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Research Article

Brief Documentation of Land and Water Ecosystem in Kubah and Santubong National Parks, Sarawak

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ABSTRACT

Kubah and Santubong National Parks are among Sarawak's heritage ecological treasures, featuring diverse land and water ecosystems that are vital to state and national biodiversity. The conservation and preservation of these parks is crucial for maintaining the sustainability of the environment and ensuring that future generations can continue to benefit from their natural beauty and resources. The parks are significant natural reserves, exhibiting unique landscapes including lush tropical rainforests and aquatic environments. Kubah National Park ecosystem includes dipterocarp trees, ferns, fungi, and detritivores, and insects; meanwhile, Santubong National Park ecosystem includes mountainous terrain, dipterocarp trees, invertebrates, and ferns. Thus, to effectively comprehend and promote conservation and preservation efforts, we have to experience biodiversity and ecology and impart to differentiate different components of the ecosystem. Therefore, a field work was conducted to experience the biodiversity and ecology of discerned organisms in various ecosystems in Kubah and Santubong National Park. The input was analysed and described selected ecosystems, plants, and animals and referred to previous scientific reports from various resources. Experiences with biodiversity and ecology are vital for future development, especially in the realms of academics, research, development, and lifelong learning, all contributing to a sustainable future.

Keywords: biodiversity, ecology, education, environment, national parks, sustainable development goal

1. INTRODUCTION

Sarawak is blessed with vast wilderness and thriving wildlife. The state has a prosperous biodiversity and ecology, packed with amazing 42 national parks, which are world-renowned (Dow and Reels, 2010). The parks are home to lush tropical rainforests and peculiar wildlife, all of which can be found in these natural parks including Kubah and Santubong National Park. This article briefly documents biodiversity and ecology-related information in an exceptionally rich ecosystem of flora and fauna of Kubah and Santubong National Park. The documentation

was aimed at observing and documenting the terrestrial ecosystem in the park. The documentation is also targeted at creating awareness on terrestrial ecosystems and education, inspiring sustainable development goals, and studying the selected flora and fauna of the area. The need suggests multiple perspectives for biodiversity and ecology of parks such as scientific geography and values (Tan et al., 2009). These perspectives are significant as a tool and valuable framework for sustainable development issues. Centres for Pre-University Studies from permission with Sarawak Forestry Corporation have allowed for ecosystem and education experience exchange in the pursuit of educational documentation for a sustainable future.

The objectives of the activity were achieved when the focus of this observation and documentation is on applying multiple perspectives of higher education for effective learning of biodiversity and ecology of the respective parks. Achievements from the trip included the basic discovery of fungi, herbaceous plants, aquatic insects, and mixed dipterocarp forest in the park. These have enabled short and basic research documentation of the park's ecosystem as well as a presentation where valuable findings were shared.

2. MATERIALS AND METHODS

2.1. Pre-documentation Preparation

The documentation was conducted by students from Life Sciences Unit, Centre for Pre-University Studies, Universiti Malaysia Sarawak. There was a day trip visit to the assigned location in order for them to conduct trekking, observation, documentation, and recording pertaining to the topic given. Prior to fieldwork, the students attended a series of lectures that encompassed the learning units of biodiversity, ecology, and environment. They have learned about ecological diversity, taxonomy, and classification of plant kingdom systems as well as the threat and conservation of biodiversity. They have also learned and training were given to them about ecological principles, ecosystems, quantitative ecology, ecology and environment in Sarawak, and conservation status of the environment in Malaysia. In addition, a brief discussion was conducted before the visit in order for the students to engage with a proper plan of study, including time, selection of location, type of ecosystem, and distance or area of documentation. The students were prepared with a literature review and pre-analysis of Kubah and Santubong National Park's ecosystem in order to establish a framework of selected studies.

