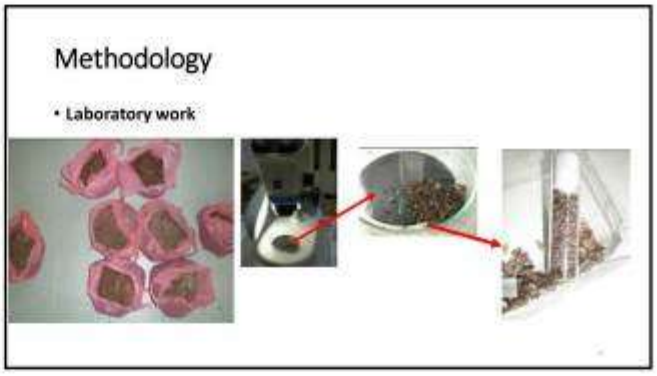
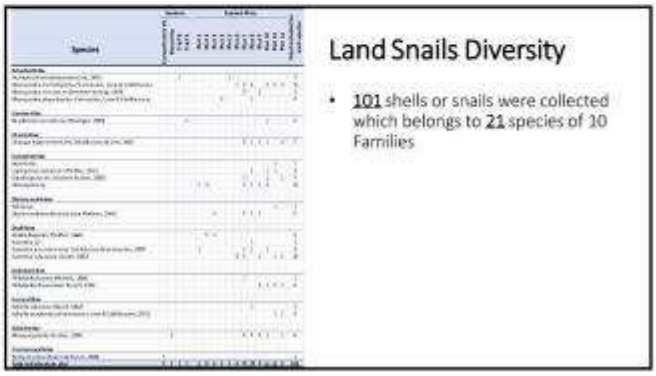
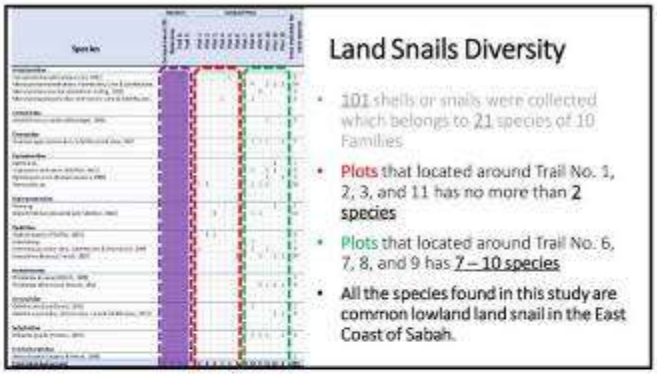
Slide Presentation

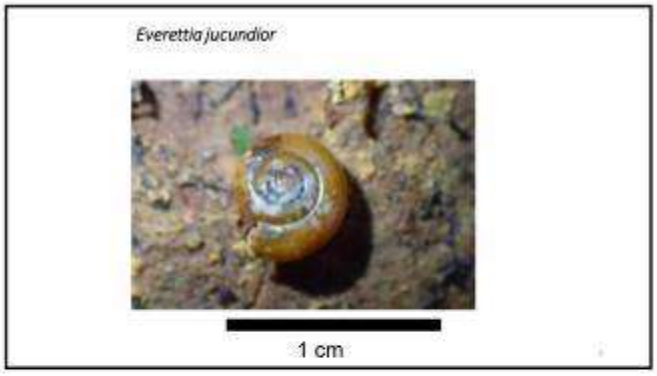


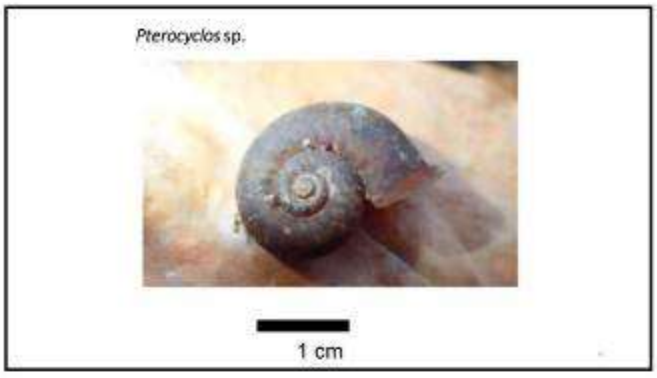


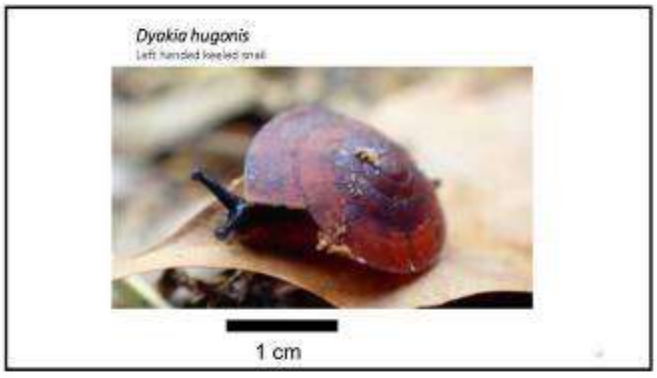





Land Snails Diversity
101 shells or snails were collected which belongs to 21 species of 10 Families
Plots that located around Trail No. 1, 2, 3, and 11 has no more than 2 species
Plots that located around Trail No. 6, 7, 8, and 9 has 7 – 10 species
All the species found in this study are common lowland land snail in the East Coast of Sabah.


Everettia jucundior
1 cm


Pterocyclos sp.
1 cm


Dyakia hugonis
1 cm


Diplommatina rubicunda
Sesame snail
0.5 cm


Everettia subconsul
1 cm

Thank you

Sabah Forestry Department
KTS Plantation Sdn. Bhd
Sanchez Vincent John and Walsius Masius

PAPER 2.9

Potential ecotourism attractions in Sungai Rawog Conservation Area, Segaliud Lokan Forest Reserve, Sabah

J.K. Lajanga[1*], A.R. Mojiol[2] & R.A. Rashid[2]

[1]Forest Research Centre, Sabah Forestry Department, P.O. Box 1407, 90715 Sandakan, Sabah, Malaysia
[2]Forestry Complex, Faculty of Science and Natural Resources, Universiti Malaysia Sabah, Jalan UMS, 88400, Kota Kinabalu, Sabah, Malaysia
**Author for correspondence: Email: jarry.lajanga@sabah.gov.my*

Abstract. This paper aims to compile the main findings from a scientific expedition of the Sungai Rawog Conservation Area (SRCA), Segaliud Lokan Forest Reserve, Sandakan, which was conducted from 8th to 18th August, 2018. A fieldwork observation was used to collect the potential attractions of the areas, including the natural landscapes, which can be developed as an ecotourism site. Findings from SWOT analysis identified the strength of flora and fauna biodiversity, as well as the stewardship of conserving the natural resources by the management. Forest encroachment is one of the identified weaknesses that needs regular monitoring systems. Developing the SRCA as an ecotourism site is an opportunity that is beneficial to KTSP, local community and the surrounding areas. On the other hand, threats from human activities and natural disasters can not be eliminated, but proactive measures can reduce the impact.

INTRODUCTION

The planning to develop ecotourism site in or around the forest reserve area is in line with Sabah Forestry Department Objective and Policy, that has been formulated to cater for the needs of all stakeholders in Sabah, and is in conformity with the internationally accepted practices of sustainable forest resource management and development. The goal of this policy is to achieve sustainable management of the state's forest resources.

For the Sabah Forestry Department Objective, it fulfills the second objective:
2. To optimise the utilisation of forest resources in order to sustain socio-economic benefits to the state.

For ecotourism development within the forest reserve, it falls in para b of the policy: Sabah Forestry Policy Goals
b. To manage the Permanent Forest Reserves so as to maximise social, economic and environmental benefits for the State and its people in accordance with the principles of sustainable forest management.

Below are some of the examples of Forest Recreation and Education Centres that have been developed by Sabah Forestry Department to cater the needs for forest recreation activities and at the same time, they have also been used for ecotourism purposes:

I. Rainforest Discovery Centre in Sandakan.
II. Rafflesia Information Centre in Tambunan.
III. Klias Peat Swamp Field Centre in Beaufort.

BACKGROUND

The United Nations World Tourism Organization (UNWTO) described the definition of tourism as "comprises the activities of persons traveling to and staying in places outside their usual environment for not more than one consecutive year for leisure, business, and other purposes".

Benefits of tourism;

i. Provides employment opportunities, both skilled and unskilled.
ii. Generates a supply of needed foreign exchange.
iii. Increases income.
iv. Increases gross domestic product.
v. Can build on existing infrastructure.
vi. Develops an infrastructure that will also help stimulate local commerce and industry.
vii. Can develop local products and resources.
viii. Help to diversify the economy.
ix. Tends to be one of the most compatible economic development activities available to an area, complementing other economic activities.
x. Has a high multiplier impact.
xi. Increases governmental revenue.

The International Ecotourism Society (TIES) defines ecotourism as "responsible travel to natural areas that conserves the environment and improves the well-being of local people".

Benefits of ecotourism (Goeldner & Ritchie 2012);

i. Provides jobs and income for local people.
ii. Makes possible funds for purchasing and improving protected or natural areas to attract more ecotourists in the future.
iii. Provides environmental education for visitors.
iv. Encourages heritage preservation and environmental preservation and enhancement (the creation of new or enlarged national and state parks, forest reserves, biosphere reserves).

In general, the tourism sector in an area was developed for various reasons, such as to generate economic benefits, to provide job opportunities for the local residents who live in the area. Next, tourism may help in preservation of the environment and cultural heritage. From the social perspective, tourism provides facilities and trading services as well as

recreation for tourists and local residents which cannot be developed without the tourism itself (Inskeep, 1996).

It cannot be denied that rural tourism empowers the rural community and brings economic benefits for them. Although the income amount (at present) is still considered small but it means a lot to the villagers. The focus on rural tourism is also timely as some popular spots are reaching saturation point with the number of tourist arrivals. To ensure their sustainability, tourists need to be diverted to new attractions which are also needed to draw repeat visitors. With more flights coming into Sabah, it would mean better connectivity internationally and potential for more tourists to come to Sabah (Chan, 2017).

OBJECTIVE

The study was conducted to investigate tourism attractions that can be developed into tourism products in SRCA, in addition the survey also evaluated the current situation in SRCA so that advantages and disadvantages of the element regarding the tourism sector in this area can be identified.

STUDY SITE

The Segaliud Lokan Forest Reserve (SLFR) which is also identified as Forest Management Unit No. 19(B) covers an area of 57,247 ha. It forms part of the FMU 19 that also comprises the Deramakot Forest Reserve which is managed by the Sabah Forestry Department. The reserve has been managed by KTS Plantation Sdn. Bhd. since 1993 under the License Agreement for Timber Tree Plantation and Wood Processing Plant which has an effective period of 96 years.

The land use classification shows that a total of 6,447ha or 11% of its total area has been set aside for conservation purposes. Apart from marking and annual monitoring basically, these areas have been ‘locked’ from any activities. To-date, less has been known of the qualities of these areas. Hence, this scientific expedition is proposed. For the purpose of this expedition, the focus area would be the conservation area along the Sungai Rawog Conservation Area, covering an area of 3,118 ha. (Sabah Forestry Department, 2018).

METHODOLOGY

The subjects for survey include natural beauty, cultural values, interesting and significant flora, fauna, landscapes, caves, waterfalls, communities’ tradition and lifestyles, which eventually can be incorporated as tourist attractions. The method used in this study were basically by ‘hands on’, which means the investigator will explore the potential area in order to get the current information. Cameras were used to capture photos for reporting.Besides surveying the forest reserve area, interesting elements surrounding the forest reserve, were also being observed to get more information of the area on the perspective of ecotourism. To get first-hand information about the site, representatives from the nearby community of the forest reserves were interviewed as to get information on

interesting elements of the area. Strength, Weaknesses, Opportunities and Threats (SWOT) of the ecotourism development of the forest reserves, have also been listed.

RESULTS AND DISCUSSION

SOURCES THAT HAVE THE POTENTIAL TO BE INTRODUCED AS TOURISM PRODUCTS

The definition of tourism products has always been focused on something virtual, such as handicrafts or waterfalls. In fact, the definition of tourism products consists of all the elements which influence the experience of a person to the destination that has been visited. Tourism products do not only consist of tourist attractions but it is also consisted of facilities and infrastructure which support the systems of tourism (Mohamed & Nordin, 2007). Tourism attractions in SRCA, Segaliud Lokan Forest Reserve, are listed as follows. However, there should be a proper inventory in the area to get complete data of the availability of tourism sources.

TOURISM ATTRACTIONS

Flora

SRCA, Segaliud Lokan FR, posseses a vast forest area that has abundant flora that can be an attraction to tourists.

Fauna

The quality of these Sabah wildlife attractions is of an international standard. The images of Sabah wildlife are very strong features of the public and private sector's tourism marketing images, both in Sabah and Malaysia (Ministry of Tourism and Environmental Development, 1996). There is a rich presence of wildlife in SRCA, Segaliud Lokan FR. According to the Forest Management Plan (FMP) for Forest Management Unit (FMU) No. 19 Sandakan (1 January to 31 December 2004) prepared by the Sabah Forestry Department, SLFR is expected to have at least 75 species of mammals (excluding bats), 220 species of birds and over 100 species of reptiles, amphibians and fish. Example of fauna that can be found in Segaliud Lokan FR: Mammals: Borneo pygmy elephants, Orang utans, Tembadau, Sambar deer, Bearded pig, Proboscis monkey and Clouded leopard. Others: Monitor lizard, snakes (cobras and pythons), fishes and prawns (Sabah Forestry Department, 2018).

