Bukit Durang

HIDDEN JEWEL OF ULU SUAI, SARAWAK

BIODIVERSITY AT A GLANCE

EDITED BY:
Jayasilan Mohd-Azlan and Aida Shafreena Ahmad Puad

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Hidden Jewel of Ulu Suai, Sarawak
Biodiversity at a Glance

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Bukit Durang
High Conservation Value Forest

This book aims to enlighten and educate stakeholders and to present some information on species distribution to the nature enthusiast. This volume draws its material from various scientists' research and experience in this area. The images illustrated on colour plates reveal the potential of this area as an interesting site for naturalists as well as for researchers.

The introductory chapter gave insight into the importance of the High Conservation Value forest and set the scene for this book. The plant component chapters showcased the complex and unique structure of the flora diversity in the Bukit Durang area. The wildlife aspects of this book covered species from an array of taxa that includes both invertebrates and vertebrates (amphibians, fish, birds & mammals). The High Conservation Value forest is also home to several endemic species, as well as species of conservation importance. The social element chapter contributes to the history of Bukit Durang while the final chapter wraps the way forward for biodiversity conservation.

The research in Bukit Durang was made possible by the generosity of Wilmar Plantations Sdn Bhd (formerly known as PPB Oil Palm Sdn Bhd), who provided funding to Universiti Malaysia Sarawak for said research. This project is aimed to assess the selected biotic diversity i.e plant, invertebrate and vertebrate groups.

▲

Orange-bellied Flowerpecker (*Dicaeum trigonostigma*).

This common species having a wide distribution have been reported up to Kelabit highlands. In Bukit Durang area, they have been mist-netted and spotted foraging in the understory. This omnivorous species has been reported to feed on seeds of 'Senduduk' Melastoma malabathricum, small insects as well as pollen and nectar.

© Photo: Badiozaman Sulaiman

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Foreword

UNIMAS studies shows that many species of conservation importance are thriving in Bukit Durang Conservation Area.
© Photo: Wilmar

Sarawak retains some of the richest biodiversity in the world. It is home to many endemic species of conservation importance. Some of these examples can be found in Sarawak's High Conservation Value forest. From its inception, UNIMAS has put biodiversity and environmental conservation at the forefront of its research niche and agenda by setting up the Faculty of Resource Science and Technology (FRST) and the Institute of Biodiversity and Environmental Conservation (IBEC). With the establishment of these two hubs of knowledge, UNIMAS' commitment increased twofold: firstly, it mapped out the necessary measures to enhance the sustainable management of Sarawak's natural resources and secondly, being in Sarawak, with its vast biodiversity and multi-ethnic population, UNIMAS academics are also continuously collaborating with the local communities, government and non-government agencies as well as national and international researchers to study the conservation of tropical biodiversity and the global environment.

In the pursuit of research excellence, we are challenged by the need to identify strategic partners. We continuously encourage our academics to explore external sources, especially in engaging private agencies to contribute to the various researches conducted at the University. One such effort has resulted in the signing of an MoA with WILMAR in 2014 with a project titled **"Identification and monitoring of Endangered, Rare and Threatened Species and their habitats in Wilmar's plantations in Sarawak"**. The synergy between WILMAR and UNIMAS is significant; not only that both agencies benefit through the conservation of biodiversity and environment, but it also highlights our rich expertise and skills in research, and at the same time motivates our young research minds who come to UNIMAS to learn about Biodiversity, in order to enhance their experience through industrial training at relevant agencies.

In line with the rapid developments in the oil palm industry and the increasing awareness in the need to conserve resources especially in Sarawak, this work is indeed substantial and considerably impactful in the current context of Malaysia's rich biodiversity and natural resources. The scope of work in this collaboration is an important milestone not only for UNIMAS-industry linkage but also significant for biodiversity conservation and sustainable development in Sarawak.

Given that this book represents but a small sample of the amount of work done by our academics in the realm of biodiversity. I would like to commend the efforts of Wilmar Plantations Sdn Bhd (formerly known as PPB Oil Palms Sdn Bhd) who supported us in collecting information on the biodiversity in some of these areas including Bukit Durang, which forms the material for the book. The work is also expected to be important for stakeholders, for better understanding and appreciation of local biodiversity.

It is my hope that this book will contribute and encourage more people to work in this area, publish more journal articles of this kind and more funders to support in this field. I anticipate that this volume will be useful to stakeholders and for the advancement of the best management practices in general.

Prof. Datuk Dr Mohamad Kadim Suaidi
Vice Chancellor
Universiti Malaysia Sarawak

Message from Wilmar

Wilmar International Limited (Wilmar) was amongst the early adopters of the High Conservation Value (HCV) approach in the oil palm sector, and we carried out HCV assessments of our own operations from as early as 2007. Since then, our approach to conservation has expanded to include High Carbon Stock (HCS) areas, as enshrined in our No Deforestation, No Peat, No Exploitation (NDPE) Policy. Our conservation areas are sanctuaries for many threatened and endangered species, which we strive to protect.

The Bukit Durang Conservation Area (BDCA) which is located in our Saremas Group of estates, adjacent to Niah, is an important conservation site in our Sarawak operation. Since 2014, our research collaboration with the Universiti Malaysia Sarawak (UNIMAS) has provided us the necessary insights into the biodiversity of the area. The findings from the systemic monitoring done by the UNIMAS researchers alongside our team on the ground are discussed in this book. The findings from this book provide some scientific evidence that the BDCA, although fragmented and surrounded by palm oil plantations, is a hidden biodiversity jewel.

While we remain guided by our biodiversity commitments, we are cognizant that we are limited by our knowledge and expertise in conservation efforts. Through collaborations with various strategic partners such as research institutes and universities like UNIMAS, we have been able to leverage scientific knowledge, and build capacity to help us strengthen the management of our conservation areas. Further cooperation with the local communities also helps us to ensure the survival of our conservation areas. For example, our partnership with the local longhouse communities in Saremas has enhanced the management of our conservation area. We recognize that local communities play an important role in the protection of our conservation areas and supporting conservation efforts on the ground.

Insectivore bird species plays an important role in regulating pest insects in oil palm plantations.
© Photo: Wilmar

I would like to extend my heartfelt gratitude to UNIMAS for collaborating with us to gather the findings on the BDCA and making this book the first publication by a Malaysian university to document the biodiversity in a Wilmar conservation area. We believe that real and lasting change on the ground can only be achieved through a multi-stakeholder effort, and we look forward to continued collaboration and partnership in the years ahead.

Jeremy Goon
Chief Sustainability Officer
Wilmar International Limited

Preface

JAYASILAN MOHD-AZLAN
& AIDA SHAFREENA AHMAD PUAD

Crested Fireback. © Photo: Jayasilan Mohd-Azlan

Sarawak is located in one of the world's unique biodiversity regions, it boasts a variety of habitat types, including a mix of dipterocarp forests with distinctive inhabitants. These habitats are often transformed into agriculture including oil palm plantations. However, the expansion of plantations to meet the global demand for vegetable oils should not be at the expense of our biodiversity and rural communities. It is important that oil palm growers play a significant role in sustainable development by being environmentally responsible and promote the conservation of natural resources and biodiversity. Therefore, biodiversity is one of the top agenda for Sarawak, whereby the state is determined to conserve and protect its biodiversity. This project sits in line with the University's niche area of biodiversity and environmental conservation and Sustainable Community Transformation.

As more global companies are being committed to 100% RSPO-certified palm oil, growers in Malaysia particularly in Sarawak need to be proactive to produce sustainable oil palm which in turn can result in significant returns and be economically transformative for this industry. As such, High Conservation Value (HCV) areas within oil palm plantation concessions should not be regarded as low value. In line with the rapid developments in the oil palm industry and the increasing awareness of the need to conserve resources, especially in Sarawak, biodiversity in remnant forests such as Bukit Durang should not be ignored and is indeed substantial and considerably impactful in the current context of Malaysia's rich biodiversity and natural resources.

We are especially thankful to the Wilmar team comprising Mr Jeremy Goon, Mr Simon Siburat, Mr Gurcharan Singh, Mr Kiaw Che Weng, Mr Asrif bin Mahmud, Mr Chang Sip Woon, Mdm Perpetua George, Ms Chin Sing Yun and Ms Ginny Ng for their support in the project. We also extend our gratitude to the staff of Wilmar Plantations Sdn. Bhd, namely, Mr James Wong, Mr Edward Enggu Anak Setu, Mr Joanes Anak John, the late Mr Golan Anak Mat, Ms Marcie Elene Marcus Jopony and Mr John Alit. The following colleagues helped with the reviews of manuscripts: Professor Cheksum Supiah Tawan, Professor Indraneil Das, Associate Professor Dr Ruhana binti Hassan, Associate Professor Dr Wong Sin Yeng, Associate Professor Dr Wong Swee Kiong, Dr Badrul Azhar Md. Sharif, Dr Jayaraj Vijaya Kumaran, Dr Mohamad Fizl Sidq bin Ramji, Mr Muhamad Ikhwan bin Idris and Ms Lisa Lok Choy Hong. We would also like to thank Research, Innovation and Enterprise Centre, Institute of Biodiversity and Environmental Conservation and the Faculty of Resource Science and Technology, UNIMAS, for logistical and administrative support. We owe a special debt of gratitude to Mr Badiozaman Sulaiman for providing images of species (Birds & Insects) that we have used in this work. Finally, we thank Wilmar for the page layout and UNIMAS Publisher for arranging its publication. We would also like to thank Forest Department Sarawak and Sarawak Forestry Forestry Corporation for their research permits.

This book provides pictorial information on the selected species' distribution and richness in the Bukit Durang HCV area. The faunal studies include insects, fishes, amphibians, birds, bats, rodents and some larger mammals. This book intends to share the output of the research with local stakeholders, management authorities and the general public. It is hoped that nature enthusiasts and those who are interested in tropical biodiversity near this region will find this book beneficial. Finally, we hope that this book will contribute to increasing knowledge and awareness of our national pride and heritage.

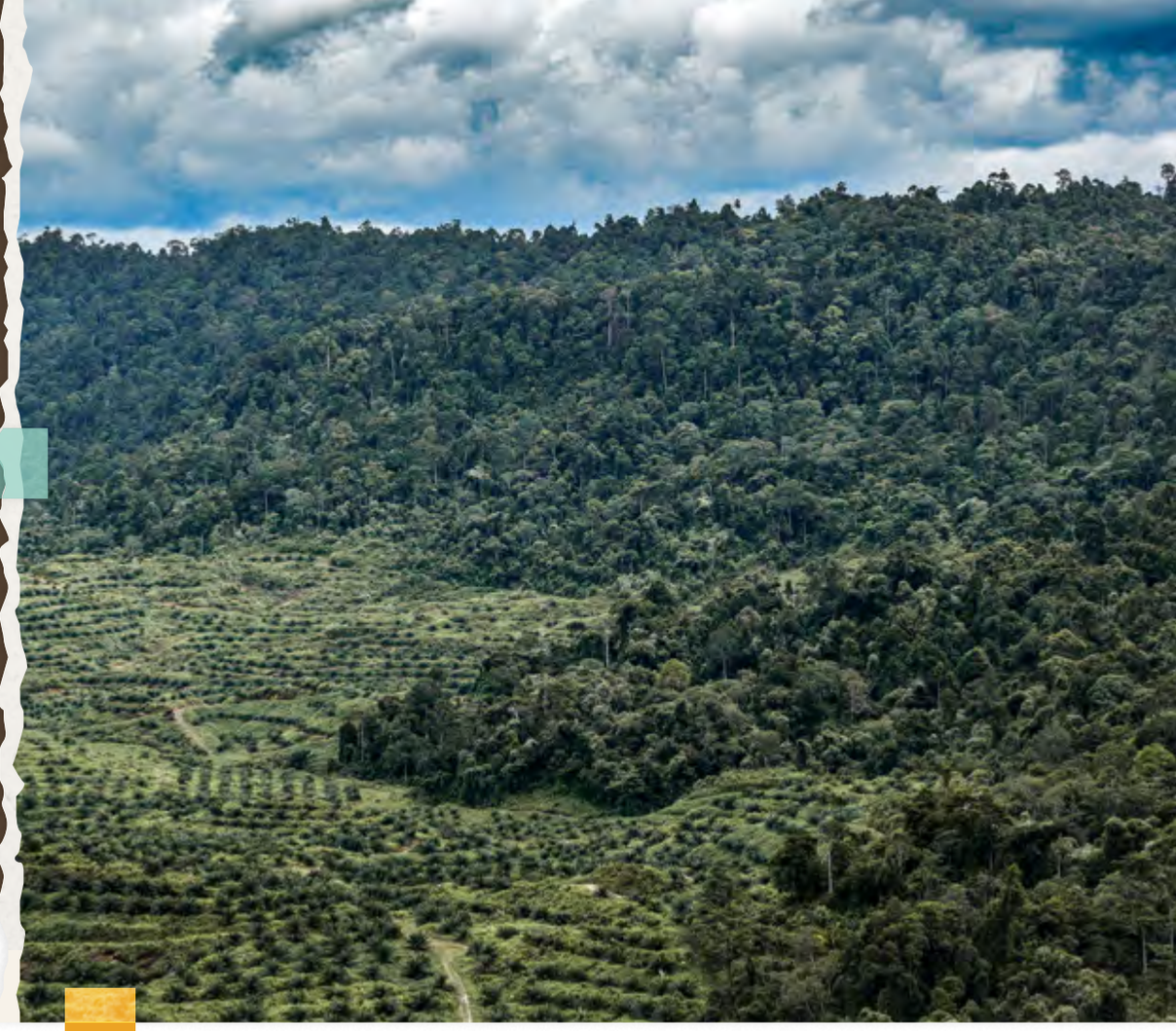
Bukit Durang forest fragment (994.6 Ha) is the largest forest patch near Saremas. It is a narrow forest (700 m wide) strip (14 km long) of steep forest (slope = 35°) with difficult access.