2.2. Study Site

The study area is located in Kubah National Park (1° 36' 45.9"N, 110° 11' 49.2"E) (Figure 1). The park is located around 25 km from Kuching city centre, and a partially undisturbed natural forest situated on a small sandstone plateau which includes Gunung Selang, Sendok, and Serapi (Das and Haas, 2010). The park is also consisting of five main vegetation types of forest, namely lowland, mixed dipterocarp, kerangas, alluvial, submontane, and high mixed dipterocarp forest (Wahab, 2012). Meanwhile, Santubong National Park is located on Damai Peninsula (1°45′46″N 110°19′20″E), which is 35 km north of Kuching. This park has covered with rainforest steeply to 810 m. It also includes 231 hectares' lowland dipterocarp forest and kerangas (heath) forest with sandy soil. The park also has a few geographical features such as sandstone layer dip on a gentle slope of 10 to 200 m from the summit to the Park Headquarters (Mohd Azlan et al., 2019). Kubah and Santubong parks have invited pertinent people who admire to promote natural environment sustainable development, conservation, and well-being (Teo et al., 2013). Various research in these parks has been carried out by educational and research institutions to support conservation and sustainable development while highlighting

the eco-education of Sarawak (Hanan, 2014; Lateef et al., 2015; Poulsen and Leong-Skornickova, 2017; Zahidin et al., 2016).

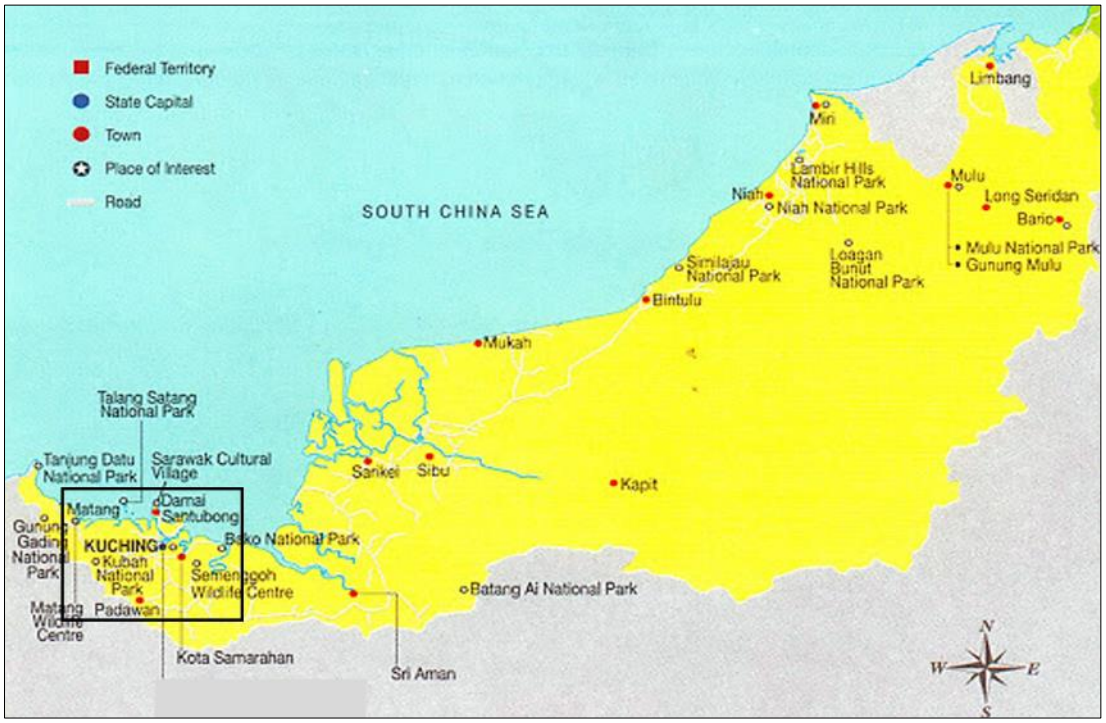

Figure 1. Map of Kubah and Santubong National Parks, Sarawak (Source:www.etawau.com)

