

HEART OF BORNEO SERIES 5

PROCEEDINGS OF THE HEART OF BORNEO SEMINAR

TAMA ABU

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TAMA ABU

FOREST DEPARTMENT SARAWAK

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PREFACE

This proceedings give us a glimpse on the findings of the Scientific Expedition to Tama Abu PF made in 2017 which was organized by the Forest Department of Sarawak.

This book is the fifth series in the Heart of Borneo publication under the Heart of Borneo Initiative for Sarawak. It highlights part of the findings of the 2017 expedition that were presented during the Heart of Borneo Seminar 2018.

This proceedings consists of twenty two papers on the findings of flora (11), fauna (9), microbial (1) and geology (1) from Tama Abu expedition. Other findings will be included in the pictorial coffee-table book (Heart of Borneo Series 7).

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GEOLOGY AND GEOHERITAGE SIGNIFICANT OF TAMA ABU AREA

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Department of Mineral and Geoscience Malaysia
Kuching, Sarawak

Abstract

The geology of Tama Abu area comprises of sedimentary rocks of Oligocene Kelabit Formation, Miocene Meligan Formation and recent sediments. All of the rock formations contributed to the geodiversities, subsequently to enrich the geoheritage significant in this area. Kelabit Formation, the oldest rock in Tama Abu area is dominant and conformably overlain by the Meligan Formation. Lithologically the Kelabit Formation comprised of mudstone or mudstone interbedded with sandstones and siltstones meanwhile Meligan Formation is composed of massive interbedded sandstones with present of minor mudstone layers. Meligan Formation crop-out and formed the hills and plateau at the higher elevation meanwhile Kelabit Formation mostly formed the lower level of the Tama Abu range. The younger deposits are composed of semi consolidated terrace, gravel, colluviums and alluvium deposited by river systems along the river, valley and lower slope within the area. Kelabit Formation had been tilted, folded and extremely faulted in few places. However, though obviously tilted but there are no indication of folding and faulting in the massive Meligan Formation sequence. Further analysis of 23 stream sediment samples indicated very low existing of economic mineral resources in this area. Meanwhile, micro-fossil analysis from 6 samples does not reveal any existing of foraminifera or benthonic fossil. Beside the important of geological evolution, the geodiversity of landforms, geological landscape, sedimentary structure and tectonic have been identified as the main characters that could contribute to the enrichment of the geoheritage significant for conservation and protection of Tama Abu area.

Keywords: *Geology, geoheritage significant, Tama Abu*

INTRODUCTION

Tama Abu Range located at Southern Kelabit Highland, Ulu Baram, the most eastern part of Miri Division, Sarawak (Figure 1). It is prominent range where the highest mountain, Mount Murud situated. As the main range of Sarawak and elongated NE - SW, the Tama Abu Range covered a large area near the international boundary between Malaysia (Northern Sarawak) and Indonesia (Northen Kalimantan). The expedition coverage concentrating on southern part of Tama Abu Range within the combination of four topography map published by Department of Survey and Mapping Malaysia (*Jabatan Ukur dan Pemetaan Malaysia* - JUPEM) in 2006 Series T738 comprising Map Sheet 7119 (Long Salt), 7219 (Bukit Kelit), 7118 (Long Banga) and 7218 (Ulu Sungai Banga). Upper Batang Baram or Ulu Baram river with its main tributeries Sungai Baleh and few others sub-tributaries such as Sungai Peluan and Sungai Banga forming natural drainage system in this area. The accessibility to this area is by road from Miri which proper tar seal road up to Long Lapok and followed by logging track/road from Long Lapok to Bario, the largest settlement in the Kelabit Highland which is located further up from study area. Existing Long Lapok-Bario logging track/road was contructed and previously maintained by Samling Sdn. Bhd. There are three nearby residential comprises of Long Banga, Long Paluan and Long Beruang at the southern part outsite expedition area; meanwhile Pa Dalih and Ramudu of Bario at the northern part outside expedition area. Long Paluan, Pa dalih and Ramudu accupied by mostly Kelabit communities; Long Banga by Kenyah and Penan communities; meanwhile Long Beruang is a special resettlement for Penan community.

The morphology of both Tama Abu Range with extension to Kelabit Highland to the North East are significant indicating the backbone highland of Sarawak. Detail geological information of this area is limited, hence the inventory on its geology and geological interpretation are still much needed. No detail geological description been done though there at least two rock formations similar to Meligan Formation and Kelabit Formation in Kelabit Highland probably existing in this area base on general previous geological report by Thomson (2015) and Haile (1962).



Figure 1: Locality of Tama Abu area. (source: Google earth map)

OBJECTIVE

There are three main objectives of the study comprising; to identify and characterize significant geological and geomorphological resources for geotourism (geo-ecotourism) and geoconservation; to integrate geological resources with biodiversity of highland area as important elements for conservation; to update geological map of Sarawak, its interpretation as well as to clarify the existing of economic mineral for clearance. The existing geological map of Sarawak not much indicated the geological information in study area (Figure 2). showing Base on accumulative geology and geodiversities information, a preliminary geodiversity and geoheritage report could be establish for future planning and development particularly on conservation efforts.

Methodology and research approach are involving literature review, fieldwork, laboratory test, data analyses and finally report writing. Literature review are inclusive collecting and preliminary analyzing geological and geomorphological information of Tama Abu area from published and non-published report, article, journal and also website. As for desktop study, literature review mainly to collect secondary data from previous study regarding geological and geomorphological information in this area. However, primary data collection throught fieldwork only commence during the scientific expedition. The approach is base on basic geological and geomorphological mapping prosedur such as identification of the site location, observation of lithology boundary and its primary structure, measurement of geological structure and documentation as well as scatching and photos taken.

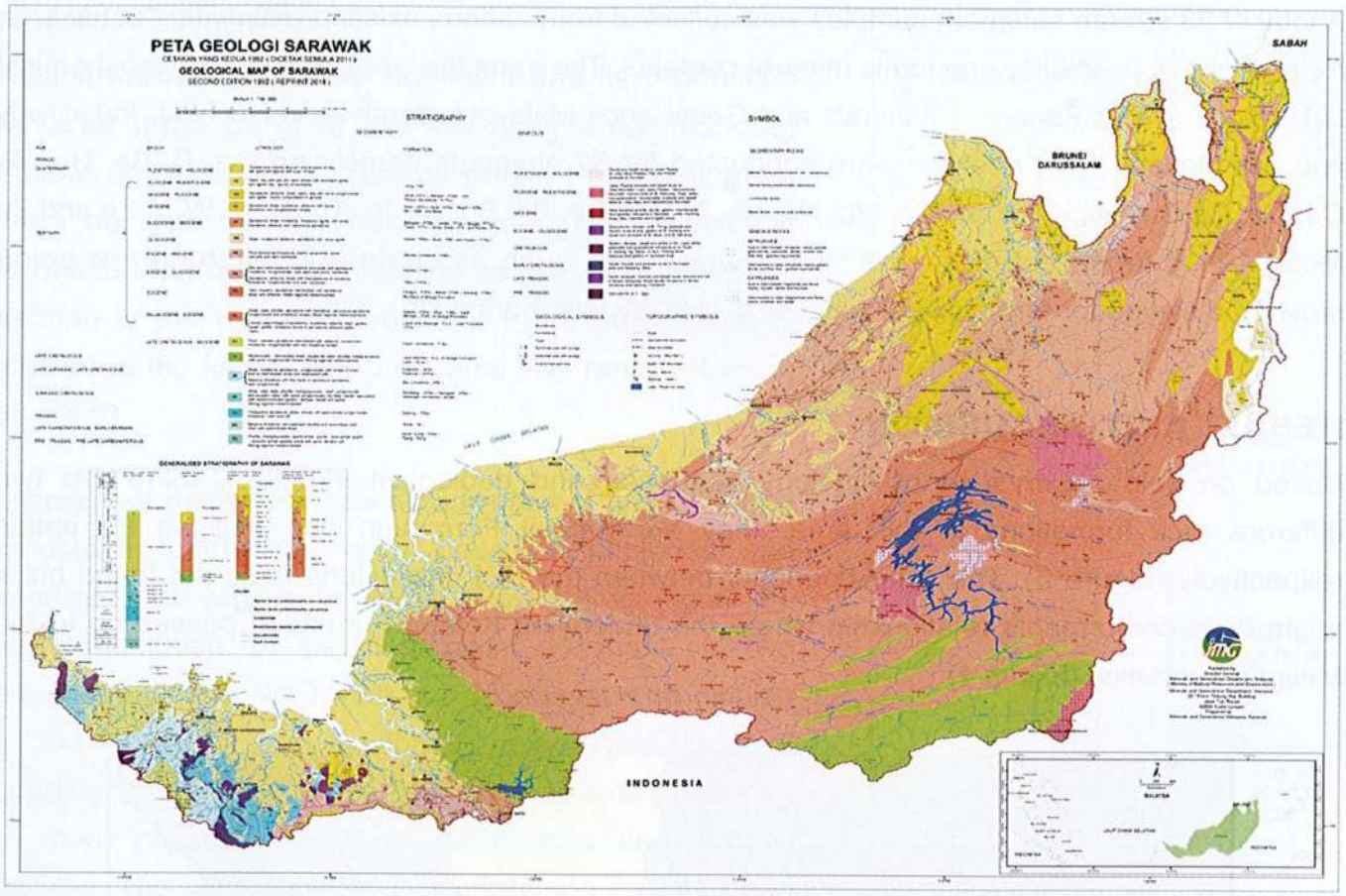


Figure 2: Geological map of Sarawak and Tama Abu area
(source: Dept. of Mineral and Geoscience Malaysia Sarawak, 2012).

Among geological tools and equipment used are geological hammer, measuring tape, compas, GPS, fieldnote, camera and citric acid. Confirmation of geological formation including rock types and mineral, geological processes, fossil identification, structure and landscape are also taking part during fieldwork. Some of the rock and residuel soil are also collected for sampling for further analysis. Identification and characterisation of geodiversity for significant geoheritage also conducted during fieldwork. Most of fieldwork was done throught traversing along the rivers, old logging track, road, and also along the existing transect established by the Forest Department Sarawak.

METHODOLOGI AND RESEARCH APPROACH

Rock samples are being selected for thin section in order to classify the rock types in detail through mineralogy and petrology analysis. A total of 12 rock samples have been selected for thin section preparation in lapidary laboratory, followed by rock classification which is being classified using microscope. All of rock samples are sedimentary rock (sandstone, shale, siltstone) and their classification is base on ratio of three main mineral comprising quartz, feldsfar and lithick by Pettijohn (1975).

A total of 23 stream sediment samples was collected from various existing river within study area for analysis of possibility economic mineral contains. The samples were sent to the Geochemical Laboratory, at Department of Minerals and Geoscience Malaysia, Sarawak in Kuching. Inductively coupled plasma (ICP) analysis were conducted for 32 elements namely Ag, As, B, Ba, Be, Bi, Ca, Co, Cr, Cu, Fe, K, La, Li, Mn, Mo, Na, Nb, Ni, Pb, Sb, Sc, Sn, Sr, Ta, Th, Ti, U, W, Y, Zn and Zr. Meanwhile, 6 loose soil from soft sedimentary rock such as shale and siltstone are being crush and sieved for foraminifera analysis (micro ancient marine life).

RESULT AND DISCUSSION

Based on field observation of lithology sequence and geological structure, there are two different rock formations in this area, they are Kelabit Formation and Meligan Formation respectively (Figure 3). The clear boundary between the rock formations was not found but it might be a conformable relationship where the underlying Kelabit Formation passes up to the Meligan Formation (Figure 4).

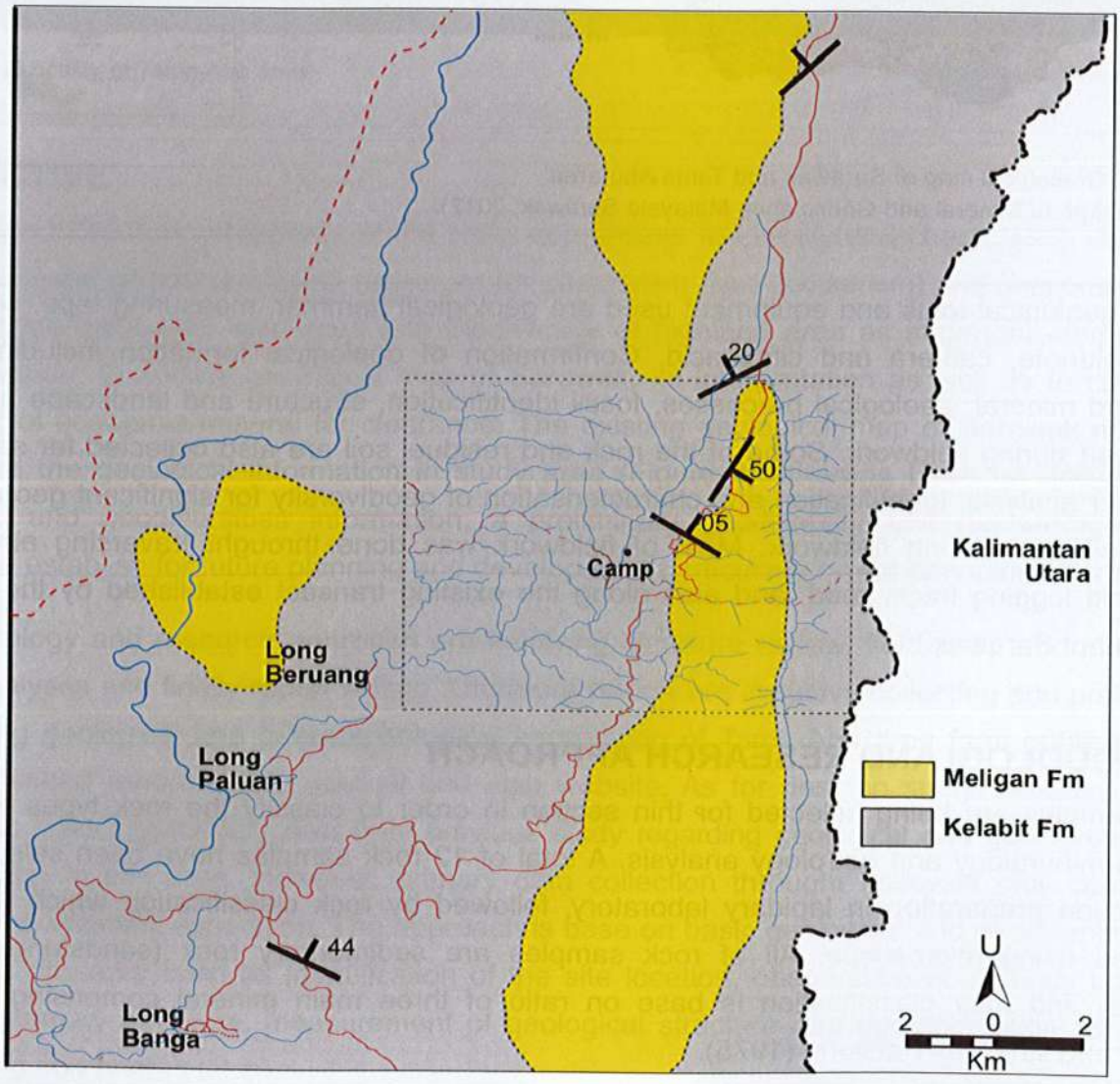


Figure 3: Geological map of Tama Abu Range and expedition area.

Kelabit Formation

Kelabit Formation is most dominant and its distribution covered large parts of the low-lying area including bottom of hills within Tama Abu range. Previously there were no type section was assigned for the Kelabit Formation but only the reference section. The reference section is the Kelapang River in Bario area which is located at the further North of Tama Abu range (Haile et al. 1962).

Lithology of Kelabit Formation comprised of predominantly mudstone interbedded with beds of siltstones and sandstone of various thickness (Figure 5 to Figure 8). The orientation of bedding plain dominant in two directions, to the Northwest and Northeast with dipping to the Northeast and Southeast respectively. Most of sandstone layer forms high ridges and small hills due to more resistant to natural weathering and surface erosion. The sandstone layer is thickening upward trend which is relatively thin layer at the bottom sequence but getting thicker at upper sequence. However, the base of the Kelabit Formation composed of grey or brownish mudstone passing up gradually to more arenaceous successions, indicated coarsening upward trend.

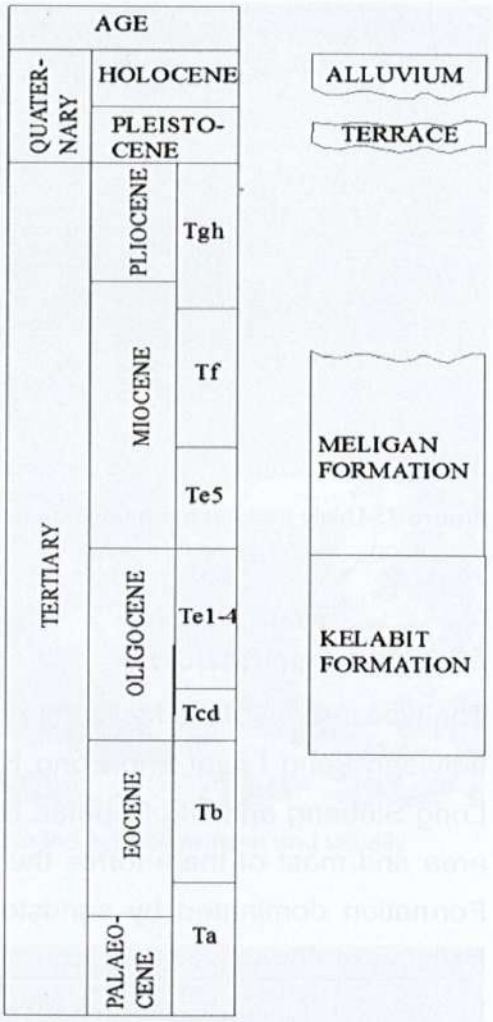


Figure 4: Stratigraphy showing the conformable relationship between Kelabit Formation and Meligan Formation (Thomson, 2015).



Figure 5: A sequence of interbedded thick sandstone and mudstone of Kelabit Formation being quaried manually for the road construction.



Figure 6: Ripple mark, an abundance sedimentary structures in Kelabit Formation.



Figure 7: Thinly bedded red mudstone bed in Kelabit Formation.



Figure 8: Rounded pable of red mudclast embeded in the light grey mudstone bed Kelabit Formation.

Meligan Formation

The type section of the Meligan Formation was defined by Liechti et al. (1960) as outcrops occurring between Long Layat and Long Kaya in Lawas. The type section was also assigned between Long Slobang and Ulu Sepetar. Not much outcrop of Meligan Formation was observed in study area and most of them forms the hills and plateau at the higher elevation. Lithology of Meligan Formation dominated by sandstone with thick to massive layer (Figure 9 to Figure 12). The bedding orientations are various but the general strike is East-West with the dipping directions to the North. Some sandstones beds show parallel laminations. The sandstone is medium grained size and well-sorted, subangular to subrounded and sometimes contain mudclasts of approximately 5cm in diameter. Average grains size 0.2mm to 0.5mm, composed of predominantly quartz, with some feldspar, minor opaque, heavy minerals present are zircons and tourmaline. This particular sandstone fining upwards bedding, which showing courser materials at the bottom sequence layer and fine grain size materials toward upper sequence. Most of the sandstone types is classified as subarkose similar lithology with the nearby Bario area.

The age indicated from the fossils found within the sandstone of Meligan Formation, Miocene (Te) (Liechti et al. 1960; Thomson, 2015). Environmental deposition of Meligan Formation probably represents the delta front of a prograding delta system. Its indicated that, during the Miocene there is an increase in input of sand into the marine environment represented by the older and more argillaceous Kelabit Formation.



Figure 9: Thick to massive sandstone Meligan Formation. The sandstone bed was tilted almost vertically.



Figure 10: Massive and hard sandstone of Meligan Formation more resistant to the surface erosion and usually formed the cascade and waterfalls.

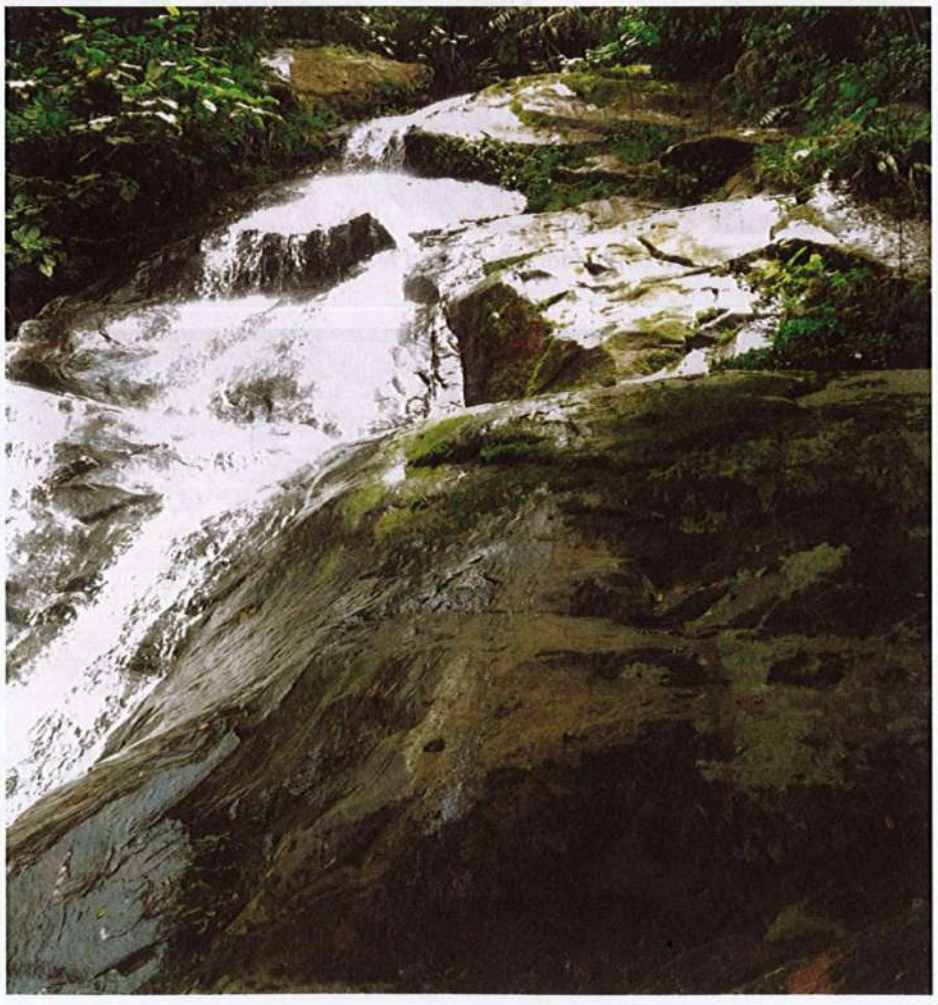


Figure 11: Sandstone of Meligan Formation occured mostly at the higher elavation and formed the cliff and cascades.

RECENT SEDIMENT

Recent sediment comprising all young deposit composed of semi consolidated terrace, gravel, colluviums and alluvium deposited by river systems obviously along the river, valley and lower slope within the study area. The size of material that forms recent sediment are various ranging from few cm up to 6-7 meter. Most of recent sediments are originated and formed by sandstone boulders from Meligan Formation (Figure 12 and Figure 13).



Figure 12: Various size of boulders deposited along several rivers within Tama Abu area.



Figure 13: Recent and un-consolidated sedimen along the rivers due to the debris flow.

ECONOMIC MINERAL EXISTING

The existing of economic mineral also highlighted and recorded based on result analysis of the 23 stream sediment samples. The stream sediment sampling relatively only covered a small area for regional geochemical sampling analysis. Most of the stream sediment samples was collected within Long Beruang and Long Paluan at the Southern area and upper tributeris of Sg. Baleh toward Bario to the North. However, the result indicated very low of economic mineral resources (Table 1). This result also supported by none existing of any igneous intrusion that might could contribute to mineralisation of older rock formations (Kelabit Formation and Meligan Formation). Less existing of economic mineral also probably due to very low grad of metamorphism or regional methamorphism by regional tectonic. A total of 23 stream sediment samples are very much lesser and insufficient to plot an anomaly map of mineral existing in this area. Appropriate and accepted anomaly map could be nicely produced from at laest few hundred to thousand of stream sediment samples. Further discussion of the result only based on average of each element from respective rivers locations as below;

Argentum (Ag): The argentum (Ag) content is mostly <0.1 ppm only TAS 19 6.49 ppm. The median value is 0.38 ppm.

Arsenic (As): The arsenic (As) content is <0.5 ppm. The median value is <0.5 ppm. The arsenic contents only show background value.

Boron (B): The boron (B) content ranges from <0.5 ppm to 6.718 ppm. The median value is 3.79 ppm.

Barium (Ba): The barium (Ba) content ranges from <0.5 ppm to 48.29 ppm. The median value is 15.14 ppm.

Berilium (Be): The berilium (Be) content ranges from <0.1 ppm to 0.805 ppm. The median value is 0.23 ppm.

Bismuth (Bi): The bismuth (Bi) content ranges from <0.1 ppm. The median value is 0.1 ppm. The bismuth contents only show background value.

Calcium (Ca): The calcium (Ca) content ranges from <0.5 ppm to 892.10 ppm. The median value is 182.99 ppm.

Cobalt (Co): The cobalt (Co) content ranges from 1.191 ppm to 9.996 ppm. The median value is 3.13 ppm.

Chromium (Cr): The chromium (Cr) content ranges from <0.5 ppm to 50.66 ppm. The median value is 7.20 ppm.

Copper (Cu): The copper (Cu) content ranges from <0.5 ppm to 9.977 ppm. The median value is 3.57 ppm.

Iron (Fe): The iron (Fe) content ranges from 0.00% to 3.04%. The median value is 0.58%.

Lantanum (La): The lantanum (La) content ranges from <0.5 ppm to 6.976 ppm. The median value is 2.49 ppm.

Lithium (Li): The lithium (Li) content ranges from <0.5 ppm to 59.91 ppm. The median value is 12.65 ppm.

Manganese (Mn): The manganese (Mn) content ranges from <0.5 ppm to 483.8 ppm. The median value is 113.67 ppm.

Molybdenum (Mo): The molybdenum (Mb) content ranges from <0.1 ppm to 0.234 ppm. The median value is 0.11 ppm.

Neobymium (Nb): The neobymium (Nb) content ranges from <0.5 ppm to 12.51 ppm. The median value is 5.32 ppm.

Nickel (Ni): The nickel (Ni) content ranges from <0.5 ppm to 29.38 ppm. The median value is 6.25 ppm.

Lead (Pb): The lead (Pb) content ranges from 2.362 ppm to 12.14 ppm. The median value is 8.79 ppm.

Stibnium (Sb): The stibnium (Sb) content ranges from <0.5 ppm to 1.986 ppm. The median value is 0.70 ppm.

Scandium (Sc): The scandium (Sc) content ranges from <0.5 ppm to 4.135 ppm. The median value is 1.10 ppm.

Stanum (Sn): The stanum (Sn) content ranges from <0.5 ppm to 3.157 ppm. The median value is 1.53 ppm.

Strontium (Sr): The strontium (Sr) content ranges from <0.5 ppm to 7.449 ppm. The median value is 2.67 ppm.

Thalium (Ta): The thalium (Ta) content is <0.5 ppm. The median value is <0.5 ppm. The thalium contents only show background value.

Thorium (Th): The thorium (Th) content ranges from <0.1 ppm to 1.297 ppm. The median value is 0.42 ppm.

Titanium (Ti): The titanium (Ti) content ranges from <0.5 ppm to 16.73 ppm. The median value is 4.41 ppm.

Uranium (U): The uranium (Us) content ranges from <0.1 ppm to 1.410 ppm. The median value is 0.22 ppm.

Tungsten (W): The tungsten (W) content ranges from <0.5 ppm to 3.489 ppm. The median value is 0.84 ppm.

Yttrium(Y): The yttrium(Y) content ranges from <0.5 ppm to 5.023 ppm. The median value is 1.56 ppm.

Zinc (Zn): The zinc (Zn) content ranges from <0.5 ppm to 49.34 ppm. The median value is 10.82 ppm.

Zirconium (Zr): The arsenic (As) content ranges from <0.5 ppm to 1.220 ppm. The median value is 0.53 ppm.

Gold (Au): The gold/aurum (Au) content ranges from <0.01 ppm to 0.25 ppm. The median value is 0.05 ppm.

Mercury (Hg): The mercury (Hg) content ranges from 2.6 ppm to 15.3 ppm. The median value is 6.73 ppm.

GEODIVERSITY AND GEOHERITAGE

Geodiversity is 'the natural range (diversity) of geological rocks (rocks, minerals, fossils), geomorphological (landform, processes) and soil features, including their assemblage of features, relationships, properties, interpretations and systems (Gray, 2004). Several geodiversities have been identified during expedition, they are consisting of rock formations, rock and mineral types, sedimentary structure, fossil, geological structure, geological landscape and geological processes (Table 2; Figure 14 to Figure 21). Most of these geodiversities scattered within the area particulally along river banks.

Geoheritage is component of geodiversity that is important to human beings (and communities) for the purposes other than resource exploitation, i.e. things we would wish to retain for present and future generations (Sullivan 1997; Eberhard 1997). Geoheritage site is derived from significance geodiversities in which the geological aspect is the fundamental.

Table 2: Geodiversity and potential of geoheritage significance value.

GEODIVERSITIES	FEATURES	SIGNIFICANCE GEOHERITAGE VALUE
Rock formations	Kelabit Formation, Meligan Formation	Scientific
Rock types	Sandstone, Mudstone, Siltstone, Red mudstone, Shale.	Scientific
Mineral types	Quartz, Feldspar	Scientific
Sedimentary structure	Bedding, Slumps Sole markings; Flute cast, Load cast, Ripple mark.	Scientific
Fossil	Types, Activities.	Scientific
Geological structure	Faults, Folds, Joint.	Scientific
Geological landscape	Mountain, Valley, Rivers, Ridges, Waterfalls.	Scientific, Aesthetic, Recreational
Geological processes	Erosion, Deposition, Rock falls, Landslide.	Scientific, Culture



Figure 14: Ripple marks.



Figure 15: Flute casts sole markings.



Figure 16: Thinly bedded sequence of sandstone and mudstone.



Figure 17: Mega size load cast.



Figure 18: Single burrow trace fossil.



Figure 19: Trace fossil.



Figure 20: Probably a rhizocretion, the secondary structure in Kelabit Formation due to the roots of the plants.



Figure 21: Flute casts as sole markings of sandstone in Kelabit Formation.

CONCLUSION

A fundamental for the existing of geodiversity and biodiversity within Tama Abu area are depending on only two sedimentary rock formation, Kelabit Formation and Meligan Formation. The richness of most geodiversity directly influences by various rock types in Kelabit and Meligan Formation. Meanwhile, diversity for geological landform are mostly influence by major geological structure within both Kelabit and Meligan Formation. However, landscape diversity and biodiversity are relying on soil types from respective parents' material of rock types. Based on the preliminary finding from this expedition, the study area is considered free from economic mineral existing. As such there is no conflict between economic minerals and conservation efforts to become a protected area. The geology and its geological evolution are fundamental elements for the integrated conservation of the nature (geodiversity and biodiversity) and cultural heritage.

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Table 1: Mineral resources

Stream sediment sample

(ppm)	TAS 1	TAS 2	TAS 3	TAS 4	TAS 5	TAS 6	TAS 7	TAS 8	TAS 9	TAS 10	TAS 11	TAS 12	TAS 13	TAS 14	TAS 15	TAS 16	TAS 17	TAS 18	TAS 19	TAS 20	TAS 21	TAS 22	TAS 23
Ag	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	6.49	<0.1	<0.1	<0.1	<0.1
As	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
B	6.090	<0.5	4.739	4.947	6.361	6.718	5.371	5.715	4.503	4.532	5.608	5.746	5.746	0.835	3.788	4.692	4.862	3.654	<0.5	<0.5	<0.5	<0.5	<0.5
Ba	<0.5	20.21	0.508	<0.5	11.66	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	27.68	40.49	27.26	23.33	48.29	20.28	26.48	31.09	33.82	32.21
Be	<0.1	0.159	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.231	0.424	0.503	0.805	0.504	0.262	0.308	0.316	0.301	0.174
Bi	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Ca	<0.5	195.2	6.892	3.656	181.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.924	483.2	680.9	467.0	579.7	892.1	389.7	378.7	442.7	413.3	237.2
Co	1.240	1.493	1.191	1.289	1.780	1.297	1.757	1.565	1.799	1.400	1.686	1.482	1.742	3.999	6.262	7.247	9.996	6.590	4.030	4.704	3.724	3.495	2.242
Cr	<0.5	1.720	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	5.777	8.458	8.337	50.09	10.57	50.66	10.28	5.994	5.360	2.467
Cu	<0.5	4.365	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	4.516	8.031	9.977	14.63	9.860	5.613	6.425	5.315	5.677	1.755
Fe	120.0	6153	275.7	108.7	7815	292.4	61.06	64.14	30.37	35.35	101.2	24.52	113.3	6872	13420	16650	30370	13860	8579	6859	9380	7306	3769
Fe (%)	0.01	0.62	0.03	0.01	0.78	0.03	0.01	0.01	0.00	0.00	0.01	0.00	0.01	0.69	1.34	1.67	3.04	1.39	0.86	0.69	0.94	0.73	0.38
La	<0.5	2.480	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	5.792	5.069	2.658	1.768	6.976	3.639	6.767	6.195	6.452	3.407
Li	0.510	7.226	0.881	0.631	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	20.00	34.78	36.15	59.91	42.95	15.33	18.40	20.77	21.16	7.647
Mn	1.738	122.2	3.880	2.097	100.5	3.299	<0.5	0.689	<0.5	<0.5	1.934	<0.5	2.159	159.8	243.9	281.0	256.6	483.8	231.0	187.4	148.6	147.5	234.2
Mo	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.234	<0.1	<0.1	<0.1	<0.1
Nb	5.644	<0.5	1.050	1.149	12.50	12.51	12.50	12.03	11.93	11.95	11.95	11.64	11.48	0.999	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ni	0.659	3.371	0.628	0.703	1.182	<0.5	<0.5	<0.5	0.598	<0.5	0.593	0.706	<0.5	8.303	13.01	14.21	29.38	15.71	20.95	8.940	7.935	8.724	6.069
Pb	8.391	2.798	9.371	9.276	11.59	10.72	9.443	10.45	10.29	10.54	9.713	10.04	9.725	4.727	10.31	12.09	17.14	9.735	5.718	5.985	6.773	4.891	2.362
Sb	1.216	<0.5	<0.5	0.722	0.942	<0.5	1.390	<0.5	1.986	1.200	0.973	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.684	<0.5	<0.5	<0.5	<0.5
Sc	<0.5	0.674	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1.332	2.283	2.623	4.135	2.540	1.132	1.377	1.319	1.332	0.544
Sn	2.242	<0.5	2.104	2.360	2.273	3.157	2.249	2.492	2.700	2.707	2.457	2.626	2.629	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sr	<0.5	4.128	<0.5	<0.5	2.601	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	5.096	5.651	4.305	6.078	7.449	3.267	5.146	4.734	4.349	3.060
Ta	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Th	<0.1	0.461	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.021	0.864	0.305	<0.1	1.311	0.382	1.068	1.044	1.297	0.729
Ti	<0.5	6.652	<0.5	<0.5	1.005	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	13.77	9.739	5.064	3.988	16.73	6.429	8.304	10.03	10.13	4.120
U	<0.1	0.296	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.674	0.378	1.410	0.200	<0.1	<0.1	<0.1	0.370
W	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.783	1.637	2.009	3.489	1.516	0.802	0.796	1.190	0.582	<0.5
Y	<0.5	0.965	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1.439	3.488	3.936	5.023	3.043	2.266	3.955	2.685	1.861	1.177
Zn	1.354	9.086	1.268	0.568	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	16.27	27.58	31.75	49.34	28.90	16.71	16.68	17.16	17.97	9.655
Zr	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.720	0.795	1.220	0.781	<0.5	<0.5	0.577	<0.5	<0.5
Au	<0.01	0.12	0.08	0.08	0.05	0.12	0.25	0.06	<0.01	0.05	0.03	<0.01	<0.01	0.07	<0.01	<0.01	<0.01	<0.01	<0.01	0.23	<0.01	<0.01	<0.01
Hg	7.1	15.3	5.8	7.4	10.1	7.0	5.1	8.4	2.6	5.3	6.9	10.4	9.1	5.2	4.1	5.5	8.0	2.9	6.4	7.9	5.5	4.8	3.9

GENERAL COLLECTION OF PLANTS AND LIVING SPECIMENS FOR SARAWAK HERBARIUM

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INTRODUCTION

Tama Abu mountain range is located at the vast central region of Borneo bordering with Kalimantan and is about 130 km from Miri town. The area is accessible by logging road and took about 10 hours to reach expedition site. Forest in this region are characterized mainly by logged over forest and forests affected by shifting cultivation carried out by the indigenous Penan people (Durst & Brown, 2005).

The importance of biodiversity richness and conservation, as conceived through this scientific expedition has directed a group of researchers from RDID to conduct general botanical collection and living plant specimens for Sarawak Herbarium. Apart from Sandakan and Kepong Herbarium, Sarawak Herbarium is one of the oldest and largest herbarium in Malaysia. Sarawak Herbarium plays an important role as an information centre of plant in Sarawak. It is internationally recognized source for references in scientific botanical study among researchers.

Previously, botanical records from Tama Abu were mostly collected by Dayang Awa and Mr Bernard Lee Meng Hock of Sarawak Forestry Department back in 1985 which also extends to areas such as Bario and Sungai Menalio. Considering botanical collections from Tama Abu were last done 32 years ago therefore not much of the forest area has been studied on and there is no comprehensive and updated data on the flora biodiversity.

The aim of our research study was to make a comprehensive and updated collection of flora from Tama Abu area for Sarawak Herbarium (SAR) and to provide a checklist that will complement baseline data on the biodiversity of Tama Abu area.

METHODOLOGY

The expedition site comprised of various forest types such as Riparian forest, Heath forest, Mixed Dipterocarp Forest (MDF) and Sub-montane forest with range from 500 m to 1200 m asl. Collections were made base on trails surrounding campsite. Total of 14 trails were prepared during the expedition and collections was divided into two (2) groups to maximize the number of fertile specimens collected. Only fertile plants specimens were collected along the trails and their surroundings. All collected plants were described, labeled, photographed and processed accordingly in preparation of Herbarium specimens. The data were later documented in Botanical Research and Herbarium Management Systems (BRAHMS) database and any unidentified specimens will be further identified through references and herbarium collections.





OUTPUT

A total of 433 specimens consist of trees, herbs and shrubs from various plant families were collected from Scientific Expedition of Tama Abu 2017. The largest family collected is Rubiaceae with the highest number of specimens collected total of 54 specimens from genus such as *Ixora, Randia, Argostemma* and *Uncaria* (Table 1). The most speciose family are Orchidaceae (53 species), Zingiberaceae (51 species) and Melastomataceae (43 species). Among interesting species collected are from family Zingiberaceae (*Zingiber jean-abdullahae*), which is the newly described species from previous expedition at Long Banga. Besides that, *Tetrastigma* sp. from Vitaceae also collected which is known as the host plant for species Rafflesiaceae. Some species with high medicinal value such as *Eurycomalongifolia* (Simaroubaceae) and *Labisia pumila* (Myrsinaceae) can also be found within the area. There are some noteworthy specimens that were collected during the scientific expedition such as *Aeschynanthus havilandii* (Gesneriaceae) which is a genus protected in Sarawak, *Macodes petola* (Orchidaceae) is a terrestrial orchid also known as jewel orchid. It is a significant species as it is listed in Appendix II of CITES. This orchid species is highly prized for its ornamental value and also because the rapid decrease of their habitat. This species is rare and critically endangered and thrives on shady, moist and humid rich habitats. (Siregar, C. 2007).

Table 1: Specimens collected according to their families

Family	Number of specimens	Family	Number of specimens
Rubiaceae	54	Myrtaceae	2
Orchidaceae	53	Polygalaceae	2
Zingiberaceae	51	Dracaenaceae	2
Melastomataceae	43	Hanguanaceae	2
Unidentified	37	Vittariaceae	2
Begoniaceae	25	Verbenaceae	2
Gesneriaceae	13	Arecaceae	2
Piperaceae	12	Hypoxidaceae	2
Annonaceae	10	Clusiaceae	2
Myrsinaceae	9	Theaceae	1
Moraceae	8	Fagaceae	1
Euphorbiaceae	8	Fabaceae	1
Meliaceae	6	Pteridaceae	1
Actinidiaceae	6	Rosaceae	1
Leeaceae	6	Pandanaceae	1
Cyperaceae	5	Apiaceae	1
Acanthaceae	5	Lycopodiaceae	1
Poaceae	5	Sapotaceae	1
Burmanniaceae	5	Thelypteridaceae	1
Flacourtiaceae	5	Dipterocarpaceae	1
Lauraceae	5	Tiliaceae	1
Vitaceae	4	Triuridaceae	1
Selaginellaceae	4	Burseraceae	1
Araceae	4	Sterculiaceae	1
Commelinaceae	4	Simaroubaceae	1
Loganiaceae	3	Rutaceae	1
Urticaceae	3	Pentaphragmataceae	1
Smilacaceae	3		

CONCLUSION

From the Tama Abu Scientific Expedition, the total estimate for flora of Tama Abu is numbered about 433 plant specimens which were successfully collected, indicating that the area contains numerous plant species. The botanical collection from the expedition also assists in updating the collection of specimens of Tama Abu in Sarawak Herbarium (SAR). The expedition also allows other researchers from different agencies such as University Malaysia Sarawak (UNIMAS), Sarawak Forestry Corporation (SFC), Forest Department Sabah (SAN), University Putra Malaysia (UPM) and Forest Research Institute Malaysia (FRIM) to help deposit their collection to SAR as contribution for documentation the flora of Tama Abu. Checklist of flora in Tama Abu is still progressing as complete identification and compilation of checklists from different organization is still ongoing.

