THE HEART OF BORNEO SERIES 21
PROCEEDINGS FOR HEART OF BORNEO
SEMINAR 2022:

GUNONG PUEH FOREST RESERVE

SCIENTIFIC EXPEDITION

Where Nature & Science Unites

HEART OF BORNEO

Sarawak

SEMINAR PROCEEDINGS 2022

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PROCEEDINGS FOR THE HEART OF BORNEO (HOB) SEMINAR 2022:

GUNONG PUEH FOREST RESERVE SCIENTIFIC EXPEDITION

"Where Nature and Science Unites"

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We also would like to accord our appreciation to our advisers, Datu Haji Hamden bin Haji Mohammad, Director of Forests, Tuan Abg Ahmad bin Abg Morni, Permanent Secretary, Ministry of Energy and Environmental Sustainability (MEESty) Sarawak, former Deputy Director of Forests (Forest Management), Tuan Jack Anak Liam, Controller of Environmental Quality Sarawak, Natural Resources and Environment Board (NREB) Sarawak, former Deputy Director of Forests (Forest Conservation and Development) and Puan Runi Anak Sylvester Pungga for their insightful counsel.

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Finally, our heartfelt thanks go to all our friends and participants from the Heart of Borneo Seminar. We sincerely appreciate their dedicated efforts and enthusiastic involvement, which significantly contributed to the creation of this comprehensive proceeding.

FOREWORD

Sarawak's Heart of Borneo (HoB) regions, known for their vast and challenging terrain, harbour significant biodiversity. Sarawak had put the conservation of biodiversity as one of the pillars that guide the implementation of activities and projects under HoB initiatives focusing on effective management of not only to our Totally Protected Areas but also to other high conservation value forests within the HoB.

Gunong Pueh Forest Reserve: HoB Scientific Expedition, the 8th scientific expedition, was held from October 5–17, 2020, after the Kelingkang Scientific Expedition in 2019. Due to the pandemic COVID-19 situation, a limited number of Forest Department researchers and staff participated in the expedition. Despite the pandemic situation, the expedition was successfully conducted and revealed the vast richness of Gunong Pueh's biodiversity.

The Proceedings entitled "Gunong Pueh Forest Reserve Scientific Expedition: Where Nature & Science Unites" detailed outcomes from soil studies, forest ecology, geospatial mapping, eco-tourism, and the diversity of flora and fauna. A noteworthy discovery included the identification of a sanctuary harbouring endemic and threatened trees, as well as an examination of floristic composition within the proposed arboretum site at Gunong Pueh Forest Reserve. I am glad to inform you that the Forest Department Sarawak has documented numerous data and findings from scientific expeditions in its HoB series of publications.

The organizing committee deserves much credit for the time and effort put in for the success of the expedition. Special appreciation goes to all esteemed participants who have been gracious to share findings which culminated into scholarly publication.

Thank you.

Datu Haji Hamden Bin Haji Mohammad
Director of Forests
SARAWAK

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PAPER 1:
COMMON SOILS OF GUNONG PUEH: SARAWAK'S SOUTHERN HEART OF BORNEO

Halipah Bujang, Mohd. Yusuf Abd. Rahman, Ahmad Zaidi Keria, Umar Abang

Forest Department Sarawak, Malaysia
Corresponding email: halipahb@sarawak.gov.my

Abstract: Gunong Pueh, located in Lundu District has been selected as the site for Heart of Borneo's (HoB) expedition in 2020. Pueh is one of the massifs developed from the igneous rocks of basic to intermediate composition. Following Sarawak Soil Classification, soils within the Pueh's expedition area mainly belong to the Skeletal and Oxisol soils group. Oxisol or lateritic soils were observed dominating the gentle slope area, whereas Skeletal soils or rocks were found at the steep or rugged terrain along the expedition's trails. The soils generally have a light to medium texture, ranging from sandy loam in the upper part to sandy clay loam in the lower horizon. They exhibit colours from dark yellowish-brown (10YR 3/6) to red (2.5YR 5/6), suggesting to be Gading soils belonging to the Oxisol group. The soils are moist and generally acidic, with in-situ pH values ranging from 5.4 to 6.7.

Keywords: Gunong Pueh, Sarawak's soils, granitic, Oxisol, Skeletal

INTRODUCTION

Soils are a complex, non-renewable natural resource that provides services to the ecosystem by supporting the growth of higher plants. They influence the existence of natural forest vegetation. Different natural habitats usually portray different types of tree composition, particularly in tropical environments. The habits of natural forests are generally adapted to their soils and environment, ranging from the lowest altitude to the higher levels of the mountainous range. There is also a mega biodiversity hotspot that comprises various species of flora, one of the unique characteristics of tropical rainforests that provides a home for fauna communities.

Ecologically, a variety of forest types naturally form from lower altitudes at sea level, going upwards to the mountainous zonation, contributing to the gradual change in the forest and sometimes reflected by the species composition within the forest itself. A similar situation applies to the Heart of Borneo (HoB) region, which spans three countries: Brunei in the north, Kalimantan (Indonesia), and Sabah and Sarawak (Malaysia) from the north to the south of Borneo.

In Sarawak, the Pueh Forest Reserve, approximately 4,081 hectares, is part of the HoB area and was selected for biodiversity exploration during the Pueh Heart of Borneo Expedition 2020. The site selection represents Sarawak's HoB Southern region, as shown in Figure 1. The expedition aimed to search for and identify various aspects of biodiversity, including flora and fauna, and explore the forest environment within Sarawak's HoB Southern region.

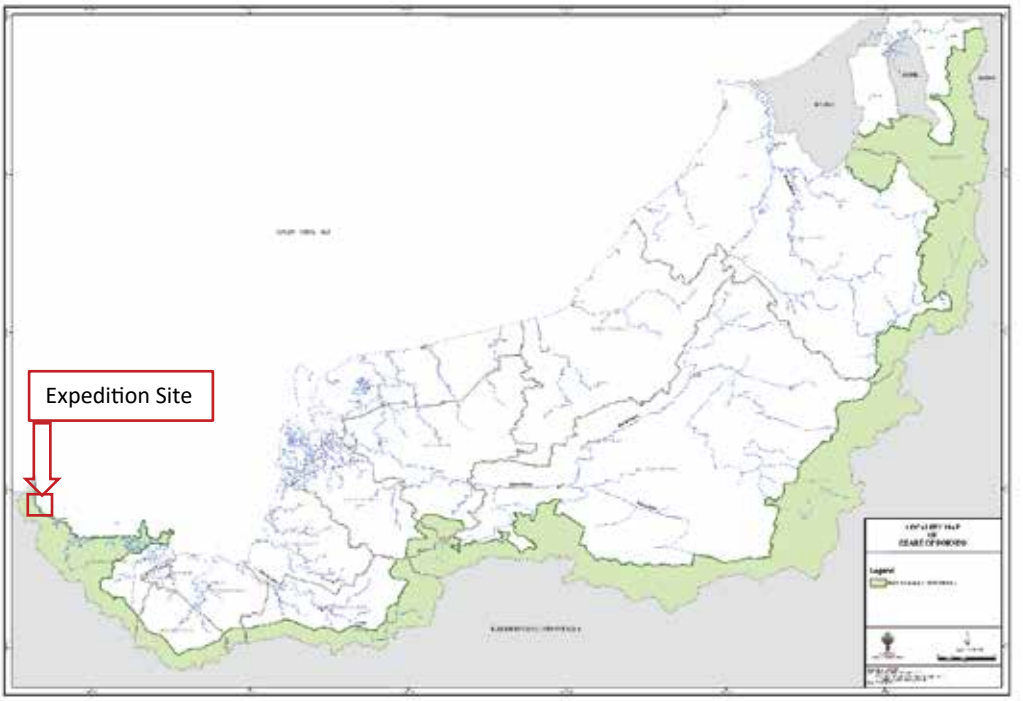

Figure 1: Heart of Borneo Sarawak area: Pueh Expedition Site 2020 (marked with red box)
(Source: Forest Department Sarawak)

The Pueh Unit, as described by Andriese (1972), rises from 200 feet to more than 5,000 feet in the Pueh massifs, comprising areas formed by igneous massifs generally between 2,000 to 3,000 feet in elevation. The rugged terrain is characterised by V-shaped valleys with most streams flowing into mountain slopes, featuring streams with waterfalls and rapids in Lundu District, Kuching Division. Hence, the natural features create a privilege for the nearby local inhabitants by providing gravity-fed natural clear water supply from year-round selected waterfalls and rapids for their daily consumption.

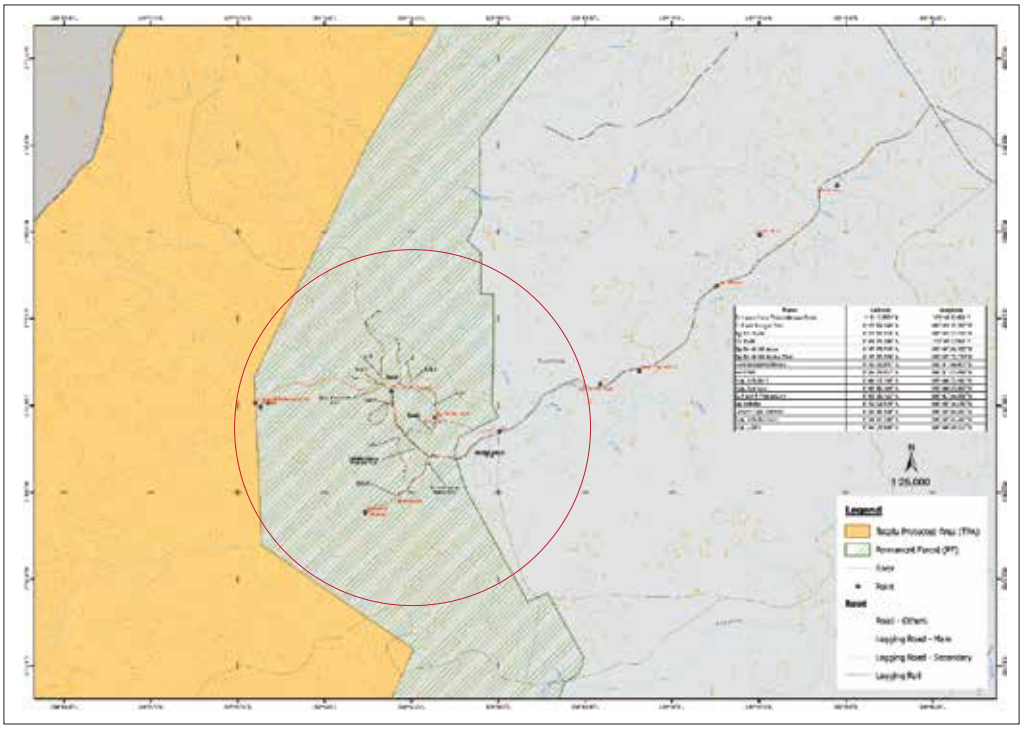

Figure 2: Trails for Heart of Borneo Expedition in 2020 (Courtesy: Forest Department Sarawak)

MATERIALS AND METHODS

Study location

The study area is situated between longitudes E: 109° 40' 0" and 109° 50' 0", and latitudes N: 1° 42' 0" and 1° 48' 0", lying in Borneo's South-Western region, specifically in Lundu, Sarawak. The area was chosen as the expedition site for exploring the biodiversity of flora, fauna, and soils, with the aim of observing the existence of natural species within the Heart of Borneo (HoB) region, as shown in Figure 2.

Methodology and materials

Selected trails within the expedition's site were walked and surveyed. Points for soil inspection were marked based on criteria such as soil location, slope position, and forest floor surface uniformity. Investigation points were marked using the Global Positioning System (GPS), assuming that the investigated point represented an area of approximately up to a 20 m radius. The investigation was then carried out manually, involving the use of an ordinary auger and common agricultural tools to prepare soil profiles. The profiles were assessed and described following the Sarawak Soil Classification System, a unique classification for Sarawak's soils. The categorisation of soils was adapted based on the Sarawak Forest Site and Soil Survey Manual (Glauner, R et al., 1997), Keys to Soil Classification Sarawak (Teng, C.S., 2004), and Memoir 1, The Soils of West-Sarawak (East-Malaysia) (Andriese, J.P., 1972).

The criteria for soil assessment during field observation included soil texture, soil colour, type of parent materials, soil origin, mode of soil derivation, and general appearance of the pedon within the soil profiles themselves. The endpoint of soil classification involved grouping soils with similar characteristics into possible units that could be geo-referenced. Classification was made based on characteristics for each identification of soil into its GROUP/FAMILY/Series.

Soil profiles were obtained from selected points before soil assessment. An ordinary auger for mineral soils, an Edelman Auger, was regularly used to obtain soil profiles, checking the soil characteristics before the pit's profile was decided and prepared. Auger profiles were observed based on each layer measured for every 20 cm thickness of soil continuously from the top surface to 120 cm downwards, vertically. Soils from each layer were placed on the auger sheet, assessed, and described for the entire layer from the earth's surface to the maximum reachable depth of 120 cm for each soil profile.

Further investigation was conducted from a represented pit that was manually dug for each type of soil, sized approximately 1 m (wide) x 1.3 m (long) x 1.2 m (depth). The pit profile would expose a better image of the underlying soil profile. Common agricultural tools such as a machete, spade, hoe, scoop, tapes, and marking stick were used in preparing the pits. Ultimately, both types of soil profiles (augers and pits) exhibited the same or similar characteristics, suggesting the soils could be classified into the same soil class and grouping. Soil auger and pit profile images for assessment are shown in Figure 5.

Each layer or horizon for each type of soil profile was observed. A reasonable quantity of fresh soils, about 2 cm^3, was placed between fingers to feel and estimate the portion of sand, clay, and silt content. The percentage or portion of sand, clay, and silt categorised its texture, with estimation made based on percentage values following the soil triangular chart (Figure 3). Another important criterion was soil colour, assigned by comparing the fresh soil's colour with the Munsell Soil Color Book/Chart. Observation and field evaluation of soil origin and parent materials were made to address proper assignment of soil grouping,

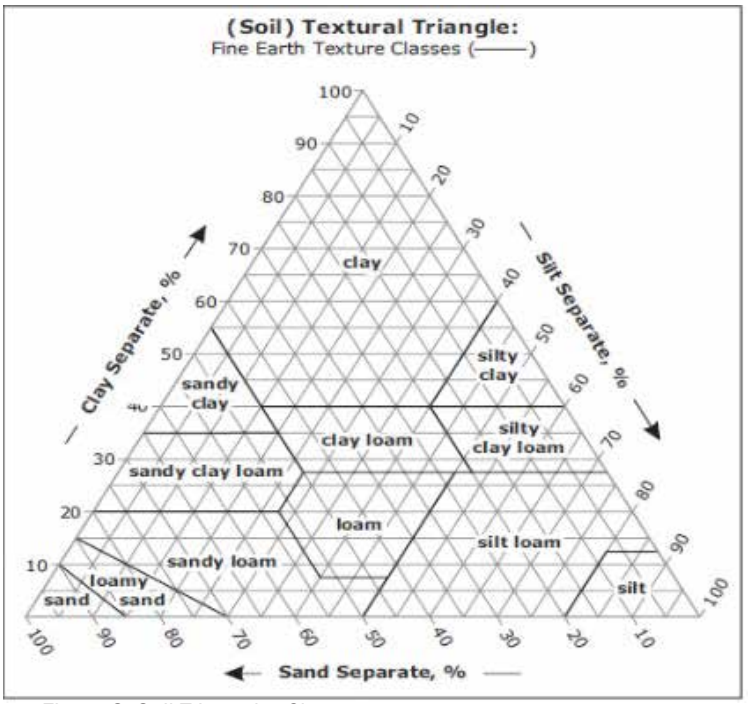

Figure 3: Soil Triangular Chart (Source: https://www.nrcs.usda.gov/)

The narrowed-down identification of soil in the field led to uncertainties. Therefore, the decision was made to extract approximately 0.5 kg to 1 kg of fresh soil samples from selected points for further investigation. The collected samples were packed in plastic bags and then brought back to the working station, where they were air-dried and processed for further laboratory investigation.

Each determination's single result was expected to be used in identifying the physical and chemical properties, such as particle size, iron (Fe) content, as well as cation exchange capacity (CEC). These determinations' results were primarily needed for the classification of this presumed soil. The determination of soil pH in the laboratory was also included to cross-check the in-situ pH readings taken using a portable pocket pH meter in the field.

RESULTS AND DISCUSSION

Findings and observations

Results and findings obtained from the investigation performed during the Heart of Borneo Expedition 2020 have generally revealed that the soils originated from in-situ weathering materials, potentially the residue soils from weathered granite and related parent rock types. This dominating soil type was commonly found along the trails and had the characteristics of a medium texture, ranging from sandy loam to sandy clay loam texture class.

Laboratory analysis results paralleled with field assessment observations. Particle size class analysis results obtained from the sample analysis indicated that the portion of clay is between 18% to 34%, increasing with soil depth. The determination of iron (Fe) content for the collected soil samples ranged from 25,042 ppm to 78,889 ppm, considered a high content of iron (Fe) for representative soils. This high iron content contributed to the criteria of red (2.5YR 5/6) to dark yellowish-brown (10YR 3/6) soils, resulting in an oxic horizon present in the soil within the studied area. Another criterion, the percentage value for cation exchange capacity (CEC) for the soils from laboratory analysis, indicated that the CEC value for the samples was considered low, ranging from 2.6 to 5.5 percent.

In principle, both findings from the field observations and uncertainties in soil sample chemical properties that required laboratory investigation have been fulfilled, suggesting the soils be classified into the Gading Series, under the OXISOL GROUP of soils.

However, there were also investigation points observed dominating the area, generally having shallow soils, suggesting the soils be assigned into the SKELETAL GROUP of soils. Although this classification segregates the soils into SKELETAL, a thin layer of soils observed overlying the Earth's surface had similar characteristics to Gading soils. There were also patches of forest floor surface observed without the presence of soil materials, but only rock categorised as rocks dominated by granite rock outcrops (Figure 6).

It is strongly believed that the investigation results obtained were probably the result of the occurrence of the observed dominant granite rocks. This type of rock was indicated in the geological map, showcasing the presence of granite rock types as small patches for the Southern region within Lundu (Kuching Division), which were also mapped in Serian and Samarahan Divisions, circled in red, as shown in Figure 4.

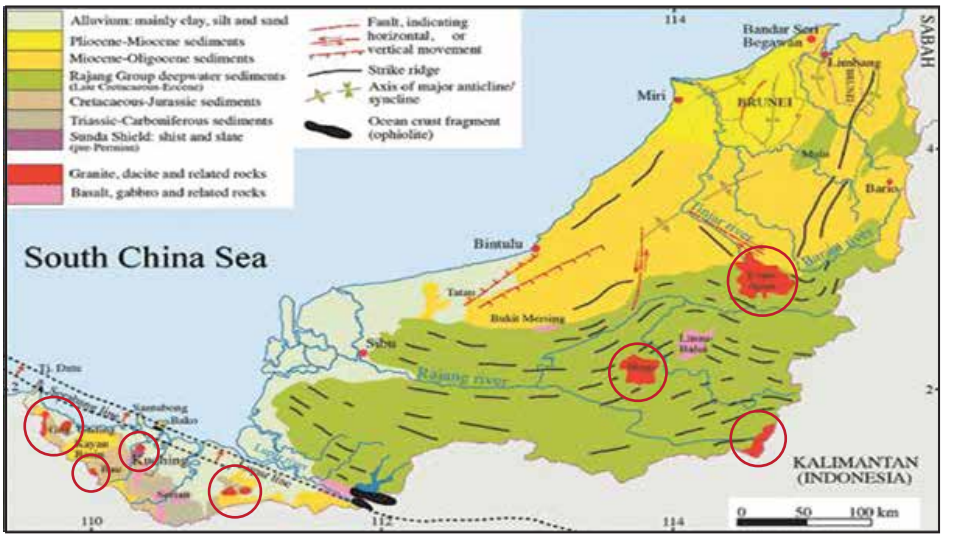

Figure 4: The Geology of Sarawak – HoB Expedition Site 2020 (red circle)
(Source: https://www.researchgate.net/figure/The-geology-of-Sarawak)

Figure 5: Soil profiles obtained from selected points within HoB's Pueh Expedition site using Edelman Auger (left) and pit digging (right)

Figure 6: Granite rock outcrops (left) and Gading soils underlying rock (right) observed within Pueh HoB's Expedition Site

CONCLUSION

The investigations and observation results obtained from all possible characteristics related to the Gading series soils belong to OXISOL Group. Therefore, soils within the Pueh HoB's expedition site were generally dominated by OXISOL, potentially the Gading soils with patches of SKELETAL soils and rocks.

RECOMMENDATION

Further soil investigations are recommended for other sites within the HoB area. Throughout this entire expedition, the occurrence of *Rafflesia* sp., likely the *'tuan-mudae'* species, was commonly spotted in the areas dominated by the Gading Series. The presence of this rare parasitic iconic plant, along with its host plant, could possibly be related to the occurrence of these soils. A more detailed study is crucial to understand the natural aspects of these soils, justifying conservation efforts to ensure the presence of the unique natural species belonging to this habitat is preserved for future generations.

ACKNOWLEDGEMENT

We express our gratitude to Forest Department Sarawak for organising the expedition. Special acknowledgements go to the Sarawak Biodiversity Centre and Sarawak Forestry Corporation for their assistance in facilitating the necessary permits for research activities throughout the entire expedition. Additionally, we extend our thanks to all participants, the local community around the expedition site, and everyone who contributed to the success of this expedition, for their valuable support and assistance.

REFERENCES

Andriese JP. 1973. Memoir I. The Soils of West- Sarawak (East Malaysia) Vol.1. Soil Survey Division Research Branch, Department of Agriculture, Sarawak, East Malaysia.

Glauner R, Evelyn J, Peter L, & Ting SP. 1997. Sarawak Forest Site and Soil Survey Manual. Forestry Department Sarawak, Malaysia

Teng CS. 2004. Keys to Soil Classification Sarawak. Cawangan Pengurusan Tanah, Jabatan Pertanian, Sarawak.

https://www.nrcs.usda.gov/

https://www.researchgate.net/figure/The-geology-of-Sarawak

PAPER 2:
STAND CHARACTERISTICS OF GUNONG PUEH FOREST RESERVE

Aurelia, D.C.[1], Army Kapi[1], Abdul Rani bin Bohari[1], Ohando anak Mupa[1], Nur Faiez Farouq bin Piee[2] and Stephenus Spencer anak Bagie[2]

[1]Research and Development Division, Forest Department Sarawak
[2]International Affairs Division, Forest Department Sarawak
Corresponding email: aurelidc@sarawak.gov.my

Abstract: Mount Pueh, or known to the locals as Gunong Pueh, is located in Lundu district and lies along the Malaysia-Indonesia border in the west of Kuching division. The mountain range was gazetted as a forest reserve in 1927 with an area of 12,950 hectare (ha) and elevation reaching 1,600 m above sea level. It is regarded as the highest mountain within the southwestern exterior of Sarawak. The forest ecosystem comprises lowland and hill mixed dipterocarp forest (MDF), Kerangas forest, riparian forest, and various stages of secondary forests after logging and shifting cultivation activities. Standing trees of all species with ≥ 10 cm diameter at breast height were assessed to better understand the forest status. Forest sampling was conducted in three (3) different sites representing three (3) forest types. A total of 248 species was recorded from the three (3) sampled sites during which surveys show most common trees found are *Elateriospermum tapos, Croton* sp., and *Teijsmanniodendron hallophyllum*. Other conspicuous and characteristic trees recorded were *Eusideron zwagerii, Strombosia ceylanica, Diospyros euphlebia* and *Shorea falscifera.*

Keywords: Gunong Pueh, forest type, assessment, tree species

INTRODUCTION

Mount Pueh, or known to the locals as Gunong Pueh, is found in the Lundu district and lies along the Malaysia-Indonesia border in the west of Kuching division. The mountain range, situated at 1◦47'15"N 109◦40'15"E with elevation reaching 1,600 m above sea level, is 1,366 m in height and regarded as the highest mountain within the southwestern exterior of Sarawak. Adjacent to Gunong Pueh, there are several villages, including the village of Sebako belonging to the Dayak Selakau tribe, providing an entrance into this mountain range (Kaicheen & Jayasilan, 2022). Gunong Pueh was constituted as part of a Permanent Forest Estate (PFE) and gazetted as a forest reserve in 1927 with an estimated area of 12,950 hectare (ha). However, over the years, due to the needs for development and conservation, substantial areas of the PFE had been either revoked or excised (Madeline & Rowina, 2020) and now GPFR covers an area of 4,082 ha while Gunong Pueh National Park, a Totally Protected Area (TPA), covers another 5,831 ha, where its boundary is above the forest reserve at 633 m a.s.l. The area is also located within the extension area of voluntary transboundary cooperation between Brunei, Indonesia and Malaysia called the Heart of Borneo (HoB) Initiative. The HoB Initiative aims to conserve and protect the environment while enhancing sustainable development that improves the people's welfare.

The forest ecosystem is diverse and consists of mainly lowland and hill mixed dipterocarp forest (MDF), Kerangas forest and riparian forest. Habitat transitions from lowland forest areas into hilly, dipterocarp forests extending further into lower montane forest areas (Kaicheen & Jayasilan, 2022). The mountain landscape is found to have big stony boulders and steep rugged surfaces. At the foothill of the area are mostly local farms of shifting cultivation practice and oil palm plantation established by the surrounding local communities of the Dayak Selakau tribe and water catchments areas. There are also signs of previous activity of selective logging and old skid trails.

Despite these disturbances, the area remains largely intact and protected, maintaining the biodiversity of Gunong Pueh. Previous findings from past expeditions provide a basis for Forest Department Sarawak to continuously document the rich diversity of the area. This study aimed to describe tree species composition and diameter distribution of different forest types in the selected study area. Further assessment and data collection will increase our reference collection and understanding of Gunong Pueh's biodiversity which can be used for future management plans for Gunong Pueh forest reserve.

Methodology and materials

Data collection

The Gunong Pueh Forest Reserve Scientific Expedition was launched on 5th October and commenced until 17th October 2022. The scientific expedition with the theme "Where Nature and Science Unites" aimed to further explore the rich biodiversity concentrated within the Gunong Pueh Forest Reserve. There were 9 trails of different elevations and forest types already mapped and prepared for the scientific expedition participants to explore and document. Three (3) sites were selected for sampling, which are Trail 1, secondary forest (*temuda*) about 100 m, riverine forest at 168 m elevation and lowland mixed dipterocarp forest at 300 m elevation.

Survey and assessment method

In each selected site, a 0.4-hectare plot is established, with each plot measuring 20 m × 200 m. The plot is divided into 40 quadrats, each measuring 10 m × 10 m. Within all 40 quadrats of the plot, all trees with a diameter at breast height (dbh) of 10 cm and above were measured and identified to the genus or species level (when possible). Voucher specimens were collected for further confirmation and identification at the SAR Herbarium. Samples were cut, pressed, and preserved in alcohol, and later dried in the oven for a week.

RESULTS AND DISCUSSIONS

Forest structure

This study has recorded a total of 248 trees of ≥ 10 cm dbh within the 3 selected sites, consisting of 31 families and 81 species. A total of 81 trees were enumerated at Trail 1 of secondary forest with density of trees per hectare 202.5 (ha-1), while 78 trees were recorded at riverine forest with tree density 195 (ha-1) along the trail to Sg. Penindih Hydro dam. Lowland mixed dipterocarp forest (LDF) recorded 89 trees with tree density 222.5 (ha-1). Tree density (trees ≥10 cm dbh) ranged from 195-222.5 individuals per hectare.

The diameter class distributions are classified into 7 classes, ranging from 10 cm - 20 cm, 20.1 cm - 30 cm, 30.1 cm - 40 cm, 40.1 cm - 50 cm, 50.1 cm - 60 cm, 60.1 cm - 70 cm and 70.1 cm - 80 cm. The most common diameter in Trail 1 is from the 10 cm - 20 cm class, followed by 20.1 cm - 30 cm, while for the riparian forest, the most common diameter class sizes are within the range of 10 cm - 20 cm class. The lowland MDF also shows common size trees are from diameter class 10 cm - 20 cm, followed by 20.1 cm - 30 cm and several individuals of 30.1 cm - 40 cm class. From the results, the least common range dbh are within the class 60.1 cm - 70 cm and 70.1 cm - 80 cm with representation of one (1) individual in each class.

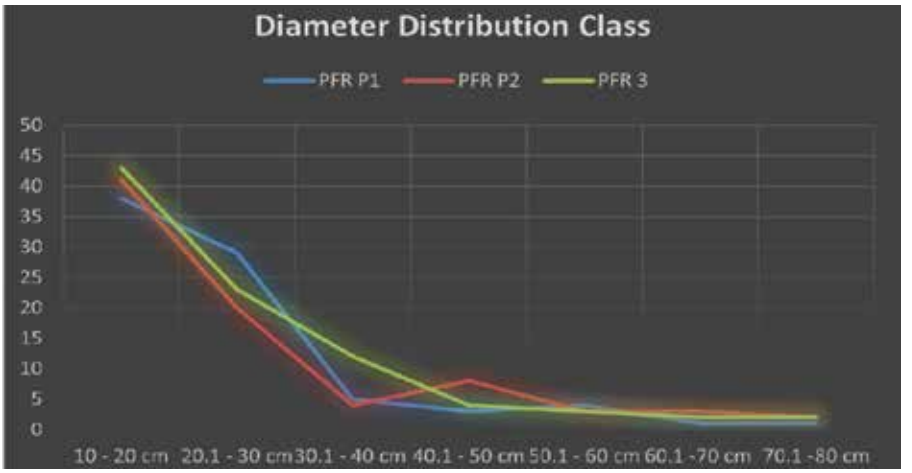

Figure 7. Chart shows the number of trees across 7 diameter classes in PFR 1 (Secondary Forest), PFR 2 (Riparian Forest) and PFR 3 (Lowland mixed dipterocarp forest). Most common diameter class range of the 3 selected sites are in the class of 10 m - 20 cm (>30 individuals).

Species composition

The family Euphorbiaceae is well-represented in the three (3) selected sites, comprising 11 species, which accounts for approximately 13.5% of the total 81 species distributed across the three plots. The five most abundant families are the Euphorbiaceae, Dipterocarpaceae, Lauraceae, Moraceae and Fagaceae. In total, the survey identified 31 families, 50 genera and 81 species in the examined areas.

Secondary Forest (SF)

In total, 36 species and 23 families have been recorded in the area. The Euphorbiaceae are dominant in this area, followed by Moraceae and Lauraceae. About 83.9% of the enumerated trees have a diameter below 30 cm dbh. Those exceeding 60 cm dbh constitute less than 5%, with the largest diameter recorded in this forest area being 80 cm, belonging to *Pometia* pinnata (Sapindaceae), locally known as Kasai. The five (5) most common species recorded are *Croton sp., Bellucia pentamera, Symplocos fasciculata, Elateriospermum tapos* and *Artocarpus kemando.*

From observation, there is a noticeable gap and disturbances in the secondary forest of Trail 1. This is primarily attributed to the limited occurrence of main canopy tree species and the absence of emergent trees within the area. Human activities, such as the collection of forest products, agriculture, or selective logging, have significantly impacted most of the dipterocarp forests at low elevations. As a result, the undergrowth is dense, and the area is dominated by many understorey tree species.

Riparian Forest (RF)

Altogether, approximately 78 trees with a diameter at breast height (dbh) of ≥ 10 cm were recorded and identified across the plot, representing 23 families and 38 species. The five most common families observed in the plots are Euphorbiaceae, followed by Verbenaceae, Clusiaceae, Myrtaceae, and Fabaceae. The five most common species are *Teijsmanniodendron holophyllum, Pentace borneensis, Eusideron zwagerii, Lithocarpus* sp. and *Saraca* sp. The highest basal area is *Alstonia scholaris*, locally known as Pelai, with 0.502 m^2/ha and it also recorded the biggest dbh of 80 cm within the plot.

Lowland Mixed Dipterocarp Forest (LDF)

The plot, set up in this forest type at about elevation of 300 m, recorded about 78 individuals within the plot. A total of 15 families and 33 species were recorded and Dipterocarpaceae was found to be the most dominant family in this habitat type and followed by Euphorbiaceae, Annonaceae, Fagaceae and Myrtaceae. *Shorea* spp, *Elateriospermum tapos*, *Lithocarpus* sp., *Syzygium* sp. & *Croton* sp. are among the five (5) most common species. The individual with the highest basal area belongs to *Dillenia excelsa* with 0.46 m^2/ha and highest dbh at 77 cm.

Table 1: Summary of tree individuals and species composition in three (3) different forest types.