2.3. Field Observation

In Kubah National Park, the students conducted the observation and documentation activities by trekking; from the Park Headquarters at 0 m up to the Summit Trail at 5 km distance (790 m altitude), with the detailed documentation and recording done at every 100 m. The sampling method was set out to be random and all forest ecosystems that have a closed distance observed (approximately 5 m) along the trekking were recorded and documented. The trekking passes through Kerangas forest, a mixed dipterocarp forest until it reaches the patches of scrub forest which takes about 3 hours. The trail demonstrated some steep and level sections and consistently ascended to the summit (Boyce and Yeng, 2008). Herbaceous plant species and fungi (Ascomycota) identified along the trekking journey were recorded. The observation and documentation were made by hand notes, photographs, and video. Preliminary identification was made during the visit, and the detailed analysis was made once returned to the campus.

In Santubong National Park, the students conducted the observation and documentation activities by trekking; beginning from the Park Headquarters at 0 m up to the Santubong Jungle Trekking Trail at 2,000 m distance, with detailed documentation and recording was done at every 100 m. The sampling method was set out to be random and all ecosystems that have a closed distance observed (approximately 5 m) along the trekking were recorded and documented. The trekking passes through jungle streams, dip pools, and waterfalls, which takes about 2 hours. As the trekking gets higher up the mountain, the gradient becomes steeper, and the vegetation types gradually change. Aquatic species and mixed dipterocarp forest identified along the trekking journey were recorded. The observation and documentation were made by hand notes, photographs and videos. Preliminary identification was made during the visit, and the detailed analysis was made once returned to the campus.

2.4. Ecosystem Identification

Records of herbaceous plant species, fungi (*Ascomycota*), aquatic species, and mixed dipterocarp forest in the respective parks which were initially recorded were further categorized according to the scientific name. A brief analysis of the collected data was done based on reference metadata, scientific and academic books, articles, journals, and official related websites to finalize the obtained results.

3. RESULTS AND DISCUSSION

3.1. The documentation of Ascomycota in Kubah National Park

Kubah National Park is located on a small sandstone plateau (Abu Bakar et al., 2016). The park has various jungle trails which lead to the summit of Gunung Serapi and waterfalls, which enable us to explore various types of flora and fauna. Dipterocarp shelters are along the trails. The objective of this study is to observe and determine the fungi Ascomycota which falls under the subkingdom of Dikarya (Haelewaters et al., 2014). This fungus is important because it is widely used as medicinal important compounds, such as for antibiotics. The fungus also contributes to the ecosystem, especially in the decomposition process, nutrient cycling, and symbiosis (Ali et al., 2018). Kubah National Park is in Kuching, Sarawak (1°36'46.0"N 110°11'48.9"E) (Figure 2). The park covers an area of 2,230 hectares of mixed dipterocarp, small scrub, Kerangas and heat forest rich in palms, orchids, and pitcher plants. The park is dominated by Gunung Serapi (911 m high) (Boyce and Yeng, 2008; Brahim, 2005; Meekiong et al., 2012; Pearce, 1992).