Birds

Birds that are endemic to Borneo, such as White Crown Sharma, Borneon Bristle-Head, Bornean Black Magpie, Bornean Crested Fireback and Blue Headed Pita are common sighting in the forest reserve daily. Rare species, such as Giant Pita and Rail Babbler also can be found in this forest (Sabah Forestry Department, 2018). Birds are important indicators of forest health and have been included when surveying biodiversity. During the 4-day bird survey, the survey team managed to acquire a preliminary insight on the diversity of bird

species in Sungai Rawog Conservation Area. The survey recorded a total 113 species from 42 families (Petol & Rudolf, 2018). All 8 species of hornbills that are found in Borneo, can be found in SRCA (Biun, 2018).

Rivers

Scenic view of the riverine area in SRCA offers a mesmerizing experience to tourists.

TOURISM ACTIVITIES THAT CAN BE EXPLORED

Jungle trekking

Tourists who are more into adventurous activities can go for jungle trekking into the jungle area. Interesting permanent trails can be developed and maintained as the jungle trekking trails for tourists. Developing a well managed and marketed trekking trip in Sabah would provide additional opportunities for the activity-based tourists, and could bring significant benefits to rural communities (Ministry of Tourism and Environmental Development, 1996).

Night walk

The trail for jungle trekking can also be used as trails for night walking activity and tourists can experience the night atmosphere in the forest.

Night safari

Using suitable vechicles e.g. pick up truck, and well equipped with torch light / spot light, tourists can go along the road in the SRCA to do night safari for an opportunity in sighting of the fauna in the area.

Wildlife sighting

Setting up a watch tower at a strategic location which have the potential for the wildlife to turn up at the place, is the best chances to encounter with the forest dweller at their natural habitat. Hence, at SRCA, the existence of natural saltlick, is the best spot that nature can offer for wildlife sighting, where these animals often go to this place to lick the salt for the minerals and nutrients.

Bird watching

The bird watching activity can be organized by taking the tourists to the locations that have the potential to watch birds of different species, especially at the areas where they have fruit trees because it is the main source of food for the birds. Besides as a hobby, bird watching can build up a greater awareness and appreciation of the broader natural world. Watching birds also alert us to problems in our own backyard – often literally. For instance, the decline of many farmland species, has revealed to scientist a wider process of environmental damage brought about by modern agricultural practices (Unwin, 2008).

Photography

The sceneries and interesting nature in the forest reserves would catch the attention of tourists who love photography. Photography will help the tourists to enjoy the beauty of

nature. Nature photography can also educate the community to appreciate and protect nature. This makes photography a useful and beneficial activity (Bakar, 2012).

Camping activity

Camping activity can be held in suitable areas. Tourists can experience more on 'hands on' camping through this activity.

Fishing – catch and release

Catch and release is a practice within recreational fishing intended as a technique of conservation. The fish that were captured will be unhooked and returned to the water. Fast measurement and weighing of the fish can be practised (Catch and release - Wikipedia.com).

Picnicking

The scenery of the Sungai Rawog Conservation Area, can be a tourism attraction and it has the potential to be a picnic spot for the tourists.

River cruising

River cruising along Sungai Rawog, while enjoying the beauty of the scenery of the river view itself and the flora along the river and perhaps an opportunistic chances to come across with the wildlife of Sungai Rawog.

SWOT ANALYSIS FOR TOURISM DEVELOPMENT IN SUNGAI RAWOG CONSERVATION AREA, SEGALIUD LOKAN FR, SANDAKAN

SWOT analysis is a strategic planning method used to evaluate the Strengths, Weaknesses, Opportunities, and Threats involved in a project or in a business venture. SWOT analysis involves specifying the objective of the business venture or project and identifying the internal and external factors that are favorable and unfavorable to achieve that objective (Albert, 1960).

i. Strengths: characteristic features of the business or team that gives it an advantage over others in the industry.
ii. Weaknesses: characteristic features that place the firm at a disadvantage relative to others.
iii. Opportunities: *external* chances to make greater sales or profits in the environment.
iv. Threats: *externa*l elements in the environment that could cause trouble for the business.

Strengths

- Managed by KTS Plantation Sdn. Bhd. This factor provides a good management base for the development of this area.
- KTS Plantation Sdn. Bhd, is a Sustainable Forest Management Licence Agreement (SFMLA) holder, manages the forest through sustainable forest management.
- KTS Plantation Sdn. Bhd, actively involved in conservation activity such as the scientific expedition in Sungai Rawog Conservation Area.

- As a FMU's area, the Sabah Forestry Department, also doing the role for managing the forest area.
- Memorandum of Understanding (MoU) between KTSP and Universiti Malaysia Sabah (UMS) can be used as a platform to strengthen Research and Development activities between KTSP and UMS on forest resources.
- Conservation is supported by both government and private sectors.
- The SRCA has been set aside for conservation purposes, which means it is free from logging and plantation operation.
- Conservation status prevents the area from become another plantation.
- Abundance of natural resources.
- Wildlife corridor.
- The presence of various species of birds.
- Rocky river bed and clear water along the stream.
- Located in the hilly terrain, quite safe from tropical storm.
- No established ecotourism spot nearby. Hence, less competition.
- Have endemic and threatened spesies of flora and fauna.
- The presence of natural salt licks, attracts wildlife to the area to get minerals and nutrients.
- Unique forest ecosystem, consisting Kerangas forest, Dipterocarp forest, secondary forest.
- Various species of fungi.
- Good road access.
- Research activities can be an added value for tourism.
- KTSP can get information on SRCA, from the scientific exploration and research conducted in the area.

Weaknesses

- SRCA, located in the rural area. Due to the distance, tourists who plan to go there must have a certain interest and motivation It will take approximately 2 hours driving from Sandakan.
- If it is raining, limited activity can be done at SRCA.
- Trails will be more slippery when it is raining or after raining.
- No regular public transportation to ease tourist movement in and out of Sungai Rawog Conservation area.
- No telecommunication line and no internet connection.
- No tourism oriented facilities yet.
- Forest ecosystems have changed due to past logging.
- Forest degradation.
- Sandy soil type, not suitable to support big trees.
- No revenue due to no economy oriented operation, leading to less control by the KTSP.
- The forest area is less explored.
- No natural features such as waterfall, lake, cave, for ecotourism attractions.
- Limited publicity of the area.
- Lack of research that has been done.

- Can be encroached from many directions.
- Poor infrastructure, hinder the needs for research purposes.
- Financial constraints in developing the area.

Opportunities

- Potential birding spot.
- Potential for wilderness camp.
- Has potential to be a new ecotourism location in Sandakan.
- Can serve as a catalyst for ecotourism development at the surrounding area.
- Environmental education site.
- Forestry research area.
- Water catchment area.
- Forest recreation area.
- Potential as a forest conservation reference to other FMUS and SFMLA holders.
- Can be developed as a 'field centre' concept ecotourism.

Threats

- Change in government policy on land use.
- Competition from existing tourist spots that have wildlife attraction in Kinabatangan.
- Development of this area can be a nuisance for the wildlife.
- Forest encroachment.
- Illegal hunting.
- Elephant roaming ground.
- Crocodile threat.
- Human – Wildlife conflict.
- Forest Fire.
- Drought.
- River pollution.
- Soil erosion.
- Diseases, such as malaria, leptospirosis.
- Development of new ecotourism site at the nearby area can be a competition.
- Disruption from tourists / researchers, such as throwing garbage and damaging plants.
- Deforestration.

CONCLUSION

From the study that had been conducted, SRCA has high potential to be developed as a nature based ecotourism attraction. A well-organized planning system must be established with the existence of sources that can be potentially developed as a tourist attraction. The tourism development process should be monitored thoroughly and various aspects should be taken into account.

ACKNOWLEDGEMENTS

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Slide Presentation

Potential Ecotourism Attraction
in Sungai Rawog Conservation Area (SRCA),
Segaliud Lokan Forest Reserve,
Sandakan, Sabah

Jarry K. Lajanga, Dr. Andy R. Mojiol & Dr. Rosmalina Abd Rashid

Definition of Tourism

United Nations World Tourism Organization definitions

"Tourism comprises the activities of person traveling to and staying in places outside their usual environment for not more than one consecutive year for leisure, business, and other purposes" (UNWTO, 2010).

Definition of Ecotourism

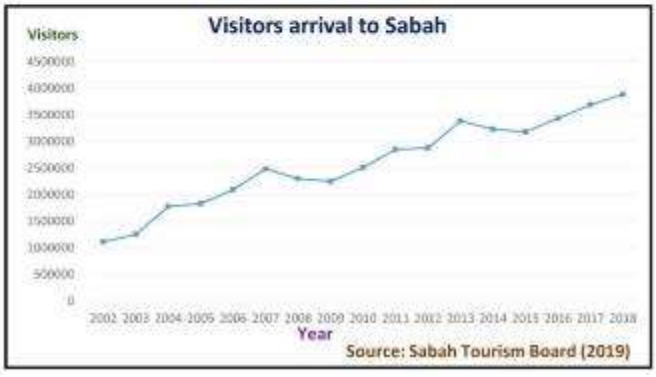
The International Ecotourism Society defines ecotourism as "responsible travel to natural areas that conserves the environment and improves the well-being of local people" (TIES, 1990).

Benefits of Tourism

- Provides employment opportunities.
- Generate foreign exchange.
- Increases income.
- Can develop local products and resources.
- Help to diversify the economy.
- Has a high multiplier impact.

Benefits of Ecotourism

- Provides jobs and income for local people.
- Provides funds for purchasing and improving protected or natural areas to attract more tourists in the future.
- Provides environmental education for visitors.
- Encourages heritage preservation and environmental preservation and enhancement (the creation of new or enlarged national and state parks, forest reserves, biosphere reserves).



Justification

With the increase of tourists to Sabah, new products have to be introduced as alternatives to the readily available tourism products.

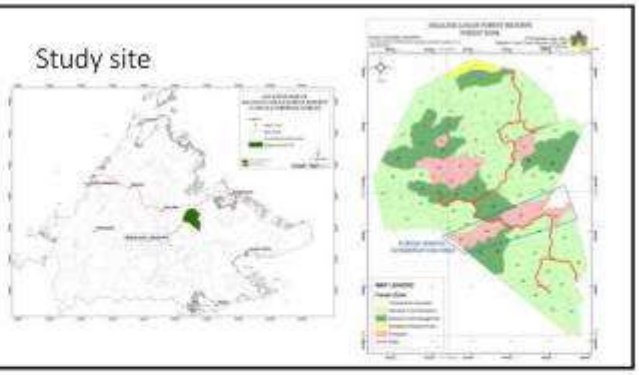
Objectives

- The aim of this study was to investigate attractions that can be developed into tourism products in SRCA.
- In addition, the survey also evaluated the current situation in SRCA so that the advantages and disadvantages of the elements related to tourism in this area can be identified.

Methodology

The natural aesthetic and cultural values, interesting and significant flora, fauna, landscape, were observed and recorded. Interviews also been carried out to the relevant people to get their ideas and opinion on ecotourism in SRCA

Study site



Potential Tourism Attraction at Sungai Rawog Conservation Area

Tourism attractions	Tourism activity
• Flora	• Wildlife viewing
• Fauna	• Jungle trekking
• Forest area	• Night walk
• Nature trail	• Night safari
• River	• Bird watching
• Panoramic view	• River cruising
	• Fishing (catch and release)
	• Camping
	• Photography


08-31-2018 07:18:58


Salt lick
Place where animals often go to lick the salt for the minerals and nutrients.


Birds - Hornbill
All 8 species of hornbill that are found in Borneo, can be found in SRCA, claim Mr. Alim Biun.
In this illustration, depicted the males of each species. From top to bottom, and from left to right, they are
Rhinoceros Hornbill (Buceros rhinoceros), Helmeted Hornbill (Rhinoplax vigil), Wrinkled Hornbill (Aceros undulatus),
White-crowned Hornbill (Aceros comatus), Wrinkled Hornbill (Rhabdotorrhinus corrugatus), Oriental Pied Hornbill (Anthracoceros
albirostris), Asian Black Hornbill (Anthracoceros malayanus) and Bushy crested Hornbill (Anorrhinus galeritus).
Sources:
113 bird species from 42 families can be found in SRCA, finding by Mr. George Hubert Peter


09-20-2018 07:14:08


Flora
A big kapur tree (*Dryobalanops sp*) found in Sungai Rawog Conservation Area


Nephenthes sp


Ecotourism activity – Jungle trekking


Ecotourism activity – River cruising


Interviews

SWOT INFORMATION FOR TOURISM DEVELOPMENT IN SRCA

Strengths

- Managed by KTSP Sdn. Bhd .
- Sabah Forestry Department, Forest Management Unit (FMU) area.
- Memorandum of Understanding (MoU) between KTSP with UMS.
- Conservation status, preventing the area for other usage.
- Research activities can be an added value for tourism.
- Abundance of natural resources.
- Wildlife corridor.
- The presence of variety species of birds.
- Clear water along the stream.
- Good road access.