ADDITIONAL INFORMATION

- Among the limitations of the study besides the limited location of trails, there were also issues with specimens which were unable to identify to species level as there may be species new to science and also due to lack of data on the Tama Abu flora in Sarawak Herbarium (SAR)
- Tama Abu Range is indeed a unique area which contains some interesting flora species. Although it has been logged over but historically it has undergone logging activities some 20 years ago using the helicopter logging method that minimizes the disturbance. Therefore, from the expedition it is found that the area still intact and capable to be a rich biodiversity area with participation from the local communities and local authorities in conservation management of the area.
- The Heart of Borneo's seminar is tentatively to be conducted in June 2018. Researchers from RDID are expected to present the research paper based on the data collected.

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BEGONIA (BEGONIACEAE) OF TAMA ABU PF, SARAWAK FOR SARAWAK HERBARIUM

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Abstract

Preliminary result of botanical survey of Tama Abu PF, Sarawak during the HOB Expedition on 14-27 August 2017 identified a total of eight species of Begonia. These include Begonia fuscisetosa *Sands,* B. papyraptera *Sands,* B. *magentifolia Kiew & S. Juliaand five un-named taxa. Four species are rather common and abundance within the expedition site in Tama Abu PF while another four species are rather localized.*

Keywords: *Begonia, Begoniaceae, Tama Abu PF, Borneo, Sarawak*

INTRODUCTION

Begonia (Begoniaceae) is one of the largest genera of flowering plants in the world with an estimated over 1500 species and Borneo is it centre of diversity (Kiew et al. 2015). Begonias grow in the deeply shaded habitat in lowland to mountain forests. Kiew et al. (2015) listed 97 species of *Begonia* from Sarawak and since then another 25 species have been added (Julia & Kiew, 2016a, 2016b; Julia et al. 2016; Kiew et al. 2016; Lin & Peng, 2017; Lin et al. 2017). This figure representing about 60% of the species in Borneo of the estimated at least 200 species in Sarawak (Julia & Kiew, 2014).

Tama Abu Permanent Forest (PF) is located at Ulu Baram, near the border with Indonesia. The campsite was reachable by 10-12 hours journey by 4WD through logging road from Miri Town. The expedition site was set up near the boundary of Tama Abu PF and along Sungai Baleh. The area consists of logged over forest (at least 20 years old) of mostly mixed dipterocarp forest. The forest is still in fairly good condition despite the past logging activities as shown by the present of many large emergent trees (e.g., *Koompassia malacenssis, Shorea* spp.). Prior to the start of the expedition, a total of 13 transects were established at the expedition site, covering forests at elevations ranging from 600-1000 m a.s.l.

METHODOLOGY

Survey of begonias were done along the well-marked transects established at Tama Abu PF, covering different elevations of mixed dipterocarp and riparian forests along Sungai Baleh. Standard methods of collecting herbarium specimens were applied and the specimens were collected for further identification. Standard plants specimens' notes, habitat and detail localities notes were recorded in the field. For each specimen, up to four duplicates were collected with the first set of duplicates to be deposited at SAR. In the absent of fertile specimen, live plants were collected for propagation at BRC Nursery for further study.

RESULTS

Preliminary species identification resulted in a total of eight species of *Begonia* recorded from Tama Abu PF. Of these, only six species are represented by complete herbarium specimens while two species are sterile. The detail list is shown in Appendix 1. The identification of some species not possible at this moment due to the absent of complete specimens (e.g., *Begonia* sp.4 and *Begonia* sp.5) or the unresolved taxonomic problems of some species such as *Begonia* sp. 1 that represent a complex species. As such, more detail taxonomic study of the species together with other species in this complex group is required.

One Bornean widespread species recorded, namely *B. fuscisetosa*, is common and abundant in the expedition area. This species is easily identified by the present of rows of stiff, dark hairs on its upper leaf surface. The species can be found along all the transects and camp site area where it grows on various microhabitats such as river valleys and earth slopes. In Sarawak, *B. fuscisetosa* is recorded from central to northern part of Sarawak. *Begonia magentifolia* is also another common species observed at Tama Abu PF. The species is first described from Gunung Mulu National Park where it grows in lowland forest at 100-140 m elevation. At Tama Abu PF, the species is recorded from hill forest up to 900 m elevation. Two colour forms of *B. magentifolia* were observed; one with leaves green above and pale green below; the other bronzy green above and magenta below. Its fruit is commonly found with three well-developed wings and three small wings. This is unusual in Bornean *Begonia* that usually have three wings but it is known from a very few species such as B. hexaptera Sands from Brunei (Sands, 1997). Other common species recorded from Tama Abu include *Begonia* sp.1 and *Begonia* sp.2. Usually these common species only collected once by our group but the species were also collected by other researchers of which their specimens were not included in Appendix 1.

The collection of *B. papyraptera* from Tama Abu PF was the second record of the species in Sarawak (the first record was from Long Banga). The species is endemic to Borneo where it is known only from Brunei and Sarawak. In Tama Abu PF, *B. papyraptera* grows in river valleys and near wet and shaded sandstone boulders near riverbank. Unlike the common and widespread *B. fuscisetosa* and *B. magentifolia*, *B. papyraptera* is only known from transect 1, 2 and 10 in Tama Abu PF. Similar to *B. magentifolia*, two colour forms were also observed in *B. papyraptera* i.e., one with leaves green above and pale green below; the other dark green above and magenta below. Other uncommon species recorded from the expedition site include *Begonia* sp.3, *Begonia* sp.4 and *Begonia* sp.5 whereby the species were recorded only from 1-2 transects.

Similar to most forests area in Sarawak, most of the begonias species from Tama Abu PF belong to Section *Petermannia* which is characterised by its erect or cane-like stem, dry capsules and the ovules or seeds are attached to two placentas. Noticeable absent is the species with creeping habit, rosette-like begonia or the low stem begonias. In comparison with Long Banga, three species are in common between Tama Abu PF and Long Banga (i.e., *B. fuscisetosa*, *B. papyraptera* and *Begonia* sp.2). Five species that were recorded from Tama Abu PF were not recorded from Long Banga during the HOB expedition in 2016 (e.g., *B. magentifolia*, *Begonia* sp.1, *Begonia* sp.3, *Begonia* sp.4 and *Begonia* sp.5).

DISCUSSION AND CONCLUSION

In terms of the total number of species, the begonia diversity in Tama Abu is comparable to that of the adjacent Long Banga forest; however, the diversity of begonia in Tama Abu PF is lower compared with the number of species known either Batang Ai NP (17 species) or Lanjak Entimau WS (18 species) (Julia & Kiew, 2016a & 2016b; Kiew et al. 2016; Lin et al. 2014, 2017). This supports observation by Beccari (1904) who wrote "*I was surprised, also, to find in quite limited area no less than five distinct species of begonia, a genus which is by no means rich in species in Borneo*". Even though at this moment, the identity of the great majority of the species are still unknown to us but the collections of complete specimens from the less botanically known area such as Tama Abu PF is very important and will contribute significantly to our knowledge of the diversity and species richness of the begonias in Sarawak. As the study of begonias of Sarawak is progressing, the un-named species that were collected during this expedition will be identified and/or described in near future.

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Appendix 1: List of Begoniaceae collected from Tama Abu PF

Begonia fuscisetosa Sands; Specimen collected: - Transcet 13, Ling *et al.* SFC8401

Begonia magentifolia Kiew & S. Julia; Specimens collected: - Transect 13, Julia *et a*l. SFC8101, Ling *et al.* SFC8413; Transect 11, Julia *et al.* SFC8126

Begonia papyraptera Sands; Specimens collected: - Transect 5, Ling *et al.* SFC8491; Transect 10, Julia *et al.* SFC8117; Transect 2, Suzana *et al.*, SFC8125

Begonia sp.1; Specimens collected: - Transect 3, Julia *et al.* SFC8115; Transect 11, Ling *et al.* SFC8467, Julia *et al.* SFC8131; Transect 13, Ling *et al.* SFC8404

Begonia sp.2; Specimens collected: - Transect 10, Ling *et al.* SFC8401; Transect 5, Ling *et al.* SFC8136; Transect 13, Julia *et al.* SFC8407, SFC8138

Begonia sp.3; Specimens collected: - Transect 3, Julia *et al.* SFC8116; Transect 4, Julia *et al.* SFC8132

Begonia sp.4; Specimen collected: - Transect 4, Julia *et al.* BRC 1700508

Begonia sp.5; Specimen collected: - Transect 4, Julia *et al.* BRC 1700454

ORCHID FLORA OF HIGHLAND FOREST IN THE TAMA ABU RANGE

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Abstract

A total of 129 specimens were collected from pre-created nine trails and one non-trails in Tama Abu forests and they were identified into 117 species and 47 genera. Most of the species documented were epiphytes, including five endemic species and also three newly recorded species for Sarawak and Borneo.The remaining is made up of 15 terrestrials or saprophytes, where some of these species are rarely encountered in the wild, including Nephelaphyllum tenuiflorum *and* Tropidia saprophytica.

Keywords: *orchids, highland forest, Tama Abu*

BACKGROUND OF STUDY

Borneo is one of the world's great centres for orchid diversity that grow epiphytically, lithophytically, terrestrially, or saprophytically in the forests. Concentrated on highland forest of Borneo, there are more than 1,700 species of orchids, all of which have a very high economic value and some are being used medicinally. These species are endangered and may have not yet been found or discovered, because of the loss of habitat resulting progressive anthropogenic forest destruction in the lowland and hill forest areas in the central region of Borneo. For this reason, a research to identify and create an inventory of orchid species that exist in Tama Abu range is a must before they become extinct along with their habitat and to build the framework for their conservation plan.

MATERIALS AND METHODS

A botanical expedition was carried out in a virgin hill to montane forest in the Tama Abu range from 13 August 2017 to 27 August 2017. Several study trails and one non-trail were studied (Table 1). The collected orchids were identified into their respective taxa based on their morphological characters and habits. Reliable references were used in the identification and classification processes such as Beaman et al. (2001), Wood (1997), and Wood (2003).

Current accepted names of the orchids were checked through KEW World Checklist of Selected Plant Families (WCSP). Expert consultations were sought in order to make an accurate identification. The information on the current distribution status was retrieved from published checklists by Wood and Cribb (1994) and Beaman et al. (2001); and international databases such as World Checklist of Selected Plant Families (WCSP), Browse Dutch Natural History Collections: BioPortal (Naturalis), and Swiss Orchid Foundation.

RESULTS AND DISCUSSION

The scientific expedition had accumulated a total of 129 orchid specimens collected from pre-created nine trails and one non-trail in the hill to montane virgin forest of the Tama Abu range. These specimens were identified to 117 species and 47 genera. Also, these species are represented mostly by Epidendroideae subfamily (115 species, 98.3%), where this also portraits the high abundant of epiphytes (111 species, 94.9%) found during the expedition. The remaining with 15 species (12.8%) were found living terrestrially, including six species (5.1%) were saprophytes that lived on decaying organic matter or humus. The different numbers of orchids collected for each trail were generally dependant on the quality of the environment and ecology features which provides availability of the energy flows. Cumulatively, a high abundant of orchid species were collected in Trail 7, including the terrestrial and saprophytic orchids, as this particular habitat was made up of hill and montane vegetations with dense tree canopy and undisturbed ground. The constantly wet environment was not just affecting the ground condition, but also had promoted the growth of mosses on the trees and rocks, which this reflects the high numbers of epiphytes were collected.

The composition of orchids found is very much similar to our previous collection from Long Banga, where the *Bulbophyllum*, *Dendrobium*, and *Coelogyne* were found to be the most abundant species collected, and the remaining are including the *Phaius* and rarely encountered saprophytic orchids; *Aphyllorchis* and *Cystorchis*. Except, three rare orchid species; *Bromheadia rupestris, Bulbophyllum botryophorum,* and *Nephelaphyllum tenuiflorum*, which were newly recorded during the Tama Abu expedition. Also, if it were to compare with the Long Banga expedition, more orchids were collected from the inland hill and montane forests instead of the riverine forest.

Importantly, the highlights of this finding are the discovery of four endemic orchid species to Borneo and one endemic species to Sarawak, and also one new record to Orchids of Sarawak and two new records to Orchids of Borneo. Some newly recorded species are shown in the Plate 1 and Plate 2. The new records, including brief information on their habit, locality, habitat, current distribution status, and significant notes are listed in the following checklist.

Checklist of the newly recorded species to Sarawak found during the current expedition in the hill and montane forest of Tama Abu range, Sarawak.

1. ***Mycaranthes latifolia* Blume;** Epiphyte. Trail 7, Tama Abu range; common. Hill and lower montane forest. Distributed in Sulawesi, Sumatra, Java; in Borneo recorded from Sarawak; and in Peninsular Malaysia is widespread.

Checklist of the newly recorded species to Borneo found during the current expedition in the hill and montane forest of Tama Abu range, Sarawak.

1. ***Phaius indigoferus* Hassk.;** Terrestrial or Lithophyte. Trail 7, Tama Abu range; not uncommon in Peninsular Malaysia. Hill to montane forests. Distributed in Thailand, Java, and Peninsular Malaysia (unspecified). **Notes:** This species has also been found in Long Banga, but the records have not been published.

2. ***Dendrobium appendiculatum* (Blume) Lindl.;** Epiphyte. Trail 4 and Trail 7, Tama Abu range; not uncommon. Lowland mixed dipterocarp forest. Distributed in Thailand, Peninsular Malaysia, Sumatra and Java.

Table 1: List of orchid species collected for the Tama Abu Heart of Borneo (HoB) Scientific Expedition, and details on their habit and abundance.

No	Subfamily		Genera		Taxa	Habit	Trails									Non-trail
							1	2	4	5	7	10	13	14	15	
1	*Epidendroideae*	1	*Acriopsis*	1	*Acriopsis liliifolia* var. *liliifolia* (J. Koenig) Seidenf.	Epiphyte				+						
		2	*Agrostophyllum*	2	*Agrostophyllum cyathiforme* J.J.Sm.	Epiphyte					+					
				3	*Agrostophyllum glumaceum* Hook.f.	Epiphyte					+					
				4	*Agrostophyllum majus* Hook.f.	Epiphyte						+	+			
				5	*Agrostophyllum* sp. (1)	Epiphyte					+					
				6	*Agrostophyllum stipulatum* subsp. *stipulatum* (Griff.) Schltr.	Epiphyte										+
		3	*Aphyllorchis*	7	*Aphyllorchis pallida* Blume	Saprophyte					+					
		4	*Appendicula*	8	*Appendicula anceps* Blume	Epiphyte					+	+	+			
				9	*Appendicula pendula* Blume	Epiphyte						+	+			
				10	*Appendicula* sp. (1)	Epiphyte			+							
				11	*Appendicula* sp. (2)	Epiphyte	+									
				12	*Appendicula torta* Blume	Epiphyte					+					
		5	*Ascidieria*	13	*Ascidieria longifolia* (Hook.f.) Seidenf.	Epiphyte				+						
		6	*Brachypeza*	14	*Brachypeza* sp. (1)	Epiphyte	+									
		7	*Bromheadia*	15	*Bromheadia rupestris* Ridl.	Epiphyte					+					
				16	*Bromheadia scirpoidea* Ridl.	Epiphyte					+					
		8	*Bryobium*	17	*Bryobium hyacinthoides* (Blume) Y.P. Ng & P.J. Cribb	Epiphyte			+							
				18	*Bryobium pudicum* (Ridl.) Y.P. Ng & P.J. Cribb	Epiphyte					+					
		9	*Bulbophyllum*	19	*Bulbophyllum apodum* Hook.f.	Epiphyte					+					+
				20	*Bulbophyllum botryophorum* Ridl.	Epiphyte					+					
				21	*Bulbophyllum farinulentum* J.J.Sm.	Epiphyte				+						

No	Subfamily	Genera		Taxa	Habit	Trails									Non-trail
						1	2	4	5	7	10	13	14	15	
			22	*Bulbophyllum flavescens* (Blume) Lindl.	Epiphyte					+					
			23	*Bulbophyllum grandilabre* Carr	Epiphyte					+					
			24	*Bulbophyllum lobbii* Lindl.	Epiphyte				+						
			25	*Bulbophyllum mutabile* (Blume) Lindl.	Epiphyte				+						
			26	*Bulbophyllum pileatum* Lindl.	Epiphyte										
			27	*Bulbophyllum uniflorum* (Blume) Hassk.	Epiphyte					+					
		10	*Calanthe*	28	*Calanthe crenulata* J.J.Sm.	Terrestrial		+							
		11	*Callostylis*	29	*Callostylis pulchella* (Lindl.) S.C. Chen & Z.H. Tsi	Epiphyte									+
		12	*Campanulorchis*	30	*Campanulorchis leiophylla* (Lindl.) Y.P. Ng & P.J. Cribb	Epiphyte			+						
				31	*Campanulorchis pellipes* (Rchb.f. ex Hook.f.) Y.P. Ng & P.J. Cribb	Epiphyte			+							
		13	*Ceratostylis*	32	*Ceratostylis eria* Govaerts	Epiphyte			+						
				33	*Ceratostylis pulchella* Holttum	Epiphyte					+					+
				34	*Ceratostylis* sp. (1)	Epiphyte					+				
		14	*Claderia*	35	*Claderia viridiflora* Hook.f	Epiphyte					+				
		15	*Cleisostoma*	36	*Cleisostoma* cf. *scortechinii*	Epiphyte				+					
				37	*Cleisostoma discolor* Lindl.	Epiphyte					+				
		16	*Coelogyne*	38	*Coelogyne incrassata* (Blume) Lindl.	Epiphyte				+					
				39	*Coelogyne* sp. (1)	Epiphyte					+				
				40	*Coelogyne* sp. (2)	Epiphyte				+					
				41	*Coelogyne* sp. (3)	Epiphyte			+						
				42	*Coelogyne* sp. (4)	Epiphyte	+								
				43	*Coelogyne* sp. (5)	Epiphyte									
				44	*Coelogyne tomentosa* Lindl.	Epiphyte									+
				45	*Coelogyne trinervis* Lindl.	Epiphyte				+	+				

No	Subfamily		Genera		Taxa	Habit	Trails									Non-trail
							1	2	4	5	7	10	13	14	15	
		17	*Crepidium*	46	*Crepidium* cf. *nemorale*	Terrestrial				+						
				47	*Crepidium lowii* (E. Morren) Szlach.	Epiphyte		+								
		18	*Cymbidium*	48	*Cymbidium* cf. *rectum*	Epiphyte										+
		19	*Cystorchis*	49	*Cystorchis aphylla* Ridl.	Saprophyte										
				50	*Cystorchis javanica* (Blume) Blume	Saprophyte			+							
				51	*Cystorchis stenoglossa* Schltr.	Saprophyte			+							
		20	*Dendrobium*	52	*Dendrobium appendiculatum* (Blume) Lindl.	Epiphyte			+		+					
				53	*Dendrobium bancanum* J.J.Sm.	Epiphyte					+					
				54	*Dendrobium blumei* Lindl.	Epiphyte					+					
				55	*Dendrobium convexum* (Blume) Lindl.	Epiphyte				+						
				56	*Dendrobium rhodostele* Ridl.	Epiphyte					+					
				57	*Dendrobium* sp. (1)	Epiphyte					+					
				58	*Dendrobium* sp. (2)	Epiphyte				+						
				59	*Dendrobium* sp. (3)	Epiphyte				+						
				60	*Dendrobium* sp. (4)	Epiphyte			+							
				61	*Dendrobium* sp. (5)	Epiphyte			+							
				62	*Dendrobium* sp. (6)	Epiphyte				+						
				63	*Dendrobium* sp. (7)	Epiphyte				+						
				64	*Dendrobium tetrachromum* Rchb.f.	Epiphyte	+									
				65	*Dendrobium truncatum* Lindl.	Epiphyte						+	+			
				66	*Dendrobium villosulum* Wall. ex Lindl.	Epiphyte					+					
		21	*Dendrochilum*	67	*Dendrochilum* cf. *filiforme*	Epiphyte					+					
				68	*Dendrochilum odoratum* (Ridl.) J.J.Sm.	Epiphyte					+					

No	Subfamily	Genera		Taxa	Habit	Trails									Non-trail
						1	2	4	5	7	10	13	14	15	
			69	*Dendrochilum pubescens* L.O. Williams	Epiphyte					+					
			70	*Dendrochilum* sp. (1)	Epiphyte					+					
			71	*Dendrochilum* sp. (2)	Epiphyte				+	+					
		22	*Dipodium*	72	*Dipodium scandens* (Blume) J.J.Sm.	Epiphyte				+					
		23	*Eria*	73	*Eria nutans* Lindl.	Epiphyte				+					
		24	*Liparis*	74	*Liparis cespitosa* (Lam.) Lindl.	Epiphyte		+							
				75	*Liparis condylobulbon* Rchb.f.	Epiphyte				+					
		25	*Micropera*	76	*Micropera* cf. *fuscolutea*	Epiphyte									+
		26	*Mycaranthes*	77	*Mycaranthes latifolia* Blume	Epiphyte				+					
				78	*Mycaranthes obliqua* Lindl.	Epiphyte									+
				79	*Mycaranthes oblitterata* Blume	Epiphyte			+						
		27	*Nephelaphyllum*	80	*Nephelaphyllum tenuiflorum* Blume	Terrestrial				+					
		28	*Oberonia*	81	*Oberonia* cf. *brachystachys*	Epiphyte				+					
				82	*Oberonia* cf. *ciliolata*	Epiphyte		+							
				83	*Oberonia fungumolens* Burkill	Epiphyte				+					
				84	*Oberonia padangensis* Schltr.	Epiphyte		+							
				85	*Oberonia* sp. (1)	Epiphyte				+					
		29	*Pennilabium*	86	*Pennilabium struthio* Carr	Epiphyte				+	+			+	
		30	*Phaius*	87	*Phaius indigoferus* Hassk.	Lithophyte				+					
		31	*Phalaenopsis*	88	*Phalaenopsis* cf. *maculata*	Epiphyte				+					
				89	*Phalaenopsis* cf. *modesta*	Epiphyte				+					
				90	*Phalaenopsis* sp. (1)	Epiphyte			+						
				91	*Phalaenopsis* sp. (2)	Epiphyte				+					
		32	*Pholidota*	92	*Pholidota carnea* (Blume) Lindl.	Epiphyte			+						
		33	*Pinalia*	93	*Pinalia* cf. *bractescens*	Epiphyte			+						
				94	*Pinalia* cf. *poryphyroglossa*	Epiphyte				+					
				95	*Pinalia latibracteata* (Ridl.) J.J. Wood	Epiphyte				+					
				96	*Pinalia saccifera* (Hook.f.) Kuntze	Epiphyte			+						

No	Subfamily		Genera		Taxa	Habit	Trails									Non-trail
							1	2	4	5	7	10	13	14	15	
		34	*Plocoglottis*	97	*Plocoglottis plicata* (Roxb.) Ormerod	Terrestrial									+	
		35	*Pomatocalpa*	98	*Pomatocalpa diffusum* Breda	Epiphyte					+					
		36	*Pteroceras*	99	*Pteroceras fragrans* (Ridl.) Garay	Epiphyte			+			+		+		
		37	*Robiquetia*	100	*Robiquetia transversisaccata* (Ames & C. Schweinf.) J.J. Wood	Epiphyte										
		38	*Taeniophyllum*	101	*Taeniophyllum* sp. (1)	Epiphyte					+					
		39	*Tainia*	102	*Tainia scapigera* (Hook.f.) J.J.Sm.	Terrestrial				+						
				103	*Tainia* sp. (1)	Terrestrial			+							
				104	*Tainia* sp. (2)	Terrestrial			+							
		40	*Thelasis*	105	*Thelasis pygmaea* (Griff.) Lindl.	Epiphyte				+						
		41	*Thrixspermum*	106	*Thrixspermum* cf. *calceolus*	Epiphyte				+						
				107	*Thrixspermum* cf. *centipeda*	Epiphyte					+					
				108	*Thrixspermum* sp. (1)	Epiphyte				+						
		42	*Trichoglottis*	109	*Trichoglottis* sp. (1)	Epiphyte					+					
		43	*Trichotosia*	110	*Trichotosia brevipedunculata* (Ames & C. Schweinf.) J.J. Wood	Epiphyte					+					
				111	*Trichotosia gracilis* (Hook.f.) Kraenzl.	Epiphyte				+						
				112	*Trichotosia vestita* (Wall. ex Lindl.) Kraenzl.	Epiphyte					+					
		44	*Tropidia*	113	*Tropidia curculigoides* Lindl.	Saprophyte				+						
				114	*Tropidia saprophytica* J.J.Sm.	Saprophyte			+							
		45	*Vanda*	115	*Vanda* sp. (1)	Epiphyte										+
2	*Apostasioideae*	46	*Apostasia*	116	*Apostasia nuda* R.Br.	Terrestrial				+						
3	*Orchidoideae*	47	*Macodes*	117	*Macodes petola* (Blume) Lindl.	Terrestrial					+					
Total	**3**		**47**		**117**		**4**	**2**	**18**	**28**	**53**	**6**	**4**	**1**	**1**	**10**

MAPANIA (CYPERACEAE) OF HEART OF BORNEO PROJECT AREA, SARAWAK

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Abstract

The occurrences and diversity of Mapania *species in the Heart of Borneo (HoB) project areas were presented. Five selected localities namely Lanjak Entimau Wildlife Sanctuary (LEWS), Ulu Baleh National Park (UBNP), Ulu Mentawai, Mulu National Park (UMMNP), Long Banga (LB) and Tama Abu Production Forest (TAPF) were surveyed during the HoB Scientific Expeditions (2008 - 2017). A total of 27 taxa (25 species) were recorded including new discovery species (*M. angustifolia, M. ballehensis, M. kipas, M. mirae, M. obscuriflora *and* M. sapuaniana*) and three undetermined species (*Mapania *sp.2, sp.4 and sp.9). The LEWS and UBNP that located in Kapit Division shows a greater number of species collected compared others from the eastern north site. The diversity of* Mapania *species in the HoB areas is considered high with about 67.5% from a total number recorded in Sarawak. As many places are yet to be surveyed, the diversity of* Mapania *in the HoB areas might be reaching more than 40 taxa.*

Keywords: *Cyperaceae, Mapania, Lanjak Entimau Wildlife Sanctuary, Ulu Sg. Mentawai*

INTRODUCTION

Cyperaceae is the third largest family in the monocotyledons and seventh largest family in the angiosperms with 106 genera and 5387 species (Govaerts et al. 2007; Zinnirah & Meekiong, 2012). They form a huge morphologically diverse, geographically widespread, and economically important family (Naczi, 2005). The genus *Mapania* first described by Aublet in 1775 and allies form one of the two branches at the base of the Cyperaceae phylogenetic tree (Zinnirah & Meekiong, 2012). This genus is widely distributed in tropical regions from Central and South America, Western and Eastern Africa, Seychelles, parts of tropical Asia, Indonesia, Malaysia, the Pacific islands and Northern Australia (Simpson, 1992; Meekiong et al. 2011). The *Mapania* species are an important component of the herb layer in tropical rainforests and is valued as an ethnobotanical plant for the indigenous folks. Several *Mapania* species are known to be used in basket and mat-making, while others are known to local people for medicinal purposes such as fever remedy.

The genus *Mapania* comprising of 120 species estimated worldwide and the greatest diversity in the genus occurs in Borneo with 36 species recorded, of which 22 species are endemic. However, knowledge on the *Mapania* in Borneo, particularly the pastoral forests of the so-called the heart of Borneo areas of Sarawak is limited due to lack of detailed studies.

MATERIALS AND METHODS

The samples of *Mapania* species were collected from five selected areas in the Heart of Borneo (HoB) Project, *viz*. Lanjak Entimau Wildlife Sanctuary (LEWS), Ulu Baleh National Park (UBNP), Ulu Mentawai, Mulu National Park (UMMNP), Long Banga (LB) and Tama Abu Production Forest (TAPF) during scientific expeditions from 2008 - 2017. A minimum of two sets of specimens was collected from the study areas with the preference of fertile plant (bearing inflorescence or fruit). The samples were identified in the field using field keys by Simpson (1992) and Miraadila et al. (2016a) and verification were done at the Kew (K), Forest Department Sarawak Herbarium (SAR), Forest Department Sabah Herbarium (SAN) and Herbarium of Universiti Malaysia Sarawak.

RESULTS

A total of 27 taxa representing by 22 species and 3 in-determined species were collected and identified from the five selected of the HoB project areas. The number recorded was considered high with 67.5% of the total number recorded for Sarawak. List of the species and comparison on the occurrences of the species from the five selected areas was showed in Table 1.

Predominantly the numbers of the species from three locations were comparable with 16 taxa each recorded for LEWS and UBNP, 15 taxa recorded from UMMNP. The occurrences of species from the LEWS, UBNP and UMMNP not much different, except few species that were found very localized. *Mapania sapuaniana* Shabdin was so far recorded only for Sg. Joh of LEW (Shabdin et al. 2013) and *M. obscuriflora* D.A. Simpson from Ulu Sepali, LEWS was a new geographical for Sarawak. *Mapania ballehensis* Miraadila, Shabdin & Meekiong, *M. kipas* Miraadila, Shabdin & Meekiong and *M. mirae* Shabdin & Meekiong (Miraadila et al. 2016a) were the three new species discovered from UBNP during the 2015 HoB Scientific Expedition. An enigmatic *M. angustifolia* Uittien which was described based upon a single collection from Mount Dulit *(Richards 1397)* also resolved with discovery of few populations in UBNP. While *M. hispida* D.A. Simpson and *Mapania* sp.4 were recorded only from UMMNP. *Mapania hispida*, however, is a common species that found in lowland coastal areas throughout Sarawak. The status of *Mapania* sp.4 was still unresolved due to the lacked information of the floral parts.

The *Mapania* collections from higher altitudes of LB and TAPF (more than 500 m a.s.l.) show decreasing in number. Only eight and nine *Mapania* taxa were recorded from LB and TAPF respectively. The result is agreeable with Miraadila (2018) stated that the distribution of *Mapania* species is more at the lowland area compare the highland forests (above 450m altitudes).

DISCUSSION

It was concluded that the occurrences of the genus *Mapania* from five selected localities of the HoB project areas were considered very diverse and high density. With the discovery of four new species (*M. ballehensis, M. kipas, M. mirae* and *M. sapuaniana*) and one new geographical record for Sarawak (*M. obscurifolia*) from the HoB project areas showed the significance of this project toward the documentation of flora for Sarawak. A rediscovery of *M. angustifolia* which was described based upon single collection (*Richards 1397* - Mount Dulit, 1932) verified the status of this species and localities in Sarawak. The LEWS and UBNP which are located in the Kapit Division (Central Sarawak) shows greater number than other study sites which are on the Eastern West of Sarawak. As many places in the HoB project areas are yet to be surveyed, it is believed that the number of *Mapania* species might be reaching more than 40 taxa.

Table 1: Comparison of the genus *Mapania* from selected areas in the Heart of Borneo (HoB Project); LEWS, Ulu Mentawai, Mulu NP, Ulu Baleh NP, Long Banga and Tama Abu PF.

Mapania species	***LEWS, Kapit***	***Ulu Mentawai Mulu NP, Miri***	***Ulu Baleh NP, Kapit***	***Long Banga Ulu Baram, Miri***	***Tama Abu PF Ulu Baram, Miri***
M. angustifolia Uittien			√		√
M. ballehensis Miraadila, Shabdin & Meekiong			√		
M. bancana (Miq.) Benth. & Hook.f. ex B.D. Jackson				√	√
M. borneensis Merr.	√		√		
M. caudata Kuk		√	√	√	
M. cuspidata (Miq.) Uitten var. angustifolia	√	√			
M. cuspidata (Miq.) Uitten var. cuspidata	√	√	√	√	
M. cuspidata (Miq.) Uitten var. petiolata	√	√			√
M. debilis C.B. Clarke ex Ridl.		√	√		√
M. enodis (Merr.) C.B. Clarke	√		√		√
M. hispida D.A. Simpson		√			
M. kipas Miraadila, Shabdin & Meekiong			√		
M. latifolia Uitten	√	√	√	√	√
M. longiflora C.B. Clarke	√				
M. meditensis D.A. Simpson	√	√			

Mapania species	LEWS, Kapit	Ulu Mentawai Mulu NP, Miri	Ulu Baleh NP, Kapit	Long Banga Ulu Baram, Miri	Tama Abu PF Ulu Baram, Miri
M. mirae Shabdin & Meekiong			√		
M. monostachya Uitten		√	√		
M. obscurifolia D.A. Simpson	√				
M. palustris (Hassk. ex Steud) F.-Vill. var. palustris	√	√	√	√	√
M. richardsii Uitten	√		√		
M. sapuaniana Shabdin	√				
M. sessilis Merr.	√	√			
M. squamata (Kurz) C.B. Clarke			√		√
M. sumatrana (Miq.) Benth. subs. sumatrana	√			√	
M. tenuiscapa C.B Clarke		√	√		
M. wallichii C.B. Clarke	√	√	√	√	
Mapania sp.2	√				
Mapania sp.4		√			
Mapania sp.9				√	√
Total No. of species	**16**	**15**	**16**	**8**	**9**

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NOTES ON THE GENUS *MAPANIA* (MAPANIOIDEA; CYPERACEAE) FROM TAMA ABU, SARAWAK

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Abstract

A list of Mapania species from Tama Abu PF of Heart of Borneo (HoB) area is presented in this paper. Tama Abu PF is considered fairly rich with Mapania species. Nine taxa were recorded of which one species is still undetermined.

Keywords: *Mapania, Cyperaceae, Tama Abu, Borneo*

INTRODUCTION

The cosmopolitan sedge family Cyperaceae is the third-largest family in the monocots, after orchids and grasses, with 106 genera and c. 5400 species. A wide variety of habitats are occupied by sedges, from swamps to sand-dunes and tropical forests to high arctic tundra. Several species are ubiquitous weeds which occur in a variety of environments; others are endemic, narrowly distributed and of conservation concern. The family Cyperaceae comprises two subfamilies, Mapanioideae and Cyperoideae. Two tribes are assigned under Mapanioideae, namely Hypolytreae and Chrysitricheae. *Mapania* Aubl., a genus in tribe Hypolytreae contains a group of mostly forest dwelling sedges which are widely distributed throughout the tropics (Simpson 1992). Borneo and Peninsular Malaysia are considered to be centers of diversity for *Mapania* with 25 and 16 species recorded respectively (Simpson 1992) and new species continue to be discovered (Shabdin et al. 2013a). Shabdin et al. (2013a; 2013b; 2016) added three species into the list and then the number has drastically increased to 43 taxa with many new species discovered in recent years (Miraadila & Shabdin, 2016; Miraadila et al. 2016a; 2016b).

Locally known as *leee* by the Saban people of Long Banga or *Ra'ah* by the Penan of Tama Abu, *Mapania* species is not a popular plant collected by botanists or plant collectors due to not attractive or difficult to dealt with (leaf with sharp prickles) as well as for herbarium specimen due to it bulkiness.

CHECKLIST OF MAPANIA SPECIES

1. ***Mapinia angustifolia*** Uittien, *rec. Trav. Bot. Neerl.* 32 (1935): 32, *A. Rev. of the Gen. Mapania (Cyperaceae)* (1992): 76. Malaysia, Borneo, Sarawak, Kapit. Type: *Richard 1397* (holo: K.!, iso: U).

   Note: Moderately robust, rhizomatous, cataphylls present (ovate to lanceolate). Leaf sheaths chocolate brown, culms 1 - several. Lower involucral bracts very small, hardly visible against the spike.

   Trail recorded: Trail No. 10

2. ***Mapania bancana*** (Miq.) Benth. & Hook. *f. ex* B.D. Jackson, *Ind. Kew* 2 (1895): 163, Simpson, *A. Rev. of the Gen. Mapania (Cyperaceae)* (1992): 49. Indonesia, Sulawesi. Type: *Amand s.n.* (K.!)

   Note: Moderately robust, stoloniferous. Leaves mostly basal, 1 cauline, up to 120 cm long, Inflorescence smaller (than *M. sumtarana* (Miq.) Benth.). Basal inflorescence bract foliaceous.

   Trail reocorded: Trail No. 12

3. ***Mapania cuspidata*** (Miq.) Uittien var. ***petiolata***, *J. Arn. Arb.* 20 (1939): 213, Simpson, *A. Rev. of the Gen. Mapania (Cyperaceae)* (1992): 113. Borneo, Malaysia, Sarawak, Matang. Type: *Ridley s.n.* (lectotype: K!).

   Note: This variety can be differentiated by having leaf-blade linear or linear elliptic, usually more than 8 times longer than broad and apex obtuse to rounded.

   Trail Recorded: Trail No. 9 and 10

4. ***Mapania debilis*** C.B. Clarke ex Ridl., *J. Str. Br. R. As. Soc.* 46 (1906): 46, Simpson, *A. Rev. of the Gen. Mapania (Cyperaceae)* (1992): 93. Malaysia, Borneo, Sarawak, Matang. Type: *Ridley 12344* (Holo: K.!).

   Note: Moderately robust to robust, rhizomatous, form dense tussocks clump. This species can be recognized by the combination of narrow leaves and small inflorescence with up to 5 spikes per plant.

   Trail recorded: Trail No. 1, 5, 6, 8, 9 & 10

5. ***Mapania enodis*** (Miq.) C.B. Clarke, *Kew Bull. Add. Ser.* 8 (1908): 53; Simpson, *A. Rev. of the Gen. Mapania (Cyperaceae)* (1992): 81. Indonesia, Sumatra. Type: *Teysmann 3685* (Bo, U).

   Note: Robust, rhizomatous herbs. Leaves basal, up to 110 cm long, blade narrowly linear, apex very gradually narrowed. Inflorescence terminal, composed of 1 spike but sometimes up to 5 spikes.

   Trail recorded: Trail No. 5, 6 and 12

6. ***Mapania latifolia*** Uittien in *Rec. Trav. Bot. Neerl.* 32 (1935): 199; Simpson, A. *Rev. of the Gen. Mapania (Cyperaceae)* (1992): 105. Borneo, Malaysia, Sarawak. Type: *Richards 1556* (holo: K!)

   Note: Similar to *M. cuspidata, M. hispida, M. meditensis* and *M. zinnirahae* in having a distinct pesudopetiole but can be differentiated by stoloniferous, trigonous to subtriquetrous. Basal inflorescence bract foliaceous.

   Trail recorded: Trail No. 12

7. ***Mapania palustris*** (Hassk. ex. Steud.) F.-Vill. var. ***palustris***, *Nov. App.* (1882): 309, Simpson, *A. Rev. of the Gen. Mapania (Cyperaceae)* (1992): 66. Indonesia, Java. Type: *Zollinger 929* (Holo: P, iso: BM, BR, L.).

   Note: Robust, rhizomatous, culms 2 - 5 per plant. Leaves basal, up to 280 cm long or more, blade linear, apex very gradually narrowed, acuminate to long acuminate, 3-nerved with distinct secondary nerves, flat to inverse w-shaped in cross-section. Inflorescence terminal, globose compose of 1 - 20 or more spikes.

   Trail recorded: Trail No. 5, 12

8. ***Mapania squamata*** (Kurz) C.B. Clarke. *Kew Bull. Add. Ser.* 8 (1905): 53, Simpson, *A. Rev. of the Gen. Mapania (Cyperaceae)* (1992): 76. Indonesia, Java. Type: *Zippelius s.n.* (Holo: Bo).

   Note: Robust to very robust, rhizomatous, cataphylls present (ovate to lanceolate). Culms several, spreading to erect. Leaves basal, up to 150 cm long. Inflorescence terminal composed of 1 - 5 spikes. Spike with large spicoid and floral bracts.

   Trail recorded: Trail No. 9 & 10

9. ***Mapania*** sp.9 ined.

   Note: Plant moderately robust to robust, rhizomatous. Culm solitary, erect. Leaves basal, up to 180 cm long. Inflorescence terminal composed of 1 - 3 spikes. Spicoid large with thin pinkish brown margin.

   Trail recorded: Trail No. 10



Mapania species from Tama Abu PF. 1: *Mapania squamata*; 2: *Mapania enodis*; 3: *Mapania palustris*; 4: *Mapania* sp.9

DISCUSSION

Tama Abu is considered fairly rich in *Mapania* species. Nine taxa were identified from the collecting including unusual taxa. *Mapania* sp.9 is similar to *M. squamata* and *M. rumputensis* Shabdin & Meekiong, a newly described species from Sri Aman, but can be differentiated by floral and fruit morphological. With many places are yet to be surveys, it is believed that the diversity of *Mapania* is Sarawak might be reaching more than 50 species.