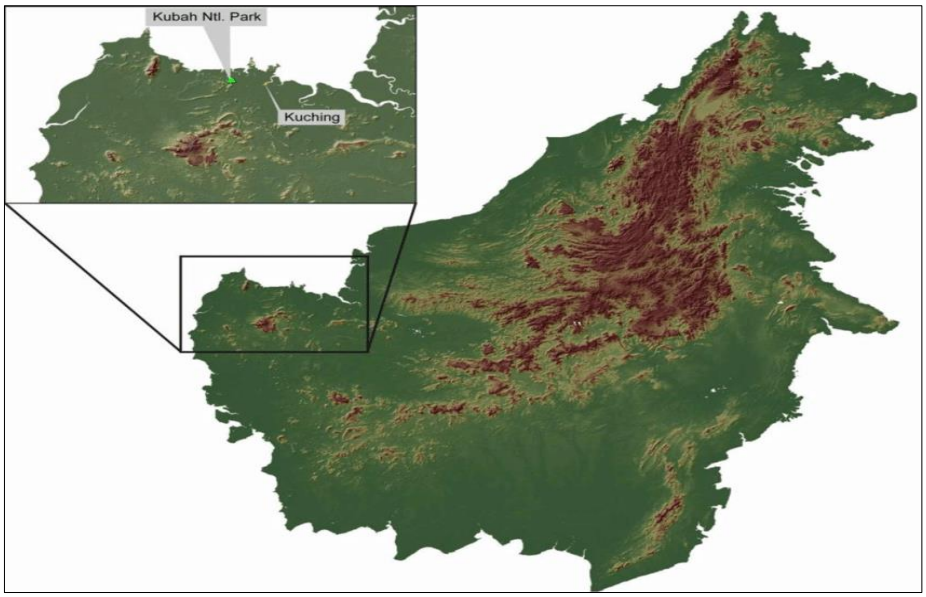

Figure 2. Map of Kubah National Park, Sarawak (Source: Das & Haas, 2010)

The study was conducted by observation and documentation of Ascomycota by trekking, beginning from the Park Headquarters at 0 m up to 790 m on Summit Trail, with detailed documentation and recording being done at every 100 m (Figure 3). The sampling method was set out to be random and have close distance. Smartphone camera was used to take the photo, a 15 cm ruler was used to measure the fungus dimension, and a weather checker application was used to measure the environmental humidity. The trail is provided with a concrete road towards the summit. The identification of Ascomycota species was carried out using various

references such as online metadata, journals, and websites based on their morphological traits. The identified Ascomycota species were recorded and described in Table 1.

The park's climate is wet and hot with the temperature between 24-34ºC which fulfils the criteria for fungi growth (Kistenich et al., 2018). The observation and documentation of Ascomycota were performed along the Summit Trail. The surroundings of the trail provide Ascomycota with a suitable habitat, as there are plenty of plants and moist soil that is necessary for their survival (Haelewaters et al., 2014).

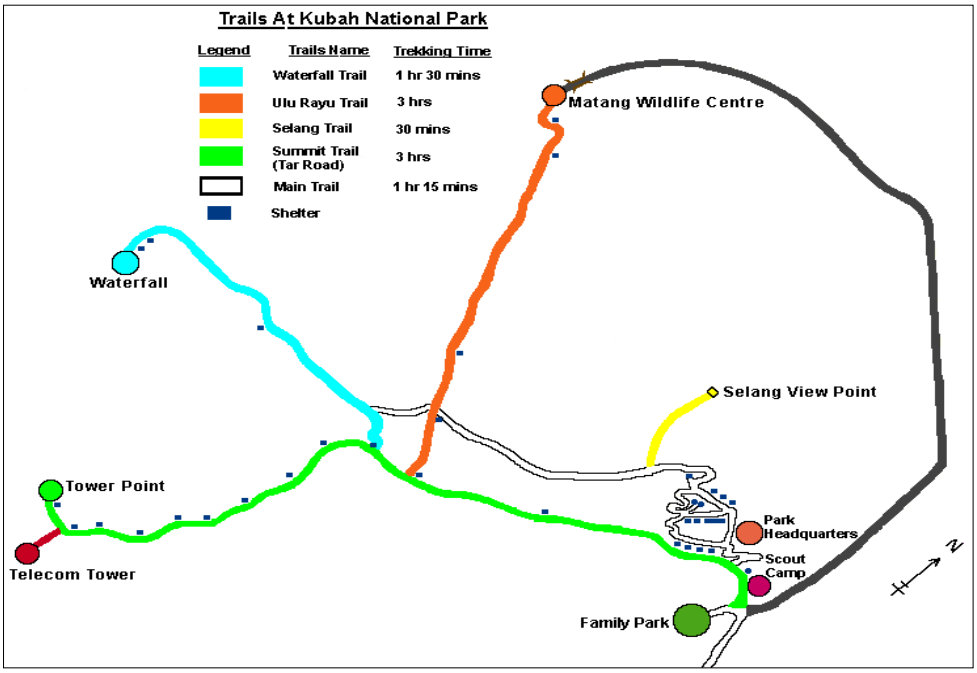

Figure 3. Kubah National Park trail map. (Source: www.sarawaktourism.com)