	Secondary Forest	Riparian Forest	Lowland Mixed Dipterocarp Forest
Family	23	23	15
Genera	31	32	22
Species	36	38	33
Tree individuals	81	78	89
Trees/ha (ha-^{1})	202.5	195	222.5

Variations in soils and altitudinal sequence result in the creation of a wide range of habitats for plants. Each of the forest types exhibits distinct differences in morphological characteristics and species complexities (PK Chai, 2000). Floristically, the lowland mixed dipterocarp forest (LDF) shows the least represented families, yet it features larger trees per hectare and is among the most species-rich compared to riparian forest and secondary forest. Euphorbiaceae is the most common family in the secondary forest and riparian forest while Dipterocarpaceae is the most common family in lowland mixed dipterocarp forest.

In species diversity, Dipterocarpaceae is dominant with high concentration of species in the Lowland Dipterocarp Forest but is poorly represented in the secondary forest and riparian forest, while Euphorbiaceae is the most dominant species in both forest types. As expected, LDF is the richest habitat for dipterocarps. The forest gap resulting from disturbances in the secondary forest and the two structured storeys of riparian forest elucidate the area's floristic richness. It is characterised by the presence of sun-loving species, shade-intolerant species, and some timber species.

CONCLUSION AND RECOMMENDATION

A total of 81 tree species from 31 families were successfully recorded within three (3) different forest types during the scientific expedition. The forest structure and floristic composition was observed to be different within the selected sites. The most common diameter class range is 10-20 cm (>30 individuals) while the most common family is the Euphorbiaceae among the three sites but Dipterocarpaceae is more dominant in Lowland Mixed Dipterocarp Forest. Most common species found in all three sites are *Elateriospermum tapos, Shorea* sp. *Teijsmanniodendron holophyllum, Croton* sp. and *Bellucia pentamera*. It is recommended to conduct a long-term inventory and extend sampling to gain a comprehensive understanding of the ecological trends within Gunong Pueh Forest Reserve.

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REFERENCES

Demies M, Hiromitsu S, Alexander KS and Gabriel TN. 2019. Tree diversity, forest structure and species composition in a logged-over mixed dipterocarp forest, Bintulu, Sarawak, Malaysia. *Transactions on Science and Technology* Vol. 6, No. 1-2, 102 – 110

Kaicheen Sally S, Jayasilan MA. 2002. *Community Structure of Mid-Sized to Large Bodied Mammals in Tropical Lowland and Lower Montane Forests in Gunong Pueh National Park, Western Sarawak, Borneo*. Nature Conservation Research 7(1): 70–79

Madeline GP, & Rowina Ruth CJ. 2020. A Compilation of Information on Permanent Forests of Sarawak. Forest Department Sarawak.

Paul Chai PK, 2000. Forest Types. In: **Soepadmo E, & Paul Chai PK**. (Eds.) Development of Lanjak-Entimau Wildlife Sanctuary as a Totally Protected Area Phase I & Phase II: A joint publication by Forest Department Sarawak and International Tropical Timber Organization (ITTO), 23-48

Rantai J, & Chai, PPK. 2007. A new checklist of the trees of Sarawak. Kuching, Sarawak: Lee Ming Press.

PAPER 3:
TREE COMPOSITION IN PROPOSED ARBORETUM SITE AT GUNONG PUEH FOREST RESERVE

Noorhana, M.S., Nur Safinas, J., Yahud, W., Yazid, K., Julia, S., Ling C.Y. & Vilma, B.

Research and Development Division, Forest Department Sarawak
Corresponding email: noorhana@sarawak.gov.my

Abstract: A study was conducted to determine the tree species composition at Gunong Pueh Forest Reserve, Lundu, Sarawak. This area lies within the Heart of Borneo (HoB) area, and is one of Sarawak's treasures that hold vast diversity of flora and fauna. A one-hectare plot was established to assess the tree composition in Gunong Pueh FR to support the proposed establishment of the arboretum site. A total of 96 trees with diameter at breast height (DBH) ≥10cm were recorded belonging to 21 families, 32 genera and 69 species. Dipterocarpaceae was the most diverse family at species level (12 species), contributing the highest basal area of 1.47 m2h1 (23.9%), followed by Euphorbiaceae, 1.01 m2h-1(16.6%). The most dominant families were Dipterocarpaceae with highest Family Importance Value Index, FIVI (59.05%), followed by Euphorbiaceae (44.62%) and Moraceae (35.30%). From all of the species recorded, six species were listed as threatened species in the IUCN Red List, of which four were listed as Endangered and Critically Endangered, while two were listed under Vulnerable and Near Threatened. Gunong Pueh is a potential arboretum site with rich and diverse flora, which are important as a plant reservoir, particularly for the Dipterocarpaceae species and functions as in-situ conservation for the threatened tree species.

Keywords: Arboretum, Gunong Pueh Forest Reserve, Tree composition

INTRODUCTION

In Sarawak, the upland forest dominated by dipterocarps in the emergent canopy is referred to as Mixed Dipterocarp Forest, MDF (Lepun & Heng, 2020). The MDF in Sarawak is the richest in biodiversity and a major forest type comprising both lowland and hill dipterocarp forests (Ashton, 1995). However, forest degradation and over-exploitation are threatening the biodiversity and ecological services provided by these forests. Hence, Myers et al. (2000) had emphasised an attempt to guide nature conservation efforts globally, by suggesting the concept of hotspot, which considers regions with exceptional concentration of endemic species, and which experience high rates of habitat loss (Lu et al., 2010). One of the 25 hotspots identified worldwide is Sundaland, which includes the Malaysia region in south-east Asia (Myers et al., 2000). Borneo alone is the most botanically diverse part, recording about 37% endemic species of 15,000 vascular plants (Raes et al., 2009).

Gunong Pueh Forest Reserve (FR) is located at the Gunong Pueh Range near Lundu, Sarawak, Southwestern of Borneo close to the Malaysia-Indonesia border. It is one of the earliest forest reserves in Sarawak, gazetted on 27th June 1927 (Jabatan Hutan Sarawak, 2020). Aside from its rich and diverse flora, Gunong Pueh FR is important as a home for many endemics, rare and threatened species such as *Trigonostemon diffusus* (Euphorbiaceae), *Melanochyla axillaris* (Anacardiaceae), *Shorea hemsleyana* (Dipterocarpaceae), *Orophea clemensiana* (Annonaceae), and the totally protected species *Rafflesia tuan-mudae* (Rafflesiaceae). The arboretum in Gunong Pueh FR is proposed to be preserved in perpetuity as an area of natural lowland dipterocarp forest, surrounded by a fascinating ecological environment. Arboretum can be defined as a repository of living plants, which consists of trees as the dominant plant type. Distinct from a nursery or park, it is established as a 'natural laboratory' for scientific research and education purposes. With the existence of various types of living plants, it serves as species conservation areas through both in-situ and ex-situ conservation (Harum & Moestrup, 2014).

Assessing the flora composition is an essential step in the conservation of forest biodiversity. The objective of this study is to provide baseline information about forest vegetation, which includes tree species composition, the number of individual trees, tree height and diameter at breast height (DBH). Therefore, the most important families for trees are identified. The information will support the data for the proposed arboretum in Gunong Pueh FR.

METHODOLOGY

Study area

The study was conducted in the vicinity of the Gunong Pueh Forest Reserve during the HoB expedition from 5th to 17th October 2020. Located within the HoB Sarawak, it spans a total area of 4,081 hectares and consists of mixed dipterocarp forest. The area serves an important role as a water catchment area, supplying water for surrounding villages.

A one-hectare plot measuring 100m x 100m was established during the expedition (1°48'04.4" N, 109°42'40.4" E). The plot was divided into 100 subplots (10m x 10m) for tree composition assessment. All trees within the plot with diameter at breast height (DBH) of 10 cm and above were tagged and numbered accordingly.

Data collection and analysis

All tagged trees within the plot were measured, identified, and photographed. Data recorded were DBH, height, species name and GPS position for each tree. Leaf samples of each tree were collected for species confirmation by comparison with the voucher specimens present at Sarawak Herbarium, as well as using reference from the Tree Flora of Sabah and Sarawak Volumes I-VI (Soepadmo & Wong 1995; Soepadmo & Saw, 2000; Soepadmo et al., 1996, 2002, 2004, 2007). All data recorded were quantified to determine the floristic composition, species dominance, diameter distribution classes and basal area contribution by all tree species.

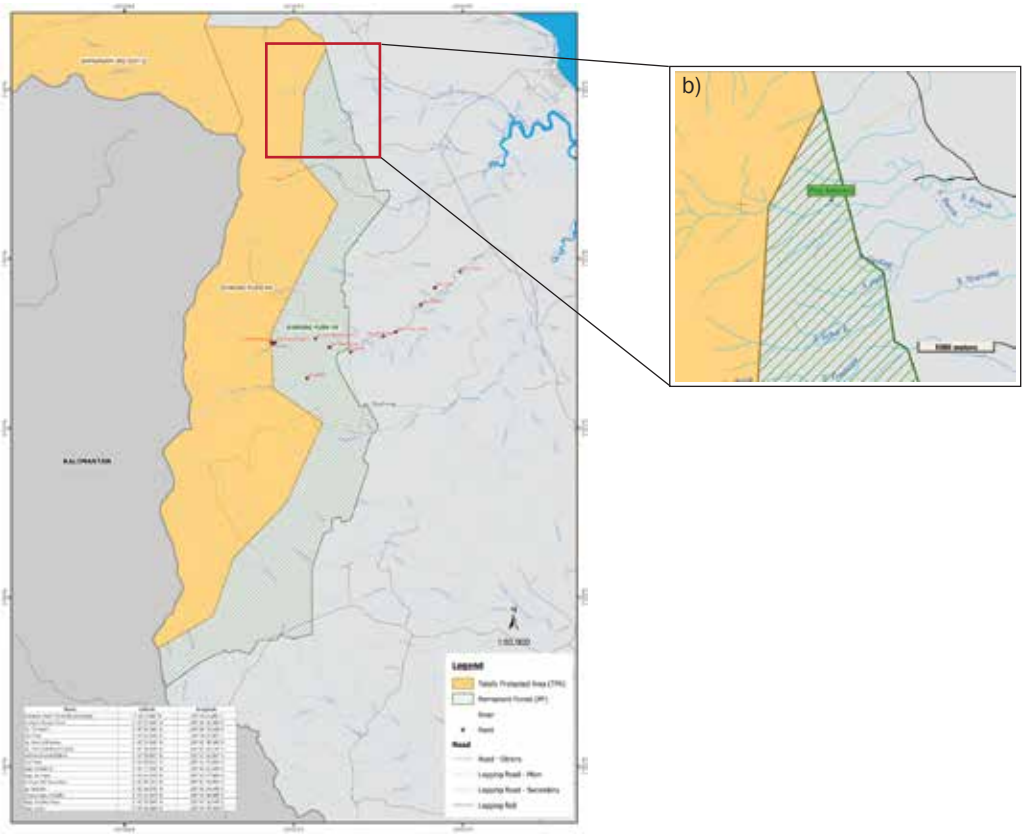

Figure 8. (a) Map of Gunong Pueh Forest Reserve, Lundu, Sarawak; (b) Study area of proposed arboretum site at Gunong Pueh Forest Reserve

RESULTS AND DISCUSSIONS

Tree species composition

A total of 96 individual trees with DBH ≥ 10 cm were enumerated in a one-hectare plot, which consists of 69 species belonging to 32 genera and 21 families. The most common families in terms of the number of trees were Dipterocarpaceae (17 individuals, 17.71%), Euphorbiaceae (16 individuals, 16.67%), Moraceae (12 individuals, 12.50%), Fagaceae (7 individuals, 7.29%) and Ebenaceae (6 individuals, 6.25%).

The Important Value Index (IVI) is a measure of how dominant a species or family was in a forested area. Old growth forests in Malaysia are normally dominated by the Dipterocarpaceae (Khairil et al., 2013), indicating that the area is still not affected by large scale disturbances. In this study, Dipterocarpaceae was the most important family with a Family Important Value Index (FIVI) of 59.1%. According to Lu et al. (2010), the elevated FIVI value resulted from the fact that Dipterocarpaceae individuals were among the large statured species in the area. Other important families with FIVI values more than 10% are shown in Table 2. Study by Khairil et al. (2013) mentioned that families with a FIVI of more than 40% can be considered dominant families in a particular community. Therefore, in this study, Dipterocarpaceae and Euphorbiaceae were clearly dominating the study area in Gunong Pueh FR.

Table 2. The eight most important families (FIVI values ≥ 10) found within the one-hectare study plot.

No.	Family	FIVI (%)
1	Dipterocarpaceae	59.1
2	Euphorbiaceae	44.6
3	Moraceae	35.3
4	Fagaceae	21.1
5	Myrtaceae	17.8
6	Ebenaceae	16.2
7	Polygalaceae	14.31
8	Sapotaceae	10.02

Basal area and tree diameter distribution

The total basal area was 6.13 m2ha-1 for the trees with DBH ≥ 10 cm, which covers a relatively small portion of the land area under study. Out of all the tree species encountered, species from Dipterocarpaceae contributed the most with a basal area of 1.47 m2ha-1. Close to this is Euphorbiaceae with a basal area of 1.01 m2ha-1 and Moraceae with a basal

area of 0.60 m2ha-1. Other species in the list had low basal areas (Table 3). This total value of basal area is considered low as basal area reported for tropical forest ranges from 28 to 52 m2ha-1 (Swaine et al., 1987). Such difference in tree basal area reflects individuals of constituent species that are related to its growth characteristics. In this study, more than 40% are small trees with DBH ranging from 10 cm to 19 cm.

Table 3. Basal area in five families

No.	Family	Basal Area (m^2ha^{-1})
1	Dipterocarpaceae	1.4678
2	Euphorbiaceae	1.0023
3	Moraceae	0.5977
4	Fagaceae	0.4907
5	Myrtaceae	0.4787

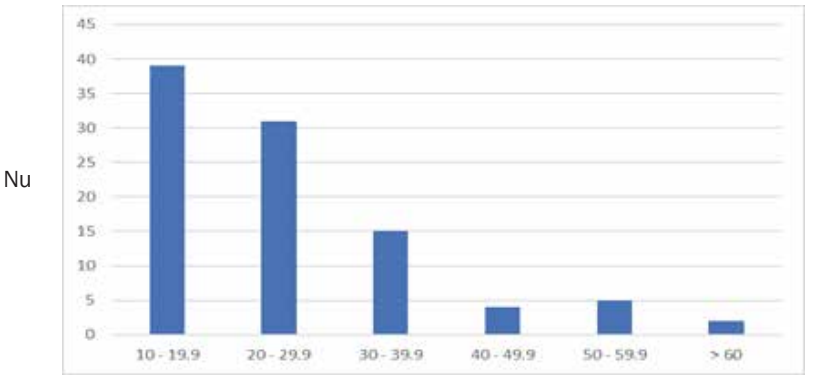

Figure 9. Distribution of trees by diameter classes in one-hectare sample plot, Gunong Pueh FR

In this study, six diameter classes were considered, ranging from 10.0 cm to ≥ 60.0 cm. The result showed that the distribution of trees followed a normal reverse J-shaped curve, where the number of stems decreased with the increase in DBH (Figure 9). There were higher number of stems for smaller diameter classes, with 40.63% of trees falling between 10 – 19.9 cm, 32.29% between 20 – 29.9 cm, 15.63% between 30 – 39.9 cm, 4.17% between 40 – 49.9 cm, 5.21% between 50 – 59.9 cm and 2.08% of trees are ≥ 60 cm. The same pattern of diameter classes was also observed in Semenggoh Arboretum (Ling & Julia, 2012). According to Whitmore (1984), the general contribution of trees with a diameter range 10 – 19.9 cm is about 50% of the total stand in tropical forests. This generally indicates that the forest stands are developing, and regeneration is ongoing (Sanwo et al., 2015). In Lepun's (2020) study, he reported that it is a common pattern in tropical forests, which suggested a healthy forest recruitment process. There are fewer trees in diameter classes 60 cm and above. This is because under the natural conditions, an old emergent tree may fall and create a gap for regeneration via natural succession (Sanwo et al., 2015).

Conservation status by IUCN Red List

A total of six species, representing 8.70% of the 69 species recorded in this study area were found to be listed in the IUCN Red List of Threatened Species (IUCN, 2023). These species fall into four different threat categories: Near Threatened (NT), Vulnerable (VU), Endangered (EN) and Critically Endangered (CR). Based on Table 4, one species was listed as Near Threatened because of the decreasing population, one species as Vulnerable, two species as Endangered and another two species as Critically Endangered. Four out of six species listed in the IUCN Red List were from the family Dipterocarpaceae.

Table 4. Species listed in the IUCN Red List

No.	Family	Species	IUCN Red List Categories
1	Dipterocarpaceae	*Dipterocarpus borneensis*	NT
2	Ebenaceae	*Diospyros daemona*	VU
3	Dipterocarpaceae	*Dipterocarpus acutangulus*	EN
4	Dipterocarpaceae	*Shorea dasyphylla*	EN
5	Dipterocarpaceae	*Shorea hopeifolia*	CR
6	Euphorbiaceae	*Trigonostemon diffusus*	CR

CONCLUSIONS

Tree composition assessment is the process of collecting information about the conditions of the vegetation within a specific area. The quantitative inventory of tree species will provide valuable insight into diversity, serving as a crucial reference for forest assessment. Furthermore, it would improve our understanding by identifying ecologically important species, guiding the implementation of conservation efforts necessary to ensure the sustainability of the forest biodiversity.

The present study may provide baseline information of the composition and structure of tree species in the natural lowland dipterocarp forest of Gunong Pueh Forest Reserve. Quantitative assessment of the tree species was carried out by sampling of the one-hectare plot. Measurements of tree diameter and height were assessed, and tree species were identified up to species level. A total of 96 trees from 69 species, 32 genera and 21 families were encountered in this study. The data collected from the measurements were used to calculate the Relative Dominance (RDo), Relative Density (RD), Relative Diversity (RDi), and Basal Area. These were used to determine the dominant tree using the Family Important Value Index (FIVI), which showed that Dipterocarpaceae was the most dominant family. The distribution of trees displays an inverse J-distribution, where the number of trees decrease with the increase in DBH, indicating growing stable populations in which regeneration of the

forest in the area is present. This forest has the potential to be a good site for seed production, gene bank and sample tree conservation. Thus, a potential arboretum site should engage in scientific research, promote conservation, and actively participate in public outreach and education to protect and preserve biological diversity. This underscores the significance of arboretums, which offer benefits to the environment, wildlife, and people.

ACKNOWLEDGEMENTS

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REFERENCES

Ashton, P.S. (1995). Biogeography and ecology. In: Soepadmo, E. and Wong, K.M. (eds.). T*ree Flora of Sabah and Sarawak (Vol.1)*. Kepong: Forest Research Institute Malaysia.

Harum, H. and Moestrup, S. (2014). *Technical guideline for arboretum establishment in West Manggarai District, Flores, Indonesia.* Department of Geosciences and Natural Resources Management, Faculty of Science, University of Copenhagen.

IUCN. (2023). The IUCN Red List of Threatened Species. Version 2022-2. https://www.iucnredlist.org. Accessed on 20th March 2023.

Jabatan Hutan Sarawak (2020). *A compilation of information on Permanent Forests of Sarawak*. *Sarawak*: Jabatan Hutan Sarawak. 68 p.

Khairil, M., Nashriyah, M., Norhayati, N., Amin, S. and Fatihah, N. (2013). Tree species composition, diversity and above ground biomass of two forest types at Redang Island, Peninsula Malaysia. *Walailak J Sci & Tech,* 10(1): 77 – 90.

Lepun, P. and Heng, R.K.J. (2020). Floristic and forest structure of hill mixed dipterocarp forest at Bukit Kana National Park, Sarawak, Malaysia. T*he Malaysian Forester*, **83 (2)**: 259 – 280 p.

Ling, C.Y. and Julia, S. (2012). Diversity of the tree flora in Semenggoh Arboretum, Sarawak, Borneo. *Garden's Bulletin Singapore*, **64(1)**:139 – 169.

Lu, X.T., Yin, J.X. and Tang, J.W. (2010). Structure, tree species diversity and composition of tropical seasonal rainforests in Xishuangbanna, South-West China. *Journal of Tropical Forest Science.* **22 (3)**: 260 – 270 p.

Myers, N., Mittermeir, R.A., Mittermeir, C.G., Da Fonseca, G.A.B., and Kents, J. (2000). Biodiversity hotspots for conservation priorities. *Nature,* **403:** 853 – 858 p.

Raes, N., Roos, M.C., Ferry Slik, J.W., Emiel van Loon, E. and Hans ter Steege. (2009). Botanical richness and endemicity patterns of Borneo derived from species distribution models. *Ecography,* **32**: 180 – 192 p.

Sanwo, S.K., Ige, P.O., Sosanya, O.S. and Ogunlaye, O.G. (2015). Tree species diversity and forest stand dynamics in a tropical rainforest in Southern Nigeria. *Malays. Appl. Biol.* **44(2)**: 65-73.

Soepadmo, E. and Saw, L.G. (eds) (2000). T*ree Flora of Sabah and Sarawak, vol. 3*. Malaysia: Sabah Forestry Department, Forest Research Institute Malaysia, & Sarawak Forestry Department.

Soepadmo, E., Saw, L.G. and Chung, R.C.K. (eds) (2002). T*ree flora of Sabah and Sarawak, vol. 4.* Malaysia: Sabah Forestry Department, Forest Research Institute Malaysia, & Sarawak Forestry Department

Soepadmo, E., Saw, L.G. and Chung, R.C.K. (eds) (2004). *Tree Flora of Sabah and Sarawak, vol. 5.* Malaysia: Sabah Forestry Department, Forest Research Institute Malaysia, & Sarawak Forestry Department

Soepadmo, E., Saw, L.G., Chung, R.C.K. and Kiew, R. (eds) (2007). *Tree Flora of Sabah and Sarawak, vol. 6.* Malaysia: Sabah Forestry Department, Forest Research Institute Malaysia, & Sarawak Forestry Department.

Soepadmo, E. and Wong, K.M. (eds) (1995). *Tree Flora of Sabah and Sarawak, vol. 1.* Malaysia: Sabah Forestry Department, Forest Research Institute Malaysia, & Sarawak Forestry Department

Soepadmo, E., Wong, K.M. and Saw, L.G. (eds) (1996). *Tree Flora of Sabah and Sarawak*, vol. 2. Malaysia: Sabah Forestry Department, Forest Research Institute Malaysia, & Sarawak Forestry Department

Swaine, M.D., Lieberman, D. & Putz, F.E. (1987). The dynamics of tree populations in tropical forest: A review. *Journal of Tropical Ecology,* **3**: 359-366.

Whitmore, T.C. (1984). T*ropical Rain Forests of the Far East,* 2nd ed. Oxford: Oxford University Press.

PAPER 4:
GUNONG PUEH FOREST RESERVE, THE SANCTUARY OF ENDEMIC AND THREATENED TREES

Vilma Bodos[1], Noorhana Mohd Sapawi[1], Army Kapi and Relin Jim

[1]Research and Development Division, Forest Department Sarawak
Corresponding email: vilmab@sarawak.gov.my, noorhana@sarawak.gov.my

Abstract: Gunong Pueh, also known as Gunong Pueh-Berumput, Gunung Poi, and Gunung Poe has a long history of scientific discovery since the early 2000s. Gunong Pueh lies along the Malaysian-Indonesian border in Sarawak's southwestern exterior and is a range with several distinct peaks. Gunong Pueh possesses a few distinctive habitats that harbour much interesting flora, leading to the collection of thousands of botanical specimens and studies on trees. Joseph Clemens and Mary Strong Clemens were amongst the scientists who had conducted botanical collections and taxonomic research at Gunong Pueh. Many of the first described herbarium specimens of a species were collected by these two renowned American botanists in the 1920s. More than 400 tree species have been discovered and out of these, 82 species of trees fall under the threatened category in the IUCN Red List, and an additional 72 tree species are endemic to Gunong Pueh Forest Reserve. High occurrences of endemic and threatened tree species would suffice to establish the Forest Reserve as a high conservation value area. Therefore, a field survey was conducted in 2020 to evaluate the presence of these high-risk tree species.

Keywords: threatened, endemic tree, high conservation value.

INTRODUCTION

Gunong Pueh is the highest mountain within the southwestern exterior of Sarawak. Apart from the neighbouring Mount Penrissen, Mount Pueh is the only remote highland discontinuing from the Batu Tibang backbone in central Borneo. Gunong Pueh was known as Mount Poi or Gunung Poe in the 19th century and it was the interest of many explorers for discoveries and scientific exploration for the reason that it is the only granite mountain and the highest elevation in Sarawak at that time (Moultan, 1913). During the 19th century, Sarawak's landmass was smaller, with Miri and Limbang divisions still under the empire of Brunei Darussalam (Figure 10). Mount Pueh contains two major habitat types, that is the lowland forests (<1000 m a.s.l.) and the lower montane forest (>1000 m a.s.l.). With huge ranges of altitude gradients, the microclimate of each habitat type is different, and it is the same with the ecological communities, such as flora and fauna species (Muscarella et al., 2020). Terrain heterogeneity of the Mount Pueh and its surrounding forests possess a high level of plant species diversity. The key metric for the conservation value of Gunong Pueh FR and the surrounding forests needs to be explored for the management and core purposes of the reserve preservation. This study aimed to assess the presence of rare, threatened, endangered, and endemic tree species in Gunong Pueh Forest Reserve (GPFR). Information on the presence of these concerned species would be valuable for the high conservation value of GPFR.

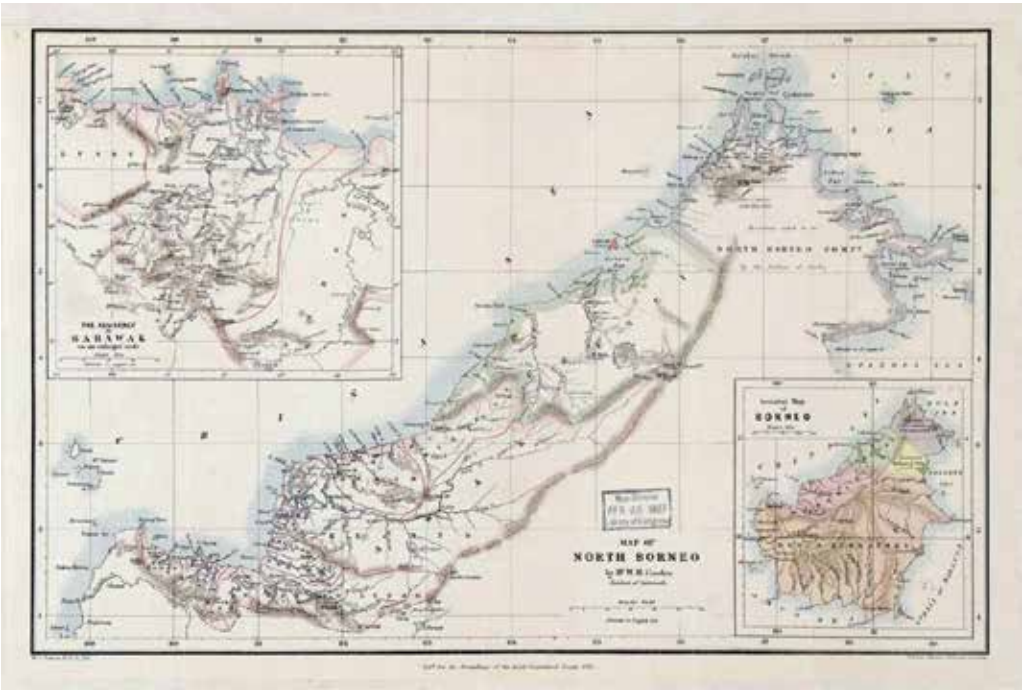

Figure 10: Map of North Borneo in the 19th century

MATERIAL AND METHOD

Primary and secondary data were obtained for this study to gather information and analyse the potential conservation value of species in the forest reserve. Field surveys were conducted in 2020 and 2021 at Gunong Pueh FR to source for new data. Transect lines were set up randomly for the data collection. Leaf specimens were collected for further species identification in Sarawak Herbarium. Secondary data were obtained from herbarium specimens, literature reviews, and unpublished reports. Red listing references i.e., IUCN and Sarawak Plant Red List publications and Geospatial Conservation Assessment Tool are the instruments used to identify species that are threatened globally and at the regional level. Various publications, references, and digitised databases online i.e., Plants of the World Online were used to categorise species endemism.

RESULTS & DISCUSSION

Historical data and landscape changes

There are nine type specimens from Gunong Pueh, which were collected by renowned botanists from all over the world since the 19th century (Table 5). A type specimen is the single herbarium sheet designated in the original publication to which the name of the taxon (genus, species, subspecies, and variety) has been assigned. The published scientific name and the description of the species are associated with this type specimen. A few valuable old herbarium specimens from Gunong Pueh were collected by Mary Strong Clemens and Joseph Clemens. These collections of type specimens from Gunong Pueh give an important contribution to botanical studies to understand the history, and dynamic of a species, particularly the ecology. The forest landscape in GPFR and its surroundings have changed over the years, leading to corresponding adjustments in the microclimate and population of tree species. Type specimens and old herbarium specimens are evidence of a species' existence in the area. The herbarium specimen is an immense source of information on the plant's morphology, distribution, the environmental niche they occupy, and sometimes on the threats at their surroundings; and, when they flower or produce seed (Royal Botanic Garden, 2023). Ground surveys of the forest area were carried out to retrieve the rare and threatened species occurrences through on-the-ground surveys and assess the threat to the habitat and population. Tabularization from gathered information (primary and secondary data) reveals that GPFR and the surroundings possess a high diversity of plants comprising 538 species from 78 families, and 240 genera.

Increasing levels of disturbance would have strong effects on the diversity of species (Alroy, 2017). It is observed that Mount Pueh and the surrounding forests have had some changes in forest landscape over the years. Factors that could cause changes in the species ecosystem and composition include (i) habitat loss, (ii) shifts in geographic changes, (iii) changes in species behaviour, (iii) population size, and (iv) changes in species interactions. The forest

microclimate fluctuates when the ecosystem is altered through forest extraction (Ewers, 2013), land clearing for agriculture expansion, and human settlement. This resulted in species habitat fragmentation, which can have a significant impact on the ecology of the species in GPFR. Because of the changing habitat, species that play an important role in seed dispersal i.e., birds, wild boar, primates, and rodents may expand or contract their ranges in response to changes in the environment, land use (cleared forest), or other factors. Bird species will shift their ranges to other forest areas in response to the loss of roosting sites and food availability. Tree species population will be decreased, and this affects the interactions between species. For example, changes in the timing of flowering in plants can affect the timing of pollinator activity.

Overall, changes in species' ecology can have wide-ranging impacts on both species and the forest ecosystem in Gunong Pueh and its vicinity. Plant species differ in terms of their requirements from the ecosystem and subsequently, their abundance and distribution vary alongside environmental gradients (Iqbal et al., 2017). Understanding the factors that cause these changes is critical for developing effective conservation and management strategies to protect and preserve these species and their habitats in time.

Table 5: Type specimens collected from Gunong Pueh

Botanical name	Family	Specimen Num	Year	Collection by
Diosypros clementium	Ebenanceae	Clemens 20098	1929	Clemens, J.; Clemens, M.S.
Diospyros lunduensis	Ebenanceae	S. 49996	1985	Othman, I.; et al.
Chionanthus macrobotrys	Oleaceae	Foxworthy 367		
Heliciopsis percoriacea	Proteaceae	S. 49967	1985	Othman, I.
Gonystylus pendulus	Thymelaceae	Clemens 20011	1929	Clemens, J.; Clemens, M.S.
Glycosmis longisepala	Rutaceae	Clemens 20001	1929	Clemens, J.; Clemens, M.S.
Ficus spiralis	Moraceae	Purseglove 4642	1955	Purseglove, J.W.
Licuala punctulata	Areaceae	S. 20472	1929	Clemens, J.; Clemens, M.S.
Orophea clemensiana	Annonaceae	20239	1929	Clemens, J.; Clemens, M.S.

Threatened tree species in global assessment red listing

According to the Global Tree Assessment (2023), there are currently over 46,000 tree species assessed, of which 38% of all trees with assessments are threatened globally with extinction. These species are categorised into different levels of threat, ranging from Least Concern (LC) to Extinct (EX). Those globally threatened species are also found in Gunong Pueh FR. A total of 82 tree species from 17 families of Gunong Pueh are threatened in global distribution with 17 species assessed as Critically Endangered, 25 as Endangered, and 40 as Vulnerable. The percentage of population decline of the species and for each threatened category throughout the world varies (Table 6). Population declines of more than 80% across global distribution and quantified periods are automatically assessed as the highest threatened category (IUCN, 2023).