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STUDY ON THE FRUIT MORPHOLOGY OF *MAPANIA* SPECIES (CYPERACEAE) EASTERN NORTH OF SARAWAK

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Abstract

The study of fruit morphology of Mapania *species from Eastern North of Sarawak is presented in this paper. The samples were collected from various localities in the Eastern North of Sarawak, includes Lambir Hills National Park (LHNP), Bukit Sembiling Nature Reserve (BSNR), Ulu Mentawai, Mulu National Park (UMMNP), Long Banga (LB) and Tama Abu Production Forest (TAPF). Matured fruits were obtained by dissecting the spike. Morphological characteristics were observed use USB Portable Microscopes (500x) and parameters were measured use digital caliper. The morphological characteristics were compared and analyzed. Fruits of M. meditensis were the biggest (9 mm long, 4.25 mm diam.) and the smallest fruit was M. debilis (2.45 mm long, 1.5 mm diam.). Overall the fruit morphological was very useful to differentiate the species level particularly the sizes, exocarp appearance and the present of costae.*

Keywords: *fruit of* Mapania, Mapania, *Cyperaceae, Eastern North Sarawak*

INTRODUCTION

The acceptation of fruit term for *Mapania* species might be confusing and not agreeable amongst botanists. Due to its small in size, many botanists are referred it as seed. According to Koyama (1969, 1971) interpreted the fruits as compound structures and considered the outer layer to be an utricle adnate to the endocarp, the inner layer representing the fruit proper. His view was supported by Simpson (1992) and thus we as well followed their argument this small part in the spicoid should call as 'fruit".

According to Simpson (1992), he emphasizes the important of fruit characteristics in identification of *Mapania* to species level. However, no study on the fruit morphological has been conducted in Southeast Asia in general and Sarawak particularly. Therefore, the aim of this study is gathering information on the fruit morphology of *Mapania* from Sarawak.

MATERIALS AND METHODS

Fifteen *Mapania* species from Eastern North of Sarawak were randomly selected for this study. The samples were collected from various localities on the Eastern North of Sarawak, such as Lambir Hills National Park (LHNP), Bukit Sembiling Nature Reserve (BSNR), Ulu Mentawai, Mulu National Park (UMMNP), Long Banga (LB) and Tama Abu Production Forest (TAPF). Voucher specimens were collected following the standard protocols as suggested by Bridson and Foreman (1992) with preference of fertile plant. The specimens were verified at the Forest Department Sarawak Herbarium (SAR), Forest Department Sabah Herbarium (SAN) and Herbarium of Universiti Malaysia Sarawak.

The fruits of *Mapania* were obtained by dissecting spike and only matured fruits were used for this study. The morphological characteristics were observed via USB Portable Microscopes (500x) and parameters were measured use digital caliper.

RESULTS AND DISCUSSION

The fruits of *Mapania* are bicarpellate or tricarpellate in which associated with the number of stigmas (Simpson, 1992; Miraadila, 2018). Usually were small from 1 mm to 8 mm diameter. Due to smaller size, few taxonomists preferring seed as correct terminology but, in this study, fruit was preferred to follow Simpson's terminology (Simpson, 1992). All the morphological and parameters of the fruits were observed and measured (Table 1). Ultimately, the fruits shapes of *Mapania* species recorded in Sarawak were ellipsoid, obovoid or ellipsoid-obovoid except three species with distinctively different. *Mapania enodis* has lageniform shaped, *M. sembilingensis* and *M. squamata* with obovoid shaped.

The fruits colour before maturity were recorded and noted that most the *Mapania* species from Eastern West of Sarawak having brown or black colour except *M. sembilingensis* and *M. tenuiscapa* with yellowish colour. The colour however, turning to brown, dark brown or black when fully matured. In term sizes, *M. meditensis* having the longest fruits with 9 mm average, followed by *M. unimasiana* and *M. enodis* with 8.25 mm and 7 mm long respectively. The shortest fruits belong to the *M. debilis* (2.45 mm long) and *M. sembilingensis* (2.5 mm long). While, the broadest fruits were *M. meditensis* with 4.25 mm diameter followed by *M. wallichii* with 3.35 mm diameter. Three species were recorded below 2 mm diameter (1-1.9 mm diameter averages) namely *M. angustifolia, M. bancana* var. *bancana* and *M. debilis*.

Most of the species recorded with apiculate apex and stipitate base fruits. Only few species recorded with distinctive apex or base. Field observations instituted that the fruit exocarp correlated to the costae. Most of the species recorded with succulent exocarp and normally without costae, while the species with hard exocarp usually with distinct (present) costae.

All these characteristics hereafter was very useful to differentiate the species. The fruit surface of all *Mapania* species in Sarawak recorded as coarsely appearance, as either wrinkle or tubercles except two species, *viz. M. bancana* var. bancana and *M. sumatrana* var. s*umatarana*. According to Simpson (1992), this was part of criterion to group those two species into section *Thoracostachyum*.

Table 1: Details on the fruit morphological of *Mapania* from eastern west of Sarawak

Species / Taxa	Shape	Colour (before maturity)	Average Length (mm)	Average Diameter (mm)	Apex	Base	Exocarp	Costae
M. angustifolia	ellipsoid	brown	3.7	1.9	conical	stipitate	succulent	absent
M. bancana var. *bancana*	ellipsoid	brown	3.15	1.55	acuminate	rounded	hard	present
M. cuspidata var. *petiolata*	ellipsoid	brown	6.4	3.25	apiculate	stipitate	succulent	absent
M. debilis	ellipsoid	brown	2.45	1.5	apiculate	stipitate	succulent	absent
M. enodis	lageniform	mid-brown	7.0	3.25	apiculate elongated	stipitate	succulent	absent
M. latifolia	ellipsoid	brown	3.9	2.6	apiculate	stipitate	succulent	absent
M. longiflora	ellipsoid	brown	6.0	2.35	apiculate	stipitate	succulent	absent
M. meditensis	ellipsoid	brown	9.0	4.25	apiculate	stipitate	succulent	absent
M. multiflora	ellipsoid	brown	4.0	2.0	apiculate	stipitate	hard	-
M. palustris var. *palustris*	ellipsoid	brown	4.25	2.9	apiculate	stipitate	succulent	absent
M. sembilingensis	obovoid	yellowish	2.5	2.15	apiculate	stipitate	succulent	absent
M. squamata	obovoid	brown	6.0	3.25	apiculate	stipitate	succulent	absent/ present
M. tenuiscapa	ellipsoid	yellowish	3.45	2.35	apiculate	conical	hard	absent
M. unimasiana	ellipsoid	black	8.25	3.15	acute	truncate	succulent	-
M. wallichii	ellipsoid	brown	4.85	3.35	apiculate	stipitate	succulent	absent



Figure 1: Fruit of selected Mapania species from Eastern North of Sarawak. 1. *Mapania cuspidata* var. *petiolata*; 2: *M. debilis*, 3: *M. latifolia*, 4: *M. longiflora*, 5: *M. meditensis*, 6: *M. palustris var. palustris*, 7: *M. unimasiana*, 8: *M. sembilingensis*.

CONCLUSION

Overall, the fruit morphological was very useful to differentiate the species level particularly the sizes, exocarp appearance and the present of costae. However, the problem that encountered during field surveys was difficulty to get fruiting plants. For example, *M. hidiriana* Miraadila, Shabdin & Meekiong which usually found with sterile or empty spike.

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FERNS OF TAMA ABU

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INTRODUCTION

The island of Borneo is within the hot spot diversity of Malesia region. Despite the great effort to study the flora of this region, and of Borneo in particular, a proper flora is still lacking. Few areas have been properly studied as the Kinabalu Mountain and some limestone substrate complex as the Mulu area. Compared with the Neotropics the Malesia region tends to have lower number of fern species but higher number of genera. This shows that at the beta diversity level, Malesia region has higher diversity as well as a more complex phylogenetic structure. This implies a more genetic diversity and related conservation issue. For example, a comparison between the fern diversity from Kinabalu Mountain and the Bolivian Andes show that Kinabalu has 14% and 23% higher number of genera and family respectively. We can conclude that the fern diversity within the island of Borneo is still poorly known and little is known about its distribution and contribution to the forest function and its ecosystem service.

In figure one is presented the distribution of Polypodiaceae family (data from GBIF) from Sarawak, Sabah, Brunei and Kalimantan, has we can see that the study site Tama Abu has only one collection number for one of the richest fern family, Polypodiaceae.

As Assistant Professor, from the University of Brunei Darussalam I have joined the HoB Expedition on the Tama Abu mountain complex. As mentioned in the proposal, during the entire period of the expedition, I conducted general collection of ferns and fern allies plant species as well as ecological study with plot-based method.

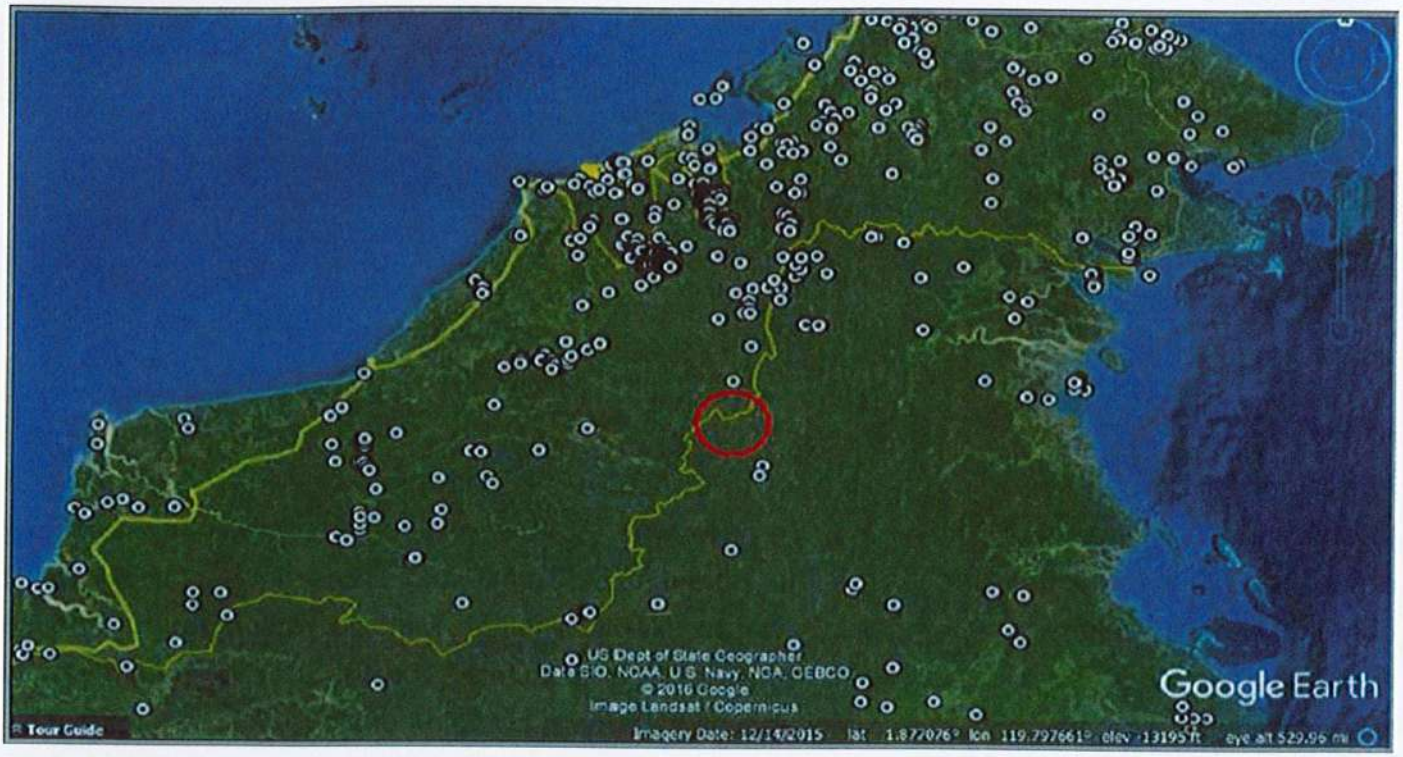


Figure 1: Distribution of Herbarium records from GBIF database for the *Polypodiaceae* family recorded in the three countries of Borneo. Every circle represents a single collection number/herbarium voucher. As it is indicated from the red circle the Tama Abu area has only a single collection number and a second close to it. *Polypodiaceae* is the richest fern family and despite it Tama Abu has only one record, it shows the poor knowledge we have for ferns and ferns-allies species diversity in this region.

FLORISTIC COMPOSITION

The collection was primarily conducted along the forest trails already provided by the organization of HoB. Moreover, further collections were conducted along and around the camp base. Samples have been equally divided between the herbarium of University of Brunei Darussalam and Forestry Department of Sarawak, Kuching.

Community distribution: The spatial pattern distribution of fern species in tropical areas is still poorly known. Fern species well known to be adapted to humid and shady area where light intensity is low and humidity concentration is high. Other studies have demonstrated the decrease of species form high humidity area to a drier environment and at the same time a change in species composition along this gradient. In this study we address the following questions: 1) How wide is the riparian zone in the Tama Abu mountain complex? 2) How species community composition changes along the humidity gradient?

In total have been conducted 24 plots within the Tama Abu study area, 18 close to river basin and 6 plots at the mountain summit where forest structure resulted dissimilar from the other mountain side. More specifically the river basin area long the mountain side were typical submountain mix dipterocarp forest whereas the summit was represented by a poor soil condition with a forest structure characterized by a drier condition and a more open canopy structure.

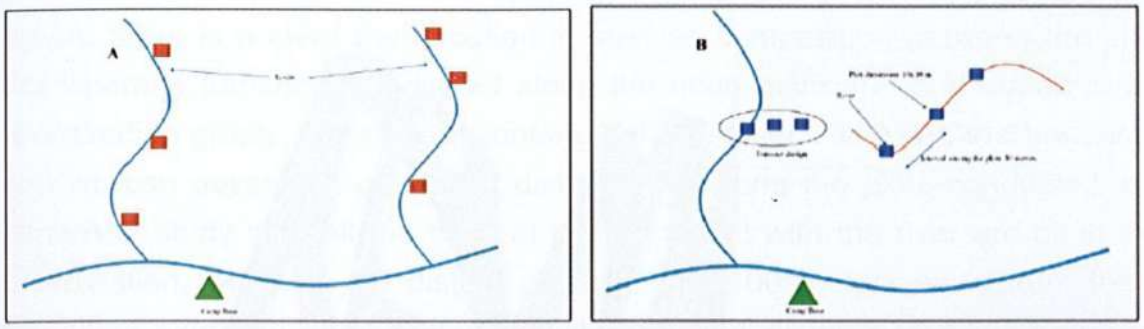


Figure 2: The transect design in the Tama Abu site. A. Six transects were conducted along the two tributaries of the main river close to the Camp base. Two extra transects were conducted at the mountain summit, not included in the map. B. Each transect consist of three plots of 10x10m with an interval of 50 meter between each other. The first plot was conducted close to the river while the third at 100m away from the river.

In total 164 collection number have been collected, all the samples have minimum of two duplicated. Of this collection number and relative vouchers, from a preliminary study has been identified 97 ferns and ferns allies' species, belonging to 37 general and 17 families. The three most abundant families were represented by Polypodiaceae (15 species), Theypteridaceae (13 species) and Athyriaceae (12 species). Despite the small area surveyed the number of species collected was particularly high showing the high richness occurring in this part of mountainous area of Sarawak. The species *Haplopteris pluridichotoma* (Fig. 2) collected on the mountain top of the study area resulted to be a new record for the area and the fifth record for the entire species. Voucher of this species are deposited in National Herbarium of Malaysia (Kuala Lumpur), Singapore, Kew Garden (UK) and Bogor Indonesia. This species is endemic to Borneo and so far, collected only in Kalimantan and central Sarawak. All the records are within a radius of less then 100km, showing that this species has a very restricted distribution and particularly on the mountain top.



Figure 3: Voucher of *Haplopteris pluridichotoma*, this species was also collected on the mountain top of Tama Abu mountain increasing the international collection from 6 records to 8 herbarium records. The species is confined in the northern part of Sarawak and Kalimantan, only above 1800m. The species belong to the Pteridaceeae family and *Haplopteris* genus. The morphology is very distinct from the common Haplopteris which are not divided and \rarely with a frond of this wide dimension.

ECOLOGICAL DIFFERENTIATION

The ecological structure of fern community within the river basin is at the moment of this report under elaboration. Results will be presented to the final seminar organized in Kuching in few months from now. What will be possible to mention so far that the spatial distribution of the species collected already show a restricted ecological niche of many fern species and a drop of species diversity along the humidity gradient. A few species have a wider distribution but still ecological related with deep mature forest structure. As we can see from the Ordination Analysis (NMDS) Fig.4A, there is a clear demarcation in species composition between the sites above 1800 meters whereas transects conducted along the river basin are all grouped in a different area of the ordination graph. When we disentangle the dataset, removing the transect from the mountain top we can observe a pattern of distribution among the plots conducted in the river basin of Tama Abu study site. All the plots at direct contact with the river are all in the central part of the ordination, whereas the distant plots 50 and 100 meters away from the river are distributed in either side of the ordination. Despite the small distance, only 100 meters, we are already able to see a clear ecological difference among the plots and showing a clear ecological niche of many fern species of northern Sarawak. A more detailed analysis will result with better ecological interpretation of this data. It will all be presented at the HoB conference, organized for this expedition.

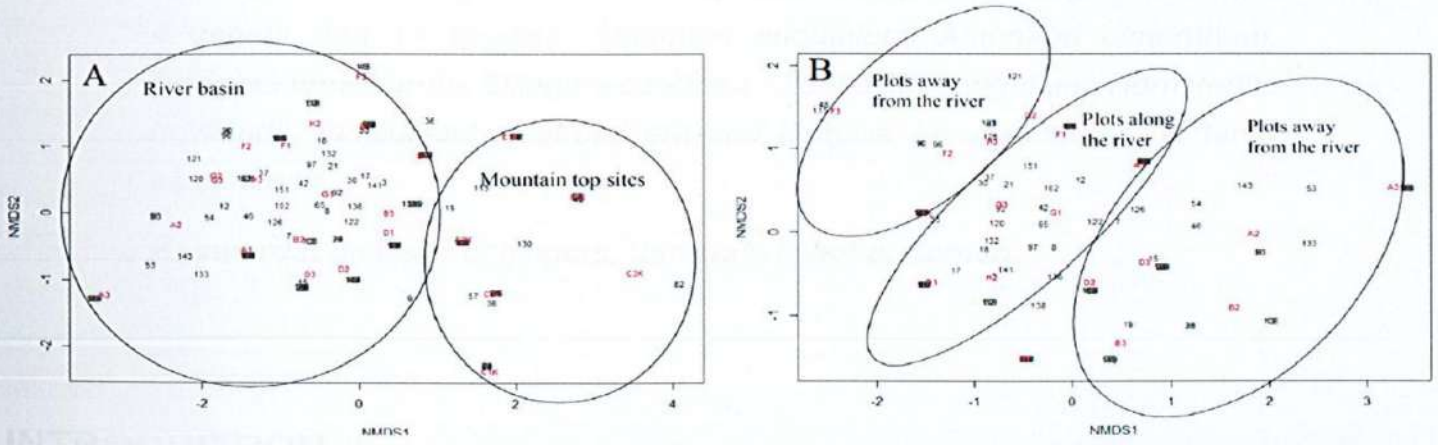


Figure 4: The Ordination Analysis, NMDS, was run with and without the transects from the mountain top. In A is a clear demarcation between the higher mountain top transect with a specific fern flora characteristic. In B the dataset without the mountain top transect. Here we can see a broad division between plots conducted along the river A1, B1, D1, F1 and G1 whereas the plots away from the river are positioned at their side.

CONCLUSION

In conclusion, we can highlight that the study area of Tama Abu has a high diversity of fern species. These results increase our knowledge of species distribution in the northern part of Sarawak. Moreover, several species have few collections deposited in national and international herbaria and this is a crucial contribution for the scientists who are working on species distribution modelling, climate change scenario and conservation action. The patter of species distribution in the river basin not only contribute on the knowledge of species distribution but more important on the ecological niche requirement of these species and the knowledge of the autecology and synecology of fern species.

ACKNOWLEDGEMENT

I would like to thank the Hearth of Borneo Initiative, the Sarawak Forestry Department all the coordinators, guide, helpers, drivers and chef for their remarkable work to allow this expedition to be a success.

PROVISIONAL CHECKLIST OF GINGERS FROM TAMA ABU PF

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Abstract

Zingiberaceae species are a diverse group of rhizomatous, aromatic perennial herbs with the centre of diversity in South-east Asia. The Zingiberaceae diversity in the Tama Abu Production Forest (TAPF) documented in this paper is a result of the survey during the Heart of Borneo (HoB) Scientific Expedition 2017. A total of 44 species belonging to 12 genera and 2 tribes were collected and recorded. The tribe Alpinieae represented by 8 genera and 30 species whilst tribe Zingiberaea with 4 genera and 14 species. Amomum anomalum, Amomum dimorphum, Etlingera brevilabrum, Etlingera coccinea, Globba atrosanguinea, Hornstedtia havilandii, Plagiostachys strobilifera and Zingiber sp. nov. are considered as common.

Keywords: *diversity of gingers, Sarawak, Heart of Borneo*

INTRODUCTION

Zingiberaceae species are rhizomatous, perennial herbs which are aromatic in any or all of its plant parts. The family Zingiberaceae comprises of 57 genera (includes four recently described genera; *Johalia, Kedhalia, Myxochlamys* and *Newmannia*) and more than 1,500 species worldwide with its centre of diversity in South-east Asia. Malaysia harbours almost 40% of the world genera and close to 30% of the world taxa (Ibrahim et al. 2011). Of these, 19 genera are known to be from Sarawak with over 180 species, includes the genus *Haniffia*, a new geographical record for Sarawak that recently discovered from Kuching Division (Wong et al. 2014). Zingiberaceae is diverse in its habit and habitat thriving in shaded forests, in mixed dipterocarp, kerangas, peat swamp, limestone, riverine habitat, secondary forests or alluvial forests with few species in montane and mangrove forests. Majority of the species are terrestrial with some species are occurring as epiphytes on the tree trunks or branches and as well as lithophytes on the rock surfaces.

The Tama Abu Production Forest (TAPF) is one of the areas in the Sarawak's Heart of Borneo (HoB) Initiative Project. There is very little information on plant diversity, particularly Zingiberacea have been conducted in the TAPF areas. Therefore, the aim of the survey was to document the occurrence and diversity of gingers in the TAPF.

MATERIALS AND METHODS

The field survey was conducted during the scientific expedition (13-19 August 2017). About established trails were surveyed. At each trail surveyed, the Zingiberaceae species was recorded and photographs were taken. The herbarium collection methods were followed by the standard herbarium method by Bridson and Forman (1992) with the preference of fertile plant. Identification of specimens and classifications were based on various keys, monographs and revisions. Specimen verifications were done at the Forest Department Sarawak Herbarium (SAR), Forest Department Sabah Herbarium (SAN) and Herbarium of Universiti Malaysia Sarawak.

RESULTS AND DISCUSSION

The surveyed enumerated 44 taxa from 12 genera and 2 tribes that included 34 identified taxa from 12 genera and 10 unidentified taxa from 9 genera (some are being studied). Of the 34 identified taxa, one is new to science and manuscript is being prepared. *Amomum anomalum, A. dimorphum, Etlingera brevilabrum, E. coccinea, Globba atrosanguinea, Hornstedtia havilandii, Plagiostachys strobilifera and Zingiber* sp. nov. are the most common ginger encountered in the TAPF.

Of the 12 genera recorded, genus *Etlingera* has the highest representative with seven taxa recorded followed by *Amomum* and *Zingiber* with six taxa each. The result showed significant similarity with Lanjak Entimau Wildlife Sanctuary (LEWS), where *Etlingera* was the most common genus recorded (Ibrahim et al. 2011). The tribe *Alpinieae* predominates (8 genera, 30 species) and *Zingibereae* (4 genera, 14 species).

The number of Zingiberaceae species recorded in this expedition is lower due to many factors. Amongst the major factor is most of the gingers are not in flowering. Without flowers or fruits, it is almost difficult to identify even up to genus level except for the taxa with a prominent characteristic such as genus *Zingiber*. The genus *Zingiber* can be differentiated from other genera by the reddish colour of lowermost of the pseudostem and pulvinus petiole. Furthermore, most of the trails were established along the terrain or slopes which were not a seemly good condition for the gingers to grow. According to Lamb et al. (2013) and Poulsen (2006), most of the gingers are preferences flatterer, wet and damp places along the streams or gullies.

The interesting finding from this expedition was the discovery of one new *Zingiber* species (*Zingiber* sp. nov.). This new species also was discovered during the Long Banga Scientific Expedition (2016). The species forms a clump of leafy shoots 1 - 1.2 m tall, up to 3 - 5 plants per clump. Inflorescences are fusiform spikes, up to 10 or more per clump. Morphologically appearance is similar to *Z. flagelliforme* Mood & Theilade but distinct by the floral characteristics. Details description and manuscript of this new species is being prepared.

With a very short surveyed period, we still managed to collect more than 40 taxa which accounting for 55% of the total genera and more than 23% of the species recorded for Sarawak, it is clear that diversity of Zingiberaceae in TAPF is diverse and we believed that the number of species might be reaching up to 60 species.

ACKNOWLEDGEMENT

Thanks to the organizer of Tama Abu Scientific Expedition, Forest Department Sarawak. We wish to express our gratitude to Universiti Malaysia Sarawak (UNIMAS) for financial support. Thanks also due to Forest Department staffs; Marzuki Bujang, Shamsul Bohari, Ahmad Ampeng, Ishak Bujang and the local people of Tama Abu who helps during the field collections.

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Appendix 1. Provisional Checklist of Gingers from TAPF

Alpinia nieuwenhuizii Valeton
Alpinia glabra Ridl. var. glabra
Alpinia sp.3

Amomum anomalum R.M. Sm.
Amomum dimorphum M.F. Newman
Amomum longipenduculatum R.M. Sm.
Amomumcf. sceletescens R.M. Sm.
Amomum sp.5
Amomum sp.6

Boesenbergia pulchella (Ridl.) Merr.
Boesenbergia stenophylla R.M. Sm.
Boesenbergia sp.3 (cf. B. laevivaginata S. Sakai & Nagam.)

Burbidgea pauciflora Valeton

Elettaria longituba (Ridl.) Holtt.
Elettaria surculosa (K. Schum.) B.L. Burtt & R.M. Sm.
Elettaria sp.3

Elettariopsis kerbyi R.M. Sm.
Elettariopsis sp.2 (corrugated leaves)

Etlingera barioensis A.D. Poulsen
Etlingera brachychila (Ridl.) R.M. Sm.
Etlingera brevilabrum (Valeton) R.M. Sm.
Etlingera coccinea (Blume) S. Sakai & Nagam.
Etlingera elatior (Jack) R.M. Sm.
Etlingera longipetiolata (B.L. Burtt & R.M. Sm.) R.M. Sm.
Etlingera sp.7

Globba atrosanguinea Teijsm. & Binn.
Globba brachyanthera K. Schum.
Globba muluensis R.M. Sm.
Globba tricolor Ridl.
Globba sp.5

Hedychium cylindricum Ridl.

Hornstedtia havilandii (K. Schum.) K. Schum.
Hornstedtia scphifera (J. Koenig) Steud.

Plagiostachys albiflora Ridl.
Plagiostachys bracteolata R.M. Sm.
Plagiostachys crocydocalyx (K. Schum.) B.L. Burtt & R.M. Sm.
Plagiostachys strobilifera (Baker) Ridl.
Plagiostachys sp.5

Zingiber coloratum N.E. Br.
Zingiber griffithii Baker
Zingiber pachysiphon B.L. Burtt & R.M. Sm.
Zingiber pseudopungens R.M. Sm.
Zingiber sp. nov.
Zingiber sp.6

PRELIMINARY FINDINGS OF MYCOHETEROTROPHIC PLANTS FROM TAMA ABU PROTECTED FOREST, ULU BARAM, SARAWAK, BORNEO

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Abstract

Thirteen mycoheterotrophic plant specimens were collected by the first author during a 10-day botanical survey of Sarawak Heart of Borneo (HoB) Scientific Expedition to Tama Abu Protected Forest, Ulu Baram from 15th to 25th August 2017. Out of the 13 specimens, 12 species were identified from seven genera and four families. However, some have yet to confirm the identifications. Further study will be conducted, in order to confirm these preliminary findings of identifications.

Keywords: *mycoheterotropic plants.*

INTRODUCTION

A Heart of Borneo (HoB) Scientific Expedition was conducted at Tama Abu Protected Forest, Ulu Baram, Sarawak, Borneo. The expedition site situated in Tama Abu Protected Forest at Southeastern part of Pulong Tau National Park, about N 03°18'37.1", E 115°28"48.7". The area mainly covered by lowland to hill mixed dipterocarp forest, ranging from 600m to 1,200m a.s.l. Logging trails within the expedition site are the evident of logging activity in the past. The main river flowing in the expedition area is Sungai Baleh. Sub-montane mossy kerangas forest can be found along ridges on the highest peak.

We focused on mycoheterotroph plants in this expedition. Mycoheterotroph plants are sometimes mistakenly called as saprophyte, but only fungi are true saprophyte as they can utilize dead organic material directly. Mycoheterotroph plants are partly or entirely non-photosynthesis plants that obtain food from mycorrhiza fungi that grow on its roots (Merckx et al. 2009). They parasitize fungi at their roots for energy and nutrient. These interesting plants are tiny, short-lived, above ground and thrive well in lowland primary rainforest, mainly near water sources. The flora of Borneo is very diverse in mycoheterotrophic plant species due to its rich vegetation, high precipitation and high temperature.

METHODOLOGY

Thirteen mycoheterotrophic plant specimens were collected by the first author (Figure 1) during a 10-day botanical survey of Sarawak Heart of Borneo (HoB) Scientific Expedition to Tama Abu Protected Forest, Ulu Baram from 15th to 25th August 2017. The 10-day field works were conducted along transects that accessible and prepared by the organizer. Each transects is about 2-4 km long, cutting through forests and streams. Collections of plants were made following standard Herbarium Collection Method. Each collected specimen is placed at BRC (Botanical Research Centre) collection room, and a duplicate is distributed to Sarawak Herbarium (SAR). For small plants, spirit collection method was used. The spirit collections are placed at BRC collection room. Identification of the plants based on published paper (Cheek & Burgt 2010; Dancak et al. 2017; Dang Van Son et al. 2015; Tsukaya et al. 2016 and etc.), experts' opinion and collaborative work with other researchers.

FINDINGS

Out of 13 specimens collected, 12 species of mycoheterotroph plants from seven genera and four families were discovered during the expedition. The four families are Burmanniaceae, Orchidaceae, Polygalaceae and Triuridaceae. Among these families, Orchidaceae and Polygalaceae are the most diverse families, with four species recorded respectively. Three species recorded from family Burmanniaceae and a single species from Triuridaceae,

Burmannia lutescens (Figure 1) is the most widespread in the area, where it can be found at almost all transects. *Burmannia championii* and *Sciaphila winkleri* only recorded once from the expedition site. Most of the species recorded from pristine mixed dipterocarp forest with high humidity, except *Gymnosiphon sp.* (Figure 1) and *Sciaphila winkleri* (Figure 2) which were recorded from mossy kerangas forest above 1,000 m elevation. All species documented are distributed in South East Asia, some species distributed up to China region, except *Epirixanthes confusa* which is endemic to Borneo.

CONCLUSION

From the 10 days of field survey, 12 species of mycoheterotroph plants identified from 13 specimens. This number could be underrepresented the richness of mycoheterotroph plants in Tama Abu, as this group of plant is easily over-looked due to their tiny size and dull colour that blend into the background colour of forest floor. The diversity of mycoheterotroph plants in Borneo is expected to be high as the environment in Borneo is suitable for them to grow. The knowledge on this plant group in Borneo is poor due to lack of expertise and they are rarely collected during floristic survey. Hence, more collection and collaboration with researchers or experts are important in order to fully understand the diversity of mycoheterotroph plants in Borneo. Further study will be conducted in order to properly identify these specimens and a full checklist of mycoheteretrophs from Tama Abu Protected Forest should be published.

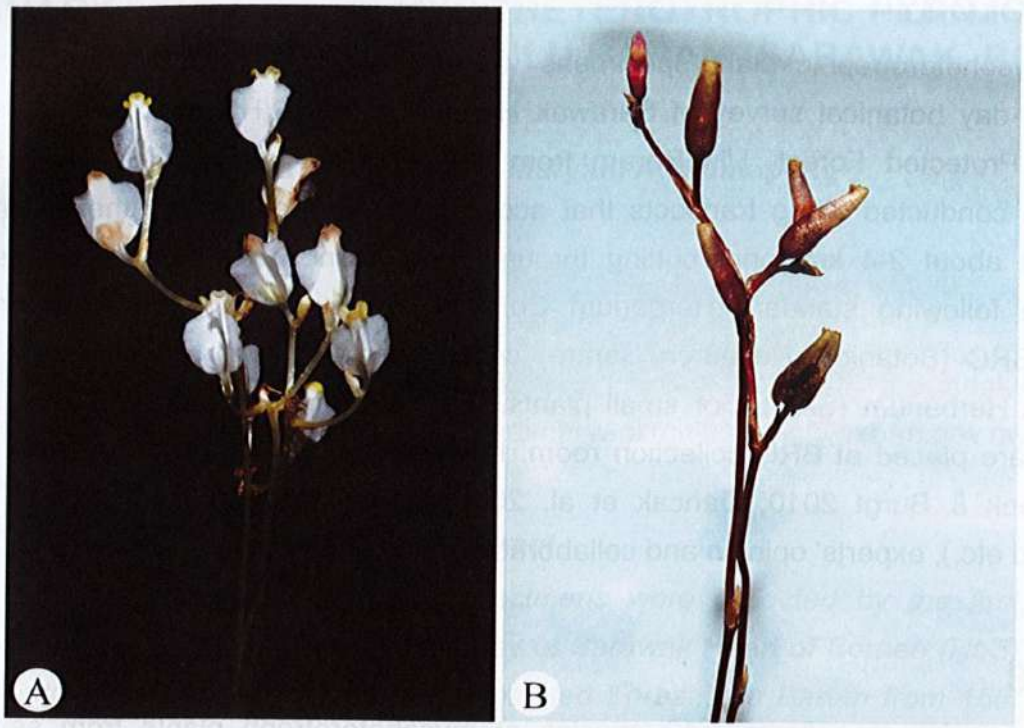


Figure 1: A: *Burmannia lutescens* Becc.; B. *Gymnosiphon* sp. (photos by Ling Chea Yiing).



Figure 2: *Sciaphila winkleri* Schltr. (photo: Ling Chea Yiing)

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The authors would like to extend our gratitude to the secretariats of HoB Expedition of Tama Abu Scientific Expedition for organizing the expedition and logistic arrangement. The first author would also like to thank the management of Sarawak Forestry Corporation for their support in this scientific expedition; and our colleagues from AFSID, Julia Sang, Army Kapi, Dino Jengka and Sirukit Dubod, for their valuable assistance during the field work. We want to thank the locals who involving in the expedition for their assistance during the field work; Dr. Yong Kien Thai for kindly lending his DSLR camera to photograph close-up photos of the specimens. Dr. Hirokazu Tsukaya for his assistance in confirming the species name which we truly in debt.

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MAMMAL DIVERSITY IN THE TAMA ABU PRODUCTION FOREST, HEART OF BORNEO, SARAWAK

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Abstract

A camera trapping study was undertaken in the Gunung Tamu Renan range in the Tama Abu Production Forest, Ulu Baram, Sarawak, from August to October 2017. The work was conducted as part of the Heart of Borneo initiative under the Sarawak Forestry Department. Thirty-two (32) cameras were established at elevations between 680-1200m for a total of 2018 trap nights. We recorded 884 independent pictures of 24 species of medium-to-large sized mammals. The most common species recorded were pig-tailed macaques, bearded pigs and porcupines, which made up 62% of all photos. We recorded the critically endangered pangolin and also five Bornean endemics; Hose's langur, collared mongoose, Hose's civet, thick-spined porcupine and the tufted ground squirrel. We also obtained a video of the elusive Bornean clouded leopard. We found no indication of the Sumatran rhinoceros or banteng which were rumoured to live (or once lived) in the area. As this study only covered a very small fraction of the Gunung Tamu Renan mountain range, it is recommended that further work be undertaken to provide more comprehensive coverage and a better understanding of the mammals of this area, and to evaluate any threats they may be facing.

Keywords: *Mammals of Heart of Borneo, camera trap*

INTRODUCTION

The trilateral Heart of Borneo (HoB) Initiative implements the sustainable management of 22 million hectares of interior forests in Borneo. Under this initiative, the Sarawak State government, Malaysia, is committed to numerous actions including scientific endeavours. In 2017, under the Sarawak Forestry Department, a scientific expedition was undertaken to the Gunung (Mount=Mt.) Tamu Renan mountain range within the Tama Abu Production Forest. Situated within the Samling logging concession, near the Kalimantan border, the expedition had the broad objectives to assess the fauna, flora, geology and anthropology of the Mt. Tamu Renan area. The results of such an expedition could inform the potential of further community development and biodiversity conservation in the area.

This report details the results of a rapid camera trap assessment of the medium to large-sized terrestrial mammals in the Mt. Tamu Renan range. As a specific focus of this scientific expedition was the detection of any potential presence of the Sumatran rhinoceros *(Dicerorhinus sumatrensis)* or banteng *(Bos javanicus)* - which have been rumoured from this region - we set cameras to specifically target these species, as well as other terrestrial mammals in the area.

METHODS

Study Area

An expedition field camp was established by the Sarawak Forest Department approximately 200km southeast of Miri, and just 4km from the Indonesian (Kalimantan) border. The campsite, at 3.30969 N, 115.48351 E, was situated 1km off the main Long Banga - Bario road in the Kelabit Highlands (Figure 1) at the southern end of the Mt. Tamu Renan mountain range at an elevation of 670m. Situated beside the Baleh River, the campsite was surrounded by highlands with peaks above 1500m. This area sits approximately 20km southeast of the Pulong Tau National Park.

The Mt. Tamu Renan mountain range is covered with near intact mixed dipterocarp forest, with areas of karanga forest on poorer soils. The mountain range was subject to selective heli-logging approximately 20 years ago, with the surrounding less-steep areas (especially to the East) having undergone traditional logging. The logged over forests outside the Mt. Tamu Renan mountain range are greatly disturbed.

Camera Trapping

Thirty-Two *Bestguarder* camera traps (model SG-990V, China) were deployed at 31 sites for 73 days, starting from 16 August and ending 27 October 2017. All cameras were deployed over a 4-day period in five main areas by two teams, all within 6km of the field-camp (Figure 1). We set cameras on the southern end of the Mt. Tamu Renan mountain range and surrounding area. Most sites were accessed by walking from established transect lines radiating from the camp site. We diversified camera placements to maximize the chances of detecting a variety of medium to large-sized terrestrial mammals, as well as the target species, Sumatran rhino and Banteng. All cameras were un-baited and placed between 675m and 1200m in elevation.

Camera trap units were set to record 1 or 2 photographs per trigger, a single photo and a short (~10 second) video or a 10-40 second video only. Cameras were operational 24 hours per day with trigger intervals set to 1 minute. The time and date of photo-capture was determined from the metadata of the digital photograph. Cameras were set at a height of 50-80cm. Small plastic covers were added to the top of cameras to help protect against rain. We considered pictures of the same species at the same site to be independent after 1 hour. 'Pictures', 'photos' or 'detections' hereafter, will generally refer to independent (1-hour separated) pictures, unless otherwise stated. All camera site locations were recorded with a 60CSx Garmin GPS.

Data analysis

Only photographs of medium-to large-sized mammals were assessed. Reference to 'mammals' hereafter will refer to medium and large-sized mammals (typically those greater than ~1kg), unless otherwise stated. Pictures of smaller species such as rats, shrews, squirrels or bats were excluded from analysis due to difficulties in accurate identification (with the exception of the conspicuous tufted ground squirrel, *Rheithrosciurus macrotis*). We likewise excluded all birds, reptiles, people, non-animal shots and animals we could not identify due to poor image quality or partial shots of the animal. The red muntjac (*Muntiacus muntjac*), and the Bornean yellow muntjac (*M. atherodes*) were grouped together as *Muntiacus* spp. due to difficulties in distinguishing between the two species in some photographs. We also grouped the two larger porcupine species (the Malayan porcupine, *Hystrix brachyura* and the endemic thick-spined porcupine *Hystrix crassispinis*) together as *Hystrix* spp.

Capture rate for a species (or group) was determined as the number of independent pictures divided by trap effort (camera trap-night; TN) and multiplied by 100, and thus expressed as captures per 100 trap-nights. Activity patterns were identified by grouping photo-captures into 1-hour timeframes and expressing these as a percentage of total photographs obtained for the species. Sunrise was at ~ 0605 hours and sunset at ~1820 hours during the trapping regime.