Cookeina tricholoma is commonly known as the eyelash cup and it is categorized in the species of Pezizomycetes (Figure 4.a). It is characterized by bodies with bright colour and short excipulum hairs or "eyelashes". These eyelashes are the most distinctive feature and are easily visible with a magnifying glass. The stem is pale pink and hairy. It grows up to about 2 cm high and 1.5 m diameter. The species is found on rotting wood, in a damp habitat. This species is widespread especially in tropical and subtropical areas, growing on dead plants or in the soil (Ekanayaka et al., 2016). *Cookeina sulcipes* has a common name called the Cup Fungus, which belongs to the family Sarcoscyphaceae (Figure 4.b). As compared with *Cookeina tricholoma*, this fungus is broader in size of the cup and has shorter hairs on the edge of the cup. The diameter of the cup is around 3 cm. It also has a shorter central stipe and is found growing solitarily or in groups with dead trees. It was reported that *Cookeina sulcipes* has high protein and low lipid with various essential amino acid content. Hence, this can be inferred that this fungus could be edible. This fungus is differing from all other species in the genus in having ascospores with a thick gelatinous sheath (Ekanayaka et al., 2016).

Daldinia concentrica is commonly known as King Alfred's cake cramp ball, and coal fungus, and has been recognized as an inedible fungus (Figure 4.c). It inhabits on dead and decaying wood. The fungus is bell-shaped, with a 2.5 cm wide and black fruiting body. Several types of insects and other small animals like to make their home in this fungus body. The fungus is useful for fire-lighting tinder, like a charcoal briquette, with particularly pungent smoke. The fungus plays a pivotal role in wood decay naturally (Ali et al., 2018).

Table 1. Classification of *Cookeina tricholoma, Cookeina sulcipes*, and *Daldinia concentrica*

Scientific name	*Cookeina tricholoma*	*Cookeina sulcipes*	*Daldinia concentrica*
Kingdom	Fungi	Fungi	Fungi
Phylum	Ascomycota	Ascomycota	Ascomycota
Class	Pezizomycotina	Pezizomycotina	Sordariomycetes
Order	Pezizales	Pezizales	Xylariales
Family	Sarcoscyphaceae	Sarcoscyphaceae	Hypoxylacae
Genus	*Cookeina sp.*	*Cookeina sp.*	*Daldinia sp.*
Species	*C. tricholoma*	*C. sulcipes*	*D. concentrica*
Common name	Eyelash cup	Cup fungus	King Alfred's cake

Kubah National Park is a great site in offering and enhancing knowledge about ecological- and research-based studies, especially in mycology. Overall, there are three types of Ascomycota species that were observed and documented, which are *Cookeina tricholoma, Cookeina sulcipes* and *Daldinia concentrica*.

Figure 4. Ascomycota documented at Kubah National Park. (a) *Cookeina tricholoma* (b) *Cookeina sulcipes* (c) *Daldinia concentrica*

3.2. The documentation of herbaceous plants in Kubah National Park

Climate change is an event occurring due to unsustainable human activities towards the environment. The event affects the diversity of organisms in the affected area. For example, the biodiversity of flora and fauna including herbaceous plants. Kubah National Park was included in the network of protected forest areas that was gazetted in 1988 and opened to the public in 1995. The park's flora diversity includes mixed dipterocarp forest with some patches of scrub forest. In this study, the plants were identified and documented by randomly examining the selected small plants located along the Summit Trail for every 100 m. The trekking was done for in total of 5 km in distance from the Park Headquarters to the summit of Gunung Serapi. Smartphone camera was used to take the photo and a 30 cm ruler was used to measure the plant dimension. The detail information about the plants was carried out once returned to the campus by organising metadata cross-reference. The identified herbaceous plant species were recorded and described.