© Photo: Wilmar

Introduction

JAYASILAN MOHD-AZLAN, CHIN SING YUN, JAMES WONG, LISA LOK CHOY HONG

The escalation of land use conversion to agriculture is one of the key drivers of the decline in critical ecosystem function and biodiversity. Vast areas of forest in the tropics have been cleared and planted for various agricultural crops including oil palm, which is one of the most important crops in many tropical countries especially Indonesia and Malaysia. The establishment of oil palm plantations is an incredibly intensive process, involving converting native vegetation, usually degraded land or logged over forest to a plantation, often leaving behind fragmented and isolated rainforest in an oil palm matrix.



Bukit Durang provides important ecosystem function in an oil palm dominated landscape.

Sarawak is the last frontier in oil palm expansion in Malaysia, as Sabah and Peninsula Malaysia have been saturated with oil palm plantations. Sarawak currently (year 2021) has 1.58 million hectares of oil palm, representing 26.9% of the total oil palm plantation area in Malaysia (5.9 Million ha). In northern Sarawak, the region of Miri has extensive oil palm plantations representing ~25% of the total area under oil palm in Sarawak. The palm oil industry is the state's third-largest foreign exchange earner after petroleum and liquified natural gas, hence land is under tremendous pressure for palm development, especially on the NCR land.

A substantial proportion of Sarawak's biodiversity is endemic to Borneo. However, how the expansion of oil palm estates across the landscape has affected these taxa is unknown. In recent years, best management practices for oil palm plantations on conservation emerged through certification standards such as the Roundtable on Sustainable Palm Oil (RSPO) and Malaysian Sustainable Palm Oil (MSPO) Certification Scheme to ensure sustainable oil palm and biodiversity-friendly plantations.

Many large oil palm estates preserve and protect forest fragments and define them as high conservation value (HCV) areas through the HCV assessment. Despite their small size and random distributions, these HCV habitat fragments may secure sufficient biodiversity to maintain essential ecosystem functions and services within the agricultural landscape. The residual HCV habitat fragments in maintaining remnant biodiversity in an intensive agricultural area are essential for improving conservation outcomes in oil palm plantations. In view of this, a series of scientific studies have been carried out in the HCV area of Wilmar Plantations Sdn Bhd, a subsidiary of Wilmar International Limited, to understand the richness of Sarawak's flora and fauna that lies within. These HCV areas are collectively called Bukit Durang Conservation Area (BDCA). There are limited long-term studies carried out in the HCVs within the oil palm landscape and the result of the studies in Bukit Durang were gathered from 2016 - 2019 which provided details on the biodiversity of conservation areas in Wilmar's estates.

Bukit Durang provides critical habitat and resources for many bird species including forest dependent species.

Bukit Durang is located within the estates of Saremas 2 and Segarmas, also commonly known as Saremas, of Wilmar Plantations. This area is in Ulu Suai which is within the administrative boundary of Sawai Land District, Miri Division, Sarawak. The concessions are bordered by various types of land use including oil palm plantations, smallholder oil palm blocks, secondary forests, orchards and teak plantations. This area lies approximately 149 km from Miri town. BDCA is a fragmented forest with an area of 994.60 ha. It was developed in the 1980s and HCV are mainly the remnant of the logged-over forest.

This secondary forest is dominated by species from the Family Euphorbiaceae, Leguminosae, Dipterocarpaceae and Moraceae. This includes some essential economic trees such as *Eusideroxylon zwageri.*, *Dipterocarpus* spp., *Shorea* spp.,

Wilmar Plantations complex is located approximately 149 km from Miri, the largest city in the northern region of Sarawak.

Bukit Durang Conservation Area.

Dryobalanops spp., *Artocarpus* spp., and *Anisoptera* spp. This thin strip of forest patch also provides crucial habitats to various species of conservation importance. Samplings for mammals, birds, amphibians, fish, insects and plants were carried out from 2014 to 2015.

The studies recorded 39 species of small mammals, 58 species of birds, 24 species of amphibians, 41 species of fish, crayfish and prawns. The presence of various species of conservation importance in the area shows that Bukit Durang is a critical biodiversity refuge that may improve species diversity in an oil palm dominated landscape for conservation and maintenance of ecosystem function.

Bukit Durang is the only remaining forest landscape within the Ulu Suai district surrounded by oil palm plantations. **Therefore, the synergy between empirical research and plantation management should be regarded as a cornerstone for biodiversity conservation in the Wilmar Plantations area in Sarawak.** This modest compilation provides information on the flora and fauna in the Bukit Durang area. This book consists of the findings from eight projects in order to shed some light on the relevant details for biodiversity management in the HCV area of Bukit Durang and provide a biodiversity snapshot of Bukit Durang Conservation Area.

This secondary forest of Bukit Durang is dominated by species from the Family Euphorbiaceae, Leguminosae, Dipterocarpaceae and Moraceae. This thin strip of forest patch provides crucial habitats to various species of conservation importance.

The studies recorded **39 species of small mammals**, **58 species of birds**, **24 species of amphibians**, **41 species of fish**, **crayfish** and **prawns**. The presence of various species of conservation importance in the area shows that Bukit Durang is a critical biodiversity refuge that may improve species diversity in an oil palm dominated landscape for conservation and maintenance of ecosystem function.

Bukit Durang harbours many ecological and economically important flora and fauna.
© Photo: Wilmar

Trees

ISMAIL JUSOH

Some economically important dipterocarp trees (*Anisoptera* spp., *Shorea* spp., *Dryobalanops* spp., and *Dipterocarpus* spp.) and non-dipterocarp species (*Artocarpus* spp., and *Eusideroxylon zwageri*) can be found in Bukit Durang.

© Photo: Jayasilan Mohd-Azlan

Introduction

The linear-shape Bukit Durang forest has an area of approximately 860 ha. These forest areas have been classified as High Conservation Value 4, which provide basic ecosystem services in critical situations. The areas are hilly with some areas with steep terrain. The altitude of the study areas is in the range of 180 to 220 m above sea level and both areas received an annual rainfall of 3000 mm throughout the year. Logging operation in the areas had stopped since 1996.

A vegetation survey was conducted from 2014 to 2015. A total of 25 plots of 20 x 20 m (0.04 ha) were established randomly. This is equivalent to one ha sampling area. All standing trees with a diameter at breast height (DBH) ≥ 5 cm within each plot were recorded. Tree diameter at breast height (1.30 m above ground level) was measured, to the nearest cm using a diameter tape. For trees with buttresses, the DBH was measured 30 cm above the top of the buttress. Species of trees were preliminarily identified in the field. Tree identification was based on bark, slash and leaves characteristics. However, if the species of the tree could not be identified, it was sufficient to identify the tree up to the genus level. The samples were brought back and detailed identification was further carried out in the UNIMAS herbarium.

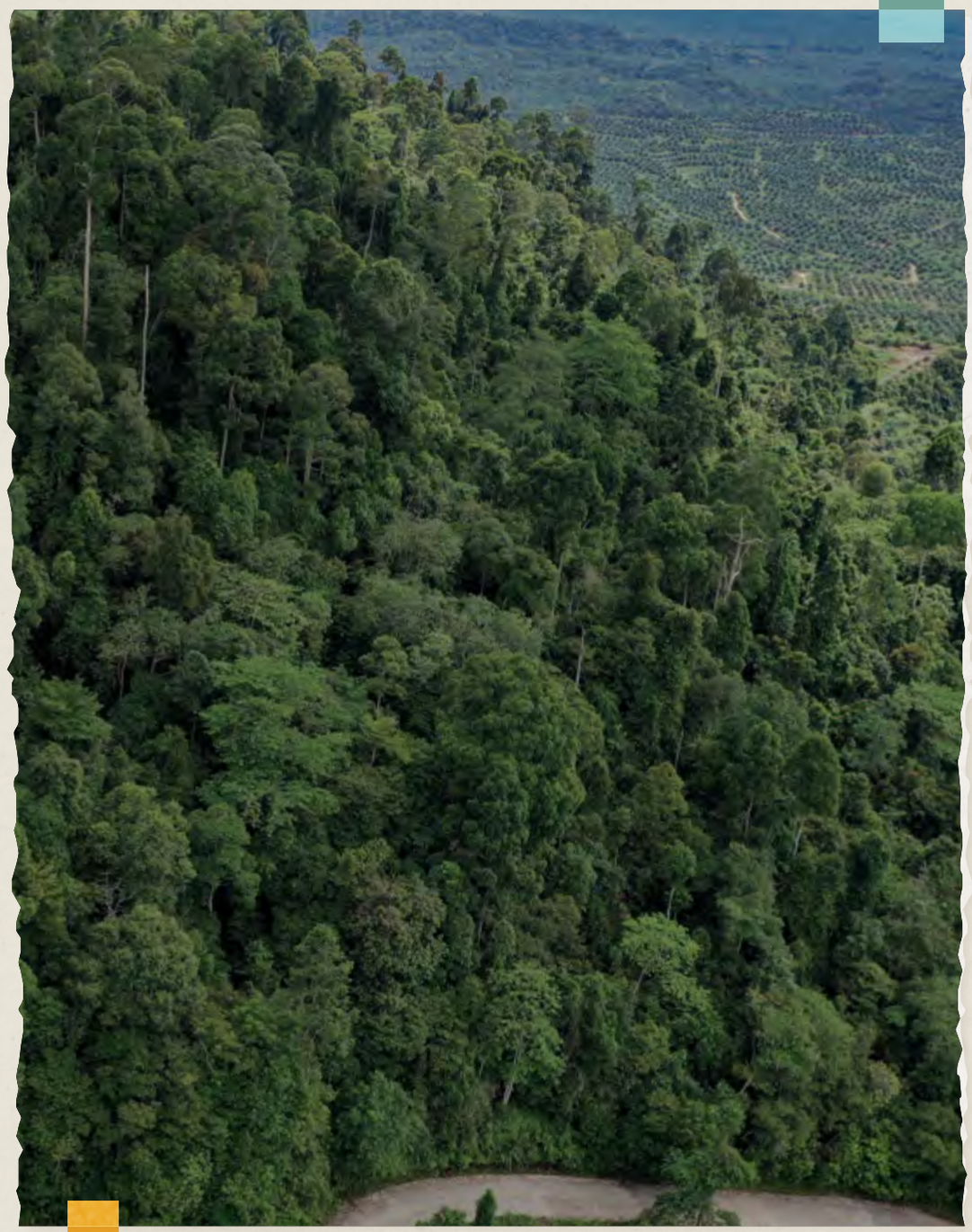


Figure 1

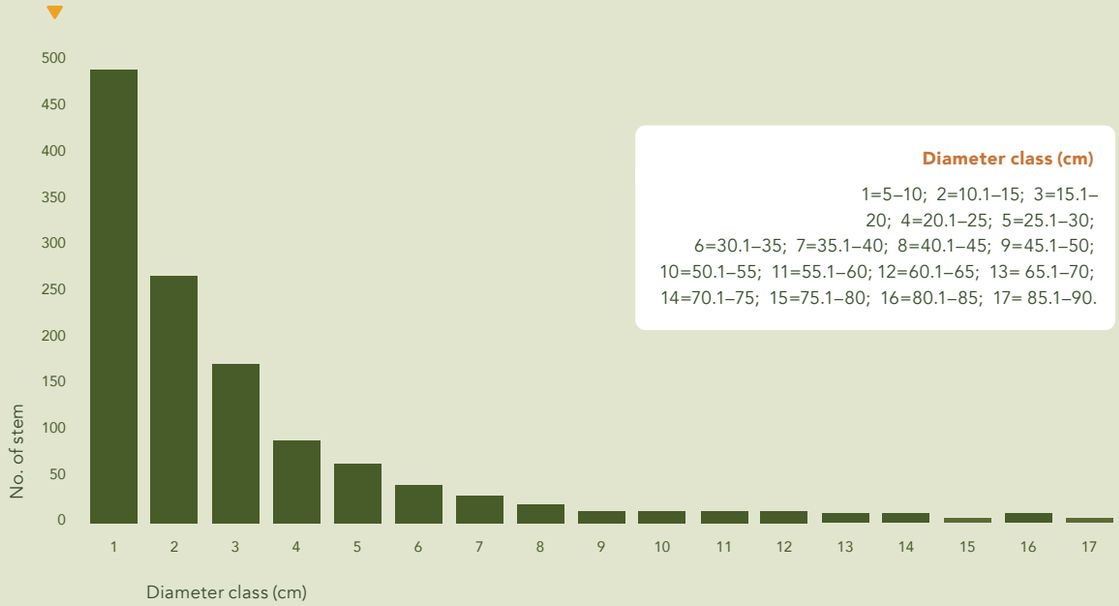
Arial view showing the steep hills of Bukit Durang. © Photo: Wilmar

Forest Structure

Analyses revealed that 40% of the trees in Bukit Durang were small trees with DBH ranging between 5 to 10 cm. Trees with this DBH range is considered saplings. Diameter size distribution showed that smaller trees are the most abundant and the number of trees decreased with diameter size (Figure 1). This observation is usually referred to as the inverted-*J* curve (Meyer, 1952). This curve illustrates that tree saplings count are high and the number of tree decline in the upper diameter classes. This distinct inverted *J*-shaped curve indicates good regeneration and recruitment status (Meyer, 1952; Brunig, 1983; Davis and Johnson, 1987). This is a typical structure in tropical forests (Richards, 1996) and regeneration will be successful (Poorter *et al.*, 1996). The inverted *J*-shaped curve showed the abundance of stems was very high at lower diameter classes and it drastically decreased as the diameter classes increase. For instance, the number of individuals of large diameter class (>30 cm) accounted for only 8 to 10% of the total tree recorded. The main reason for the decreasing percentage of the large diameter class is due to the extraction of large-diameter trees during logging.