SWOT INFORMATION FOR TOURISM DEVELOPMENT IN SRCA

Opportunities

- Has potential to be a new ecotourism location in Sandakan.
- Can serve as a catalyst of ecotourism development at the surrounding area.
- Potential wilderness camp.
- Potential birding spot.
- Environmental Education site.
- Forest recreation area.
- Water catchment area.
- Forest conservation references to other FMU's
- Field centre ecotourism area
- Forestry research area

SWOT INFORMATION FOR TOURISM DEVELOPMENT IN SRCA

Weaknesses

- No natural features such as waterfall, lake, cave, for ecotourism attractions.
- Can be encroach from many directions.
- No telecommunication line and no internet connection.
- No tourism oriented facilities yet
- Can be encroached from many direction.

Threats

- Human – Wildlife conflict.
- Diseases, such as malaria, leptospirosis.
- Forest encroachment
- Forest fire
- River pollution

Conclusion

With the attraction that can be found here, SRCA have a high potential to be develop as a new tourism destination in Sandakan, Sabah.

Acknowledgement

- Hornbills video clip : Mr. Paul Liau, KTS Plantation Sdn Bhd.
- Clouded leopard video clip : Dr. Bakthiar Effendi Yahya, Universiti Malaysia Sabah.
- Elephant, tembadau, deer, orang utan, and argus video clip: Wildlife Research Unit, Forest Research Centre, Sabah Forestry Department.
- Sabah Forestry Department.
- KTS Plantation Sdn Bhd.
- Universiti Malaysia Sabah.
- And all that been involved to make the Sungai Rawog Conservation Area Expedition and Conference successful one.

Quote of the day

Most of the tourist who come to Sandakan, is to visit and experience the nature here.

Yang Berbahagia Datuk Mashor Mohd Jaini,
Chief Conservator of Forest, Sabah Forestry Department

The longer time, the tourist stay in Sandakan, the more they will contribute to Sandakan economy.

Dr. Robert Cyril Ong Kim Leong
Deputy Chief Conservator of Forest for Research and Development,
Sabah Forestry Department.


Thank you for your attention

QUESTION & ANSWER SESSION

Session 2: Wildlife Diversity & Tourism Potentials

Name: Assoc. Prof. Dr. Mahmud Sudin
(Agency: Universiti Malaysia Sabah)
Question: Did electric fencing solve the human-wildlife conflict in Telupid?

Hussien Muin: There are no cases of human-elephant conflict reported after an electric fence was built in Kg. Gambaron, Telupid.

Name: Dr. Benedict Topin (Agency: Kadazandusun Cultural Association Sabah)
Comment: *Tongir*, a type of cicada, usually make sounds at 6 o'clock in the evening. We need to document this information.

Razy Japir: We call it 6 o'clock cicada. The scientific name is *Megapomponia merula*. It is the biggest cicada in Sabah.

Name: Dr. Wong Siew Te
(Agency: Bornean Sun Bear Conservation Centre)
Question: Could you elaborate on the issues of encroachment and poaching in Sungai Rawog Conservation Area?

Assoc. Prof. Dr. Henry Bernard: Illegal activities might be happening in SRCA. One of the wildlife camera traps in Compartment 49 disappeared or was suspected to be stolen. Such activities will damage the faunal biodiversity of Sungai Rawog Conservation Area.

Name: Guptah V. G. Nair
(Agency: Sabah Forestry Department)
Question: How did the researcher came out with 8 species and possibly 9 species? Is the electric shock technique safe for smaller fishes?

Prof. Dr. Abdul Hamid Ahmad: We are actually not very sure about the identity of some fishes. We may have recorded 8 or 9 species. The technique is safe for adult and juvenile fishes because it will only jam the fish for a few minutes. However, if you electrocute them for a very long time, they will die.

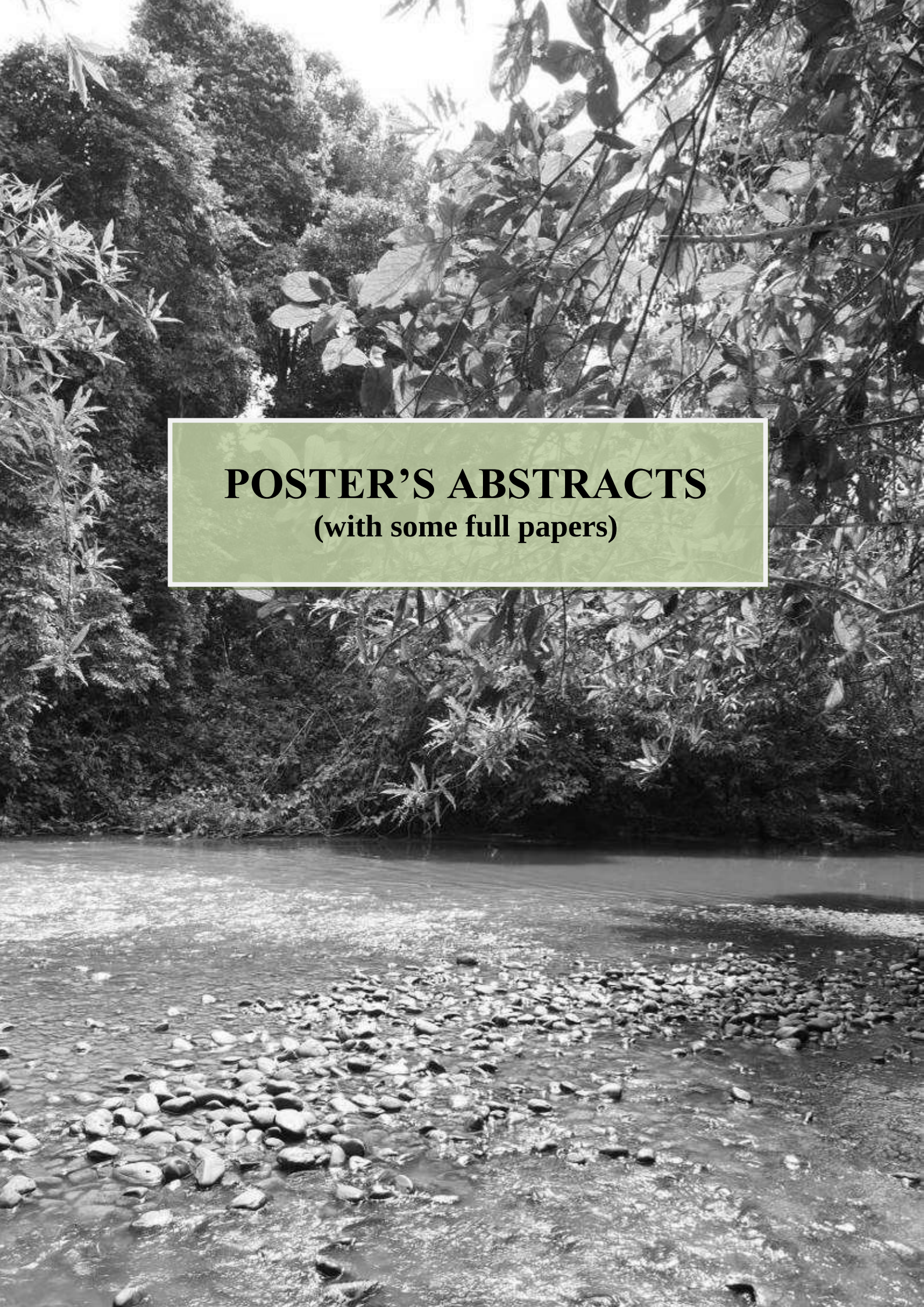
Name: Daim Balingi
(Agency: Sabah Forestry Department)
Question: What are the mitigation measures to prevent forest fire in Sungai Rawog Conservation Area?

Paul Liau: We have a comprehensive FMP that includes forest fire mitigation measures. So far, there is no forest fire incidents recorded. We have combined the forest fire monitoring team with the wildlife monitoring team. The encroachment reported by Dr. Henry is an isolated case. We are going to have combined honorary wildlife warden training with all the

stakeholders. We are also collaborating with Sabah Wildlife Department in various aspects especially that involve rare, threatened and endangered species.

Dr. Benedict Topin: Wild banana trees (*Pisang Kera*) were used as a traditional method in preventing forest fires.

Name: Prof. Dr. Abdul Hamid Ahmad
(Agency: Universiti Malaysia Sabah)
Comment: Recent studies estimated that there are 1,400 elephants in Sabah. I agree with Hussein Muin that electric fencing might not be the best solution. Dr. Megan English who conducted a study in Kinabatangan, proved that elephants eat grasses. In wildlife management's point of view, we still need some time to settle on many issues before we can see a solution.



POSTER'S ABSTRACTS
(with some full papers)

POSTER 1 (FULL PAPER)

SOIL ASSESSMENT OF SUNGAI RAWOG CONSERVATION AREA (SRCA) IN SEGALIUD LOKAN FOREST RESERVE, SABAH

E.K.M. Dyi, S. Dullah & J. Titin

Forest Research Centre, Sabah Forestry Department
**Author for correspondence. Email: EstherDyiKa.Mei@sabah.gov.my*

Abstract. A soil assessment study was conducted during the scientific expedition at Sg. Rawog Conservation Area (SRCA), Segaliud Lokan Forest Reserve with the aim to assess and evaluate the soil conditions of SRCA. During the expedition, 11 soil samplings were conducted in 4 types of forest ecosystem in SRCA namely disturbed kerangas forest, disturbed Kapur Merah forest, late secondary forest and disturbed Lowland Mixed Dipterocarp forest (LMDF). Soil within these 4 types of forest ecosystems were investigated based on soil and site characteristic namely depth, colour, texture, pH, parent material, drainage condition and slope gradient. Soils in the area were classified as Sook and Brantian Association. Both soil associations derived from same parent material which is alluvium. Dominant soil unit for Sook Association includes Gleyic Acrisol, Gleyic Podzol and Orthic Acrisol. Brantian Association dominant soil units are Orthic Acrisol, Ferric Acrisol and Gleyic Acrisol. The topography of the areas are generally undulating terrain, elevation ranges from 30 to 120 a.s.l., drainage condition varies from moderately well to poorly drained. Two types of soil colour were recorded and they range from brownish gray to white (podzosol) and dark brown to yellowish (well drained soil). The soil texture ranges from sandy to sandy clay loam. The soil pH ranges from 4.12 to 5.18 (top soil) and 4.46 to 6.06 (subsoil).

INTRODUCTION

Segaliud Lokan Forest Reserve (SLFR) falls under Class II Commercial Forest Reserve since 1984. In 1993, under licence of Agreement for Timber Tree Plantation and Wood Processing Plant, granted KTS Plantation Sdn Bhd to manage SLFR for 96 years. KTS Plantation Sdn Bhd has designated approximately 11% or 6447 ha of the reserve for conservation purposes. Sg. Rawog Conservation Area is part of concession area. This area is understudied. Therefor, a scientific expedition organized by KTS Plantation Sdn Bhd and Sabah Forestry Department was conducted with the objectives to document the biodiversity of SRCA from various research by other government agencies and universities, to enhance the management prescription of the area, to comply with certification requirement for HCVF management and to compile all research findings from the expedition.

During this scientific expedition, forest soil assessment study was conducted to assess and evaluate the soil conditions of SRCA. Soil is an important component of forest ecosystem as it helps to regulate importance ecosystem, such as decomposition, water

availability, nutrient uptake and potential carbon pools on the earth, which can impact carbon storage and emission through soil organic matter (SOM) management (FAO, 2015). Reliable soil data through soil assessment activity can help to promote sustainable forest management for the security of the forest ecosystem, soil and watershed.

MATERIALS AND METHODS

Study Site

Sg. Rawog Conservation Area (SRCA) is situated between 117° 30' – 117° 38'E and latitude 05° 30' – 05° 25'N. Covering a total of 3,118 ha of land area, SRCA has been logged in the past. SRCA is an important riparian area for the Rawog river that flows from Deramakot in the West to the IOI Estate in the East. SRCA is classified under Brantian and Sook Association with dominant soil unit Acrisols and associated soil unit cambisols, humic acrisols, gleyic acrisols (under Tanjung Lipat Family). The topography of SRCA generally undulating terrain, elevation ranges from 30 to 120m.a.s.l.

Materials

Materials used in this study included a soil auger, GPS, Munsell Colour Chart, soil description hand book, plastic bags, camera and measuring tape.

Soil Sampling

A total of 11 soil samplings were conducted in 4 types of forest ecosystem, namely disturbed kerangas forest, disturbed Kapur Merah forest, late secondary forest and disturbed Lowland Mixed Dipterocarp forest (LMDF). Soil within these 4 types of forest ecosystems were investigated based on soil characters such as depth, colour, texture, pH, parent material, drainage condition and slope gradient. Soil profiles were examined by using the soil auger. Soil samples (depth 0-15cm and 15-30cm) were collected for laboratory analysis. GPS coordinates of all soil sampling points were recorded.

RESULTS AND DISCUSSION

Table 1: Soil sampling GPS points, soil association and drainage condition.

Soil Sampling Label	Latitude	Longitude	Elevation (m)	Soil Association	Drainage condition
KTS 1	05°26'44.1"	117°31'30.5"	50	Sook	Moderately well
KTS 2	05°26'50.4"	117°31'33.7"	69	Sook	Moderately well
KTS 3	05°26'43.1"	117°31'39.3"	85	Sook	Moderately well
KTS 4	05°27'34.0"	117°33'46.9"	41	Sook	Moderately

KTS 5	05°27'30.8"	117°33'37.4"	72	Sook	well Moderately well
KTS 6	05°27'43.7"	117°33'45.6"	70	Sook	Moderately well
KTS 7	05°28'06.9"	117°37'14.9"	80	Brantian	poor
KTS 8	05°28'08.4"	117°37'11.1"	99	Brantian	Moderately well
KTS 9	05°27'50.6"	117°33'52.6"	54	Sook	Poor
KTS 10	05°27'44.2"	117°33'37.0"	34	Sook	Moderately well
KTS 11	05°27'44.3"	117°33'35.9"	46	Sook	Moderately well

Table 2: Soil depth, colour, texture and pH.