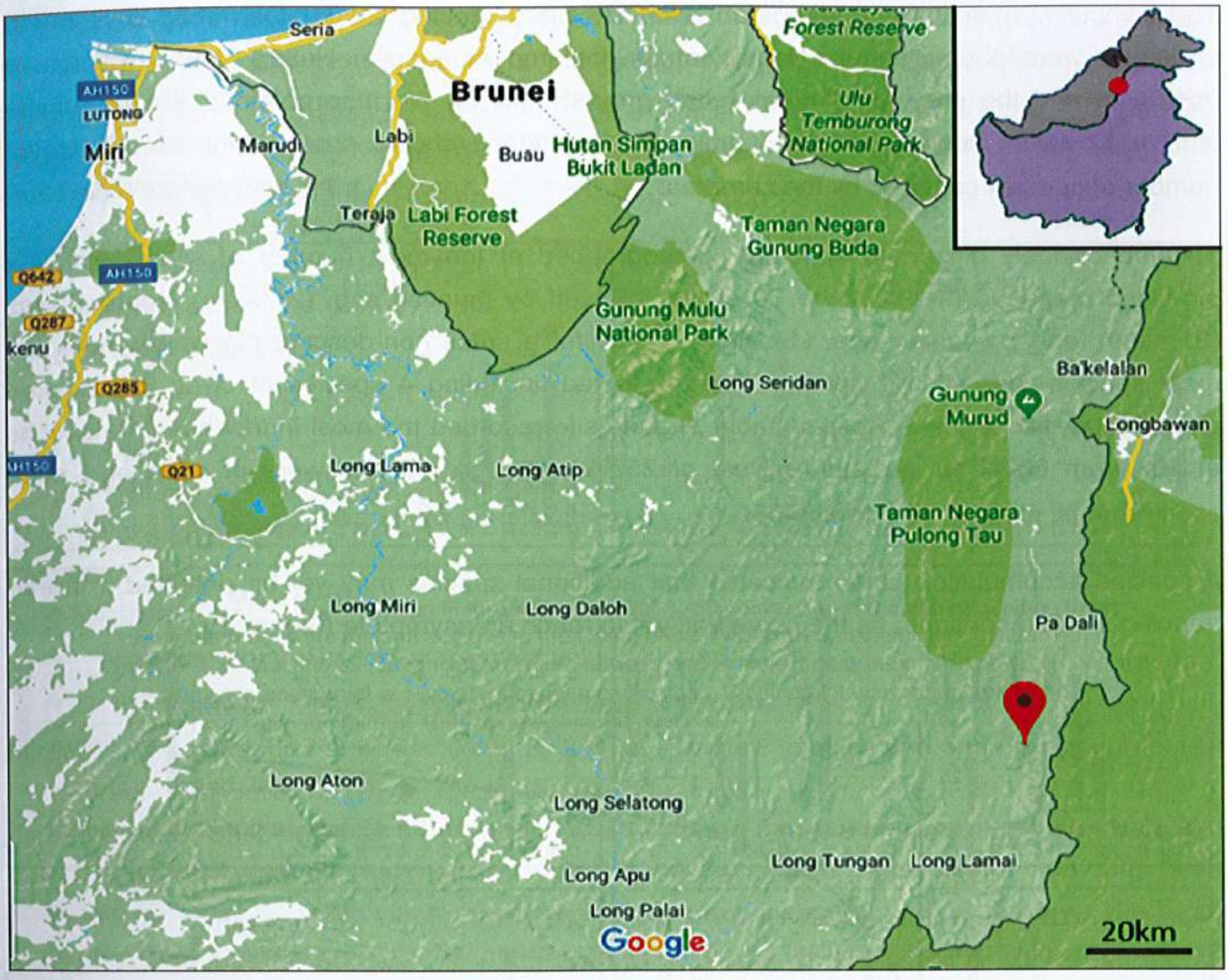


Figure 1: Location of the field site (red pin) at Gunung Tamu Renan range, Tama Abu Production Forest, Ulu Baram, Miri Division, Sarawak.

RESULTS

From the 32 cameras deployed, 31 cameras were in operation at 30 sites for the trapping period, with one camera failing to function. These 31 cameras operated for a total of 2018 trap nights, with each camera operational for an average of 65 days over the trapping regime. We obtained a total of 2184 animal pictures of which 1962 were of medium-large sized mammals. From these 1962 mammal pictures, we obtained 884 independent (1 hour separated) detections. These results in a capture rate of 43.8%, or 44 independent mammal captures/ 100 trap nights.

A total of 24 species from 13 families were documented (which includes both the Malayan and thick-spined porcupines, although these two species have been grouped as *Hystrix* spp.) (Table 1). The most commonly photographed species was the pig-tailed macaque (representing 22.9% of all independent pictures), bearded pigs (21.8%) and porcupines spp. (17.5%). The most rarely photographed species were the Bornean clouded leopard and collared mongoose, each of which was only photographed once.

The pangolin, a critically endangered species, was detected at 3 sites, while 5 Bornean endemics were photographed; Hose's langur, collared mongoose, Hose's civet, thick-spined porcupine and the grey form of the tufted ground squirrel. We also obtained a video of the elusive Bornean clouded leopard (Table 1). Appendix I shows photographs of a selected number of species captured by the cameras.

The most widely dispersed species - photographed at the most number of sites - was the pig-tailed macaque (at 24 of the 30 sites), followed by muntjac spp. (21 sites), bearded pigs (21 sites), and porcupine spp. (14 sites). One site, a small non-descript pig wallow, was the most species-rich, with 11 species being detected, including 4 species of civet; the masked palm, Malay, banded and Hose's (Table 1). One site recorded the most independent detections at 163 from 65TN for a Capture Rate of 250%, although pictures were of commonly seen species; pigs, muntjac and porcupines.

A species accumulation curve indicates that additional species may yet be detected if further trapping were to continue, as the curve has yet to reach an asymptote (Figure 2).

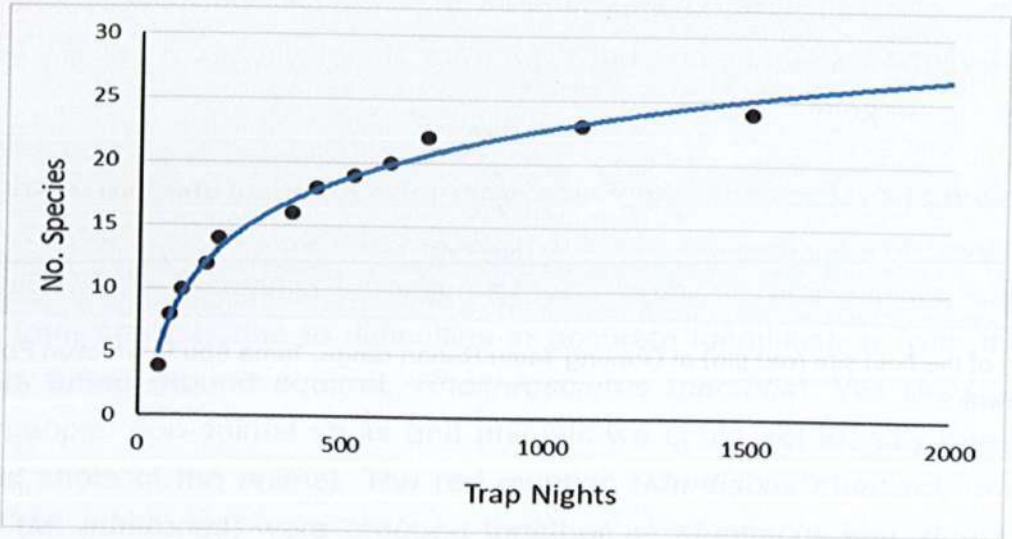


Figure 2: A species accumulation curve for medium to large-sized mammals photo-captured during the Tama Abu scientific expedition, 2017. Twenty-four (24) species captured over 2018 nights.

The activity patterns of eight species of smaller carnivores are shown in Figure 3. Although the samples sizes are very small for a number of species, the majority of these species show nocturnal behaviours. The yellow-throated marten, short-tailed mongoose and marbled cat show strong diurnal activity, while the cathemeral masked palm civet can be found throughout the day and night.

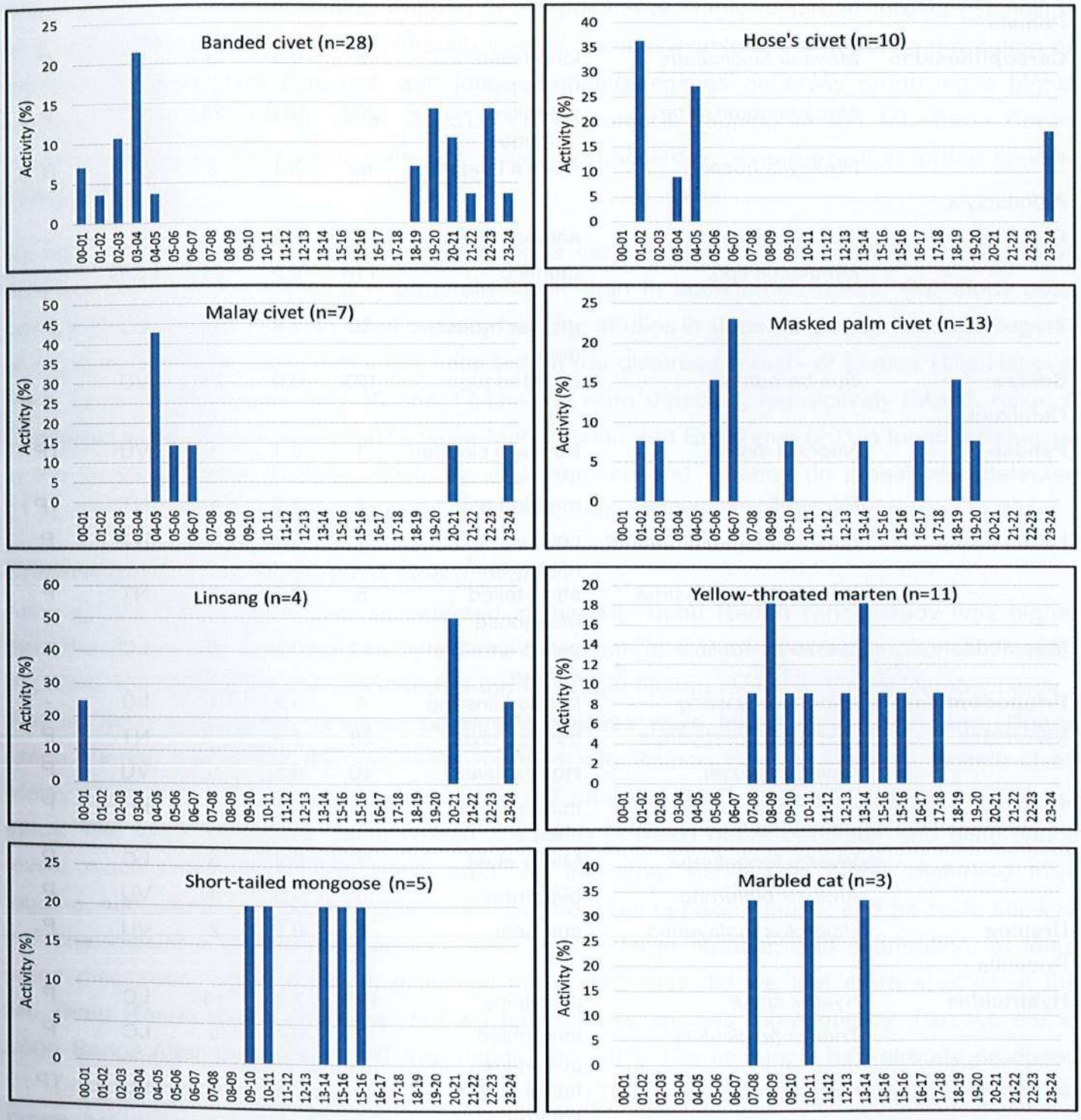


Figure 3: Daily activity patterns of some of the smaller carnivores detected during the Tama Abu expedition in 2017.

Table 1. Mammal species photo-captured during the Tama Abu scientific expedition, 2017. IP: number of independent pictures, CR: capture rate (IP per 100 trap nights), Sites: sites occupied (max. 30), IUCN: IUCN red list categories, Srwk: Sarawak wildlife protection categories; P = protected species, TP= totally protected species, - = unlisted. * = Bornean endemic.

Order/Family	Species	English name	IP	CR	Sites	IUCN	Srwk
Primate							
Cercopithecidae	*Macaca fascicularis*	long-tailed macaque	5	0.3	3	LC	P
	Macaca nemestrina	pig-tailed macaque	203	10.0	24	VU	P
	Presbytis hosei	Hose's langur*	62	3.1	3	VU	TP
Artiodactyla							
Cervidae	*Rusa unicolor*	sambar deer	8	0.4	5	VU	-
	Muntiacus spp.	muntjac	110	5.5	21	LC/NT	-
Tragulidae	*Tragulus napu*	greater mouse deer	36	1.8	8	LC	-
Suidae	*Sus barbatus*	bearded pig	193	9.6	21	VU	-
Carnivora							
Felidae	*Neofelis diardi*	Bornean clouded leopard	1	0.1	1	VU	TP
	Pardofelis marmorata	marbled cat	3	0.2	1	NT	TP
Herpestidae	*Herpestes semitorquatus*	collared mongoose*	1	0.1	1	NT	P
	Herpestes brachyurus	short-tailed mongoose	5	0.3	3	NT	P
Mustelidae	*Martes flavigula*	yellow-throated marten	11	0.6	5	LC	-
Prionodontidae	*Prionodon linsang*	banded linsang	4	0.2	4	LC	-
Viverridae	*Hemigalus derbyanus*	banded civet	28	1.4	13	NT	P
	Diplogale hosei	Hose's civet*	10	0.5	5	VU	P
	Paguma larvata	masked palm civet	13	0.6	7	LC	P
	Viverra tangalunga	Malay civet	7	0.4	5	LC	P
	Arctictis binturong	binturong	5	0.3	4	VU	P
Ursidea	*Helarctos malayanus*	sun bear	5	0.3	2	VU	P
Rodentia							
Hystricidae	*Hystrix spp.#*	porcupine*	155	7.7	14	LC	P
	Trichys fasciculata	long-tailed porcupine	8	0.4	5	LC	P
Sciurinae	*Rheithrosciurus macrotis*	tufted ground squirrel*	8	0.4	5	VU	TP
Pholidota							
Manidae	*Manis javanica*	pangolin	3	0.2	3	CR	P

both Malayan and thick-spined porcupines were detected

DISCUSSION

Mammal diversity

The 24 species of mammal we detected from the Mt. Tamu Renan range represents a relatively moderate number of potential species, when compared to other camera trapping studies in Borneo, particularly from undisturbed forests in Sabah. In Sabah, often in excess of 30 mammal species can be camera-trapped in the pristine or lightly disturbed forests (Samejima et al. 2012, Bernard et al. 2013), although there is a considerable effect of trapping duration on the number of species detected, with longer trapping regimes generally producing a higher number of species (Tobler et al. 2005). Further camera trapping in the Mt. Tamu Renan mountain range, in the more remote, and less disturbed areas, should result in further species being found.

As much of Sarawak's forests have undergone various forms of disturbance, the mammal diversity from camera trapping is generally lower than in undisturbed areas. Our study does compare quite favourably with other camera trapping studies in Sarawak, in terms of the diversity of medium and large sized mammals detected. In the disturbed forests of Lambir Hills National Park, or plantation areas, only 15 and 17 species were detected, respectively (Mohd. Azlan & Engkamat 2006, Giman et al. 2007), while Mohd. Azlan and Engkamat (2013) found 21 species in the Lanjak Entimau Wildlife sanctuary, and Simpson and Traeholt (in press) also detected 21 species from the Long Banga area, Ulu Baram, during the HoB scientific expedition in 2016.

Comparisons to Long Banga 2016, HoB expedition

Although the 24-mammal species detected in this Mt. Tamu Renan range study was higher than the 21-species from the nearby (15km) Long Banga study in 2016 (Simpson & Traeholt in press), the 'quality' of species found at the Mt. Tamu Renan range was considerably better - that is, more threatened, endemic or elusive species were found at the Mt. Tamu Renan range. During this study, the sun bear, marbled cat, Borneo clouded leopard, Hose's civet, Malay civet and tufted ground squirrel were all photographed - but not in the Long Banga study. The forest in the Mt. Tamu Renan area was in much better condition and disturbance levels much lower. The Long Bang area, on the other hand, was highly disturbed from logging, agricultural and village settlements, and from human disturbance, and as such, showed a fauna indicative of disturbed areas - such as the large number, and distribution, of long-tailed macaques, which thrive in disturbed areas. Not only did we find more species at the Mt. Tamu Renan mountain range, but we found these species more quickly than we did at Long Banga.After only about 500 trap nights, the Tamu Renan range had already produced 21 species, while Long Banga had only produced 17 species. The forests of Mt. Tamu Renan range not only allow the photo-capture of more species but facilitate such species to be captured more readily.

The good quality of the forest at Mt. Tamu Renan area is no doubt, responsible, at least in part, for the better 'quality' species seen here. However, we also trapped at a slightly higher elevation at Mt. Tamu Renan, to a maximum of 1200m, while only to at 1080m in Long Banga, and this may also have influenced the number and diversity of species recorded at each site. The camera trapping duration was also longer at Mt. Tamu Renan than in Long Banga, and thus this would also facilitate further species being detected. However, although the trapping regime was longer at Tamu Renan, the divergent species accumulation curves, even after 500 trap nights, makes it unlikely that the Long Banga study would reach the 24-species recorded at the Mt. Tamu Renan range even if trapping continued for a similar time-frame.

A number of species that found in Long Banga, were not captured at the Mt. Tamu Renan area. In Long Banga, the arboreal small-toothed palm civet was detected once during the Long Banga study, but not at Mt. Tamu Renan - most likely because we did not target this type of habitat at Mt. Tamu Renan. We also detected the conspicuous moon rat and the leopard cat, neither of which were detected in the current Mt. Tamu Renan study. These species are more commonly found in disturbed areas however, and thus may be expected from Long Banga. When considering both studies together, 27 mammal species were detected from 3137 trap nights.

Mt. Tamu Renan study area

The forests of the study area, within the Mt. Tamu Renan mountain range of the Tama Abu Production forest, are generally less disturbed than some of the surrounding areas. The study area is situated on the steep sided mountain range, and as such, has only been subjected to selective heli-logging two decades ago. There has not been any recent logging, and as such the forest is relatively undisturbed. This is particularly noticeable when compared to the forests of the Long Banga area, which were the focus of the Heart of Borneo scientific expedition in 2016. As the Mt. Tamu Renan study site is not situated in close proximity to any villages, the human disturbance levels are also lower here. Hunting would also be expected to be lower at the Mt. Tamu Renan field site (mountain range) as the nearest villages (Long Peluan, Long Beruang) are quite distant, and our village guides report that they do not often visit the area.

Despite past reports of the presence of Sumatran rhinoceros and Banteng in the area, we found no indication that they are here. The steep terrain would suggest that the area is not suitable, although both species may have used the forest in the general vicinity in the past, including in the Tama Abu Production Forest area. Banteng prefer to feed on grasses, and as such can be found in large grasslands, which can also include river banks, old swidden areas and along the sides of logging roads (Phillipps & Phillipps 2016). As we did not undertake any work in this type of habitat, the chances of finding either the Banteng or rhino would be remote. The banteng is considered to be extremely rare in Sarawak, while the Sumatran rhino thought to be extinct in the State (Havmøller et al. 2015, Kretzschmar et al. 2016, Phillipps & Phillipps 2016). The nearest populations of banteng are thought to be over the border in the large grasslands of North Kalimantan (Gardner et al. 2016), while Phillipps & Phillipps (2016) state that areas of Mulu NP still harbour the species. Further work throughout other reported areas - and within suitable habitat - would be required to verify the distribution of Banteng in Sarawak.

As the main Mt. Tamu Renan range of the study area stretches in excess of 20km, the camera trapping conducted in this study only covered a very small fraction of the overall range, at the extreme southern end. To get a better understanding of the mammal fauna, more extensive studies (in terms of duration and extent) are warranted. It would be beneficial to conduct further work throughout the entire mountain range in this area - including the higher elevations, which are in excess of 1800m - to get a more comprehensive understanding of the mammals living here, their distribution, and also any hunting pressure they may be under.

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Appendix I. Selected pictures from the camera trapping study at Tama Abu, 2017. Hose's langur (top), Bornean clouded leopard (middle), Hose's civet (bottom)



Tufted ground squirrel (top), Yellow-throated marten (middle), Binturong (bottom)



Sun bear (top), Banded civet (middle), Red muntjac (bottom)

SMALL MAMMALS AT TAMA ABU, ULU BARAM RANGE, SARAWAK

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Abstract

The main objective of this paper is to gather, identify and document the baseline information on small mammal in Tama Abu. A total of 80 collapsible traps and 80 Sherman traps were setup to capture non-volant small mammals and oil palms were used as baits for the traps. Six harp traps were setup to capture insectivorous bats and 10 mist-net were set up to capture frugivorous bats. All traps and nets were setup for eight consecutive nights. Other than trapping, direct observations were also carried out by using binoculars to spot any arboreal species. As results, a total of 17 species of mammals from 10 families were recorded. Of these, Maxomys rajah, M. whiteheadi and Balionycteris maculata were mostly captured with five individuals respectively. Six species of mammals were observed including Hylobates funereus, Rheithrosciurus macrotis and Helarctos malayanus. This forest area is still playing its role in providing habitats for these species. Therefore, it is important to conserve this area for future generation.

Keywords: *Heart of Borneo (HoB), Survey, Small Mammals, Tama Abu, Sarawak*

INTRODUCTION

At present, there were approximately 221 species of mammals documented in Borneo with at least 78% (173 spp.) are classified as small mammals (Emmons, 1990). Of these, there were at least 92 species from eight families of bats (Chiroptera) documented in Borneo (Payne et al. 1985). Therefore, it is important to identify and document this information from various localities including Tama Abu, Ulu Baram, Sarawak.

Heart of Borneo (HoB) Scientific Expedition was organized by Sarawak Forestry Department from 16 until 24 August 2017 to gather baseline information on biodiversity. This information is vital for policy makers and foresters to formulate practical and effective policies and plans in order to conserve this area. Being the largest state in Borneo Island, it is gifted that this state is dense with rich biodiversity including certain endemic species like Orang utan (*Pongo pygmaeus*), Proboscis monkey (*Nasalis larvatus*) and Ochraceous-bellied Bornean Maxomys (*Maxomys ochraceveinter*) (Payne, 2005).

STUDY AREA

The expedition site is located about 130km from Miri city and is only accessible by four-wheel drive (4WD) vehicles and take about 11 hours through logging roads to reach the site. Tama Abu is a primary forest inhibit with biodiversity of flora and fauna. No previous study has been carried out before since the site identification and site preparation at Tama Abu have started only early in 2017.

MATERIALS AND METHODS

This survey was conducted at Trail 1 located in Tama Abu, Ulu Baram Range started from 16 - 24 August 2017. A total of 80 collapsible traps and 80 Sherman traps were setup to capture non-volant small mammals and oil palms were used as baits for the traps. Collapsible and sherman traps were set up alternately left and right along the 800 m trails. Six harp traps were setup to capture insectivorous bats and 10 mist-net were set up to capture frugivorous bats. All traps and nets were setup for eight consecutive nights. Other than trapping, direct observations were also carried out by using binoculars to spot any arboreal species. Standard measurements were collected such Head-Body Length (HB), Tail Length (TL), Hind Foot (HF), Ear Length (E), Forearm (FA), live weigh (W) in gram and sexes. All captured mammals were released after they were identified, measured, photographed and documented.

RESULTS AND DISCUSSION

Approximately there are 298 species of wild land mammals in Malaysia and 221 have been recorded in Borneo, of which 92 species are bats (Payne & Francis, 2007). These 14 days expedition at Tama Abu succeeded to assemble a total of 17 species of mammals from 10 families. Of these, 5 species were insectivorous bats, 2 frugivorus bats and four species from Muridae family. During direct observation, we managed to record a few species such as North Bornean Gibbon (*Hylobates funereus*), Malayan Sunbear (*Helarctos malayanus*) and also including endemic species which are Tufted Ground Squirrel (*Rheithrosciurus macrotis*).

This finding was supported by Thorington and Hoffmann (2005) said that this species can be found on the island of Borneo including Malaysia (Sabah and Sarawak), Brunei Darussalam, and Indonesia (Thorington et al. 2012). The other endemic species recorded was Ochraceous-bellied Bornean Maxomys (*Maxomys ochraceiventer*).

For Volant-small mammals, the most abundant species recorded was spotted-winged fruit bat (*Balionycteris maculata*) with five individuals. This may due to the presence of roosting area nearby the trail. This finding can be supported by previous study that spotted-winged fruit bat has been found roosting in small groups in crowns of palm and clumps of epiphytic ferns (Phyne & Francis, 2007). As for non-Volant mammals, Rajah Spiny Rat (*Maxomys rajah*) recorded the highest number with five individuals. This abundant due to Maxomys rajah is a predominant terrestrial species (Payne & Francis, 2007) and they are common forest rat (Phillips & Phillips, 2016).

CONCLUSIONS

This forest area is still playing its role in providing habitats for these species. At least four endemic species were recorded during this survey. Therefore, conserving this pristine environment would help to maintaining this biodiversity heritage to exist for future generation.

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Table 1: List of mammals recorded in Tama Abu

No	Families	Scientific Name	Common Name	Individuals	Remarks
1	Rhinolophidae	*Rhinolophus sedulus*	Lesser Wooly Horseshoe Bat	1	
2	Pteropodidae	*Balionycteris maculata*	Spotted-winged Fruit Bat	5	
		Macroglossus minimus	Lesser Long-tongued Fruit Bat	1	
3	Hipposideridae	*Hipposideros cervinus*	Fawn Horseshoe-bat	2	
		Hipposideros galeritus	Cantor's Leaf-nosed Bat	1	
4	Vespertilionidae	*Kerivoula intermedia*	Small Woolly Bat	1	
		Kerivoula papillosa	Papillose Woolly Bat	1	
5	Muridae	*Maxomys ochraceiventer*	Ochraceous-bellied Bornean Maxomys	1	
		Maxomys rajah	Rajah Spiny Rat	5	
		Maxomys surifer	Red Spiny Rat	1	
		Maxomys whiteheadi	Whitehead's Spiny Rat	5	
6	Hylobatidae	*Hylobates funereus*	North Bornean Gibbon		*Observation*
7	Sciuridae	*Rheithrosciurus macrotis*	Tufted Ground Squirrel		*Observation*
8	Ursidae	*Helarctos malayanus*	Malayan Sunbear		*Observation*
9	Suidae	*Sus scrofa*	Wild Boar		*Observation*
10	Sciuridae	*Exilisciurus exilis*	Least Pygmy Squirrel		*Observation*
		Exilisciurus whiteheadi	Tufted Pygmy Squirrel		*Observation*
No. of Individuals				**24 ***	
No. of Species				**11 ***	
No. of Families				**6 ***	

*Exclude observation

NOTES ON REPTILES AT TAMA ABU, ULU BARAM, SARAWAK

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Abstract

Sarawak Forestry Department organized a Scientific Expedition on Heart of Borneo (HoB) at Tama Abu, Ulu Baram, Sarawak from 16th until 24th August 2017 to gather baseline information on biodiversity at this area including reptiles. During this expedition, active searches were carried out throughout the dates using snake hooks and snake tongs. Trail 1 was selected during this survey. A total of eight species of reptiles from seven families were recorded. Of these, one species endemic to Borneo namely Calamaria borneensis (Bornean Reed Snake) was determined. More species is expected to be recorded as intense research on reptiles at Tama Abu will be carried out in future.

Keywords: *Survey, Reptiles, Tama Abu, Sarawak*

INTRODUCTION

Malaysia is recognized as one of 12 mega biodiversity countries in the word (The Star Online, 2016). The tropical rain forests of Malaysia support vast numbers of biodiversity. Forests serve as habitats for numerous animals living within by providing shelter and resources. This includes a total of 268 species of reptiles with 69 species are endemic (Biodiversity in Malaysia, 2006).

Sarawak is the largest Malaysian state located on Borneo Island. According to Ministry of Natural Resources and Environment (2014), Sarawak is well gifted with dense rainforests, occupying a land mass covering 12.4 million hectares and predominantly with three main types of forests. These are Hill Mixed Dipterocarp Forest, Peat Swamp Forests and Mangrove Forests. The plentiful diversity of habitats and ecosystems supports great numbers of unique reptiles such as Bornean Reed Snake (*Calamaria borneensis*), White-collared Reed Snake (*Pseudorabdion albonuchalis*) and Sarawak Water Snake (*Amphiesma sarawacensis*) (Das, 2007; Forest Department Sarawak, 2018).

Therefore, a survey for reptiles was carried out in 2017 at Tama Abu, Ulu Baram, Sarawak during Heart of Borneo Expedition. Tama Abu are located 130 km from Miri town. The area majorly comprises with unharmed lowland vegetation and unpolluted rivers. It is also lying mostly on sandstones, composed of quartz sand and intermittently silt and clays. The existences trails are mostly steep due to mountainous terrain (Syahida & Suhaida, 2017). The objective of this survey is to identify and document the diversity and abundance of reptiles in Tama Abu during the scientific expedition.

MATERIALS AND METHODS

This survey was conducted at Trail 1 located in Tama Abu, Ulu Baram Range started from 16 - 24 August 2017. The length of the surveyed trail approximately 800m. Survey for reptiles were conducted by active search along the trail on daytime. Specimens such as lizards, geckos and skinks were caught by hand meanwhile snakes were captured using snake hook and snake tongs. Each captured individual was kept in separate plastic bag and taken to temporary basecamp to get measurements of tail (T) and total length (TL). Each species collected then was photographed, identified and release to nature. Das (2010) was used for identification.

RESULTS AND DISCUSSION

A total of eight species of reptiles comprising of agamid, skink and snakes were identified. The eight reptiles were represented by seven families namely Agamidae, Scincidae, Calamariidae, Natridae, Viperidae, Eublepharidae and Colubridae. The total number of individuals collected was six with only one individual represents each species. Two individuals namely *Gonyosoma oxycephalum* and *Sphenomorphus cyanolaemus* however unable to captured and only be visually identified through direct observation during the search. The most abundance families recorded was Calamariidae with two species namely *Calamaria pavimentata* and *Calamaria borneensis*, followed by Agamidae (*Draco maximus*), Natridae *(Psammodynastes pulverulentus)*, Viperidae (*Parias sumatranus)*, Eublepharidae *(Aeluroscalabotes felinus)*, Colubridae *(Gonyosoma oxycephalum)* and Scincidae *(Sphenomorphus cyanolaemus)* with only one species for each family respectively. Species account of Tama Abu is presented herein.

SPECIES ACCOUNT

Order: Squamata
Family: Agamidae
Large Flying Lizard
Draco maximus (Boulenger, 1893)
Location found: Found resting on tree trunk at height around 2 meter above ground.
Description: Only one individual was recorded. The species is a large, robust flying lizard with no spinous projection above eye. This diurnal lizard mainly inhabits river edges in forests from the lowlands to about 1000m. Species distribution includes Peninsular Malaysia, Sumatra, Borneo and the Natuna Islands (Das, 2007).

Order: Squamata
Family: Eublepharidae
Cat Gecko
Aeluroscalabotes felinus (Günther, 1864)
Location found: Found on the ground near temporary expedition basecamp.
Description: Only one individual was recorded. This forest dwelling lizard is the only species within the genus *Aeluroscalabotes*. This nocturnal and insectivorous species inhabit lowland rainforests and peat swamp forest at elevation up to 1000m asl (Das, 2007). The cat gecko is known distributed in Thailand, Peninsular Malaysia, Singapore, Sumatra and Borneo.

Order: Squamata
Family: Scincidae
Blue-throated Forest Skink
Sphenomorphus cyanolaemus (Inger & Hosmer, 1965)
Location found: Sighted during climbing up a tree located at the edge of surveyed trail up to at least 3m.
Description: Only one individual recorded. This diurnal species possesses slender body with relatively long limbs. The species inhabits lowland forests and possess capability of climbing trees to at least 5m (Das, 2010). Species distribution includes Peninsular Malaysia, Sumatra and Borneo.

Order: Squamata
Family: Calamariidae
Collared Reed Snake
Calamaria leucogaster (Bleeker, 1860)
Location found: Found while hiding under leaf litter at approximately 300m of Trail 1.
Description: Only one individual recorded. It is a small snake with total length up to 223mm. Body is slender and cylidirical with short head and tail. The species inhabits lowland forest and the mid-hills (Grismer & Chan-Ard, 2012). It is primarily fossorial and burrows in soil, leaf litter or hiding under which makes it hard to spot in the wild. The species distributed in Indonesia (Kalimantan, Sumatera); Malaysia (Peninsular Malaysia, Sabah, Sarawak)

Order: Squamata
Family: Calamariidae
Bornean Reed Snake
Calamaria borneensis (Bleeker, 1860)
Location found: Found while moving on the boulder located near temporary expedition basecamp.
Description: Only one individual recorded. This Bornean endemic snake is presumed to depend on the existence of close canopy cover for its survival (Das, 2017). The species has been recorded inhabit leaf litter in lowland forest floor. This species distributed in Brunei Darussalam, Indonesia (Kalimantan) and Malaysia (Sabah, Sarawak).

Order: Squamata
Family: Viperidae
Sumatra Pit Viper
Parias sumatranus (Raffles, 1822)
Location found: Found resting on tree branch at height around 1.5 meter above the ground.
Description: Only one individual recorded. This nocturnal species inhabits moist lowland and upland primary forests, and sometimes occur in plantations. The snake was the common encountered species during the expedition. Few expedition teams successfully recorded the species at different trails in Tama Abu. This species is reported to be quite common and is known to inhabit natural and altered environments throughout its wide distribution (Inger et al. 2013). However, in Peninsular Malaysia and Thailand, this species is rare and found only in primary forests. The species distributed in Malaysia, Indonesia (Kalimantan, Sumatera), Singapore and Thailand.

Order: Squamata

Family: Natricidae

Common Mock Viper

Psammodynastes pulverulentus (Boie, 1827)

Location found: Found entangled on small tree branch located at approximately 400m of Trail 1.

Description: Only one individual captured. The snake is considered common and harmless species. It active both day and night. The Common Mock Viper inhabit a wide range of elevations, from forested lowlands to montane regions of up to 1600 meters. The species widely distributed in throughout South-East Asia including Malaysia, Myammar, Thailand, Laos, Cambodia, Java and Sumatra (Das, 2010).

Order: Squamata

Family: Colubridae

Red-tailed Racer

Gonyosoma oxycephalum (Boie, 1827)

Location found: Sighted moving on tree branch located at Trail 1.

Description: One individual was sighted in Trail 1 and visually identified during the search. This is a diurnal; arboreal snake occurs up to 1,100 m a.s.l. It inhabits primary forest, but appears to prefer edge habitats, secondary growth, plantations and rural gardens and (Wogan et al. 2012). The species well distributed in South-East Asia including Malaysia, Singapore, Myammar, Laos, Cambodia, Vietnam and Java.

Table 1: List of herpetofauna recorded in Tama Abu

Families	Scientific Name	Common Name	Individuals	Remarks
Agamidae	*Draco maximus*	Great Flying Dragon	1	
Calamariidae	*Calamaria leucogaster*	Collared Reed Snake	1	
	Calamaria borneensis	Bornean Reed Snake	1	
Natridae	*Psammodynastes pulverulentus*	Common Mock Viper	1	
Viperidae	*Parias sumatranus*	Sumatra Pit Viper	1	
Eublepharidae	*Aeluroscalabotes felinus*	Cat Gecko	1	
Colubridae	*Gonyosoma oxycephalum*	Red-tailed Racer		*Observation*
Scincidae	*Sphenomorphus cyanolaemus*	Blue-throathed Forest Skink		*Observation*
No. of Individuals			**6 ***	
No. of Species			**6 ***	
No. of Families			**6 ***	

*Exclude observation

CONCLUSION

The survey provides a preliminary insight of Tama Abu. This area seems to functions as habitat for variety of reptiles. There are possibilities that many species of reptiles are yet to be discovered. More regular surveys could be conducted to provide better checklist of reptiles in Tama Abu. Later, effective conservation measures can be strategized in order to conserve its biodiversity.

ACKNOWLEDGEMENT

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CHECKLIST OF BIRD AT TAMA ABU, ULU BARAM, SARAWAK

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Abstract

Survey was carried out at Trail 1 from 16 - 24 August 2017 in Trail 1, Tama Abu, Ulu Baram Range, Sarawak. The main objective of this survey was to identify, document and update the checklist of birds in Tama Abu. A total of 10 mist-net were set up to capture avifauna. All nets were setup for nine consecutive days. Other than mist-netting technique, direct observations were also carried out by using binoculars to spot any birds species. As results, a total of 37 species from 23 families of birds were recorded. Few species were spotted including Icthyophaga humilis, Hydrornis schwaneri and Microhierax fringillarius.

Keywords: *Survey, Avifauna, Mist-Net, Tama Abu, Sarawak*

INTRODUCTION

Heart of Borneo (HoB) is one of the initiatives to protect large forest complexes involving three countries namely Malaysia (Sabah and Sarawak), Brunei and Indonesia (Kalimantan). In Malaysia, Sarawak is also known as one of top leaders in forest protection inhibiting by thousands of flora and fauna. According to ASEAN Centre for Biodiversity (2010), HoB covers one of the largest transboundaries rainforest areas with more than 22 million hectares of tropical rainforest across these three countries. The initiative is a conservation agreement between these three governments to protect and conserve the rainforest biodiversity of Borneo (WWF, 2017).

Borneo is a unique island and amongst of the most diverse fauna with more than 280 species of mammals, 440 species of freshwater fishes, almost 300 species of reptiles and more than 650 species of birds with high percentage of each of this group is endemic (Myers, 2016). Of these, 584 species of birds are recorded in Sarawak (Clement, 2018).

A series of scientific expeditions have been carried out starting from 2008 under the initiative. The recent scientific expedition was carried out in 2017 at Tama Abu, Baram of Sarawak which located 130 km from Miri town. The area majorly comprises with unharmed lowland vegetation and unpolluted rivers. It is also lying mostly on sandstones, composed of quartz sand and intermittently silt and clays. The existences trails are mostly steep due to mountainous terrain (Syahida & Suhaida, 2017). The objective of this survey is to document the diversity of birds in Tama Abu, Sarawak.

MATERIALS AND METHODS

This survey was conducted at Trail 1 located in Tama Abu, Ulu Baram Range started from 15 - 24 August 2017. A total of 10 mist nets (12m x 2.6m x 30mm) were setup at each plot at about 0.5m above ground. The location of the mist nets was randomly chosen at the potential fly-path for nine consecutive nights. Captured birds were temporarily stored in cloth bags while before identified using references books. Standard measurements were Bill Length (BL), Bill Depth (BD), Bill Width (BW), Head Bill (HB), Wing Length (WL), Wing Span (WS), Total Length (TL), Tail (TA) and Tarsus (T) and sexes. All birds were released after they were photograph, measured and documented.

RESULTS AND DISCUSSION

The expedition was located about 130 km from Miri city and was only accessible by four-wheel drive (4WD) vehicles and take about 11 hours through logging roads to reach the site. Tama Abu is a primary forest inhibit with biodiversity of flora and fauna. No previous study has been carried out before since the site identification and site preparation at Tama Abu have started only early in 2017.

The expedition in Tama Abu was able to recorded 37 species of birds from 23 families including observations method. Of these, Pycnonotidae was the highest family with eight individuals captured followed by Monarchidae, Muscicapidae and Picidae with two individuals captured for each family respectively. Most of captured species was furgivorous birds. This might be due to the availability of fruit trees nearby the sampling site.

The wet weather might be the effect of the capture rate. During survey in Tama Abu the, light to heavy rain occurred almost every day during the day and night. Robbins (1981) mentioned that effects of weather on avian activities appear to vary among species and habitats. Weather can have considerable effect on avian activity, net visibility and mist-netting success (Stewart, 1971; Quinlan & Boyd, 1976; Robbins 1981). Thus, the harsh weather such as strong winds and rain usually results in reduction on capture rates (Robbins 1981; Grue et al. 1981).

Out of 37 species were recorded, based on IUCN Red list, seven species are Near Threatened such as Hose's Broadbill, Short-Tailed Babbler and White-Bellied Epornis and also one Vulnerable species which is Greater Green Leafbird. The populations also suspected to be in decline owing to habitat destruction and probably collecting for the cage bird trade (del Hoyo et al. 2003). In Malaysia Borneo, it is conservatively estimated only 22% of land cover constitutes forest that has never been logged and even in Sarawak, strong commercial pressure to convert non-productive logged forest to oil palm plantation (Myers, 2016).

CONCLUSIONS

The small number of individuals and low number of species caught may be due to rainy weather that have forced them to reduce daily activities. However, there are possibilities that many species of birds are yet to be discovered in this area and regular surveys could be conducted to provide better checklist. The habitat loss also may lead to declining the huge numbers of animal and plant species over the years. Therefore, our responsibilities to ensure the healthy ecosystem sustains the precious biodiversity for next generation.