Figure 2

STEM DENSITY ACCORDING TO DIAMETER CLASS DISTRIBUTION.



Tree Species Composition

A total of 1,198 trees with 302 species in 129 genera of 51 families were recorded. It is species-rich considering they were logged about 20 years ago. A recent study carried out at the 10-year logged-over area at Sg. Asap MPOB Research Station recorded 187 species representing 45 families with a basal area of 28.7 m^2/ha (Bujang, 2014) within a total sampling area of 0.88 ha. In a one-ha plot at Matang Wildlife Centre (MWC), Kubah National Park recorded 270 species from 123 genera in 54 families with a basal area at 31.7 m^2/ha for trees with DBH ≥ 5 cm (Bohari, 2015). This shows that the species composition of trees at Bukit Durang is comparable to the MWC forest.

The top 10 families with the high number of species recorded are shown in Table 1. The top two commonest families, in terms of number of stems, in the Bukit Durang forest are Dipterocarpaceae (23.7%) and Euphorbiaceae (15.6%). The third, fourth and fifth families were Myrtaceae (5.8%), Myristicaceae (5.5%) and Phyllanthaceae (3.8%), respectively.

Figure 3

Diameter at breast height (DBH) is one of the most common dendrometric measurements of diameter of a standing tree. © Photo: Wilmar International

Table 1

TOP 10 FAMILIES FOR ALL TREES ≥ 5 CM DBH IN BUKIT DURANG FOREST.

SPECIES			FAMILY	ABUNDANCE		
Rank	No. of spp.	%		Rank	No. of Stems	%
1	41	13.6	Dipterocarpacaeae	1	284	23.7
2	19	6.3	Myristicaceae	4	66	5.5
3	17	5.6	Euphorbiaceae	2	180	15.0
4	15	5.0	Myrtaceae	3	70	5.8
5	15	5.0	Phyllanthaceae	5	45	3.8
6	15	5.0	Lauraceae	8	39	3.3
7	13	4.3	Annonaceae	7	40	3.3
8	12	4.0	Sapotaceae	13	29	2.4
9	12	4.0	Malvaceae	14	27	2.3
10	11	3.6	Anacardiaceae	6	41	3.4

Table 2

DIVERSITY INDICES OF TREES SPECIES OF BUKIT DURANG WITH DBH ≥ 5 CM.

INDICES	VALUE
Shannon-Wiener (H')	2.25
Simpson (1 - D)	0.99
Pielou's evenness (J)	0.39
Margalef (D_{mg})	43.59

It is a well-established fact that the lowland tropical forest is dominated by the family Dipterocarpaceae (Slik, 2005). In terms of number of stems, it is common to have Dipterocarpaceae make up more than 20% of the total tree inventoried. An extensive study by Slik (2005) found that the commonest family in the lowland dipterocarp forest of Borneo was Dipterocarpaceae and it made up 21.9% of the total tree enumerated. Dipterocarpaceae is the most common family of the Bukit Durang forest represented by 23.7% of the total trees recorded. Other similar studies as below also showed that Dipterocarpaceae is one of the common families occurring in the lowland tropical forest. For instance, a primary lowland forest in Berau, East Kalimantan recorded 25% of trees inventoried were from the Dipterocarpaceae family (Sist and Saridan, 1999). Floristics composition of regrowth forest of MWC dominated by 27.2% Dipterocarpaceae (Bohari, 2015). The domination of Dipterocarpaceae at Barito Ulu, Central Kalimantan primary forest was lower with 20.2% (Brearley, 2004).

The species diversity indices are presented in Table 2. It is apparent that the richness and abundance of the tree community in the study site are high and most species are represented by a similar number of individual in a particular species as shown by Shannon-Weiner and Simpson's index. However, quantities of species are unevenly distributed as indicated by the low Pielou's evenness index (0.39). The Margalef index measures species richness and it showed that Bukit Durang is rich in tree species.

The value of diversity indices (Shannon-Weiner and Simpson's index) are considered high. The rich tree species can be attributed to the selective logging employed previously in the area. There is no evidence of other major disturbance, apart from logging, like slash and burn, major windthrows or other significant disruption. Except for pioneer species that dominated the logging tracks, the forests are largely made up of primary species. It can be said that the diversity of trees are high and complex despite being selectively logged about 20 years ago.

The dominant species in Bukit Durang forest based on importance value index (IVI) was *Macaranga triloba* (11.8) followed by *Elateriospermum tapos* (9.5) (Table 3). *Macaranga triloba* is a light-demanding or pioneer species that dominate canopy openings and disturbed areas indicating disturbance. The higher the intensity of disturbance the higher the number of pioneer species (Goodale *et al.*, 2012). Disturbance due to logging is visible by the presence of logging tracks and the remnant of tree stumps in Bukit Durang forests.

Table 3

TOP 10 DOMINANT SPECIES RECORDED FROM BUKIT DURANG FOREST.

No	Taxon	Family	Local Name	IVI
1	*Macaranga triloba* (Thunb.) Müll.Arg.	Euphorbiaceae	Benuah cincin merah	11.8
2	*Elateriospermum tapos* Blume	Euphorbiaceae	Kelampai	9.5
3	*Shorea parvifolia* Dyer	Dipterocarpaceae	Meranti sarang punai	7.4
4	*Shorea pubistyla* P.S. Ashton	Dipterocarpaceae	Meranti bulu merah	7.3
5	*Shorea subcylindrica* Slooten	Dipterocarpaceae	Lun	6.1
6	*Syzygium arcuatinervium* (Merr.) Craven & Biffin	Myrtaceae	Ubah merah	4.6
7	*Shorea beccariana* Burck	Dipterocarpaceae	Engkabang langgai	3.6
8	*Shorea leprosula* Miq.	Dipterocarpaceae	Meranti tembaga	3.5
9	*Nauclea maingayi* Hook.f.	Rubiaceae	Empitap	3.5
10	*Shorea macrophylla* (de Vriese) P.S. Ashton	Dipterocarpaceae	Engkabang jantong	3.3

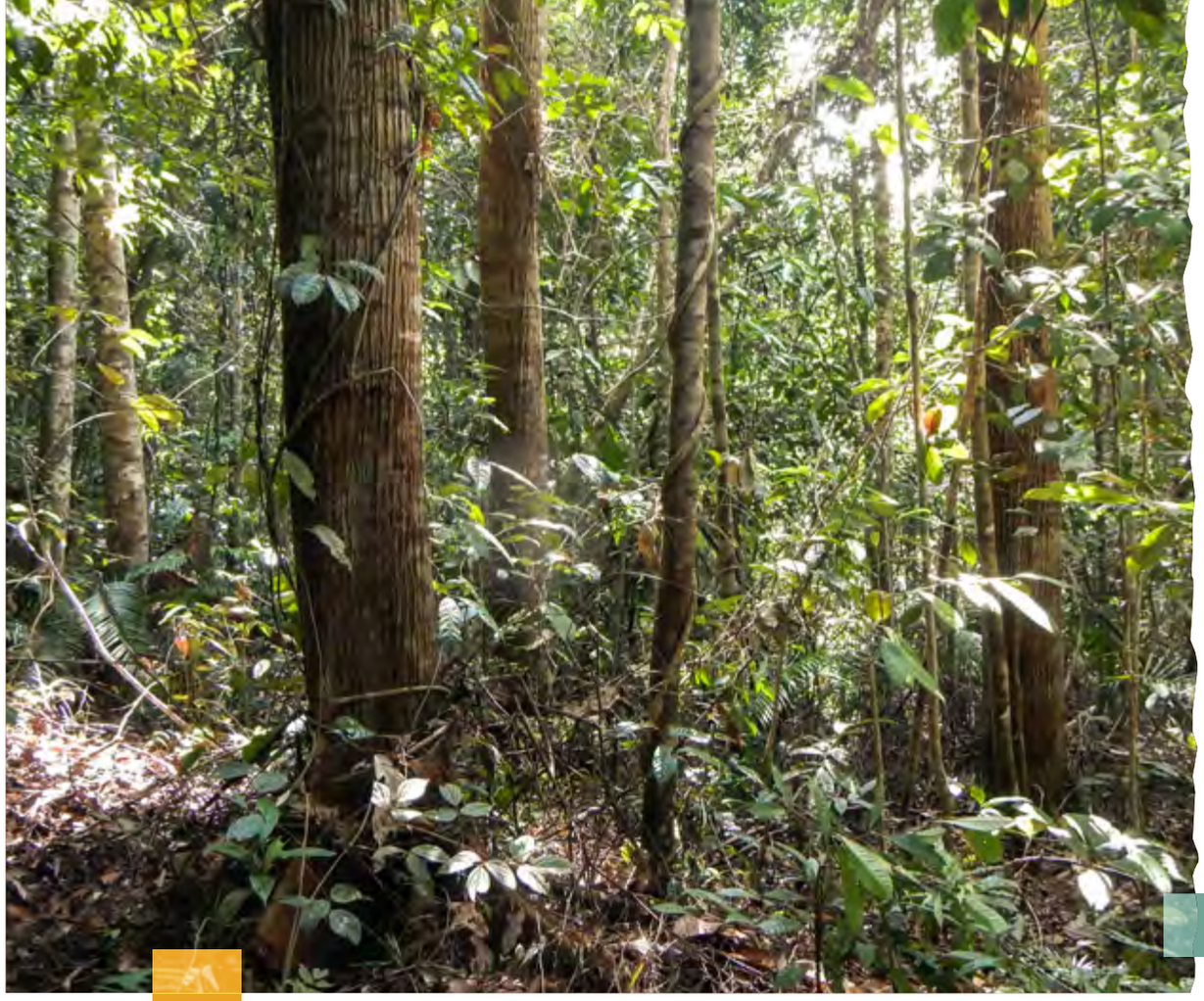


Figure 4

Shorea parvifolia trees. The ***S. parvifolia*** tree characterised by reddish-brown, deeply fissured bark and stout buttresses.
© Photo: Ismail Jusoh

Six out of 10 dominant species were Shorea spp. Among them, *Shorea parvifolia* is the most common species (Figure 4). Locally it is known as meranti sarang punai. This emergent tree has 70 – 200 cm in diameter with straight, cylindrical bole and can grow up to 65 m tall with buttress up to 4 m high (Soepadmo *et al.*, 2002). It can grow in a wide variety of well-drained soils and up to 80 m altitudes above sea level. Its timber is classified as light hardwood and traded under 'Light Red Meranti'. Its wood density ranges from 290 to 835 kg/m^3 at 15% moisture content and used for a variety of products such as panelling, joinery, light carpentry, furniture, plywood, crates, boxes, veneers and other purposes.

Another notable species in the top 10 list (Table 3) is *Shorea macrophylla*. It is known as Engkabang jantong locally and its fruits are the largest among all Engkabang. It can grow up to 45 m tall with DBH up to 150 cm. Its timber is known as light red meranti. *Shorea macrophylla* is one of the fastest-growing Shorea species and is one of the most important sources of illipe nuts (Figure 5). This tree is duped as 'tree butter' because the fresh fruits are the source of Engkabang oil (Minyak engkabang) and it can be used for food, skin treatment, production of cosmetic, candles, soap and substitute for cocoa butter. In Sarawak, this tree is protected and used in reforestation, agroforestry activities and rehabilitation of degraded land. *Shorea macrophylla* is conserved and protected under the Wild Life Protection Ordinance Sarawak (1998) (WLPO, 1998). Its timber is classified as light hardwood with an air-dry density range between 415 to 625 kg/m^3. It produces high-quality timber and is used for a wide variety of products including interior and exterior panelling and joinery, light carpentry, boxes and crates, veneer and plywood.