Soil Sampling Label	Soil depth(cm)	Soil Colour	Soil Texture	Soil pH
KTS 1	0 - 15	7.5 YR 4/2 - Brown	Loamy sand	5.16 - 5.88
	15 - 29	7.5 YR 6/2 - Pinkish gray	Sandy Loam	
	30 - 84	10 YR 7/1 - Light gray	Sand	
KTS 2	0 - 7	7.5 YR 4/3 - Brown	Clay loam	4.90 - 6.06
	7 - 26	7.5 YR 6/2 - Pinkish gray	Loamy sand	
	26 - 61	7.5 YR 7/2 & 10 YR 6/4 - Pinkish gray & dull yellow orange	Sand	
KTS 3	0 - 11	7.5 YR 3/2 - Dark brown	Sandy loam	5.00 -5.48
	11 - 34	10 YR 5/8 -Yellowish brown	Sandy loam	
	34 - 100	5 YR 5/8 - Bright reddish brown	Sandy clay	
KTS4	0 - 8	10 YR 5/8 - Yellowish red	Sandy clay loam	4.53 - 4.87
	8 - 27	7.5 YR 5/6 - Strong brown	Sandy clay loam	
	27 - 60	7.5 YR 5/8 - Strong brown	loam	
KTS 5	0 - 8	7.5 YR 4/6 - Strong brown	Sandy loam	4.12 - 4.46
	8 - 27	7.5 YR 5/8 - Strong brown	Sandy loam	
	27 - 110	5 YR 5/8 - Yellowish red	Sandy clay loam	

KTS 6	0 - 12	5 YR 4/3 - Reddish brown	Loamy sand	5.18 - 5.53
	12 - 26	7.5 YR 5/6 - Strong brown	Sandy loam	
	26 - 110	7.5 YR 5/8 - Strong brown	loam	
KTS 7	0 - 11	10 YR 4/1 - Brownish gray	Loamy sand	4.71 - 5.82
	11 - 40	10 YR 6/2 - Grayish yellow brown	Loamy sand	
	40 - 50	7.5 YR 8/1 - White	Sand	
KTS 8	0 - 7	5 YR 3/3 - Dark reddish brown	Sandy loam	4.59 - 5.18
	7 - 41	7.5 YR 5/8 - Strong brown	Sandy clay loam	
	41 - 110	5 YR 5/8 - Yellowish red	Sandy clay	
KTS 9	0 - 20	7.5 YR 4/2 - Brown	Loamy sand	5.12 - 5.38
	20 - 70	10 YR 7/6 - Bright yellowish brown	Sandy loam	
	72 - 110	5YR 5/6 & 10 YR 7/1- Yellowish red & light gray	Sandy clay loam	
KTS 10	0 - 12	7.5 YR 4/2 - Brown	Sandy clay loam	4.30 - 5.30
	12 - 29	10 YR 5/6 - Yellowish brown	Sandy clay loam	
	29 - 100	10 YR 7/8 - Yellow	Loam	
KTS 11	0 - 16	7.5 YR 5/3 - Brown	Sandy clay loam	5.00 - 5.25
	16 - 53	10 YR 5/8 - Yellowish brown	Sandy clay loam	
	53 - 110	7.5 YR 6/8 - Reddish yellow	Sandy clay	

Sook Association

Soil in this association derived from alluvium (parent material) and its landform is made of low terrace which composed coarse leached sand and in the floodplains it composed of coarse alluvium overlaid by shallow peat in place. The floodplains are imperfectly drained. The dominant soil unit includes Gleyic Acrisol, Gleyic Podzol and Orthic Acrisol becomes the dominant soil found in the sandy terrace (Acres *et al.*, 1976).

Brantian Association

The landform comprises terrace remnants of old alluvium. The alluvium is medium to fine in texture and sometimes interspersed with peddle deposits. On the terrace top and gentle

slopes, deep and well drained profile of Orthic and Ferric are dominant soil. At the flooding level area, Gleysols which shows strong brown and yellowish mottles occurs (Acres *et al.,* 1976).

Uniqueness, treats and recommendation

The unique finding from this study showed SRCA consists of combination two types of soil profile which are podzosols (indicates kerangas forest) and well-drained soil (soil colour ranges dark brown to yellowish). Shallow soil thickness at kerangas forest impacted low nutrient supply to the trees, and may affect trees growth. SRCA may prone to treat by human activities such as illegal forest harvesting, poaching and forest fires. Human encroachment over and over again might trample vegetation and soil, eventually causing damage that can lead to loss of biodiversity and other impacts. The impact of catastrophic fire may directly affect belowground processes which can alter nutrient inputs, increase soil temperature, erosion, negative impact on evapotranspiration rates and decrease moisture avalability (Neary *et al.*,1999). Therefore, comprehensive forest fire prevention and regular patrolling are recommended for the conservation of unique forest ecosystem such as Kerangas forest.

CONCLUSION

Soils in SRCA are classified as Sook and Brantian Association, both derived from same material alluvium. Dominant soil units for Sook Association include Gleyic Acrisol, Gleyic Podzol and Orthic Acrisol. For Brantian Association dominant soil units are Orthic Acrisol, Ferric Acrisol and Gleyic Acrisol. The topography of the sampling areas are generally undulating terrain, elevation ranges from 30 to 120m.a.s.l, drainage condition varies from moderately well to poorly drained, with their soil colour ranges from brownish gray to white (podzolic area) and dark brown to yellowish (in well drained soil). The soil texture ranges from sandy to sandy clay loam. The soil pH ranges from 4.12 to 5.18 (top soil) and 4.48 to 6.06 (subsoil). Regular human encroachment might trample vegetation and soil, which could lead to loss of biodiversity and negative impact to the soil. Comprehensive forest fire prevention and regular patrolling are recommended for the conservation of unique forest ecosystem of SRCA.

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POSTER 2

DISTRIBUTION AND ABUNDANCE OF ZINGIBERACEAE IN SG. RAWOG, CONSERVATION AREA, SEGALIUD LOKAN FOREST RESERVE SANDAKAN

W.J. Lintangah, N.O. Dosuil, A.R. Mojiol, A.E.A. Jobin & M. Maid
Faculty of Science and Natural Resources, Universiti Malaysia Sabah

This study was carried out to explore the diversity of species under the Zingiberaceae family at Sg. Rawog Conservation Area, Segaliud Lokan Forest Reserve, Sandakan. The study was conducted through observations and recording of species along four expedition trails, namely trails 6, 7, 8 and 11. A total number of 15 species were recorded from the genus of *Alpina* Roxb. (2), *Amomum* Roxb., *Elettaria* Maton., *Etlingera* Giseke. (4), *Globa* L., *Hornstedtia* Retz., *Plagiostachys* Ridl. (2), and *Zingiber* Mill (2). The total number of individual species by clumps recorded were 737 with the highest number from the *Alpinia aquitica* (40.98%), followed by *Elettaria* sp (29.31%), *Plagiostachys* sp (1) (13.57%) and *Hornstedtia* sp. (9.09%). The highest distribution of individual species from the study site is *Elettaria* sp. (71.88%), followed by the species of *Alpinia aquitica* and *Plagiostachys sp* (1) with each 68.77% respectively, and *Globa* sp (25%). The Shannon diversity Index of Zingiberaceae species was recorded at H'=1.5512 while the degree of evenness (E) in species abundance was 0.5728.

POSTER 3

DISTRIBUTION OF *ETLINGERA COCCINEA* (TUHAU) IN KTS PLANTATION, SEGALIUD LOKAN FOREST RESERVE, SANDAKAN

W.J. Lintangah, A.E.A. Jobin, N.O. Dosuil, M. Maid & J. Kodoh
Faculty of Science and Natural Resources, Universiti Malaysia Sabah

A study on the distribution of wild *Etlingera coccinea* (Tuhau) was conducted to compare the distinctive attributes of the species in the different spot sites at compartment 4(C4), 9(C9), 14(C14) and 56(C56) in Segaliud Lokan Forest Reserve. The C56 is located within the area of Sg. Rawog conservation area. Four plots (5 x 3m) were established in every study site. All sites are situated in slope area with a water source and have a distinct amount of shade and disturbance. The C4 site which characterised as actively harvested and received the highest light intensity (46.9 lux) recorded the highest number of clump (52), stalk (163), shoot (52), inflorescence (14) and infructescence (1). The study site in C56 recorded the lowest number of clump (23), shoot (2), inflorescence (1) and infructescence (1). This area received the least disturbance and low light intensity (18.95 lux). The longest average length of the stalk was observed in C56 at (2.8m) whereas the shortest was observed in C4 (2.02m). ANOVA analysis showed significant differences among all sites on the number of clumps ($p=0.006$), stalk ($p=0.02$) and shoots ($p=0.00$) at significant level of $p<0.05$. There was no significant difference in the length of stalk ($p=0.148$) in all sites.

POSTER 4 (FULL PAPER)

POTENTIAL ORNAMENTAL PLANTS OF SG. RAWOG CONSERVATION AREA, SABAH

S. Suzana, A. Damit, M.A.M. Andi & J.B. Sugau

Forest Research Centre, Sabah Forestry Department, P.O. Box 1407, 90715 Sandakan, Sabah, Malaysia
**Author for correspondence. Email: suzana.sabran@sabah.gov.my*

INTRODUCTION

Sg. Rawog conservation area (SRCA) is designated as Conservation area by the KTS Plantation Sdn. Bhd. within the Segaliud Lokan Forest Reserve, a Class II Production Forest Reserve located in the middle part of Sabah. Based on Sandakan Herbarium Database, there are more than 1060 herbarium collections sampled from the Segaliud Lokan FR by the staff of Sandakan Herbarium during the period of 1947 to 2006. The scientific expedition was conducted from 8th to 12th August 2018 and was participated by the researchers and students from variously agencies and departments. A survey on ornamental plants was conducted during the expedition. Ornamental plants are the most important floral wealth of any country, with the excellence of floral beauty, fragrance, colour and foliage leading to a great commercial and export value in the global market (Tipot & Paul, 2004). The objective of this survey was to identify and document potential ornamental plant in SRCA.

STUDY SITE

The study area is accessible by gravelled and sealed road from Sandakan-Telupid Highway and is surrounded by oil palm plantation. Deramakot Forest Reserve is the nearest forest in the southwest. Sandakan is the nearest town where the key government administrative offices are located.

METHODOLOGY

The ornamental plants were collected in all existing trails (Table 1) which is located inside the targeted areas as provided by the KTS Plantation management. The live ornamental plants were collected based on these following characteristics features:

a. Good form, shape and size of the plant
b. Colourful flowers and fruits
c. Attractive colours and arrangement of the foliage
d. Good branching pattern
e. Ease of propagation

In the field, the common ornamental plant species were identified directly to species level while those could not readily identify, it was collected as vouchers or herbarium specimens

for subsequent determination at the Sandakan Herbarium (SAN). Plant classification is based on Stevens, P.F. (2001 onwards), Christenhusz *et al.* (2011) and based on World of Ferns website, Hassler (2019). Relevant flora references were also consulted e.g., Soepadmo *et al*., 1995, 1996, 2000, 2002, 2004, 2007, 2011, 2014 and Safreena, *et al.* (2018). All collected plants were propagated in the Forest Research Centre (FRC) Nursery.

Table 1: Location of plots in SRCA, Segaliud Lokan FR, Sabah.

Trail number (date)	Latitude	Longitude	Elevation (m)	Forest Formation
Trail 1 & Trail 3 (9/8/18)	5.446700 5.445570	117.528050 117.527150	71	Disturbed Lowland MDF
Trail 8, Trail 9, Trail 10 & Trail 11 (10/8/18)	5.460740 5.467777	117.570600 117.621174	65	Disturbed Lowland MDF kerangas

RESULTS AND DISCUSSION

The survey recorded 14 taxa of plants with ornamental potential from the reserve, of which eight taxa endemic to Borneo, including one endemic to Sabah (Table 2). This study is a preliminary finding for other studies such as cultivation and propagation techniques.

Table 2: List of the ornamental plant species from SRCA.

No.	Species	Family	Endemism
1.	*Photos atropurpurascens*	Araceae	EB
2.	*Arthrophyllum diversifolium*	Araliaceae	Not
3.	*Begonia* cf. *beryllae*	Begoniaceae	Not
4.	*Hanguana major*	Hanguanaceae	EB
5.	*Aechynanthus tricolor*	Gesneriaceae	EB
6.	*Bauhinia kockiana* var. *kockiana*	Fabaceae	Not
7.	*Nepenthes ampullaria*	Nepenthaceae	Not
8.	*Benstonea pumila*	Pandanaceae	EB
9.	*B. rustica*	Pandanaceae	EB
10.	*Freycenetia biloba*	Pandanaceae	EB
11.	*Pandanus motleyanus*	Pandanaceae	ES

12.	*Boesenbergia pulchella*	Zingiberaceae	EB
13.	*Selaginella conferta*	Selaginellaceae	EB
14.	*Selaginella wallichii*	Selaginellaceae	Not

*EB=Endemic to Borneo *ES=Endemic to Sabah

RECOMMENDATION

We propose one species, namely *Freycinetia motleyanus* (Pandanaceae) as the plant species conservation target to be monitored. The justification for the selection of this endemic species is that it is easily recognizable in the field.