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Table 1: List of birds recorded in Tama Abu

No	Families	Scientific Name	Common Name	Individuals	IUCN	Remarks
1	Alcedinidae	*Actenoides concretus*	Rufous-collared Kingfisher	1	LC	
2		*Alcedo euryzona*	Blue-banded Kingfisher	1	LC	*Given by UNIMAS*
3	Calyptomenidae	*Calyptomena hosii*	Hose's Broadbill	1	NT	
4	Columbidae	*Chalcophaps indica*	Emerald Dove	1	LC	
5	Irenidae	*Irena puella*	Asian Fairy Bluebird	1	LC	
6	Megalaimidae	*Psilopogon chrysopogon*	Gold-whiskered Barbet	1	LC	
7	Monarchidae	*Hypothymis azurea*	Black-naped Monarch	2	LC	
8	Muscicapidae	*Ficedula dumetoria*	Rufous-chested Flycatcher	1	LC	
9		*Cyornis concretus*	White-tailed Flycatcher	2	LC	
10	Picidae	*Meiglyptes tukki*	Buff-necked Woodpecker	2	NT	
11	Pellorneidae	*Trichastoma malaccense*	Short-tailed Babbler	1	NT	
12	Pycnonotidae	*Alophoixus phaeocephalus*	Yellow-bellied Bulbul	4	LC	
13		*Alophoixus tephrogenys*	Grey-cheeked Bulbul	1	LC	
14		*Tricholestes criniger*	Hairy-backed Bulbul	3	LC	
15	Timaliidae	*Stachyris poliocephala*	Grey-headed Babbler	1	LC	
16	Accipitridae	*Haliastur indus*	Brahminy kite		LC	*Observation*
17		*Icthyophaga humilis*	Lesser Fish Eagle		NT	*Observation*
18	Bucerotidae	*Buceros rhinoceros*	Rhinoceros hornbill		NT	*Observation*
19	Chloropseidae	*Chloropsis sonnerati*	Greater Green Leafbird		VU	*Observation*

Table 1: List of birds recorded in Tama Abu

No	Families	Scientific Name	Common Name	Individuals	IUCN	Remarks
20	Dicaeidae	*Prionochilus percussus*	Crimson-breasted Flowerpecker		LC	*Observation*
21	Falconidae	*Microhierax fringillarius*	Black-thighed Falconet		LC	*Observation*
22	Meropidae	*Merops philippinus*	Blue-tailed Bee-eater		LC	*Observation*
23	Muscicapidae	*Kittacincla malabarica*	White-rumped Shama		LC	*Observation*
24		*Muscicapa dauurica*	Asian Brown Flycatcher		LC	*Observation*
25	Nectariniidae	*Arachnothera hypogrammica*	Purple-naped Sunbird		LC	*Observation*
26		*Arachnothera longirostra*	Little Spiderhunter		LC	*Observation*
27	Pellorneidae	*Trichastoma rostratum*	White-chested Babbler		LC	*Observation*
28	Pittidae	*Hydrornis schwaneri*	Bornean Banded Pitta		LC	*Observation*
29	Pycnonotidae	*Pycnonotus goiavier*	Yellow-vented Bulbul		LC	*Observation*
30		*Pycnonotus brunneus*	Red-eyed Bulbul		LC	*Observation*
31		Brachypodius atriceps	Black-headed Bulbul		LC	*Observation*
32	Rhipiduridae	*Rhipidura albogularis*	Spotted Fantail		LC	*Observation*
33	Timaliidae	*Cyanoderma erythropterum*	Chesnut-winged Babbler		LC	*Observation*
34		*Stachyris nigricollis*	Dark-throated Babbler		NT	*Observation*
35	Turdidae	*Geokichla citrina*	Orange-headed Thrush		LC	*Observation*
36	Trogonidae	*Harpactes duvaucelii*	Scarlet-rumped trogon		NT	*Observation*
37	Vireonidae	*Erpornis zantholeuca*	White-bellied Epornis		LC	*Observation*
		No. of Individuals		**23 ***		
		No. of Species		**15 ***		
		No. of Families		**11***		

*Exclude observation

THE ODONATA COLLECTED DURING THE TAMA ABU SCIENTIFIC EXPEDITION, HEART OF BORNEO SARAWAK 2017

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Abstract

The results of collecting of Odonata (dragonflies and damselflies) during the Tama Abu Scientific Expedition, Heart of Borneo (HoB) Sarawak 2017, organised by the Sarawak Forest Department, in Telang Usan District of Miri Division, are presented. Thirty-two species of Odonata were recorded in the area, 31 of these at the expedition site. All species found at the expedition site were forest dependent species, it is these species that are typically of highest conservation concern. Seventy-four percent of the species collected at the expedition site are endemic to Borneo. The most notable individual records are those of Protosticta sp. cf kinabaluensis, Telosticta berawan, Telosticta ulubaram, Matronoides cyaneipennis, Rhinoneura caerulea, Coeliccia nemoricola and Tetrathemis sp. cf platyptera. Overall the diversity of Odonata found at the expedition site is low, but this agrees with previous data from the Tama Abu Range; possible reasons for this are briefly discussed.

Keywords: *Odonata, biodiversity, Sarawak, Miri Division, Telang Usan, endemic species*

INTRODUCTION

This paper describes the results of collecting of the insect order Odonata (dragonflies and damselflies) carried out during the Tama Abu Scientific Expedition, Heart of Borneo (HoB) Sarawak 2017; most of which was carried out within the Tama Abu Forest Reserve (referred to as the expedition site hereafter). The expedition site is located in the area often referred to as the Upper Baram, and administratively within Telang Usan District in Sarawak's Miri Division. Since the Upper Baram is a rather imprecisely defined area, all discussion of the area surrounding the expedition site is given in terms of Telang Usan District instead.

Odonata are insects with aquatic larvae; representatives of the order can be found at almost all freshwater habitats. They are carnivorous as both adults and larvae and are not vectors for any human disease; indeed, they play at least some role in keeping mosquito populations under control. Although present on every continent apart from Antarctica, the order is most diverse in the world's tropical regions. In the wet tropics many species are forest dwelling and may be particularly sensitive to environmental disturbance; for this reason, they are considered to be good candidates for ecological indicator species. The family level taxonomy for Odonata adopted by Schorr and Paulson (2018) is used in this publication.

Odonata had never, to the author's knowledge, been collected at the expedition site prior to the 2017 expedition. However, the author and various collaborators have collected Odonata at many other locations in Telang Usan District, including some in the Tama Abu Range. The only areas in Telang Usan District for which checklists have been published to-date are the Ulu Moh area and Sungai Sii areas (Dow & Ngiam, 2015) and Usun Apau National Park (Dow, Reels & Ngiam, 2015); checklists for other areas are in preparation. However specimens from other areas in the district are referred to in many publications: Laidlaw (1918), Laidlaw (1920), Laidlaw (1922), Hincks (1930), Laidlaw (1931), Laidlaw (1932), Kimmins (1936), Lieftinck (1937), Lieftinck (1965), van Tol & Norma-Rashid (1995), Dow (2010a; 2010b), Kalkman & Villanueva (2011), Dow & Reels (2011), Dow & Orr (2012), Dow (2013), Dow (2014), Dow, Hämäläinen & Stokvis (2015), Hämäläinen, Dow & Stokvis (2015), Seehausen & Dow (2016), Dow (2017), Dow, Stokvis & Ngiam (2017). Additionally, Odonata were collected by C.Y. Choong in the Long Banga area during a previous expedition organised by the Sarawak Forest Department, the results of which have not yet been published.

MATERIALS AND METHODS

Sampling

Collecting was carried out using handheld nets. Only adult Odonata were collected. Specimens were preserved by treatment with acetone and subsequent drying. At each location the aim was to collect at least one specimen of each species present. In cases where species are difficult to distinguish in the field, or of particular interest, an effort was made to take longer series of specimens. However, many adult odonates are difficult to capture, hence not every species encountered was successfully collected. The locations listed for each species are those where specimens were collected, unless otherwise noted.

Collecting locations

The following codes for groups of samplings sites are used below.

Tama Abu Forest Reserve Locations:

1. Transect 4 stream system; a rocky and generally high gradient stream system and one of its tributaries, which was sampled to the seepages at its head. This stream system is in largely undisturbed forest.
2. Trailside on Transect 4.
3. Streams on Transect 3. Slightly lower gradient than the Transect 4 system, rocky with some low gradient muddy seepage areas. The forest around these streams has been disturbed by logging activities in the past.
4. A Forest pond near to Transect 3.
5. Transect 5/7 stream system. A rocky stream system in largely undisturbed forest, mostly with very steep banks.
6. Trailside on Transects 5 and 7.
7. The camp water supply stream. A high gradient stream system and a small tributary and seepage nearby in forest disturbed by logging in places.
8. The camp river (Sungai Baleh). A large torrential stream with many boulders.
9. In the camp and along path from road to camp.

Others:

10. Streams crossing the road between the camp junction and the Long Banga junction; logged forest.

Some of the locations at the expedition site are shown in Figure 1.

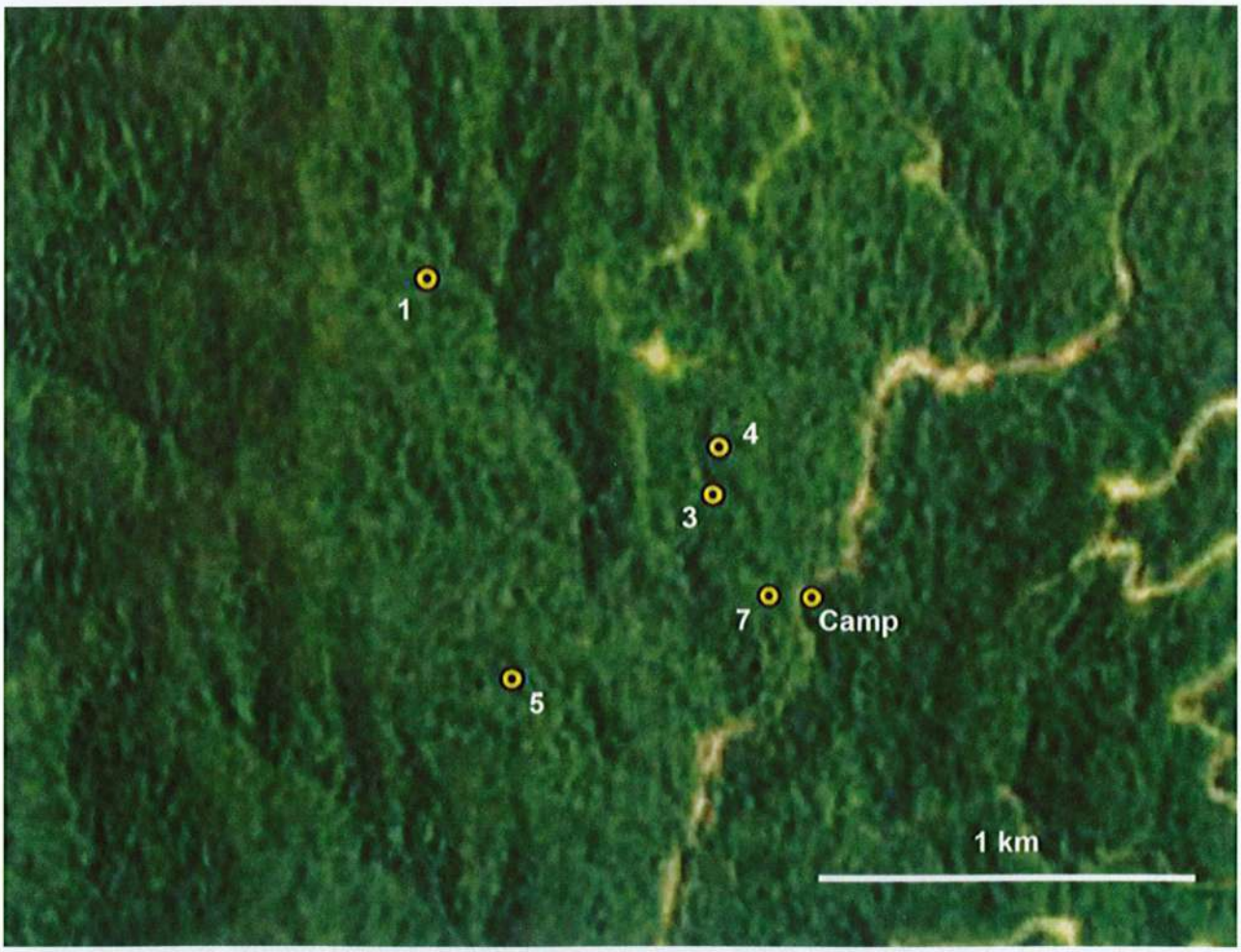


Figure 1: Some of the collecting locations at the expedition site. Base image from Google Earth.

ANNOTATED LIST OF SPECIES COLLECTED

Zygoptera (Damselflies)

Platystictidae

The Platystictidae is a moderately large family which presents many taxonomic problems. They occur from India across most of Asia, and southwards as far as New Guinea, with species in three subfamilies; a separate subfamily occurs in the neotropics. It is widely recognised that the old world Platystictidae need for a major revision. There are many platystictid species in Sarawak, due to difficulties in determining whether some forms are separate, unnamed, species or local variants of known species it is not possible to give an exact figure, but over 30 species are already known to occur in the state. More species will undoubtedly be found. Seven species were found at the expedition site.

Drepanosticta actaeon Laidlaw, 1934 - Endemic to Borneo. Figure 2. Locations 1, 7.

Drepanosticta sp. cf *crenitis* Lieftinck, 1933 - A small sized species or complex of closely related species. Endemic to Borneo. Locations 1, 5, 7.

Drepanosticta rufostigma (Selys, 1886) - Usually the most common member of the Platystictidae in Sarawak. Endemic to Borneo. Locations 1, 3, 7.

Drepanosticta versicolor (Laidlaw, 1913) - A common, small sized species. Endemic to Borneo. Locations 1, 5, 7.

Protosticta sp. cf *kinabaluensis* Laidlaw, 1915 - An unnamed species, known from Mount Kinabalu and the Crocker Range in Sabah and a few scattered locations in Sarawak. Endemic to Borneo. Locations 1, 2.

Telosticta berawan Dow & Orr, 2012 - A single female that might be that of *T. berawan* but is not that of the next species. Endemic to Borneo. Location 7.

Telosticta ulubaram Dow & Orr, 2012

This species is only known from the Upper Baram area, as its name suggests; only a few locations are known for it. Endemic to Borneo. Figure 3 shows a specimen collected in the Ulu Moh area. Location 1.



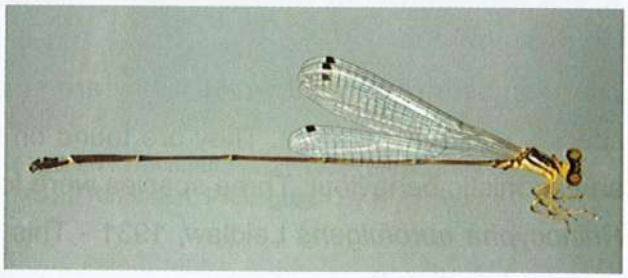


Figure 2: (left) *Drepanosticta actaeon* male (photograph taken at Gunung Mulu National Park). Photograph by R.A. Dow. **Figure 3:** (right). *Telosticta ulubaram* male (specimen from Ulu Moh). Photograph by R.A. Dow.

Calopterygidae

A large cosmopolitan family of medium-to large-sized damselflies found on forest streams and rivers. At least eight species occur in Sarawak. In Borneo the family is dominated by the *amoena*-group of the genus *Vestalis*; most of the species in this group are very similar, with metallic green bodies and clear wings, which flash with bright metallic colours when caught by the sun. Three species were found at the expedition site.

Matronoides cyaneipennis Förster, 1897 - A montane and upland species, known from Mount Kinabalu south to Gunung Melatai. Endemic to Borneo. Figure 4. Location 1.

Vestalis amnicola Lieftinck, 1965 - A common species in steep, forested terrain. Endemic to Borneo. Locations 1, 5, 7, 10,

Vestalis beryllae Laidlaw, 1915 - Locally common in steep forested terrain, the males, distinctive because of their very long abdomens, are often found far from water. Endemic to Borneo. Locations 1, 2, 6.



Figure 4: *Matronoides cyaneipennis* male (photograph taken at Mount Kinabalu). Photograph by G.T. Reels.

Chlorocyphidae

The members of this old world family are small and mostly very brightly coloured. At least 15 species occur in Sarawak. They are found on forest streams and are notable for their courtship and agonistic behaviour. Three species were found at the expedition site.

Rhinocypha aurofulgens Laidlaw, 1931 - This is a species of rocky forest streams. Endemic to Borneo. Location 8.

Rhinocypha spinifer Laidlaw, 1931 - An upland and montane species. Endemic to Borneo. Figure 5. Locations 1, 5.

Rhinoneura caerulea Kimmins, 1936 - This species was seen but could not be collected, however the genus is certain and it is probable that the species is actually *R. caerulea*, a seemingly rare montane species only known from a few locations in Sarawak, including one in Pulong Tau National Park. The altitude at which it was seen (approximately 1100m a.s.l.) is lower than that at most locations where the species has been found. Endemic to Borneo. Figure 6 shows a specimen collected in the Hose Mountains. Location 1.

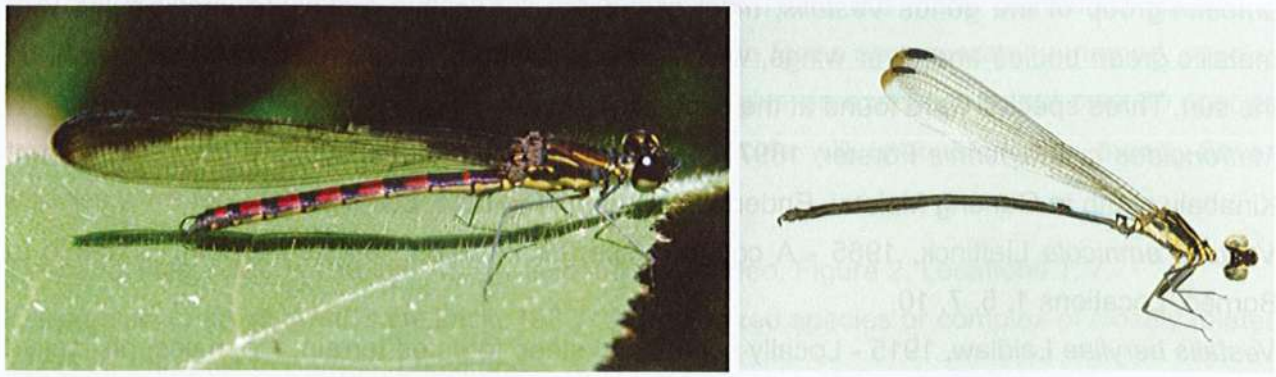


Figure 5: (left). *Rhinocypha spinifer* male (photograph taken in the vicinity of Pulong Tau National Park). Photograph by R.A. Dow. **Figure 6:** (right). *Rhinoneura caerulea* male (specimen from the Hose Mountains). Photograph by R.A. Dow.

Devadattidae

This small family includes only a single genus, *Devadatta*, and was previously included in the Amphipterygidae. Only one species, *Devadatta podolestoides* Laidlaw, 1934, was thought to occur in Sarawak until recently, when it was discovered that a number of distinct but very similar species had all been treated as *D. podolestoides* (see Dow, Hämäläinen & Stokvis 2015). The true *D. podolestoides* has not been found east of the Lupar River. Two species were found at the expedition site.

Devadatta aran Dow, Hämäläinen & Stokvis, 2015 - A common species in the Tama Abu Range. Endemic to Borneo. Figure 7. Locations 1, 3, 6, 10.

Devadatta clavicauda Dow, Hämäläinen & Stokvis, 2015 - Usually the most common *Devadatta* species in the lowlands of Sarawak and also occurring at higher altitudes. Endemic to Borneo. Locations 3, 5, 7.



Figure 7: *Devadatta aran* male (photograph taken at Mount Kinabalu). Photograph by R.A. Dow.

Euphaeidae

These are medium-sized damselflies of forest streams and rivers. The family, well represented in Sarawak with eight species recorded, is mostly Asian but reaches as far west as extreme south-eastern Europe. Species are mostly darkly coloured, but some have iridescent wing markings. Only one species was found at the expedition site.

Euphaea subnodalis (Laidlaw, 1915) - This species is locally common on larger, rocky, streams in the interior of Sarawak. Endemic to Borneo. Locations 8, 10.

Platycnemididae

The Calicnemiinae and Platycnemidinae are the subfamilies occurring in Borneo that have traditionally been placed in the Platycnemididae. More recently old world species formerly placed in the Protoneuridae, and the enigmatic genus *Onychargia* Selys, 1865, have been transferred to the Platycnemididae. Three species were found at the expedition site.

Coeliccia nemoricla Laidlaw, 1912 - A montane species known from the Tama Abu Range and north and east as far as Mount Kinabalu. Endemic to Borneo. Locations 1, 5.

Coeliccia cf nemoricla Laidlaw, 1912 - A locally common, but as-yet-unnamed species, often confused with the last. Endemic to Borneo. Location 3.

Coeliccia nigrohamata Laidlaw, 1918 - A common species of streams and marshy areas in forest. Endemic to Borneo. Locations 3, 5, 10.

Coenagrionidae

This is a large, cosmopolitan and very diverse family, and includes both forest and non-forest species. Fourteen genera are currently known from Sarawak, with over 40 species, but only two species were found at the expedition site.

Stenagrion dubium (Laidlaw, 1912) - This species is very common on small streams in steep forested terrain in Sarawak. Endemic to Borneo. Locations 1, 3, 5, 7.

Teinobasis laidlawi Kimmins, 1936 - An uncommon species in Sarawak, where it occurs at ponds and swampy areas in forest in the hilly and mountainous interior. Endemic to Borneo. Location 4.

Anisoptera (Dragonflies)

Aeshnidae

A medium-sized family with a worldwide distribution. Many species are large or very large. The majority of species found in Sarawak are crepuscular (dusk and evening flying). Only one species was found at the expedition site.

Indaeschna grubaueri (Förster, 1904) - A common species that breeds in forest pools. Location 4.

Gomphidae

A large family with a worldwide distribution, but relatively poorly represented in Borneo. The Gomphidae have well-separated eyes, which distinguishes them from all other families of Anisoptera found in Borneo. Gomphids are typically very wary and elusive; many species are poorly known. Two species were found at the expedition site.

Leptogomphus williamsoni Laidlaw, 1912 - A locally common but elusive forest stream species, typically found in hilly and mountainous terrain. Endemic to Borneo. Location 3.

Sieboldius japponicus (Selys, 1854) - This large and unmistakable species was seen on the Sungai Baleh downstream from the camp. Location 8.

Macromiidae

Formerly included in the Corduliidae, the representatives of this family are fast flying; most species occur on forest streams. One species was found at the expedition site.

Macromia westwoodii Selys, 1874 - The most commonly encountered *Macromia* species in mountainous terrain in Sarawak. Location 1.

Synthemistidae

Bornean species now generally accepted to fall within the Synthemistidae were previously included in the Corduliidae or treated as *incertae sedis*. One species was found at the expedition site.

Idionyx sp. - Two female *Idionyx* were captured in the camp; unfortunately, the females of *Idionyx* species occurring in Borneo cannot be identified to species at this time. Location 9.

Libellulidae

The largest family of the Odonata, with a worldwide distribution. Considerable variety exists in this family of mostly small-to medium-sized species. Males are often brightly coloured. Five species were found at the expedition site, another species only at location 10.

Cratilla metallica (Brauer, 1878) - A widespread forest species, it breeds in forest pools. Locations 4, 9.

Lyriothemis biappendiculata (Selys, 1878) - A locally common forest species, typically found in muddy low gradient seepages. Figure 8. Location 3.

Orthetrum glaucum (Brauer, 1865) - A common species. Locations 10.

Orthetrum pruinosum schneideri Förster, 1903 - A common species in many forested areas. Figure 9. Location 5.

Tetrathemis sp. cf *platyptera* Selys, 1878 - A female, it appears to be that of an uncommon species found in the uplands of Sarawak and allied to, or possibly merely the Bornean form of, *T. platyptera*. Location 4.

Zygonyx ida errans Lieftinck, 1953 - A species usually associated with fast-flowing waters, one individual was caught at the camp site. This subspecies was placed under *Z. iris* Selys, 1869 until recently (see Dow *et al.* 2018) and is endemic to Borneo. Location 9.

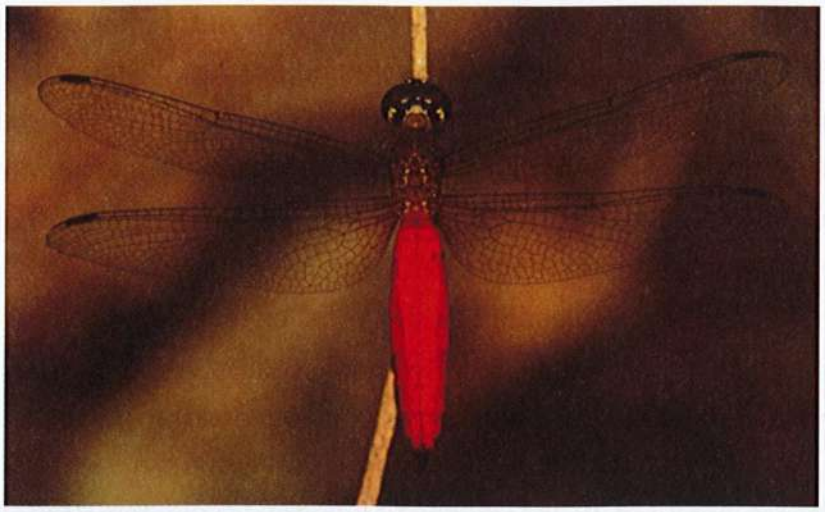




Figure 8: (left). *Lyriothemis biappendiculata* male (photograph taken at Lambir Hills National Park). Photograph by G.T. Reels. **Figure 9:** (right). *Orthetrum pruinosum schneideri* male (photograph taken at Kubah National Park). Photograph by R.A. Dow.

DISCUSSION AND CONCLUSIONS

Thirty-two species of Odonata from 12 families were collected or observed during the expedition; of this one species was only found away from the main expedition site. The most noteworthy species found during the expedition, including some worthy of special attention from a conservation viewpoint, are listed in Table 1. The damselfly family Platystictidae was by far the best represented family at the expedition site, with seven species recorded; this is not unusual in steep forested terrain in the interior of Sarawak. Although the species inventory for the expedition site is certainly not complete (for instance it is almost certain that additional species from the Aeshnidae, Gomphidae, Chlorogomphidae and Macromiidae are present in the area), it is safe to say that the diversity of Odonata there is rather low. This result is disappointing, but unsurprising since it agrees with results from other parts of the Tama Abu Range, for instance only 26 species have been recorded within Pulong Tau National Park (although the higher altitude of most locations sampled there is a factor). In contrast some other areas in Telang Usan District appear to have much higher odonate diversity, for instance: the Ulu Moh area on the border with Indonesia approximately 66 km southwest of the expedition site (62 species); the Sungai Sii area approximately 70 km to the southwest (66 species); Gunung Kalulong approximately 90 km to the west (56 species). Of these areas, the surveyed part of the Ulu Moh area spans a similar but somewhat lower altitudinal range (ca 600-950m a.s.l.) to that at the Tama Abu expedition site (sampled for Odonata at ca 700-1200m a.s.l.), surveyed parts of Gunung Kalulong are at ca 300-900m a.s.l. and the Sungai Sii area is lower, ca 250-350m a.s.l. Although altitude undoubtedly plays a part in the lower diversity in the Tama Abu Range, another factor is variety of habitats and terrain; sampled habitats at the expedition site were almost all streams in steep terrain, with just one forest pond sampled, whereas a greater range of stream types and in some cases other habitat types such as ponds and even patches of swamp have been sampled in the other areas mentioned.

However even the lower variety of habitats at the expedition site does not entirely explain the low odonate diversity there, since if only similar sites to those at the expedition site are considered other areas still have a greater diversity; there does appear to be a geographical element to this puzzle.

Table 2 summarises the numbers of families and of species collected during the expedition at each of the locations within the expedition site listed in Section 0; location 10, outside of the expedition site, is excluded. Location 1 has the most species, but it received the most collecting effort and it is likely that, for instance, locations 3 and 5 would prove to have similar diversity with more collecting effort.

Of the 31 species recorded at the expedition site, all are forest dependent species. Twenty-two of the 31 species found at the expedition site are endemic to Borneo, this is approximately 74% of the species found during the expedition, and slightly higher than the overall percentage of Odonata found in Borneo that are endemic to Borneo (approximately 72%). For the Zygoptera, every species found at the expedition site is endemic to Borneo.

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Tables and Table captions

Table 1. The most noteworthy species found at the expedition site.

Species	Comment
Protosticta sp. cf kinabaluensis	An unnamed species, known from a few locations in Sarawak; also known from Sabah.
Telosticta berawan	*Telosticta berawan* has a draft Vulnerable IUCN Red List assessment and is known with certainty from very few locations.
Telosticta ulubaram	This species has a draft Vulnerable IUCN Red List assessment and is only known from a few locations.
Matronoides cyaneipennis	Although already known from the upper Baram, this species is more common at higher elevations than the author reached during the expedition.
Rhinoneura caerulea	*R. caerulea* is an apparently rare species with a Data Deficient IUCN Red List assessment; if (unlikely) the species seen during the expedition is not *R. caerulea* then it will almost certainly be an unnamed species.
Coeliccia nemoricola	The true *C. nemoricola* has a relatively small range.
Tetrathemis sp. cf platyptera	This species, if distinct from *T. platyptera*, is known from only a few sites in Borneo.

Table 2. Numbers of species and families collected at the nine locations sampled for Odonata at the expedition site.

Location	Number of species	Number of families
1	15	7
2	2	2
3	8	6
4	4	3
5	9	7
6	2	2
7	8	4
8	3	3
9	3	2

THRIPS (INSECTA: THYSANOPTERA) OF TAMA ABU

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Abstract

A survey of thrips was conducted during the Tama Abu Scientific Expedition from 15-26 August 2017. In total 46 species belonging to three families were collected. The majority (50% or 23 species) of the collected species were from the family Thripidae. A total of eight species of Thysanopetara are new record for Malaysia, include Aoratothrips tenuis (subfamily Pancheaothripinae), Celidothrips sp. and Elaphrothrips sensitivus (subfamily Idolothripinae), Dolichothrips indicus, Holothrips falcatus, Xylaplothrips pictipes, Propesolomonthrips mindori and Haplothrips imperatae (subfamily Phlaeothripinae). An annotated list of Thysanoptera collected is provided. This list is by no mean exhaustive as it is based on upon a limited collecting period; many further species can be certainly being expected from the Tama Abu Range and its adjacent areas.

Keywords: *Heart of Borneo, Sarawak, Thysanoptera*

INTRODUCTION

The Thysanoptera, commonly known as thrips, contain more than 6000 described species classified into two suborders, the Terebrantia and Tubulifera (ThripsWiki, 2018). Adults thrips have small bodies ranging in size from 0.5-15.0 mm, asymmetric mouthparts, and narrow fringed wings. Most thrips are phytophagous or fungivorous, although a few are carnivorous as predators of other small insects. These insects inhabit a wide range of environments, living in flowers, or on leaves and dead plants. Although some thrips species are important as pests of agriculture, many play crucial roles in the ecosystems of tropical forests as pollinators of Dipterocarpaceae (Appanah & Chan, 1981) and as well as providing food for other animals including birds, lizards and spiders.

The Thysanoptera fauna of the Tropics, including Malaysia, is still far from well known. Recent and past field studies on Thysanopera have concentrated on various parts of Peninsular Malaysia, and only very limited work on this group has been carried out in East Malaysia (Sabah and Sarawak). The species checklists of Thysanoptera published by Mound and Azizah (2009), and Eow et al. (2012) are mainly focussed on Peninsular Malaysia.

The documentation of Sarawak's biodiversity began in the period 1854-1862, when the eminent naturalist Alfred R. Wallace carried out a collecting expedition in the Malay Archipelago. The paper he wrote in 1855 during his expedition, 'On the law which has regulated the introduction of new species' is now often referred as the 'Sarawak Law' paper. Wallace made a vast collection of beetles and butterflies from Borneo, but there is no information on Thysanoptera in his collection.

The earliest field work on Thysanoptera in Sarawak was probably that of E. G. Bryant who collected many specimens from Mount Matang, Sarawak between 1913 and 1914. Bryant's collection was later studied by R.S. Bagnall who described a large number of new species from here, including the important pest thrips, *Megalurothrips typicus* Bagnall 1914 and *Thrips orientalis* (Bagnall) 1915. In 1915, Bagnall published in the Sarawak Museum Journal a paper entitled "A preliminary account of the Thysanoptera of Borneo"; this is probably the earliest Thysanoptera paper to be published in a local journal. Palmer and Mound (1974) re-examined Bryant's collection with the addition of a few interesting specimens from Sarawak including a male of *Elaphrothrips bakeri* and one of *Machatothrips biuncinatus*, collected by R.C. Wallace (no date of collection, but probably between 1950 and 1960).

A recent field study of Thysanoptera in Sarawak was carried out by Kudo (1997) who described four new species of *Hydatothrips* based on material he collected from Taman Negara Bako, Sarawak. Mound and Okajima (2015) added another four new species of *Dolichothrips* based on specimens collected from Lambir Hill National Park. Reporting his results from the 2016 Heart of Borneo expedition to Long Banga, Baram, Ng, Y.F. presented a list of 23 species of Thysanoptera. Several of these may be new species.

This paper presents the results the short 2017 Heart of Borneo expedition to Tama Abu, located in the southeast of Pulong Tau National Park, Sarawak. An annotated checklist of Thysanoptera so far recorded during the expedition and previous records between 1915-2017 is provided.

STUDY SITE

The expedition site was located at about N 03° 18' 37.1", E 115° 28' 48.7" (southeast of Pulong Tau National Park). The expedition base camp was set up at approximately 400–500 metres a.s.l. and is surrounded by old logged forest and patches of pristine forests. At least 10 sampling trails were made during the expedition, including some that were steep-climb trails stretching up to heath forest at 1300 metres a.s.l. Our sampling sites also included two nearby villages, Long Peluan and Long Beruan. Beside that, we also carried out sampling along the main logging road (route to Bario) between the expedition base camp and Long Beruan.

SAMPLING

The sampling of Thysanoptera was carried out using a beating tray and searching for leaf-galls on vegetation along the sampling trails. Targets include dead leaves, twig and branches, and bamboos, trees, grasses (Poaceae), *Ficus trees*, climbers, orchids and other flowers.

RESULTS AND DISCUSSION

Adults specimens of a total of 46 species of Thysanoptera were collected, representing three families and five subfamilies. The majority of species were from the family Thripinae which can be classified into three subfamilies, namely Panchaetothripinae, Sericothripinae and Thripinae.

The species of Panchaetothripinae are all leaf-feeding thrips, although adults can occasionally be found on flowers of various plants. Several species are known as greenhouse thrips and pests of horticultural plants. In the wild, many species have an association with fern fronds. During this expedition, we collected three panchaetothripine species. *Aoratothrips tenuis* (Figure 1), collected on *Ficus* leaves is a new record for Malaysia. This species was described from Java, Indonisia and recorded from Thailand. The other two, *Helionothrips annosus* and *Phibalothrips rugosus*, are commonly collected in Malaysia; the latter species is widespread on grasses and is often known as 'grass-thrips'.

Only a single species was collected belonging to the subfamily Sericothripinae, an unidentified *Hydatothrips* sp. Species of this subfamily are very tiny, roughly about 1mm in body length, and are collected rarely from various plants, usually only with intensive sampling on leaves. Only three genera are recognized in this subfamily and many species are difficult to identify.

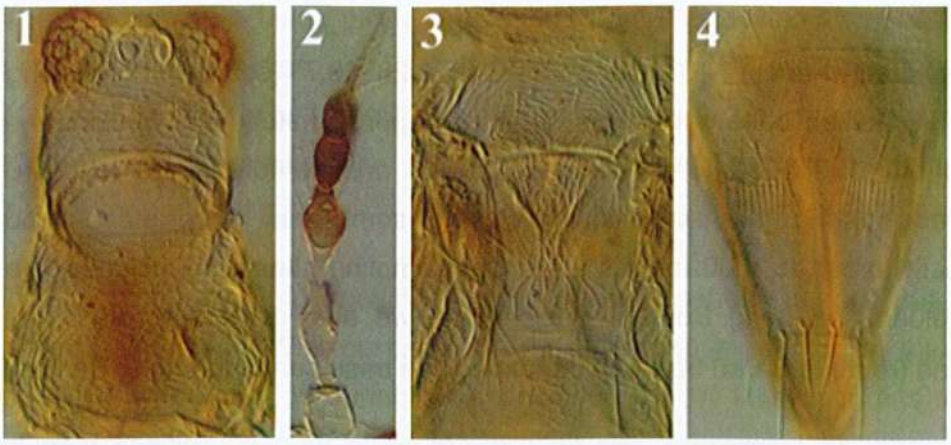


Figure 1: *Aorathrips tenuis* Priesner (collected on *Ficus leaves*)

Thripinae is the second largest subfamily of Thysanoptera. Many species are important pests of agriculture, causing physical damage. A small number of species are vectors of plant diseases. Many species of Thripinae live in flowers and some live on leaves, some species exhibit host preferences. During this expedition, we collected at 19 species of Thripinae, most of which are common and widespread on various plant species; an exception was *Dichromothrips smithi* which specifically breeds on orchids.

Phlaeothripidae are classified into two subfamilies, the Idolothripinae and Phlaeothripinae. The species of these subfamilies are robust in body structure, often highly sexually dimorphic and many live on dead twigs, branches and leaves. Idolothripinae are fungus spore-feeders. Many members of Phlaeothripinae feed on fungal hyphae, but others are phytophagous and induce galls on leaves, and a few are flower-living. In total 23 species of Phlaeothripidae were recorded. Of these *Celidothrips sp., Elaphrothrips sensitivus, Dolichothrips indicus, Holothrips falcatus, Xylaplothrips pictipes, Propesolomonthrips mindori* and *Haplothrips imperatae* are new records for Malaysia. The last two were particularly interesting as they have not been seen since their original descriptions - the first from the Philippines, and the second from Sumatra.

Further intensive studies in Borneo can be expected to add considerably more species to the current list of thrips from the island, and thus to the Malaysian Thysanoptera species list. Table 1 present the list of Thysanoptera collected from Sarawak. These data are based on information from the Thysanoptera catalogue available in ThripsWiki, combined with the results from recent expedition.

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Table 1: A Checklist of Thysanoptera recorded and described from Sarawak between 1915-2017. (* = new record for Malaysia)

No.	Family/subfamily/species	Tama Abu Expedition	Long Banga Expedition	Recorded (R) or Described (D) from Sarawak. (ThripsWiki 2018)
	THRIPIDAE			
	Dendrothripinae			
1	*Asprothrips* sp.n.		√	
	Panchaetothripinae			
2	*Aoratothrips tenuis* Priesner, 1933	√*		
3	*Helionothrips annosus* Wang [from *Litsea cubida* lvs]	√		
4	*Phibalothrips rugosus* Kudo	√	√	
	Sericothripinae			
5	*Hydatothrips* sp. indet.	√		
6	*Hydatothrips (Zonothrips) besar* Kudo, 1997			D
7	*Hydatothrips latisensibilis* Kudo, 1997		√	D
8	*Hydatothrips longicaudalis* Kudo, 1997			D
9	*Hydatothrips onari* Kudo, 1997			D
10	*Neohydatothrips medius* Wang, 1994		√	
	Thripinae			
11	*Anaphothrips sudanensis* Trybom	√		
12	*Arorathrips mexicanus* (Crawford)	√		
13	*Bolacothrips striatopennatus* (Schmutz)	√		
14	*Chaetanaphothrips leeuweni* (Karny) [from *Ipomoea batatas*]	√		
15	*Chaetanaphothrips ipomoeae* Nonaka and Okajima, 1992		√	
16	*Chaetanaphothrips ?machili*	√		
17	*Clypeothrips* sp?		√	
18	*Dendrothripoides innoxius* (Karny) [from *Ipomoea batatas*]	√		
19	*Dendrothripoides poni* Kudo, 1977		√	
20	*Dichromothrips smithi* (Zimmermann) [from *Arundina*]	√	√	

No.	Family/subfamily/species	Tama Abu Expedition	Long Banga Expedition	Recorded (R) or Described (D) from Sarawak. (ThripsWiki 2018)
21	*Danothrips alis*		√	
22	*Echinothrips* sp.n		√	
23	*Filipinothrips baltazarae* Reyes	√		
24	*Frankliniella schultzei* (Trybom)	√		
25	*Megalurothrips usitatus* (Bagnall)	√		
26	*Megalurothrips typicus* Bagnall, 1915			D
27	*Microcephalothrips abdominals* (Crawford)	√	√	
28	*Rhamphothrips* spp. indet.	√	√	
29	*Scirtothrips dorsalis* Hood	√	√	
30	*Scirtothrips dobroskyi* Moulton, 1936		√	
31	*Takethrips* sp.		√	
32	*Stenchaetothrips bambusae* (Shumsher, 1946)		√	
33	*Thrips coloratus* Schmutz	√		
34	*Thrips florum* Schmutz	√	√	
35	*Thrips orientalis* (Bagnall), 1915			D
36	*Thrips palmi* Karny	√		
37	*Thrips parvispinus* (Karny)	√	√	
38	*Trichromothrips* spp. indet.	√		
39	*Trichromothrips trifaciatus* (Priesner)	√	√	
	PHLAEOTHRIPIDAE – IDOLOTHRIPINAE			
40	*Celidothrips* sp. indet.	√*		
41	*Dinothrips spinosus*			R
42	*Elaphrothrips ?bakeri* (1 male collcted by C.R. Wallace)	√	√	R
43	*Elaphrothrips sensitivus* Priesner	√*		
44	*Holurothrips ornatus* Bagnall, 1914			D
45	*Machatothrips antennatus* (Bagnall), 1915			D
46	*Machatothrips biuncinatus* Bagnall, 1908			D
47	*Machatothrips lentus* Palmer & Mound	√	√	
48	*Mecynothrips simplex* Bagnall	√		

No.	Family/subfamily/species	Tama Abu Expedition	Long Banga Expedition	Recorded (R) or Described (D) from Sarawak. (ThripsWiki 2018)
49	*Meiothrips annulipes* (Bagnall), 1914			D
50	*Nesothrips lativentris* (Karny)	√		
	PHLAEOTHRIPIDAE – PHLAEOTHRIPINAE			
51	*Adraneothrips* spp. Indet.	√		
52	*Andrethrips floydi* Mound	√		D
53	*Apelaunothrips consimilis* (Ananthakrishnan)	√		
54	*Azaleothrips richardi* Okajima & masumoto	√		
55	*Baenothrips murphyi* (Stannard)	√	√	
56	*Docessissophothrips laticeps*			D
57	*Dolichothrips chikakoae* Mound & Okajima, 2015			D
58	*Dolichothrips eriae* Mound & Okajima, 2015			D
59	*Dolichothrips fialae* Mound & Okajima, 2015			D
60	*Dolichothrips indicus* (Hood)	√*		
61	Dolichothrips utae Mound & Okajima, 2015			D
62	*Ecacanthothrips andrei* Palmer & Mound	√		
63	*Ecacanthothrips leai* Moulton	√		
64	*Ecacanthothrips tibialis* (Ashmead) collected 1913 by E. G. Bryant at Mount Matang	√		R
65	*Haplothrips gowdeyi* (Franklin)	√		
66	*Haplothrips imperatae* Priesner	√*		
67	*Haplothrips ganglebaueri* Schmutz	√		
68	*Heliothripoides boltoni* Dang, Mound & Qiao, 2014			D
69	*Holothrips caudatus* (Bagnall), 1915			D
70	*Holothrips falcatus* Okajima	√*		
71	*Psalidothrips ?grandis*	√		
72	*Psalidothrips ?ascitus*	√		
73	*Propesolomonthrips mindori* Reyes	√*		
74	*Tetracanthothrips borneensis* Bagnall, 1915			D
75	*Veerabahuthrips* sp.		√	
76	*Xylaplothrips pictipes* (Bagnall)	√*		

THE CADDISFLIES (INSECTA: TRICHOPTERA) OF TAMA ABU

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Abstract

Caddisfly adults and their aquatic larvae were collected beside and from the river and streams in the Tama Abu Heart of Borneo Expedition 2017 area. Processing of the specimens in the laboratory in Australia, resulted in identification of 33 separate species, most of them recognised as described species; among samples were representatives of nine families. Filter-feeders were predominant; noticeably absent were members of free-living, predatory families. Similar studies at other times of year are recommended.