Piper betle was recorded at below 800 feet (Figure 5.a). This species can grow well in humid rainforests if it has adequate soil moisture. The plant is likely to be found at shady areas and prefers soils that contain abundant of organic matter (Nik Muhammad Nasir et al., 2015). C*urcuma longa* was recorded at 200 feet and above (Figure 5.b). This species grows at warm and moist conditions, preferring soil that is loose, dry, and contains organic matter. This plant cannot grow well in waterlogging soils or rocky soils as it is not suitable for the rhizomes to grow (Mustaffa et al., 2011). *Bidens pilosa* was also recorded (Figure 5.c). This species can be found anywhere in areas where there is plentiful of sunlight (Sekar et al., 2014). *Zingiber zerumbet* was recorded in moist soils that are rich in organic matter under partially shaded areas (Figure 5.d). The species can be easily found along the forest edges and at rocky soils near

streams (Brahim, 2005). *Musa acuminata* was found at 2,000 feet (Figure 5.e). This species can thrive in places with high temperatures up to 35°C but unable to withstand strong winds. The plant can grow well in most fertile soils that are always damp (Tan et al., 2009). Finally, *Angiopteris evecta* was recorded at 2,600 feet (Figure 5.f). This species grows perfectly anywhere along the Summit Trail. The spores are easily spread whenever the climate is suitable (Mustaffa et al., 2011). The study was documented and identified 6 different types of herbaceous plants in Kubah National Park namely, *Piper betle*, *Curcuma longa*, *Bidens pilosa*, *Zingiber zerumbet*, *Musa acuminate* and *Angiopteris evecta*. The park's environment, which is humid and hot, are compatible for these plants to grow.

Figure 5. Herbaceous plants documented at Kubah National Park. (a) *Piper betle* (b) *Curcuma longa* (c) *Bidens pilosa* (d) *Zingiber zerumbet* (e) *Musa acuminate* (f) *Angiopteris evecta*

3.3. The documentation of aquatic insects in Santubong National Park

Sarawak has more than 80% of the area covered with forest (Appanah et al., 1998). There are five main types of forest in Sarawak which are mixed dipterocarp, peat swamp, mangrove, Kerangas and montane forest. Santubong National Park was also made up of these forests, making it a perfect place for scientific observation sites and studies including aquatic insects. The elevation of Mount Santubong is 810.2 m (2,658 ft). The study area was in Santubong National Park (1°45'46"N 110°19'20"E) (Figure 6). The park is located on the Damai Peninsula, 35 km north of Kuching. It is rising steeply to 810 m and irregular rainforest-covered peaks. The rain-forested slope of Gunung Santubong has natural attractions such as mangrove forest, rivers, near shore waters, and mudflats (Mohd Azlan et al., 2019). The study was conducted by observation and documentation on aquatic insects by trekking, beginning from the Park Headquarters at 0 m up to the Santubong Jungle Trek at 2,500 m distance (Figure 7). The sampling method was set out to be random and have close distance. Smartphone camera was used to take the photo, 15 cm ruler was used to measure the insect's dimension (Hidayat et al., 2018). The detail information about the insects was carried out once return to the campus by organising metadata cross-reference. The identified insects' species were recorded and

described in Table 2. The study was recorded three types of aquatic insects which are Odonata, Coleoptera and Hemiptera which were found along the Jungle Trek Trails in Santubong National Park (Figure 8).