CONCLUSION

A total of 14 taxa (including eight taxa endemic to Borneo and one taxa endemic to Sabah) were collected and identified. The findings from this survey can be used as a basis for further study, such as on cultivation and propagation techniques of the species.

ACKNOWLEDGMENTS

We thank the KTS Plantation Sdn. Bhd. for co-organizing the expedition. We also thank the Chief Conservator of Forests, Deputy Chief Conservator of Forests (FSP) and Deputy Chief Conservator of Forests (R&D) for their continuous support. En. Jumri Abd. Hamid provided maps and the staff of the Systematic Botany section are gratefully acknowledged for their hard work in the field.

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Ornamental plants in Sg. Rawog Conservation Area

A & D. *Pandanus motleyanus* (Pandanaceae); **B.** *Arthrophyllum diversifolium* (Araliaceae); **C.** *Bauhinia kockiana* var. *kockiana* (Fabaceae); **E.** *Boesenbergia pulchella* (Zingiberaceae); **F.** *Nepenthes ampullaria* (Nepenthaceae); **G.** *Begonia* cf. *beryllae* (Begoniaceae); **H.** *Selaginella conferta* (Selaginellaceae) & **I.** *Aeschynanthus tricolor* (Gesneriaceae).

POSTER 5

NEPENTHES OF SUNGAI RAWOG CONSERVATION AREA IN SABAH, MALAYSIA

A. Damit, S. Suzana & J.B. Sugau
Forest Research Centre, Sabah Forestry Department

Nepenthes is the genus of the tropical pitcher plants that is widely known for their carnivorous and unusual jug-shaped leaf extension to trap and digest fauna for nutritional benefit. Two species of *Nepenthes* namely the *N. ampullaria* and *N. mirabilis* were recorded during the botanical survey in Sungai Rawog Conservation Area within the Segaliud Lokan Forest Reserve, Sabah. These species are among the most common and widespread lowland *Nepenthes* species. The natural hybrid between the two species, *N. ampullaria* x *N. mirabilis* or also known as *Nepenthes* x *kuchingensis*, was also found where both parent species dwell together. *Nepenthes ampullaria* grow abundantly in the *kerangas* forest at the Compartment 49.

POSTER 6

FERNS AND LYCOPHYTES OF SG. RAWOG CONSERVATION AREA, SEGALIUD LOKAN FOREST RESERVE, SABAH

M.A.M. Andi[1], M. Gumbilil[1], J.B. Sugau[1], J. Gissil[2] & M. Suleiman[2]
[1] Forest Research Centre, Sabah Forestry Department
[2] Institute for Tropical Biology and Conservation, Universiti Malaysia Sabah

A survey on ferns and lycophytes was carried out from 9th to 17th August 2018 in Sg. Rawog Conservation Area (SRCA), Segaliud Lokan Forest Reserve, Sabah. The aim was to document the species richness of ferns and lycophytes, and to identify interesting or high conservation value species, such as endemic, rare and threatened species. More than 30 specimens of ferns and lycophytes were collected during the survey, comprising 15 families and 21 genera. Out of these, 32 species of ferns and lycophytes of SRCA were identified. Despite the low number of species collected, there are several interesting findings, such as *Selaginella conferta* (Selaginellaceae), a Bornean endemic lycophyte, which is only reported from Sabah, Sarawak, and Kalimantan. Other noteworthy species are *Tectaria borneensis* (Tectariaceae), which is restricted to Borneo and Sumatra islands, and *Pneumatopteris michaelis* (Thelypteridaceae) which was previously endemic to the Philippines. The latter species was only collected once in Borneo in 1927. These findings show that the forests in SRCA contain high conservation value ferns and lycophytes species, and these findings are vital for the formulation of the SRCA management plan. A further study on ferns and lycophytes should be extended in other parts of the conservation area to assess the diversity of this group of plants in the near future.

POSTER 7

PRELIMINARY STUDY ON FUNGUS DIVERSITY IN SG. RAWOG CONSERVATION AREA

V. Paul, C. Isah & J.J. Jakiwa
Forest Research Centre, Sabah Forestry Department

A preliminary study on fungus diversity was carried out from 14th to 17th August 2018 in Sg. Rawog Conservation Area (SRCA), Segaliud Lokan Forest Reserve (FMU 19B), Sabah. The purpose of the study was to survey the diversity of mushroom forming-fungi or macrofungi. Opportunistic sampling is one of the methods that is used in conducting the study of fungi in the forest in which "fungal forays" or survey is conducted along the way. The fungi that were identified in the field were photographed and identified. The study recorded 36 genera from 21 families. The most common family found was Polyporaceae. The most interesting species from this study area was *Filoboleus manipularis*, a glowing mushroom. From this study, we managed to identify 1 edible mushroom (*Auricularia* sp.) and 3 deadly poisonous mushrooms (*Amanita similis, Amanita virginea and Gymnopilus* sp.*)*. DNA-based methods for detection and identification of fungi are essential to properly identify the unidentified species of fungi, due to the difficulties in distinguishing them using morphological characters because they appear identical.

POSTER 8

MACROFUNGI OF SG. RAWOG CONSERVATION AREA

M.H.S. Kassim & J.S. Sathiya Seelan
Institute for Tropical Biology and Conservation, Universiti Malaysia Sabah

Sabah, Northern Borneo is considered as one of the most important biological sites for many endemic species of flora and fauna. The kingdom fungi (Basidiomycota) is not well explored in the tropical forests and always has been overlooked compared to plants and animals. So far, Agaricomycetes contains approximately 16,000 described species, which is 98% of the described species in the Agaricomycotina (Kirk et al. 2001). Agaricomycetes produce mushrooms, and are therefore the most familiar and conspicuous of all Fungi. Fungi (mushroom forming fungi, polypores, and corticioid) are heterotrophic organisms that utilize natural substrates for their survival. Thus, their different nutritional modes as saprophytic (wood and litter decomposers) and mutualists (mycorrhizal and endophytes) are highly valuable to the forest ecosystem as major decomposers, 'natural booster' for the growth of dipterocarp tree seedlings, and help in nutrient cycling through mycorrhizal association (Hibbett et al. 2001). Borneensis-Agaricomycetes project addresses species identification, taxonomy, phylogenetic and evolutionary relationships of all macrofungi in Sabah. As part of this, we participated in Sg. Rawog Conservation Area expedition to survey and document Agaricomycetes by opportunistic sampling. As a result, a total of 120 macrofungi specimens were collected from 12 trails with 3 forest types including Kerangas forest, Lowland Dipterocarp forest, and Hill Dipterocarp forest during the expedition. Out of these

collections, there were 26 genera and 108 species were recorded in this study. The genera identified are including *Mycena* sp., *Amanita* sp., *Auricularia* sp., *Filoboletus* sp., *Favolus* sp., *Schizophyllum* Poster 8 sp., *Cookeina* sp., *Marasmius* sp., *Parasola* sp., *Ganoderma* sp., *Polyporus* sp., *Amauroderma* sp., *Boletus* sp., *Hygrocybe* sp., *Termitomycetes* sp., *Fomes* sp., *Trametes* sp., *Cymatoderma* sp. *Geastrum* sp., *Lycoperdon* sp., *Ramaria* sp., *Clitocybe* sp., *Corticium* sp. (Corticoid), *Armillaria* sp., *Ophiocordyceps* sp., *Cordyceps* sp., and *Russula* sp. A total of 14 species were ectomycorrhizal mushroom that include fungi from genus *Boletus* sp., *Russula* sp., *Amanita* sp., and *Ramaria* sp. 33 species were saprophytic i.e. *Fomes* sp., *Trametes* sp., *Ganoderma* sp., *Mycena* sp., and *Favolus* sp. As for Ascomycota, three species were collected. An *Armillaria* sp. which was recorded was parasitic to plant root and entomopathogenic fungi from the genus of *Ophiocordyceps* sp. and *Cordyceps* sp. Six wild edible mushroom were recorded i.e. *Amanita* sp., *Auricularia polythricha* (Korong), *Auricularia delicata* (Telinga Kera), *Cookeina* sp. (Cendawan Mangkuk), *Favolus* sp., and *Schizophyllum commune* (Kodop). Three poisonous mushroom, *Amanita cookeri*, *Amanita frostiana* and *Trogia* sp also have been collected during the expedition. Interestingly, one species of bioluminescence mushroom also has been recorded which is the *Filoboletus manipularis*. Further molecular analysis will be conducted for species level identification.

POSTER 9

THE SIGNIFICANT ROLES OF SALT LICKS ON WILDLIFE IN SEGALIUD LOKAN FOREST RESERVE

H.F.W. Soehady E., M.S. Sarjani & B. Musta
Faculty of Science and Natural Resources, Universiti Malaysia Sabah

Two salt lick areas (namely SL1 and SL2) were selected to study its soil characteristics and micronutrients adsorption when compared to non-salt lick soils (SC). The study area is located at Segaliud Lokan Forest Reserve which consists of steeply to gently dipping sedimentary rocks. The physical characteristics show SC contain low moisture content (19.83% to 23.52 %) compared to SL1 (27.65% to 45.49%) and SL2 (39.78% to 47.08%) and low organic content as well (1.96%) compared to SL1 and SL2 (2.32% to 4.32%). Based on particle size distribution, SC is classified as sandy loam, SL1 is loamy sand and SL2 range from clayey loam to clay. Soils from SL2 consist higher finer particles compared to SL1 and SC. This provides large surface area for micronutrients adsorption such as Ca, Co, K, Mg, Na and Zn for animal's consumption. Soils from SC show average concentration of 216.31 µg/g, 0.09 µg/g, 251.95 µg/g, 119.34 µg/g, 0.23 µg/g and 8.17 µg/g for each element respectively. Meanwhile SL1 consists average concentration of Ca 2472.72 µg/g, Co 5.62 µg/g, K 472.93 µg/g, Mg 1252.11 µg/g, Na 739.24 µg/g and Zn 20.68 µg/g and SL2 consists average concentration of Ca 975.53 µg/g, Co 14.21 µg/g, K 1142.17 µg/g, Mg 2273.02 µg/g, Zn 31.56 µg/g but low detection of Na. In conclusion, SL1 and SL2 show higher concentration of micronutrients compared to SC due to the percentage of finer particles and existence of clay minerals, such as illite and montmorillonite which provide higher rate of nutrient adsorption, thus the soils are suitable as salt lick for wildlife consumption.

POSTER 10

NOTES ON BAT DIVERSITY IN SUNGAI RAWOG CONSERVATION AREA, SABAH, MALAYSIA

A. Amat[1,2], U.S. Daud[1], J. Senawi[3] & A. Mahyudin[1]
[1]Institute for Tropical Biology and Conservation, University Malaysia Sabah
[2]Faculty of Sciences and Natural Resources, University Malaysia Sabah
[3]Faculty of Science and Technology, Universiti Kebangsaan Malaysia, Bangi

Survey for bat diversity was conducted for three succesive nights at four trails in Sungai Rawog Conservation Area during the scientific expedition. Thirty-three (33) bats were captured, consisting of 14 species from four families, which were Pteropodidae, Hipposideridae, Rhinolophidae and Vespertilionidae. Pteropodidae, the fruit and nectar bat family was represented by a single species *Cynopterus minutus*, while the insectivorous bats of Hipposideridae, Rhinolophidae and Vespertilionidae were presented by thirteen species. These bat species, namely are *Hipposideros diadema*, *H. ridleyi*, *H. galeritus*, *Rhinolophus sp*., *R.borneensis*, *R.trifoliatus*, *R.sedulus*, *R.* cf. *acuminatus*, *Kerivoula intermedia*, *K. minuta*, *K.papillosa*, *K.pellucida* and *K.hardwickii*. From IUCN Red List, it is found that the conservation status of *Hipposideros ridleyi* is considered as Vulnerable (VU) due to the population detrimental across the globe. Besides, another four species – *Rhinolophus sedulus*, *Kerivoula intermedia*, *K.minuta* and *K. pellucida* are listed under Near Threatened (NT) status, while others are listed under Least Concern (LC) category with minimal information on their population stability. However, none of the listed bat species recorded in Sungai Rawog Conservation Area are protected under Sabah Wildlife Conservation Enactment, 1997. This piece of information highlights the role of Sungai Rawog Conservation Area as a refugia for endangered bat species in the east coast of Sabah.

POSTER 11

BAT OBLIGATE ECTOPARASITE DIVERSITY AND ITS PREVALENCE AT SUNGAI RAWOG CONSERVATION AREA, SABAH, MALAYSIA

U.S. Daud[1], A. Amat[1], C. Balinu[2] & A. Mahyudin[1,3]
[1]Institute for Tropical Biology and Conservation, [2] Faculty of Medicine and Health Sciences,
[3]Biotechnology Research Institute, Universiti Malaysia Sabah.