Table 6: Summary of threatened plant species of Gunong Pueh FR in global red listing

Conservation Status (IUCN, 2022)	Total Species	Family	Population declines at global scale
Critically Endangered	17	5	>90% for 11 species >80% for 2 species
Endangered	25	6	>70% for 11 species >50% for 9 species
Vulnerable	40	14	>50% for 10 species >30% for 21 species
Total	**82 species**	**17 families**	

Priority tree species for conservation action

Species assessed as threatened for the distribution of Sarawak are to be prioritised for the need for immediate attention and conservation action based on their level of endangerment. Sarawak Plant Red List listed 103 threatened species of Dipterocarpaceae (Julia et al., 2014; Julia & Vilma, 2016). For the non-dipterocarp families, only species that are endemic to Sarawak are included in the prioritisation listing. Of 538 species documented, twenty-six (26) species are assessed as threatened in Sarawak. These species are classified as threatened due to the population decline and habitat fragmentation varies from the range of 30% to 80% and some with localities from one location to less than 10 subpopulations throughout the state. All the twenty-six threatened species are not listed as protected in Wild Life Protection Ordinance, 1998 and of these, fourteen (14) species are not in the Totally Protected Areas (TPA).

Gunong Pueh FR harbours several species that are at a high risk of extinction, underscoring its significance as a priority conservation area. Those tree species that are critical for immediate preservation are those with minimal conservation measures; the fourteen species where all populations are situated outside the TPA network (Table 7), and no record of *in-situ* or *ex-situ* conservation are in place. Several studies stated that for most threatened plants, the direct factors leading them susceptible to extinction are human activities (Groom et al., 2006).

Table 7: Summary of state-level threatened tree species.

Conservation Status (SPRL & IUCN Red List)	Total Species	Family	Distribution in TPA network	Species outside the TPA network
Critically Endangered	6	5	None	*Alangium circulare, Dryobalanops fusca, Gonystylus pendulus, Hopea depressinerva, Orophea clemensiana & Trigonostemon diffusus*
Endangered	9	4	4 species	*Jarandersonia purseglovei, Kibatalia borneensis, Kopsia tenuis, Melanochyla axillaris & Shorea cordata*
Vulnerable	11	2	8 species	*Glycosmis longisepala, Vatica compressa & Vatica oblongifolia* ssp. *selakoensis*
Total	**26 species**	**9 families**		**14 species**

Rare and Endemic Species

GPFR has a high-level of endemic tree species. Endemic tree species are trees that are native to and found only in a particular region and not naturally found elsewhere in the world. The study revealed that the forest reserve has seventy-two (72) species that are endemic to either Malaysia, Borneo, or Sarawak. Figure 11 shows the breakdown of endemicity of GPFR tree species. Of these 72 endemic species, 47 are assessed as threatened in the IUCN Red List of Threatened Species (2022).

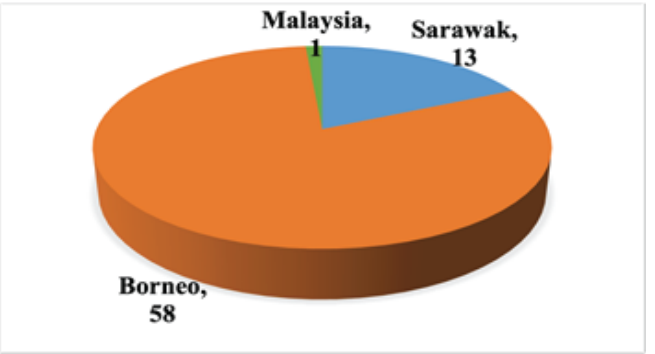

Figure 11: Breakdown of endemicity of tree species in Gunong Pueh Forest Reserve

Further categorisation of thirteen (13) tree species endemic to Sarawak (Figure 11) reveals that all are in the threatened category with five under Critically Endangered, five are Endangered and three are Vulnerable, globally, and regionally (Sarawak). However, the most critical ones are species that are only found in Mount Pueh and its surrounding forests. Four tree species have been documented as endemic to Mount Pueh, never recorded elsewhere outside the Lundu district (Table 8). These rare Mount Pueh endemic tree species have evolved to adapt to the unique environment of the area; thus, they are an impor-

in GPFR and play a significant role in maintaining biodiversity of the reserve. Some studies have shown that the species richness of small populations is always reduced by human activities, mainly by habitat destruction and fragmentation (Chen et al., 2014). Therefore, GPFR is a very important area for the four species that are rare and endemic to Mount Pueh.

Table 8: Summary of species endemic to Mount Pueh

Botanical Name	Family	Notes	Global Conservation Status
Orophea clemensiana	Annonaceae		Critically Endangered B1ab(ii,iii)+2ab(ii,iii)
Trigonostemon diffusus	Euphorbiaceae	Known only from two collections (Gunong Pueh)	Critically Endangered B2ab(ii,iii)
Jarandersonia purseglovei	Malvaceae		Endangered B1ab(I,ii,iii)+2ab(I,ii,iii)
Gonystylus pendulus	Thymelaceae		Critically Endangered A4ac; B1ab(ii,iii)+2ab(ii,iii)

Figure 12: The flower of *Trigonostemon diffusus*, a small tree species that is only found at Mount Pueh.

CONCLUSIONS AND THE WAY FORWARD

The presence of rare, endemic, and threatened species of trees in Gunong Pueh Forest Reserve fulfilled one of the high conservation values, that is the concentrations of biological diversity including endemic species, and rare, threatened, and endangered species that are significant to global, regional, or national levels. The findings of this study revealed the indicators and the critical need for conservation priorities in Gunong Pueh FR. Preserving endemic and threatened plant species is crucial to maintain biodiversity and ecosystem stability. The next step to be taken after the species prioritisation for conservation is in-situ conservation, by safeguarding the natural habitat of prioritised species, where the species can grow and reproduce without disturbance. Other than that, is the detailed research and monitoring of the forest reserve and the species' habitat. Regular monitoring and research are essential to understand the threats facing the plant species and to develop effective conservation strategies. This includes studying their ecological requirements in the forest reserve, population dynamics, and genetic diversity. Additionally, to ensure that conservation efforts are efficiently implemented, public education and awareness need to be mainstreamed in societies. Educating the public about the importance of conservation and the threats causing species extinction can help to generate support and raise awareness. In conclusion, understanding the ways in which plant species ecology can change over time due to anthropogenic effects is important for managing and conserving biodiversity, where this would require a combination of scientific research, monitoring, and adaptive management strategies that consider the complex and dynamic nature of ecosystems and the species that inhabit Gunong Pueh Forest Reserve.

ACKNOWLEDGEMENTS

We are grateful to Forest Department Sarawak and its divisions, particularly the Research and Development Division (RDD) and the International Affairs Division (IAD) for organising the scientific expedition and giving us the opportunity to discover more important findings for biodiversity conservation. Special thanks to the technical staff of RDD for their assistance in carrying out field surveys and data collection activities.

REFERENCES

Alroy, J. 2017. Effects of habitat disturbance on tropical forest biodiversity. PNAS: Vol 114, No. 23. http://www.pnas.org/cgi/doi/10.1073/pnas.1611855114.

Chen, Y., Yang, X., Yang, Q., Li, D., Long, W. & Luo, W. 2014. Factors Affecting the Distribution Pattern of Wild Plants with Extremely Small Population in Hainan Island, China. PLoS ONE 9(5):ee97751.doi:10.1371/journal.pone.0097751.

Ewers R. M. & Banks-Leite, C. 2013. Fragmentation Impairs the Microclimate Buffering Effect of Tropical Forests. PLoS ONE 8(3): e58093. doi:10.1371/journal.pone.0058093

Global Tree Assessment. 2023. Conservation Assessments for all the World's Tree Species. https://www.bgci.org/our-work/networks/gta. Accessed on 15th March 2023.

Groom, M. J., Meffle, G. K. & Carroll C. R. 2006. Principles of Conservation Biology. Sunderland: Sinaurer.

Iqbal, M., Khan, S.M., Khan, M.A., Ahmad, Z., Abbas, Z., Khan, S.M. & Khan, M.S. 2017. Distribution pattern and species richness of natural weeds of wheat in varying habitat conditions of district Malakand, Pakistan. Pak. J. Bot. 49(6).

I**UCN. (2023)**. The IUCN Red List of Threatened Species. Version 2022-2. https://www.iucnredlist.org. Accessed on 14th January 2023.

Julia, S., Vilma, B., Esther, S. & Chong, L. 2014. SARAWAK PLANT RED LIST Dipterocarpaceae Series I: Dipterocarpus, Dryobalanops & Shorea. SARAWAK FORESTRY CORPORATION Sdn. Bhd. Sarawak, Malaysia. 193 p.

Julia, S. & Vilma, B. 2016. SARAWAK PLANT RED LIST Dipterocarpaceae Series II: Anisoptera, Cotylelobium, Hopea, Parashorea, Upuna & Vatica. SARAWAK FORESTRY CORPORATION Sdn. Bhd. Sarawak, Malaysia. 105 p.

Moultan, J. C. 1913. Some notes on a short collecting trip to Mt. Poi, Sarawak, undertaken recently by the Raffles Museum, Singapore, and the Sarawak Museum. Journal of the Straits Branch of the Royal Asiatic Society. No. 65 (December, 1913), Malaysian Branch of the Royal Asiatic Society. pp. 1-12 (12 pages)

Muscarella, R., Kolyaie, S., Morton, D. C., Zimmerman, J. K. & Uriarte, M. 2020. Effects of topography on tropical forest structure depend on climate context. Journal of Ecology. 108:145-159. doi:10.1111/1365-2745.13261.

Royal Botanic Garden. 2023. The Herbarium. https://www.kew.org/science/collections-and-resources/collections/herbarium. Accessed on 18th March 2023.

PAPER 5:
MACROFUNGI DIVERSITY OF GUNONG PUEH FR LUNDU

Shirley Chip[1], Abdul Ghani Yusuf[1], Abu Serah Aboi[1], Junes Bodui[1], Mustapa Mat[2], Fatin Nasrin Batrishyia[2], Sharifah Rohaidah Wan Alam[1], Noorhana Mohd Sapawi[1]

[1]Research And Development Division, Forest Department Sarawak, KM10 Jalan Datuk Amar Kalong Ningkan, 93250 Kuching, Sarawak

[2]International Affairs Division, Forest Department Sarawak, Level 13, Bangunan Baitul Makmur II, Medan Raya, Petra Jaya, 93050 Kuching, Sarawak
Corresponding email: shirleych@sarawak.gov.my

Abstract: Macrofungi (commonly referred as mushroom) are characterised by conspicuous spore-bearing structures or fruiting bodies produced by two classes of higher fungi (Ascomycetes & Basidiomycetes) found typically above ground on soil or on their food sources. The rainforest of Sarawak is endowed with a vast diversity of macrofungi with various features and functions in the forest ecosystems. Therefore, the scientific expedition to Gunong Pueh Forest Reserve (FR) in October 2020 was timely, as it aimed to document pertinent information on macrofungi diversity, specifically within the logged-over Permanent Forest Estate (PFE) area. A total of 61 specimens were collected with preliminary identification recording eighteen (18) families dominated by Polyporaceae and thirty-three (33) genera. The majority of the specimens, amounting to more than 80%, were found inhabiting rotten trees, branches, and twigs while the rest were living on soil debris, rotten roots and living trees. Among the unique shapes of macrofungi recorded are polyporus, gilled, cup, coral, puffball, jelly, woody, bird's nests, and earthstar. All the macrofungi specimens were deposited in the Sarawak Fungarium for future reference. Continuous documentation on macrofungi diversity is essential to attain comprehensive data for further applied research on its significant contribution in our rainforest.

Keywords: Macrofungi diversity, Gunong Pueh FR, Logged-over PFE, Sarawak Fungarium

INTRODUCTION

In fact, fungal perspective is almost neglected in the assessment of global biodiversity trends (e.g., Butchart et al. 2010, IPBES 2018), thus we are urged to unravel the answer on how to integrate scattered mycological knowledge. Fungi contributes to the function of healthy forest ecosystems by forming mutualistic symbiosis associations with plants, playing major roles in nutrient cycling by decomposing organic matter, providing food for animals, and creating habitat diversity for many forest organisms (Castellano et. al., 2021). Therefore, comprehensive biodiversity management shall include mycodiversity data for effective conservation measures and management practices. Subsequently, database development begins with specimen collection and documentation of ecological requirements and responses to forestry. Appertaining to this, the scientific expedition to Gunong Pueh FR in October 2020 had provided priceless findings on macrofungi diversity specifically within one of the logged-over Permanent Forest Estate (PFE) area in the tropical forest of Sarawak.

Macrofungi

Gradual research had confirmed that fungi are not plants as they are not made of cellulose and did not contain chlorophyll to convert carbon dioxide into sugars by using the sunlight (Peter & Shelly, 2011). Fungi are made up of microscopically thin, tubelike hyphae that can often be seen as cobwebby threads on rotten wood or root, in damp leaf litter and in compost. The hyphal walls absorb nutrients from its hosts in the form of simple sugars and amino acids or exude enzymes that disperse into more complex substrates, where organic material is decomposed. Hyphae form mycelium that produces fruiting bodies after some time. Fungal fruiting bodies comprise various shapes and sizes, which mainly enable the sexual blending of two or more genetic types and produce spores for dispersal.

All macrofungi belong either to Ascomycota or Basidiomycota, which are known as the two fungal phyla that produce large, visible fruitbodies. Generally, macrofungi are categorised into saprotrophic, pathogenic, and mutualistic. Saprotrophic species is the primary recycler that releases energy and nutrients stored in dead wood and fallen trees through the decomposition process. Pathogenic species kills individual trees, thus contributing to the disturbance of forest dynamics. Mutualistic species conducts symbiotic relationships with over ninety percent of the world's trees and flowering plant species (David P. & Brian, 1992). Some macrofungi species are important sources of food for many arthropods, animals, and humans while a few are being used traditionally by humans to cure certain illnesses or diseases.

Fungarium of Sarawak

The Sarawak Fungarium was established in 1976 by Forest Department Sarawak under the Forest Pathology Unit to focus on plant disease research, especially on Acacia mangium, while also conducting collection on macrofungi. In 2011, the Forest Pathology Unit was renamed as the Mycology Programme and since then, the documentation of macrofungi samples became a major focus. Currently, the Fungarium houses a reference collection of more than 6,000 dried and wet specimens from an estimated 54 families and 108 genera. Other collections are the samples of plants infected by fungal diseases, stained log

samples caused by sap-stain fungi and a few specimens from overseas. The oldest specimen recorded is the polyporus macrofungi called Pycnoporus sanguineus that was collected in 1954. These collections are important references that hold the untold story of fungi biodiversity in Borneo and Sarawak to be precise.

HoB Gunong Pueh FR Scientific Expedition 2020

Gunong Pueh FR covers an area of 4,081 hectares (ha) with approximately 600 m elevation above sea level, reaching Gunong Pueh National Park boundary. Located in Lundu District, Gunong Pueh FR lies within the Heart of Borneo (HoB) region after the expansion of HoB area from Sri Aman Division to Kuching Division was approved by the State Government in 2018. With the growing trend of hiking enthusiasm nowadays, Gunong Pueh FR has become a popular place of interest due to its captivating natural surroundings, including waterfalls, beautiful scenery from high elevations, and a vast diversity of flora and fauna. Therefore, the HoB Gunong Pueh FR Scientific Expedition 2020 came at an opportune time to document essential information on the diversity of flora and fauna, including macrofungi, specifically within the logged-over Permanent Forest Estate (PFE) area.

The selected site for the HoB Gunong Pueh Scientific Expedition 2020 comprises the large area of mixed dipterocarp forest (MDF), riverine forest along Sungai Sebako and Sungai Penindih, and patches of kerangas transition to MDF on the lower part. The last logging activities were wrapped up 10 years ago, thus large timber trees are rarely seen except along the river buffer zone. During the expedition, four (4) research transects were accessed for macrofungi study that includes the MDF, kerangas transition to MDF and riverine forests. Most days within the expedition period were hot with few occurrences of downpour and intermittent rain. Overall, fieldwork to document macrofungi diversity in Gunong Pueh FR needs good stamina to hike up slopes and traverse rocky terrain.

MATERIALS AND METHOD

Macrofungi assessment work consists of field observation, data recording and sample collection. The field equipment used were Garmin GPS, camera, paper bag, bottle, zip-lock plastic bag, knife, field notebook and pen. Along the research transect, observation was made on potential habitats of macrofungi such as the dead/rotten/decay trees, logs, branches, twigs, stumps and roots, leaf litter, soil debris and living plants. The information on forest type, coordinates, habitat, morphology, and obvious changes was recorded in the field notebook. Photographs of the fresh sample and its habitat were taken before being placed in the paper bag or bottle. Paper bags and bottles filled with 70% EtOH solution were used to keep dry and wet specimens respectively. Preliminary identification (ID) was conducted at the base camp by observing its physical character using hand lens, recording the description in ID forms (Gills or Non-Gills) and referring to the Fungi Checklist for comparison. Some specimens need to be cross sectioned using penknife to see the interior parts. Every sample was measured and labelled with specimen numbers. Every specimen was photographed again on dark coloured board with measurement and numbering labels. Dry specimens were subjected to sun drying while wet specimens remain in the 70% EtOH solution.

Figure 13: Recording field information

Figure 14: Taking photographs of fresh samples

Figure 15: Collecting samples

Figure 16: Sample identification

RESULTS AND DISCUSSION

A total of 61 macrofungi specimens were collected with preliminary ID recording 18 families and 33 genera. Among the collection, Family Polyporaceae was leading in numbers, followed by Marasmiaceae and Hymenochaetaceae while many others were barely spotted along the selected research transects. All the specimens are being kept in the Sarawak Fungarium for future reference and re-ID by local or foreigner experts.

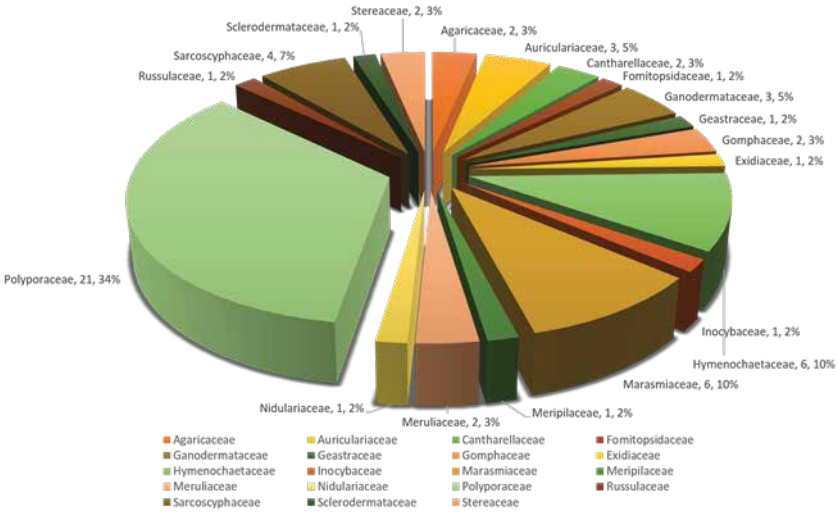

Figure 17: Family summary

Genus/Species record from each Family and its habitat information are as follows:

Table 9: Genus/Species of macrofungi and habitat

Family	Genus/Species	Habitat
Agaricaceae	Unknown	On dead wood
	Lycoperdon sp.	On dead root
Auriculariaceae	*Auricularia mesenterica*	On dead wood & tree
	Auricularia sp.	On dead branch
Cantharellaceae	*Cantharellus* sp.	On soil & forest debris
Fomitopsidaceae	*Piptoporus* sp.	On dead branch
Ganodermataceae	*Amauroderma rugosum*	On soil
	Ganoderma australe	On dead tree
	Ganoderma sp.	On dead tree
Geastraceae	*Geastrum* sp.	On soil & forest debris
Gomphaceae	*Ramaria* sp.	On soil & forest debris
Hericiaceae	*Hericium* sp.	On dead branch
Hymenochaetaceae	*Phellinus* sp.	On dead tree & wood & on living tree
Inocybaceae	*Crepidotus* sp.	On dead tree
Marasmiaceae	*Marasmius* sp.	On dead branch, soil & forest debris
	Trogia sp.	On dead branch
Meripilaceae	*Rigidoporus* sp.	On dead tree & wood
Meruliaceae	*Cymatoderma* sp	On dead branch
Nidulariaceae	*Cyathus* sp.	On dead branch
Polyporaceae	*Favolus* sp.	On dead wood
	Coriolus sp.	On dead tree & branch
	Coriolopsis sp.	On dead branch
	Lenzites acuta	On dead wood
	Microporus xanthopus	On dead branch
	Microporus sp.	On dead or decay branch
	Panus sp.	On dead tree
	Polyporus sp.	On dead branch
	Trametes sp	On dead tree & branch
Russulaceae	*Rusulla* sp.	On forest debris
Sarcoscyphaceae	*Cookeina* sp.	On dead branch
	Cookeina tricholoma	On decay wood
	Cookeina sulcipes	On dead wood
Sclerodermataceae	*Scleroderma* sp.	On forest debris
Stereaceae	*Stereum* sp.	On dead tree & wood

More than 80% specimens were found inhabiting dead or decaying trees, branches, twigs, and roots while the rest were living on soil, forest debris and standing trees. Wood-inhabiting fungi are key species that are primarily responsible for wood decay in the forest ecosystems hence, open up the dead wood resource for most other wood-inhabiting organisms (Lonsdale et al. 2008).

Overall findings recorded various types and shapes of macrofungi, including woody, polyporus, gilled, cup, coral, puffball, jelly, bird's nests, hairy, agaric and earthstar.

Family: Ganodermataceae | Family: Hymenochaetaceae

Ganoderma sp.

Ganoderma sp.

Phellinus sp.

Figure 18: Woody fungi

Woody fungi are also called bracket or shelf fungi. It is morphologically characterised by woody fruitbodies with pores or tubes on the underside. Most of the woody fungi are important agents of wood decomposers while some soil-inhabiting species form mycorrhiza with trees.

Family: Agaricaceae | Family: Marasmiaceae | Family: Polyporaceae

Figure 19: Gilled fungi

Gilled fungi come in various sizes, colours, and forms with two (2) main parts consisting of a stem and a cap. The gills or lamellae on the underside provide a large area for the development of spores. Gilled fungi are either fleshy, firm, soft or fragile and even deliquesce.

Family: Sarcoscyphaceae

Cookeina sulcipes

Cookeina tricoloma

Figure 20: Cup fungi

Cup fungi often grow in small troops, formed by a deep cup-liked fruiting body containing spores. The cups catch rainwater causing the spore-containing cells to swell and later ruptures when dry out, dispersing the spores. According to the local community of Gunong Pueh FR, cooked Cookeina sp. can be consumed as food.

Family: Gomphaceae

Cookeina sulcipes

Figure 21: Coral fungi

Coral fungi also known as the clavarioid fungi or colloquially called club fungi. Its gelatinous fruitbodies appear like clubs or elongated spindles either branched or unbranched. Spores are being produced on the surface of mostly upright, simple and branched basidiocarps.

Family: Auriculariaceae

Cookeina tricoloma

Figure 22: Jelly fungi

Jelly fungi are common edible mushrooms that can be prepared as food in various cuisines. Its gelatinous fruitbody is an advantage in retaining moisture and prolonging the spores' formation. Some are ectomycorrhizal while others might be wood-rotter or parasites.

Family: Nidulariacea

Cyathus sp.

Figure 23: Bird's nests fungi

Family: Sclerodermataceae

Scleroderma sp.

Figure 24: Puffball fungi

Bird's nests fungi rely on heavy rain drops to splash out its tiny, egg-like packets of spores from its nest-like cups. It prefers mossy, fallen branches in damp, shady areas. Antibiotics called striatins have been isolated from *Cyathus striatus*, as well as an extract that potentially cure cancer.

Puffball fungi are known as common ectomycorrhizal associates of trees. The fruitbodies contain masses of blackish spores that are released as they split open at the top. Some have gone underground and rely on animals to spread their spores.

Family: Geastraceae

Cyathus sp.

Figure 25: Earthstar fungi

Earthstar fungi together with the puffball and bird's nests, are artificially classed as gasteromycetes or "stomach fungi " since all these produce spores inside their fruitbodies. This extraordinary and attractive fungi depend on the raindrops to puff-out its spores.

Family: Hymenogastraceae

Gymnopilus sp.

Figure 26: The “Laughing fungi”

It is said that certain Gymnopilus sp. resulted in an exceptional effect to the brain, either being consumed raw or cooked. Common mushroom toxicity symptom on the victim is the extraordinary “happy” or “laughing” behaviour. Hence, this agaric fungi are called the “Laughing fungi” by the local community.

Incessant documentation of macrofungi diversity is important to attain comprehensive data for future references especially in managing the diversity of flora and fauna efficiently within the logged-over PFE. Besides that, the captivating presence of macrofungi with various features and colours can potentially become one of the essential eco-tourism assets in Gunong Pueh FR.

CONCLUSIONS

Apparently, most of the macrofungi recorded in Gunong Pueh FR plays crucial roles to decompose dead wood while the rest were accountable to break down molecules in forest debris and some might be pathogenic to their hosts. Along the selected research transects, Polyporaceae were the most dominant, followed by Marasmiaceae and Hymenochaetaceae. Other than its importance as primary recycler in the forest ecosystems, the colourful and fantastic shape of macrofungi can potentially become a source of wonder and fascination for nature enthusiasts and the scientist community.

Way forward for mycological research in Forest Department Sarawak (FDS) is the development of a database system through collaboration with Sarawak Information System Sdn. Bhd. (SAINS) under the State Government 12th Malaysia Plan Budget. Main focus is to digitise the existing data and specimen collection into a standard database system. Concerning the guidance and knowledge enhancement for the officers, experts from local education institutes such Universiti Malaysia Sabah are being engaged as Research Advisors in mycological related study.

Furthermore, study on both macrofungi and microfungi is also being included in the Sarawak-Japan partnership project called "The Project on Development of Management Systems for Multiple Utilisation of Biodiversity in the Tropical Rainforests at the Protected Areas in Sarawak" or SATREPS. This project is technically being supported by JICA and the Japan Science and Technology Agency (JST) with the target to develop basic infrastructures for scientific research, train local researchers through technology transfer and knowledge sharing as well as to develop data sharing systems.

RECOMMENDATION

Further observation on macrofungi diversity should be conducted especially focusing on the areas around the hiking trails. Simultaneously, the ethnomycology knowledge should be obtained from the discerning person through various methods such as interview, story-telling session, demonstration and distribution of questionnaires. Next, the findings should be documented well in the form of scientific reports, information materials, including magazines, posters, flyers and coffee-table books as well as printed on souvenir items such as key-chains, shirts etc. that can be disseminated to the public. Meanwhile, the local people especially those involved with tourist guiding should be exposed with immense knowledge and understanding on the presence of macrofungi in Gunong Pueh FR.

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REFERENCES

Castellano MA, Crabtree CD, Mitchell D, Healy RA. 2021. *Eight new Elaphomyces species (Elaphomycetaceae, Eurotiales, Ascomycota) from eastern North America. Fungal Systematics And Evolution* 7: 113-131.

David L, Marco P, Ottmar H. 2008. W*ood-decaying fungi in the forest: conservation needs and management option*s. Eur J Forest Res (2008) 127:1–22.

David P, Brian S. 1992. *The Mushroom Identifier. London*: The Apple Press.

Geoffrey K. 1991. *The Pocket Guide To Mushrooms And Other Fungi*. Great Britain: Dragon's World Ltd.

Kadri R, Otto M, Asko L. 2021. *Polypore fungi as a flagship group to indicate changes in biodiversity – a test case from Estonia. Runnel et al.: IMA Fungus* (2021) 12:2.

Peter R, Shelley E. 2011. *The Book of Fungi: A Life-Size Guide To Six Hundred Species From Around the World*. United Kingdom: Ivy Press.

PAPER 6:
DISCOVERY OF EXTRAORDINARY MYCOHETEROTROPHIC PLANTS OF GUNONG PUEH FOREST RESERVE

Ling Chea Yiing

Sarawak Herbarium, Kuching, Sarawak, Malaysia
Corresponding email: lingcy@sarawak.gov.my

Abstract: The Heart of Borneo (HoB) Scientific Expedition was organised by Forest Department Sarawak, which aims to document the variety of rich flora and fauna from the Heart of Borneo areas in Sarawak. A botanical survey was conducted at Gunong Pueh Forest Reserve (FR) under the Heart of Borneo Scientific Expedition in October 2020. Expedition sites consist mainly of hill mixed dipterocarp forest. A total of seven (7) species from four (4) families of mycoheterotrophic plants were discovered during the expedition. Family Orchidaceae were found to be the most diverse family with four species recorded, and one species documented from family Polygalaceae, Burmanniaceae and Petrosaviaceae respectively. Of these, one new record, one rare and one Borneo endemic species were documented. Most of the species were discovered in mainly deeply shaded undisturbed or less disturbed forests. The discovery of mycoheterotrophic plants in Pueh FR could under-represent the richness of these extraordinary plants as they are often small-sized and easily overlooked. The diversity of mycoheterotrophic plants in Borneo are expected to be high due to the suitable environment for them to grow. However, most of the mycoheterotrophic plants are under-studied and rarely collected. Hence, the future study of this group is elaborated here.

Keywords: Mycoheterotrophic, Gunong Pueh, diversity, Borneo

INTRODUCTION

The series of Heart of Borneo (HoB) Scientific Expeditions were organised by Forest Department Sarawak from 2010 till 2020, which aimed to document the diversity of flora and fauna in the Heart of Borneo areas. One of the scientific expeditions at Gunong Pueh FR was conducted from 5-17 October 2020. Gunong Pueh FR is in Lundu District (Figure 27), gazetted in 1927 with an area of 12,950 hectares. The mountain range lies along the Sarawak and Indonesia border, with elevation over 1,600 m above sea level. It consists mainly of hill mixed dipterocarp forest, kerangas forest and riparian forest, sometimes with large granite boulders. The foothill of the area is mainly shifting cultivation areas and oil palm plantations.

Over 500 species of mycoheterotrophic plants are distributed worldwide (Merckx et al., 2009; Merckx, 2012). It is commonly found in humid dense forest and often shaded where the forest floor is covered with leaf litter. The term mycoheterotrophic was first introduced by Leake (1994), which refers to plants lacking chlorophyll but directly parasitic upon other plants. Mycoheterotrophic plants are sometimes mistaken as saprophytes due to their inability to do photosynthesis. Mycoheterotrophy refers to the ability of plants to obtain carbon from fungi living in the soils. They are often short-lived, small-sized, above ground, dull in colour and grow mainly near water sources.

Due to its proximity to Kuching and accessibility, over 1,000 herbarium specimens from Gunong Pueh and its vicinity were kept in the Sarawak Herbarium. Of these, only one specimen of mycoheterotrophic plant was documented. Hence, this expedition is important for mycoheterotrophic plant survey to understand the biodiversity of this group of plants in Sarawak.

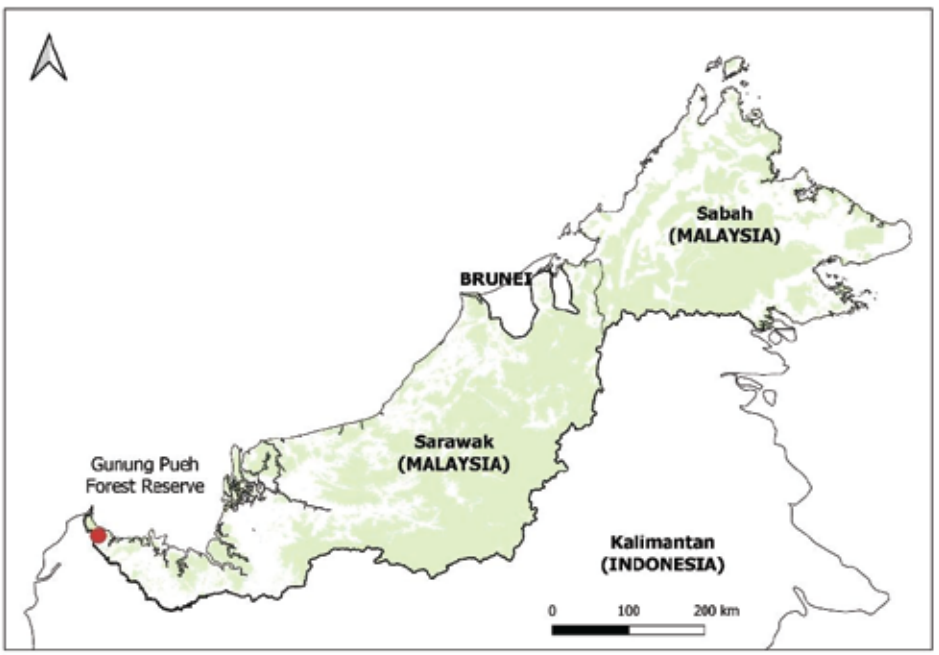

Figure 27: Gunong Pueh FR located at South-Western Sarawak

METHODOLOGY

Field surveys were conducted along the transects prepared by the organiser. Each transect is about 1–4 km long, cutting through forests and streams. Collection of plants were made following the standard Herbarium Collection Method. Each collected specimen was placed at the Sarawak Herbarium (SAR). For small plants, the spirit collection method was used. Preservation of spirit material was made using Copenhagen Solution (70% ethanol, 28% distilled water & 2% glycerol). Identification of the plants was done based on published papers (Dancak et al., 2017; Merckx, 2012; Tsukaya et al., 2016 etc.), and collaborative work with experts.