Figure 5

Shorea macrophylla (Engkabang jantong). (A) A large ***S. macrophylla*** tree with cylindrical bole (B) Mature winged-fruit will spin around when it drops from the canopy. (C) The nuts are dried and processed for Minyak engkabang, solidified and stored in bamboo tubes.
© Photo: Ismail Jusoh

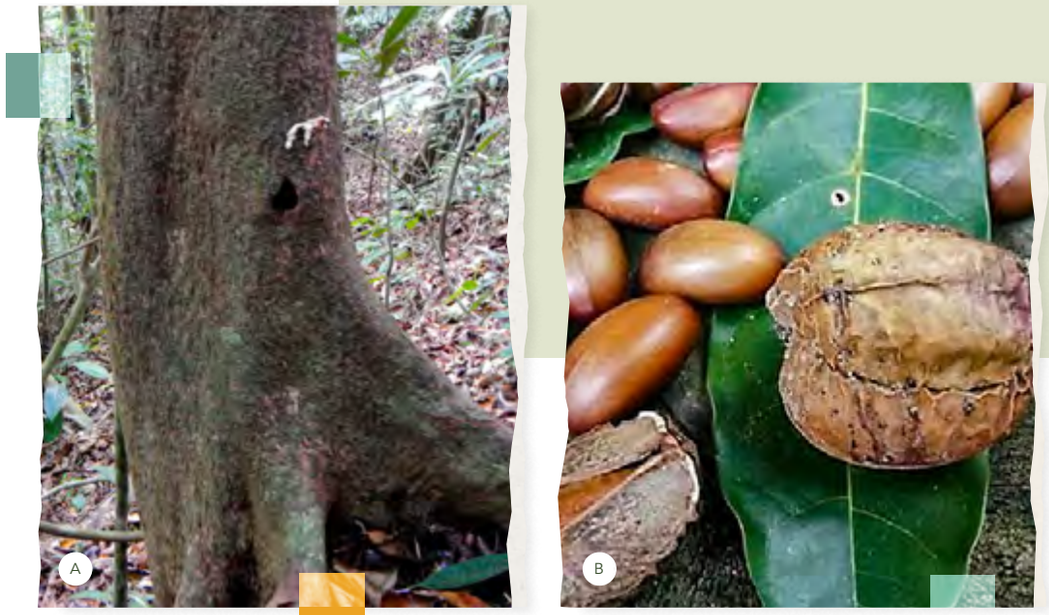


Figure 6

Elateriospermum tapos tree locally known as Kelampai. (A) It produces bluish-white latex when the bark is cut. (B) The mature fruit with seeds.
© Photo: Ismail Jusoh

air-dry is ranged from

0.385 to 0.755 g/cm^3

0.415 to 0.625 g/cm^3

(MTC, 2006).

Elateriospermum tapos is common in Bukit Durang. Generally, it occurs in the primary forest up to 600 m altitudes. It is a small to medium size tree that grows up to 30 m tall and 60 cm in diameter. The locals call it Kelampai or Dungku and in Peninsular Malaysia, it is known as Perah or Perah ikan. The trunk is an irregular shape, twisted, fluted, with a small buttress. The bark, leaves and fruits produce sticky bluish-white latex when slashed or cut (Figure 6). Traditionally, this latex is used in the healing of rupture on feet soles (Chai *et al.*, 1989, Lim 2012). It is believed that seed extract can be used to treat hypertension, diabetes and obesity (Arshad and Gan, 2019).

One medium size (DBH 22.6 cm) *Calophyllum langinerum* Miq. tree was recorded in Bukit Durang (Figure 7). The distribution and frequency of this species are rare. This tree is an evergreen tree, growing up to 38 m tall. Its canopy can reach the main canopy of the forest. The tree bole is cylindrical, usually without buttress and the diameter can be reached up to 81 cm (Sim and Lemmens, 1994). This species can be found in mixed dipterocarp forest, hill dipterocarp forests up to 950 m above sea level, heath forest as well as peat swamp forest. It is a Light Hardwood timber with a density range from 465-865 kg/m^3 traded as Bintangor. It was reported that two compounds, (+)-Calanolide A and (-)-Calanolide B has been isolated from the latex of this species and they had shown to be effective against HIV. To ensure the availability of a source of the raw material *C. laginerum* is conserved and protected under WLPO (1998).

Several protected trees were recorded (Table 4). There are protected under the Wild Life Protection Ordinance Sarawak (1998) (WLPO, 1998). Under the ordinance, anyone found guilty can face imprisonment for one year and a fine of 10 thousand ringgit. Protected plants recorded include species of *Goniothalamus* spp. and *Eurycoma longifolia*. These species are common in this area. These plants are protected under WLPO, 1998, however, internationally none of them are listed in any conservation initiatives.

Figure 7

Calophyllum lanigerum tree (Pokok bintangor). (A) The cylindrical bole of Pokok bintagor. (B) Latex of exudes from ***Calophyllum lanigerum*** tree bark.
© Photo: Ismail Jusoh

Table 4

LIST OF PROTECTED PLANTS RECORDED AT BUKIT DURANG

Species	Local name	Protection / conservation status
Shorea macrophylla (de Vriese) P.S. Ashton	Engkabang Jantong	All Protected under WLPO (1998)
Shorea pinanga Scheff.	Engkabang (Engkabang Langai Bukit)	
Calophyllum lanigerum Miq.	Bintangor	
Ficus aurata (Miq.) Miq.	Ara/Tempan	
Ficus delosyce Corner	Ara/Tempan	
Ficus geocharis Corner	Entimau	
Eurycoma longifolia Jack	Tongkat Ali	
Goniothalamus velutinus Airy Shaw	Kayu Hujan Panas	

* WLPO (1998)—Wild Life Protection Ordinance Sarawak (1998).

Concluding Remarks

Bukit Durang forests exhibit the typical characteristics of a lowland tropical rainforest. The tree communities are rich, very diverse and the spatial distribution of tree species are uneven. Regeneration and recruitment of species are good, indicating the status of both forests are generally healthy. The occurrence of protected tree species indicates high conservation value of Bukit Durang forests. Enrichment planting of economically important species that have become endangered should also be part of the conservation program. Frequent monitoring of the areas are required to maintain as well as sustain them as high conservation value forest.

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The Understory Plants of Bukit Durang Forest

AIDA SHAFREENA AHMAD PUAD, MOHAMAD ALI DARUS, WAN NUR FATIHA WAN ZAKARIA, SITI NOOR AISHAH MOHD NOOR, SEKUDAN TEDONG & HIDIR MARZUKI

Forest understory sometimes can be used as an indicator of forest health.

© Photo: Wong Sin Yeng

Introduction

The understory is an important component of forest ecosystems where plants or herbaceous layer that grow up to 1m above the ground, remain under shade and obtain less light (Yusof *et al.*, 2010). Some of the understory plant families that can be found in tropical forest include Acanthaceae (Ghazoul & Sheil, 2010), Rubiaceae (Lü *et al.*, 2011), Zingiberaceae, and Vitaceae (Rubeli, 1986). Although there is a growing awareness that the understory plants serve a special role in maintaining the structure and function of forests, this stratum remains an underappreciated aspect of forest ecosystems. Therefore, this study investigated the primary data regarding understory plant species at Bukit Durang forest within an oil palm plantation that had been designated as a High Conservation Value (HCV) area. This study complemented the study of tree community structure where the field methods sampled both tree and understory strata simultaneously. The understory plots are nested within the tree plots.

Plant samples were collected using a standard quadrat method. A total of 25 plots of 10m x 10m were established randomly (depending on the vegetation and contour). Red ribbons were used as border markers and placed in corners of each plot. Slope corrections were made for horizontal distances. At each plot, the coordinates and elevation were recorded with GPS. All understory species within the plots were counted and identified in the field. However, if the plant species could not be identified, it was sufficient to identify the plant up to the genus level. Voucher specimens were also collected and pressed following the standard procedure, and oven dried. Taxon identification was further carried out in UNIMAS herbarium or compared with specimens in Sarawak Herbarium (SAR). Plant names followed the published flora of related families found in this study or referred to an expert.

Findings

A total of 431 individuals belonging to 48 species, 41 genera, and 24 families were recorded in Bukit Durang. Out of the 24 families recorded, Arecaceae has the most number of individuals recorded at 96 (22.27%) followed by Araceae with 94 individuals (21.81%), Cyperaceae with 54 individuals (12.53%), Zingiberaceae with 47 individuals (10.91%) and Thelypteridaceae with 24 individuals (5.57%). A complete family listing is shown in Table 1. The most dominant species in Bukit Durang forest is *Homalomena* sp. from the aroid family (Araceae) followed by *Calamus* sp. (Arecaceae), *Boesenbergia* sp. (Zingiberaceae), *Calamus ingens* (J.Dransf.) W.J.Baker (Arecaceae), and *Phrynium* sp. (Marantaceae) (Table 2). Two diversity indices were used to calculate the species diversity to show the richness and abundance of the plants in Bukit Durang forest. The values for both indices are high where the value above 3.0 for Shannon-Weiner Diversity Index (H') indicates that the structure of habitat is stable and balanced while Simpson's Diversity index (D) is close to 1 indicating high diversity (Table 3).

Table 1

LIST OF FAMILIES RECORDED IN BUKIT DURANG FOREST.

No	Family	No. of Individual	(%)	No	Family	No. of Individual	(%)
1	Arecaceae	96	22.27	13	Gesneriaceae	6	1.39
2	Araceae	94	21.81	14	Gleicheniaceae	4	0.93
3	Cyperaceae	54	12.53	15	Nephrolepidaceae	4	0.93
4	Zingiberaceae	47	10.90	16	Polypodiaceae	3	0.71
5	Thelypteridaceae	24	5.57	17	Piperaceae	3	0.71
6	Pandanaceae	23	5.34	18	Asparagaceae	2	0.46
7	Marantaceae	21	4.87	19	Schizaeaceae	2	0.46
8	Hypoxidaceae	13	3.02	20	Tectariaceae	1	0.23
9	Blechnaceae	10	2.32	21	Dioscoreaceae	1	0.23
10	Adiantaceae	7	1.62	22	Fabaceae	1	0.23
11	Melastomataceae	7	1.62	23	Orchidaceae	1	0.23
12	Athyriaceae	6	1.39	24	Vitaceae	1	0.23
					Total	**431**	**100**

Discussion

As shown in this study, **a total of 24 families, 41 genera and 48 taxa were recorded from Bukit Durang forest and show high species diversity (Table 3).** The overall abundance and diversity of species is probably enhanced with the availability and heterogeneity of light, soil nutrients, soil moisture, and substrates. Understory vegetation plays a critical role in nutrient cycling and energy flow although it often contributes relatively a small portion to the biomass of overall forest ecosystems (Su *et al.*, 2019). Secondary forests such as Bukit Durang provide plenty of forest resources which can contribute directly or indirectly to living things such as animals, insects, and other organisms as well as humans. Some importance of understory plants includes the uses of plants as food resources, ornamental, traditional medicine, as well as for handicrafts and cultural uses (Sayok *et al.*, 2011). Understory plants can also be used for food flavouring, agrochemical, pharmaceutical and fragrance production (Yusof *et al.*, 2010). Some uses of the species identified in this study are reported and discussed.

Table 2

THE FIVE MOST DOMINANT SPECIES RECORDED FROM BUKIT DURANG FOREST.

No	Species	Family	IVI (%)
1	*Homalomena* sp.	Araceae	19.36
2	*Calamus* sp.	Arecaceae	18.30
3	*Boesenbergia* sp.	Zingiberaceae	11.99
4	*Calamus ingens* (J.Dransf.) W.J. Baker	Arecaceae	8.86
5	*Phrynium* sp.	Marantaceae	8.83

Table 3

DIVERSITY INDICES OF UNDERSTORY PLANTS OF BUKIT DURANG FOREST

Indices	Value
Shannon-Wiener (H')	3.309
Simpson (D)	0.948

A total of 24 families, 41 genera and 48 taxa of understory plants were recorded from the Bukit Durang forest and show high species diversity. The most dominant species is a species from the genus *Homalomena* of the aroids family (Araceae).

About 22.27% of the total individual understory plants are from the palm family (Arecaceae) which is dominated by the genus *Calamusor,* more popularly known as the rattan.

The ferns and fern allies make up about 14.15% of the understory plants in this study with a total of 10 families recorded, namely Blechnaceae, Gleicheniaceae, Athyriaceae, Polypodiaceae, Tectariaceae, Schizaeaceae, Thelypteridaceae, Nephrolepidaceae, Thelypteridaceae, and Adiantaceae.

The most dominant species in this study is a species from the genus *Homalomena* of the aroids (Araceae) family (Fig. 1). Borneo has the richest and diverse aroids in the world where there are more than 1,000 aroid flora species in Borneo (Boyce *et al.*, 2010). There are at least 300 *Homalomena* species where many of the species do not have a formal scientific name (Sulaiman & Boyce 2010). The *Homalomena* found in this study belongs to the Hanneae Complex (Wong, pers. comm.) and is one of the many *Homalomena* species that is yet to be described. Aroids are not only food plants; they are also gaining popularity as ornamental plants, be it outdoor or indoor where many species display very decorative leaves and inflorescences. Other aroid species found in this study are *Scindapsus pictus* Hassk. and *S. longistipitatus* Merr. where *S. pictus* has already been widely cultivated as ornamental plants due to its aesthetics value (Hanum *et al.*, 2005). This species is widely found in hill forest and lowland forest.

The most dominant species of Bukit Durang is a species from the genus *Homalomena* of the aroids (Araceae) family. The *Homalomena* found belongs to the Hanneae complex and is one of the many species that is yet to be described.