Sampling for bats' ectoparasites was conducted for three consecutive nights at four trails during Sungai Rawog Conservation Scientific Expedition in August 2018. Thirty-three (33) bat hosts were captured and screened for ectoparasites, covering 14 species from four families. Only seven (7) cases of infection were detected during this study, involving seven bat species. These bat species are *Hipposideros diadema*, *H. ridleyi*, *H. galeritus*, *Rhinolophus* sp., *R.sedulus*, *Kerivoula minuta* and *K.hardwickii*. The rate of prevalence is found to be equal among these seven species with 3.03%. The ectoparasites reported in this study were contributed by two (2) orders- Diptera and Mesostigmata, with three (3) families -

Nycteribiidae, Streblidae and Spinturnicidae. About 42% of bats' ectoparasites were dominated by family Streblidae, followed by Spinturnicidae (36%) and Nycteribiidae (22%). None of the listed ectoparasites in from this study have been reported harmful to the human. Yet, the information obtained from this study will help the management of Sungai Rawog Conservation Area to plan a mitigation measure for health and public safety in the future.

POSTER 12

A BRIEF GLANCE ON THE ANTS OF SG. RAWOG

B.E. Yahya. & H.M. Chin
Institute for Tropical Biology and Conservation, Universiti Malaysia Sabah

Ants were sampled in two areas during the Sg. Rawog Scientific Exploration. This ant exploration in Sg. Rawog was aimed at documenting the ants that are present in the area. Aspects on spatial composition of ants in the sampling sites were analyzed and discussed. Several collecting techniques were used in collecting the ants namely winkler, pitfall and random collection using litter sieve and direct capture. At a glance, the area maintains approximately 60 litter ant species (based on winkler sample) which consist of 7 subfamilies (Dolichoderinae, Dorylinae, Ectatomminae, Formicinae, Myrmicinae, Ponerinae, and Proceratinae). Myrmicinae recorded the highest ant genera recorded (8 genera: *Carebara, Crematogaster, Lophomyrmex, Monomorium, Myrmecina, Pheidole, Strumigenys* and *Tetramorium*) followed by Ponerinae (5 genera: *Anochetus, Hypoponera, Leptogenys, Odontoponera* and *Ponera*), Formicinae (3 genera: *Myrmoteras, Paratrechina* and *Pseudolasius*) and Dolichoderinae (2 genera: *Dolichoderus* and *Technomyrmex*). Dorylinae, Ectatomminae and Proceratiinae each recorded 1 genus. *Carebara* was the most abundant ant followed by *Paratrechina, Tetramorium, Pheidole, Hypoponera* and *Strumigenys*. The species rich and abundant ants were *Hypoponera* (10 species, 74 individuals), *Pheidole* (8 species, 105 individuals), *Carebara* (7 species, 229 individuals), *Strumigenys* (7 species, 65 individuals), *Tetramorium* (6 species, 106 individuals). Based on the spatial pattern, ants may demostrate competition reduction amongst them to ensure their survival. Further information on ants of Rawog will be revealed when more samples are processed and analyzed.

POSTER 13 (FULL PAPER)

TERMITE FAUNA OF SG. RAWOG CONSERVATION AREA

R. Homathevi*, H.M. Chin & Azrul

Institute for Tropical Biology and Conservation, Universiti Malaysia Sabah, Jalan UMS, 88400 Kota Kinabalu, Sabah, Malaysia.
** Author for correspondence. Email: homa.ums@gmail.com*

Abstract. This paper presents a preliminary list of termite species collected from Sg. Rawog Conservation Area. Termites were manually collected using standardized 100 m x 2 m belt transect, single transect, at all selected trails. A total of 14 species of termite, belonging to 10 genera of two families (Rhinotermitidae and Termitidae) were recorded within the forests sites of Sg. Rawog. The termite assemblage was dominated by the family Termitidae, comprising of wood-dwelling termites. The termite diversity is lower compared to any other primary forest and all species are commonly found in typical Malaysian forests.

Keywords: Termite, Sg. Rawog, Diversity, belt transect

INTRODUCTION

Termites are important members of the soil macrofauna throughout the humid tropics. The dominance of termites in tropical ecosystems is mainly related to their ability to utilize dead plant material rich in cellulose (the most abundant organic matter on the earth) (Abe, 1995). They become important in ecological processes such as decomposition of organic matter, improving soil structure, redistribution of mineral and organic materials and the enhancement of organo-mineral complex formation (Wood and Johnson, 1986; Bignell *et al*. 1997; Brussaard and Juma 1996; Lavelle 1996). Termite assemblages are also known as sensitive indicators of anthropogenic habitat disturbance. They show characteristic changes in species richness and functional group composition along disturbance gradients, including those imposed by logging and the conversion of natural forest ecosystems to plantations or subsistence crop fields (Eggleton *et al*., 1997, 1999; Bignell *et al*. 1997). This paper presents a preliminary list of termite species collected from Sg. Rawog Conservation Area, Segaliud Lokan, Telupid, Sabah.

MATERIALS AND METHOD

Termite sampling was conducted using three standardized 100 m x 2 m belt transects, along the designated trails within the Sg. Rawog Conservation Area. Sampling using the protocol described by Jones and Eggleton (2000) was employed. Successive 5 m sections of the transect were sampled by two people for 30 minutes per section. All microhabitats known to harbor termite species were explored. These include carton runways on tree trunks and

above-ground vegetation, dead wood in all stages of decay, root mats, tree root systems and buttresses, surface soil, subterranean and epigeal nests, nests inside wood and arboreal nests up to 2 m above ground level.

The samples were preserved in 90% alcohol and subsequently identified to species or assigned to morphospecies by referring to Thapa (1981). Feeding and nesting group were allocated according to Collins (1984), Eggleton *et al*. (1997) and Jones and Brendell (1998).

RESULTS & DISCUSSION

A total of 14 species of termite, belonging to 10 genera of two families (Rhinotermitidae and Termitidae) were recorded within the forest sites of Sg. Rawog (Table 1). Termitidae (10 species) was the dominant family, with Termitinae comprising of eight species followed by single species for Macrotermitinae and Nasutitermitinae. The subfamilies Termitinae, Macrotermitinae and Nasutitermitinae are common in most tropical forests. Termitinae is more dominant in SE Asian forest meanwhile Nasutitermitinae has more species in the Amazonian rainforest. The family Rhinotermitidae represented by four species, is the most important family of lower termites and is very common in the rainforest of the Oriental region. Some important genera commonly recorded in Malaysian forests as well as at Sg. Rawog Conservation Area are *Heterotermes*, *Coptotermes* and *Schedorhinotermes*. Rhinotermitidae is also known to be abundant in areas where there are plenty of damp logs.

Table 1. Termite species collected from Sg. Rawog Conservation Area using single standardized transect: Feeding groups, l = litter feeders, epy = micro-epiphyte feeders, s/w = soil/wood interface feeders, w = wood feeders, (f) = fungus growers. Nesting groups, a = arboreal, e = epigeal, h = hypogeal, w = in dead wood.

	Frequency	Feeding group	Nesting group
Family : Rhinotermitidae			
Heterotermes tenuior	17	w	h
Coptotermes sp.	1	w	w
Schedorhinotermes brevialatus	34	w	w
Schedorhinotermes sarawakensis	3	w	w
Family : Termitidae			
Sub-family : Macrotermitinae			
Macrotermes gilvus	1	w/ l(f)	e
Sub-family : Termitinae			
Microcerotermes serrula	5	w	w

Microcerotermes dubius	11	w	w
Homallotermes eleanorae	4	s / w	e
Pericapritermes nitobei	1	s	h
Pericapritermes dolichocephalus	1	s	h
Procapritermes sp.	1	s	h
Dicuspiditermes nemorosus	19	s	e
Dicuspiditermes santschii	1	s	e
Sub-family : Nasutitermitinae			
Hospitalitermes sp.	1	epy	a
Total	**14 species**		

Five functional groups of termites were recorded within the study area. The wood feeding species made up 43% of the termites sampled. The wood-feeding termites were common in the study area. Fungus growers also known as litter feeders, were represented by *Macrotermes gilvus*. Only one soil/wood interface-feeder species encountered, *Homallotermes eleanorae*. A similar trend of wood feeding termites dominating the assemblage in disturbed habitat is still evident in the present and previous study.

The termites collected were inclusive of subterranean, mound, wood and arboreal nest-building species. Wood nesters were relatively abundant (36%) followed by four hypogeal nesters, four epigeal nester and one arboreal nester. A similar trend of wood nesters dominating the assemblage in disturbed habitat is still evident in this study.

CONCLUSION

The species richness of the termite assemblages at Sg. Rawog Conservation Area was relatively lower compared to other forest sites in Sabah. A similar trend of non-soil feeding termites dominating the assemblage in disturbed habitat is still evident in the present and previous study.

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POSTER 14

DRAGONFLY AND DAMSELFLY FAUNA OF SG. RAWOG CONSERVATION AREA IN SEGALIUD LOKAN FOREST RESERVE, SABAH

A.D.Dg. Fazrinah[1], A.Y.C. Chung[1], R. Japir[1], J.L.Yukang [1] & C.Y. Choong [2]
[1]Sabah Forestry Department
[2]Universiti Kebangsaan Malaysia, Bangi

Some 31 Odonata species were recorded in Sg. Rawog Conservation Area during the survey. Sixteen of them were dragonflies while the remaining were damselflies. The number of species recorded is high, considering that sampling was only conducted for three working days. The survey was carried out along the riverine area of Sg. Rawog, a few ponds adjacent to the base camp in Compartment 56, and forested trails in Compartments 49 and 61. For damselflies, three Bornean endemic species were recorded, namely *Rhinagrion elopurae, Coeliccia nigrohamata* and *Prodasineura hyperythra*. The Flatwing, *Rhinagrion elopurae,* is listed as a near threatened species under the IUCN Red List. It is also interesting to note that the Pixie, *Brachygonia oculata*, was found in abundance in the stagnant water within the mixed dipterocarp and heath forest floor in Compartment 61. It is among the smallest dragonflies in the world.

POSTER 15 (FULL PAPER)

A CHECKLIST OF THE HERPETOFAUNA IN RAWOG VALLEY, SEGALIUD LOKAN FOREST RESERVE, SABAH, MALAYSIA

P. Y. Imbun*, B. Butit & J. Lapidin

Education and Research Division, Zoology & Entomology Unit, Sabah Parks, P. O. Box 10626, 88806 Kota Kinabalu, Sabah
**Author for correspondence. Email:* dingguron@yahoo.com

Abstract. A survey of herpetofauna was conducted in Sungai Rawog Valley Conservation Area, Segaliud Lokan Forest Reserve, on 13-18 August 2018. The survey resulted in 30 species of herpetofauna being encountered, consisting of 22 anuran species and eight reptile species. Rhacophoridae contributed the highest species richness, having nine species. Two forest trails and the camp area are potential herpetofauna hotspot for the area. Many amphibian species were encountered in these sites due to the existence of water bodies that act as habitats for amphibian reproduction. The majority of the herpetofauna species are those associated with disturbed forest environments.

INTRODUCTION

Herpetofauna is a specific group of animals that comprise the amphibian and reptilian species. Herpetofauna forms part of the vertebrate communities in tropical forest ecosystems, inhabiting habitats from the sea level up to montane areas. As part of the research activities in Rawog expedition, a survey of herpetofauna was conducted on 13 – 18 August 2018. The expedition focused on the conservation area along the valley of Rawog River, covering an area of 3,118 ha. The Rawog valley is part of the Segaliud Lokan Forest Reserve (SLFR) which is managed by KTS Plantation Sdn. Bhd. under the License Agreement for Timber Tree Plantation and Wood Processing Plant since 1993. The expedition was co-organized by Sabah Forestry Department (SFD) and KTS Plantation with the main objective of documenting the biodiversity of the area.

MATERIALS AND METHOD

Study area

The SLFR is a Class II forest reserve and is located southwest of Sandakan covering an area of 57,247 ha. It is dominated by lowland dipterocarp forest belonging to the *Parashorea tomentella*/*Eusideroxylon zwageri* Forest Type. *Shorea johorensis* (seraya majau), *Dryobalanops lanceolata* (kapur paji), and *Dipterocarpus caudiferus* (keruing putih) are usually associated with the forest type. Pioneer species such as Laran, Binuang and Magas are also found in the area indicating some form of previous forest disturbance. The general terrain is steeply undulated, with slopes covering 88% of the area and ridges with 5% of the area of varying steepness. Only 9% of the land is flat (less than 50 gradients). The climate of the area is typically tropical with high rainfall and hot all year round. The area receives between 3,000-3,500 mm of rain yearly, and the mean annual temperature is 27ºC, with the highest being 36ºC and lowest about 21ºC.

Sampling sites

The Rawog river is located south in SLFR and together with two other SLFR rivers form part of the upper Kinabatangan river system. The valley of Rawog river is made up of old alluvial deposits. The river banks are covered with gravel and stone beds.

The herpetofauna survey was conducted in the middle part of the Rawog valley conservation area (Figure 1). Based on preliminary observation of previous SFD survey, this part of the Rawog valley contains potentially rich biodiversity. A total of seven sites were surveyed, which included six forest trails and the surrounding area of the expedition camp site (Table 1).

Table 1. Description of the habitats of the different sampling sites.

Sampling sites	Description of habitat
Trail 6	Slightly hilly forest with several streams and ponds.
Trail 7	Hilly forest, connected with Trail 8.
Trail 8	Old selectively logged forest. Near Rawog river. Abundance of forest pools.
Trail 9	Secondary forest, dense growth of shrubbery.
Trail 10	Heath forest, connected with Trail 8
Trail 12	Upper part of Rawog river. Heath forest with puddles of rain water. Streams are absent.
Camp site	Secondary forest.