RESULTS AND DISCUSSIONS

A total of seven (7) species from four (4) families of mycoheterotroph plants were discovered during the expedition. Family Orchidaceae is the most diverse family with four species recorded, and one species documented each from family Polygalaceae, Burmanniaceae and Petrosaviaceae respectively (Table 10) (Figure 28).

Table 10: List of mycoheterotrophic plants collected from Pueh Forest Reserve

Family	Genus	Species
Burmanniaceae	*Burmannia*	*Burmannia sp. oblonga*
Orchidaceae	*Didymoplexiella*	*Didymoplexiella borneensis* (Schltr.) Garay
Orchidaceae	*Didymoplexis*	*Didymoplexis micradenia* (Rchb.f.) Hemsl.
Orchidaceae	*Gastrodia*	*Gastrodia javanica* (Blume) Lindl.
Orchidaceae	*Lecanorchis*	*Lecanorchis multiflora* J.J.Sm.
Petrosaviaceae	*Petrosavia*	*Petrosavia stellaris* Becc.
Polygalaceae	*Epirixanthes*	*Epirixanthes elongata* Blume

Most of the species were discovered in undisturbed or less disturbed forests along the rivers or hill mixed dipterocarp forest. *Gastrodia javanica* can be found along the disturbed and shaded main trail toward Gunong Pueh National Park. *Didymoplexis micradenia* was found growing near to bamboo clumps, almost covered by bamboo leaf litter. This species is a new record for Borneo. *Petrosavia stellar*is is one of the rare species for Sarawak, so far only recorded from five localities in Sarawak. The last record of this species was collected in 1976 from Gunung Mulu National Park. It is rare, probably due to its small size and easily overlooked. One species recorded is endemic to Borneo, namely *Didymoplexiella borneensis.*

Figure 28: Family Orchidaceae - A*: Didymoplexiella borneensis;* B*: Didymoplexis micradenia;* C*: Lecanorchis multiflora;* D*: Gastrodia javanica.* Family Burmanniaceae - E*: Burmannia sp.* Family Polygalaceae - F*: Epirixanthes elongata.* Family Petrosaviaceae - G*: Petrosavia stellaris.*

CONCLUSION

A total of seven species of mycoheterotroph plants were documented during this expedition. One species is endemic to Borneo and another one is a new record to Borneo. Continuous surveys in Gunong Pueh FR may result in discovery of more mycoheterotroph plants. The diversity of mycoheterotroph plants is expected to be high due to the suitable environment and microhabitat for them to thrive. Besides the mycoheterotroph plants, other interesting discoveries were documented during this field survey as more surveys will lead to more exciting discoveries.

REFERENCES

Dancak, M., Hrones, M., Sukri, R.S., Metali, F. & Joffre A.A. (2017). Novitates Bruneienses, 9. A synopsis of *Epirixanthes* (Polygalaceae) in Brunei Darussalam and notes on species elsewhere. *Gardens' Bulletin Singapore*. 69(2):179–187.

Leake JR. (1994). The biology of myco-heterotrophic ('saprophytic') plants. New Phytologist 127: 171–216.

Merckx, V., Martin I. Bidartondo and Nicole A. Hynson. (2009). Myco-heterotrophy: when fungi host plants. *Annals of Botany*. 104: 1255–1261

Merckx, V.S.F.T. (2012). Mycoheterotrophy: An Introduction. In: Merckx, V. (eds) *Mycoheterotrophy*. Springer, New York, NY. https://doi.org/10.1007/978-1-4614-5209-6_1

Tsukaya, H., Suleiman, M. & Okada, H. (2016). A new species of *Epirixanthes* (Polygalaceaea) from Imbak Canyon, Sabah, Borneo. Phytotaxa. 266(2):146–150

PAPER 7:
BEGONIA (BEGONIACEAE) OF GUNONG PUEH, SARAWAK, BORNEO

Julia Sang & Ling Chea Yiing

Research & Development Division, Forest Department Sarawak
Corresponding email: julias2@sarawak.gov.my, lingcy@sarawak.gov.my

Abstract: With over 2,000 species recorded worldwide, *Begonia* is the sixth largest genera of flowering plants in the world. In Borneo, a total of 229 species and one subspecies are known to date. Of these, about 69% of the Bornean species are found in Sarawak, making our state a hotspot for *Begonia* diversity in Borneo. The first *Begonia* specimen from Gunong Pueh was collected by Clemens, J. & Clemens, M.S. in 1929. Since then, at least nine different taxa have been collected from Gunong Pueh and its surrounding areas. During the HoB expedition to Gunong Pueh in 2020, a total of 14 specimens were collected, representing *Begonia paoana* and three undescribed taxa. Five other taxa which were previously collected from Gunong Pueh and its surrounding areas were unfortunately not found during this expedition. Continuous exploration of forest areas particularly within the Heart of Borneo is important to enhance our knowledge on highly diverse groups such as *Begonia.*

Keywords: *Begonia, diversity*, Gunong Pueh, Heart of Borneo

INTRODUCTION

The *Begonia* species is locally known as 'daun riang' in the native Iban language and various other names by different ethnic groups in Sarawak such as 'kuru' or 'da'on kru' in Bidayuh and 'asam batu' in Malay. The begonias can be easily recognised by their unequal asymmetric leaves which come in many shapes, size, texture, and colour. Other easily identifiable characteristics include alternated leaves arrangement, presence of stipule, separate male and female flowers that are both produced on the same plant, petaloid tepals, inferior winged ovaries, usually 3-winged fruit, rarely 4-5-wings and its habit ranges from small creeping species, rosette-like plant to erect branched or unbranched plants. The begonia is probably a less popular ornamental plant compared to orchids. Nevertheless, the popularity of the species as indoor ornamental plants is getting more popular among the plant enthusiasts, particularly in other countries outside Sarawak. In Sarawak, the leaves are eaten raw or cooked by the locals as vegetables or as food flavour that give a sour taste.

Begonia is the sixth largest genera of flowering plants in the world with over 2,000 species (excluding hybrids) (Frodin, 2004, Hughes et al., 2015-). The family Begoniaceae is largely distributed in the tropics. To date, a total of 229 species and one subspecies are known from the island of Borneo (Hughes et al., 2020; Julia et al., 2022). These figures consistently increase yearly as more and more species are described worldwide, particularly in Southeast Asia. With over 200 species and more taxa awaiting formal description, Borneo has the highest diversity of *Begonia* compared to other regions such Peninsular Malaysia (53 species) and the Philippines (160 species) (Kiew, 2005; Hughes et al., 2015-). About 69% of the species recorded for Borneo can be found in Sarawak making our state the hotspot for *Begonia* in Borneo.

HISTORY OF BEGONIA COLLECTIONS IN GUNONG PUEH

The first *Begonia* specimen collected from 'Mount Poi', currently known as Gunong Pueh, was done by Joseph Clemens and his wife, Mary Strong Clemens, in 1929. Joseph Clemens, the former Chaplain of the American Army since 1902 and his wife made large collections of specimens in Sarawak between May to November 1929. Unfortunately, the specimens collected by Joseph Clemens from Gunong Pueh are impossible to be identified to species level as the specimens are incomplete. In addition, none of the specimens collected during the expedition resembles the specimens collected by Clemens; therefore, the mystery as to the identity of the specimens remains unknown. Since Clemens' collection in 1929 and based on the herbarium specimen records at Sarawak Herbarium (SAR), at least nine different taxa have been collected from Gunong Pueh (sometime spelled as 'Poi') and its surrounding areas, including Gunung Berumput and Gunung Bekumpai in the northern part of Pueh Range. These taxa are represented by a total of 17 specimens at SAR. Other species previously collected from Gunong Pueh include *Begonia propinqua* and *Begonia poaana*. Both *B. propinqua* and *B. paoana* are widespread in Kuching division and West Kalimantan (for *B. paoana*).

BEGONIA COLLECTIONS DURING THE EXPEDITION TO GUNONG PUEH IN 2020

During the Heart of Borneo expedition to Gunong Pueh in 2020, the objectives were to locate as many *Begonia* species as possible and to collect complete specimens (i.e., specimens with flowers and fruits). Complete herbarium specimen is crucial for the correct identification of plant species such as begonias. Many species of Begonia in Borneo are very similar in their vegetative characteristics but entirely different in their reproductive characteristics. Without complete materials of flowers and fruits, along with meticulous observations, these species may superficially appear to be the same; hence, they are often wrongly identified or overlooked in the field. During the expedition, the survey areas include the forest trails set up during the expedition, such as the proposed Arboretum trail near Kampung Selebat at elevation between 87-650 m above sea level (Figure 29). Standard herbarium collection technique was applied, and the taxa was described as complete as possible in the field for their habit, leaf characters, inflorescence, male and female flowers, fruits, and habitat.

Figure 29: Collection sites during the HoB expedition to Gunong Pueh

A total of 14 specimens were collected representing Begonia paoana and three undescribed taxa were collected from various collection sites during the expedition (Table 11). The list of all specimens from Gunong Pueh and surrounding areas are listed in Appendix 1. All the taxa collected during this expedition have been collected in the past and were recollected during this expedition with more complete specimens. Five other taxa, which were previously collected from Gunong Pueh and its surrounding area, are unfortunately not found during this expedition. These taxa are most likely collected from different parts of Gunong Pueh in the past that were not covered during this expedition.

Table 11: Collection sites for the taxa

Taxa	Collection site
Begonia paoana	Trails 1, 2, 4, 9
Begonia sp. 1	Trail 9 & Sebako Waterfall
Begonia sp. 2	Trails 1, 2, 4, 5, HOB's camp, Sg. Selebat
Begonia sp. 3	HOB's camp

Despite the close geographical proximity of Gunong Pueh and Gunung Gading, none of the species known from Gunung Gading occurs at Gunong Pueh. This is rather expected for Begonia as most of the begonias species in Borneo are considered narrow endemic. The re-collections of the same taxa after 50 years of their previous collections as shown by the examples of begonias indicate that some fairly good and suitable habitats for many species are still present at Gunong Pueh. Based on the existing specimens collected in the past and those specimens collected during this expedition, the diversity of the begonias of Gunong Pueh at present are nine taxa.

CONCLUSION

The importance of forest areas such as Gunong Pueh should not be underestimated. The forest areas at Gunong Pueh and the surrounding areas remain as important habitats for many interesting species, including possibly new species. Continuous exploration of forest areas particularly within the Heart of Borneo is important to provide an opportunity to uncover Sarawak's rich biodiversity.

ACKNOWLEDGEMENTS

We would like to thank all the team members during this expedition particularly Yolanda Salleh, Syed Nazreen, Relin Jim, Army Kapi, Kuza Keram, Kamal Zaini and the local guides from Kampung Sebako for their company and assistance in the field.

REFERENCES

Frodin DG. 2004. History and concepts of big plant genera. TAXON 53 (3): 753–776. https://doi.org/10.2307/4135449

Hughes, M., Moonlight, P.W., Jara-Muñoz, A., Tebbitt, M.C., Wilson, H.P. & Pullan, M. 2015–. Begonia Resource Centre. Online database available from http://padme.rbge-.org.uk/begonia/.

Hughes, M., Girmansyah, D., Randi, A. & Ningsih, H.N.R. 2020. Eleven new records, three new species and an updated checklist of Begonia from Kalimantan, Indonesia. Gardens' Bulletin Singapore 72(1): 33–58. DOI: 10.26492/gbs72(1).2020-05

Julia, S., Kiew, R. & Ling, C.Y. 2022. Additions to the *Begonia* flora of Sarawak, Borneo, I: Twelve new species and a new record. Edinburgh Journal of Botany 79, Article 410: 1–46. https://doi.org/10.24823/EJB.2022.410

Kiew, R. 2005. Begonias of Peninsular Malaysia. Natural History (Borneo) Publication. 308 pages.

APPENDIX 1: LIST OF BEGONIA SPECIMENS FROM GUNONG PUEH AND SURROUNDING AREAS

Begonia paoana Kiew & S.Julia

Specimens examined — Lundu: Sungai Batu, *Mamit S 35257*; Sampadi FR, *Othman S 37825; Seremban, Othman S 49855; Biawak, Yahud S 59912; Gunong Pueh, Ling et al. S 106640, Julia et al., S 107102, S107109, 107125, S 103126, S107127.*

Notes: The specimens previously collected from Gunong Pueh were misidentified as *B. asperula* or *B. congesta* in SAR herbarium. *Begonia asperula* is an invalid name (i.e., the name was never validly published for the species) that is often used by many herbarium users. On the other hand, *B. congesta* is a limestone-restricted species.

Begonia propinqua Ridley

Specimens examined — Lundu: Gunung Bekumpai, *Yazid S 106424, S 106425*

Begonia sp. 1

Specimens examined —Lundu: Gunung Berumput, *Burtt & Woods B 2868*, Bukit Panjo, A*wa & Illias S 47382*; Sungai Sebako, *Awa & Ilias S 46990*; Gunong Pueh, *Julia et al. S 107124, S 107101, S 107150.*

Note: These specimens were misidentified as *B. holttumii* in SAR herbarium; however, *B. holttumii* is an endemic species to Peninsular Malaysia.

Begonia sp. 2

Specimens examined — Lundu: Sungai Sebako, *Awa & Illias S 46985*; Gunong Pueh, *Ling et al. S 106642; Julia et al. S 107103, S 107146.*

Begonia sp. 3

Specimens examined — Lundu: Gunung Berumput, *Burtt & Wood B 2813*; Gunong Pueh, *Ling et al. S 106643, S 106634.*

Begonia sp. 4

Specimens examined — Lundu: Mount Poi, *J & M.S Clemens 20109l.*

Begonia sp. 5

Specimens examined — Lundu: Gunong Pueh FR, *Mamit S 34455; Sungai Batu, Mamit S 35258.*

Begonia sp. 6

Specimens examined — Lundu: Gunung Berumput, *Burtt & Wood B 2822.*

Begonia sp. 7

Specimens examined — Lundu: Gunung Berumput, *Julaihi et al S 73507.*

PAPER 8:
FERNS AND FERN - ALLIES OF GUNONG PUEH FOREST RESERVE, LUNDU SARAWAK

Khairunnisa O., Stafannie Nilla M.R., Mohamad Zainuddin, M. K., Mohamad Zamri B., Ahmad Faiz Z., Jerry Nunong E.

Research and Development Division (RDD)
Forest Department Sarawak, KM10, Jalan Datuk Amar Kalong Ningkan, 93250 Kuching, Sarawak
Corresponding email: khairuno@sarawak.gov.my

Abstract: Gunong Pueh Forest Reserve was gazetted on 22nd June 1927, encompassing 4,081 hectares and primarily characterised by hill forest. From 5th October 2020 until 17th October 2020, Heart of Borneo (HoB) in collaboration with the Research and Development Division (RDD) of Forest Department Sarawak organised a scientific expedition to Gunong Pueh Forest Reserve. One of the aims is to update flora documentation including ferns. Through surveying along the trails and random sampling, a total of 36 ferns and fern-allies were collected. There are 19 families identified with Polypodiaceae as the commonly found family in the study area. Some of the recorded species are *Anthrophyum* sp., *Davallia denticulata, Diplazium riparium, Microsorum alternifolium, Selaginella polystachya and Vittaria ensiformis.*

Keywords: Gunong Pueh Forest Reserve, Heart of Borneo (HoB), Research and Development Division (RDD), Fern and fern-allies

INTRODUCTION

Gunong Pueh Forest Reserve is located in Lundu, Sarawak. It was gazetted on 22nd June 1927, covering an area of 4,081 ha with at least four forest types, namely lowland dipterocarp forests, lower hill dipterocarp forests, upper hill dipterocarp forests, and low montane forests, which is home to various biological resources. With a small hydro dam built nearby, this forest reserve also serves as a water source for the community.

Ferns and fern-allies are part of the Pteridophyte group under the plant kingdom, which is seedless and reproduced through spores. There are about 12,000 species of ferns, making them the second-largest group of vascular plants (Nitta et al., 2022). Ferns and fern-allies differ from other vascular plants in that they reproduce via spores rather than seeds and have both gametophyte and sporophyte life cycles. The identification of ferns is predominantly based on the sorus. The formation of sori and sporangia occurs on the adaxial surface of the lamina of the fertile frond. Sori can appear close to or far from the margin of the pinna and come in any shape, including round, oval, oblong, and elongated. In fern-allies, sporangia can be found at the axis of sporophylls, either scattered or in strobili.

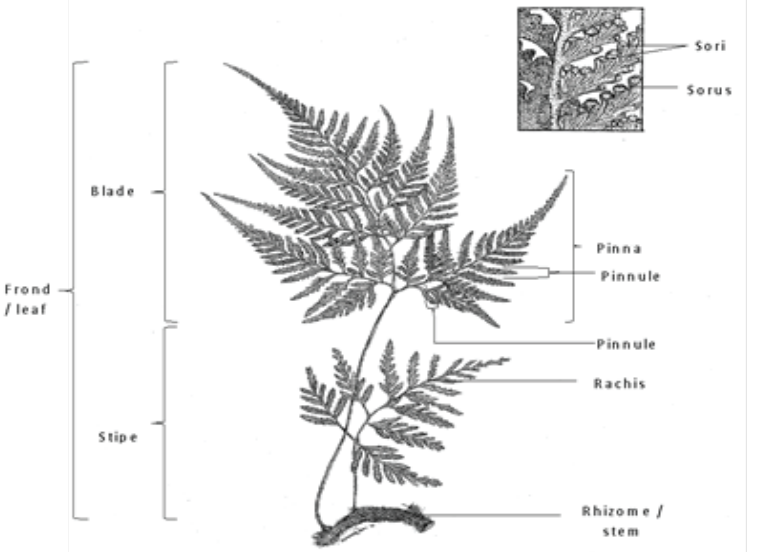

Figure 30: Structure of ferns where the leaves of true ferns, also known as fronds, are larger (megaphylls) compared to fern-allies, which are small scale-like (microphylls).

Usually, ferns and fern-allies can be found in vast vegetation types including secondary forests, plantation areas, or near the roadside. Some of the species are used as ornamental plants such as *Asplenium nidus*, the bird nest's fern. In Sarawak, there are species that are used in local delicacies, namely the Stenochlaena palustris or locally known as midin and *Diplazium esculentum*, and recorded as traditional medicine, *Blechnum orientale*, treatment for boils.

Previous studies on documentation of ferns and fern-allies in Sarawak are from Kubah National Park (Mohammad Azizi, 2016) and Bau District (Meekiong, 2004; Nur Safinas et al., 2016 & Racheal et al., 2016). No study has been reported so far from Gunong Pueh Forest Reserve, thus, the objective of this study is to document the ferns and fern-allies within this area. The data obtained from this study will be useful in producing a preliminary checklist for the forest reserve.

MATERIALS AND METHOD

Study site

The fieldwork was conducted in Gunong Pueh Forest Reserve, which is located in Lundu area with 4,081 ha located at 1°49'59.99"N latitude and 109°39'0.01" E longitude. A total of eight trails were surveyed during the expedition (Figure 31).

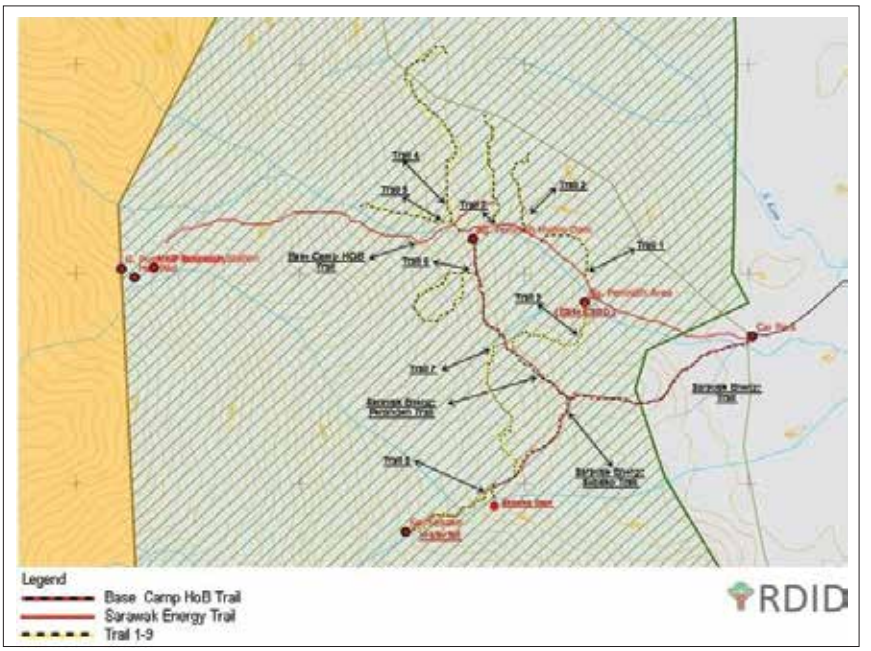

Figure 31: Surveys were conducted in Trail 1, Trail 2, Trail 4, Trail 6, Trail 5, Trail 9, Waterfall, and Pueh Forest Reserve (Pueh FR).

Specimen collection and voucher preparation

Fertile ferns were collected along the transects and off-trail. Data including the morphological characteristics, habitat, and GPS reading were recorded in Sarawak Herbarium field books. Specimens collected were tagged with Sarawak Herbarium numbers, pressed, and soaked in ethanol for preservation in the field before being oven-dried once back at the herbarium. All specimens were then mounted on A3 paper cardboards.

Specimens' identification

The specimens were identified through comparison with reference specimens in Sarawak Herbarium (SAR). Published articles and books were also used in the identification process including Piggott (1988), Holttum (1949), and Cobb (1963). Specimens were deposited at SAR and duplicates were sent to other herbaria such as Kepong and Sandakan.

RESULTS AND DISCUSSION

There are 19 families, 25 genera, and 33 species of fern and fern-allies were recorded with two unidentified specimens from a total of 36 specimens collected. Fern consists of 17 families, 23 genera, and 31 species while fern-allies recorded two families, two genus, and two species. The family Polypodiaceae has the most species, namely *Microsorum alternifolium* (Willd.) Copel, Polypodium verrucosum Wall, Crypsinus albidosquamatus (Blume) Paris, *Microsorum heterocarpum* (Blume) Ching and *Leptochilus decurrens* Blume. The family of Tectariaceae and Pteridaceae recorded four species each, Thelypteridaceae with three species, Lygodiaceae, Aspleniaceae, and Nephrolepidaceae with two species each.

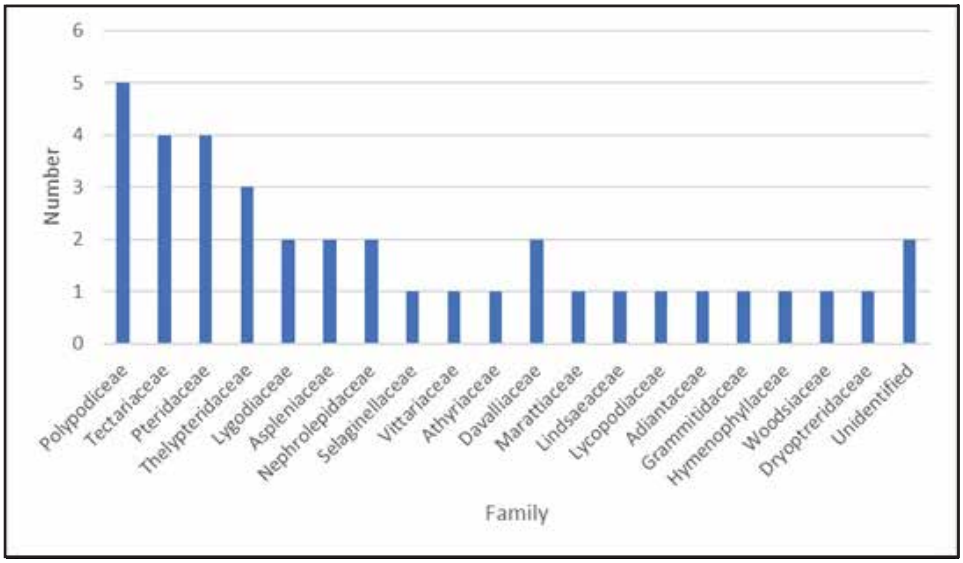

Figure 32: Families of fern and fern-allies recorded in Gunong Pueh Forest Reserve.

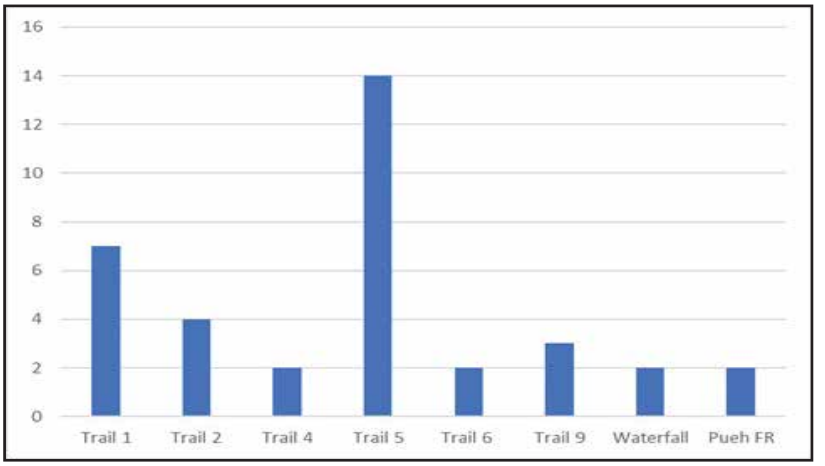

Figure 33: Number of specimens collected from each trail

Trail 5 recorded the highest number of specimens collected. This trail is a riverine forest with most of the specimens growing on the rock surface covered with mosses. This condition is suitable for ferns as it prefers moist and shaded areas. Nevertheless, species such as *Polypodium verrucosum* Wall., *Davallia denticulata* (Burm.) Mett., and *Pronephrium nitidum* Holtt have been shown to thrive in open areas. Certain fern species may adapt to exposed and dry environments (Cobb, 1963; Hietz, 2010).

The number of species recorded in this study is lower than the previous studies conducted in Kubah National Park (Mohammad Azizi, 2016) and Bau District (Meekiong, 2004) given that the survey conducted during this expedition covers only a limited area. Further explorations of the area may yield a higher number of species. From the species recorded in this study, *Davallia denticulata* (Figure 34), *Asplenium nidus* (Figure 35) and *Vittaria ensiformis* (Figure 36) are species with potential ornamental value with their unique frond shape and arrangement. T*aenitis blechnoides* (Figure 37) from the family *Pteridaceae* is known as a postnatal protective medicine in Malaysia (Schneider & Tawan, 2016).

Figure 34: *Davallia denticulata*

Figure 35: *Asplenium nidus*

Table 12: List of fern and fern-allies of Gunong Pueh Forest Reserve

Family	**Species**
Adiantaceae	*Monogramma dareicarpa*
Aspleniaceae	*Asplenium nidus*
	Asplenium batuense
Athyriaceae	*Athryium* sp.
Davalliaceae	*Davallia denticulata*
	Davallia repens
Dryopteridaceae	*Pleocnemia irregularis*
Grammitidaceae	*Xiphopteris alternidens*
Hymenophyllaceae	*Hymenophyllum* sp.
Lindsaeaceae	*Lindsaea ensifolia*
Lycopodiceae (fern-allies)	*Lycopodium sp.*
Lygodiaceae	*Lygodium longifolium*
	Lygodium sp.
Marattiaceae	*Christensenia* sp.
Nephrolepidaceae	*Nephrolepis* sp.
Polypodiaceae	*Microsorum alternifolium*
	Polypodium verrucosum
	Crypsinus albidosquamatus
	Selliguea heterocarpa
	Microsorum heterocarpum
Pteridaceae	*Taenitis blechnoides*
	Antrophyum callifolium
	Antrophyum reticulatum
	Antrophyum sp.
Selaginellaceae (fern-allies)	*Selaginella polystachya*
Tectariaceae	*Tectaria platanifolia*
	Tectaria barberi
	Tectaria sp1.
	Tectaria sp2.
Thelypteridaceae	*Pronephrium nitidum*
	Mesophlebion beccarianum
	Abacopteris salicifolia
Vittariaceae	*Vittaria ensiformis*
Woodsiaceae	*Diplazium riparium*

Figure 36: *Vittaria ensiformis*

Figure 37: *Taenitis blechnoides*

CONCLUSION

An updated checklist of 33 species of ferns and fern-allies has been presented in this study. Most specimens were collected from the family of Polypodiaceae with five specimens and four specimens each from the family Tectariaceae and Pteridaceae. The number of specimens shows that Gunong Pueh Forest Reserve is considered quite rich in pteridophytes. Further detailed survey is recommended within the area to provide a more comprehensive checklist of ferns and fern-allies.

REFERENCES

Chai, P.P.K. 2006. Medicinal Plants of Sarawak. Paul Chai P.K.

Chen, L., & Boo, C. M. (2017). 1001 *Garden plants in Singapore* (3rd ed.). National Parks.

Cobb, B. 1963. A field guide to the Ferns. United States, America: Houghton Mifflin Company Boston.

Hietz, P. 2010. Fern adaptations to xeric environments. *Fern Ecology*. 140-176. 10.1017/CBO9780511844898.006.

Holttum, R.E. (1949). The Classification of Ferns. Biological Reviews, 24: 267-296. https://doi.org/10.1111/j.1469-185X.1949.tb00577.x

Meekiong, K. 2004. Fern and fern-allies in Sarawak Bau Limestone Biodiversity, *The Sarawak Museum* Journal, 6: 187-192.

Mohammad Azizi, H.J. 2016. Enumeration of Ferns and Fern-allies of Kubah National Park, Sarawak Enumeration of Ferns and Fern-allies of Kubah National Park, Sarawak.

Nitta, J.H., Schuettpelz, E., Ramirez-Barahona, S., and Iwasaki, W. 2022. An Open and Continuously Updated Fern Tree of Life (FTOL). bioRxiv 2022.03.31.486640; doi: https://doi.org/10.1101/2022.03.31.486640

Nur Safinas, J., Mohizah, M., Noorhana, M.S., Yahud, W., Yazid, K., Mohammad Zainuddinn, M.K., Abdul Jalil, K., Wan Omarshah, W.P., & Nor Ezzawanis, A.T. 2017. Preliminary Study on Ferns and Lycophytes of Dered Krian National Park, Bau, Sarawak. *In Proceedings of Colloquium on Dered Krian National Park Scientific Expedition 2016*, pp. 56–60.

Piggot, A.G. 1988. Ferns of Malaysia in Colour. Kuala Lumpur, Malaysia: Tropical Press Sdn. Bhd.

Rachael, R., Tawan, C.S., & Meekiong, K. 2017. Study on Ferns and Fern Allies at Dered Krian National Park, Bau, Sarawak. In *Proceedings of Colloquium on Dered Krian National Park Scientific Expedition 2016*, pp. 61-76.

Schneider, H., & Tawan, C. S. 2016. *Taenitis blechnoides* (PROSEA). *Taenitis blechnoides* (PROSEA) - PlantUse English. Retrieved January 28, 2023, from https://uses.plantnet-project.org/en/Taenitis_blechnoides_(PROSEA)

Suis, M., Majuakim, L., & Suleiman, M. 2021. Fern species richness patterns and their environmental preferences across elevation gradient on Mount Trus Madi, Sabah, Malaysia. *Journal of Tropical Forest Science*, 33(1), 58-68. https://doi.org/10.26525/jtfs2021.33.1.58

PAPER 9:
GINGERS OF GUNONG PUEH

Meekiong Kalu[1], Stephen P. Teo[2], Mohd Akmal Raffi[1] & Yazid Kalbi[3]

[1]Faculty of Resource Science & Technology, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak

[2]Forest Department Sarawak, Bangunan Baitul Makmur II, Medan Raya, Petra Jaya, 93050 Kuching, Sarawak

[3]Forest Department Sarawak, Research and Development Division, Jalan Penrissen, 93250 Kuching, Sarawak

Abstract: Ginger species is a diverse group of rhizomatous, aromatic perennial herbs with the centre of diversity in Southeast Asia. The Zingiberaceae diversity in the Pueh Forest Reserve (FR), Sarawak, documented in this paper includes surveys conducted during the Pueh Scientific Expedition, and data from the previous inventories works. A total of 49 taxa from 18 genera (including non-native species) of gingers were recorded from the Pueh FR and its peripheral areas. *Etlingera, Zingiber* and *Hornstedtia* are the most diverse genera recorded with 8, 4 and 4 species respectively. The variety of gingers recorded from the Gunong Pueh FR is impressive. The number is expected to be larger because the exploration only covered a tiny portion of the Pueh Range.