Figure 6. Map of Santubong National Park, Sarawak. (Source: www.googlemaps.com)

Figure 7. Santubong National Park trail map. (Source: www.sarawak-vacation-destinations.com)

Figure 8. Aquatic insects documented at Santubong National Park. (a) Odonata (b) Coleoptera (c) Hemiptera

Table 2. Description of Odonata, Coleoptera, and Hemiptera (Dow & Reels, 2010; Grimm, 2013; Rostami et al., 2012)

Organism	Odonata (Figure 8.a)	Coleoptera (Figure 8.b)	Hemiptera (Figure 8.c)
Morphological traits	Blue short abdomen, long brown tail, two wings with black and clear pattern, three pairs of legs, approximately 3 cm long.	Blackish and sometimes bronzy and metallic. The forelegs are long and slender, while the middle and hind legs are short, flattened, and fold tightly under the body. Generally, the middle and hind legs are used for swimming while the front legs are adapted for grasping food or prey. Hind legs are equipped with swimming hairs. This hair spread out which increases the surface area. Thus, they tend to reduce water resistance. These adaptations make them as an efficient swimmer. The differences between Whirligig beetles and other beetles are that they have a short antenna and two pairs of compound eyes which one pair above the water and one pair below water.	Elongated legs and body, two antennae and brown in colour.
Life cycle	Incomplete metamorphosis (hemimetabolism), they have different habitats and diets at different stages.	Undergo complete metamorphosis. Involved four stages which are egg, larva, pupa, and adult.	Go through the egg stage, nymphal form (five instar stages), and finally the adult stage.
Habitat	Mainly found near the freshwater area.	Mainly found at waterfalls near the stone where slow sections of flowing waters are located.	The Gerridae was found in freshwater area
Reproduction	This species portrays courtship behaviour for mating. Usually, the male will show their colourful and beautiful wings (brighter colour on their abdomen), and they might show their fitness by presenting to the female about their flying ability.		
Significance	This insect is beneficial to their habitat because they feed on only a small portion of small insects and therefore see not causing major harm. They are also the elements that beautify the nature due to their large variety of	This insect acts as a small predator and scavenger. It cleans the water of dead or dying insects and helps to control the populations of most aquatic invertebrates. In turn, the fish and other predators will eat the larvae.	Gerridae is known to be able to walk on water due to having long hydrophobic legs which allow the weight of their bodies to be distributed equally to help them stay above the water. Not only those but hydrofuge

	morphology, especially colours.		hairs line the body surface of the water strider. These hairs are tiny hydrophobic hairs which cover the entire body of Gerridae. This feature allows the body of this insect to be water resistant and prevent water to add extra weight.
Classification	Kingdom: Animalia Phylum: Arthropoda Class: Insecta Order (Family): Odonata Suborder: Zygoptera	Kingdom: Animalia Phylum: Arthropoda Class: Insecta Order: Coleoptera Family: Gyrinidae	Kingdom: Animalia Phylum: Arthropoda Class: Insecta Order: Hemiptera Superfamily: Gerroidea Family: Gerridae

3.4. The documentation of mixed dipterocarp forest in Santubong National Park

Sarawak is well-known with its rainforest that estimated to be around 140 million years old. Santubong National Park, which is located 35 km north of Kuching, Sarawak, is surrounded by this rainforest filled with unique biodiversity. Rainforest is the centre of the evolution and distribution of many endemic species of flora and fauna. The forest was widely dominated by mixed dipterocarp. The dipterocarp forest occurs just above sea level to an altitude of about 900 m. Dipterocarp forest in Santubong National Park is classified as hill dipterocarp forest. The largest tree recorded in this forest was Dipterocarpaceae (Bodos et al., 2014; Jugi et al., 2014; Teo et al., 2013). The study area is in Santubong National Park (1°45'46"N 110°19'20"E). The park is located on the Damai Peninsula, 35 km north of Kuching. The park was surrounded with rainforest-covered slopes. The area is around 17.4 km^2 (Kanzaki et al., 2003). The specific study area was along the Santubong Jungle Trek which is 2.5 km from the Park Headquarters. The identification of mixed dipterocarp forest species was carried out using various references such as online metadata, journals, and websites based on their morphological traits. The identified mixed dipterocarp forest species were recorded and described in Table 3.