Figure 1

Homalomena sp. Habit variegated. © Photo: Aida Shafreena Ahmad Puad

Figure 2

Scindapsus pictus showing its variegated leaves. © Photo: Aida Shafreena Ahmad Puad

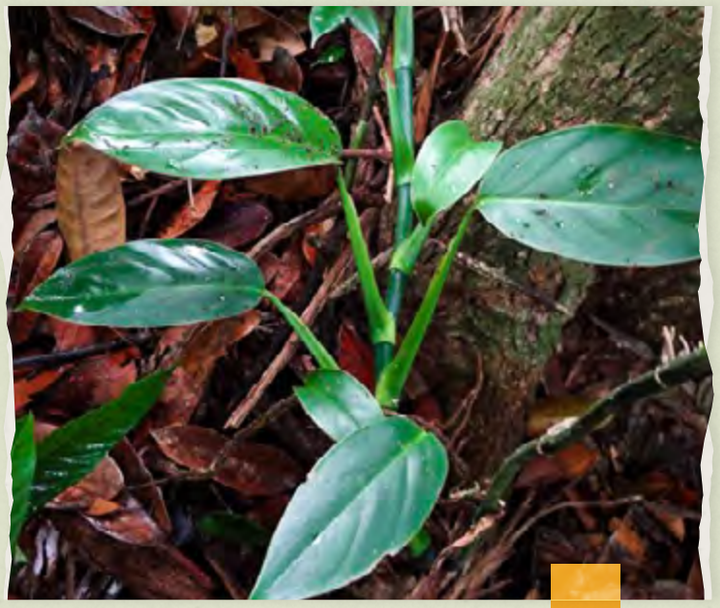

Figure 3

Scindapsus longistipitatus with long and winged petiole. © Photo: Aida Shafreena Ahmad Puad

Figure 4

Calamus ingens showing its habit and inflorescence.
© Photo: Benedikt Kuhnhaeuser

Bukit Durang forest is also rich in the palm family (Arecaceae) where about 22.27% of the total individual understory plants are from this family. Palms can be recognized by their fan-shaped or feather-like fronds (leaves) and fiber-covered trunks or stems. Palms are among the most extensively cultivated plant families and have great economic importance. Palms can be used to derive food and common products. **The palms in Bukit Durang are dominated by the genus *Calamus* or more popularly known as the rattan. One of the *Calamus* species recorded in this study is *Calamus ingens* (J.Dransf.) W.J.Baker — an endemic species to Borneo (Fig. 4). This species is usually found on damp slopes near valley bottoms or along streams. The leaves can be used for thatching and the sarcotesta (fleshy seedcoat) is sweet and edible.** Another *Calamus* species could not be identified as the species was not fruiting or flowering. Other palm species recorded in this study include *Oncosperma horridum* (Griff.) Scheff., *Gigantochloa* sp., *Licuala* sp. and *Khortalsia* sp. The *Licuala* has been widely used as ornamental plant and some *Licuala* species have been used as food wrapping (Hanum *et al.*, 2005).

The ferns and fern allies make up about 14.15% of the understory plants in this study with a total of 10 families recorded, namely Blechnaceae, Gleicheniaceae, Athyriaceae, Polypodiaceae, Tectariaceae, Schizaeaceae, Thelypteridaceae, Nephrolepidaceae, Thelypteridaceae, and Adiantaceae. Ferns are an important part of the world's flora and frequently dominate forest understories. It also colonises open areas, invade waterways and survive in nutrient-poor wastelands and eroded pastures. The important role for ferns in conservation and restoration is due to its extraordinary adaptations to many disturbances, including their abilities to accumulate toxins in their environment (Sharpe *et al.*, 2012). Humans use ferns for food, medicine, agriculture and horticulture (Sharpe *et al.*, 2012). In general, ferns are of minor economic importance to humans. Nevertheless, ferns are popular horticultural plants and many species are grown in ornamental gardens or indoors. *Mesophlebion chlamydophorum* (Rosenst. ex C. Chr.) Holttum from the family Thelypteridaceae has great potential as ornamental plants. *Blechnum orientale* Linn. from the family Blechnaceae is harvested for food where young shoots are cooked before eaten (Lee & Gibot, 1986) and this species is also reported as a potential candidate to be used as a medicinal drug (Lai *et al.*, 2010).

One of the challenges while conducting this study was that many plants were either not in flowering or fruiting or at a very young stage during the data collection, making identification very challenging. Most of the plants can be identified only at the genus level due to the reason mentioned earlier.

Figure 5

Clear demarcation and maintenance of the boundary of Bukit Durang is crucial to minimize encroachment.
© Photo: Wilmar

Conclusion

Bukit Durang forest is rich and showed a high diversity of understory plant species. The species found are beneficial species that belong to various plant families. Our findings suggest that forested area is important in conserving plant diversity in oil palm landscape. Understanding the importance of biodiversity and evaluating how changes in vegetation impact ecosystem processes is critical. Therefore, more study should be carried out to expand our understanding of its ecological significance in the ecosystem.

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Insects

RATNAWATI HAZALI, SITI NURLYDIA SAZALI, WAN NURAINIE WAN ISMAIL, ISAAC STIA MARCELLINUS, ANIS NORSYAHIRA MOHD RAFFI, FADZRAHNI TARSHA MOHD USTAR, MOHD ASHRAF ABDUL MUTALIB, NUR SITI AISYAH ZARIMIN, QUMIDDIN AB RAZAK, SITI HANISAH ZAHURI, WAHAP MARNI AND MOHAMAD JALANI MORTADA

Cosmodela aurulenta (Coleoptera: Carabidae), or commonly known as the golden-spotted tiger beetle, is a species commonly found in open areas or in lowlands near riverbanks. The species is 14 to 16 mm in length, the body is dark greenish with three distinctive spots on each sides of the elytra. There is also the presence of pale coloured hairs on the abdomen and legs. The species are known to be opportunistic predators of smaller invertebrates, with characteristic large mandibles and enlarged compound eyes. The species is also observed to show brief flights.

©Photo: Isaac Stia Marcellinus

Introduction

Insects are important components of global biodiversity and play a significant role in ecosystem functioning. The presence or absence of insects is important to the distribution, abundance and diversity of plants and vertebrates, which typically are the premier species in conservation efforts (Miller, 1993). Insects are often used in environmental studies as bioindicators due to their diversity and abundance (Chung, 2013). This study aimed to document the species composition of three main insect groups: butterflies (Lepidoptera), beetles (Coleoptera) and true bugs (Hemiptera) in Bukit Durang High Conservation Value Forest (HCVF). Samplings of insect fauna of Bukit Durang HCVF were conducted from 22-27 January 2014, 24-30 August 2014 and from 4-11 February 2015. Four methods of collection were carried out in this study: (i) modified Pennsylvanian light trap, (ii) aerial-netting, (iii) baited-trap, and (iv) hand-picking.

“Insects are often used in environmental studies as bioindicators due to their diversity and abundance.

Species Composition of Butterflies

A total of 65 species of butterflies from 42 genera, representing four families including Papilionidae, Pieridae, Nymphalidae and Lycaenidae, were documented (Table 1). This represents about 7% of the total number of 939 butterfly species recorded from Malaysian Borneo (Abang, 2006). The family Nymphalidae with 47 species (72.3%) represented the most speciose family recorded. The Rajah Brooke's Birdwing (*Trogonoptera brookiana brookiana*) is the only protected insect species in Sarawak under the Sarawak Wildlife Protection Ordinance 1998. The Rajah Brooke's Birdwing and Golden Birdwing (*Troides amphrysus flavicollis*) are also listed in Appendix II under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

Table 1

LIST OF BUTTERFLY SPECIES RECORDED IN BUKIT DURANG HCVF.

Family/Subfamily	Scienfic Name	Common Name
Papilionidae		
	Trogonoptera brookiana brookiana	Rajah Brooke's Birdwing
	Papilio demoleus	Lime Butterfly
	Arisbe sarpedon sarpedon	Common Bluebottle
	Arisbe doson evemonides	Common Jay
	Balignina neptunus doris	Common Neptune
	Troides amphrysus flavicollis	Golden Birdwing
Pieridae		
Pierinae	*Leptosia nina malayana*	Psyche Butterfly
	Appias paulina athena	White Albatross
	Saletara panda distanti	Triangle White
	Catopsilia scylla cornelia	Yellow Imigrant
	Eurema hecabe hecabe	Common Grass Yellow
	Eurema blanda blanda	Three Spot Grass Yellow
	Eurema simulatrix tecmesa	Hill Grass Yellow
	Eurema nicevillei nicevillei	Banded Grass Yellow
	Gandaca harina elis	Tree Yellow
	Pareronia valeria lutescens	Wanderer
Nymphalidae		
Danainae	*Euploea diocletianus lowii*	Magpie Crow
	Euploea mulciber portia	Striped Blue Crow
	Ideopsis vulgaris interposita	Blue Glassy Tiger
	Parantica agleoides borneensis	Black Tiger
	Parantica aspasia aspasia	Yellow Glassy Tiger
Satyrinae	*Elymnias hypermnestra nigrescens*	Common Palmfly
	Amathusia phidippus phidippus	Palm King
	Discophora necho cheops	Great Duffer
	Coelites euptychioides euptychioides	
	Faunis canens borneensis	Common Faun
	Faunis stomphax stomphax	Banded Faun
	Mycalesis anapita fucentia	Common Bush Orange
	Mycalesis fuscum adustata	Malayan Bush Brown
	Mycalesis horsfieldi hermana	Horsfield's Bush Brown
	Mycalesis mineus macromalayana	Dark Brand Bush Brown
	Mycalesis orseis borneensis	Purple Bush Brown
	Orsotriaena medus medus	Dark Grass Brown
	Thaumanthis odona panwila	Blue-banded Jungle Glory
	Ypthima baldus selinuntius	Common Five-Ring
	Ypthima fasciata fasciata	Malayan Six-Ring
	Ypthima pandocus sertorius	Common Three-Ring
	Zeuxidia amethystus wallacei	Common Saturn
Nymphalinae	*Vindula erota montana*	Common Cruiser
	Vindula dejone dejone	Malay Cruiser
	Cirrochroa satellita satellita	
	Cethosia hypsea hypsea	Malayan Lacewing
	Junonia atlites atlites	Grey Pansy
	Junonia orithya metion	Blue Pansy
	Hypolimnas anomala anomala	Malayan Egg-fly
	Hypolimnas bolina philippensis	Great Egg-fly
	Neptis hylas sopatra	Common Sailor
	Neptis duryodana duryodana	Malayan Sailer
	Pandita sinope sinope	Colonel

Family/Subfamily	Scienfic Name	Common Name
Nymphalidae		
Nymphalinae	*Athyma kanwa kanwa*	Dot-dash Sergeant
	Athyma nefte subrata	Colour Sergeant
	Athyma pravara pravara	Lance Sergeant
	Athyma reta reta	Malay Staff Sergeant
	Moduza procris agnata	The Commander
	Tanaecia clathrata coerulescens	Violet-bordered Viscount
	Tanaecia pelea djataca	Malay Viscount
	Euthalia godarti vacillaria	
	Euthalia iapis ambalika	Horsfield's Baron
	Bassarona dunya monara	Great Marquis
	Lexias dirtea chalcenoides	Black Tipped Archduke
	Lexias pardalis dirteana	Archduke
	Charaxes bernardus repititus	Tawny Rajah
	Cupha erymanthis erymanthis	Rustic
Lycaenidae		
Lycaeninae	*Arhopala epimuta*	Common Disc Oakblue
	Jamides lugine	

Species Composition of Beetles

A total of 62 species of beetles from 53 genera and representing 22 families, were documented (Table 2). The family Scarabaeidae with 14 species (22.6%) represented the most speciose family recorded. Out of these, the largest Three-horned beetle in Borneo, with 50-115 mm in length, *Chalcosoma moellenkampi* is a Bornean endemic. This commonly encountered species occurs in lowland to montane forests.

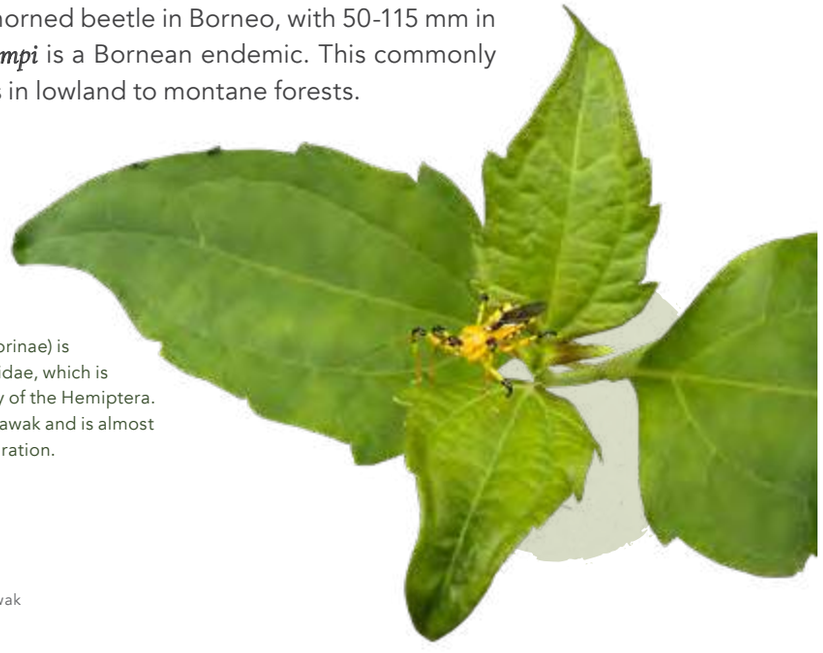

Figure 1

Velinus nigrigenu (Hemiptera: Harpactorinae) is an assassin bug from the family Reduviidae, which is considered the main predaceous family of the Hemiptera. This species is widely distributed in Sarawak and is almost similar to *Cosmolestes picticeps* in colouration.
© Photo: Ratnawati Hazali

Table 2

LIST OF BEETLE SPECIES RECORDED IN BUKIT DURANG HCVF.