Keywords: Zingiberaceae, diversity, Gunong Pueh Scientific Expedition, Gunong Pueh FR

INTRODUCTION

Gingers are rhizomatous, perennial herbs with aromatic plant parts that belong to the Zingiberaceae family. The Zingiberaceae family has 53 genera and about 1200 species worldwide, with Southeast Asia being the most diverse. Malaysia is home to about 40% of all global genera and nearly 30% of all known ginger taxa (Ibrahim et al. 2011). Sarawak has reported 21 genera and approximately 200 species (Meekiong & Teo, 2022; Meekiong et al. 2021); the precise number has not been determined as additional investigation is required.

Gingers have a wide range of behaviours, predominantly terrestrial, lithophytic, and rheophytic, with a few epiphytic (Lamb et al. 2013; Poulsen, 2006). *Alpinia epiphytica* Meekiong, Ipor, & Tawan, for example, is the sole species in the genus having an epiphytic habit (Meekiong et al. 2011). Gingers thrive in a wide range of habitats, from mangrove to mixed dipterocarp forests, kerangas, riverine, limestone, and up to montane forests at 2000 m altitude.

The ginger categorisation used in this article is based on the most recent taxonomic review conducted by de Boer et al. (2018) and Poulsen et al. (2018).

MATERIALS AND METHODS

Sites

Field surveys have been conducted in the Pueh FR and its adjacent areas since 2007, including a mini scientific expedition in 2014 (organised by RDID, FDS).

Materials and Methods

Only fertile samples of ginger (bearing flowers, fruits, or both) were collected as voucher specimens. The collection process followed standard methods as suggested by Bridson and Forman (1992). Voucher specimens were used for identification and verification, conducted at the Herbarium of the Forest Department of Sarawak (SAR).

RESULTS AND DISCUSSION

From the field work, a total of 49 taxa from 18 genera were recorded from the Pueh FR and its adjacent areas (including non-native species). All the species in the genus *Curcuma* and *Kaempferia* and three other species (*Alpinia galanga, Zingiber officinale, & Z. ottensi*) are non-native plants that were cultivated in the orchards for spices, medicinal, or sacramental purposes. *Etlingera, Zingiber*, and *Hornstedtia* were the most specious genera with 8, 4, and 4 species, respectively. Most of the Etlingera species recorded were dominated by open spaces of secondary forest and large forest gaps. For instance, E. coccinea and E. megalochielos were common and abundant along the trails to Sebako waterfall.

Gunong Pueh is the type locality and is thought to be the only place for *Borneocola argenteanus* (synonym: *Scaphochlamys argentea; S. depressa*), as it has never been collected or reported elsewhere. However, our recent study discovered that the distribution range of this species was extended further towards Gunung Buri in the Sabal FR area. Another *Borneocola* species recorded during the expedition was *Borneocola* sp. 3, which was previously collected and identified as S. conccina by Ridley during his expedition to Mount Poi. The specimen, however, differs from the *S. conccina* described in Peninsular Malaysia, and therefore it is conceivably a new taxon. While two Scaphochlamys, namely *S. limiana* and *S. samunsamensis*, are endemic to the Gunong Pueh FR, the populations of those two species are, however, subject to increasing threat from agricultural activities at the foothills of the mountain range.

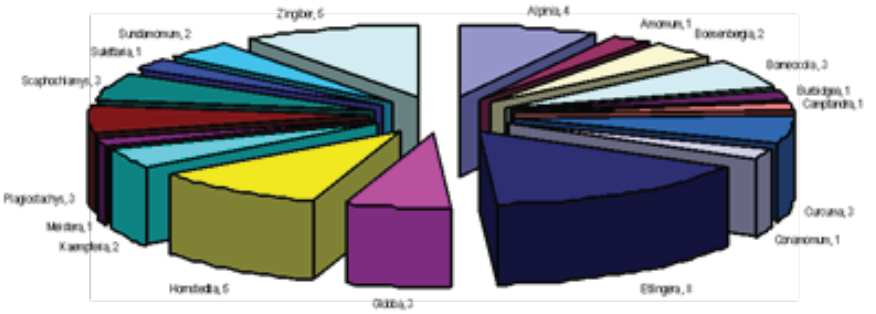

Figure 38. Zingiberaceae diversity (by genus) in Pueh FR

CONCLUSION

The diversity of gingers at Gunong Pueh FR is considered high, with 49 species from 18 genera recorded. Two *Scaphochlamys* species (namely, *S. limiana & S. samunsamensis*) are endemic to the area. The number of ginger species reported herein will surely increase as many areas are yet to be explored. Therefore, further study is strongly recommended to understand and uncover the diversity of gingers from the Gunong Pueh FR.

ACKNOWLEDGEMENTS

We would like to thank Forest Department Sarawak for organising the scientific expedition and the Research, Development, and Innovation Division (RDID) for the use of the herbarium and other facilities to determine and verify the specimens

REFERENCES

Bridson, D. & Forman, L. (1992). T*he Herbarium Handbook.* Royal Botanic Garden, Kew.

De Boer, H., Newman, M.F., Poulsen, A.D., Droop, J., Fer, T., Hien, L.T.T., Hlavata, K., Lamxay, V., Richardson, J.E., Steffen, K. & Leong-Skarnicova, J. (2018). Convergent morphology in Alpinieae (Zingiberaceae): Recircumscribing *Amomum* as monophyletic genus. *Taxon*, 67(1): 6 – 36.

Ibrahim, H., Norhati, M.R., Meekiong, K., Ipor, I.B., Tawan, C.S., Hidir. M., Lam, N.F., Lim, C.K. & Ampeng, A. (2011). Gingers of Lanjak Entimau Wildlife Sanctuary. IN: MOHAMED, H.M., I.B. IPOR, MEEKIONG, K., SAPUAN, A. & A. AMPENG (Eds.). *Lanjak Entimau Wildlife Sanctuary – Hidden Jewel of Sarawak*. Jointly published by Academy Sciences Malaysia & Forest Department Sarawak, Kuala Lumpur: 59 – 77.

Lamb, A., Goblik, J. Ardiyani, M. & Poulsen, A.D. (2013). *A Guide of Gingers of Borneo*. Natural History Publications (Borneo), Kota Kinabalu.

Meekiong, K. & Teo, S.P. (2022). *Zingiberaceae of Sarawak. Walinga*, Kuching, Sarawak.138 pp.

Meekiong, K., Teo, S.P., Liam, J., Yeo, F.K.S., Runi, S.P., Raffi, A., Salina, H., Salleh, H. & Shabdin, Z. (Eds.) (2021). *The Heart of Borneo Series 14; Monocotyledons Series 2: Gingers of Sarawak's Heart of Borneo*. Forest Department Sarawak, Kuching. 69 pp.

Poulsen, A.D., Mathisen, H.B., Newman, M.F., Ardiyani, M., Lofthus, O. & Bjora, C.S. (2018). *Sulettaria*: A new ginger genus disjunct from *Elettaria cardamomum. Taxon*, 67(4): 725–738.

Poulsen, A.D. (2006). *Gingers of Sarawak*. Natural History Publications (Borneo). Kota Kinabalu. 102 pp.

A list of Gingers from Pueh FR

Alpinia Roxb.

*A. aquatica (*Retz.) Roscoe

A. galanga (L.) Willd.*

A. glabra Ridl. var. glabra

A. ligulata K. Schum.

Amomum Roxb.

A. stenosiphon K. Schum.

Boesenbergia Kuntze

B. oligosperma (K. Schum.) R.M. Sm.

B. pulchella (Ridl.) Merr.

Borneocola Y.Y. Sam.

B. argenteanus (R.M. Sm.) Y.Y. Sam [syn: Scaphochlamys argentea R.M. Sm.; S. depressa Mas Izzaty, Tawan & Meekiong].

B. biru (Meekiong) Y.Y. Sm. [syn: S. *biru* Meekiong]

Borneocola sp.3 indet.

Burbidgea Hook. *f.*

B. nitida Hook. *f.*

Camptandra Ridl.

C. gracillima (K. Schum.) Valeton *[Camptandra parvula* var. angustifolia Ridl.]

**Curcuma* L.

C. amada Roxb.* [syn: *C. mangga* Val. & van Vijp]

C. longa L.*

C. zanthorrhiza Roxb.*

Conamomum Ridl.

C. xanthophlebium (Baker) Skornick & A.D. Poulsen *Etlingera* Giseke

Etlingera Giseke

E. brachychila (Ridl.) R.M. Sm. var. *brachychila*

*E. coccinea (*Bl.) S. Sakai & Nagam.

E. elatior (Jack) R.M. Sm.

E. foetens (Bl.) R.M. Sm.

E. megalocheilos (Griff.) A.D. Poulsen

E. nasuta (K. Schum.) R.M. Sm.

E. rubromarginata A.D. Poulsen & Mood

E. velutina (Ridl.) R.M. Sm.

Globba L.

G. atrosanguinea Teijsm. & Binn.

G. brachyanthera K. Schum.

G. pumila Ridl.

Hornstedtia Retz.

H. affinis Ridl.

H. havilandii (K. Schum.) K. Schum.

H. reticulata (K. Schum.) K. Schum.

H. scyphifera (J. Koenig) Steud.

H. tomentosa (Bl.) Bakh. f.

**Kaempferia* L.

K. galanga L.*

K. pulchra Ridl.*

Meistera Giseke

M. gyrolophos (R.M. Sm.) Skornick & M.F. Newman

Plagiostachys Ridl.

P. albiflora Ridl.

P. crocydocalyx (K. Schum.) B.L. Burtt & R.M. Sm.

P. roseiflora Julius & A. Takano

Scaphochlamys Baker

S. limiana Meekiong & Yazid

S. polyphylla (K. Schum.) B.L. Burtt & R.M. Sm.

S. samunsamensis Meekiong & Hidir

Sulettaria A.D. Poulsen & Mathisen

S. surculosa (K. Schum.) A.D. Poulsen & Mathisen

Sundamomum A.D. Poulsen & M.F. Newman

S. borealiborneense (I.M. Turner) A.D. Poulsen & M.F. Newman

S. dictyocoleum (K. Schum.) A.D. Poulsen & M.F. Newman

Zingiber

Z. griffithii Baker

Z. longipedunculatum Ridl.

Z. officinale Roscoe

Z. ottensi Valeton

Z. puberulum Ridl. var. *borneense* R.M. Sm.

**non-native, cultivated.*

PAPER 10:
COMMUNITY AWARENESS STUDY WITHIN GUNONG PUEH FOREST RESERVE

Silvester Jemat Anak Arbit[1] , Siti Rohaiya Binti Kipli[1], Azahari Bin Omar[1]

[1]Forest Department Sarawak (MALAYSIA)
silvesja@sarawak.gov.my, sitirk@sarawak.gov.my, azahario@sarawak.gov.my

Abstract: The main aim of this study was to identify the level of awareness for communities living in the immediate vicinity of the forest reserve. The target population was the communities from two villages, which are Kampung Sebako and Kampung Judin. 115 participants were selected from the target population through stratified random sampling. The results showed that 51.9% from Kampung Sebako's targeted population and 58.3% from Kampung Judin's targeted population acknowledged the existence of a forest reserve near their respective residence. Furthermore, 72.2% out of Kampung Sebako and 66.7% from Kampung Judin's targeted population shows an encouraging finding pertaining to the proposed eco-tourism development taking place at Gunong Pueh Forest Reserve henceforward. It is recommended that new and attractive eco-tourism products are initiated to alleviate local community's income and reduce community-forest dependency. Moreover, local communities coexist with government agencies to manage forest resources within the Heart of Borneo (HoB) area for socio economic and environmental sustainability.

Keywords: awareness, eco-tourism, social

INTRODUCTION

Community forest management has been identified as a win-win option to reduce deforestation while improving the welfare of rural communities. Despite considerable investment in community forestry globally, systematic evaluations of the impact of these policies at appropriate scales are lacking (Raharjo et al., 2017). The global community has recognised the importance of forest for biodiversity and prioritised the preservation of forest biodiversity and ecosystem functions through multiple multilateral agreements and processes such as the Convention on Biodiversity' Aichi Targets and the Sustainable Development Goals.

Gunong Pueh Forest Reserve (FR) was gazetted in 1927 with an area of approximately 32,000 acres, located in Lundu district, northwest of Kuching Division, Sarawak and situated on the borders with the Indonesian Province of West Kalimantan. Major ethnic tribe residing in the vicinity of the forest reserve is from sub-Dayak groups called Selakau/Selako. The patterns of life in principle are inseparable from the surrounding environment both forests, rivers, and other natural resources. This is related to the livelihoods of the ethnic tribe that generally cultivate fruit trees, hunt for meat, catch fish and collect non-timber forest products such as rattan, agarwood, medicinal ingredients, and others.

i. Destruction of forests

Deforestation is the removal or destruction of large areas of forest. It happens for many reasons such as logging, agriculture, natural disasters, urbanisation, and mining. Although deforestation occurs worldwide, it is a particularly critical issue in the Amazon rainforests of Brazil. The tropical forest and the species of plants and animals within them are disappearing at a rapid rate. The effects of deforestation are long lasting and devastating. Malaysia has seen a 60 percent decline in log exports due to dwindling harvestable forest resources.

ii. Solutions for deforestation

Forest conservation is the practice of planting and maintaining forested areas for the benefit and sustainability of future generations. The conservation of forest also stands and aims at a quick shift in the composition of tree species and age distributions. Forest conservation involves the upkeep of natural resources within a forest that are beneficial to both humans and the environment. Forests are vital for human life because they provide a diverse range of resources; they store carbon and act as a carbon sink, produce oxygen and help in regulating hydrological cycle and provide wildlife habitat, mitigate natural hazards such as flood & landslides (Pawar & Rothkar, 2015).

The current constraint is that there is a lack of understanding between various parties about the importance of forest reserves as conservation areas as a result of differences in interests, for example the private sector who want to exploit the resource and people who want to use part of the area to grow crops and for settlement purposes.

STUDY PURPOSES AND OBJECTIVES

The main objective of the study is to study the level of awareness of two forest dependent villages. This study aims to describe and analyse the process of managing conservation forest areas carried out by government agencies with local community as stakeholders. In addition, this study is to find out the level of awareness which plays an important role in joint management and to ease the implementation of conservation programs between agencies and communities.

STUDY SITES

Geographically, Gunong Pueh Reserve is located at 1°43'14.9"N 109°41'27.0"E whereas the location of this research was done in two villages, namely Kampung Sebako and Kampung Judin. Both villages are situated ranging from 120 meters to 3 kilometres distance from forest reserve boundary.

METHODOLOGY

The approach in this study is qualitative in nature with the intention of understanding the awareness level of two villages. Qualitative research used in this study aims to describe the level of awareness behaviour displayed by the community using questionnaire survey forms. A total of 115 participants were interviewed using stratified random sampling method, representing 10 percent from the total population. The relevant data were collected from demographic, social and economic aspects.

DATA ANALYSIS

All the collected data were converted into relative numbers such as percentage to observe the overall situation and divided all samples into components to examine the level of awareness.

DISCUSSION

Our survey reveals that, from 115 sampled households, males occupied 63.5% while the remaining 36.5% are females. Table 13 depicts that among 115 samples, the majority of their age (38.2%) range between 41-60 years old, followed by 27% of participants age from 61-80 and 24.3% age 21-40 years old and lastly one (0.9%) out of 115 samples age 81-100.

Table 13: Population distribution by age factor

Age (years)	Total Samples		Male		Female	
	Number	%	Number	%	Number	%
21 – 40	28	24.4	16	25.4	12	23.1
41 – 60	55	47.8	30	47.6	25	48.1
61 – 80	31	27.0	17	27.0	14	26.9
81 – 100	1	0.8	0	0	1	1.9
Total	**115**	**100**	**63**	**100**	**52**	**100**

Lifestyle of individuals is purely dependent on the level of education. Marlin et al., (2008) noted that low literacy levels have negative impacts on individual, health and well-being, community participation, training, labour force, employment and economic development including awareness level. Table 14 reflects that maximum literate persons are secondary school educated (62.5%), followed by primary school (20.9%) and graduate level (2.6%), whereas 16 participants or 13.9% from the total sample are illiterate.

Table 14: Level of education per total sample

	Level of Education							
	Primary school		Secondary school		Graduate		No education	
	Number	%	Number	%	Number	%	Number	%
Total	**24**	**20.9**	**72**	**62.6**	**3**	**2.6**	**16**	**13.9**

The occupation of an individual refers to his trade, profession, and type of daily work. The occupational structure of a society is the product of a number of intimately related factors (Chandna, 2010). Occupation is a major factor to determine the economic status of an individual, as different types of occupation reflect different incomes. In this study area, most participants are actively engaged in cultivation rather than working for income. In spite of it, many of them are also engaged in other occupations, such as government servant, business activity and working in the private sector. 87 (75.7%) of the participants were self-employed mainly working as farmers and collecting forest resources such as non-timber forest products as an income. Only 20 (17.4%) of them are employed and 8 (6.9%) people are unemployed.

Table 15: Source of income

	Income					
	Employed		Self-employed		Unemployed	
	Number	%	Number	%	Number	%
Total	**20**	**17.4**	**87**	**75.7**	**8**	**6.9**

Throughout the interview, a few questions were asked pertaining to the importance of forest to the environment as well as the benefit to the people living surrounding it. This knowledge includes direct benefit on the social impact, economy, and livelihood of the community. From 115 participants, 80.6% answered that forest is the main contributor to the water supply, 58.7% agreed that forest is the source of income, whereas 14.6% knew its benefit as climate regulation and lastly 5.6% answered that forest contributed to the cultural influence of Selako ethnicity.

Table 16: Percentage of participants who are aware of the importance of forest

	Types of importance			
	Climate regulatory	Source of income	Water supply	Cultural influence
Total (%)	14.6	58.7	80.6	5.6

Boundary demarcation is of utmost importance to distinct forest reserve areas from stateland. Signboard locations within the forest reserve were clearly marked and visible to the public, which include dos and don'ts when entering such areas. Table 17 reveals that 81.1% of participants recognised the existence of Gunong Pueh FR located near their settlement, whereas 61.2% did not know the differences of FR and NP within the same area. Lastly, 69.5% give their support to the future plan on developing Gunong Pueh FR as an attraction for ecotourism hotspot.

Table 17: Awareness on Forest Reserve

Answers	**Existence of Gunong Pueh FR (%)**	**Differences between Gunong Pueh FR and Gunong Pueh NP (%)**	**Acceptance to develop Gunong Pueh FR as an ecotourism hotspot (%)**
Yes	81.1	38.8	69.5
No	18.9	61.2	30.5

CONCLUSION

The above analysis plainly indicates that the overall level of awareness of the two villages located near Gunong Pueh FR is sufficient. 69.5% of the sampled participants had agreed to the proposed development plan when they realised the potential benefit to be gained from ecotourism activities to the micro economy per say. Furthermore, most of them are forest-dependent communities and the ecosystem plays an important role to their source of income as well as other potential resources such as water supply and food security. Although comparatively more participants recognised forest as their main water supply, awareness on deforestation and wildlife conservation is still crucial in sustainable management of forest reserves.

REFERENCES

S. Raharjo et al. (2017). "Community forest management in Indonesia: Avoided deforestation in the context of anthropogenic and climate complexities," *Glob. Environ. Chang*.

K. V. Pawar dan R. V. Rothkar. (2015). "Forest Conservation & Environmental Awareness," in P*rocedia Earth and Planetary Science*. vol. 11, 212–215.

Chandna, R.C. (2010). Geography of Population: Concepts, Determinants and Patterns, *Kalyani Publishers, New Delhi,* p. 313.

Marlin, A., Zwicker, G., Zappia, S., and Bruce, D. (2008). Impacts of Low Literacy Levels in Rural New Brunswick, Report submitted to The Rural Secretariat, Agriculture and Agri-Food, Canada, March.

PAPER 11:
UNLOCKING THE ECOTOURISM POTENTIAL OF GUNONG PUEH FOREST RESERVE

Abang Nuradzizi, A. B., Ahmad, A., Michael, M. & Madeline G. P.

Forest Department Sarawak, Sarawak
Corresponding email: nuradzb1@sarawak.gov.my

Abstract: Gunong Pueh, located at the sub-district of Sematan, Lundu, was constituted as a forest reserve on 22nd June 1927. As one of the oldest forest reserves in Sarawak, the ecotourism potential of the area is yet to be discovered. Therefore, this study was conducted to explore the ecotourism potential that lies in and surrounding Gunong Pueh. The data collection was based on interviews, observations, hiking, experiencing and desktop study. It was found out that Gunong Pueh has several attractions of nature, adventure, culture, food, and festivals including Sebako Waterfall, the traditional longhouses, rafflesia, corpse flower and more. This study will be used to develop Gunong Pueh for ecotourism activities as the attraction in the sub-district of Sematan.

Keywords: Gunong Pueh Forest Reserve, ecotourism potential, culture, adventure, nature.

INTRODUCTION

Background of Gunong Pueh Forest Reserve

Gunong Pueh Forest Reserve (GPFR) is in Sematan sub-district, of Lundu District, Kuching Division, Sarawak. This area was constituted as a forest reserve on 22nd June 1927 during the Brooke administration by H. B. Crocker, the Acting Chief Secretary, Sarawak, which covers an area of 32,000 acres or 12,949.94 hectares under three (3) extensions. The last extension was dated 10th October 1958, by A.R. Snelus, the Acting Chief Secretary under the British administration. To date, GPFR covers an area of 4,081 hectares, where a large part of the forest reserve has been constituted as Gunong Pueh National Park (GPNP). GPFR was once a logging area but has been closed permanently in stages since the 1980s. For the record, both GPFR and GPNP are located within the Heart of Borneo (HoB) Initiative area.

Locality

The locality of this research is within GPFR and its nearby area.

OBJECTIVES

Permanent Forest Estates (PFEs) are usually known as timber harvesting forests and planted forests. The ecotourism activities, on the other hand, are happening within the Totally Protected Areas (TPAs), which are the national parks and nature reserves. However, the State Government is looking into forest beyond timber in the PFE, therefore, ecotourism is one of the activities that may promise profitable income generation to both local communities and the government. In this study, the potential of ecotourism will be explored and discovered to plan the development of GPFR.

The objectives of this paper are to:

i. document the local stories as a part of the locals' culture;
ii. explore the nature; and
iii. exploring the adventures of Gunong Pueh.

METHODS

In this paper, the criteria are grouped into three main components: Culture, Nature and Adventure.

i. Culture
    - Local stories

ii. Nature
    - Geographical features such as rivers and waterfalls;
    - Flora;
    - Fauna and;
    - Weather conditions of GPFR during the expedition.

iii. Adventure
    - The trails.

The methods used were interviews, hiking, and observations apart from desktop study.

FINDINGS

Culture: The history and the folklores

The folklores or stories of GPFR were gathered from key persons of the local community such as the headmen and researchers. The documentation of these stories is important for tracing the history of GPFR and the activities of the local people.

Local stories are among the tools used by elders to strengthen their families' ties with their children by educating them on the importance of the environment. Nowadays, folklore can be used for tourists as components of the tourism's wellness and healing program.

The tracing of local stories and the documentation of this folklore will help younger generations to have a better understanding of the culture of the place and its people. Therefore, appreciation towards the hardships of older generations is always remembered and cherished by both locals and tourists. Additionally, proper recording of local stories is useful in tracing back roots to prevent them from becoming extinct over time (The Conscious Club, 2019)

How was Pueh named?

The Pueh area is populated by multi–racial people. One of the key ethnic groups residing surrounding GPFR is the Bidayuh people of the Salako sub–ethnic. This race is unique to the Lundu area, and Pueh itself was first settled by their ancestors.

The history itself originates more than 250 years ago. At that time, the Salako tribe lived in an area beyond the mountains, which is now called Kalimantan Barat, Indonesia. They lived a happy life there, however, due to the population growth, their area was not able to support more so they had to seek for a new settlement area with fertile soil, abundant food source and most importantly, the security of their people.

The headman then grouped a few young and brave men to scout for a new area. Sadly, they went back with no luck. One day, an elder suggested to the headman for the group to scout the area beyond the mountains. Those brave men took up the challenge and went there after making proper preparations.

The journey up to the mountains was tough. Some of the days were hot and some of it were rainy. Several days had passed but they were still unable to reach the top. Their food supplies were getting low.

One day, one of the scouts felt that they were getting closer to the top as the ambient temperature was getting cooler and the ground was flatter. They then decided to have a rest once they reached there.

They were stunned. The views beyond the mountains were mesmerising. The crystal clear rivers and high waterfalls, the green tropical forest and the white sandy beach charmed them as nothing like this can be seen in their village. One of them uttered the word 'poi' which means beautiful scenery in Salako.

After a few days of exploring the area, they went back home. They reported to their headman and when they referred to the place, they called the place Poi as nobody has ever named that place. That name is still used until now and is stylised into Pueh. The first longhouse of Pueh; Bantang Nek Bujur still exists until now, which was named after their first headmen or *Antuha Kampokng*, Bujur anak Sanger in 1875.

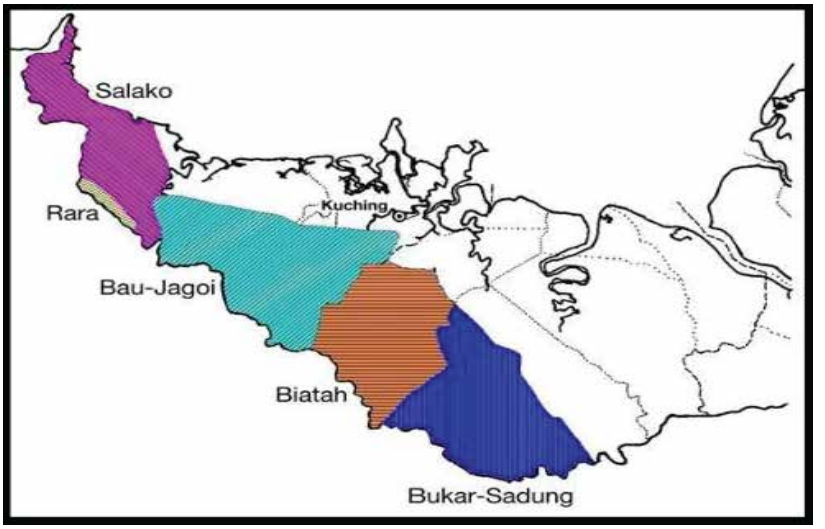

Figure 39: The distribution map of Bidayuh in Sarawak

The spirits of Gunong Pueh

Another story told by the locals was a spirit which lived within the labyrinth of Gunong Pueh. It is said that Gunong Pueh had never been explored before because the elders prohibited their children to go beyond the mountains as evil spirits await them.

Those pilgrims were not well versed in that new area. As they scout for food sources, some of them fail to return home. Words had it that they got lost and all of them have been the victims of the hungry evil spirits. The elders immediately barred their children from wandering into that area. However, the condition of their newly planted crops was still not ready to be harvested. Some of them were forced to try their luck by sneaking into that area, adding more people into the missing list.

A Salako warrior heard about the rumours for a while. He had enough that he did not want more people to go missing inside the labyrinth. People are needed to do work in the village. He prepared himself to fight the evil spirit.

As he wandered cautiously into the forest and then into the confusing labyrinth, he found some fresh skeletons of both humans and animals. His feelings were mixed, sad and angry, but he had to continue his quest. As the day was getting darker, he was greeted by a deep and fierce voice, scaring him to not to go further or his life would be in danger.

As he looked at the source of the voice, he found out that the voice came from a big black leopard. His fangs were long and big, which were enough to kill any animal and human in seconds. The warrior calmed himself down.

The leopard tried to scare him by telling him that no men or no animals can escape from his fangs and no weapons can ever hurt him. He also added that his magic and strength increased with all the hearts of men and animals that he had consumed before. He even mocked the warrior that there is no heart he had never tasted before.

It was a riddle. The warrior knew that this would be the clue to break the magic. A warrior like him shall not only know how to fight, but also need to be smart.

“I know, there is a heart you have never tasted before!”

“Little man, what is it?”

“The heart of a mite!” shout the warrior.

As the leopard heard the answer, his face quickly changed. The warrior knew his answer was correct that the leopard’s invincibility was fading away, and he quickly stabbed the leopard’s heart, which killed the leopard instantly. The warrior then went back home and was celebrated as a hero.

The wisdom of the Sebat People

The Sebat area within GPFR is divided into two main villages, Kampung Sebat Dayak, and Sebat Melayu. The area has no name and during the olden days, the people of the estuarine were warned by nearby villages that their village was in great danger. They were told that their village was the target of the sea pirates.

After hearing the news, the people of the estuary tried to counter the attack. However, the local people lacked weapons and most of them had no fighting skills.

On the day of the attack, they saw three bangkongs or long boats with red fabric owned by those sea pirates waiting to ambush their settlement. The villagers were urged to keep their voice down and nobody was allowed to make any sudden movement. They saw that the pirates were sailing the boats back and forth from the downstream to the upstream to search the village but failed to see one. They went back to the sea empty handed.

The villagers came out happily and their plan worked out. Before the attack, they were working together to close (*tebat* in Bahasa Sarawak) the estuarine of their village by using palm (apong) trees. With that wisdom, their village was safe and untouched, and they officially named their village as Kampung Sebat as a commemoration for the hardship and the wisdom they went together to null the attack.

Nature

Geographical features

This tropical climate forest of GPFR is located at Pueh – Berumput Mountain Range, which borders the Malaysia – Indonesia territory. The highest point of this forest reserve is estimated to be at 660 meters above the sea level.

Based on the local story, there are four main waterfalls that have been discovered so far. The first one is Penindih Waterfall, known as the highest waterfall in GPFR, consisting of twelve levels of waterfalls. Located about two hours of hiking from the nearest settlement of Kampung Sebako, the tourists will need to climb a few concrete staircases before continuing to walk into the forest, which heads straight to the waterfalls.

Another popular waterfall located at GPFR is Jangkar Waterfall. It is very near to Kampung Jangkar and it took only a few minutes of walking to reach the destination. The third waterfall that is accessible by vehicles is Sebat Waterfall, while Mancar Tika'ongk' Waterfall is located at Kampung Pasir Hulu. With the exception of Sebat Waterfall, all the waterfalls are known as fast flowing rivers with boulders. Therefore, the tourists might need to be careful to ensure their safety during water recreation activities.

These beautiful waterfalls have no proper or formal management, thus entrance of the tourists is not limited and controlled. Therefore, proper management needs to be set up to limit the carrying capacity towards conservation. In addition, entrance management will allow the control of fees and everyone in the village receives benefits from their area.

The crystal clear and refreshing water from the mountain range offers wellness and healing for those seeking relaxation and de–stressing from the hectic lifestyle in the city. According to Florida Health in 2018, nature therapy can make humans relax more, apart from improving their concentration, decreasing heart disease and high blood pressure risks, and increasing vitamin D.

Figure 40: Penindih Waterfall

Figure 41: Sebat Waterfall

Figure 42: Jangkar Waterfall

Figure 43: Mancar Tika'ongk

Flora

Pakma, the largest flower in the world, can be found blooming here and it is endemic to Sarawak. Named after Charles Brooke, the Second White Rajah in 1868, this *Rafflesia tuan–mudae* is a totally protected plant under the Sarawak Wild Life Protection Ordinance, 1998.

Apart from rafflesia, a giant flower can also be seen blooming in this forest reserve locally known as *bunga bado* or *bunga mayat*, which is also known in English as the corpse flower or giant voodoo lily. This *Amorphophallus* hewittii attracts insects such as flies to pollinate the pollen (Claudel, 2021) by releasing its foul smell. In addition, the vibrant colour and gigantic size are also noticeable by both tourists and researchers. According to the locals, tubers of the young bunga mayat can be served as local delicacies.

Figure 44: P*akma* or *Rafflesia tuan–mudae*

Figure 45: *Bunga bado* or *Amorphophallus hewittii*

Fauna

Among the wildlife spotted by camera traps here in GPFR are the Bornean Clouded Leopard (*Neofelis diardi borneesis), Great Argus Pheasant (Argusianus argus), Marbled Cat (P*ardofelis marmorata) and Bay Cat (catopuma badia). All of them are totally protected animals under Sarawak Wild Life Protection Ordinance, 1998.

Figure 46: Bornean Clouded Leopard *(Neofelis diardi borneesis)*

Figure 47: Great Argus Pheasant *(Argusianus argus)*

Figure 48: Marbled Cat
(Pardofelis marmorata)

Figure 49: Bay Cat
(Catopuma badia)

Rain, wind, and temperature

The adventures in GPFR depend on how tourists want to experience them, with nature playing an important role. The ecotourism team conducted this research from 8th to 10th October 2020 at Gunong Pueh's Heart of Borneo (HoB) Research Camp. Usual hiking trip would take about 3.5 hours from the base to the camp, which is located approximately at 660 m from mean sea level. During the research period, it was observed that it was rainy, so the trail became more slippery, and the journey was extended one and half hour more than usual.

According to the Drainage and Irrigation Department of Sarawak (DID), heavy rainfall of GPFR based on Sematan Station was recorded to be 46.5mm on 7th October and it was continued with moderate rainfall at 12.0mm on 8th October 2020.

When the researchers arrived at the HoB Camp, it was found out that the camp was partially damaged due to the strong wind. This phenomenon was believed to happen in the middle of the Southwest Monsoon (May to September) towards the transition monsoon (September to October). The Southwest Monsoon wind was estimated to be less than 15 knots (27.8km/h) while the transition period's wind is weak but blows from different directions.