Figure 9. Mixed dipterocarp forest documented at Santubong National Park. (a) *Shorea ovata* (b) *Dryobalanops beccarii* (c) *Dipterocarpus crinitus*

Table 3. Description of *Shorea ovata*, *Dryobalanops beccarii*, and *Dipterocarpus crinitus.*

Name	Description
Shorea ovata **(Figure 9.a)**	The species was recorded in the lowland and hill rainforest and predominantly among the canopy and emergent trees of mature forest (Corlett & Primack, 2005). The size is approximately 158 cm circumference of the tree trunk and 50.29 cm diameter. The species was documented at 989 m depth of the Santubong Jungle Trek 2.5 km loop.
Dryobalanops beccarii **(Figure 9.b)**	The species is one of the endangered species in the world. It is also belongs to Dipterocarpaceae family (Jugi et al., 2014). The size is 245.5 cm circumference of the tree trunk and 79.10 cm diameter. The species was documented at 1,130 m depth of the Santubong Jungle Trek 2.5 km loop. The species are abundant in mixed dipterocarp forests at altitudes to 700 m. The plant tends to have larger leaves when mature compared to juveniles.
Dipterocarpus crinitus **(Figure 9.c)**	The species was recorded at undulating land and low hills, rising mainly at low altitudes on leached clay-rich soils and rarely ascending to 850 m (Corlett & Primack, 2005). The tree is at risk from habitat loss and has been listed as endangered in the IUCN Red List of Threatened Species (2011) (IUCN, 2017). The size is 405 cm circumference of the tree trunk and 128.90 cm diameter. Based on the observation, the species was documented at 1,669 m depth of the Santubong Jungle Trek 2.5 km loop.

Dipterocarpaceae was recognized as the largest tree family in Santubong National Park (Bodos et al., 2014). Along the Santubong Jungle Trek, three different species of Dipterocarpaceae have been observed and recorded at different depths of the forest, *Shorea ovata* (989 m), *Dryobalanops beccarii* (1,130 m) and *Dipterocarpus crinitus* (1,669 m).

4. CONCLUSION

Biodiversity and ecology in Kubah and Santubong National Park are important for conservation of the park. The study was identified and documented three different types of aquatic insects and four different species of mixed dipterocarp forest tree in Santubong National Park, meanwhile, three different species of Ascomycota and 6 different types of herbaceous plants in Kubah National Park. Information of these flora and fauna can be developed into a database for education and research purposes such as diversity and environmental awareness in Malaysia.

Conflict of Interest
The authors declare that they have no competing interests.

Author Contribution Statement
Mohamad Fhaizal Mohamad Bukhori, Rohaiza Daud, Christharina S Gintoron, Muhamad Ikhwan Idris, Roberta Chaya Tawie Tingga and Mohd Ridwan Abd Rahman: Conceptualisation and Design; Mohamad Fhaizal Mohamad Bukhori, Rohaiza Daud, Christharina S Gintoron, Muhamad Ikhwan Idris, Roberta Chaya Tawie Tingga and Mohd Ridwan Abd Rahman: Funding Acquisition; Mohamad Fhaizal Mohamad Bukhori, Rohaiza Daud, Christharina S Gintoron, Muhamad Ikhwan Idris, Roberta Chaya Tawie Tingga and Mohd Ridwan Abd Rahman: Execution of the Experiment; Mohamad Fhaizal Mohamad Bukhori, Rohaiza Daud, Christharina S Gintoron, Muhamad Ikhwan Idris, Roberta Chaya Tawie Tingga and Mohd Ridwan Abd Rahman: Data Collection and Visualisation; Mohamad Fhaizal Mohamad Bukhori: Formal Analysis and Interpretation of the Data; Mohamad Fhaizal Mohamad Bukhori: Original Draft: Mohamad Fhaizal Mohamad Bukhori, Rohaiza Daud, Christharina S Gintoron, Muhamad Ikhwan Idris, Roberta Chaya Tawie Tingga, Mohd Ridwan Abd Rahman and Anang Setiawan Achmadi: Review and Editing; Mohamad Fhaizal Mohamad Bukhori: Project Administration.

Data Availability Statement
We have presented all our main data in the form of figures and tables. The data sets supporting the conclusions of this article are included within the article.

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