Family	Scientific Name
Attelabidae	*Apoderus* sp.
Bostrichidae	*Rhizopertha dominica*
Carabidae	*Cicindela sumatrensis*
	Cicindela sp.
	Cosmodela aurulenta
	Cosmodela versicolor
	Pheropsophus occipitalis
Cerambycidae	*Olenecamptus bilobus*
	Pterolophia melanura
	Ropica sp.
	Trirachys orientalis
Cetoniidae	*Glycyphana quadricolor sinuata*
	Euselates cineracea
	Euselates sp.
Chrysomelidae	*Aulacophora flavomarginata*
	Chrysolina sp.
	Dicladispa armigera
	Lema pectoralis
	Lilioceris sp.
	Monolepta sp.
	Promecotheca nuciferae
Cleridae	*Necrobia rufipes*
Coccinellidae	*Coccinella arcuate*
	Henosepilachna vigintioctopunctata
Curculionidae	*Sitophilus granaries*
	Hypomeces squamosus
Dytiscidae	*Copelatus tenebrosus*
Elateridae	*Anchastus* sp.
	Agrypnus sp.
	Melanotus sp.
	Melanoxanthus sp.
	Neodiploconus sp.

Family	Scientific Name
Endomychidae	*Parindalmus quadrilunatus*
Erotylidae	*Encaustes* sp.
Languriidae	*Pachylanguria* sp.
Lampyridae	*Pteroptyx* sp.
Lucanidae	*Aegus chelifer*
	Aegus sp.
	Ceruchus sp.
	Prosopocoilus occipitalis
Nitidulidae	*Carpophilus* sp.
Passalidae	*Aceraius* sp.
Rutelidae	*Mimela maculicollis*
Scarabaeidae	*Adoretus compressus*
	Anomala concha
	Anomala matricula
	Anomala viridis
	Apogonia expeditionis
	Apogonia destructor
	Apogonia minor
	Chalcosoma caucasus
	Chalcosoma moellenkampi
	Dipelicus borneensis
	Exopholis hypoleuca
	Oryctes rhinoceros
	Rhomborrhina splendida
	Serica sp.
Staphylinidae	*Paederus* sp.
	Scopaeus sp.
Tenebrionidae	*Tenebroides mauritanicus*
	Tribolium castaneum
	Uloma orientalis

Species Composition of True Bugs

A total of four families, four subfamilies, nine genera and 10 species of true bugs were sampled during this study (Table 3). The family Reduviidae with seven species represented the most diverse family recorded.

Table 3

LIST OF TRUE BUG SPECIES RECORDED IN BUKIT DURANG HCVF.

Family/Subfamilly	Scienfic Name
Alydidae	
Micrelytrinae	*Leptocorisa acuta*
Reduviidae	
Harpactorinae	*Astinus nebulo*
	Cosmolestes picticeps
	Coranus fuscipennis
	Velinus nigrigenu
	Sycanus macracanthus
	Sycanus sp.
	Polididus armatissimus
Pentatomidae	
Pentatominae	*Tolumnia maxima*
Pyrrhochoridae	
Pyrrhochorinae	*Dysdercus* sp.

Figure 2

The *Apogonia expeditionis* (Coleoptera: Scarabaeidae) is a common polyphagous beetle with a length between 9 to 10 mm. This beetle is a pest in oil palm plantations where the adults are known to show irregular chewing on some portions on the edges of the leaves. The species is also known to eat other plant material other than oil palm trees. This species is exclusively nocturnal, feeding all through the night and burying themselves at sunrise.
© Photo: Isaac Stia Marcellinus

Figure 3

Apogonia expeditionis (Coleoptera: Scarabaeidae)
© Photo: Siti Nurlydia Sazali

Conclusion

Overall, the documentation of three insect groups, namely, butterflies (Lepidoptera), beetles (Coleoptera) and true bugs (Hemiptera) in Bukit Durang High Conservation Value Forest (HCVF) during multiple sampling occasions has been successfully achieved. It is recommended that further studies should consider other trapping methods such as the Malaise trap, pitfall trap, intercept panel trap and sticky trap which could potentially increase the capture rates of other insect species. Hopefully, the species accounts presented in this pilot project could be useful as a preliminary checklist which could be a kick-start to initiate more comprehensive studies in discovering other insects within Bornean forests.

Acknowledgements

This project was funded by Wilmar Plantations Sdn Bhd. We are especially thankful to Mr John Anak Alit, Mr Edward Enggu Anak Setu, Mr Joanes Anak John and the late Mr Golan Anak Mat, for their field assistance. We would also like to thank the Faculty of Resource Science and Technology, UNIMAS for the logistic and administrative supports.

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Aquatic Fauna

KHAIRUL ADHA A. RAHIM, AWANGKU SHAHRIR NAQUIDDIN AWG SUHAILI, MUHAMMAD IMRAN KHAIRUL ADHA, MELISSA DENNIS CHONG & MOHAMAD ASYRAF MOHAMAD SULAIMAN.

Examples of fish habitats survey at streams and rivers in Bukit Durang areas.

© Photo: Khairul Adha A. Rahim

Introduction

Studies on species composition, ecology and distribution of freshwater fish have been carried out in various habitats and sites in Sarawak (Khairul Adha *et al.*, 2018, 2009; Nyanti and Jongkar, 2007; Parenti and Lim, 2005; Watson and Balon, 1984). Kottelat and Lim (1995) listed about 250 species of freshwater fish that occurred in the state of Sarawak and Brunei.

Despite the high fish diversity documented for freshwater habitats in Borneo, limited information is available on the freshwater fish and other aquatic fauna inhabiting the aquatic ecosystem in palm oil plantations. The development and expansion of oil palm cultivation generally will impact the natural habitat and influence the biodiversity of flora and fauna (Schrier-Uijl *et al.*, 2013).

Generally, there are fewer studies focused on the diversity and abundance of freshwater fishes in rivers and streams such as in oil palm plantation ecosystems in Malaysia. Thus, the objective of this study is to determine the species composition of aquatic fauna that would be useful to initiate the plan for the conservation and management of fish and other aquatic fauna at Bukit Durang surrounding areas in the Wilmar oil palm plantation.

Materials & Methods

The fish samples were collected at six stations in the stream and rivers at the lower part of Bukit Durang's surrounding areas using gill nets of different mesh sizes (1.0, 1.5, 2.0, 2.5, 3.75, 4.0 and 5.0 cm) cast nets and scoop nets. The crayfish specimens were caught using the combination of two baited folding crab traps. The fishing nets were placed in the water for a period of 3 to 12 hours, overnight.

Results and Discussion

A total of 621 individuals from 36 species of aquatic faunas including fishes, freshwater prawns, and crayfish were collected from six locations in the palm oil plantation. These include 34 species of fishes and one species of freshwater giant prawn and crayfish, respectively (Table 1).

Thirty-one fish species from eight fish families collection were native fauna. Cyprinidae fish family represented 48.6% of the total fish caught, comprising 25 species and 302 individuals. Fish species such as *Cyclocheilichthys apogon* and *Nematabramis everetti* are the major fish collected during the surveys. Inger and Chin (1990) also reported that cyprinids fish formed the major collection of their surveyed in Borneo.

Figure 1

The Indo-Pacific tarpon (*Megalops cyprinoides*), also locally known as ikan bulan. This is amphidromus fish which regularly migrate between freshwater and the sea in both directions. Adults fish are generally found in estuaries, coastal and sea, however young and juvenile fish also inhabits in rivers, upstream lakes, and swampy backwater. This species is also as one of a popular recreational fish.
© Photo: Khairul Adha A. Rahim

Table 1

LIST OF FISHES, FRESHWATER PRAWNS AND CRAYFISH COLLECTED FROM BUKIT DURANG SURROUNDING AREAS.

Family	Scientific Name	Local/English Name	Status
Bagridae	*Hemibagrus planiceps*	Baung /Freshwater catfish	Native
	Hemibagrus nemurus	Baung /Freshwater catfish	Native
Balitoridae	*Homalopteroides nebulosus*	Susuh batang/	Native
Channidae	*Channa lucius*	Bujuk/Forest snakehead	Native
Cichlidae	*Oreochromis mossambicus*	Tilapia	Introduced
	Oreochromis niloticus	Tilapia	Introduced
Clariidae	*Clarias batrachus*	Keli kayu / Catfish	Native
Cyprinidae	*Barbodes banksi*	Spotted barb	Endemic
	Barbonymus collingwoodii	Kepiat	Endemic
	Barbonymus gonionotus	Lampam Jawa/Java barb	Introduced
	Barbonymus schwanefeldii	Lampam sungai/Tinfoil barb	Native
	Barbodes binotatus	Spotted barb	Native
	Barbodes sealei	Turungau/ Bornean spotted barb	Endemic
	Cyclocheilichthys apogon	Engkaras/Beardless barb	Native
	Cyclocheilichthys armatus	Buin	Native
	Anematichthys repasson	Buin	Native
	Hampala macrolepidota	Dungan /Jungle perch	Native
	Hampala bimaculata	Sebarau	Endemic
	Nematabramis borneensis	-	Endemic
	Nematabramis everetti	-	Endemic
	Osteochilus vittatus	Terbul/Bonylip barb	Native
	Osteochilus kahajanensis	Palau	Native
	Osteochilus waandersii	Bantak batu	Native
	Parachela hypophthalmus	Lalang/Glass barb	Native
	Parachela oxygastroides	Lalang/Glass barb	Native
	Puntioplites bulu	Tenggalan/ Crossbanded barb	Native
	Puntius brevis	Seluang/Swamp barb	Native
	Rasbora argyrotaenia	Seluang/ Silver rasbora	Native
	Rasbora bankanensis	Seluang/ Susur Batang	Native
	Rasbora caudimaculata	Seluang/ Giant scissortail	Native
	Rasbora kalochroma	Seluang/Clown rasbora	Native
	Rasbora volzii	Seluang	Endemic
Hemiramphidae	*Hemirhamphodon kuekenthali*	Jolong jolong/Halfbeak	Native
Megalopidae	*Megalops cyprinoides*	Ikan bulan/ Tarpon	Native
Parastacidae	*Cherax quadricarinatus*	Australian redclaw crayfish	Introduced
Palaemonidae	*Macrobrachium rosenbergii*	Giant freshwater prawn	Native

Other common fish species found included *Homalopteroides nebulosus* (Susur batang), *Hemibagrus planiceps* and *Hemibagrus nemurus* (Baung), *Channa lucius* (Bujuk), *Clarias batrachus* (Keli) and *Hemirhamphodon kuekkenthali* (Jolong jolong). Seven endemic species in Borneo such as *Barbonymus collingwoodii*, *Barbodes banksi*, *Barbodes sealei*, *Hampala bimaculata*, *Nematabramis borneensis*, *Nematabramis everetti* and *Rasbora volzii* were collected from higher stream and rives areas such as in *Sg. Cermin*. Parenti (1996) stated that the freshwater fish of Borneo have been described as having a high degree of endemism. However, two fish species of tilapia (*Oreochromis mossambicus* and *Oreochromis niloticus*) and javanese barb (*Barbonymus gonionotus*) collected during this survey, have been identified as introduced fish.