Figure 50: Partially damaged structure of the Gunong Pueh's Heart of Borneo (HoB) Research Camp

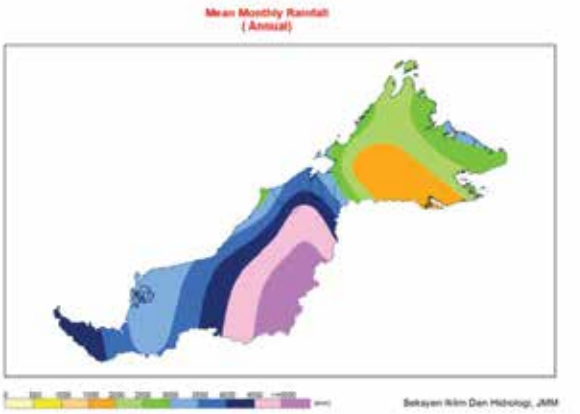

Figure 51: Mean Monthly Rainfall of East Malaysia

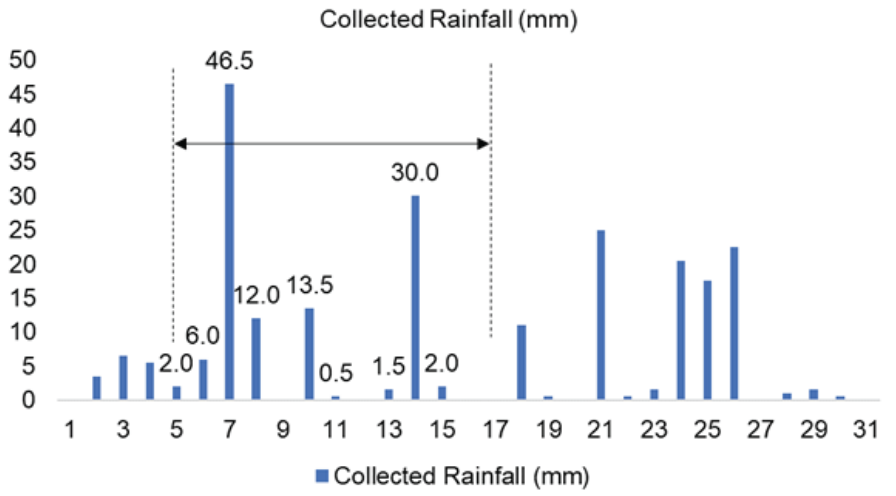

Figure 52: Rainfall in October 2020

Table 18: Rainfall recorded based on Sematan Rainfall Station of 2016 – 2020 in mm

Year/ Month	(mm)					
	2016	2017	2018	2019	2020	Average
Jan	623.5	659.5	531.5	1244.0	907.0	793.1
Feb	992.5	549.5	534.0	414.5	291.5	556.4
Mar	550.5	222.0	329.0	103.0	178.0	276.5
Apr	157.5	145.0	216.5	76.5	245.0	168.1
May	185.0	158.0	238.0	75.0	106.5	152.5
Jun	96.5	112.5	95.5	122.5	172.0	119.8
Jul	83.0	93.5	53.3	196.0	261.5	137.5
Aug	114.5	149.0	55.5	64.0	165.0	109.6
Sep	113.5	221.5	238.5	46.0	312.5	186.4
Oct	181.5	212.5	168.0	103.0	231.5	179.3
Nov	164.5	184.0	204.5	239.5	463.0	251.1
Dec	683.0	308.5	356.0	1555.0	451.5	670.8

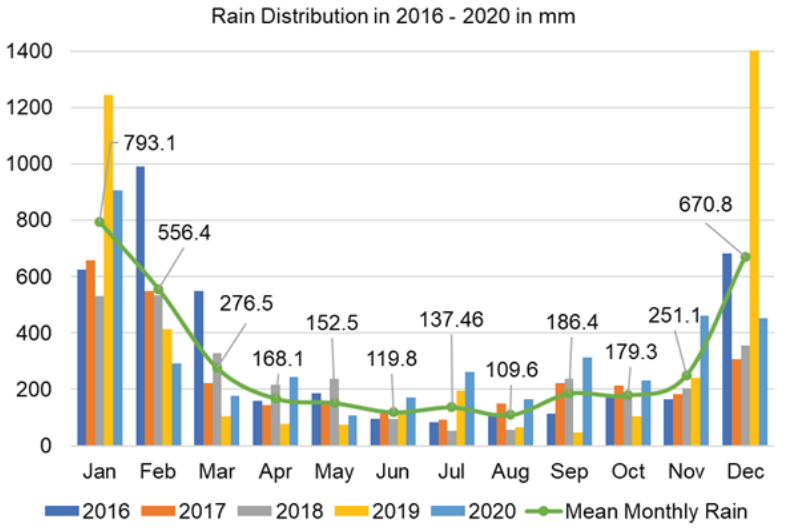

Figure 53: Rainfall Distribution based on Sematan Rainfall Station of 2016 – 2020 in mm

On 8th October, a water surge or *kepala air* was observed at Sungai Sebako. The heavy rainfall on the day before had contributed to that natural phenomenon. However, this phenomenon is unpredictable; therefore, the tourists are advised to be extra careful during the rainy season. In addition, the water supply to the camp was also observed to be turbid as a tree was found to have fallen, causing a large quantity of unearthed soil to enter the water supply stream.

By combining these two elements, the wind and the rain, the ambience of HoB Camp was found to be very cool. Temperature recorded around 2 a.m. on 9th October 2020 was as low as 7°C. This situation may allow the hikers to prepare themselves physically and mentally with additional hiking gear to conquer Gunong Pueh's summit. This temperature is suitable for those who seek a cool and refreshing mountainside for relaxing and de-stressing.

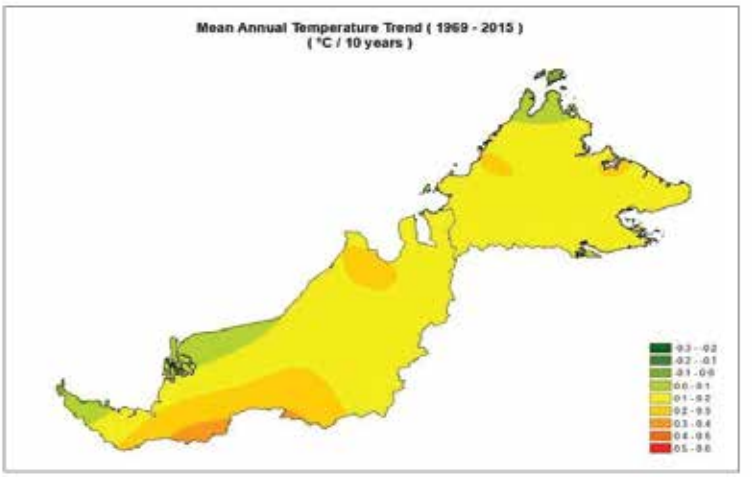

Figure 54: Mean Annual Temperature Trend (1969 – 2015) in °C/10 years

Adventure

Trails

GPFR has two main trails; the first trail was the HoB Camp trail and the second trail was the Sebako – Penindih Waterfall Trail. Meanwhile, the Pipeline Trail is a trail, which is used as the connecting trail to both trails.

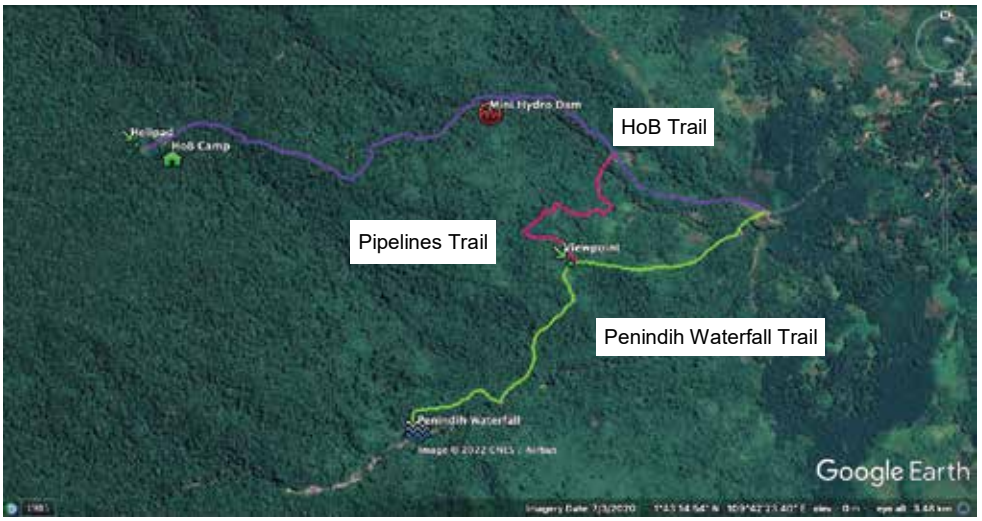

Figure 55: Trails of Gunong Pueh Forest Reserve

Figure 56: Gunong Pueh's Heart of Borneo Research Camp trail's elevation profile

Figure 56 as above shows the trail to Gunong Pueh's Heart of Borneo Research Camp with a distance of 3.14km. The elevation profile shows that the average slope falls between –19.8% to +16.3% with maximum slope at +25.0% and this slope is classified within terrain Class III (Jabatan Perancang Bandar dan Desa Pulau Pinang (JPBDPP), 2012).

Meanwhile, for hiking classification, according to Valenti in 2014, the slope is considered to be under Class II, which is defined as more difficult hiking, some of which may be off-trail, and may require putting hands down for balance at times. It is estimated that a fit hiker would get to reach the HoB Camp within 3.5 hours.

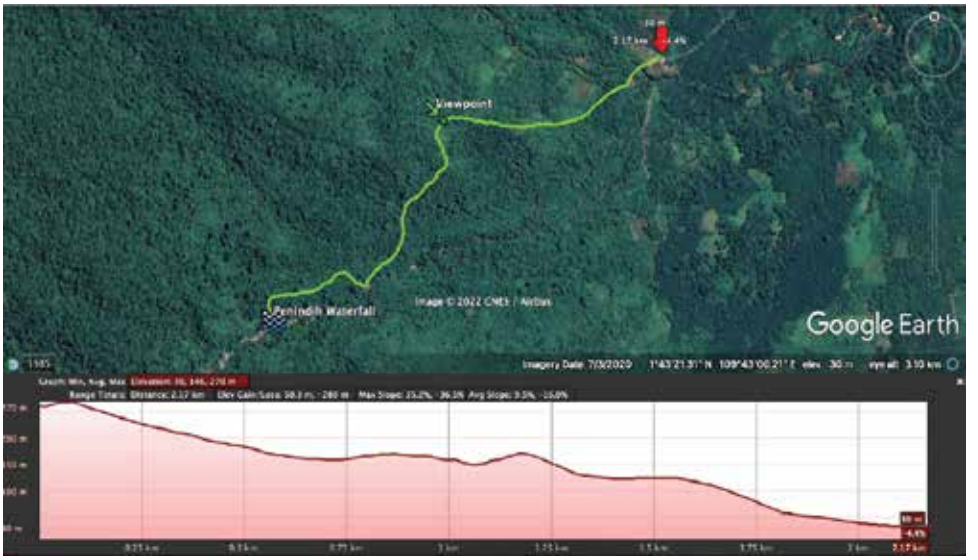

Figure 57: Trail to Penindih Waterfall

Figure 57 shows the trail to Sebako – Penindih Waterfall which was recorded at 2.17km long. A fit hiker shall arrive at the seventh level of the waterfall within two hours. The trail elevation profile indicates the slope ranges from –16.0 to +9.5% which falls within terrain Class I – II even though the maximum slope was recorded at +35.2%, which is higher than HoB Trail. However, the hiking classification is considered at Class 1 with easy hiking with minimal elevation gain and few obstacles (Valenti, 2014).

From the base until the Viewpoint, the tourists would have to climb several hundreds of concrete steps, which is quite challenging to the hikers' mental and physical strength. At the Viewpoint, the tourists will have the chance to capture the beauty of Gunung Gading towards the east and Sebako – Penindih Waterfall to the west, which the trail leads to the waterfalls.

Figure 58: Connecting Trail

Meanwhile, the connecting Pipeline Trail is the shortest trail, which is recorded at approximately 1.05km. This trail measured the steepest slope at +43.0% with the average of –13.1 to +18.9%. This slope will be giving the tourists an option to experience the challenge of GPFR instead of using concrete stairs. A fit hiker will take about one hour to use this trail, which is classified as terrain Class I – II with climbing Class II.

These trails shall be maintained regularly and shall be made as the main trails to ensure no new trails opened in the future. Opening new trails might have negative impacts towards conservation, especially on the wildlife. Apart from that, the safety of tourists can be strengthened and Search and Rescue (SAR) will be easier with a smaller area to be covered, reducing time, cost, and workforce.

ISSUES AND RECOMMENDATIONS

Limitation

Issues faced in this research is the number of staff. In this research, there are only two personnel placed under the Recreation and Permanent Forests Estates Management Area Section. This section is also newly established in March 2020.

Apart from that, the information of GPFR was based on a few of the departmental staff, which was scattered and must be compiled to be amended as a complete information. During the expedition, proper guidelines of ecotourism research were not finalised.

In addition, *Perintah Kawalan Pergerakan Pemulihan* (PKPP) or Recovery Movement Control Order was implemented in Sarawak during the expedition, therefore, reducing the movement and limiting physical interviews conducted among the local people to get information on GPFR.

Recommendation for research

Three categories were selected in this research, namely Culture, Nature, and Adventure. In the Culture category, local or traditional products shall be included as well as costumes, dance, and arts.

Two more categories shall be added in the future including the Food and Festival to cover all components.

Potential of Ecotourism

GPFR has a high potential for ecotourism for the world to explore. The culture itself portrayed by the local stories shall be made into proper documentation for culture preservation. The stories itself can be inspired into plays, dances, or into movies to be shared to the world. Apart from that, local stories can be used as a reference for those purposes.

In addition, under the Adventure category, even though the trails built are straightforward without any detour or junction, it is recommended that any hiking activity shall be guided by nature guides. The nature guides will be able to control the tourists, as well as to serve as first aid staff and porters.

Meanwhile, water recreation at those waterfalls shall be expanded such as flying foxes. For kayaking, further research shall be made to ensure the safety and suitability of the river for such activities. Water activities shall be limited on the rainy season to avoid any mishap especially during the unpredicted water surge.

Research tourism shall be planned to develop especially on the flora and fauna, which the researchers are able to collect information regarding the biodiversity of GPFR to be shared to the world. Academic tourism can also be enabled for the students to enjoy nature and at the same time, get some hands-on knowledge under the Nature category.

REFERENCES

Ching, Y. P. (1994). Rafflesia tuan-mudae Becc. Parasitic Plant Connection. https://parasiticplants.siu.edu/Rafflesiaceae/Raff.TuanMudae.page.html

Claudel, C. (2021). The many elusive pollinators in the genus Amorphophallus. *Arthropod-Plant Interactions* 15:833–844. https://link.springer.com/article/10.1007/s11829-021-09865-x

Department of Town and Country Planning Selangor (2012). Safety Guidelines for Hillside Development 2012. Towards A Safe & Green Environment. http://www.mbpp.gov.my/sites/default/files/penangsafety1409.pdf

Florida Department of Health (2018). 5 Health Benefits of Spending Time in Nature. *Florida Health*. https://www.floridahealth.gov/newsroom/2018/06/062818-article-5-health-benefits-of-spending-time-in-nature.html

Jabatan Pengairan dan Saliran Sarawak (2022). Data Hujan.

Malzer, C., (2019). The conscious club. *The Wisdom of Myth and Folklore: Why We Need Stories to Keep us Alive as a Society.* https://theconsciousclub.com/articles/2019/10/9/the-wisdom-of-myth-and-folklore-why-we-need-stories-to-keep-us-alive-as-a-society

Ministry of Environment and Water (n.d). Iklim Malaysia. Official Website of Malaysian Meteorological Department. https://www.met.gov.my/pendidikan/iklim/iklimmalaysia

Valenti, M. (2014). How to Choose the Right Hike. Active. https://www.active.com/outdoors/articles/how-to-choose-the-right-hike

PAPER 12:
PRELIMINARY STUDY ON CONSUMER-GRADE DRONE FOR MONITORING OF GUNONG PUEH FOREST RESERVE, LUNDU

Mohd Firdaus Bohari[1], Mohd Basri Mahidin[2], Muliadi Aden, Jamali Mohamad, Abdul Halim Odit, Reodrich Richard and Jayneeca Lawen

Forest Department Sarawak, Kuching, 93050, Sarawak, (Malaysia)
Corresponding email: firdausb@sarawak.gov.my[1], mohbasri@sarawak.gov.my[2]

Abstract: Application of dynamic remotely operated navigation equipment or drones for aerial mapping in forestry operations has been widely used because drones are a more economical and low-cost platform. A consumer-grade quadcopter multirotor drone with non-metric RGB digital camera, which was not designed explicitly for photogrammetric surveying was used to capture images. The capacity of consumer-grade drones (CGD) was studied by measuring effective distance for drone activity and the recommended flying time and effective distance were averaged for a single lithium polymer 3-cell battery. In this exercise, the flight line interval for drone operation at maximum permitted altitude calculated was recommended to maintain minimum side overlap between photos. Data was processed using standard procedure and software which was then imported as raster into open-source GIS software. The vegetation indices from CGD and Sentinel-2 were extracted and together compared with on-screen digitising for open area size differences.

Keywords: drone, aerial mapping, photogrammetric surveying, Sentinel-2

INTRODUCTION

Advancement of dynamic remotely operated navigation equipment or drone, or technically known as unmanned aerial vehicle or unmanned aerial system, is rapid. With interchangeable payloads, RGB, Multispectral, LiDAR, and thermal data can be used for planning, maintenance and especially decision-making of a project. Previously drones were built mainly for intelligence (military) purposes and have recently been built to suit the consumer market by being compact and affordable (Newcome, 2004). Thus, the drones were categorised as consumer-grade drones (CGD), professional/enterprise, agriculture and military. The objectives were (i) to study the capabilities of CGD for forest monitoring supplementing satellite imagery and (ii) to study manual flight mission planning efficiency of CGD and (iii) observe the difference in area calculated using CGD and Sentinel-2.

EQUIPMENT AND METHOD

Equipment Category and Selection

Readily available equipment in the department was further categorised under Drone, Ground Control Station and Field Data Processor. Drone selected was a consumer grade drone (CGD) weighing less than one (1) kilogram with fixed (non-changeable) non-metric RGB digital camera. The interface for capturing images and video transmission from drone fly cam was installed on a 7.9" tablet with 3GB RAM selected as GCS. A Laptop with 24GB RAM and 4GB GPU was selected as the field data processor (FDP).

Area of Interest (AoI) Criteria

Gunong Pueh lies along the Malaysian-Indonesian border in Sarawak's southwestern exterior and is a range with several distinct peaks. Gunong Pueh was known as Mount Poi or Gunung Poe in the 19th century and was the interest of many explorers for discoveries and scientific exploration (Moultan, 1913). AoI selection criteria was open area of less than 100 hectares within Gunong Pueh Forest Reserve (GPFR).

Aerial Survey Mission Planning

Mission planning was according to the manual flight method. Flight altitude (AGL), ground sampling distance (GSD), drone speed (horizontal, m/s), orientation of flight lines, camera configuration (timer setting) was calculated.

Data Processing

Data processing process was done using FDP on-site importing images (.jpg) from drone, photo alignment, building dense cloud, mesh, texture, digital elevation model (DEM), and orthomosaic. Output was exported to (.tiff) format. Sentinel-2 imagery ingested in September and October 2020 was used to georeference orthomosaic processed from CGD data.

Data Analysis

The output was reprojected from WGS84 to Timbalai 1948 Borneo Rectified Skew Orthomorphic (BRSO) Meter. The image was then subset according to the AoI shapefile before imported to Geographic Information System (GIS) software as a raster for data analysis. Vegetation indices values were extracted, and open area was digitised on-screen and the polygon was calculated using the calculate geometry tool.

RESULTS AND DISCUSSION

Capabilities, Performance and Reliability of Selected Equipments

CGD Capability

1,612 hectares was surveyed out of 4,081 hectares total area of GPFR (Figure 59). Total drone operation time was 42 hours. The Lithium Polymer (LiPO) 3s battery with capacity of 3500 milliAmp hour (mAh) recorded an average of 25 minutes flight time, covering up to 50 hectares per flight. It was necessary to monitor CGD temperature considering the site temperature is at average 30 to 32oC on a sunny day. Effective CGD operation was 2KM vertical distance. The modern photogrammetric processing combined with state of the art computer vision algorithms (Hartley & Mundy, 1993) makes it possible to obtain mapping products even with cameras with high distortion such as fish eye lens cameras.

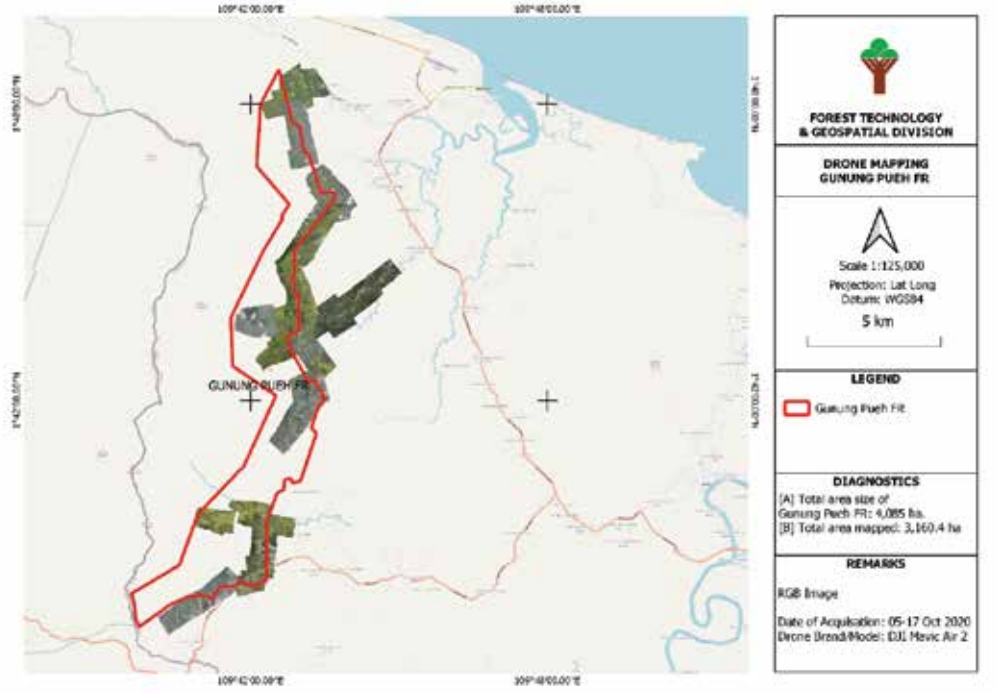

Figure 59: 1,614 hectares of GPFR surveyed using CGD

GCS Performance

The 7.9" A12 Bionic Chip with 64-bit architecture is light (300.5 grams) and suitable as a ground control station for aerial surveying. The brightness of the tablet was set to full (500 nits). The fully-charged battery with capacity of 5,124mAh lasted up to 4 hours in one mission. Features and capabilities available on GCS of a CGD were mirrored by several defence contractor handheld ground control systems (Lockheed, 2013) in terms of navigation and mode of operation.

FDP Reliability

A total of 4,348 photos were processed in 15 batches on-site using the selected FDP with an average of 290 photos per batch. Processing time recorded from aligning photos to exporting orthomosaic was between 45-60 minutes per batch. Battery life of the FDP played an important role in processing at site. A car power inverter was used to charge CGD batteries and to power up the FDP. The specification of the selected FDP met the requirements to process data (Agisoft, 2023).

Manual Flight Mission Planning Efficiency

CGD was sufficient to monitor an area less than 100 hectares. Operating at a limited 120 meters height above ground level (CAAM, 2016), one nadir angled photo would cover up to 2.5 hectares of an area (Table 19). The map produced with CGD orthomosaic had higher spatial resolution compared to Sentinel-2 at 1:5,000 scale (Figure 60). High spatial resolution means objects for digitising seen in the image were shown in more detail and the result of creating classified raster was a more accurate representation of the landscape. Despite the clarity, Sentinel-2 was still a superior remote-sensing tool in terms of coverage, especially to monitor areas more than 100 hectares.

With the advancement of drone technology, drones can execute aerial surveys autonomously or automatically. It was observed that drones that can do so, although categorised as a cross-over to enterprise or professional category, were expensive with price difference up to RM 4,000 compared to CGD. Having basic drone handling and remote sensing knowledge helped optimise the usage of CGD for forest monitoring purposes. Designing and executing a good image acquisition plan is the most important part of any aerial photogrammetric project as the ultimate success of the project depends more upon good quality photographs than on any other aspect (Wolf & Dewitt, 2000).

Table 19: Result of different drone models tested at 120 meters height (AGL)

Model	Sensor Size (mm)	Photo size (px)	Focal length (mm)	GSD (cm/px) at 120 m	Area per photo (hectare)	Distance between flight line (m)	Horizontal speed (m/s)	Camera Timer (s)
CGD 1	6.3x4.7	4000x2250	4.0	4.7	**1.9**	56.4	7.1	3
CGD 2	6.4x4.8	4000x2250	4.0	4.8	**2.1**	57.6	7.2	3
*CGD 3	13.2x8.8	5472x3648	10.3	2.8	**1.6**	45.9	10.2	3
*CGD 4	6.17x3.4	4000x3000	5.0	3.7	**1.6**	44.4	7.4	3
*CGD 5	6.17x4.5	4000x3000	4.0	4.6	**2.5**	55.2	9.2	3

* supports autonomous mission planning

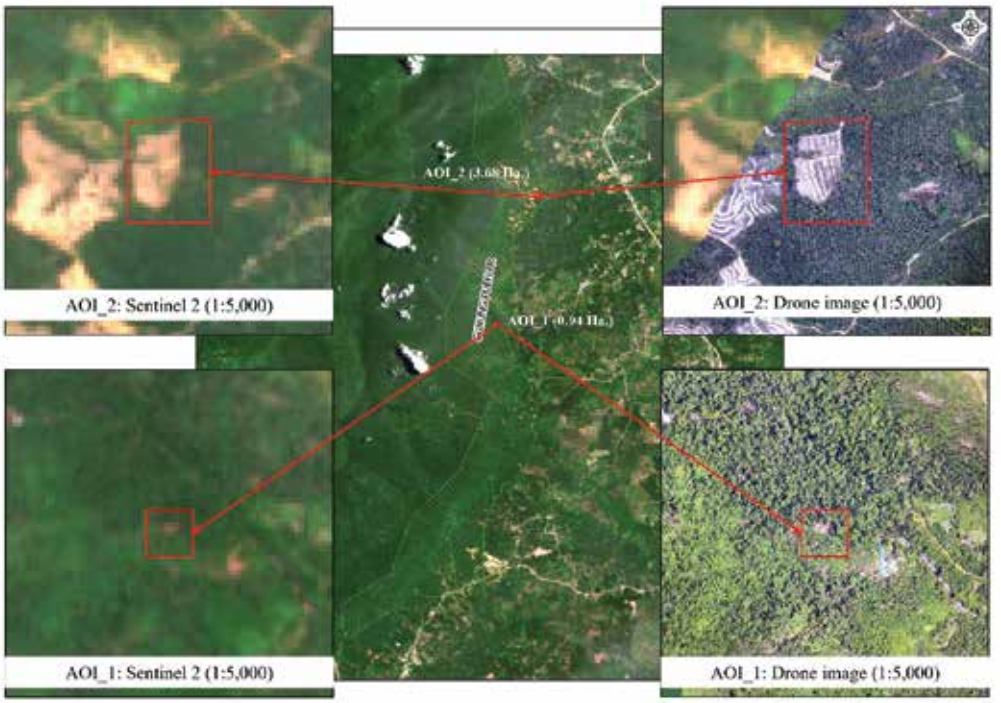

Figure 60: Higher resolution of maps with CGD orthomosaic at 1:5,000 scale.

Compared Area Calculation

Area calculated (hectares) from on-screen digitising was higher than Normalized Difference Vegetation Index (NDVI) computed in both areas of interest and sources as shown in Table 20 and Figure 62. The pixel of NDVI from Sentinel-2 was coarser than CGD (Figure 61). Open Area calculated from CGD was lower than Sentinel-2. The CGD's higher spatial resolution and low flight altitudes above ground level, positioning it at a proximity to the surface, were crucial attributes for its observed higher sensitivity better than Sentinel-2 (Lazaro et al., 2022).

Table 20: Area difference calculated by geometry calculator in GIS software.

AOI	Source	Method	Calculated Area (Ha.)	Area difference (Ha.)
1	Sentinel-2	NDVI (raster to polygon)	0.08	0.05
		On-Screen Digitizing	0.13	
	CGD	NDVI (raster to polygon)	0.05	0.03
		On-Screen Digitizing	0.08	
2	Sentinel-2	NDVI (raster to polygon)	0.88	0.41
		On-Screen Digitizing	1.29	
	CGD	NDVI (raster to polygon)	0.83	0.33
		On-Screen Digitizing	1.16	

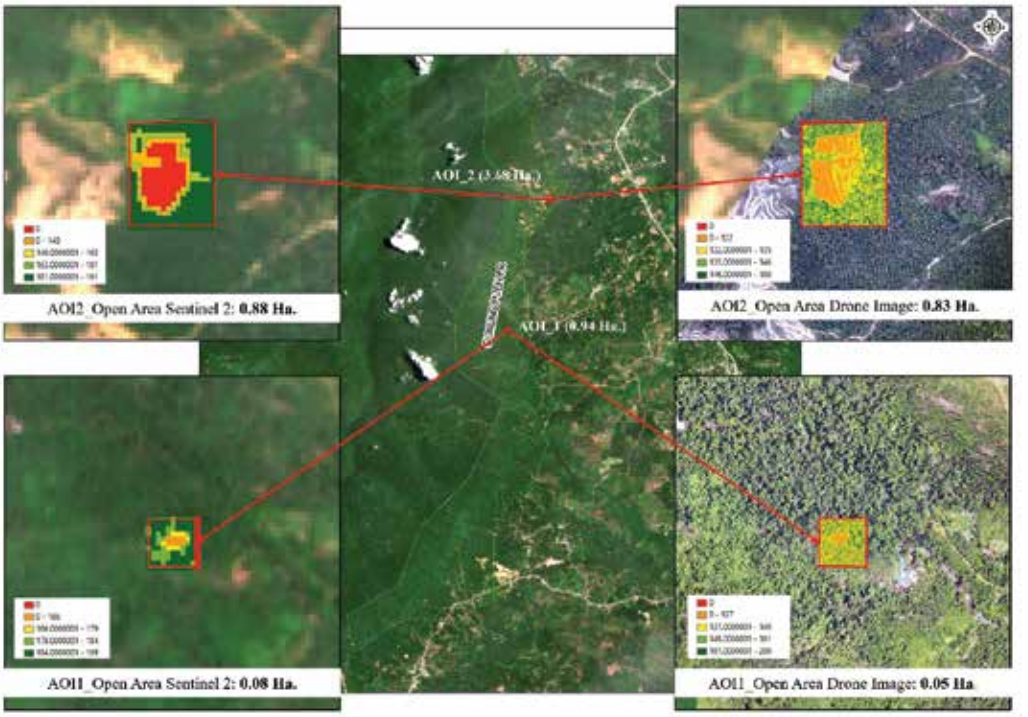

Figure 61: Open area calculated from NDVI analysed by GIS software.

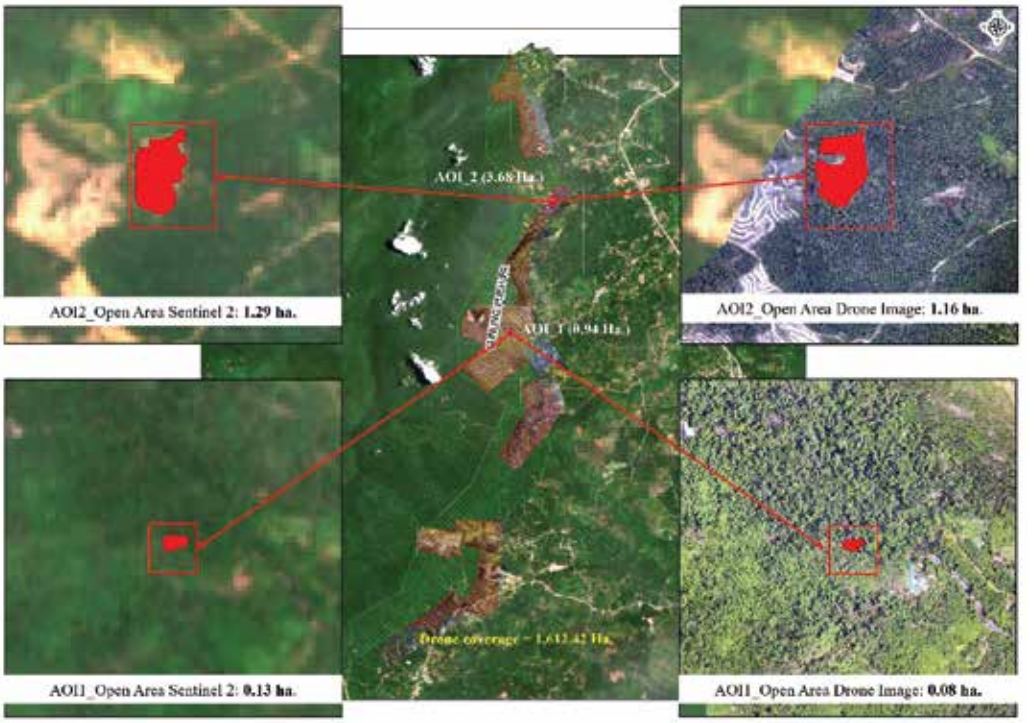

Figure 62: Open area calculated from on-screen digitising method.