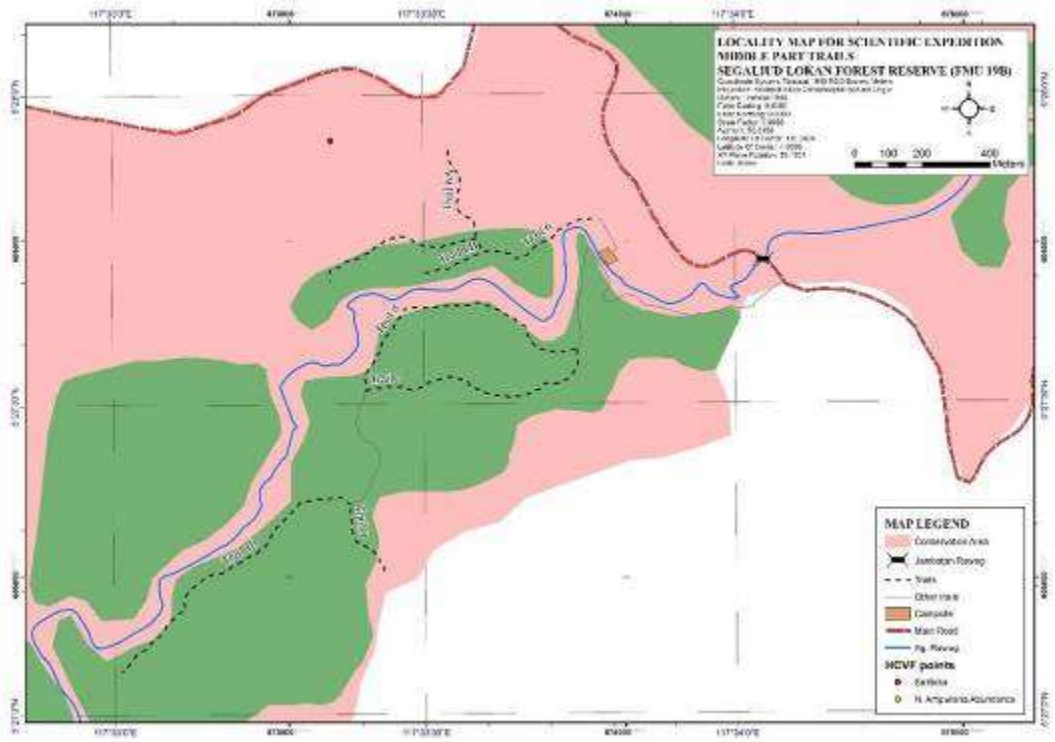

Figure 1. Sampling sites of the herpetofauna survey focused mainly in the middle part of the Rawog valley conservation area.

Sampling of hepertofauna

Sampling of herpetofauna was carried in forest trails and stream transects during the day. Stream transects were searched for stream dependent amphibians and reptiles. Surveys were also carried out at night. Opportunistic sampling was carried out where herpetofauna sighted or heard were recorded. Hand-grabbing technique was used to capture individuals of herpetofauna in the field. Live photographs of each specimen were taken and individuals of rare or easily identified species were released after measurements and other essential data were recorded.

Collected specimens were preserved in 10% formalin and later transferred to 70% ethanol for long-term preservation. Identification of amphibians were based on keys in Inger & Stuebing (1997 & 2005), Imbun (2014) and Inger *et al.* (2017), whilst reptiles were identified by referring to Inger & Tan (2010). Other suplementary reference books included Das (2004) for lizard's taxonomy and, Stuebing & Inger (1999) and Stuebing *et al*. (2014) for snake's taxonomy. The herpetofauna specimens were deposited at the Zoology Museum at Kinabalu Park.

RESULTS AND DISCUSSION

The survey yielded a total of 55 collected specimens during the four working days of the survey, of which 49 individuals were amphibians and six individuals were reptiles. These specimens belong to four families of amphibians (Dicroglossidae, Microhylidae, Ranidae, Rhacophoridae) and four families of reptiles (Agamidae, Gekkonidae, Scincidae, Colubrinae) respectively. Twenty two amphibian species and eight reptilian species were encountered (Table 2). It was observed that the amphibian family Rhacophoridae contributed nine species, the highest species richness, for the survey.

Table 2. Species composition of herpetofauna in Rawog valley, Segaliud Lokan Forest Reserve. (*Endemic to Borneo)

FAMILY	**SPECIES**
REPTILES	
Agamidae	*Gonocephalus liogaster*
	Draco quinquefasciatus
Gekkonidae	*Gecko gecko*
Scincidae	*Sphenomorphus hassi*
	Tropidophorus beccari
	Eutropis rudis
Colubrinae	*Boiga jaspidea*
	Gonyosoma oxycephalum
AMPHIBIANS	
Microhylidae	*Microhyla borneensis**
	*Kalophrynus meizon**
	Metaphrynella sundana
Ranidae	*Abavorana luctuosa*
	Amnirana nicobariensis
	*Hylarana megalonesa**
	Hylarana erythraea
	Pulchrana glandulosa
Dicroglossidae	*Fejervarya limnocharis*
	Limnonectes finchi

	Limnonectes leporinus
	Limnonectes paramacrodon
	Occidozyga sumatrana
Rhacophoridae	*Kurixalus chaseni*
	Polypedates colletti
	Polypedates leucomystax
	Polypedates macrotis
	Polypedates otilophus
	Rhacophorus nigropalmatus
	Rhacophorus harrissoni
	Rhacophorus pardalis
	Rhacophorus rufipes

Species richness was the highest in Trail 6, Trail 8 and camp site (Figure 2). Less herpetofauna species were found in other sampling sites. Both Trail 6 and Trail 8 provide suitable habitats for the reproduction of amphibians by having source of water bodies. Thus, many amphibian species were found in these trails. In Trail 9, only the common lizard, *Eutropis rudis*, was spotted. Many of the amphibian species found during the survey were inhabitants of disturbed forests or open areas. These include *Fejervarya limnocharis*, *Hylarana erythraea, Abavorana luctuosa*, *Hylarana megalonesa*, *Amnirana nicobariensis*, *Polypedates leucomystax*, *Polypedates macrotis* and *Polypedates otilophus*. All of the sampling sites has been disturbed previously by logging activities, giving rise to secondary forests and old growth forest. Such environment attracts herpetofauna species that can adapt to forest disturbance and therefore flourish in abundance. *Eutropis rudis*, *Polypedates colletti* and *Kurixalus chaseni* were also encountered in many of the sampling sites (Table 3).

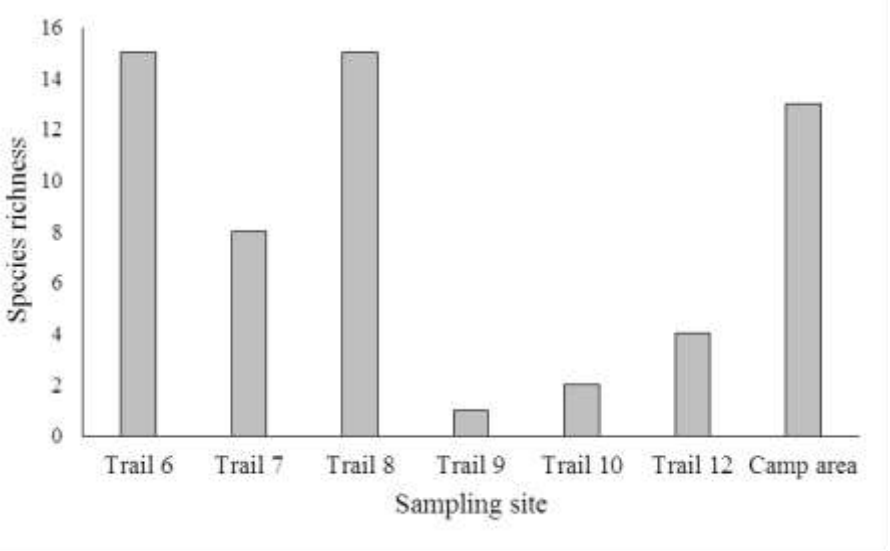

Figure 2. Species richness of herpetofauna in different sampling sites of Rawog Valley.

Table 3. Species composition of herpetofauna in the sampling sites of Rawog Valley.

FAMILY	SPECIES		Trail 6	Trail 7	Trail 8	Trail 9	Trail 10	Trail 12	Camp site
Dicroglossidae	*Occidozyga*	*sumatrana*	x						
Dicroglossidae	*Fejervarya*	*limnocharis*							x
Dicroglossidae	*Limnonectes*	*leporinus*	x						
Dicroglossidae	*Limnonectes*	*paramacrodon*	x		x				
Dicroglossidae	*Limnonectes*	*finchi*	x						
Microhylidae	*Microhyla*	*borneeensis*		x	x				
Microhylidae	*Kalophrynus*	*meizon*							x
Microhylidae	*Metaphrynella*	*sundana*		x	x				
Ranidae	*Abavorana*	*luctuosa*							
Ranidae	*Amnirana*	*nicobariensis*	x		x				x
Ranidae	*Hylarana*	*megalonesa*	x		x				x
Ranidae	*Hylarana*	*erythraea*							x
Ranidae	*Pulchrana*	*glandulosa*			x				
Rhacophoridae	*Kurixalus*	*chaseni*	x	x	x			x	x
Rhacophoridae	*Polypedates*	*macrotis*	x		x			x	
Rhacophoridae	*Polypedates*	*colletti*	x	x	x			x	
Rhacophoridae	*Polypedates*	*leucomystax*	x						x
Rhacophoridae	*Polypedates*	*otilophus*							x
Rhacophoridae	*Rhacophorus*	*pardalis*	x		x				x
Rhacophoridae	*Rhacophorus*	*rufipes*			x				
Rhacophoridae	*Rhacophorus*	*nigropalmatus*							x
Rhacophoridae	*Rhacophorus*	*harrissoni*		x					
Scincidae	*Eutropis*	*rudis*	x	x	x	X	x	x	x
Scincidae	*Sphenomorphus*	*hassi*		x			x		
Scincidae	*Tropidophorus*	*beccari*	x						
Agamidae	*Gonocephalus*	*liogaster*			x				
Agamidae	*Draco*	*quinquefasciatus*	x						
Gekkonidae	*Gekko*	*gecko*	x	x					x
Colubrinae	*Boiga*	*jaspidea*			x				
Colubrinae	*Gonyosoma*	*oxycephalum*			x				x

CONCLUSION

Considering the slightly disturbed nature of the environment, the survey resulted in adequate amount of herpetofauna species. The majority of the species are constituents of disturbed or modified ecosystems. More species are likely to be found with frequent sampling and continuous monitoring of the area.

ACKNOWLEDGEMENT

We thank Sabah Forestry Department for organizing the Rawog expedition and KTS Plantation for logistics support. Our field excursions would not have been possible without the assistance of Mr. Dividson Markau and Mr. Walsius Masius to whom we are indebted to.

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POSTER 16

A PRELIMINARY ASSESSMENT OF ANURAN DIVERSITY OF THE SG. RAWOG CONSERVATION AREA IN SEGALIUD LOKAN FOREST RESERVE, SABAH

Pg.M.S. Salam, J.A. Hing & I. Brandon
Sabah Forestry Department

The objective of this study is to determine the species diversity of frogs and toads in the Sg. Rawog Conservation Area, Segaliud Lokan Forest Reserve (SLFR) which is also known as Forest Management Unit No. 19(B), covering an area of 57,247 ha. The study provides useful baseline information to build future studies on anurans in SLFR, as well as to contribute to our current knowledge of anuran diversity and distribution in Sabah. Specimens were sampled by Visual Encounter Survey (VES) with the help of torchlight to pinpoint sample locations, and where possible, hand-grabbing technique. Three sampling sites were selected within the lowland mixed dipterocarp and kerangas forest area. A total of 1,268 individuals were caught, consisting of 19 frog and toad species, belonging to five families, were recorded from three sampling sites. The mean Shannon Index was 1.31 while Simpson Index was 2.89 and Fisher Alpha Index was 2.49. Eight Bornean endemic species were recorded during the survey. The endemic anuran species recorded during the survey provide significant information to enhance the conservation of Sg. Rawog area. Conservation and maintenance of this area is crucial to also conserve the anuran species. Future studies should be conducted to establish stronger data and enhancing the reliability of studies regarding anurans in this area. Sg. Rawog Conservation Area has high potential for "anuran tourism" because has high number of endemic species, good morphological attractiveness and behavioural enticement of species.

POSTER 17

DIVERSITY AND DISTRIBUTION OF ICHTHYOFAUNA IN SELECTED RIVERS IN SUNGAI RAWOG CONSERVATION AREA, SEGALIUD LOKAN FOREST RESERVE

N.S.S. Kamal., J. Jumian & A.Y.L. Hastie
Forest Research Centre, Sabah Forestry Department

A preliminary survey on ichthyofauna was carried out in two tributaries of the Sungai Rawog (Sg. Sapa Magang and Sg. 25K), and the main river channel of Sungai Rawog, within the Sungai Rawog Conservation Area, Segaliud Lokan Forest Reserve. Fishes were collected using various fishing gears, namely fish traps (*bubu*), cast nets and gill nets over a period of four days. A total of 349 individuals were trapped, and comprising 28 species, belonging to nine families (Anguillidae, Cyprinidae, Siluridae, Bagridae, Mastacembelidae, Nandidae, Eleotridae, Osphronemidae, Tetraodontidae). Sungai 25K recorded highest species richness with 17 species followed by Sungai Rawog (13), and Sungai Sapa Magang recorded low richness with only 8 species. All recorded species except one (*Barbonymus goniotatus*) are native, and seven species are endemic to Borneo. The ichthyofauna were dominated by the cyprinids (64.3%) and *Barbodes sealei* was the most abundant species. Although the survey was conducted over a short sampling period, the rivers indicated relatively rich ichthyofauna community. Continuous long-term monitoring of fish communities at these rivers can provide inferences on the forest management practices within its watershed.