Keywords: *indicator species, light-trapping, species diversity, endemics*

INTRODUCTION

Caddisflies (Trichoptera) provide food for fishes, bats, birds and some stream invertebrates, and are often used as indicators of the clean, safe, waters needed for healthy communities, and for good stocks of fish. Caddisflies were the focus of this study during the Tama Abu Heart of Borneo Expedition 2017 of 13 to 27 August 2017.

Caddisflies have aquatic larvae (Fig. 1), usually collected by netting or hand-picking, and winged adults (Fig. 2) most of which can be collected at lights at night. To date around 354 species of caddisfly have been described for all Borneo (see Appendix 1). This is a very low figure when compared with the number described for the smaller land mass of Thailand - more than 1000 species, and Morse in Yong & Yule (2008) predicted a figure nearer 600 species for Borneo. Thus, collection of undescribed species was expected (Figure 1 and 2).

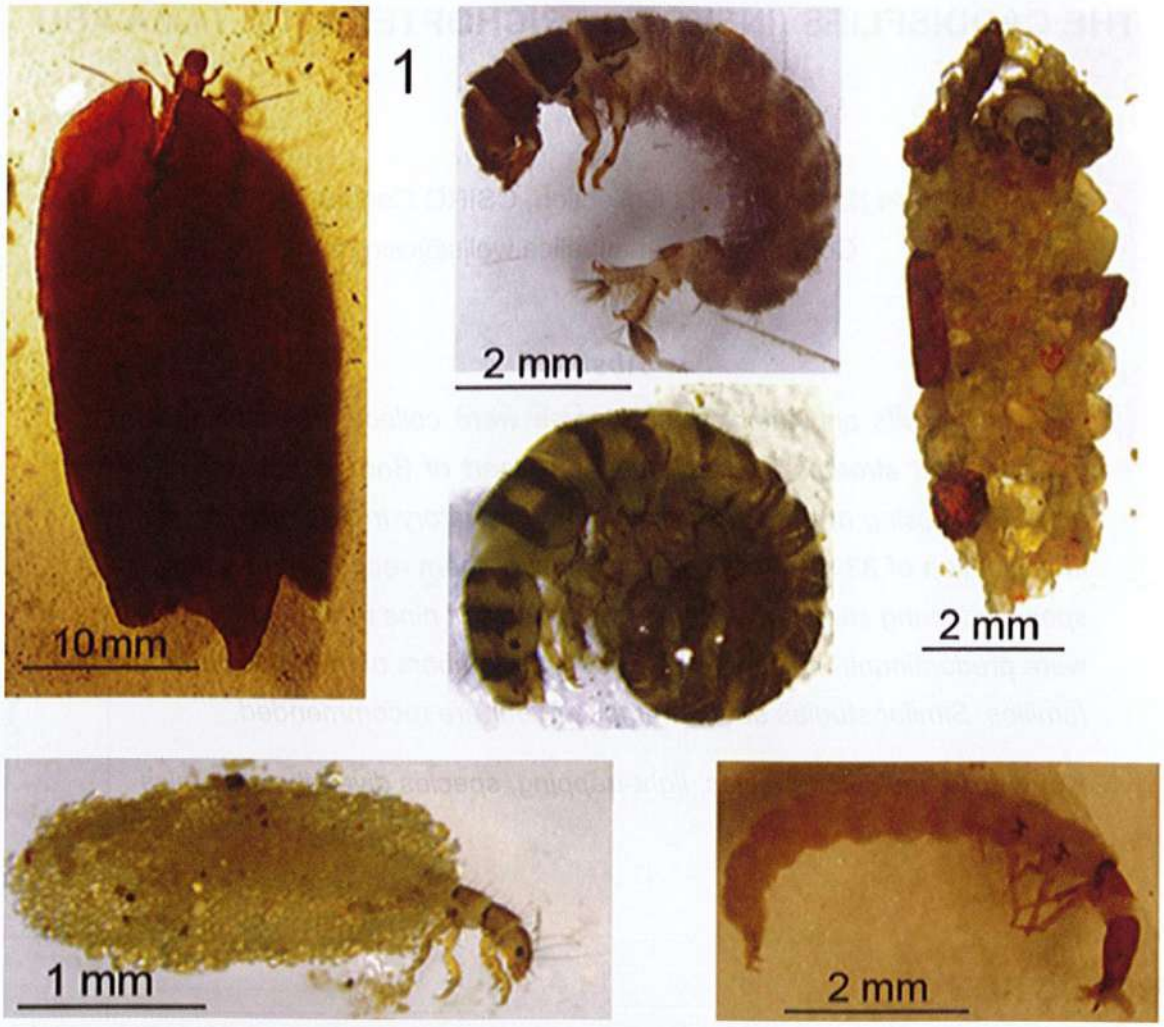


Figure 1: Examples of larvae and cases of caddisflies collected in the streams in the vicinity of the camp site during the Tama Abu Heart of Borneo Expedition 2017 of August 2017.

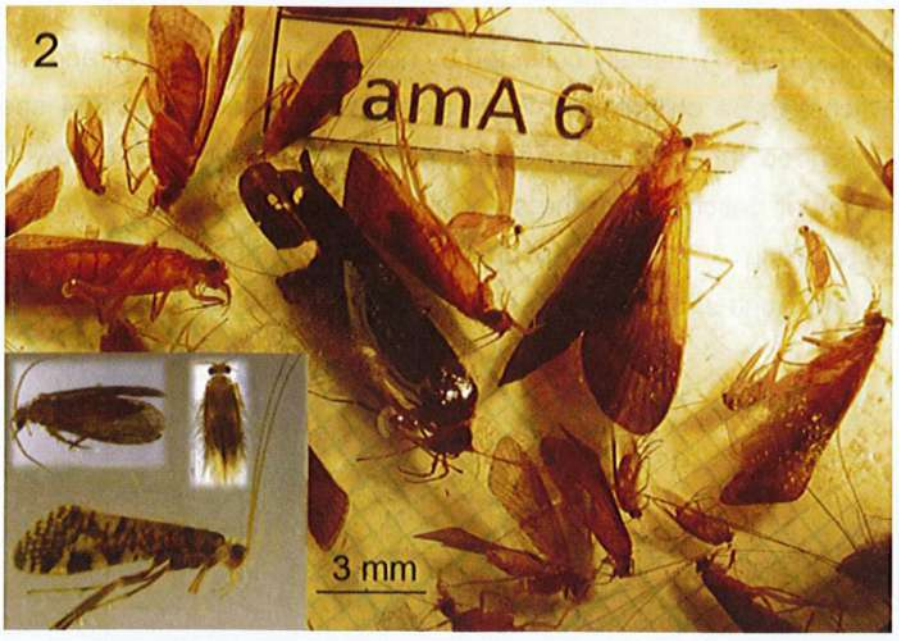


Figure 2: Sample of adult caddisflies collected at the UV light beside Sungai Baleh; inset, three of the less commonly collected species.

METHODS

For collection of adult caddisflies, a simple, improvised, readily transportable UV light, as illustrated in Fig. 4, was set up on rocks beside Sungai Baleh (Figure 3) just upstream from the Camp, at approximately 03°18'37" N, 115°28'49" (southeast of Pulong Tau National Park). The set-up proved to be most effective, the umbrella protecting the light and small plastic tray of 70% ethanol, even on a night of very heavy rain.

RESULTS

Good samples of caddisfly adults were taken over a number of nights, and samples of larvae were collected by hand-picking from smaller streams in the forest (Figure 5), and from other streams along the Miri-Bario road (Figure 3 - 6).



Figure 3-6: Fig.3, Sungai Baleh at the Expedition campsite following heavy rain, showing sediment-rich water; Figure 4, improvised, easily transportable light trap used successfully to collect adult caddisflies; Figure 5, small forest stream - caddisflies in tortoise-shell cases were found gripping to the rock surfaces from which they scrape the diatoms and microinvertebrates from the rock surface for food; Figure 6, lower and upper views of case of one of the 'scrapers' - water in these small streams was clean and leaf packs caught on the rocks supported detritivorous and filter-feeding caddisflies.

Larvae were identified to genus using the key provided by Morse in Yong and Yule (2008) and adults were identified to species, or if not possible, to genus, mostly using the figures provided by Malicky (2010). Examples of the features used to determine identities of caddisfly species are given in Figures 7-10. Wiggins' (2004) key to adults was useful for determining generic placement of some species (Figures 7-10).

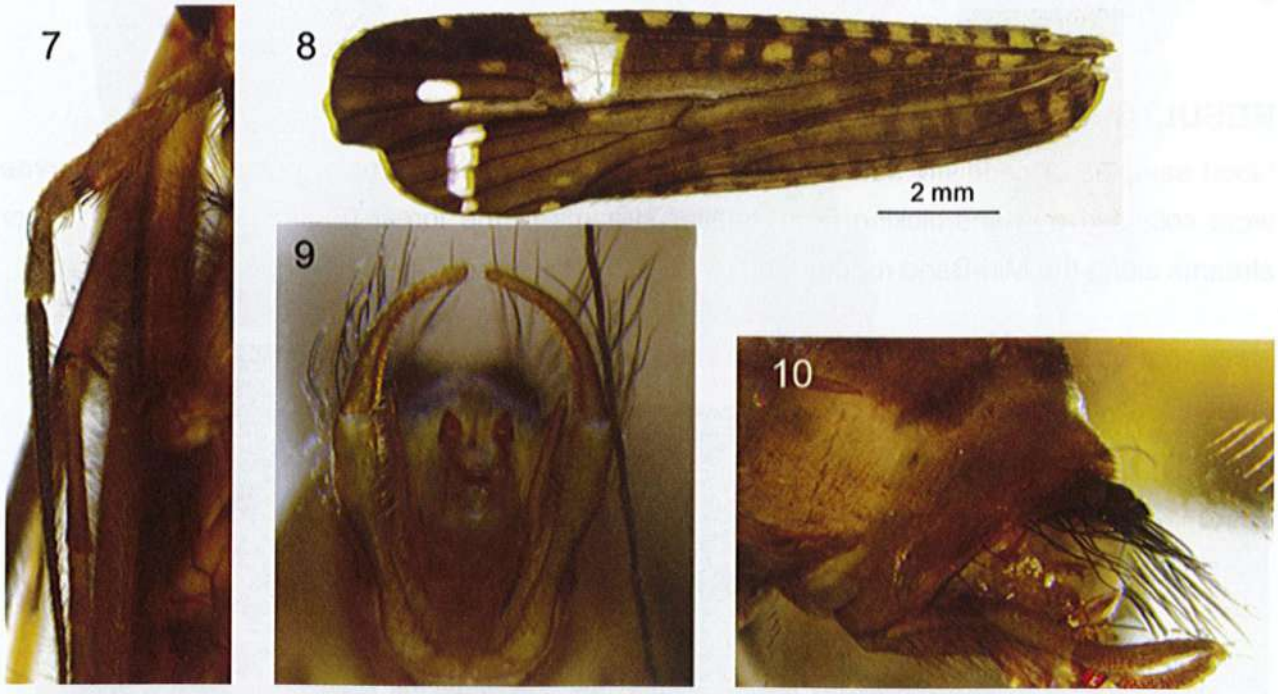


Figure 7-10: Features of male of *Pseudoleptonema* sinuatum, examples of characteristics used in identification of caddisfly species: Figure 7: maxillary palp; Figure 8: right fore wing, showing venation; Figures. 9, 10: genitalia in ventral and lateral views.

Established names were available for most of the adult caddisflies collected. For several species (and for all larvae) generic assignment only has been possible. A checklist of species for the collections from Tama Abu is given in Table 1. No earlier records for this particular area have been found in the literature.

Presently known 'distributions' of species given in Table 1 below are taken mostly from the original papers, supplemented by data given in Malicky (2010) for broader non-Bornean occurrence of several species.

In total, adults of 33 species were collected. These represent nine families, among them genera usually recognised to be filter feeders/collectors (most common in terms of species diversity); scrapers, scraping periphyton (epilithos) from the upper surfaces of rocks in flowing water (most abundant); predators (few); and shredders (rare, although larvae were abundant in small tributaries on the slope leading to river).

DISCUSSION

Only three of the 29 species for which names are available are found beyond Borneo (notwithstanding that several identifications are tentative only, as indicated by question marks). Thus, somewhere close to 90% of species taken in this Tama Abu reach of Sg. Baleh are e ndemic.

Surprising, however, is the particular mix of genera and families collected. While larvae of some of the species were undoubtedly living in the often-fast-flowing Sg. Baleh, undoubtedly larvae of others, such as the single specimen of *Anisocentropus* (a shredder of rotting leaves) and many of the scrapers, were living in the small mostly sediment-free, tributary streams feeding into the larger river.

Several families were conspicuous by their absence although recorded from elsewhere in Borneo. Among these are Rhyacophilidae and Hydrobiosidae, with predatory larvae; Philopotamidae, Stenopsychodidae, and Dipseudopsidae, all of which filter water through nets and feed on the fine particles collected; Goeridae and Lepidostomatidae, two groups of detritivores; and Helicopsychidae, scrapers that feed on epilithos.

Table 2 gives comparisons between the known Trichoptera fauna of Borneo, the collections made at Tama Abu, and the Australian fauna with which the author is familiar. Of surprise among the Tama Abu collections, was the relatively high diversity of species of Hydropsychidae - 30% compared to 16% among the entire Bornean fauna and 5% for Australia. Hydropsychids are all net-spinner, filter feeder/collectors, and apparently are able to cope with the relatively high sediment loads of the river such as apparent during much of the collecting period (see Fig. 3). In the Tama Abu collections most species were represented by few male specimens, some by only one, but for some large numbers of females were taken. Although such disproportionate ratios seem to be counter-intuitive, similar results have been found by others for streams in Borneo (Fikri et al. 2013; Fikriet al. 2016), and Peninsular Malaysia (Suhaila et al. 2012; Suhaila et al. 2014; Nor Zaiha et al. 2015).

Psychomyiidae were also surprising diverse (see Tables 1 and 2). Members of this family are case-making, 'scrapers' scrapers' that cling tightly to the surface of submerged rocks and feed on the epilithos, i.e. the growth of micro-algae (diatoms) and other organisms on rocks. One species was quite abundant - this was identified tentatively as *Psychomyia alkibiades.* Psychomyiid larvae (Fig. 6) were seen on rocks in the small tributaries (Fig. 5) flowing out of the forest into Sg. Baleh and the adults may have come from the small streams rather than the river.

Notably absent among the Tama Abu collections are Philopotamidae, a group of silk tube-spinning, filter-feeders, although these appear to be diverse elsewhere in Borneo. In Australia, members of this family are often common in leaf packs and other detritus, so the flushing of such material by fast flow and spates in the river may account for their absence. Similarly, cased larvae of the long-horned caddisflies, Leptoceridae, and predators such as ecnomids are noticeably few, and rhyacophilids and hydrobiosids absent. Since most predatory larvae live free and uncased, they are likely to be swept away by the strong currents, as are the light vegetable material and even the sand grain cases of leptocerids. A list of caddisflies recorded for Borneo is given in Appendix 1. As can be seen data presented here for the Tama Abu site represent a brief snapshot only. Given the wide range of habitats available in Borneo and even in the forest of Tama Abu, undoubtedly further widespread collecting across the entire year would be useful.

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Table 1: *Checklist of Trichoptera collected from 14th to 25th August on the HoB Tama Abu Expedition 2017.* Larval trophic groups are indicated as well as the general distributions, following Malicky (2010). (* Species marked with an asterix are known only from Borneo).

Family	Genus	Species	Larval trophic roup	Other records
Glossosomatidae	**Agapetus*	*abram*	scrapers	Sabah, Kinabalu NP, Poring hot spring, Sg. Kipungit
Hydroptilidae	*Hydroptila*	*dayung*	scrapers	Sabah: Lahad Datu; Thailand, Vietnam
	**Hydroptila*	*kebawah*	scrapers	Sabah: NE Ranau, Sg Mokodou; Sarawak: N of Bario, Sg Dapur
	Hellyethira	*bulat*	green algae feeders	Sabah; Brunei; Sarawak; Pen. Malaysia, Sumatra, Thailand
	Pseudoxyethira	*sp.*	scrapers/ herbivores	Widespread genus SE Asia, Japan to Australia
Polycentropodidae	**Nyctiophylax*	*temburongensis*	filter feeders	Brunei: Temburong
	**Pseudoneureclipsis*	*deianeira*	filter feeders	Sabah: Sg. Segama, Danum Valley
	**Pseudoneureclipsis*	*tlepolemos*	filter feeders	Kalimantan: catchments of Seturan & Rian Rivers
	**Polyplectropus*	*simei*	filter feeders	Brunei, Bukit Relak; Sabah

Family	Genus	Species	Larval trophic roup	Other records
Hydropsychidae	*Cheumatopsyche	*chimaira*	filter feeders	Brunei: Temburong
	*Cheumatopsyche	*ernstheissi*	filter feeders	Brunei: Temburong
	*Cheumatopsyche	*sipitanga*	filter feeders	Sabah: Sipitang, Mendolong Nursery
	*Cheumatopsyche	temburonga	filter feeders	Brunei: Temburong
	*Hydropsyche	arkas	filter feeders	Sabah: Kinabalu NP, Poring hot spring, Sg Kipungit
	*Hydropsyche	askanios	filter feeders	Brunei: Temburong
	*Hydropsyche	autolykos	filter feeders	Brunei: Temburong
	*Hydropsyche	isolata	filter feeders	Sabah: Mt Kinabalu, Kiau
	*Polymorphanisus	quadripunctatus	filter feeders	Borneo (in publication as 'Borneo: Nanga Raven')
	*Pseudoleptonema	sinuatum	filter feeders	Kalimantan, Melawi Basin, Kapuas
Ecnomidae	*Ecnomus	phoibos	predators	Kalimantan: catchments of Seturan and Rian Rivers, ~70km south of Malinau
	*Ecnomus	yulae	predators	East Kalimantan: Kelian R. trib Mahakam River, 250km W of Samarinda

Family	Genus	Species	Larval trophic roup	Other records
Psychomyiidae	*Psychomyia	adebratti	scrapers	Sabah: Sipitang, Mendolong Nursery
	*Psychomyia	alkibiades	scrapers	Sabah
	*Psychomyia	polydektes	scrapers	Kalimantan: catchments of Seturan and Rian Rivers, ~70km south of Malinau
	*Psychomyia	mendolongensis	scrapers	Sabah, Sipitang, Mendolong Nursery
	*Psychomyia	polymestor	scrapers	Kalimantan: catchments of Seturan and Rian Rivers, ~70km south of Malinau
	*Psychomyia	trifurcata	scrapers	Sabah: Sipitang, Mendolong Nursery
	*Paduniella	teukros	scrapers	Kalimantan: catchments of Seturan and Rian Rivers, ~70km south of Malinau
Xiphocentronidae	*Melanotrichia	polydeukes	filter feeders/scrapers	Kalimantan: catchments Seturan & Rian rivers
	Melanotrichia	hanuman	filter feeders/scrapers	Thailand, Sumatra
Calamoceratidae	*Anisocentropus	sawan	shredders	Sabah: Kinabalu NP, headquarters
Leptoceridae	*Oecetis	laomedon	predators	Kalimantan: Malinau

Table 2: *Comparison of caddisfly families, numbers of species and % of fauna known from Borneo and Australia (as of November 2017) with the collection made during Tama Abu Heart of Borneo Expedition 2017.* Note the Oriental/ Old World families missing entirely from the Australian fauna, most of which were also not taken at Tama Abu, and the second set of 'southern' families represented in Australia but not represented in the Bornean Fauna. [Data taken from Blahnik, Holzenthal & Huisman 2009; Malicky 2010; and the online Australian Faunal Directory, ABRS 2017].

	BORNEO #species	% of total	TAMA ABU #species	% of total	AUST #species	% of total
FAMILY						
Stenopsychidae	1	0.30%	0	0.00%	9	0.01%
Odontoceridae	1	0.30%	0	0.00%	5	0.01%
Rhyacophilidae	2	0.60%	0	0.00%	0	0.00%
Limnocentropodidae	2	0.60%	0	0.00%	0	0.00%
Glossosomatidae	4	1.20%	1	3.00%	23	7.00%
Xiphocentronidae	4	1.20%	2	6.00%	0	0.00%
Brachycentridae	4	1.20%	0	0.00%	0	0.00%
Goeridae	4	1.20%	0	0.00%	0	0.00%
Helicopsychidae	4	1.20%	0	0.00%	15	4.00%
Hydrobiosidae	5	1.40%	0	0.00%	67	8.00%
Calamoceratidae	6	1.70%	1	3.00%	10	0.10%
Dipseudopsidae	12	3.42%	0	0.00%	1	<<0.01%
Ecnomidae	18	5.10%	2	6.00%	123	15.00%
Lepidostomatidae	19	5.40%	0	0.00%	0	0.00%
Polycentropodidae	25	7.10%	4	12.00%	18	2.10%
Psychomyiidae	39	11.11%	7	21.00%	3	<0.01%
Leptoceridae	45	12.80%	2	6.00%	180	22.00%
Philopotamidae	50	14.25%	0	0.00%	82	10.00%
Hydroptilidae	53	15.10%	4	12.00%	158	18.00%
Hydropsychidae	53	15.10%	10	30.00%	36	5.00%
Antipodoeciidae	0		0		1	
Oeconesidae	0		0		1	
Atriplectididae	0		0		2	
Chathamiidae	0		0		2	
Limnephilidae	0		0		2	
Plectrotarsidae	0		0		5	
Kokiriidae	0		0		5	
Tasimiidae	0		0		7	
Helicophidae	0		0		8	
Philorheithridae	0		0		15	
Conoesucidae	0		0		23	
Calocidae	0		0		32	
TOTAL	**351**		**33**		**833**	

APPENDIX 1: Checklist of Bornean caddisflies, 2017 (Families arranged phylogenetically). [Data from Blahnik et al. 2009; Malicky 2010]

Rhyacophilidae
Rhyacophila abimael
Rhyacophila argentipunctella

Hydrobiosidae
Apsilochorema cabang
Apsilochorema kinabalu
Apsilochorema moselyellum
Apsilochorema segitiga
Apsilochorema tajuk

Glossosomatidae
Agapetus abram
Glossosoma achbor
Glossosoma akban
Temburongpsyche anakan

Hydroptilidae
Chrysotrichia bitnik
Chrysotrichia coodei
Chrysotrichia gajah
Chrysotrichia hermani
Chrysotrichia paruparu
Chrysotrichia syrinx
Chrysotrichia tajam
Hellyethira bulat
Hellyethira piala
Hellyethira selaput
Hydroptila batang
Hydroptila begap
Hydroptila berkait
Hydroptila bibir
Hydroptila daun
Hydroptila dayung
Hydroptila halus
Hydroptila incertula
Hydroptila kebawah
Hydroptila lampai
Hydroptila lidah
Hydroptila obscura
Hydroptila selene
Hydroptila sudip
Hydroptila tharsis
Hydroptila theiodamas
Hydroptila thisbe

Orthotrichia asymetris
Orthotrichia jani
Orthotrichia kinabalu
Orthotrichia lebar
Orthotrichia newi
Orthotrichia persiphone
Orthotrichia polyhimnia
Orthotrichia runchung
Orthotrichia sinit
Orthotrichia styx
Orthotrichia thgeia
Orthotrichia triton
Oxyethira bogambara
Oxyethira campanula
Pseudoxyethira bilah
Pseudoxyethira buluhalus
Pseudoxyethira gerigi
Pseudoxyethira jari
Pseudoxyethira kait
Pseudoxyethira keesi

Philopotamidae
Chimarra antheae
Chimarra caduca
Chimarra chanchuluni
Chimarra cuspidata
Chimarra cygnus
Chimarra danumensis
Chimarra dejongi
Chimarra demeter
Chimarra denticula
Chimarra devogeli
Chimarra drepane
Chimarra duitensis

Chimarra fuilianae
Chimarra gerson
Chimarra gyrospina
Chimarra jannekae
Chimarra karlijnae
Chimarra kinabaluensis
Chimarra lambi
Chimarra liwaguensis
Chimarra montana
Chimarra noloyan
Chimarra noohi
Chimarra phillipsae
Chimarra phlegyas
Chimarra physanoton
Chimarra polyneikes
Chimarra preapicalis
Chimarra prokrustes
Chimarra scolops
Chimarra silausilau
Chimarra sinitorum
Chimarra stenodactylus
Chimarra tawitawi
Chimarra terramata
Chimarra thaumas
Chimarra thyestes
Chimarra tityos
Chimarra vantoli
Chimarra vanwelzeni
Chimarra ventritropis
Chimarra xiphosella
Gunungiella anthea
Gunungiella berduri
Gunungiella kakatua
Gunungiella lekuk
Gunungiella parang
Gunungiella paruh
Gunungiella tanduk
Wormaldia sarawakana

Stenopsychidae
Stenopsychodes ochripennis

Polydentropodidae
Nyctiophylax padangensis
Nyctiophylax poias
Nyctiophylax temburongensis
Pahamunaya erymanthos
Pahamunaya nacesiveci
Pahamunaya prometheus
Polyplectropus bela
Polyplectropus beria
Polyplectropus deimos
Polyplectropus irroratus
Polyplectropus monticolz
Polyplectropus orientalis
Polyplectropus pluto
Polyplectropus polydoros
Polyplectropus simei
Polyplectropus torrenticola
Pseudoneureclipsis deasyria
Pseudoneureclipsis deianeira
Pseudoneureclipsis perses
Pseudoneureclipsis polyidos
Pseudoneureclipsis salmoneus
Pseudoneureclipsis silpa
Pseudoneureclipsis thestios
Pseudoneureclipsis tithonus
Pseudoneureclipsis tlepolemos

Psychomyiidae
Eoneureclipsis limax
Paduniella dentrobia
Paduniella pleisthenes
Paduniella polyphemos
Paduniella teukros
Paduniella tmolos
Psychomyia adebratti
Psychomyia aigina
Psychomyia alkibiades
Psychomyia bruneiensis
Psychomyia deidameiaa

Psychomyia deiphobos
Psychomyia demodokos
Psychomyia enyo
Psychomyia falcata
Psychomyia husim
Psychomyia lramosa
Psychomyia mendolongensis
Psychomyia pajauensis
Psychomyia phobos
Psychomyia plexippos
Psychomyia podaleiros
Psychomyia polydarkes
Psychomyia polydektes
Psychomyia polykrates
Psychomyia polymestor
Psychomyia sipitonga
Psychomyia theoklymenos
Psychomyia trifurcata
Tinodea betuel
Tinodea chaine
Tinodea cheran
Tinodea fulvus
Tinodea igok
Tinodea malicki
Tinodea silvicola
Tinodea solinvictus
Tinodea tricalcaratus
Tinodea zohar

Xiphocentronidae
Drepanocentron job
Melanotrichia dakcha
Melanotrichia polydeukes
Proxiphocentron thanatos

Ecnomidae
Ecnomus alus
Ecnomus auratus
Ecnomus basmati
Ecnomus dares
Ecnomus digitatus
Ecnomus gada
Ecnomus gapit
Ecnomus heman
Ecnomus lothan
Ecnomus perseis
Ecnomus phoenix
Ecnomus phoibos
Ecnomus promat
Ecnomus retusus
Ecnomus talenoi
Ecnomus tegap
Ecnomus yulae

Dipseudopsidae
Dipseudopsis contorta
Dipseudopsis digitata
Dipseudopsis elongata
Dipseudopsis immaculata
Dipseudopsis infuscata
Dipseudopsis maculata
Dipseudopsis nebulosa
Dipseudopsis nervosella
Dipseudopsis nieuwenhuisi
Dipseudopsis spectabilis
Dipseudopsis stabatensis
Hyalopsyche winkleri

Hydropsychidae
Aethaloptera sexpunctata
Amphipsyche parva
Amphipsyche petiolata
Cheumatopsyche akisena
Cheumatopsyche chimaira
Cheumatopsyche contexta
Cheumatopsyche duma
Cheumatopsyche ernstheissi
Cheumatopsyche globosa
Cheumatopsyche lucida
Cheumatopsyche maculipennis
Cheumatopsyche mendolonga
Cheumatopsyche pulchripennis

Cheumatopsyche sipitanga
Cheumatopsyche stigma
Cheumatopsyche temburonga
Cheumatopsyche tinjar
Cheumatopsyche triptolemos
Cheumatopsyche varia
Diplectrona dulitensis
Diplectrona elongata
Diplectrona eunomia
Diplectrona extrema
Diplectrona fulvofusca
Diplectrona kallisto
Diplectrona lampetia
Diplectrona lavinia
Diplectrona maculata
Diplectrona moorei
Diplectrona octomaculata
Diplectrona oculata
Diplectrona pseudofasciata
Hydropsyche ares
Hydropsyche arkas
Hydropsyche askanios
Hydropsyche autolykos
Hydropsyche banksi
Hydropsyche irroatella
Hydropsyche isolata
Macrostemum distinguendum
Macrostemum fenestratum
Macrostemum luteipes
Macrostemum opulentum
Macrostemum pallipes
Macrostemum trifasciatum
Oestropsyche vitrina
Polymorphanisus fuscus
Polymorphanisus muluensis
Polymorphanisus ocularis
Polymorphanisus quadripunctatus
Polymorphanisus scutellatus
Pseudoleptonema sinuatum

Brachycentridae
Micrasema borneense
Micrasema philomele
Micrasema prokne
Micrasema tereus

Limnocentropodidae
Limnocentropus borneonius
Limnocentropus grandis

Goeridae
Goera alleni
Goera gaetam
Goera gerar
Goera trispina

Helicopsychidae
Helicopsyche adebratti
Helicopsyche elisa
Helicopsyche malickyi
Helicopsyche mjoebergi

Lepidostomatidae
Lepidostoma bidentatum
Lepidostoma bisculum
Lepidostoma capreolus
Lepidostoma conjunctum
Lepidostoma corollatum
Lepidostoma cratis
Lepidostoma curtipendulum
Lepidostoma dulitense
Lepidostoma erectum
Lepidostoma grande
Lepidostoma kellyi
Lepidostoma medium
Lepidostoma octolobium
Lepidostoma oreion
Lepidostoma pendulum
Lepidostoma quaternarium
Lepidostoma tenellum
Lepidostoma tridentatum
Lepidostoma uncinatum

Leptoceridae

Adicella anakpana
Adicella bavanga
Adicella danumensis
Adicella gada
Adicella hiddekei
Adicella ilia
Adicella kydippe
Adicella thoas
Ceraclea modesta
Ceraclea trimegistos
Leptocerus genius
Leptocerus servius
Leptocerus toxeus
Oecetis diokcura
Oecetis halirrhotios
Oecetis hellen
Oecetis hippolytos
Oecetis irad
Oecetis koyana
Oecetis laomedon
Oecetis lynkeus
Oecetis mane
Oecetis maron
Oecetis najade
Oecetis nereide
Oecetis paris
Oecetis peleus
Setodes achilleus
Setodes alexandros
Setodes amazone
Setodes eumenide
Setodes korybante
Setodes kyklope
Setodes kythereia
Setodes laistrygone

Setodes molossos

Setodes mopsos
Setodes nigroochraceaus
Setodes terminalis
Symphitoneuria sabaensis
Tagalopsyche brunnea
Tagalopsyche jolandae
Triaenodea bulupendek
Triaenodea pellectos
Triaenodea plutonis

Odontoceridae

Marilia sumatrana

Calamoceratidae

Anisocentropus brevipennis
Anisocentropus flavomarginatus
Anisocentropus golem
Anisocentropus sawan
Ganonema extensum
Ganonema ochraceelum

MICROBIAL DIVERSITY OF SOIL SAMPLES COLLECTED FROM TAMA ABU, MARUDI, MIRI

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Abstract

SBC joined the Tama Abu scientific expedition from 13th to 20th August 2017. The objective of this expedition was to collect soil samples for microbial isolation. We have successfully isolated and selected 290 microbial strains (82% actinobacteria and 18% fungi strains). These strains are stored as part of our Microbial Natural Product Library (MNPL) strain collection.

Keywords: *Microbial diversity, Sarawak, Sarawak Heart of Borneo*

INTRODUCTION

Our study is targeted in the isolation of fungi and actinobacteria from environmental samples around Sarawak as part of the Natural Product Discovery programme at Sarawak Biodiversity Centre (SBC). Heart of Borneo expedition to Tama Abu had given us the opportunity to collect samples from a yet explored site. This report entails the microbial collection obtained from soil samples collected.

MATERIAL AND METHODS

Sample collection

For this study, 3 composite samples from each trail were collected. For each trail, 10 sub-samples, 20 m apart were collected using an auger at depth of 5 - 10 cm. Samples were then placed in sterile zip lock bag to be processed at SBC.

Sample pretreatment

For microbial isolation, the samples were subjected to several pretreatments, this allows effective isolation of targeted microbes by limiting the growth of other unwanted microorganism such as the Gram-negative bacteria. Composite soil samples were air-dried for 2 weeks at room temperature. Soil pH and moisture content were recorded.

Actinobacteria isolation

Air-dried soil samples undergo 4 different pretreatments; heat (Kim et al. 1995), humic acid (Hayakawa & Nonomura, 1987), antibiotic serial dilution (Hayakawa et al. 2000) and flodding method (modified from Suzuki et al. 1999). The samples were then diluted and spread onto 4 different enrichment media (i) soil extract agar, SEA (ii) humic acid vitamins agar, HVA (iii) actinomycetes isolation agar, AIA and (iv) boric acid agar, BAA. All media were added with 25ppm nalidixic acid, 25ppm cycloheximide and 1ppm terbinafin, except for BAA.

- SEA: 250 ml soil extract, D-glucose 10 g/ L, yeast extract 0.5 g/ L, K2HPO4 0.5 g/ L and agar 15 g/ L (modified from Hamaki et al., 2005)
- HSV: humic acid 1.0 g/, Na2HPO4 0.5 g, KCl 1.7 g/ L, MgSO4.7H2O 0.05 g/ L, FeSO4.7H2O 0.01 g/ L, CaCl2.2H2O 0.735 g/ L, CaCO3 0.02 g/ L, agar 16 g/ L; trace element, vitamin mixture (modified from Hayakawa and Nonomura, 1987)
- AIA: sodium caseinate 2 g/ L, L-Asparagine 0.1 g/ L, Sodium propionate 4 g/ L, K2HPO4 0.5 g/ L, MgSO4 0.1 g/ L, FeSO4 0.001 g/ L, Agar 15 g/ L
- BAA: boric acid 1.5 g/L, CaCO3 1 g/L, Agar 15 g/L.

Fungi isolation

Air dried soil samples transferred onto growth media using 2 techniques; stamping method (Hunter-Cevera and Belt, 1992) and serial dilution method (Stevens, 1974). Growth media used were (i) soil extract agar (SEA) (ii) modified potato dextrose agar (mPDA), (iii) modified malt extract agar (mMEA).

- mPDA: potato dextrose broth 6.63 g/ L, agar 15 g/L. Kanamycin 0.1 g/ L, chloramphenicol 0.1 g/ L, ystatin 1 g/ L and rose bengal 3.3 g/ L.
- mMEA: malt extract 20 g/ L, peptone 1 g/ L, glucose 20 g/ L, agar 15 g/ L. Nystatin 1 g /L, chloramphenicol 2 g/ L and rose bengal 3.3 g/ L.

Strain identification

Strain identification were carried out using both morphological and molecular techniques. Morphology were observed on yeast extract-malt extract agar, ISP 2 (Shirling & Gottlieb, 1966) for actinobacteria and potato dextrose agar, PDA for fungi. Sporulation were observed soil extract agar (modified from Hamaki *et al.* 2005) for actinobacteria and water agar (20 g/ L agar) for fungi. Sporulation were directly observed using 50x long distance objective (Olympus LMPLFLN; Olympus, Tokyo, Japan). DNA was obtained by the "freeze-thaw" modified method by Muramatsu et al. 2003. Molecular identification was made using 16S rDNA (27F and 1492R) for actinobacteria and Internal transcribed spacer (ITS 4 and ITS 5) for fungi respectively.

Strain storage

All cultures are stored as replicates in 20-25% glycerol at -80°C and -150°C freezer. Fungi cultures were also stored in water at 4°C.

RESULTS AND DISCUSSION

Soil sample

During the expedition, 3 composite top soil samples (from Trail 2, 6 and 7) were collected (Figure 1). Soil characteristics are as follows (i) soil sample from trail 2: Elevation 80 - 260 m, pH 4.85, moisture content 13.3%; (ii) soil sample from trail 6: Elevation 420 - 600 m, pH 4.36, moisture content 16.9% and (iii) soil sample from trail 7: Elevation 1660 - 1670 m, pH 4.11, moisture content 14.3%.



Figure 1: Composite soil samples from trail 2, 6 and 7 (left to right)

Microbial Diversity

For microbial isolation, 237 actinobacteria and 53 fungi strains have been isolated and selected. Actinobacteria strains identified belongs to 16 genera; *Streptomyces* (93, 39.2%) *Actinoallumurus* (38, 16%), *Nocardia* (35, 14.8%), *Streptacidiphilus* (23, 9.7%), *Kitasatospora* (8, 3.4%), *Micromonospora* (5, 2.1%), *Microbispora* (3, 1.3%), *Mycobacterium* (3, 1.3%), *Dactylosporangium* (2, 0.8%) and (1, 0.4%) for each of the following genera; *Actinomadura*, *Catenulispora, Nocardioides, Nonomuraea, Planosporanigum, Rhodococcus* and *Streptosporangium* while 20 strains (8.4%) are still being identified (Figure 2). Forty (40, 16.8%) actinobacteria strains having blast homology below 99% when compared to NCBI Genbank indicates that the strains may be of new species or genus (Figure 3).

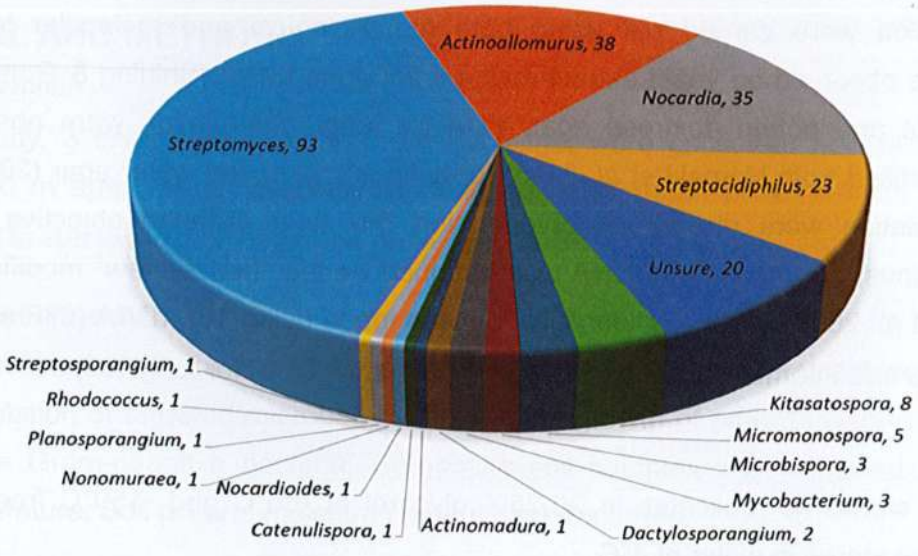


Figure 2: Diversity of actinobacteria genera isolated.

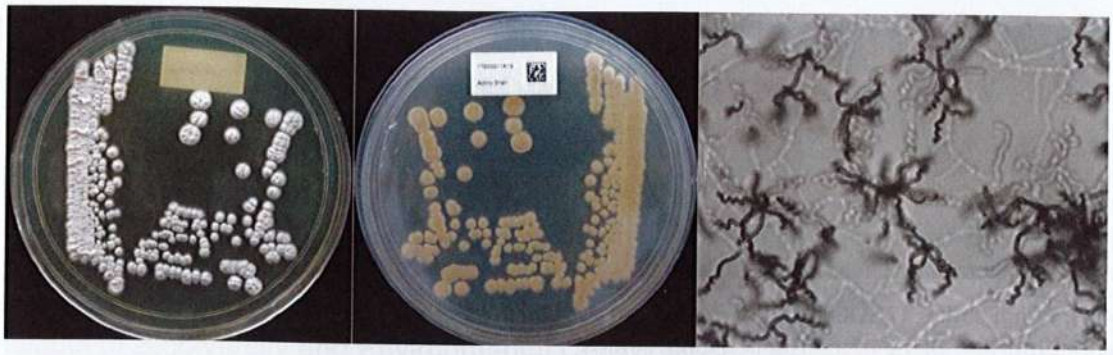


Figure 3(a): Actinobacteria strain 17SO0011A19, *Nocardia niigatensis* 96% (surface, reverse and spore chain at 750x: left to right)



Figure 3(b): Actinobacteria strain 17SO0012A22, *Micromonospora peucetia* 98% (surface, reverse and spore chain at 750x: left to right); **Figure 2:** Among actinobacteria strains of potential new genus or species.