CONCLUSION AND RECOMMENDATION

Aerial survey for forest monitoring using drone compliments satellite imagery by providing higher resolution and real-time data dissemination. Due to the limited operating time of a CGD, it is best to be used for areas less than 100 hectares due to the operation height limit of 120M (AGL). Equipment selected (including CGD, GCS and FDP) was satisfactorily sufficient in terms of capability, performance, and reliability. Raster from CGD without NIR or multispectral sensor can be used to extract vegetation index to calculate open area size. On-ground testing of technology needs to be done before deployment, especially forestry related applications. The combination of remote sensing and GIS has assisted forest monitoring in terms of cost and real-time data acquisition. The addition of CGD for forest monitoring will further improve the process in terms of accuracy and clarity of on-ground conditions and situations. A study on the accuracy of CGD by conducting a perimeter survey on ground is recommended. Utilisation of suitable drones for volume calculation and estimation is highly recommended. It is also recommended that a centralised drone operation be established to ensure drone operation conducted in accordance with regulations, sufficient operators and suitable drones are procured for the purpose of forest monitoring.

ACKNOWLEDGEMENT

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REFERENCES

Newcome, L. R. 2004. Unmanned Aviation: A Brief History of Unmanned Aerial Vehicles; American Institute of Aeronautics and Astronautics, Inc.: Reston, VA, USA.

Civil Aviation Authority of Malaysia. 2016. Malaysian Civil Aviation Regulations

Moultan, J. C. 1913. Some notes on a short collecting trip of Mt. Poi, Sarawak, undertaken recently by the Raffles Museum, Singapore, and the Sarawak Museum. Journal of the Straits Branch of the Royal Asiatic Society. No. 65 December, 913), Malaysian Branch of the Royal Asiatic Society. pp. 1-12 (12 pages)

Wolf, P. R. & Dewitt, B. A. 2000. Elements of Photogrammetry: with Applications in GIS (Vol.3). McGraw-Hill New York

Agisoft. 2023. Agisoft Metashape User Manual Professional Edition Version 2.1. Agisoft LLC (Pub), Calgary, CA.

Lockheed, M. 2013. mGCS Capabilities Guide: Mini and Small UAV Ground Control Operator Software. http://www.lockheedmartin.com/content/dam/lockheed/data/ms2/-documents/cdl-systems/mGCSCapabilitiesGuide-2013.pdf. Accessed on 18th March 2023

Lazaro, J.M., Patrick A.N., Richard D.A., Hamza K.K., John K.B., Emmanuel R.N., Linus K.M. 2022. Comparative Assessment of UAV and Sentinel-2 NDVI and GNDVI for Preliminary Diagnosis of Habitat Conditions in Burunge Wildlife Management Area, Tanzania. https://www.mdpi.com/2673-4834/3/3/44. Accessed on 20th March 2023.

PAPER 13:
PRELIMINARY REPORTS ON HERPETOFAUNAL INVENTORY OF GUNONG PUEH FOREST RESERVE

Mohamad Yazid Hossman[1] & Paulus Meleng[1]

[1] Research and Development Division, Forest Department Sarawak, Kuching, 93250, Sarawak, (Malaysia)
Corresponding email: mohamayh@sarawak.gov.my

Abstract: Gunong Pueh Forest Reserve (Gunong Pueh FR) is a protected hill mixed dipterocarp forest, located approximately 100 km West of Kuching, with an area of 4,081 ha and is an extended area under the Heart of Borneo Initiative (HoB) since 2018. Two scientific expeditions were conducted in April 2015 and October 2020 with the aim to provide an inventory update of flora and fauna within the area including a list of herpetofauna. A total of 27 species of amphibians and 20 species of reptiles were collected during this survey using general hand caught technique and pitfall trap. Based on the data collected, more than half of this collection has not been previously reported since the pioneer survey conducted and published in 2007. As this survey only covers approximately 40% of the total herpetofauna in the area, these findings provide an additional and updated inventory of herpetofauna in Gunong Pueh FR. Therefore, an extensive survey should be conducted in future to expand the findings and to provide guidance on conservation efforts of herpetofauna within the area.

INTRODUCTION

Amphibians and reptiles are groups of tetrapod vertebrates, which are collectively known as herpetofauna. Amphibians include frogs, toads, caecilian and salamanders, which are ectothermic in nature, with shell-less egg, permeable skin, and with complex life cycle. Reptiles on the other hand refer to a group of snakes, lizards, alligators and turtles, which are often described as having scaly skin and eggs with complete shells and are also oviparous ectothermic animals (Catenazzi et al., 2016).

Gunong Pueh Forest Reserve (FR) is in the southwestern part of the state of Sarawak, which is covered by a protected hill mixed dipterocarp forest, located approximately 100 km West of Kuching. With an area of 4,081 ha, Gunong Pueh range lies along the Malaysia – Indonesia border, with two primary peaks, Gunung Kanyi and Gunung Berumput with peak elevation above 1000m above sea level. Gunong Pueh FR is an extended area under the Heart of Borneo Initiative (HoB) since 2018.

The lowland area of the mountain is mainly of a secondary forest, where a steep, small to medium sized stream runs from the upper part of the mountain. These streams provide water supply to the locals for domestic use and serve as recreational spots for local visitors and foreign tourists. Higher area to the peak of the mountain is mainly vegetated by dipterocarp trees with wider streams and stronger current. Rocky outcrops are commonly found at lower elevation of the forest area while sandstone and boulders are more dominant at the upper region forest of Gunong Pueh FR.

Borneo, is one of the largest islands of the Indo-Malayan Archipelago and is the second largest tropical island in the world, covering a total land area of approximately 743,380 sq km (Das, 2004). The island has been marked as one of the most biodiverse regions on the planet, yet it is susceptible from years of severe deforestation activities that has affected the rainforest on the island, particularly in the low-lying land areas (Bryan et al., 2013; Gaveau et al., 2014). Reports of biodiversity surveys within the area including herpetofauna are still under-explored and therefore this study is aimed to provide an updated and additional inventory of herpetofauna species in Gunong Pueh FR and to explore potential unique indigenous species that can be found specifically within the target area.

STUDY SITE AND METHODOLOGY

Two separate expeditions were conducted in April 2015 and October 2020 at Gunong Pueh FR. Field surveys were mostly conducted along the forest trails and streams, which started from the bottom of the mountain up to the highest point with an approximated elevation of 620m above sea level, at the tip of the border between Forest Reserve (FR) area and Totally Protected Area (TPA).

Sample collection was conducted by general hand caught method and pitfall traps during daytime in which the search area covers underneath leaf litter, in between rocks and dead logs. At nighttime, survey was conducted along trails, streams, ponds using hand torch and also by locating and identifying specific calls that these anurans made during night time. Images were recorded during the encounter and specific data such as collection time, site of capture and environmental data including current temperature, humidity and weather were also recorded. Specimens were later measured, fixed and preserved in 10% formalin, which were then finally preserved in 70% alcohol as part of laboratory voucher specimens at the Research and Development Division of Forest Department Sarawak.

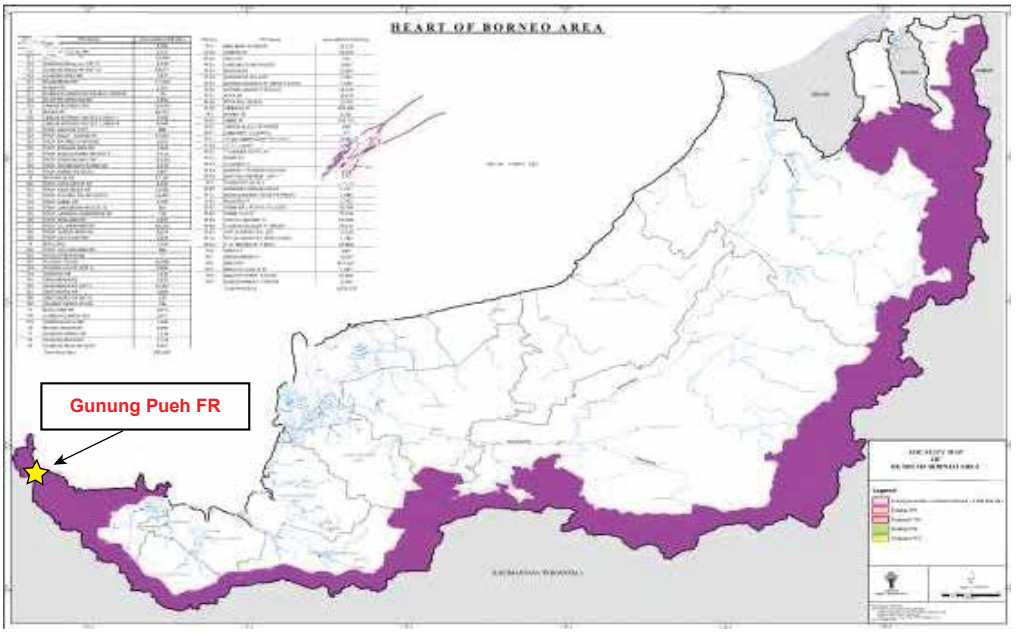

Figure 63: Gunong Pueh FR study site which is located within the Heart of Borneo (HoB) region, an area that covers an approximately 2.7 million hectare of forest land in Sarawak (reproduced from: Forest Department Sarawak, 2020)

RESULTS AND DISCUSSION

A total of 47 species of amphibians and reptiles were collected from Gunong Pueh FR. Amphibians contribute to a total of 27 species which belong to six families while 20 species of reptiles belonging to nine families were listed and described in Table 20.

The most encountered group of amphibians at the study site are from the family Bufonidae and Ranidae in which both families are represented by seven species respectively. Bufonid toads from the genus *Ansonia, Pelophryne* and *Ingerophrynus* are common lowland toad species that inhabit forest floor, on leaves of herbaceous plant and nearby water source in mature secondary forest to primary forest. The recorded species of Ranidae family include *Odoranna hosii, Meristogenys jerboa, Pulchrana picturata, P. Signata, Staurois guttatus*,

Chalcorana megalonesa and *C. raniceps* (Figure C). Frogs from the family Dicroglossidae have the second most diverse species inhabiting the study site, which are of the genus *Fejervarya* and *Limnonectes*. All species from these family groups are common forest floor inhabitants, thriving along river streams that serve as feeding and breeding grounds, and are found from lowland mountain areas of secondary forest to an elevation above 600 m above sea level.

The study also recorded two distinctively large toad species from the genus *Phrynoidis* which include *P. asper* and *P. juxtasper* that were mainly found along river streams with strong currents as this area provides shelter and as breeding site. Four species of leaf litter frogs of the Family Megophryidae from the genus *Leptobrachium, Leptolalax* and *Megophrys*, including the famous Bornean Horned Frog, *M. nasuta*, were recorded while both family Microhylidae and Rhacophoridae were the least diverse species. Microhylidae, the 'narrow – mouthed frog' was represented by the genus *Kalophrynus* or commonly known as 'sticky frog' where *K. heterochirus* and *K. meizon* (Figure A & B) were recorded, while for the tree frog family, Rhacophoridae, was represented by the 'bush frog' Philautus refugii and the common four-lined tree frog Polypedates leucomystax. P. refugii were only recorded from an elevation of 600 m above sea level, sitting on leaves one to two meters above ground while P. leucomystax can be found both on the ground and up to a few meters above ground, on tree branches.

The most dominant reptiles recorded from this study are the gekkonids lizard which has the highest number of species with seven species deriving from five genus, followed by agamids lizards with four species from three genus and one species of forest skink. All geckos, agamids and skink species reported are common inhabitants of human residential areas and found abundant in the secondary and primary forest in tropics. Two species of tortoise are also recorded in this survey which are from the species of *Cuora amboinensis* and *Trionychidae subplana* where both are recorded motionless near a small stream at low elevation at night.

A total of three species of highly venomous elapid snakes, two species of colubrids snake and both one species from the family Phythonidae and Viperidae were recorded in this study. Three species of snake from family Elapidae recorded in this study includes the 'banded krait' *Bungarus fasciatus*, the 'blue coral snake', *Calliophis bivirgata* and the infamous 'King *Cobra', Ophiophagus* hannah. Another venomous group of snakes is Viperidae, the 'keeled pit-viper' *Tropidolaemus subannulatus*, an arboreal species which inhabit primary and secondary forest from lowland to medium elevation area. All four snake species from these two families are highly venomous, which may result in fatality when improperly treated.

Family Colubridae snakes are mostly non-venomous, and two species recorded in this survey were *Lycodon tristigatus* (Figure H) and the 'reed snake' *Calamaria leucogaster* (Figure G). L. tristigatus was collected on a branch less than one meter above ground and *C. leucogaster* was captured while it tried to escape under leaf litter during heavy rain. *Melayophython reticulatus*, the common reticulated pythons from family Phythonidae were observed a few times swimming in the slow-moving stream near base camp as we believed the area is its feeding territory.

Table 21: List of Amphibians and Reptiles recorded from Gunong Pueh Forest Reserve

Amphibians				
No.	**Family**	**Genus**	**Species**	**Remarks**
1	Bufonidae	*Ansonia*	*leptopus*	
2			*longdigita*	
3			*spinulifer*	
4		*Ingerophrynus*	*divergens*	
5		*Pelophryne*	*signata*	
6		*Phrynoidis*	*asper*	
7			*juxtasper*	
8	Dicroglossidae	*Fejervarya*	*limnocharis*	
9		*Limnonectes*	*kuhlii*	
10			*kong*	
11			*leporinus*	
12			*palavanensis*	
13	Microhylidae	*Kalophrynus*	*heterochirus*	
14			*meizon*	
15	Megophryidae	*Leptobrachium*	*abotti*	
16		*Leptolalax*	*gracilis*	
17			*cf. marmoratus*	
18		*Megophrys*	*nasuta*	
19	Ranidae	*Chalcorana*	*megalonesa*	
20			*raniceps*	
21		*Odoranna*	*hosii*	
22		*Meristogenys*	*jerboa*	
23		*Pulchrana*	*picturata*	
24			*signata*	
25		*Staurois*	*guttatus*	
26	Rhacophoridae	*Philautus*	*refugii*	
		Polypedates	*leucomystax*	

Reptiles				
	Family	**Genus**	**Species**	**Remarks**
1	Agamidae	*Bronchocela*	*cristatella*	
2		*Draco*	*sumatranus*	
3		*Gonocephalus*	*grandis*	
4			*liogaster*	
5	Gekkonidae	*Aeluroscalabotes*	*felinus*	
6		*Cyrtodactylus*	*consobrinus*	
7			*pubisulcus*	
8		*Gehyra*	*mutilata*	
9		*Hemidactylus*	*frenatus*	
10			*platyurus*	
11	Scincidae	*Tropidophorus*	*brookei*	
12	Colubridae	*Calamaria*	*leucogaster*	
13		*Lycodon*	*tristigatus*	
14	Elapidae	*Bungarus*	*fasciatus*	
15		*Calliophis*	*bivirgatus*	
16		*Ophiophagus*	*hannah*	Observation
17	Phythonidae	*Melayophython*	*reticulatus*	Observation
18	Viperidae	*Tropidolaemus*	*subannulatus*	
19	Geoemydidae	*Cuora*	*amboinensis*	Observation
20	Trionychidae	*Dogania*	*subplana*	Observation

Figure A : Male *Kalophrynus heterochirus* calling from under leaf litter, **Figure B** : 'Sticky frog', *Kalophrynus meizon,* **Figure C** : *Chalcorana raniceps*, **Figure D** : *Ansonia spinulifer,* **Figure E** : 'Cat gecko' *Aeluroscalabotes felinus,* **Figure *F*** *: Gonocephalus liogaster,* **Figure G** : *Calamaria leucogaster,* and **Figure H** : *Lycodon tristigatus.*

CONCLUSION

The inventory results of herpetofauna obtained and recorded from the field survey at Gunong Pueh FR during the HoB expeditions may provide preparatory or groundwork on the diversity of the herpetofauna inhabiting the target location area. There are a substantial number of species that are yet to be discovered and recorded, and therefore further surveys and field work studies should be conducted continuously to extend and update the inventory list of herpetofauna species in the area. Herpetofauna and other wildlife species are well known to be negatively impacted by deforestation and other anthropogenic activities, conservation efforts hence play a key role in maintaining and preserving the forest ecosystem, wildlife and its biodiversity to its best possible condition for the coming generations.

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REFERENCES

Bryan, J.E., Shearman, P.L., Asner, G.P., Knapp, D.E., Aoro, G. & Lokes, B. (2013). Extreme differences in forest degradation in Borneo: comparing practices in Sarawak, Sabah, and Brunei. *PLoS ONE*, 8, e69679.

Catenazzi, A., Richards, S. & Glos, J. (2016). *In Core Standardized Methods for Rapid Biological Field Assessment.* Larsen, T.H. (ed). Conservation International, Arlington, Virginia, USA, pp. 109-126.

Das, I. (2004). *Lizards of Borneo*. Natural History Publications (Borneo), Kota Kinabalu. pp. 1-4.

Gaveau, D.L.A., Sloan, S., Molidena, E., Yaen, H., Sheil, D., Abram, N.K., Ancrenaz, M., Nasi, R., Quinones, M., Wielaard, N. & Meijaard, E. (2014). Four decades of forest persistence, clearance and logging on Borneo. *PLoS ONE*, 9, 1–11.

PAPER 14:
A SURVEY OF THE TERMITES (INSECTA : ISOPTERA) AT GUNONG PUEH FOREST RESERVE, LUNDU, SARAWAK

Paulus Meleng, Mohd. Nafri Ali, and Whilander Lawrence

Research and Development Division, Forest Department Sarawak (Malaysia)
Corresponding email: paulusm@sarawak.gov.my

Abstract: The aim of this study was to survey the termites at Gunong Pueh Forest Reserve, Lundu, Sarawak. The forest reserve is known for its magical crystal-clear water of rivers, waterfalls and mountains. So far, there has been no study of Termites reported from this area. During this study, termites were collected by random sampling along five transect lines for 4 days (7th, 8th, 9th and 10th October 2020). Termite mounds, nests, leaf litter, dead or rotten woods and soil were sampled and observed. Termite samples were preserved inside a plastic tube with 80% alcohol. A total of 175 tubes of termites were sampled during the study. Termite samples were identified according to their morphological characters using a microscope. Out of 175 tubes, 150 tubes (85.71 %) were identified to species while 4.57 % or 8 tubes were only able to be identified to genus level. 17 (9.71 %) samples were unable to be identified due their incomplete body parts or the absence of soldier caste. About 30 known species belonging to 22 genera from three families of termites were recorded during the survey. Among the three families, Termitidae was best represented from the study area. The results were, however, lower as compared to the study by Collin (1984) who listed 77 species from Gunung Mulu National Park and 60 species listed by Paulus et.al (2006) from Lambir Hills National Park. Results also show most of the species nested in wood on the soil. Epigeal mound species were much less compared to the wood on the soil nesting.

Keywords: *Termites, Isoptera, Pueh Forest Reserve.*

INTRODUCTION

Pueh Forest Reserve was gazetted as a Forest Reserve in 1927. It consists mainly of hill mixed dipterocarp forest. Much of the forest is secondary, having been used for shifting cultivation and the surrounding areas are cultivated into rubber and oil palm plantation. The forest reserve is about 120 kilometres from Kuching City and a 30-minute drive from Lundu or Sematan Town. The forest reserve is believed to harbour rich biodiversity yet to be fully explored and recorded. The earliest record from Mount Pueh was from a famous biologist, Eric Mjöberg (1882–1938), a Swedish naturalist, who was the Curator of the Sarawak Museum between 1922–1924. Mjöberg's herpetological collections from Gunong Pueh between October to December 1923, and other localities in Borneo, were reported by Smith (1925). Mjöberg, unfortunately, left little by way of written records, of his ascent of Pueh and the collections he made. During a scientific expedition to the summit of Mount Berumput on 6–14 May 2002, 26 species of birds, four species of bats and one species of rat were observed. In 2012, Drury A. Dow reported 67 species of dragonflies from his study at Gunong Pueh. However, there has been no record of termites study reported from the area.

Termites are the dominant arthropod decomposers in tropical lowland forests (Wood & Sands, 1978; Matsumoto & Abe, 1979; Collin, 1983) and play a central role in nutrient fluxes (Lawton et al., 1996; Bignell et al., 1997; Tayasu et al., 1997; Eggleton et al., 1999). In many tropical forests termites are present at very high densities and are the dominant arthropod detritivores. For example, in the lowland rain forests of Malaysia, termite populations can exceed 38 million individuals per hectare (Abe & Matsumoto 1979) and can represent 60% of individuals among the soil macro-invertebrate assemblage and 42% of its biomass (Collins 1979). The ecological impact of termites is derived from this vast abundance. Termites contribute significantly to the world's ecosystems by recycling the materials, resulting in the maintenance of nutrient composition and balance. There are about 2,650 species of termites that have so far been documented worldwide (Kambhampati & Eggleton, 2000). Different species have their own uniqueness in diet preference, habitat, micro niche and species-specific intestinal microbes, hence disparately affect the ecosystem carbon flow and productivity (Bong et.al., 2012). Most of the termites depend on degraded wood material as their main source of food. Others feed on living trees, soil, leaf litter, lichens and faeces. In Malaysia alone, there are about 200 species of termites. Norsyarizan Jamil et.al, (2015), reported 19 species of termite, including 13 genera and 8 subfamilies from Samunsam Wildlife Sanctuary. Apart from this there has been no other published report on termites in Lundu region.

OBJECTIVES OF THE STUDY

Keeping in view the important role of termites as ecosystem engineers, and the damages they cause to living trees and dead logs, twigs and branches, the present study was conducted to survey the termites assemblage, especially their distribution and population as compared to previous records from other study sites in Sarawak such as Gunung Mulu National Park, Dered Krian National Park and Lambir Hills National Park.

MATERIALS AND METHODS

The study was carried out from 7th – 13th October 2020 at Pueh Forest Reserve, Lundu, Sarawak. The survey was conducted to detect the presence of termite species and activity in soil and trees in the forest reserve. Collection of worker and soldier termites were made on fallen logs, leaf litters, mud tubes, peel-off tree bark, standing dead trees, soil, nest, termite gallery, foraging termite and termite mound. Living trees were also inspected for termite activity. Random samplings were done along five (6) different transects inside the Forest Reserve: Transect 1, 2, 3, 4, 5, and 8. Termites samples collected were kept in 80% ethanol and brought back to the laboratory for identification. They were identified using a microscope, mainly through soldier termite keys by Tho (1992) and Thapa (1981).

The soldier identification features included (1) shape and characteristics of the head and mandibles, (2) antenna, (3) post-mentum, (4) pro-, meso- and meta-notum, (5) Size and colouration of termites, and (6) other individual characteristics.

RESULTS AND DISCUSSION

A total of 163 tubes of termites were sampled during the six-day sampling at the forest reserve. 117 tubes or 72% were able to be identified up to species. Another 45 tubes (27.8%) were identified only to genus level while another 1 tube (7%) were unable to be identified. These species represent three (3) families of termites: Termitidae, Rhinotermitidae and Kalotermitidae. They were further classified into 20 genera and 26 known species. As shown in Table 21, Family Termitidae with 22 known species is the most dominant family of termite at Pueh Forest Reserve. Our results also showed that most of the termites were found to be nesting in wood on the soil. Out of 26 known species, only 7 species (21%) were soil feeders while 24 species (79%) were wood feeders. Drywood termite, Kalotermitidae is the least represented with only two genera recorded.

During the survey, we manage to cover and sample 8 transects with a total of 6 sampling days. The species accumulation curve as shown in Figure 64 indicated that the sampling effort is far from enough. Every sampling day will result in new discovery for termites in the park. This also shows that more sampling efforts should be conducted to discover more species.

Table 22: List of species according to family and subfamily

Family	Subfamily	Genus	Species	Food type w-wood / s-soil
Termitidae	Termitinae	*Procapritermes*	*sarawakensis kalshoveni*	s
		Prohamitermes	*rectangularis*	s
		Dicuspiditermes	*nemerosus brevialatus*	s
		Pericapritermes	*santschii*	s
		Microcapritermes	*rectagularis*	w
		Microtermes	sp.	w
		Microcerotermes	*medioobscurus*	s
		Amitermes	*comis*	s
		Homallotermes	*santschii sabahensis*	s
	Apicotermitinae	*Euhamitermes*	*santschii*	-
	Macrotermitinae	*Macrotermes*	sp.	w
		Odontotermes	*rectangularis dentatus*	w
	Nasutitermitinae	*Nasutitermes*	*latignathus longipes*	w
		Termes	*longipes*	w
		Subulitermes	*setiger*	w
		Hospitalitermes	*sarawakensis*	w
		Longipeditermes	*rectagularis*	w
		Schedorhinotermes	*sarawakensis longipes*	w
Rhinotermitidae	Coptotermitinae	*Coptotermes*	*medioobscurus*	w
	Rhinotermitinae	*Schedorhinotermes*	*longipes*	
Kalotermitidae		*Glyptotermes*	*Santschii longinasus*	w

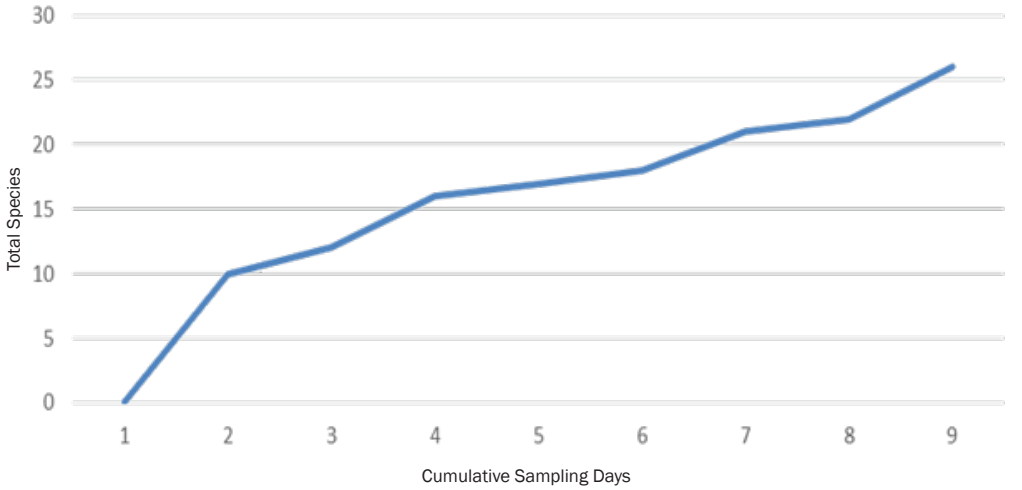

Figure 64: Species accumulation curve

Table 23: The number of termites according to family and subfamily in selected national parks in Sarawak

FAMILY SUBFAMILY	East Malaysia	Mulu NP	Lambir Hills NP	Dered Krian NP	Bukit Kana NP	Gunong Pueh FR
KALOTERMITIDAE	7	3	3	-	1	2
RHINOTERMITIDAE						
Heterotermitinae	1	1	1	1	1	0
Coptotermitinae	4	3	2	1	4	1
Termitogetoninae	1	0	1	0	0	0
Rhinotermitinae	10	9	10	2	5	1
	(16)	**(13)**	**(14)**	**(4)**	**(11)**	**(4)**
TERMITIDAE						
Apercotermitinae	0	0	0	0	0	1
Termitinae	27	23	20	6	10	16
Macrotermitinae	6	6	6	1	3	1
Nasutitermitinae	42	27	17	5	8	4
	(75)	**(56)**	**(43)**	**(12)**	**(21)**	**(22)**
Total genera	**38**	**30**	**25**	**14**	**21**	**20**
Total species	**97**	**72**	**60**	**16**	**31**	**26**

The overall species richness of termites in Pueh Forest Reserve (26 species) was relatively lower compared to the total number of species reported from several other studies conducted in Gunung Mulu National Park (72 species). Lambir Hills National Park (60 species) but higher than Dered Krian National Park (16 species). Lower number of species reported from Dered Krian National Park was due to the park itself mainly consisting of limestone forest.

CONCLUSION AND RECOMMENDATIONS

It is very clear that the number of species recorded by us from Pueh Forest Reserve was underrepresented as compared to the expected total termite fauna of the area. Our data is lower to that reported from Mulu National Park and Bukit Lambir National Park with similar habitat but with more sampling efforts. There could be several other reasons for this poor species composition from our survey. Our sampling approach and effort may have been underrepresented for certain species. The habitats that we chose to sample in our study may not have been representative of all soil types, vegetation formations or forest types.

Most of the termites collected feed on litter and woody decomposed materials (fallen trunks, branches, leaves) lying on the ground surface. These species are important in the decomposition of plant material in natural landscapes.

Conclusively from this preliminary study, Pueh Forest Reserve harbours a minimum of 26 species of termites. This study is the first termite assemblage survey at Pueh Forest Reserve and the results can be used as the baseline data for future surveys. More extensive collections and inventories are suggested to get a better representation of the entire termite composition within the area.

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REFERENCES

Abe, T. & Matsumoto, T. 1979. Studies on the distribution and ecological role of termites in a lowland rain forest of West Malaysia. 3. Distribution and abundance of termites in Pasoh Forest Reserve. *Japanese Journal of Ecology* 29:337–351.

Bignell, Il, D.. E., P. Eggleton, L. Nunes & K. L. Thomas, 1997, Termites as mediator of carbon fluxes in tropical forest: budgets for carbon dioxide and methane emissions. In:Watt, A.D., N. E. Stork & M.D. Hunter (eds), Forests and Insects, Chapman and Hall, London pp. 109 – 134

Collins NM (1979) Observations on the foraging activity of *Hospitalitermes umbrinus* (Haviland) (Isoptera: Termitidae) in the Gunong Mulu National Park, Sarawak. Ecological Entomology, 4: 231–238.

Dow, R.A. (2012b) Odonata collected at Gunong Pueh, Kuching Division, Sarawak, Malaysia in October 2012. *International Dragonfly Fund Report*, 54, 1–21.

Eggleton, P., R. Homathevi, D. T. Jones, J. MacDonald, D. Jeeva, D. E. Bignell, R. G. Davies & M. Maryati,1 1999. Termite assemblages, forest disturbance and eenhouse gas fluxes in Sabah, East Malaysia. philosophical Transactions of the Royal Society, 354: pp 91-1802.

J.C.F. Bong, P.J.H. King, K.H. Ong and N.M. Mahadi, 2012. Termites Assemblages in Oil Palm Plantation in Sarawak, Malaysia. *Journal of Entomology*, 9: 68-78.

Kambhampati, S. and P. Eggleton, 2000. Phylogenetics and Taxonomy. In: Termites: Evolution, Sociality, Symbioses, Ecology, Abe, T., D.E. Bignell and M. Higasi (Eds.). Kluwer Academic Publishers, Dordrecht, pp: 1-23.

Lawton, J. H., D. E. Bignell, G. F. Bloemers, P. Eggleton & M. E. Hodda, 1996. Carbon flux and diversity of nematodes and termites in Cameroon forest soils. Biodiversity and Conservation, 5: 261-273.

Norsyarizan Jamil, Wan Nurainie Wan Ismail, Siti Shamimi Abidin, Mazdan Aki Amaran and Ratnawati Hazali, 2015. A Preliminary Survey of species composition of termites (Insecta: Isoptera) in Samunsam Wildlife Sanctuary, Sarawak. Tropical Life Science Research,2017 Jul; 28(2): 201–213.

Paulus Meleng, Yoko Takematsu and Missiah Lariwoo, 2006. Termite Fauna of Lambir Hills National Park. Termite Fauna of Lambir Hills National Park : P*roceeding of International Symposium on Forest Ecology, Hydrometeorology and Forest Ecosystem Rehabilitation in Sarawak (March 2006)*, pp. 20 - 26

Smith M A 1925. Contribution to the herpetology of Borneo. Sarawak Museum Journal 3(8): 15–34

Tayasu, I., T. Abe, P. Eggleton & D. E. Bignell, 1997 Nitrogen and carbon isotope ratios in termites: an indicator of trophic habit along the gradient from wood-feeding to soil-feeding. Ecological Entomology 22: pp 343-351

Thapa, R.S., 1981. Termites of Sabah (East Malaysia). Sandakan: Sabah Forest Department, Malaysia.