Figure 2

The redclaw crayfish (***Cherax quadricarinatus***) was introduced from Australia into Malaysia in 1990 for culture but has spread throughout Malaysia. Its broad tolerance to environmental factors and attractive colours makes the species ideal for both the aquaculture and aquarium industry.
© Photo: Khairul Adha A. Rahim

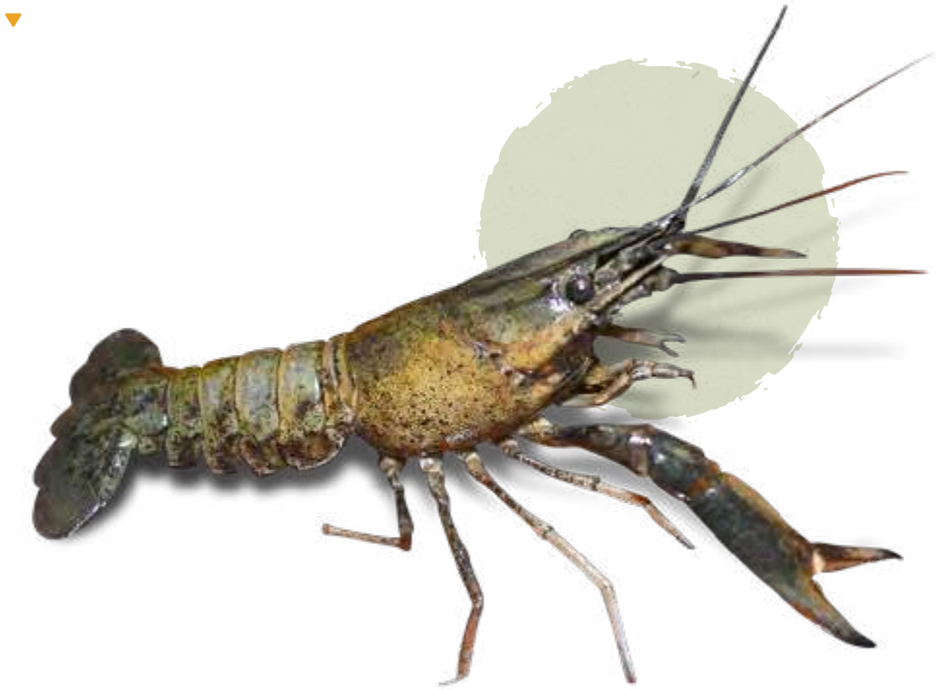

Figure 3

Giant prawn (*Macrobrachium rosenbergii*)

The giant freshwater prawn or locally known as udang galah is native prawn species and has been farmed commercially. The prawn can be found in most inland freshwater areas including lakes, rivers, swamps, irrigation ditches, canals and ponds, as well as in estuarine areas.
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Figure 4

Lampam Jawa (*Barbonymus gonionotus*)

Silver barb or locally known as Lampan Jawa is one of the popular cultured fish in Malaysia. This species was introduced from Indonesia and Thailand in the late 1950s. This species commonly occurs at midwater to bottom depths in rivers, streams, dams, and reservoirs throughout Malaysia.
© Photo: Khairul Adha A. Rahim

Figure 5

Tilapia (*Oreochromis* sp.)

Tilapias (*Oreochromis* spp.) together with hybrids were introduced from Indonesia, Thailand and Taiwan since 1944. This species commonly occurs in a wide variety of freshwater habitats like rivers, lakes, sewage canals and irrigation channels.
© Photo: Khairul Adha A. Rahim

Figure 6

Terbul (*Osteochilus* sp.)

Osteochilus sp. (Bonylip barb) or locally known as ikan terbul is the most common species in Malaysia and Southeast Asia. It can be found in all types of freshwater habitat but usually associated with large streams with slow current and muddy to sandy substrate.
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Figure 7

Buin (*Cyclocheilichthys* sp.)

Cyclocheilichthy sp. or Beardless barb is locally known as ikan temperas or buin. This species is commonly found in small streams canals and ditches with slow moving or standing water.
© Photo: Khairul Adha A. Rahim

Figure 8

Hampala bimaculata

Hampala bimaculata is one of an endemic fish species of Borneo and is locally known as ikan dungan. The fish is commonly found in clear rivers or streams with running water with sandy to muddy bottoms.
© Photo: Khairul Adha A. Rahim

Figure 9

Examples of fish habitats survey at streams and rivers in Bukit Durang areas.
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The redclaw crayfish, ***Cherax quadricarinatus*** was the most abundant species and represented almost 50% of the total sample collection. ***C. quadricarinatus*** is a native species to river catchments in northern Australia and south-eastern Papua New Guinea (Lawrence and Jones, 2002). The existence of the crayfish which was found in all the stations surveyed has caught the attention of local people, claiming that they suffer losses due to the damage caused by the crayfish to their catch and fishing nets (Awangku Shahril ***et. al.***, 2006). The domination of redclaw crayfish in the streams and rivers in these areas may potentially threaten the diversity of native aquatic fauna through competition for food and habitats, spawning areas, refuge and predation (Becker ***et al.***, 2005). According to the locals, the area is also habitat for freshwater prawns but competition may have reduced the number of native prawn species (Awangku Shahril, 2020). Only one specimen of freshwater prawn, ***Macrobrachium rosenbergii*** was found in the river during this study.

The number of aquatic species collected during this study is relatively high. However, about 54% of aquatic fauna collected are introduced species. Many studies (eg. Brown and Moyle, 1997; Khairul Adha ***et al.***, 2013; Awangku Shahrir ***et al.***, 2016) have shown that the introduction of non-native fish causes a threat to the native biodiversity. Thus, the importance of managing and sustaining native species diversity is one of critical concern. The present surveys showed that non-native fish, crayfish and freshwater mussels have been successfully introduced and established in aquatic habitats including streams and rivers in the surrounding areas of Bukit Durang.

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Frog Assemblage

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Megophrys nasuta, a very loud honk of vocalization is a trade mark of the horned frog. The frog is medium to large sized with pointed triangular projection as the extension of the eyelids. It lives in flat steep rain forests and easily camouflages with the forest floor litter. Adults breed at streams with weak to moderate currents (Inger et al., 2017). The species can be found throughout Borneo Sumatra and Peninsular Malaysia.

© Photo: Elvy Quatrin Deka

Introduction

About half of Bornean amphibians are endemic to the island, being restricted to specific habitats, from lowland dipterocarps to submontane forests. They tend to be sensitive to their environment and water quality in particular and thus, can serve as good environmental indicators. Negative changes in water quality are known to cause a higher rate of tadpole fatality and deformation. Berry *et al.* (2010) revealed that logging has adversely affected amphibian abundance. Thus, the anuran is an ideal indicator of ecosystem health. Many large plantations have set up High Conservation Value (HCV) areas to provide a network of wildlife refuges that may have once inhabited pristine and undisturbed forests, complying with international code of conduct for such plantations. The HCV forest thus functions to maintain or enhance biodiversity values within homogenous vegetation.

The impact of rainforest degradation due to its conversion to oil palm plantations on amphibians is relatively unknown. Additionally, information on anuran communities in oil palm plantations is still limited to a few studies to date (Gillespie *et al.*, 2012; Faruk *et al.*, 2013; Norhayati *et al.*, 2014; Zainudin *et al.*, 2019). Faruk *et al*. (2013) found that anuran communities in plantations consisted of species that thrive in disturbed areas. Furthermore, Harrison and Bruna (1999) stated that fragmented habitats cannot simply represent the original habitat and that their biotas may be altered to a great extent, thus assuming that conserving small remnant areas will not guarantee species conservation.

Anurans are susceptible to habitat change, thus, their community ecology would be potentially affected if natural habitats are modified and / or altered by human disturbances. With previous findings as well as the sensitivity of the anurans, it is important to assess the connectivity of the frog assemblages at HCV areas. The assemblages structure of anurans along the established HCV areas at Bukit Durang, Wilmar Plantations were documented in this chapter. It will provide insight into the function of HCV areas for the conservation of biodiversity maintenance in large oil palm plantations.

Figure 1

Ingerophrynus divergens is a small stocky toad with many scattered warts on the sides and back, a pair low crests runs between the eyes. None of the toes are fully webbed indicating non stream dweller species. The species lives in the leaf litter of the floor of primary and secondary forests below 700 m sea level with breeding sites on intermitten streams and rain pools (Inger *et al*, 2017). The species can be found throughout Borneo and Sumatra.

© Photo: Elvy Quatrin Deka

Survey Site Localities

Sites localities include Hulu Sungai Bukit Durang (N03°27.430', E113°49.933) as the HCV area, and Hilir Sungai Bukit Durang (N03°27.188', E113°50.273') as plantation area (Figure 2).

Field samplings were conducted on three separate ocassions between September 2013 and March 2015, with 1-2 nights for sampling sites. Line transects of 5 m both from the stream banks and plantation areas were employed. Visual Encounter Survey (VES) and frog sounds were used to detect the anurans with a minimum of four personnel for each visit. The animals were located by headlamps and caught by hand. All representative specimens were euthanised with chlorobutanol, fixed in 10% formalin and later stored in 70% alcohol as voucher. A similar sampling method was employed at each site. Muscle tissues from selected frogs were dissected and preserved in 70% ethanol for further studies. Specimens were deposited at the UNIMAS Zoological Museum, and identified using Inger & Stuebing (1997; 2005) and Inger ***et al.*** (2017).

Figure 2

Site localities of sampling at the Saremas and Segarmas Oil Palm Plantations

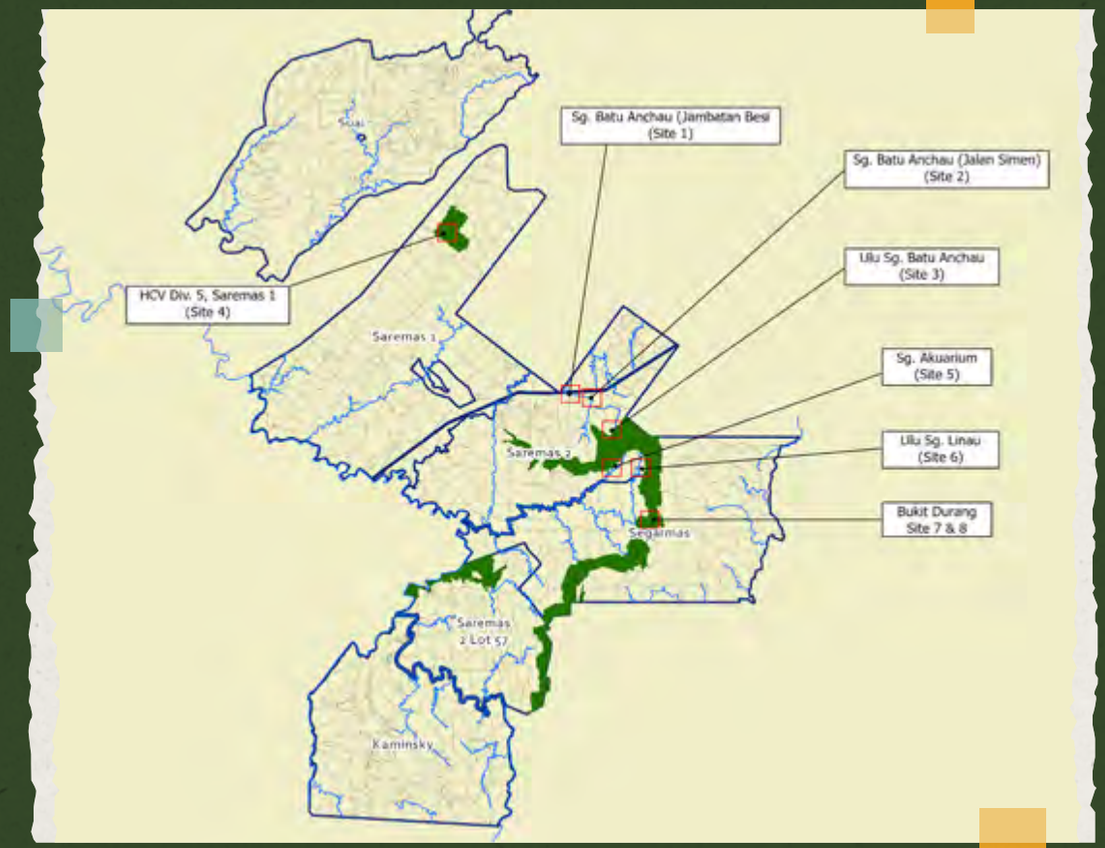

Figure 3

Alcalus sariba on rock of Ulu Sg. Batu Anchau.
© Photo: Elvy Quatrin Deka

Species Occurrence

A total of 181 individuals representing seven families, 12 genera and 24 species were obtained from all locations at Wilmar Plantation (Table 1). From this, 40 percent was represented by the family Dicroglossidae, 28 percent from Ranidae, 10 percent from Bufonidae, 12 percent from Megophyridae, five percent represented by Rhacophoridae, three percent from Ceratobatrachidae and two percent from Microhylidae. **The most common species was *Limnonectes kuhlii* followed by *Pulchrana glandulosa* (11.60%), *Chalcorana raniceps* (8.29%), *Pulchrana signata* (8.29%) and *L. leporinus* (8.29%).** In contrast, *Alcalus sariba* formerly known as *Alcalus shelfordi*, *Pelophryne signata*, *Limnonectes malesianus*, *Leptobrachium* sp., and *Pulchrana baramica* were represented by a single individual (Table 1). Interestingly Hulu Sg Bukit Durang was accounted for 30% of endemism with two species categorized as Near Threatened by IUCN 2016 (Table 1). Yet Hilir Sg Bukit Durang has no endemism as expected by plantation area.

Table 1

LIST OF SPECIES RECORDED IN BUKIT DURANG AREA WITH ITS CONSERVATION STATUS AND PERCENTAGE OF ENDEMISM. LC—LEAST CONCERNED, NT—NEAR THREATENED.