A total of 24 out of 53 fungi strains were identified using molecular identification. Among which, 8 strains (35%) are potentially new species or genus. Identified strains consists of six genera (*Aspergillus, Ophiocordyceps, Paecilomyces, Penicillium, Talaramyces* and *Trichoderma*) and five families (*Aspergillaceae, Hypocreaceae, Ophiocordycipitaceae, Thermoascaceae* and *Trichocomaceae*). Images of some of the strains are as seen in Figure 4.

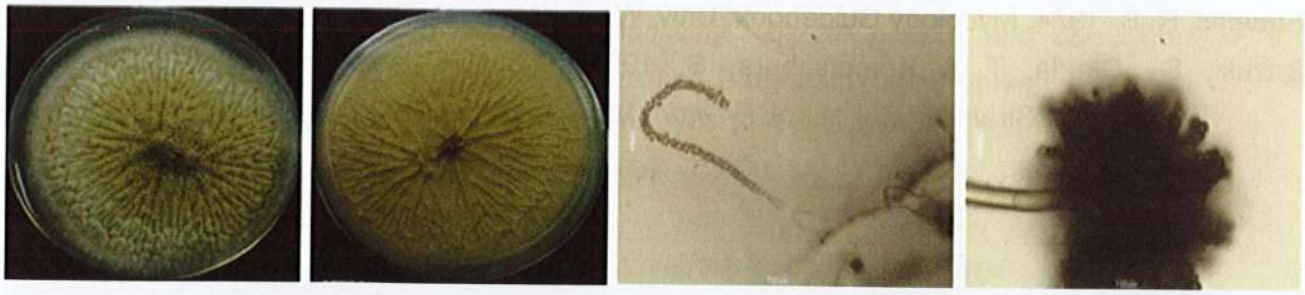


Figure 4(a): Fungi strain 17SO0011-F2, *Aspergillus niger*, 99% (surface, reverse, spore chain 500x: left to right)

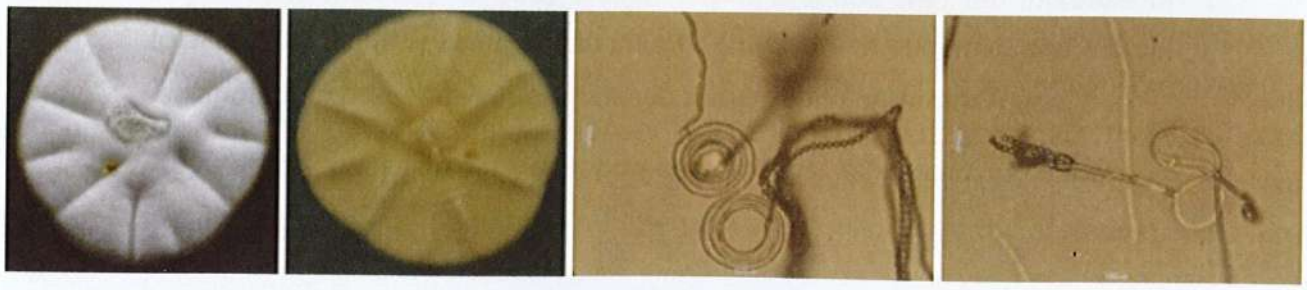


Figure 4(b): Fungi strain 17SO0013-F13, *Penicillium adametzii*, 99% (surface, reverse, spore chain 500x: left to right)

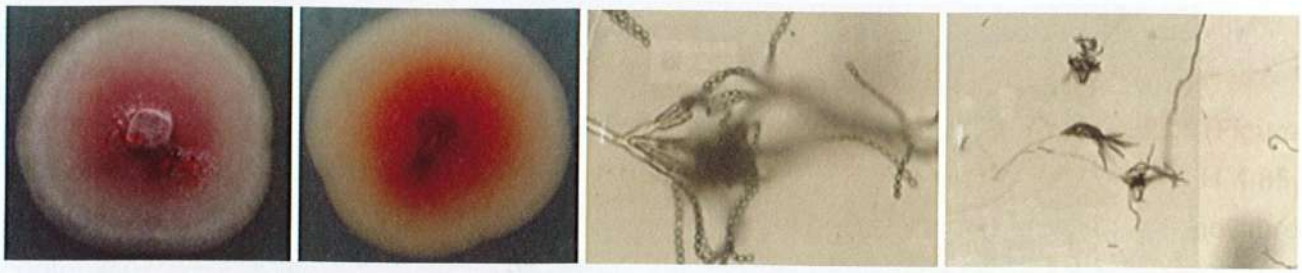


Figure 4(c): Fungi strain: 17SO0013-F20, *Penicillium verruculosum*, 99% (surface, reverse, spore chain 500x: left to right); **Figure 4:** Some of the isolated fungi strains

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STREAM FAUNA OF SOUTHERN TAMA ABU RANGE IN SARAWAK, MALAYSIA, BORNEO

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Abstract

The drainages in southern Tama Abu Range are classified between 1st and 4th order streams, having narrow and shallow channels, high gradient, rocky substrates and fast flowing water. The water is tea-coloured in appearance in dry months but turn to muddy during heavy rain. A rapid assessment of stream fauna was conducted at six stations of two streams adjacent to a basecamp of Tama Abu Scientific Expedition 2017. Our rapid assessment had identified 45 species of stream fauna comprising fish, crabs, shrimps, snails and larvae of aquatic insects. Less species of stream fauna recorded probably correlated with the nature of physical characteristics of the streams as mentioned above that limit habitat used and adaptation by many species. Within the fish communities, the semah, Tor douronensis *is the most dominant, with the size range in total length and weight is 5.5-25.6cm and 1.5-188.7g, respectively. Growth pattern and condition factor of five fish species analyzed (i.e.,* Barbodes sealei, Lobocheilos bo, Paracrossochilus acerus, Tor douronensis and Gastromyzon bario*) indicate a sign of poor wellbeing of the fish communities. The growth pattern of the five species is 2.976, 2.847, 2.558, 3.042 and 2.941, respectively, whereas the condition factor is 1.187, 0.852, 0.894, 0.951 and 1.529, respectively. Only T. douronensis exhibits an isometric growth which suggest the increase of body weight is proportioned with the increase of total length. Some species of fish caught are Bornean endemic, and a crab, Isolapotamon borneensis is endemic to upper reach of Baram River.*

Keywords: *aquatic insects, decapod crustaceans, fish, molluscs, Baram*

INTRODUCTION

Some ichtyological researches had been conducted in Baram River, covering lower and upper reaches as well oxbow lakes and limestone cave systems which are parts of the river system (Watson, 1981; Watson & Balon, 1984; Nyanti et al., 1998; 2006; Nyanti & Grinang, 2007; Sibat, 2015). However, fish samples of the studies had never been catalogued thus the number of species of fish found in the river system remained unknown. Also, the identification of fish specimens in the studies had followed the outdated taxonomic keys. This suggests that compiling of fish species from the studies is not probable because lack of accuracy. Nonetheless, the past studies indicate high species richness of fish in Baram River many of which has significance to fisheries activities (Watson, 1981; Watson & Balon, 1984).

In comparison to fish fauna, macroinvertebrates of Baram River such as crustaceans, molluscs and aquatic insects have relatively less studied (Shabdin & Abang, 1998; Grinang & Nyanti, 2007) primarily due to less of interest among researchers and very few taxonomic experts in this aquatic organism. Some sections of the river system had not been scientifically explored whereas the area is currently threatened by anthropogenic activities. These scenarios imply that a lot more to study on biodiversity of Baram River. This paper provides information on fish fauna and macroinvertebrates from southern part of Tama Abu Range which is important to fill the gap of information on river fauna of Baram basin.

MATERIALS AND METHODS

Study site

The drainages of southern Tama Abu Range are dendritic form and classified between 1st and 4th order streams. The streams are narrow and shallow with high gradient, rocky substrates and fast flowing water. The water is tea-coloured in appearance in dry month and turn to muddy during heavy rain as result of logging activities in the catchment. Two streams surveyed were Sg Puak and its tributary, Sg Sekuan. Sg Puak is a third order stream with stream channel of about 10 m wide. The adjacent forests have been logged and timber harvesting activity is still operating at the upstream of the river. Six stations at the two streams were surveyed comprise habitat pools and riffles.

Sampling of fishes and macroinvertebrates

Fish were collected by using electric-shocking technique within a 100 m stretch at each station. In addition, cast-net was used by throwing the net for 20 times at deeper stations. Scoop net with 400 micron of mesh size was used to collect macroinvertebrates. Fishes were identified using keys of Kottelat *et al.* (1993) and referred to fish catalogue by Kottelat (2013) for taxonomic validation. The fish were measured for total length (mm), standard length (mm) and weight (g) that were used to estimate growth pattern and condition factor of the fish. The macroinvertebrates were identified to possible taxonomic level using keys in Yule & Yong (2004).

Statistical analysis

Biomass of fish fauna was calculated based on the wet weight in gram. Analysis of growth pattern and condition factor was performed for five species, namely *Gastromyzon bario, Barbodes sealei, Lobocheilos bo, Paracrossochilus acerus* and *T. douronensis* by using length-weight relationships method. The length-weight relationships of the fish were estimated using the formula, $W = aL^b$ where, W and L is the weight (in gram) and total length (in cm), respectively. The formula was logarithmic transformed to obtain a linear expression, $\ln W = \ln a + b \ln L$ where, *a* and *b* is the intercept and slope of the straight line, respectively (Froese 2006). The least squares regression of LWRs was run in GraphPad Prism version 8.3. The *b* value implies type of growth of fish of which, $b = 3$ is isometric, and $3 < b < 3$ is allometric (Froese 2006). The value of $b < 3$, $b = 3$ or $b > 3$ is interpreted as growth rate of fish to be poor, normal or over, respectively. Fulton's condition factor *(K)* was determined with the formula, $K = 100W/L^3$ (Froese 2006). The condition factor was used to evaluate degree of well-being of the fish. The condition factor implies that the heavier fish with a body length will has better condition thus the higher *K* value the better the condition of fish.

RESULTS AND DISCUSSION

Stream fauna diversity

The rapid assessment of stream fauna in Tama Abu Range had recorded 45 species comprising fish, crabs, shrimps, snails and larvae of aquatic insects. Less species of stream fauna recorded might have correlated with the nature of physical characteristics of the streams that limits habitat used and adaptation by many species.

The fish fauna consisted 10 species and two families with *Tor douronensis* (semah) was the dominant (Table 1). Except for *T. douronensis*, the other nine species are endemic to Borneo. By carefully examining the species list of fish recorded in previous studies (see Nyanti et al., 1998; Nyanti & Grinang, 2007), we suggest that about 55 species in 12 families of fish are now known to inhibit upper reaches of Baram River (Table 1). Another 18 species recorded in the previous studies were excluded because the known geographical distribution of the species is outside of Borneo (see Kottelat, 2013). In the case of the species that occur in other parts of Borneo, they also treated as invalid if natural barriers like mountainous range can potentially limit their historical dispersal to upper reaches of Baram River. For instance, some sucker fish recorded from upper reaches of Baram River are the species that first described from mountainous streams in Sabah and endemic to the area. Therefore, we treated the identification of the 18 species as not valid and fresh specimens are needed to verify the taxonomic identity. The fish fauna of upper reaches of Baram River is dominated by cyprinids and gastromyzons with both families contain more than 40% of the total species (Figure 1).

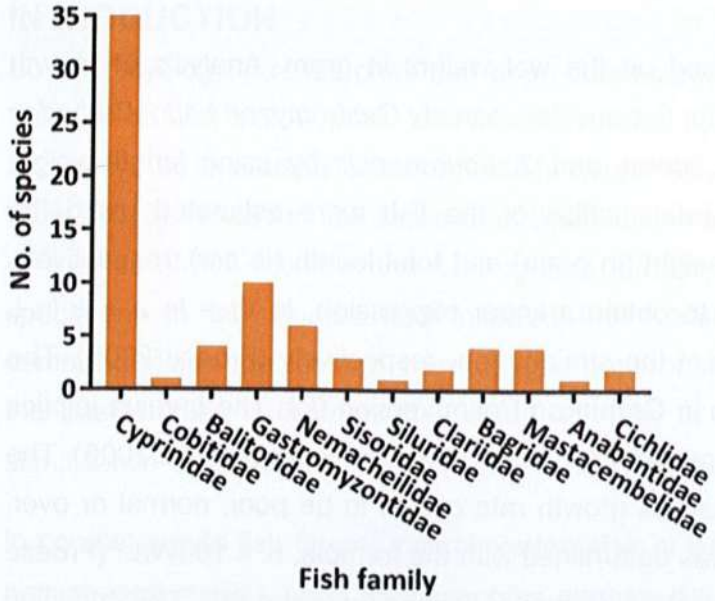


Figure 1. Species composition of fish fauna recorded from upper reaches of Baram River (1998–2017).

The macroinvertebrate fauna of southern Tama Abu Range comprise 42 taxa with aquatic insects were the most diverse (Table 2; Figure 2). Some taxa are endemic to Borneo and a true freshwater crab, *Isolapotamon borneensis* is endemic to upper reach of Baram River. The present study adds the number of macroinvertebrates found in upper reaches of Baram River to 90 taxa (Table 2).

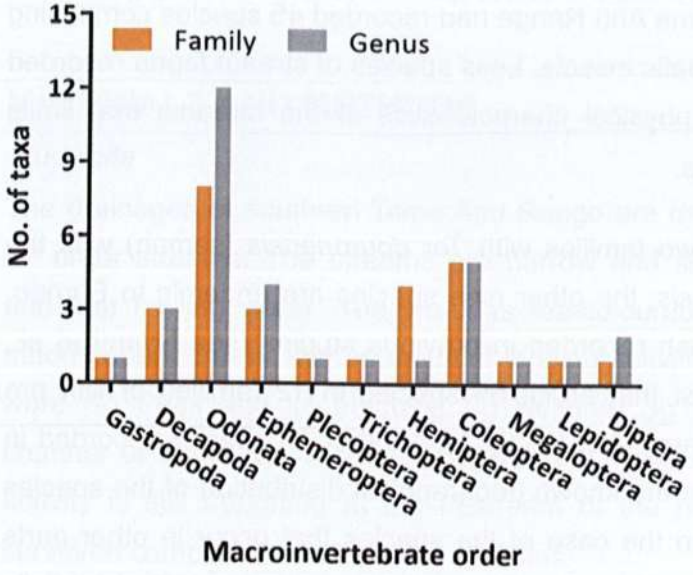


Figure 2. Taxa composition of macroinvertebrate fauna recorded from southern part of Tama Abu Range.

Growth patterns and condition factor of five fish species

The most dominant species, *T. douronensis* shows size range in total length and weight of 5.5-25.6 cm and 1.5-188.7 g, respectively. Growth pattern and condition factor of five fish species i.e., *Barbodes sealei, Lobocheilos bo, Paracrossochilus acerus, Tor douronensis* and *Gastromyzon bario* indicate a sign of poor condition. The growth pattern of the five species was 2.976, 2.847, 2.558, 3.042 and 2.941, respectively (Figure 3), whereas the condition factor was 1.187, 0.852, 0.894, 0.951 and 1.529, respectively (Figure 4). *T. douronensis* exhibits an isometric growth which suggest the increase of body weight is proportioned with the increase of total length. The biomass of the fish fauna was low which is correlated with small fish caught (Figure 4).

The fish species representative in streams of southern Tama Abu Range is low, whereas the macroinvertebrate fauna is very diverse. This is typical biodiversity composition for high gradient and fast flowing river system. The section of the river serves as spawning ground for the fish like *Tor* species. The habitat also important as gene pool for stream macroinvertebrates because it is pristine environment. We anticipated that conserving of the area could offer much more long-term benefits (e.g., ecological services and genetic pool) than any development activities.

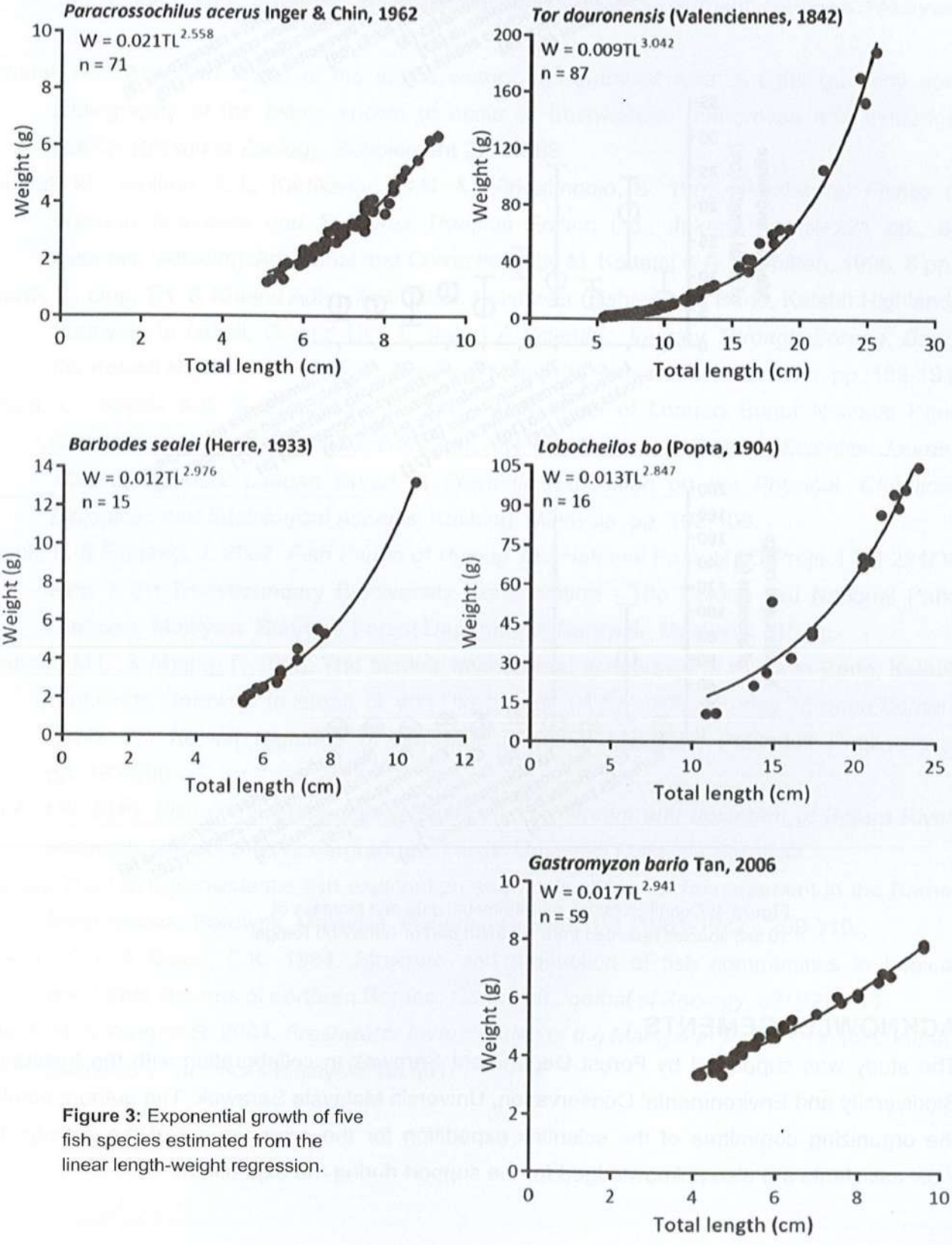


Figure 3: Exponential growth of five fish species estimated from the linear length-weight regression.

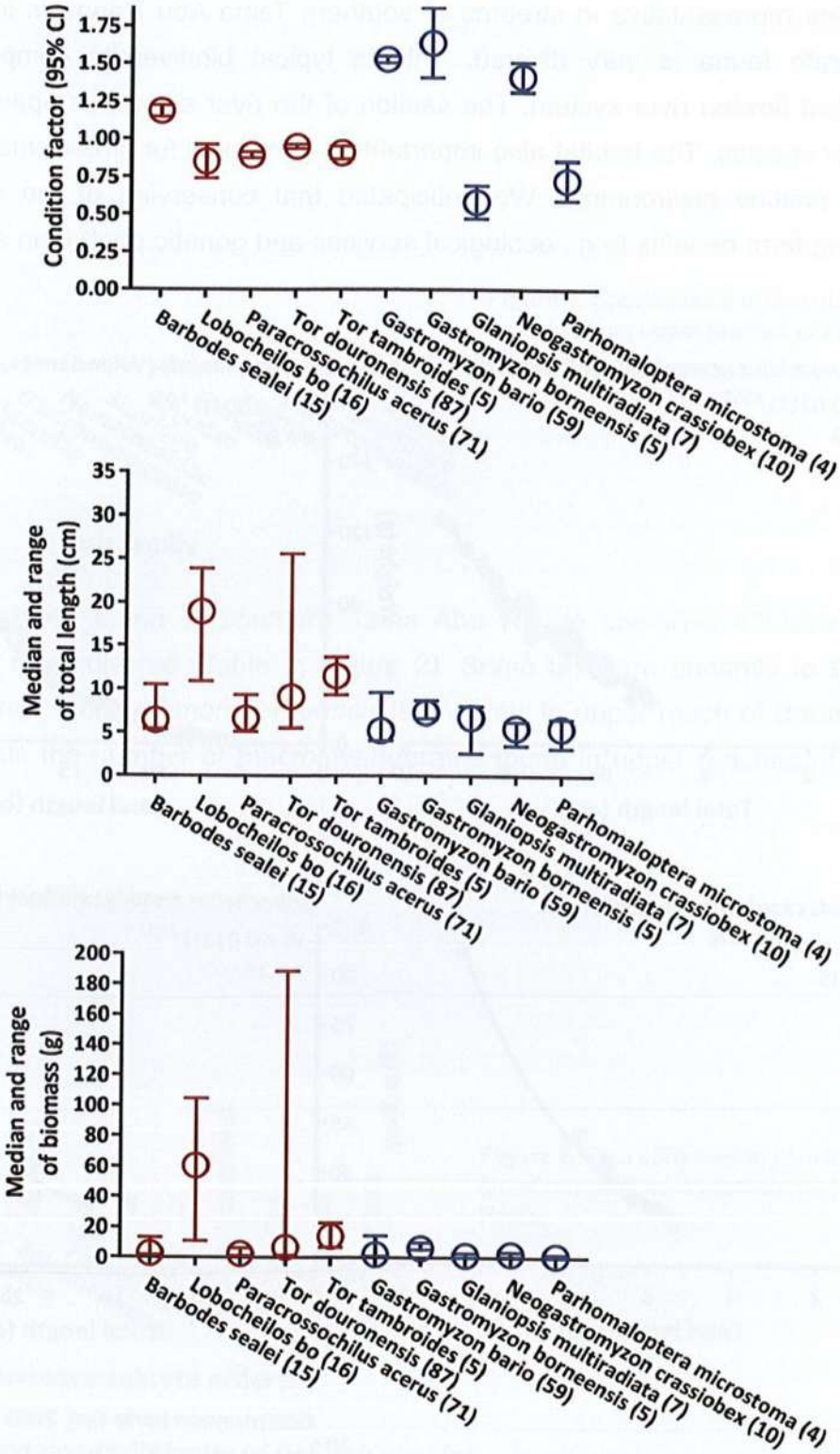


Figure 4: Condition factor, morphometric data and biomass of 10 fish species recorded from southern part of Tama Abu Range.

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Table 1. List of fish fauna recorded from upper reaches of Baram River including the present study at southern of Tama Abu Range.

Class/Order/Family	Species	Nyanti et al. (1998)	Nyanti & Grinang (2007)				Present study
		Bario	DD	UD	DT	UT	
Actinopterygii							
Cypriniformes							
Cyprinidae							
	Barbodes everetti (Boulenger, 1894)			1			
	Barbodes sealei (Herre, 1933)	1					1
	Barbonymus balleroides (Valenciennes, in Cuvier & Valenciennes, 1842)				1		
	Barbonymus collingwoodii (Günther, 1868)				1	1	
	Barbonymus schwanenfeldii (Bleeker, 1854)	1				1	
	Barbonymus sinueri (Weber & de Beaufort, 1916)					1	
	Diplocheilichthys pleurotaenia (Bleeker, 1855)	1					
	Hampala ampalong (Bleeker, 1852)		1		1		
	Hampala bimaculata (Popta, 1905)	1	1	1	1	1	
	Lobocheilos bo (Popta, 1904)	1	1		1	1	1
	Lobocheilos falcifer (Valenciennes, in Cuvier & Valenciennes, 1842)		1		1	1	
	Lobocheilos kajanensis (Popta, 1904)		1		1	1	
	Luciosoma setigerum (Valenciennes, in Cuvier & Valenciennes, 1842)				1		
	Nematabramis borneensis Inger & Chin, 1962	1	1	1	1	1	
	Nematabramis everettii Boulenger, 1894		1	1	1	1	
	Nematabramis steindachneri Popta, 1905		1	1	1	1	
	Osteochilus borneensis (Bleeker, 1856)				1	1	
	Osteochilus enneaporos (Bleeker, 1852)		1		1	1	
	Osteochilus intermedius Weber & Beaufort, 1916		1		1	1	
	Osteochilus spilurus (Bleeker, 1851)					1	
	Osteochilus waandersii (Bleeker, 1853)		1	1	1	1	
	Paracrossochilus acerus Inger & chin , 1962	1	1	1	1	1	1
	Paracrossochilus vittatus (Boulenger, 1894)		1	1	1	1	

Class/Order/Family	Species	Nyanti et al. (1998)	Nyanti & Grinang (2007)				Present study
		Bario	DD	UD	DT	UT	
	Puntius brevis (Bleeker, 1849) *			1			
	Rasbora argyrotaenia (Bleeker, 1849)	1	1	1	1	1	
	Rasbora borneensis Bleeker, 1860		1	1		1	
	Rasbora caudimaculata Volz, 1903			1			
	Rasbora cephalotaenia (Bleeker, 1852)				1	1	
	Rasbora dusonensis (Bleeker, 1850)		1	1		1	
	Rasbora einthovenii (Bleeker, 1851)			1			
	Rasbora ennealepis Roberts, 1989		1	1	1	1	
	Rasbora lateristriata (Bleeker, 1854)	1	1	1			
	Systomus orphoides (Valenciennes, 1842)			1			
	Tor douronensis (Valenciennes, 1842)	1	1	1	1	1	1
	Tor soro (Valencienes, 1842) *	1	1	1	1	1	
	Tor tambra (Valenciennes, in Cuvier & Valenciennes, 1842)		1	1	1	1	
	Tor tambroides (Bleeker, 1854)	1	1	1	1	1	1
Cobitidae							
	Pangio anguillaris (Vaillant, 1902)			1			
Balitoridae							
	Balitoropsis ophiolepis (Bleeker, 1853)				1		
	Homaloptera ocellata van der Hoeven, 1830 *					1	
	Homaloptera orthogoniata Vaillant, 2002				1	1	
	Homaloptera stephensoni (Hora, 1932)				1	1	
	Homaloptera wassinkii (Bleeker, 1853)		1		1	1	
Gastromyzontidae							
	Gastromyzon bario Tan, 2006						1
	Gastromyzon borneensis Gunther, 1874	1	1	1	1	1	1
	Gastromyzon contractus Roberts, 1982					1	
	Gastromyzon danumensis Chin & Inger, 1989 *		1		1		
	Gastromyzon fasciatus Inger & Chin, 1961		1	1	1	1	
	Gastromyzon lepidogaster Roberts, 1982 *		1		1	1	
	Gastromyzon megalepis Roberts, 1982					1	
	Gastromyzon monticola (Vaillant, 1890) *		1	1	1	1	

Class/Order/Family	Species	Nyanti et al. (1998)	Nyanti & Grinang (2007)			Present study
		Bario	DD	UD	DT	UT	
	Gastromyzon ornaticauda Tan & Martin-Smith, 1998 *						
	Gastromyzon pariclavis Tan & Martin-Smith, 1998 *		1				
	Gastromyzon punctulatus Inger & Chin, 1961		1	1	1	1	
	Gastromyzon ridens Roberts, 1982		1	1	1	1	
	Glaniopsis multiradiata Roberts, 1982						1
	Glaniopsis hanitschi Boulenger, 1899 *	1					
	Neogastromyzon cf. *crassiobex* Tan, 2006						1
	Parhomaloptera microstoma Boulenger, 1899	1	1	1	1	1	1
	Protomyzon borneensis Hora & Jayaram, 1952 *	1					
Nemacheilidae							
	Nemacheilus chrysolaimos (Valenciennes, in Cuvier & Valenciennes, 1846) *					1	
	Nemacheilus fasciatus (Valenciennes, in Cuvier & Valenciennes, 1846) *			1		1	
	Nemacheilus kapuasensis Kottelat, 1984		1	1	1	1	
	Nemacheilus lactogeneus Roberts, 1989 *		1	1			
	Nemacheilus longipectoralis Popta, 1905 *			1		1	
	Nemacheilus olivaceus Boulenger, 1894		1	1			
	Nemacheilus pterifferae (Bleeker, 1853) *			1			
	Nemacheilus saravacensis Boulenger, 1894			1			
	Nemacheilus selangoricus Duncker, 1904			1			
	Nemacheilus spiniferus Kottelat, 1984			1		1	
	*Sundoreonectes lactogenesis**			1			
	Sundoreonectes obesus (Vaillant, 1902)			1			
Siluriformes	*Sundoreonectes sabanus* (Chin, 1990) *	1		1			
Sisoridae							
	Glyptothorax major (Boulenger, 1894)		1	1	1	1	
	Glyptothorax platypogon (Valenciennes, in Cuvier & Valenciennes, 1840)		1	1	1	1	
	Glyptothorax platypogonides (Bleeker, 1855)		1		1	1	

Class/Order/Family	Species	Nyanti et al. (1998)	Nyanti & Grinang (2007)			Present study
		Bario	DD	UD	DT	UT
Siluridae						
	Kryptopterus macrocephalus (Bleeker, 1858)				1	
Clariidae						
	Clarias batrachus (Linnaeus, 1758)	1				1
	Clarias leiacanthus Bleeker, 1851				1	
Bagridae						
	Hemibagrus baramensis (Regan, 1906)	1			1	1
	Hemibagrus nemurus (Valenciennes, in Cuvier & Valenciennes, 1840)		1		1	1
	Hemibagrus planiceps (Valenciennes, in Cuvier & Valenciennes, 1840)		1		1	1
	Pseudomystus robustus (Inger & Chin, 1959)	1				
Synbranchiformes						
Mastacembelidae						
	Macrognathus aculeatus (Bloch, 1786)				1	1
	Macrognathus keithi (Herre, 1940)				1	1
	Macrognathus maculatus (Valenciennes, in Cuvier & Valenciennes, 1832)				1	1
	Mastacembelus notophthalmus Roberts, 1989 *				1	
	Mastacembelus unicolor (Valenciennes, in Cuvier & Valenciennes, 1832)	1				
Perciformes						
Anabantidae						
	Anabas testudineus (Bloch, 1792)	1				
Cichlidae						
	Oreochromis mossambicus (Peters, 1852)	1				
	Oreochromis niloticus (Linnaeus, 1758)	1				

DD & UD - downstream and upstream Sg Dapur, DT & UT - downstream and upstream Sg Tutoh

"downstream" and "upstream" here are defined as section of the river in upper reaches of the river system

* fresh specimens are required to verify the species identity

Table 2. List of macroinvertebrate fauna recorded from upper reaches of Baram River including the present study at streams in southern of Tama Abu Range.

Phyllum/Class/Order/Family		Species	Shabdin & Abang (1998)	Grinang & Nyanti (2007)	Present study
			Bario	PTNP	
Rotifera		Undetermined	1		
Ciliophora (synonym Ciliata)		Undetermined	1		
Nematoda		Undetermined	1		
Oligochaeta		Undetermined	1		
Mollusca					
Neogastropoda	Buccinidae	*Cleanigricans* A. Adams, 1855			1
Tardigrada		Undetermined	1		
Arthropoda/Maxillopoda					
Copepoda/Harpacticoida		Undetermined	1		
Arthropoda/Crustacea					
Ostracoda		Undetermined	1		
Decapoda	Gecarcinucidae	*Sundathelphusa tenebrosa* Holthuis, 1979		1	1
	Potamidae	*Isolapotamon borneense* Ng & Tan, 1998			1
		Isolapotamon collinsi Holthuis, 1979		1	
		Isolapotam on doriae (Nobili, 1900)		1	
	Palaemonidae	*Macrobrachium pilimanus* De Man, 1879		1	1
Arthropoda/Insecta					
Odonata	Calopterygidae	*Neurobasis longipes* Hagen, 1887		1	1
		Vestalis amabilis Lieftinck, 1965		1	
	Chlorocyphidae	*Heliocypha biserata* (Selys, 1859)		1	
		Libellago hyalina (Selys, 1859)		1	
		Libellago sp. (1 morphospecies)			1
		Rhinocypha aurofulgens Laidlaw, 1931		1	
		Rhinocypha sp. (1 morphospecies)			1
	Coenagrionidae	*Ceriagrion bellona* Laidlaw, 1915		1	
		Ceriagrion cerinorubellum (Brauer, 1865)		1	
		Stenogrion dubium (Laidlaw, 1912)		1	
		Ceriagrion sp. (1 morphospecies)			1
	Euphaeidae	*Dysphaea dimidiata* (Selys, 1853)		1	
		Euphaea impar (Selys, 1859)		1	
		Euphaea subnodalis (Laidlaw, 1915)		1	
		Euphaea sp. (2 morphospecies)			1

Phyllum/Class/Order/Family		Species	Shabdin & Abang (1998)	Grinang & Nyanti (2007)	Present study
			Bario	PTNP	
	Protoneuridae	*Prodasineura verticalis* (Selys, 1860)		1	
	Aeshnidae	*Indaeschna* cf. grubaueri (Förster, 1904)		1	
		Indaeschna sp. (1 morphospecies)			1
		Oligoaeschna sp.		1	
	Chlorogomphidae	*Chlorogomphus* cf. *dyak* (1 morphospecies)		1	1
	Corduliidae	*Macromia westwoodii* Selys, 1874		1	
		Macromia sp. (1 morphospecies)		1	1
	Gomphidae	*Burmagomphus insularis* Laidlaw, 1914		1	
		Ictinogomphus decoratus (Laidlwa, 1914)		1	
		Ictinogomphus sp. (1 morphospecies)			1
		Macrogomphus sp.		1	
		Siebodius japponicus (Selys, 1854)		1	
	Libellulidae	*Brachygonia aculata* (Brauer, 1878)		1	
		Cratilla metallica (Brauer, 1878)		1	
		Diplocodes trivialis (Rambur, 1842)		1	
		Neurothemis ramburii (Brauer, 1866)		1	
		Neurothemis sp. (1 morphospecies)			1
		Onychothemis coccinea Brauer, 1868		1	
		Orthetrum chrysis (Selys, 1891)			1
		Orthetrum glaucum (Brauer, 1865)			
		Orthetrum pruinosum (Burmeister, 1839)		1	
		Orthetrum sabina (Drury, 1773)		1	
		Orthetrum sp. (1 morphospecies)			1
		Rhyothemis phyllis (Sulzer, 1776)		1	
		Rhyothemis triangularis Kirby, 1889		1	
		Tholymis tillarga (Fabricius, 1798)		1	
		Trithemis aurora (Brumeister, 1839)		1	
		Tyriobapta torrida Kirby, 1889		1	
Ephemeroptera	Baetidae	*Baetis* sp. (2 morphospecies)	1	1	1
	Heptageniidae	*Cinygmina* sp. (2 morphospecies)		1	1
		Epeorus sp. (1 morphospecies)		1	1
	Isonychiidae	*Isonychia winkleri* Ulmer, 1939		1	1
	Tricorythidae	Undetermined (1 morphospecies)		1	

Phyllum/Class/Order/Family		Species	Shabdin & Abang (1998)	Grinang & Nyanti (2007)	Present study
			Bario	PTNP	
Plecoptera	Perlidae	*Etrocorema* sp. (1 morphospecies)	1	1	
		Phanoperla sp (1 morphospecies)		1	1
		Tetropina sp. (1 morphospecies)		1	
Trichoptera	Hydropsychidae	*Hydropsyche* sp. (2 morphospecies)	1	1	1
	Hydroptilidae	Undetermined (1 morphospecies)		1	
	Lepidostomatidae	Undetermined (1 morphospecies)		1	
	Stenopsychidae	Undetermined (1 morphospecies)		1	
Hemiptera	Aphelocheiridae	*Aphelocheirus* sp. (3 morphospecies)		1	1
	Gerridae	*Amemboa* sp. (1 morphospecies)		1	1
		Limnogonus sp. (1 morphospecies)		1	1
		Rheumatogonus sp. (1 morphospecies)		1	
		Ptilomera sp. (1 morphospecies)		1	1
		Ventidius sp. (2 morphospecies)		1	1
	Nepidae	*Cercometus asiaticus* (Amyot & Serville, 1843)		1	1
	Veliidae	*Rhagovelia sarawakensis* Polhemus & Polhemus, 1988		1	
		Rhagovelia sp. (1 morphospecies)		1	1
Coleoptera	Elmidae	Undetermined (1 morphospecies)	1	1	1
	Eulichadidae	*Eulichas* sp. (1 morphospecies)			1
	Dytiscidae	Undetermined (1 morphospecies)		1	1
	Gyrinidae	*Porrhorrhynchus marginatus* Castelnau, 1934		1	1
	Hydrophilidae	Undetermined (2 morphospecies)		1	
	Psephenidae	*Eubrianax* sp. (2 morphospecies)		1	1
Megaloptera	Corydalidae	*Protohermes* sp. (1 morphospecies)		1	1
Orthoptera	Blatteridae	Undetermined (1 morphospecies)		1	
	Tetrigidae	Undetermined (1 morphospecies)		1	
Lepidoptera	Pyralidae	Undetermined (1 morphospecies)		1	1
Diptera	Blephariceridae	*Philorus* sp. (1 morphospecies)		1	
	Chironomidae	*Chironomus* sp. (2 morphospecies)		1	
	Simulidae	*Similium* sp. (2 morphospecies)		1	1
	Tipulidae	*Tipula* sp. (1 morphospecies)			1

PTNP - Pulong Tau National Park (26 streams)

"undetermined" implies species of the specimen cannot be ascertained but show distinct characters from the known species

"morphospecies" is used when the specimens can be distinguished but not possible to be identfied to species due to lack of key characters either it is at juvenile stage or in incomplete form





Plate 1:
Geomorphological characteristics of river system in southern part of Tama Abu Range.



Plate 2: stream fauna of Tama Abu. (1) *Tor douronensis*, (2) *Lobocheilos bo*, (3) *Gastromyzon barrio*, (4) *Neogastromyzon cf. crassiobex*, (5) *Sundathelphusa tenebrosa*, (6) *Macromia westwoodii*, (7) *Aphelocheirus* sp. and (8) *Clea nigricans*

DIPTEROCARP DIVERSITY ASSESSMENT IN TAMA ABU

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Abstract

During the expedition, surveys were conducted along the trails (TR) set up: TR2, TR3, TR4, TR5, TR6, TR7 and TR10. A total of 28 species from 4 genera were recorded, 5 species are listed in the Sarawak Plant Red List threatened category: Endangered (2) and Vulnerable (3), while the rest are either Near Threatened (2) or Least Concerned (21). In terms of endemism, 50% of the species recorded are Borneo endemics. Understanding the diversity present is the first step towards conservation management, however the occurrence records can also be further utilized in combination with environmental layers for the generation of Species Distribution Models (SDMs) for further ecological and conservation research.

Keywords: *Dipterocarp, IUCN Red List, Borneo endemics*

INTRODUCTION

With a pantropical distribution, the Borneo island is known to be the site that has the greatest Dipterocarpaceae species diversity. Based on the figures in Volume 5 of the Tree Flora of Sabah and Sarawak, the total number of species recorded for these two states alone is 267 species. Sarawak has recorded 249 species, which is approximately 93% of the total species recorded. Of these 249 species, a total of 22 species are known to be endemic to the State of Sarawak. In the last five years, the State has seen the publication of two series of Sarawak Plant Red List: Dipterocarpaceae (2014; 2016) that provided essential information such as the updated conservation status at the State level, habitat, species short notes and most importantly the species' geographical distribution in relation to forest cover. These distribution data were gathered not solely on herbarium specimens alone but also from voucher specimens obtained from ecological plots or survey observations. These publications have been an essential source of reference especially when it comes to the implementation of management plans for in regards to forest resources utilization and the conservation of threatened species within the State.

Given the State has an extensive land area of 124,451km2 there exist the possibility of areas where extensive surveys have yet to be conducted or revisited due to challenges such as ease of accessibility and one such area would be Tama Abu. Looking back at the records, the last survey conducted for the area was in the 1980s' therefore the purpose for this study is to resurvey peripheral area of Tama Abu Range to gather species distribution data, with the aim to utilize the data for forest management plans and potential biodiversity conservation studies.

METHODS

During the expedition, surveys were conducted along the trails (TR) set up at an altitude range of 670-1200m: TR2, TR3, TR4, TR5, TR6, TR7 and TR10 as set down by the organizers. Species that are located along the trail to a distance of 5 m away on each side will be listed and its GPS location recorded with 60CSx. Apart from identification on site, voucher specimens such as leaf samples and pictures of bark were obtained for verification at the SAN's herbarium in Sabah.