Tho, Y.P., 1992. Termites of Peninsular Malaysia. Forest Research Institute Malaysia, Malaysia, Kepong, Malaysia.

Wood, T. G. & W. A. Sands, 1978. The role of termites in ecosystems. In: Brian, M. V. (ed.), Production ecology of ants and termites. Cambridge University Press, Cambridge. pp. 245-29

PAPER 15:
ORNITHOLOGICAL SURVEY OF GUNONG PUEH, LUNDU SARAWAK

Dayang-Nuriza AA., Nurqamareena K., Hilda-Jelembai N. I., & Madeline-George P.

Constitution and Conservation Division, Forest Department Sarawak
Corresponding email: nurizaa@sarawak.gov.my

Abstract: There are many drivers contributing to the loss of biodiversity, namely habitat fragmentation, climate change, pollution and over exploitation of biological resources. Such factors require instant conservation actions and plans to sustain the remaining ecosystem. This ornithological survey was conducted at one of Sarawak's Forest Reserves, which is at Gunong Pueh Forest Reserve located in Lundu, Sarawak. The survey resulted in 86 individuals with 29 species and 13 families. The sampling period was from 5th to 18th October 2020 at Gunong Pueh Forest Reserve. The total effort of the survey was 4644 net hours. Emerald Dove, Chalcophaps indica was one of the most abundant species caught during the survey followed by Little Spiderhunter, Arachnothera longirostra. The survey highlights two notable findings; i) Bornean Banded Kingfisher and ii) Bornean Spiderhunter for their endemic status. Based on the findings, bird species composition in Gunong Pueh Forest Reserves highlights the importance of conserving the area.

Key words: *mist net, conservation, Sarawak, Gunong Pueh*

INTRODUCTION

Habitat alteration and destruction are major contributors to the loss of our biodiversity. Human activities such as logging and clearing forests for agriculture have been known to have high impacts on organisms living in a habitat. Habitat degradation is a serious threat (Zakaria et al., 2005) especially to forest birds which are highly dependent on forests for survival. To evaluate the impacts of logging towards avifauna diversity, an example of a model has been made such as Multispecies Occupancy Models (Carrillo-rubio et al., 2014). The model enables managers and landholders to measure biodiversity and helps in addressing and making valuable decisions.

Birds are important biological indicators to the forest ecosystem health as they are mobile and are easy to sample (Daily, 1997). As bird's ecology are getting well understood, and their ability to be found in every environment (Burough, 1986), this makes them perfect bioindicators. '*Conservation*' is the sustainable use of resources and encompasses protection as well as exploitation (Rawat & Agarwal, 2015), thus both in-situ and ex-situ conservation are important in sustaining the ecosystem. This survey will aid in in-situ conservation as it highlights the species population in Gunong Pueh Forest Reserve.

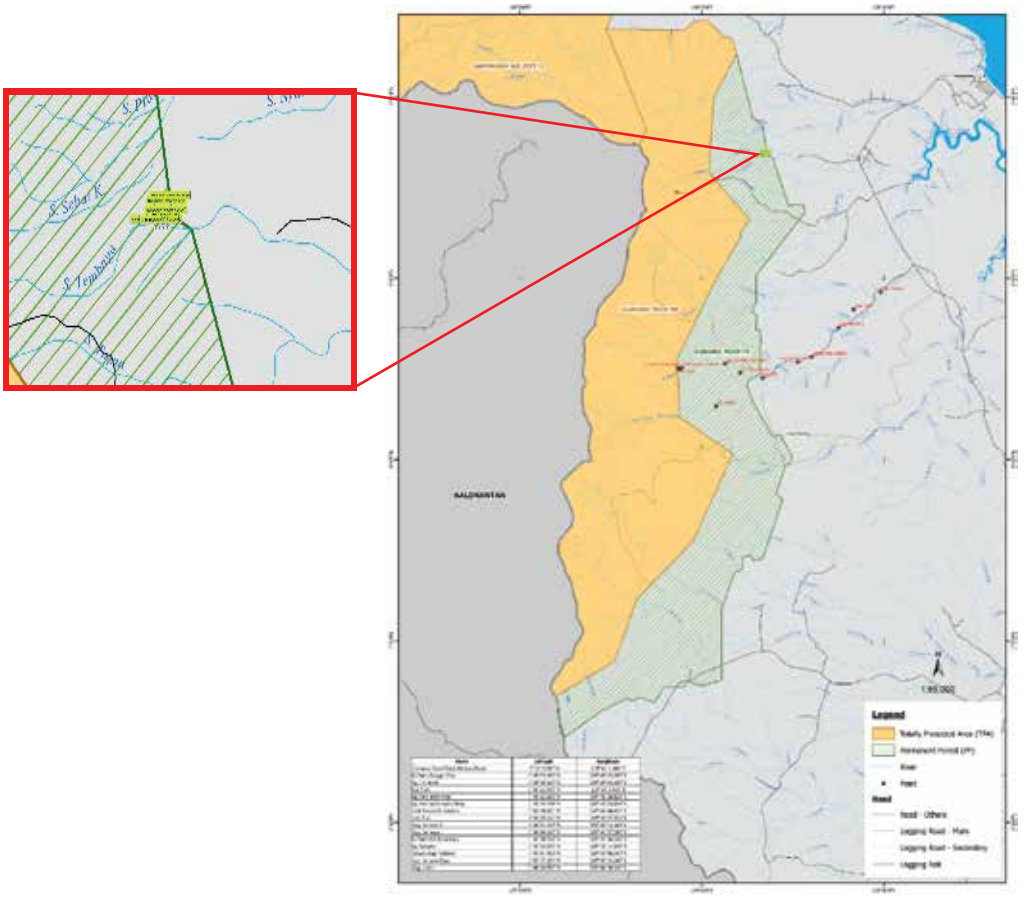
The recent studies on avifauna at Gunong Pueh was conducted by Gawin et al., (2014) in search of the endemic Mountain Black-eye, *Chlorocharis emiliae*. There is limited information on avifauna of Gunong Pueh. Thus, this study aims to produce an avifauna checklist of Gunong Pueh Forest Reserve.

MATERIALS AND METHODS

Study Area

The study was conducted within the Permanent Forest Estate in Gunong Pueh (N 01o 46' 59.99" E 109o 43' 00.20"). Gunong Pueh Forest Reserve (GPFR) is located 112.8 kilometres from Kuching City. The surface cover of Gunong Pueh is steep and rocky (Ampent *et al*., 2018), which makes the area difficult to access. The highest peak of Gunong Pueh reaches 1,600 m above sea level. There is still a small patch of virgin forest despite the surrounding areas being heavily logged.

Figure 65: Study area at Permanent Forest Estate in Gunong Pueh



Sampling Method

The ornithological survey was carried out using the mist-netting method. 43 mist nets were deployed for 9 sampling days with a total effort of 4160.25 net hours. The mist nets operated from 0600 to 1800 hours and were checked frequently every 2 hours to prevent the birds from entangling in the mist nets for a long period of time. The captured birds were measured, identified, and released. The measurements include Sex, Weight (WT), Tarsus (TR), Bill Length (BL), Bill Depth (BD), Bill Width (BW), Head Bill (HB), Wing Length (WL), Wing Span (WS), Tail Anus (TA) and Tail (TL). Moulting (Molt) and Brood Patch (BP) were recorded in the data sheet for reference purposes. The birds were identified using field guide books; Phillipps' Field Guide to The Birds of Borneo (Phillipps & Phillipps, 2014) and Birds of Borneo (Myers, 2016).

RESULTS AND DISCUSSIONS

The survey resulted in a total of 86 birds from 29 species and 13 families. The most abundant species recorded was the Emerald Dove, *Chalcophaps indica* with 12 individuals, followed by Little Spiderhunter, *Arachnothera longirostra* with 9 individuals. Of the 29 species mist-netted, one species, Grey-cheeked Bulbul, is listed as 'Vulnerable' (VU) in the IUCN Red List (2021) and four are listed as 'Near Threatened' (NT) comprising of Rufous-collared Kingfisher, Short-tailed Babbler, Buff-necked Woodpecker and Fluffy-backed Tit Babbler. According to the IUCN Red List (2021), most of the species caught were listed as 'Least Concern' (LC)'. Two Bornean endemic species caught were Bornean Banded Kingfisher and Bornean Spiderhunter. Among the birds captured, Blue-banded Pitta was listed as Totally Protected under Sarawak's Wild Life Protection Ordinance (SWPO), 1998. The findings indicate the importance of conserving Gunong Pueh Forest Reserve and preserving bird diversity.

Table 24: The list of bird species recorded from mist-netting.

Abbreviations: SWPO 1998 = Sarawak Wild Life Protection Ordinance, 1998, TP = Totally Protected, P = Protected, NP = Not Protected, IUCN, LC = Least Concern, NT = Near Threatened, VU = Vulnerable.

Family	Common Name	Scientific Name	Number of Individuals	IUCN (2021)	SWPO (1998)
Alcedinidae	Bornean Banded Kingfisher	*Lacedo pulchella*	1	LC	P
	Rufous-backed Kingfisher	*Ceyx rufidorsa*	5	LC	P
	Rufous-collared Kingfisher @ Chestnut-collared Kingfisher	*Actenoides concretus*	3	NT	P
Cisticolidae	Rufous-tailed Tailorbird	*Orthotomus sericeus*	3	LC	NP
Columbidae	Emerald Dove	*Chalcophaps indica*	12	LC	NP
Dicaeidae	Yellow-breasted Flowerpecker	*Prionochilus maculatus*	2	LC	NP
Eurylaimidae	Black-and-red Broadbill	*Cymbirhynchus macrorhynchos*	1	LC	NP
Laniidae	Tiger Shrike	*Lanius tigrinus*	1	LC	NP
Muscicapidae	Rufous-chested Flycatcher	*Ficedula dumetoria*	3	LC	NP
Nectariniidae	Little Spiderhunter	*Arachnothera longirostra*	9	LC	NP

	Purple-naped Sunbird	*Hypogramma hypogrammicum*	1	LC	NP
	Bornean Spiderhunter	*Arachnothera affinis*	3	LC	NP
Pellorneidae	Black-capped Babbler	*Pellorneum capistratum*	4	LC	NP
	Moustached Babbler	*Malacopteron magnirostre*	3	LC	NP
	Short-tailed Babbler	*Malacocincla malaccensis*	2	NT	NP
Picidae	Buff-necked Woodpecker	*Meiglyptes tukki*	1	NT	P
	Rufous Woodpecker	*Micropternus brachyurus*	1	LC	P
Pittidae	Blue-banded Pitta	*Erythropitta arquata*	1	LC	TP
Pycnonotidae	Cream-vented Bulbul	*Pycnonotus simplex*	1	LC	NP
	Olive-winged Bulbul	*Pycnonotus plumosus*	2	LC	NP
	Grey-cheeked Bulbul	*Alophoixus tephrogenys*	1	VU	NP
	Hairy-backed Bulbul	*Tricholestes criniger*	3	LC	NP
	Red-eyed Bulbul	*Pycnonotus brunneus*	5	LC	NP
	Spectacled Bulbul	*Pycnonotus erythropthalmos*	3	LC	NP
	Yellow-bellied Bulbul	*Alophoixus phaeocephalus*	4	LC	NP

Timaliidae	Chestnut-winged Babbler	*Stachyris erythroptera*	1	LC	NP
	Fluffy-backed Tit-Babbler	*Macronus ptilosus*	4	NT	NP
	Grey-headed Babbler	*Stachyris poliocephala*	5	LC	NP
	Horsfield's Babbler	*Malacocincla sepiaria*	1	LC	NP
	Total number of individuals			86	
	Total number of species			29	
	Total number of families			13	

Figure 66: Species accumulation curve throughout the nine sampling days

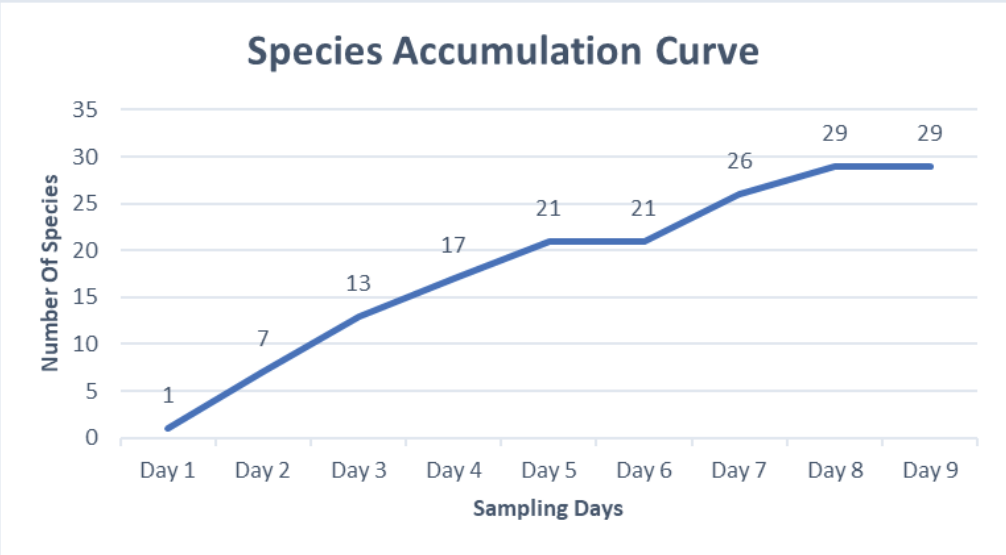


Figure 66 shows the number of species caught per day throughout the sampling period. The number of species is gradually increasing daily and reaches asymptote on Day 9, with a total of 29 species recorded. According to Figure 66, the accumulation curve reached asymptote, however the bird's species value might increase and rise if the sampling period were to be extended in the future.

CONCLUSION

A total of 86 birds with 29 species and 13 families were recorded during the survey. From this survey, two endemic birds were recorded, and one species from the Pycnonotidae family was listed as 'Vulnerable' in IUCN Red List (2021). The ornithological checklist from this survey indicates that there are potential species yet to be recorded at Gunong Pueh Forest Reserve.

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REFERENCES

Burrough, P. A. (1986). *Principles of geographical information systems for land resource assessment.* Clarendon Press, Oxford.

Carrillo-Rubio, E., Kery, M., Morreale, S. J., Sullivan, P. J., Gardner, B., Cooch, E. G., & Lassoie, J. P. (2014). Use of multispecies occupancy models to evaluate the response of bird communities to forest degradation associated with logging. *Conservation Biology*, 28(4), 1034-1044.

Gawin, D. F., Rahman, M. A., Ramji, M. F. S., Smith, B. T., Lim, H. C., Moyle, R. G., & Sheldon, F. H. (2014). Patterns of avian diversification in Borneo: the case of the endemic Mountain Black-eye *(Chlorocharis emiliae). The Auk: Ornithological Advances*, 131(1), 86-99.

Myers, S. (2016). Birds of Borneo. Bloomsbury Publishing.

Phillipps, Q. & Phillipps, K. (2014) Phillipps's Field Guide to The Birds Of Borneo, Sabah, Sarawak, Brunei and Kalimantan. Third Edition. Oxford: John Beaufoy Publishing Ltd. 373 pp.

Zakaria, M., Leong, P. C., & Yusuf, M. E. (2005). Comparison of species composition in three forest types: Towards using bird as indicator of forest ecosystem health. *Journal of biological sciences,* 5(6), 734-737

SESSION 1

Rapporteur: Nur Bazilah Ismail, Nur Safinas Jelani, Bibian Diway, Princilla Leong and Linna Chieng				
Title of paper: Discovery of Extraordinary Mycoheterotrophic Plants of Gunong Pueh Forest Reserve				
Presenter: Ling Chea Yiing		Organisation: Forest Department Sarawak		
Date: 2 August 2022		Session 1: Flora And Ecology		
No	Name	Organisation	Question	Answer
1	Hajah Mohizah Binti Haji Mohamad	Forest Department Sarawak	Are mycoheterotrophs an indicator for forest health?	Mycoheterotrophic plants have potentially been used as a biological indicator for healthy forest because they prefer good forest rather than disturbed forest based on collection made in Long Banga (3 species) as compared to Tama Abu (4 species) even though both are logged-over forest.

Rapporteur: Siti Hanim Sahari, Ng San Hui, Teng Xin Yao and Linna Chieng Mee Ngik				
Title of paper: Begonia (Begoniaceae) of Gunong Pueh, Sarawak, Borneo				
Presenter: Julia Sang		Organisation: Forest Department Sarawak		
Date: 3 August 2022		Session 1: Flora & Ecology		
No	Name	Organisation	Question	Answer
1	Dr. Victor Luna	Kementerian Pelancongan dan Kreatif Industri (MTCP)	There was a presenter who presented about arboretum establishment and mentioned the forest as a living museum. What can be done or planned with all the resources found? How can we capitalise on all these resources that can be used to uplift the community in terms of the ecotourism (community-based tourism) aspect? For example, the local community surrounding the Pueh area can be a guardian or able to protect the forest.	All the findings discovered from Pueh, whether it is information or photos, can be used as promotional materials for ecotourism for the area. The information from the presentation such as data, photos and results can be used for ecotourism. (Madeline George Pau - JHS) This is a further comment on the ecotourism part. Gunong Pueh Forest Reserve is one of the areas that are intended for ecotourism and co-management with the community. G. Pueh Forest Reserve is bordering G. Pueh National Park, so it could be the buffer zone for the park. The development could happen in G. Pueh Forest Reserve, but the wilderness area could be in G. Pueh National Park. So, the Department intends to develop that area as one of the amenity forests but at this moment it's still categorised under forest reserve.

				During the expedition, there is also study on social economic and ecotourism potential. G. Pueh also has several waterfalls but not many know that the waterfalls are within the forest reserve, and this could be the potential for ecotourism. Forest Department also has prepared a policy direction for the Premier on how the national park can be developed as part of the amenity forest or national forest (*hutan lipur*).
2	Madeline George Pau	Jabatan Hutan Sarawak	Do you have any plan for Begonia, such as commercialization and generating revenue for the State other than documenting the findings?	Begonia is also called a "gold mine". Singapore has been cultivating Begonia as an ornamental plant and the market price can range from USD 100-200 per plant for certain species. I am not involved in doing tissue culture, propagation, or commercialization of this plant, but I welcome the audience or any group of people that are interested to investigate this to join the research together.

Rapporteur: Siti Hanim Sahari, Ng San Hui, Teng Xin Yao and Linna Chieng Mee Ngik				
Title of paper: Ferns and Fern-Allies of Gunong Pueh Forest Reserve, Lundu, Sarawak				
Presenter: Stafannie Nilla Anak Marshall Rio		Organisation: Forest Department Sarawak		
Date: 3 August 2022		Session 1: Flora & Ecology		
No	Name	Organisation	Question	Answer
1	Dr Affendi bin Suhaili	Forest Department Sarawak	Will you be able to describe a certain fern to certain types of tree species?	For epiphytic fern, no observation was made so far for certain types of fern to certain types of tree species. The study on the species of fern with certain types of tree species is interesting and might be considered for future study.

Rapporteur: Siti Hanim Sahari, Ng San Hui, Teng Xin Yao and Linna Chieng Mee Ngik				
Title of paper: Gingers of Gunong Pueh				
Presenter: Dr. Meekiong Kalu		Organisation: Universiti Malaysia Sarawak (UNIMAS)		
Date: 3 August 2022		Session 1; Flora And Ecology		
No	Name	Organisation	Question	Answer
1	Dr Affendi bin Suhaili	Forest Department Sarawak	Any loss of species maybe because of climate change?	Based on the observation, *Borneocola argentianus* and *Scaphochlamys limiana* population is decreasing as compared to the previous observation. However, *Scaphochlamys samunsam* population is maintained.
2	Ketua Kaum	Kampung Sebako 1	Adakah kemajuan di kawasan Sebako memberi manfaat kepada penduduk dan menghalang kebebasan penduduk di kawasan tersebut? Peraturan perlu dibuat oleh pihak JHS untuk kebebasan orang awam keluar masuk GPNR dan hasil kajian penyelidikan perlu dikongsi kepada penduduk setempat.	(Madeline George Pau – JHS) Perancangan telah dibuat dalam penglibatan komuniti dalam ekopelancongan bersama dengan agensi Jabatan Hutan Sarawak dan Kementerian Pelancongan. Tiada halangan untuk keluar masuk ke kawasan Sebako disebabkan kawasan tersebut bukan kawasan hutan simpan. Penyediaan buku bergambar iaitu *Birds of Gunong Pueh* dalam proses pembuatan dan akan dikongsi kepada penduduk

				(Hajah Mohizah Binti Haji Mohamad - JHS) Sebuah arboretum akan diwujudkan bagi kawasan tersebut di mana arboretum akan membantu pembelajaran kepada pelajar sekolah dan identifikasi pengecaman pokok. Latihan akan dibuat kepada penduduk kampung bagi membolehkan penduduk kampung untuk mengendalikan program tersebut pada masa akan datang.
				(Puan Runi Sylvester Pungga - JHS) Penyelidikan yang dibuat akan dikongsikan bersama orang kampung bagi memastikan penduduk kampung juga ambil tahu apa yang ada. Penyelidik untuk mengenalpasti spesies tumbuhan yang berpotensi yang mempunyai nilai untuk dikomersilkan seperti untuk tumbuhan hiasan, ubatan dan sebagainya. Pihak Jabatan Hutan Sarawak untuk membuat perancangan pengurusan untuk potensi spesies dengan kerjasama Kementerian pelancongan. Ini bertujuan untuk menambah pendapatan penduduk kampung selain mencegah pengunjung daripada mengambil tumbuhan semasa memasuki hutan. Ekspedisi saintifik kedua boleh dianjurkan di kawasan lain Gunong Pueh untuk meneroka kawasan Gunong Pueh dengan lebih menyeluruh
				(Dr Meekiong Kalu - UNIMAS) Kajian bagi mengetahui asal usul nama kampung di kawasan Sematan telah dibuat sejak 2 tahun yang lepas. Projek dokumentasi nama tumbuhan dalam Bahasa Etnik Selako sedang diusahakan Bersama DBP.

SESSION 2

Rapporteur: Siti Hanim Sahari, Ng San Hui, Teng Xin Yao and Linna Chieng Mee Ngik				
Title of paper: Socio Economy Study for Community within Gunong Pueh Forest Reserve				
Presenter: Sylvester Jemat Anak Arbit		Organisation: Forest Department Sarawak		
Date: 3 August 2022		Session 2: Technology, Socio and Ecotourism		
No	Name	Organisation	Question	Answer
1	Ms Norazlin	Pejabat Daerah Kecil Sematan	Kenapa hanya 3 kampung yang terlibat dalam kajian? Terdapat 13 buah kampung di daerah Sematan dan terdapat ramai peserta homestay	Masa ekspedisi hanya 2 minggu sahaja, Cadangan akan dibuat pada masa akan datang untuk melibatkan semua kampung di kawasan tersebut. Kajian akan melihat bukan hanya potensi ekopelancongan tetapi merangkumi NTFP-makanan, kraftangan, hasil hutan, produk semua kaum dan masyarakat
				(Runi Sylvester Pungga - JHS) ● Tumbuhan popular untuk NTFP ialah spesis buluh dan bemban. ● Untuk Kampung Semapu, hasil kebun adalah 0% - sebab jauh dari hutan simpan, lebih banyak mengusahakan sawit, kurang ruang utk hasil hutan.

Rapporteur: Siti Hanim Sahari, Ng San Hui, Teng Xin Yao and Linna Chieng Mee Ngik				
Title of paper: Unlocking the Ecotourism Potential of Gunong Pueh Forest Reserve				
Presenter: Abang Nuradzizi bin Abang Bolhi		Organisation: Forest Department Sarawak		
Date: 3 August 2022		Session 2: Technology, Socio and Ecotourism		
No	Name	Organisation	Question	Answer
1	Dr Meekiong Kalu	Universiti Malaysia Sarawak		Saranan untuk mencari denai-denai yang telah digunakan oleh penyelidik terdahulu seperti: 1889 – Eric George (Curator Museum) 1854– Alfred Wallace 1905 – HN Rigley, untuk tarikan pelancongan.
2	Ms Norazlin	Pejabat Daerah Kecil Sematan		Mencadangkan untuk berhubung dengan Pejabat Daerah Sematan untuk sejarah Kampung Sebako.
3	Tn. Haji Azahari bin Omar	Jabatan Hutan Sarawak		● Terdapat Management Plan oleh UPM untuk Daerah Sematan, 2 kawasan dan 3 kampung yang telah dipersetujui. ● Meluaskan kajian NTFP untuk meliputi bemban.

Rapporteur: Siti Hanim Sahari, Ng San Hui, Teng Xin Yao and Linna Chieng Mee Ngik				
Title of paper: Preliminary Study on Consumer - Grade Drone for Monitoring of Gunong Pueh Forest Reserve, Lundu				
Presenter: Mohd. Firdaus bin Bohari		Organisation: Forest Department Sarawak		
Date:		Session 2: Technology, Socio and Ecotourism		
No	Name	Organisation	Question	Answer
1	Tn. Haji Azahari bin Omar	Forest Department Sarawak	How to reduce error?	Bila berlaku error, pengiraan akan jadi kurang tepat (eg. luas), jadi adjust ketepatan based on ground survey, iaitu ketepatan sukatan berpandukan pihak Land & Survey, authority for boundary. Adjust ketinggian drone ikut terrain for better effect.
				(Dr Affendi bin Suhaili - JHS) i. Satelit tidak boleh lihat terperinci untuk ketinggian >10m. ii. Topography correction- membetulkan ke 7m.

SESSION 3

Rapporteur: Nur Bazilah Ismail, Nur Safinas Jelani, Bibian Diway and Princilla Leong				
Title of paper: Preliminary Reports on Herpetofaunal Inventory of Gunong Pueh Forest Reserve				
Presenter: Mohammad Yazid bin Hossman		Organisation: Forest Department Sarawak		
Date: 3 August 2022		Session 3: Fauna		
No	Name	Organisation	Question	Answer
1	Tn. Hj Azahari bin Omar	Jabatan Hutan Sarawak	1.Mengapa kebanyakan masa kajian herpetofaunal dijalankan pada waktu malam?	Kajian herpetofaunal juga ada dibuat pada waktu siang. Namun, kebanyakan herpetofaunal aktif pada waktu malam. Justeru, waktu malam adalah waktu yang sesuai untuk menjumpai ular atau katak.
			2.Terdapat komuniti yang menjadikan katak sebagai makanan. Namun, diketahui ada jenis katak yang beracun. Bagaimana cara untuk mengetahui katak tersebut adalah beracun atau tidak?	Sekitar 70% - 80% katak adalah tidak beracun. Selalunya katak yang beracun adalah daripada kategori kodok. Namun, tidak semua jenis kodok adalah beracun. Sebagai contoh spesis *Phrynoidis asper* mempunyai bintik putih di belakang badan. Ia berfungsi sebagai racun untuk melindungi dari pemangsa. Saya pernah bertanya kepada komuniti yang makan katak dari jenis spesis tersebut. Mereka membuang kulit luaran katak terlebih dahulu sebelum dimakan. Antara semua jenis katak, katak dari spesis *Limnonectes palavanensis* adalah jenis yang kerap dimakan.
2	Madeline George Pau	Jabatan Hutan Sarawak	Mengapa kajian katak dilakukan dan apakah kepentingan kajian katak untuk hutan?	Katak juga merupakan indikator kepada kesihatan hutan. Sekiranya tiada katak, ini menunjukkan tahap kesihatan sesuatu ekosistem hutan.

Rapporteur: Nur Bazilah Ismail, Nur Safinas Jelani, Bibian Diway and Princilla Leong				
Title of paper: A Survey of the Termites (Insecta: Isoptera) at Gunong Pueh Forest Reserve, Lundu, Sarawak				
Presenter: Paulus Anak Meleng		Organisation: Forest Department Sarawak		
Date: 3 August 2022		Session 3: Fauna		
No	Name	Organisation	Question	Answer
1	Tn. Hj Azahari bin Omar	Jabatan Hutan Sarawak	Di dalam jadual pembentangan, mengapa termite jenis Apecotermitinae hanya ditemui di Pueh berbanding kawasan kajian yang lain?	Lokaliti Pueh berlainan berbanding dengan kawasan kajian yang lain. Oleh sebab itu Apecotermitinae hanya ditemui di Pueh sahaja
2	Ms Halipah	Ministry of Tourism	Any tips on how to check for termites when buying a new house?	Membuat rawatan anti-termite dan perlu bertanya kepada mereka sama ada rawatan tersebut dilaksanakan sebelum rumah dibina

Rapporteur: Nur Bazilah Ismail, Nur Safinas Jelani, Bibian Diway and Princilla Leong				
Title of paper: Ornithological Survey of Gunong Pueh, Lundu Sarawak				
Presenter: Dayang Nuriza binti Abang Abdillah		Organisation: Forest Department Sarawak		
Date: 3 August 2022		Session 3: Fauna		
No	Name	Organisation	Question	Answer
1	KK Aman Masulin	Ketua Kaum Kpg. Sebako	Berdasarkan kepada hasil penemuan dalam slaid pembentangan, apakah penyumbang kepada penurunan populasi burung kerana tiada sebarang aktiviti menangkap burung di kawasan Pueh dan sekitarnya.	Untuk makluman, apa yang dibentang adalah merujuk kepada IUCN Red List bagi keseluruhan dunia. Secara amnya, antara faktor penyumbang kepada penurunan populasi burung adalah kehilangan habitat. Ada sesetengah spesis hidup di habitat yang berlainan. Sebagai contoh burung Blue-banded Pitta adalah endemik kepada Borneo. Burung ini tinggal di kawasan pergunungan dan berbukit. Sekiranya habitat mereka diceroboh, ini akan mengganggu populasi. Selain itu, terdapat juga aktiviti pemburuan burung murai batu untuk pertandingan bunyi burung. Ini turut akan mempengaruhi populasi burung.
2	En. Harun	Ministry of Urban, Development and Natural Resources	Based on the slide, Blue-banded Pitta was mentioned to be endemic to Borneo, but why is it categorised as least concern on the IUCN Red List?	Terdapat beberapa faktor Blue-banded Pitta berada di kategori *least concern* dalam IUCN Red List. Kebarangkalian data untuk burung Blue-banded Pitta secara keseluruhan dunia adalah tidak mencukupi dan taburan untuk Borneo adalah stabil. Justeru, penyelidik

				haruslah sentiasa mengemaskini hasil penemuan kajian kepada pihak yang berkaitan agar pihak ini dapat memaklumkan pihak berkuasa hidupan liar untuk mengemaskini butiran di dalam IUCN Red List.
3	Nadia Cindy	Wildlife Conservation Society Malaysia Programme	Apakah metodologi survei burung yang digunakan selain daripada pemerhatian visual, bunyi dan survei/ temubual bersama orang kampung? Adakah terdapat burung dari spesis lain seperti hornbill dijumpai semasa kajian ekspedisi?	Teknik *mist netting survey* turut digunakan dalam kajian survei burung. Pemerhatian juga dibuat sepanjang ekspedisi ini. Sepanjang kajian ekspedisi, tiada hornbill ditemui ketika kajian ekspedisi. Namun terdapat perancangan pada masa hadapan untuk *bird watching* dan membuat *mist netting survey* di kawasan lain sekitar Pueh. Ini supaya dapat menambah informasi senarai inventori burung dan membuat *diversity* spesis burung di kawasan Gunong Pueh FR. Ketika ekspedisi yang lalu, data adalah terhad dan hanya 29 spesis burung dijumpai. Justeru, pengiraan *diversity index* tidak dapat dibuat selain daripada faktor cuaca yang menyukarkan aktiviti *bird watching*.
4	Edris Ak Kabong	Penduduk Kpg. Judin, Sematan		<u>Suggestion:</u> Terdapat satu spesis burung yang kerap berada di kebun penduduk Kampung Judin di sekitar Sg. Pueh. Penduduk tempatan menggelar burung tersebut “burung kakuk”. Burung itu mempunyai badan yang besar dan mempunyai tanduk di kepala seperti kenyalang tapi sedikit berlainan serta suara yang nyaring. Pihak Jabatan mungkin boleh datang untuk membuat kajian atau survei berkenaan spesis burung tersebut

APPENDIX


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SAINTIFIK HUTAN SIMPAN
Where Nature and Science
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EKSPEDISI SAINTIFIK HUTAN


SEMINAR HEART OF BORNEO (HoB) SARAWAK
EKSPEDISI SAINTIFIK HUTAN SIMPAN GUNONG PUEH
"Where Nature and Science Unites"
02 - 03 Ogos 2022
UCSI Hotel Kuchin


PERMANENT FORESTS
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