POSTER 18

THE STATUS OF PARASITE INFESTATION AMONG FISHES IN SUNGAI RAWOG CONSERVATION AREA

H.H. Mahsol
Institute for Tropical Biology and Conservation, Universiti Malaysia Sabah

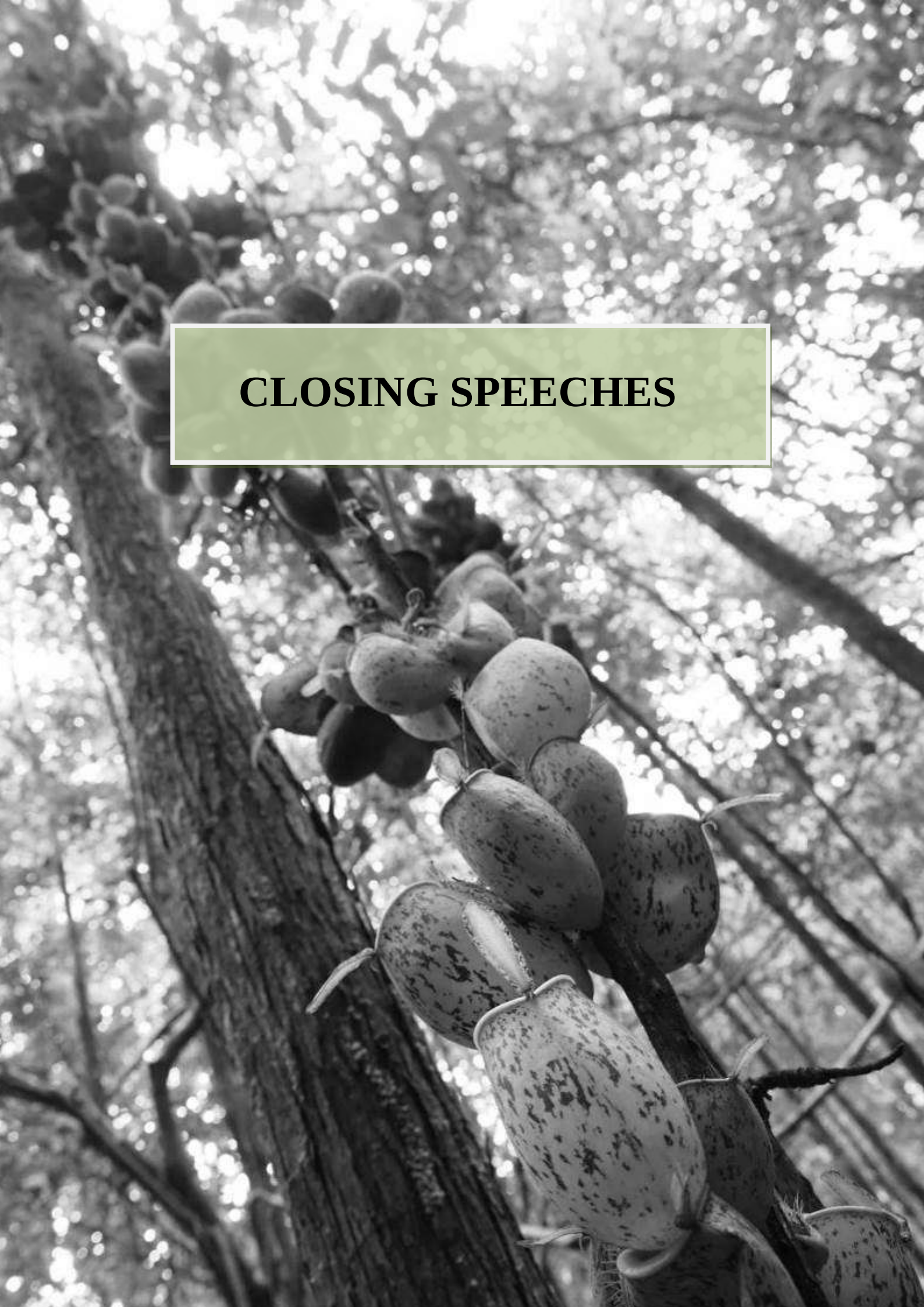
A survey of parasite infestation among fishes in Sungai Rawog Conservation Area (SRCA), Segaliud Lokan Forest Reserve (FMU 19B) was conducted on 8 – 12 August 2018. Only two species were selected because of their character of size (large fishes) and more abundant to be suspected of being infected. The overall targets of this study are to estimate the prevalence of parasites among fishes in Sungai Rawog and to measure any risk or effect from this infestation. The fishes were collected with electro-shocker and net. A total of twelve individual fishes with the ratio of 50:50 of two species *Hampalamacrolepidota* and *Channa melasoma* (Family: Cyprinidae and Channidae). Only two groups of parasites were recorded in this study; Monogenea and Lernaeopodidae. All of the parasites were observed in gills with Monogenea (50%) and Lernaeopodidae (50%). The overall parasitic infestation rate was only 17%. Lastly, from the data analysis of SPSS and Epi-Info, there were no significant associations between parasitic infestation with family groups (P=0.5) among fishes in Sungai Rawog Conservation Area. The risk analysis stated that Family Cyprinidae and Channidae had same risk of having parasite infestation by those parasites of Monogenea and Lernaeopodidae.

POSTER 19

PRELIMINARY ASSESSMENT OF AVIFAUNA IN A RECOVERING LOWLAND FOREST IN SEGALIUD LOKAN FOREST RESERVE, SABAH, MALAYSIA

A. Biun[1], G.H. Petol[2], A. Anthony[1], V. Rudolf[2], S. Sulaiman[3], J. Andrew[3], L. Mikal[3] & M.J. Jamal[4]
[1]Sabah Parks
[2]Sabah Forestry Department
[3]Universiti Malaysia Sabah (UMS)
[4]KTS Plantation Sdn. Bhd.

It has been well known by researchers that the lowland protected areas in Sabah, Malaysia, in general, have received little ornithological attention. Here we describe the avian community at a small portion of Segaliud Lokan Forest Reserve, an area of mixed lowland rainforest habitats within the riparian protection area. We present observations from Sungai Rawog Scientific Expedition, including an annotated list of the 121 species recorded belong to 34 families. Measurements of it abundance determined from the 560 individual number were listed in the 28 species checklists of 20 species list derived from three consecutive days (15 – 17th August, 2018) of observation. Although parts of forests reserve are recovering from historic high-intensity logging, they are a valuable habitat for many lowland rainforest bird species, including uncommon species such as Bornean Necklaced Partridge, Great Argus, and Blue-headed Pitta and all eight species of hornbills found in Borneo are here as the large passerine birds which strongly live associated with lowland primary forest. The diversity of birds at Rawog highlights the importance of preserving degraded tropical forest for conservation. Our observations serve as a valuable baseline assessment of the avifauna in this region, which is particularly important in this era of rapid environmental destruction and land conversion into agriculture.



CLOSING SPEECHES

6.1 CLOSING REMARKS BY SABAH AREA OPERATION (SAO) MANAGER (FORESTS) OF KTS PLANTATION SDN. BHD., MR. COLLIN GOH

Yang Berbahagia Mr. Indra Purwandita, Senior Assistant Chief Conservator of Forests,
All heads of government departments,
All heads of non-governmental organisations,
Senior managers from KTS group of companies
Foresters, lecturers, students,
Ladies and gentlemen,

Today, TOGETHER WE – the Industry, the University, the Research Institution, Government and Non-government Agencies, have demonstrated what we can achieve together through collaboration for a common cause. To bring diverse discipline to the table is no easy task, let alone to organize an event with just a handful of 'Young and New' staff in KTSP. Nevertheless, all of this has been possible with the voluntarily effort and goodwill from everyone. I mean EVERYONE. Thank you very much.

While most of us were celebrating the Chinese New Year, the Working Committee headed by Dr. Arthur and team have been working in endless hours to make sure that 'findings' of the expedition is not just 'kept on the selve' but rather packed as take home message for all in a well-organized seminar like this. Thank you, Dr. Arthur.

Ladies and gentlemen,

Today's Seminar, through the papers and posters, has provided us a glimpse of the complexity of forest being managed in the Segaliud Lokan Forest Reserve. The flora and fauna diversity deservse correct understanding and must be sufficiently accomodated in the Forest Management Plan of the reserve or else it will end up in a chaotic conflict of survival. I believe this is similar with all of the Forest Management Units in Sabah. Without the involvement of experts from the various disciplines as we see today, Sustainable Forest Management will remain an elusive target even though it has become the most discussed subject in a seminar like this.

The old adage notion that forestry industry is just about 'Fell and Sell' a tree is now thing of the pass. We realized that the industry evolved at faster rate more than we expect. Hence, we are determined to continuously embrace the approach of 'Scientifically Evident-based Practices'. We need good foresters to develop models and methods to navigate us forward.

Ladies and gentlemen,

As mentioned by the Managing Director, Dato' Henry Lau this morning, the results from the expedition will be used to improve our management of conservation areas in a holistic manner which is now being incorporated into our Forest Management Plan for the period of 2019-2028.

Encouraged by your support, we are looking forward for more collaborative activities in future as we gear up with the Field Research Station as mentioned by the Managing Director, Dato' Henry Lau.

Perhaps the priority will be focusing on understanding the aspect of co-habitant between RTE species and Operation activities in SLFR. Otherwise, we may not do justice to these species which may be deprived of their preferred habitat.

Ladies and gentlemen,

On behalf of KTS group of companies, I would like to say thank you to all participants, the speakers, the poster presenters, the session chairpersons for all the support to ensure this event a successful one as we see today. Perhaps we are yet to pull down the curtain as more collaborative activities are planned for the future. We would also like to apologize for any short-comings during the Scientific Expedition and also during this Seminar. Although we may have thought we have done the best, we realize our best may not be good enough and perhaps we can learn and improve in the future.

Thank you.

Mr. Collin Goh
Sabah Area Operation (SAO) Manager (Forests)

6.2 CLOSING SPEECH BY THE DEPUTY CHIEF CONSERVATOR OF FORESTS (R&D), DR. ROBERT C. ONG
(Speech delivered by Senior Assistant Chief Conservator of Forests, Mr. Indra Sunjoto)

Ladies and gentlemen,

With great privilege, I would like to thank the Session Chairpersons and all paper presenters for sharing their findings at Sg. Rawog Conservation Area. I am sure all of us here are hoping that the information gathered from this seminar as well as comments from the audience, will be useful for KTS Plantation and Sabah Forestry Department in managing this conservation area. I am proud to see a fair number of participation of local researchers from Universiti Malaysia Sabah, Sabah Parks, Sabah Forestry Department, Sabah Wildlife Department and World Wildlife Fund, and not to miss out, Dr Miyabi Nakabayashi of Ryukyus University, Japan in collaboration with Sabah Forestry Department and two internship undergraduate students from Portland University from the States were involved in this expedition. The expedition has also been aired in our local TV network, RTM1, ensuring that our efforts are not for our own personal glory but to be communicated and socialized the importance of Sg. Rawog to a larger audience in Malaysia, as what our honorable Chief Minister is critical about.

As some of you may realize that the surrounding forests of Sg. Rawog have been exploited for timber in the past, yet findings from fauna and flora still suggest that these once severely disturbed ecosystems are crucial for their continuous survival. Hence, placing this area as conservation zone under sustainable forest management practices by KTS Plantation is appropriate and crucial for the maintenance of biodiversity in Sabah.

Ladies and gentlemen,

The Forestry Department and KTS Plantation will take note of the various points brought up in this seminar, including the most important key finding of critical concentration of biodiversity in Sg. Rawog. The department, forest managers and relevant stakeholders will evaluate and formulate biodiversity monitoring programme that is much in line with the statewide monitoring of critical and important forest landscape, ecosystems and species programmes.

Equally important points were brought up on the potential of recreation activities that can be further studied and developed, including wildlife viewing and fishing recreation. There are few salt-lick sites were identified within the conservation area, and I was also told that many also found throughout the management unit which are accessible by road. Rawog river itself is potential water bodies that fishing recreation can be developed. Thus, we can develop and promote recreation as part of revenue generating income for Sabah without further degrading this important forest landscapes.

Ladies and gentlemen,

In conclusion, your valuable time, energy and support for this Sg. Rawog Scientific Expedition Seminar is very much appreciated. I hope that many of you have gained much understanding from the presentations and posters at the exhibition booth. Both, Sabah Forestry Department and KTS Plantation appreciate your participation and contribution towards a better understanding of living harmony with nature and develop sustainable income to support the state prosperity. Lastly, I appreciate KTS Plantation in sponsoring this seminar. With that, I declare this seminar is officially closed.

Sekian, Terima Kasih.

Dr. Robert C. Ong
Deputy Chief Conservator of Forests (R&D)

Some snapshots from the Seminar on 21st of February, 2019.

Expedition participants in action

The expedition in TV1

SRCA wildlife in camera trapping

SRCA insects in action

SRCA Seminar in action

SRCA Seminar in TV1

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