RESULTS

A total of 28 species from four genera were recorded (Table 1), whereby 50% of the species recorded are Borneo endemics, with the majority of the recorded species falling under the light wood timber category. Based on the Sarawak Plant Red List (2014; 2016), five species recorded are listed under the Threatened Category: Endangered and Vulnerable.

Table 1: Dipterocarp species IUCN status at the regional and global level.

No.	Species	IUCN Sarawak	IUCN Global	Distribution
1.	*Hopea beccariana*	LC	Crictically Endangered	WD
2.	*Hopea dryobalanoides*	LC	None	WD
3.	*Hopea kerangasensis*	LC	Crictically Endangered	WD
4.	*Hopea nervosa*	LC	CE	WD
5.	*Parashorea malaanonan*	EN	CE	WD
6.	*Parashorea smythissi*	NT	None	Borneo
7.	*Shorea accuminatissima*	VU	CE	Borneo
8.	*Shorea beccariana*	LC	None	Borneo
9.	*Shorea confusa*	VU	None	Borneo
10.	*Shorea faguetiana*	LC	Endangered	WD
11.	*Shorea guiso*	EN	Crictically Endangered	WD
12.	*Shorea havilandii*	LC	None	Borneo
13.	*Shorea hopefolia*	LC	Crictically Endangered	WD
14.	*Shorea macroptera*	LC	None	Borneo
15.	*Shorea obscura*	LC	Endangered	Borneo
16.	*Shorea ovata*	LC	Endangered	WD

No.	Species	IUCN Sarawak	IUCN Global	Distribution
17.	*Shorea parvifolia*	LC	None	WD
18.	*Shorea parvistipulata*	NT	None	Borneo
19.	*Shorea patoensis*	LC	None	Borneo
20.	*Shorea pauciflora*	LC	Endangered	WD
21.	*Shorea pilosa*	LC	None	Borneo
22.	*Shorea scrobiculata*	LC	None	WD
23.	*Shorea smithiana*	VU	Crictically Endangered	Borneo
24.	Shroea ferruginea	LC	None	Borneo
25.	*Vatica albiramis*	LC	None	Borneo
26.	*Vatica odorata*	LC	None	WD
27.	*Vatica sarawakensis*	LC	Crictically Endangered	Borneo
28.	*Vatica umbonata*	LC	Least Concerned	WD

**CR: Crictically Endangered; EN: Endangered; VU: Vulnerable; NT: Near Threatened; LC: Least Concerned; NE: Not Evaluated*

DISCUSSION AND CONCLUSION

Result obtained is interesting as even though more than 80% of the species does not fall under the Threatened Category at the regional level, but in view of climate change and urban development, conservation of the species' population is important as at the Global level 46% of the recorded species falls under the Threatened Category and 50% are Not Evaluated. This is especially crucial when it comes to species that are endemic to Borneo. If the Borneo species distribution is to be viewed at a Borneo scale, there is high a possibility that though not threatened in Sarawak, it might be critically endangered in Sabah or in Kalimantan. An example would be *Shorea havilandii*, although it is Least Concern in Sarawak, the species is considered rare for the State of Sabah.

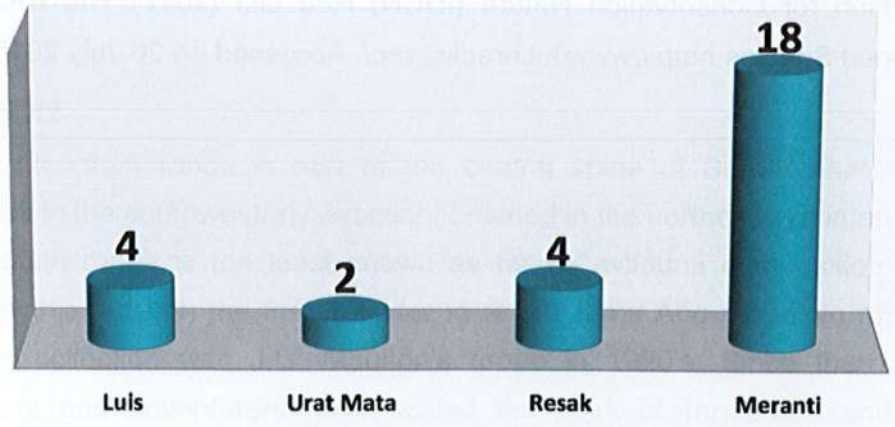


Figure 1: Number of species recorded in the different groups

Aside from that the species presence count is not a true indication on the population dynamics of the individual species. Further work needs to be conducted to have a grasp of the population dynamics within the area. As some species tends to congregate and form gregarious stands such as *Shorea faguetiana*, in which numerous plants ranging from seedlings, saplings, poles and adults were observed but when it comes to the Vatica group it is a different scenario. Take for example V. *sarawakensis*, species that is known to not congregate but instead has a scattered distribution, throughout the expedition survey there was only one observation in which a sapling was recorded.

Overall, the preliminary information generated through this expedition may be used as a reference for future research may it be setting up of Permanent Sampling Plots for the monitoring of population dynamics; or diversification of gene pool in species rescue collection for the establishment of *Ex situ* collections or Dipterocarp arboretum and a myriad of research work that aims to greatly enhanced the State's goal in practicing Surtainable Forest Management in the long term.

ACKNOWLEDGEMENT

Sincere thanks to the Ministry of Natural Resources and Environment and Sabah Forestry Department for making the funds available for the research. Heartfelt thanks to the Director of Sarawak Forest Department and the HoB's Secretariat for their support and commitment in the organisation of the expedition.

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BIRDS OF SOUTHERN TAMA ABU RANGE, ULU BARAM, SARAWAK

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Abstract

A mist-netting survey was carried at Tama Abu, Ulu Baram, Sarawak, from 15 to 18 August 2017 as part of multi-disciplinary expedition under the Heart of Borneo Initiative. A total of 20 mist nets were deployed in a primary hill dipterocarp forest (Trail 1 and 2) and additional 10 mist nets were set up on a ridge (Trail 5). A total of 25 species of birds from 13 families were captured. The three most abundant species were Yellow-bellied Bulbul (8 individuals), Little Spiderhunter (7 individuals) and Grey-cheeked Bulbul (6 individuals). Timaliidae was the most species-rich family, represented by six species. Sub-montane species endemic to Borneo included Hose Broadbill and Bornean Banded Pitta, represented by one individual each. Protected species recorded include Rufous-backed Kingfisher (Cexy rufidorsa), Rufous-collared Kingfisher (Actenoides concretus), Rufous Piculet (Sasia abnormis) and White-rumped Shama (Copsychus malabaricus). The majority of birds are insectivorous, represented by members of the family Timaliidae, Turdidae and Muscicapidae. Species accumulation curve have reached asymptote at our sampling site and with the method we employed, indicating that we have sampled all the species possible with our mist net. We believed that more species would have been recorded if we had sampled more sites (if we had more time) and included visual and vocal methods in our survey.

INTRODUCTION

The Tama Abu mountain range is part of the central spine of Borneo that stretches from Sabah to Sarawak in the southwesterly direction. Located in the northeastern interior of Sarawak, Tama Abu mountain range is the least known as far as avifauna composition is concerned. According to Smythies (1999) the first outsider to reach Tama Abu mountain range and make an ornithological collection was J.C. Moulton's group in 1920's. Since then only hardcore mountain climbers and adventurers have scaled the peak of Tama Abu and travelled the jungle paths within this mountain range but none has published any bird list.

A lot more is known however about the avifauna of Bario and the Kelabit Highlands, which is the plateau to the east of Tama Abu mountains. This is largely due to the work of Mr Tom Harrison who served as paratrooper there during the second world war and collected extensively in the Plain of Bah in the Kelabit Highlands between 1940 and 1960. Tom Harrisons' collection of montane avifauna feature prominently in Smythies' first edition of The Birds of Borneo published in 1960. After a long spell of inactivity, ornithological exploration to the Kelabit Highlands was revived by Sreedharan who observed and mist netted birds around Bario between October 1993 and November 1994 (Sreedharan 1995) and Gregory-Smith who participated in the Bario Scientific Expedition organised by Universiti Malaysia Sarawak in 1995 (Gregory-Smith 1998). This was later followed by Wang who published his bird notes of Bario (Wang 2004) and Sreedharan who published a book on the birds of Bario and the Kelabit Highland (Sreedharan 2011). The latest ornithological expedition to the Kelabit Highlands was a joint UNMIAS-LSU expedition in July-August 2011 (Sheldon et al 2013). In all these expeditions to the Kelabit Highlands, no significant collection was made in Tama Abu Range.

Under the Heart of Borneo Initiative, a scientific expedition to the Southern part of Tama Abu Range was organised by Forestry Department Sarawak from 13-27 August 2017. The base camp was located about 15 km straighline distance northeast of Long Bangga, along the bank of a tributary of Baleh River (base camp located at N 3o 18' 37.4", E115o 29' 2.3") at approximately 700 meters above sea level. This report presents the result of our mist-netting survey as part of this expedition. The objective of the survey was to produce a checklist of the birds for this part of Tama Abu Range, their conservation status and feeding guilds.

MATERIALS AND METHODS

Thailand-made mist nets (9 meters long, 2.5 meters high, 30 mm mesh size, 3 shelves) were used to capture birds in this survey (Figure 1). A total of 20 mist nets were deployed on the hill slopes along Trail 1 and 2.

Five nets were initially deployed on the opposite side of the river from the base camp but was moved further up the slope (to elevantion 785 meters asl) on the second day when the nets proved to be unproductive. An additional 10 mist nets were set up on the ridge at Trail 5 by the small mammal team led by Dr Faisal to catch bats, and incidental catch of birds were recorded in the list reported here. The nets were checked every two hours and any bird captured was identified, weighed, measured, ringed and then released on site.

The species names and feeding guilds of the birds follow that of Smythies (1999). Conservation status of each species was checked against the list of protected and totally protected species under Schedule 1 of the Sarawak Wild Life Protection Ordinance 1998 (SWLPO 1998) and IUCN Red List of Threatened Species 2017 (IUCN 2017).

The terrain where the survey was carried out was hilly with steep slopes of up to 40 degrees. Elevation ranges from 700 meters near the river to 780 meters above sea level at the highest mist net point. The forest where the nets were set up along Trail 1 and 2 consisted of hill dipterocarp forest with little signs of previous logging activity. Further up the slope from the mist netting site, logging had taken place as evidenced by presence of tree stumps and secondary forest where gaps were created by tree fall and logging skid trail.



Figure 1: Removing a Yellow-bellied Bulbul from a mist net at trail 1.

RESULTS AND DISCUSSION

Species list

A total of 25 species of birds from 13 families were netted during this survey (Table 1). The most common species was Yellow-bellied Bulbul with 8 individuals netted. Twelve species were caught only once.

Table 1: List of birds netted during the Tama Abu Range Expedition.

Family/Species	Common Name	Number captured
COLUMBIDAE		
Chalcophaps indica (Linnaeus) 1758	Emerald Dove	1
TROGONIDAE		
Harpactes duvaucelii (Temminck) 1824	Scarlet-rumped Trogon	1
ALCEDINIDAE		
Alcedo euryzona Temminck 1830	Blue-banded Kingfisher*	1
Ceyx rufidorsa rufidorsus Strickland 1847	Rufous-backed Kingfisher*	1
PICIDAE		
Meiglyptes tukki (Lesson) 1839	Buff-necked Woodpecker*	3
EURYLAIMIDAE		
Calyptomena hosei Sharpe 1892	Hose Broadbill	1
PITTIDAE		
Pitta schwaneri Bonaparte, 1850	Bornean Banded Pitta	1
IRENIDAE		
Irena puella (Latham) 1790	Asian Fairy Bluebird	3
PYCNONOTIDAE		
Alophoixus bres (Lesson) 1832	Grey-cheeked Bulbul	6
Tricholestes criniger (Blyth) 1845	Hairy-backed Bulbul	3
Alophoixus phaeocephalus (Hartlaub) 1844	Yellow-bellied Bulbul	8
TIMALIIDAE		
Trichastoma malaccense (Hartlaub) 1844	Short-tailed Babbler	2
Trichastoma sepiarium (Horsfield) 1821	Horsfield's Babbler	1
Malacopteron magnum Eyton 1839	Rufous-crowned Babbler	1
Malacopteron cinereum Eyton 1839	Scaly-crowned Babbler	1
Stachyris leucotis (Strickland) 1848	White-necked Babbler	1
Stachyris maculate (Temminck) 1836	Chestnut-rumped Babbler	2
TURDIDAE		
Zoothera interpres (Temminck) 1827	Chestnut-capped Thrush	1
Copsychus malabaricus (Scopoli) 1786	White-rumped Shama*	2
Enicurus borneensis Sharpe 1889	Bornean Forktail	1
MUSCICAPIDAE		
Rhinomyias ruficauda Sharpe 1877	Rufous-tailed Jungle-flycatcher	2
Cyornis concretus (S. Muller) 1835	Dark Blue Flycatcher	2
VANGIDAE		
Philentoma pyrhopterum (Temmink) 1836	Rufous-winged Philentoma	2
NECTARINIIDAE		
Hypogramma hypogrammicum (Müller, 1843)	Purple-naped Sunbird	5
Arachnothera longirostra (Latham) 1790	Little Spiderhunter	7

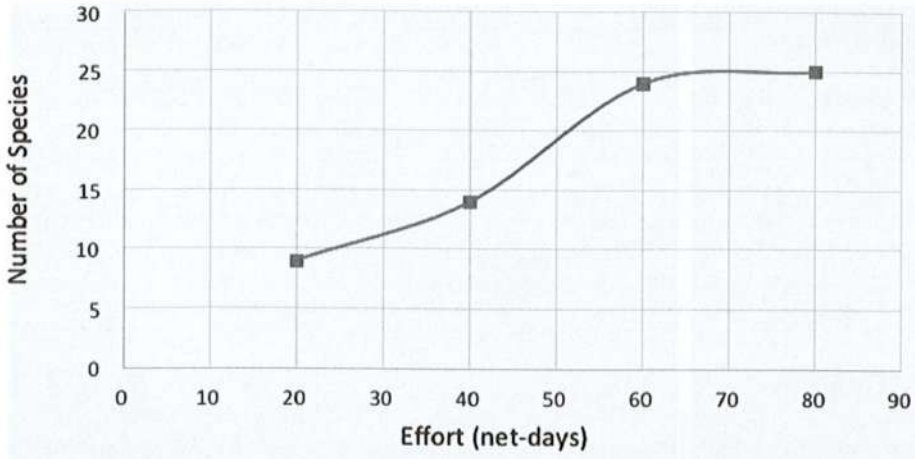


Figure 2. Bird species accumulation curve, based on mist net technique.

The species accumulation curve (Figure 2) has reach saturation for have been caught had there been more effort in terms of the number sites sampled and the use of a combination of survey methods that include birds that use the space above our mist nets (eg. canopy birds). For the site that was sampled using mist net. However more individuals and species would example, Sreedharan (2011) recorded 223 species and Sheldon et al. (2013) recorded 114 species of birds in the Kelabit Highland. Nevertheless the value of our finding is that it presents the first record of birds at this particular site which has not been sampled before, and it contains a number of montane and sub-montain birds endemic to Borneo.

Because the list was based on mist met method alone, most of the birds captured are those which commonly use the understorey of primary forest, specifically from the ground level up to 3 meters above ground. The primary forest site where the nets were deployed has a canopy of about 30 meters above ground hence canopy dwelling birds are not well represented in our sample.

Given below is a brief description of selected species.

A single individual of White-necked Babbler was caught on mist-nets set on a steep slope. According to Wells (1985) this bird is a slope specialist inhabiting the understorey. According to Smythies (1999) it is scarce but widespread in the lowland and foothills. It feeds on insects, mainly small beetles, flies, caterpillars and small locust (Smythies 1999).

A female Hose Broadbill (with brood patch which suggests breeding) characterised by its light blue abdomen and black spots on the wing and weighing 87 g (Figure 4) was netted in the afternoon of on 15 August 2018. This bird is a **sub-montane endemic** in Borneo, with patchy distribution from sea level up to 910 m and reported to be quite common in the upper Baram catchment of Kelabit Highlands (Smythies 1999).



Figure 3: White-necked Babbler.

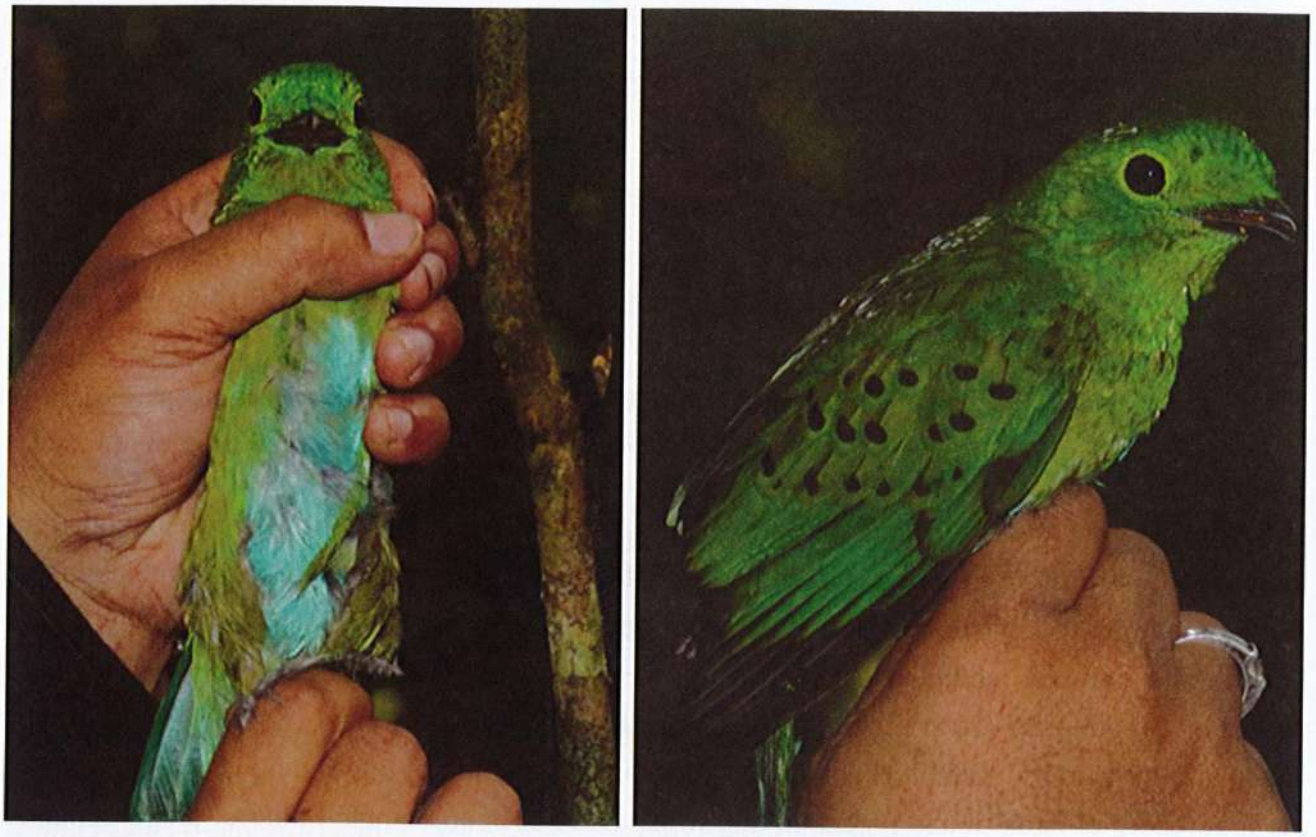


Figure 4: Hose broadbill, characterised by light blue abdomen and black spots on its wing.

A pair of Dark Blue Flycatcher (Fig 5) male weighing 24 g and female weighing 30 g) was captured on a net set on a ridge at Transect 5. The female has a brood patch, indicating breeding. This bird is a **sub-montane resident** prefering the hill slopes of primary forest, usually found at 600-1200 meters above sea level (Smythies 1999).



Figure 5: Dark Blue Flycatcher caught at Trail 5. Male (top) has blue colouration on the head and chest while female (bottom) is brownish.

Among the song birds captured at Transect 1 are Chestnut-capped Thrush (Figure 6) and White-rumped Shama (Figure 7). The Chestnut-capped Thrush is a shy bird that inhabits the understorey of primary forest throughout Borneo and often recorded via mist net due to its secretive nature. It is a popular songbird in Java and has been bred in captivity for this purpose (Phillipps and Phillipps 2014). White-rumped Shama inhabits a wide range of forest habitats from logged and unlogged mixed dipterocarp forest to secondary forest and overgrown tree plantations, mangroves and coastal vegetations (Smythies 1999). The bird is frequently trapped and the males are sold as songbird due to their rich song repertoire.



Figure 6: Chestnut-capped Thrush is a popular songbird in Java.



Figure 7: White-rumped Shama.



Figure 8: A Bornean Fork Tail.

A Bornean Banded Pitta weighing 42 g (Fig. 9) was captured on a mist net set on the hill slope at Transect 1. This bird is a scarce resident of forested slopes and hills where it is locally common. It has been recorded in Mulu and Kelabit Highlands (Phillipps and Phillipps 2014). It feeds on insect, including ants and cockroaches.



Figure 9: Bornean Banded Pitta



Figure 10: Scarlet-rumped Trogon. The scarlet colour on the rump is very obvious in the male.

A male Scarlet-rumped Trogon (34 g) was netted on a ridge at Transect 5. The male bird is distinguished by its scarlet rump (Fig 10). It is a common resident throughout the lowland forest of Borneo (Smythies 1999), feeding on insects among the foliage.

CONSERVATION STATUS AND FEEDING GUILD

Only four species of bird were categorised as protected species under SWLPO 1998, these are Blue-banded Kingfisher, Rufous-backed Kingfisher, Buff-necked Woodpecker and White-rumped Shama. None of the species captured are categorised as threatened species under IUCN 2017. Had the survey methods cover wider areas over longer periods and include observations, totally protected species such as pheasants, hornbills and eagles would have been recorded. These birds has been recorded in the Kelabit Highlands by earlier ornithologist (Sreedharan 2011; Sheldon et al. 2013).

The majority of birds netted in this survey are insectivores (64%) followed by insectivores-frugivores (24%) (Table 2). The insectivores are represented mainly by members of the family Timaliidae (Babblers),Turdidae (Thrushes and Forktails) and Muscicapidae (Flycatchers). The babblers feed mainly at ground level while the thrushes, forktails and flycatchers are arboreal and foliage-gleaning specialist. The predominance of insectivores over the other feeding guilds are typical of tropical forest ecosystem (Edwards et al. 2009; Pang et al. 2017) and related to the continuous availability of insect preys compared to seasonal and patchy distribution of fruits.

Table 2. Conservation status and feeding guilds of birds. Where more than one feeding is indicated, the first is the primary feeding guild.

Common Name	Conservation Status	Feeding guilds
Emerald Dove	LC, NP	Frugivore-Insectivore
Scarlet-rumped Trogon	LC, NP	Insectivore
Blue-banded Kingfisher	LC, P	Piscivore (fish, lizard)
Rufous-backed Kingfisher	LC, P	Insectivore
Buff-necked Woodpecker	LC, P	Insectivore
Hose Broadbill	LC, NP	Frugivore-Insectivore
Bornean Banded Pitta	LC, NP	Insectivore
Asian Fairy Bluebird	LC, NP	Frugivore-Insectivore
Grey-cheeked Bulbul	LC, NP	Insectivore-Frugivore
Hairy-backed Bulbul	LC, NP	Insectivore-Frugivore
Yellow-bellied Bulbul	LC, NP	Insectivore-Frugivore
Short-tailed Babbler	LC, NP	Insectivore
Horsfield's Babbler	LC, NP	Insectivore
Rufous-crowned Babbler	LC, NP	Insectivore
Scaly-crowned Babbler	LC, NP	Insectivore
White-necked Babbler	LC, NP	Insectivore
Chestnut-rumped Babbler	LC, NP	Insectivore
Chestnut-capped Thrush	LC, NP	Insectivore
White-rumped Shama	LC, P	Insectivore
Bornean Forktail	LC, NP	Insectivore
Rufous-tailed Jungle-flycatcher	LC, NP	Insectivore
Dark Blue Flycatcher	LC, NP	Insectivore
Rufous-winged Philentoma	LC, NP	Insectivore
Purple-naped Sunbird	LC, NP	Nectarivore/Insectivore/ Frugivore
Little Spiderhunter	LC, NP	Nectarivore/Insectivore

LC: Least Concern under IUCN Red List of Threatened Species 2017

NP: Not protected under Sarawak Wild Life Protection Ordinance 1998

P: Protected under Sarawak Wild Life Protection Ordinance 1998

This paper reports the first account of the birds in Tama Abu Range, and it is limited to birds that can be caught using mist net. It is recommended that a visual and vocalisation survey of birds should be done following the road to Bario, with frequent incursion into the forest. This would cover larger area and would yield more species, comparable perhaps to the result of earlier survey done in Bario and the Kelabit Highlands.

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A brief note on *Ternstroemia* (Pentaphylacaceae) of Tama Abu P.F., Ulu Baram, Sarawak, Malaysia

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Abstract. A specific collection of *Ternstroemia* was made during a scientific expedition under the Heart of Borneo (HoB) initiative in Tama Abu Permanent Forest (P.F.), Ulu Baram, Sarawak from 15th to 26th of August 2017. The study was aimed to collect and identify all species of *Ternstroemia* found within the area. There were four species collected in Tama Abu P.F., i.e., *T. aneura* Miq., *T. bancana* Miq., *T. lowii* Stapf. and *T. magnifica* Stapf. ex Ridl.. These four species are common in the highlands and *kerangas* habitats of Borneo. To date, there are 17 species of *Ternstroemia* that are recognised in Borneo (including possibly eight species new to science) whereby 16 species are recorded from Sarawak. The findings from this expedition will be included in the ongoing taxonomic revision of *Ternstroemia* in Borneo and also the Tree Flora of Sabah and Sarawak documentation.

Keywords: Borneo, scientific expedition, taxonomic revision

INTRODUCTION

Ternstroemia (previously included in the Theaceae family) is a pantropical genus of about 100 species, consisting of trees, shrubs and epiphytes. This genus is commonly found in the lower to upper montane forests, occasionally in lowland mixed dipterocarp and *kerangas* forests, particularly along riverbanks and forest on ultramafic soil, on altitude up to 4000 m.

A comprehensive taxonomic revision of the genus in Borneo is currently being undertaken by the first author. Thus far, there are 17 recognised species of *Ternstroemia* in Borneo. Previous researchers who studied this genus in Borneo, i.e., Cockburn (1980), Argent *et al.* (1997), Coode *et al.* (1996) and Anderson (1980), had only listed the species based on respective territories within the island without any detail descriptions of each species. For example, Anderson (1980) had listed nine species of *Ternstroemia* from Sarawak, namely *T. aneura* Miq., *T. bancana* Miq., *T. citrina* Ridl., *T. denticulata* (Pierre) Ridl., *T. hosei* Ridl., *T. lowii* Stapf., *T. macrocalyx* Airy Shaw, *T. magnifica* Stapf. ex Ridl. and *T. penangiana* Choisy and one undetermined species. Unfortunately, no key to the species was provided.

In Sarawak, this genus is locally known as Medang Pajal, particulary by the Iban community (Anderson 1980) as seen in specimen labels and also from personal communication with botanists and collectors during several fieldwork conducted in Sarawak. The term Medang Pajal is also referring to certain species based on the leaf sizes (either small

or big) e.g., *T. hosei* is specifically known as Medang Pajal Daun Kecil due to its small leaves. Similarly, species with big-sized leaves, such as *T. magnifica,* is known as Medang Pajal Daun Besar (Anderson 1980).

There are no specific uses of *Ternstroemia* in Borneo, but some information from the specimen labels, especially those from Ranau and Telupid districts in Sabah, noted that the wood of *T. bancana* is normally used by local people for house construction. In Peninsular Malaysia, the wood of this species was listed as a timber species by Ridley (1922). In terms of conservation, *T. bancana* has a good potential to be used for restoration of degraded areas as 90% of its seeds could be germinated within a month period (Sosef *et al.* 1998).

Under the Heart of Borneo (HoB) Sarawak initiative, a scientific expedition at Tama Abu P.F. was conducted to study the fauna and flora diversity, the aquatic habitat, the sociology and anthropology of the local communities and tourism potential of the area with a view in contributing to the well-being of the local communities and enhancing conservation. A specific study on *Ternstroemia* species (Pentaphylacaceae) was conducted within the area with the objective to collect and identify all species of *Ternstroemia* found within the area.

MATERIAL AND METHODS

Study Site

Tama Abu Range is a mountain range located in Sarawak and is nearby to Long Labid, Raan Ngela and Long Aar. The expedition site is located at about N 03° 18' 37.1", E 115° 28' 48.7" in the south eastern of Pulong Tau National Park (Figure 1). The site is about 130 km from Miri Town and is only accessible by four-wheel drive car (about 11-hour drive). Basically, the area is covered by patches of virgin forests and, was logged-over about 20 years ago. The area is surrounded by hilly forests with several peaks reaching to 1000 m a.s.l. The closest settlement of the Penan people is Kg. Long Banga, about an hour drive from the expedition site. The vegetation of Tama Abu P.F. consists of the lowland to upland hill dipterocarp and *kerangas* forests.

Sampling of plants

Collections of *Ternstroemia* were carried out along Trail No. 1 to Trail No.11, which were established along Sg. Balleh. The vegetation types along these trails are mostly lowland hill dipterocarp, upland dipterocarp, *kerangas* forests (peak of Trail No. 4), and the elevation ranges from 250 m to 1018 m a.s.l.

In the field, the habit, and the colour of leaves and other parts of plants were recorded for each collection. About 4–6 duplicates of voucher specimens (consisting of leafy twigs without fruits or flowers) were gathered. Digital images of habit and close-up views of other parts of the plants were taken. Prior to identification, the specimens were oven-dried at a temperature range of 45–50°C for several days at Sarawak Herbarium (SAR). Further identification was done at Sandakan Herbarium (SAN) by cross-checking with herbarium specimens and the literature materials.

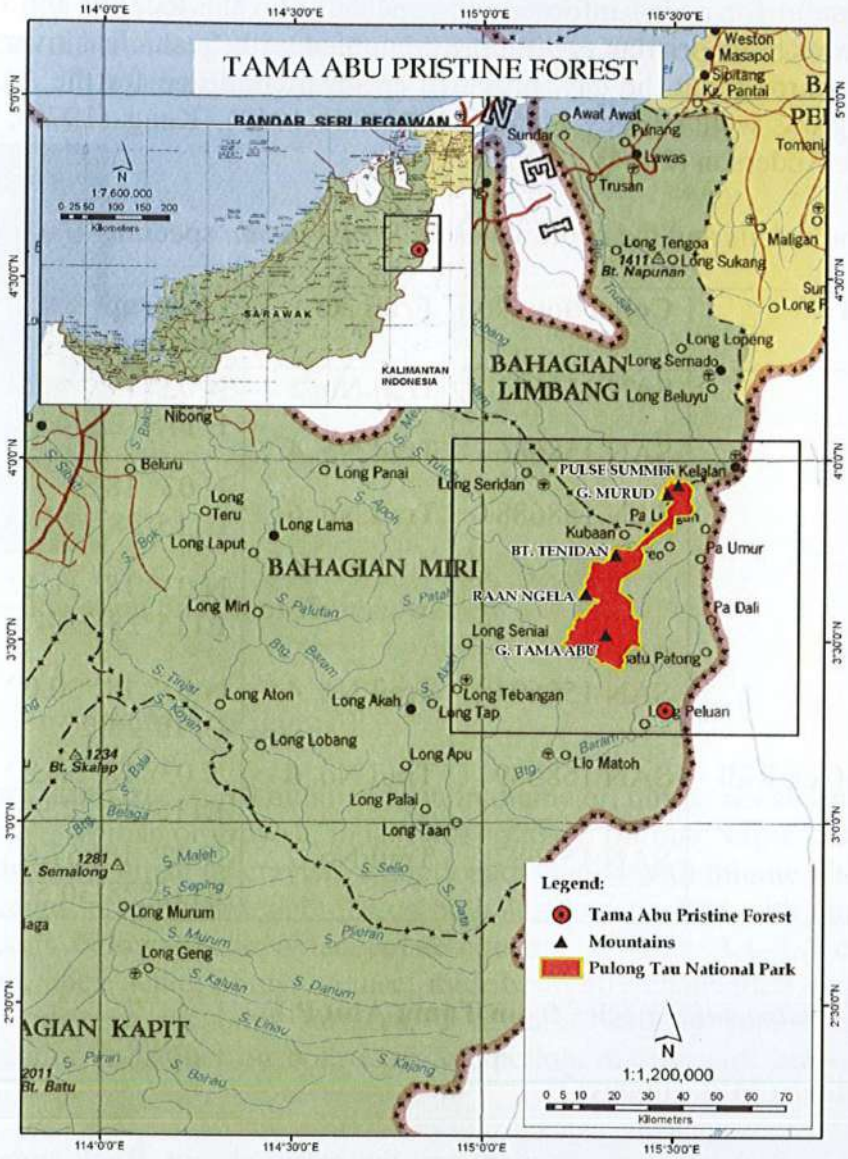


Figure 1. The location of Tama Abu P.F. in Sarawak, Malaysia (source: GIS Unit, Forest Research Centre, Sabah Forestry Department).

RESULTS AND DISCUSSION

A total of six specimens, representing four species of *Ternstroemia*, i.e., *T. aneura*, *T. bancana*, *T. lowii* and *T. magnifica* were collected in Tama Abu P.F., along Trails 2, 4, 6 and 7 (Table 1). *Ternstroemia lowii* which is found in *kerangas* forest is an endemic species to Borneo. The other three species are common and widespread in the highlands of Borneo. A short note on each species is included in this paper. These findings, however, are far from complete due to lack of collection because of the unfavourable weather during the expedition. The flowering and fruiting seasons were over as a few seedlings were seen on the forest floor.

Thus, all of the specimens collected were sterile. However, the finding of the four species of *Ternstroemia* is useful for added information, especially on the locality and distribution of this genus in Sarawak. The pristine environment coupled with fresh clear river of Sg. Balleh and high humidity throughout the day, provided an ideal condition for the Asian species of *Ternstroemia* to grow well (Ridley (1922), Kobuski (1963), Keng (1978), Coode *et al.* (1996), Beaman & Anderson (2004).

Table 1. Collection details and the coordinates of *Ternstroemia* specimens at Tama Abu P.F.

Species Collected	Collection No.	Trail No.	Geographical Position	Elevation (m)
T. aneura Miq	SAN 158681	Trail No. 2	N 03° 19' 06.7" E 115° 28' 42.4"	955
	SAN 158686	Trail No. 4		
	SAN 158688	Trail No. 6	N 03° 18' 49.1" E115°28'32.1"	920
			N 03° 18' 31.1" E115°28'28.4"	838
T. bancana Miq.	SAN 158694	Trail No. 4	N 03° 18' 30.0" E115°28'27.3"	893
T. magnifica Stapf. ex Ridl.	SAN 158689	Trail No. 6	N 03° 18' 32.2" E115°28'22.9"	908
T. lowii Stapf.	SAN 158687	Trail No. 7	N 03° 18' 57.8" E115°28'30.5"	1018

Short notes on *Ternstroemia* species from Tama Abu P.F.

***Ternstroemia aneura* Miq.** (Figure 2)

Small tree, *c.* 5 m tall, 4 cm in diameter; buttresses absent. **Bark** smooth to flaky or cracking, greyish to reddish brown; inner bark dark red, fibrous. **Sapwood** yellowish. **Twigs** terete, drying greyish brown, smooth, glabrous. **Leaves** dark green above, paler beneath, thin-coriaceous, smooth and glabrous on both surfaces; blade ovate, 2.5–8 × 2.5–4.5 cm, base cuneate, margin slightly involute or wavy, apex rounded or acute; midrib slightly channelled above, raised below; lateral veins indistinct on both surfaces, 3–5 pairs, slightly joining near the margin; intercostal venation slightly distinct above, indistinct below; petiole glabrous, slender, 0.3–2 cm long.

Distribution: Sumatra, Peninsular Malaysia, Borneo, the Philippines, Papua New Guinea and Java. In Sarawak, known from Bario, Kapit, Kuching, Lawas, Lundu, Marudi, Miri, and Serian districts.

Notes: Only one individual of this species was found during the expedition. This species is easy to recognise by its whitish and angular twig, petiole and pedicels. The nerve is distinct, especially on the upper surface of the leaves.

(less than 8 cm long) with indistinct nerves on both surfaces. The twig, petiole and pedicel are greyish-brown and rounded. The indistinct nerves of its leaves, and rounded twig, petiole and pedicel can differentiate this species from the two closely related species that also have small leaves, i.e., *T. bancana* and *T. lowii*.



Figure 2. The flowering branch of *T. aneura*.

***Ternstroemia bancana* Miq.** (Figure 3)

Medium-sized tree, *c.* 10 m tall, 11 cm in diameter; buttresses absent. **Bark** smooth to flaky or cracking, whitish or greyish; inner bark orangey, fibrous. **Sapwood** yellowish. **Twigs** sub angular, drying whitish or greyish, smooth and spotted with minute black dots, glabrous. **Leaves** coriaceous, smooth and glabrous on both surfaces, spotted with minute black dots or slightly glaucous below; blade oblanceolate-obovate, 6–10 × 3.4–7.2 cm, base cuneate, margin smooth, apex acute, obtuse, retuse; midrib slightly channelled above, raised below; lateral veins indistinct on both surfaces, 5–6 pairs, slightly joining near the margin; intercostal venation indistinct on both surfaces; petiole drying dark brown, glabrous, stout, 0.6–2 cm long.

Distribution: Sumatra, Peninsular Malaysia, Singapore and Borneo. In Sarawak, it is common and widespread in Kapit, Kuching, Marudi and Miri districts.

Notes: Only one individual of this species was found during the expedition. This species is easy to recognise by its whitish and angular twig, petiole and pedicels. The nerve is distinct, especially on the upper surface of the leaves.



Figure 3. The fruiting branch of *T. bancana*.

***Ternstroemia magnifica* Stapf. ex Ridl.** (Figure 4)

Medium-sized tree, *c.* 15 m tall, *c.* 13 cm diameter; buttresses absent. **Bark** smooth to lenticellate, cracking, reddish pink or brown; inner bark yellowish, granular or mottled. **Sapwood** pale yellow to brownish pink, fibrous. **Twigs** terete, drying greyish brown, fissured, glabrous. **Leaves** thick coriaceous, glabrous and smooth on both surfaces, slightly glaucous below; blade obovate, 10.5–17 × 7–10 cm, base cuneate or slightly decurrent, margin entire, apex obtuse or abruptly acuminate, acumen *c.* 0.2 cm long; midrib slightly to deeply channelled above, raised below; lateral veins indistinct to distinct on both surfaces, 9–14 pairs, slightly joining near the margin; intercostal venation distinct on both surfaces; petiole drying dark brown to blackish, glabrous, stout, 2–4 cm long.

Distribution: Peninsular Malaysia, Borneo, the Philippines and New Guinea. In Sarawak, recorded from Bintulu, Kuching, Lawas, Lundu and Miri districts.

Notes: This species is common on the highlands of Borneo. It is easy to recognise from the other three species of *Ternstroemia* in Tama Abu P.F. due to its tree size, large leaves, and stout and long petiole. In addition, the young shoots of the leaves are normally reddish in colour. This species could reach up to 40 m tall with 40 cm dbh, however, the tallest individual in the study site is only 15 m tall.



Figure 4. The fruiting branch of *T. magnifica*.

***Ternstroemia lowii* Stapf.** (Figure 5)

Treelet, *c.* 5 m tall, *c.* 5 cm diameter; buttresses absent. **Bark** smooth, whitish; inner bark reddish brown, fibrous. **Sapwood** pale yellow. **Twigs** terete or slightly subangular, glabrous. **Leaves** thick coriaceous, shining, rugulose above, smooth below, glabrous on both surfaces; blade elliptic, obovate 3.5–8 × 1.5–3.5 cm, base oblique; margin slightly involute, apex rounded, acute or short acuminate, acumen *c.* 0.1 cm long; midrib sunken above, raised below; lateral veins indistinct on both surfaces, 4–6 pairs, slightly joining near the margin; intercostal venation indistinct on both surfaces; petiole drying brown to black, glabrous, stout, 0.5–2 cm long.

Distribution: Endemic to Borneo (Sabah, Sarawak, Brunei and Kalimantan). In Sarawak, it is recorded from Baram, Bario, Bintulu, Kapit, Kuching, Lawas, Limbang, Marudi, Miri and Sri Aman districts.

Notes: This species is commonly found in the montane forests of Borneo. The shinning, waxy and thick leaves are the distinguishing characters of this species. The twig, petiole and pedicel of this species are rounded. Only one individual was found in the *kerangas* habitat of Tama Abu P.F.



Figure 5. The fruiting branch of *T. lowii.*

CONCLUSION

Even though only four species of *Ternstroemia* were recorded in Tama Abu P.F., there were a few seedlings of *T. aneura* observed along the trails especially on the hilly parts with elevation above 800 m a.s.l. The *kerangas* forest in high elevation, particularly the peak of Trail No. 7, is an important habitat for the endemic species, *T. lowii*, as only one individual tree of this species was found during the expedition. It is recommended to carry out further collection of *Ternstroemia* during flowering or fruiting seasons, especially in areas that were not covered during the expedition. In addition, this is also the first record of *Ternstroemia* collection from Tama Abu P.F. as fieldwork has never been conducted in the area before.

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