Locality	Site Category	Family	Species	No. of Individual	IUCN 2016	% of endemism
Hulu Sg Bukit Durang (N species=10)	HCFV	Bufonidae	*Ingerophrynus divergens**	9	LC	
		Bufonidae	*Ansonia leptopus*	3	NT	30%
		Rhacophoridae	*Polypedates leucomystax*	3	LC	
		Ranidae	*Pulchrana signata*	3	LC	
		Dicroglossidae	*Limnonectes kuhlii*	9	LC	
		Dicroglossidae	*Limnonectes ingeri**	1	NT	
		Megophyridae	*Leptobrachium abbotti**	4	LC	
		Megophyridae	*Leptobrachium* sp.	1	not listed	
		Ranidae	*Pulchrana glandulosa*	2	LC	
		Bufonidae	*Pelophryne signata*	1	NT	
Hilir Sg Bukit Durang (N species =4)	Plantation	Rhacophoridae	*Polypedates leucomystax*	1	LC	
		Ranidae	*Pulchrana glandulosa*	2	LC	0%
		Ranidae	*Chalcorana raniceps*	1	LC	
Sg Kolam (N species =3)	HCFV	Dicroglossidae	*Limnonectes paramacrodon*	1	NT	
		Dicroglossidae	*Limnonectes kuhlii*	3	LC	
		Megophyridae	*Leptobrachella mjobergi**	2	LC	33.3%
		Ceratobatrachidae	*Alcalus sariba*	1	LC	
Sg Akuarium (N species=16)	HCFV	Dicroglossidae	*Limnonectes kuhlii*	14	LC	
		Dicroglossidae	*Limnonectes leporinus**	6	LC	37.50%
		Ranidae	*Pulchrana glandulosa*	5	LC	
		Megophyridae	*Megophrys nasuta*	2	LC	
		Bufonidae	*Ingerophrynus divergens**	4	LC	
		Ranidae	*Pulchrana signata*	5	LC	
		Dicroglossidae	*Limnonectes ingeri**	1	NT	
		Ranidae	*Chalcorana raniceps*	3	LC	
		Megophyridae	*Leptobracella* sp.*	7	LC	
		Bufonidae	*Ansonia longidigita**	2	NT	
		Dicroglossidae	*Limnonectes paramacrodon*	2	NT	
		Dicroglossidae	*Limnonectes finchi**	2	LC	
		Dicroglossidae	*Limnonectes malesianus*	1	NT	
		Microhylidae	*Metaphrynella sundana*	1	LC	
		Ranidae	*Pulchrana baramica*	1	LC	
		Dicroglossidae	*Fejervarya limnocharis*	1	LC	

Locality	Site Category	Family	Species	No. of Individual	IUCN 2016	% of endemism
Tengah Sg Batu Anchau (N species =3)	Plantation	Ranidae	*Chalcorana raniceps*	2	LC	
		Ranidae	*Pulchrana glandulosa*	2	LC	0%
		Dicroglossidae	*Fejervarya limnocharis*	2	LC	
Sg Batu Anchau (N species=4)	Plantation	Dicroglossidae	*Fejervarya limnocharis*	3	LC	
		Rhacophoridae	*Polypedates leucomystax*	2	LC	0%
		Ceratobatrachidae	*Alcalus sariba*	3	LC	
		Ranidae	*Pulchrana glandulosa*	1	LC	
Ulu Sg Batu Anchau (N species= 9)	HCFV	Dicroglossidae	*Limnonectes kuhlii*	5	LC	
		Dicroglossidae	*Limnonectes leporinus**	8	LC	
		Dicroglossidae	*Limnonectes ingeri**	10	NT	
		Ranidae	*Pulchrana glandulosa*	7	LC	33.3%
		Ranidae	*Chalcorana raniceps*	9	LC	
		Ceratobatrachidae	*Alcalus sariba**	1	not listed	
		Ranidae	*Hylarana signata*	5	LC	
		Rhacophoridae	*Nyctixalus pictus*	2	NT	
Sungai Linau (N species=7)	HCFV	Microhylidae	*Metaphrynella sundana*	2	LC	
		Megophyridae	*Megophrys nasuta*	4	LC	
		Microhylidae	*Metaphrynella sundana*	1	LC	
		Ranidae	*Pulchrana signata*	2	LC	
		Ranidae	*Pulchrana glandulosa*	2	LC	28.6%
		Dicroglossidae	*Limnonectes paramacrodon*	1	NT	
		Dicroglossidae	*Limnonectes finchi**	2	LC	
		Dicroglossidae	*Limnonectes leporinus**	1	LC	

Figure 4

Kuhl's Creek Frog, *Limnonectes kuhlii*.
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Brief Notes on Species Assemblages at Bukit Durang

Hulu Sg Bukit Durang

Hulu Sg Bukit Durang holds the highest number of species (10) and individuals (36) encountered at the study sites. The high abundance might be due to the type of vegetation and microhabitats found in this HCV area. Interestingly, an amplexus of the bufonid *Ingerophrynus divergens* was observed in the area as shown in Figure 5.

It is also noticeable that the most abundant species found in this survey was *Limnonectes kuhlii*, a riparian frog that occurs mainly at Hulu Sg Bukit Durang, as well as Sg Aquarium and Sg Kolam. The species occurs in primary and old secondary forests. The frog is considered fully riparian, as it rarely moves over a few meters from the edge of small to mid-sized streams, with moderate current (Inger *et al.* 2017). It prefers rocky areas with moderate currents, type of microhabitats that are found in Hulu Sg Bukit Durang. These types of microhabitats were also preferred by most frogs, explaining the high diversity of species at Hulu Sg Bukit Durang.

Figure 5

Amplexus in a pair of the Crested Toad, *Ingerophrynus divergens*, on dead leaves of forest floor at Hulu Sg Bukit Durang.
© Photo: Elvy Quatrin Deka

Hilir Sg Bukit Durang

Hilir Sg Bukit Durang is surrounded by plantations. This can be reflected by the number of frog assemblage in this area. A total of four species, represented by five individuals were encountered for *Limnonectes paramacrodon*, which has been categorized as Near Threatened under IUCN Red List. No endemics were found during the survey. Other species found were mostly forest edge species such as *Pulcharana glandulosa* (Figure 6), *Chalcorana raniceps* (Figure 8) as well as a species commensal with man, *Polypedates leucomystax*.

Figure 6

A Rough-sided Frog, *Pulchrana glandulosa* on tree bark at Sg Anchau.
© Photo: Elvy Quatrin Deka

Figure 7

The Bornean endemic pagma frog, the Giant River Frog, *Limnonectes leporinus*.
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Figure 8

A Jade-backed Stream Frog, *Chalcorana raniceps* on overhanging vegetation at Hilir Sg Bukit Durang.
© Photo: Elvy Quatrin Deka

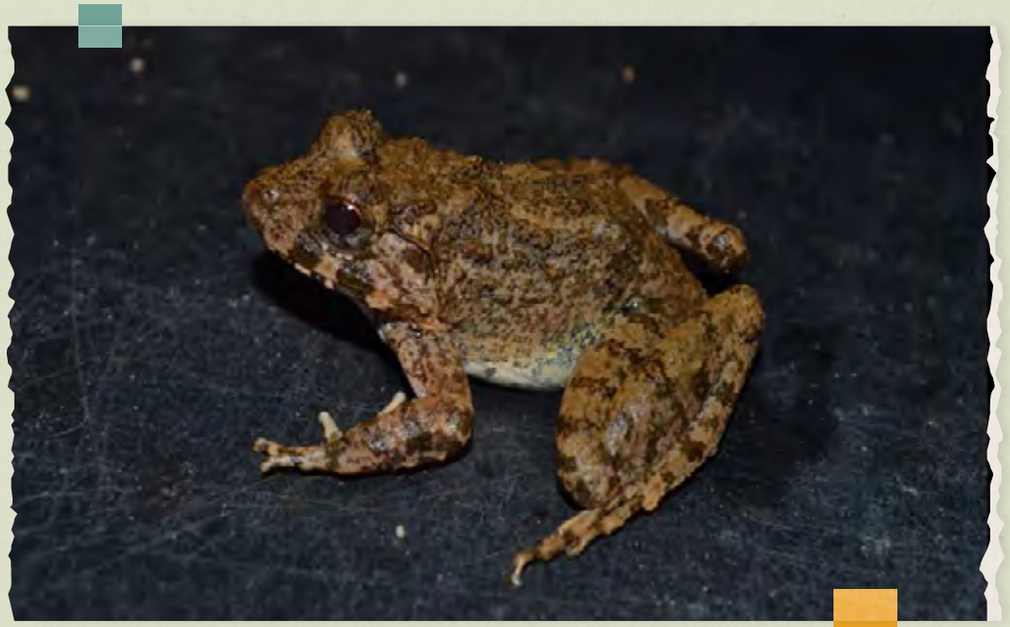

Figure 9

The endemic Bornean frogs, Rou gh Guardian Frog, *Limnonectes finchi* captured at Sg Linau.
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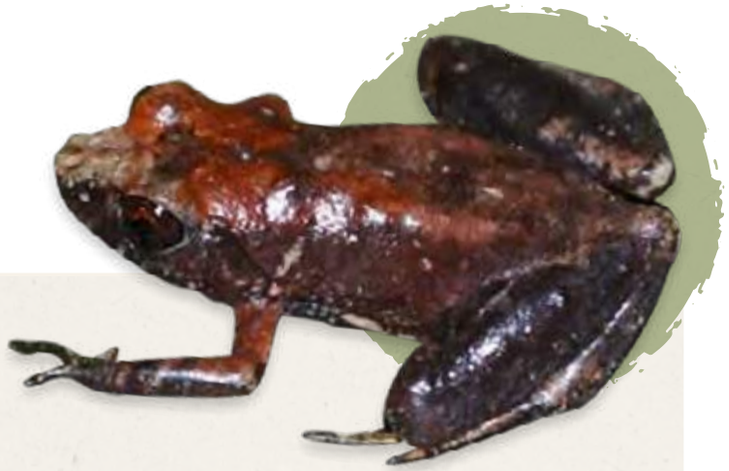

Figure 10

A Mjoöberg's Dwarf Litter Frog, *Leptobrachella mjobergi* recorded at Sg Kolam.
© Photo: Elvy Quatrin Deka

Conclusion

In general, the anuran assemblage structure is diverse with two main assemblages–the HCVF dwellers and the plantation dwellers. The HCVF areas harbor the highest diversity species as well as endemic species compared to the other study site within the plantation area. Hence, these HCV areas are functioning and should be maintained as high priority areas for faunal conservation within the oil palm plantation. Furthermore, the number of species was found to be significantly influenced by water temperature, turbidity, salinity and level of dissolves oxygen (Zainudin *et al.*, 2019). Hence, those environmental parameters should be taken into account when dealing with plantation management.

Acknowledgements

This study was funded by Wilmar Plantations Sdn Bhd. We would like to thank Wilmar and staff, as well as Universiti Malaysia Sarawak for the research funding and facilitation throughout the study period.

Figure 11

Limnonectes ingeri.
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Birds

JAYASILAN MOHD-AZLAN, SALLY SOO KAICHEEN,
LISA LOK CHOY HONG, AUDREY VOON MEI FANG

The Rufous-tailed Tailorbird Inhabits forest edges, including shrubby habitats and field edges and is relatively common in Bukit Durang area.

© Photo: Badiozaman Sulaiman

Introduction

Significant proportions of the Bornean rainforest have been converted to agricultural landscapes (i.e. oil palm (*Elaeis guineensis* Jacq) plantation), resulting in many of its remaining forests being fragmented and isolated. These forest patches are regarded as ecologically depauperate and have lower conservation value as many keystone species are absent, which has reduced ecological functions (Miller-Rushing *et al.*, 2019). However, to minimise the impact of the monoculture plantations on the ecosystem, forest remnants' roles should not be neglected as they retain some of the biodiversity remnants. Additionally, forest fragments that maintain a certain degree of environmental or social significance are regarded as high conservation value forests (HCVF) (Jennings *et al.*, 2003).

Birds are a useful indicator to assess ecological integrity in tropical rainforests (Koh, 2008; Şekercioğlu *et al.*, 2002; Bibby *et al.*, 1992). Birds are common, widespread, and vary in their responses to environmental changes and are also relatively easy to study (Edwards *et al.*, 2014; Koh, 2008; Gregory *et al.*, 2003; Şekercioğlu *et al.*, 2002; Dmowski, 1999). Monitoring these species allows for early warnings of environmental shifts (i.e. the effect of forest fragmentation) (Gregory *et al.*, 2003). This group also serves many ecological roles, such as seed dispersals, pollinators and pest control agents (Padoa-Schioppa *et al.*, 2006). Birds can be suitable indicators for understanding forest patches' quality, such as Bukit Durang in Saremas, Wilmar Plantations area. Some forest specialists can be affected due to forest fragmentation. Therefore, it is crucial to understand understorey birds' ecology (i.e. those recorded only from the forest) in HCVF within monoculture plantations. The plantation may confine their habitat access, ultimately threatening some forest specialists (Şekercioğlu *et al.*, 2002).

Oil palm trees are expected to reach their ultimate yield after six to 12 years of planting and require a replant after 24–26 years when it gets to the optimum stage (i.e. low fruit production, too tall to harvest) (Ismail & Mamat, 2002). Different ages of oil palm may harbour distinct bird species composition. Therefore, the fragmented forest in the oil palm landscape positively affects diversity compared to the one without a forest. Most studies showed lower species richness in oil palm plantations than in forests across various taxa such as butterflies, birds, and small mammals (Mohd-Azlan *et al.*, 2019a; Mohd-Azlan *et al.*, 2019b; Dislich *et al.*, 2017; Koh, 2007). The diversity in the oil palm landscape is mostly made up of generalist species with a high toleration level and a lower proportion of overlap between forest and oil palm plantations. Therefore, this study aims to describe the bird species richness in Bukit Durang HCVF, which can be used as an indicator to monitor future environmental changes.

Figure 1

Blue-throated Bee-eater (*Merops viridis*), an areal hunter predominantly feed on flying insects such as dragonflies, bees and wasps.
© Photo: Jayasilan Mohd-Azlan

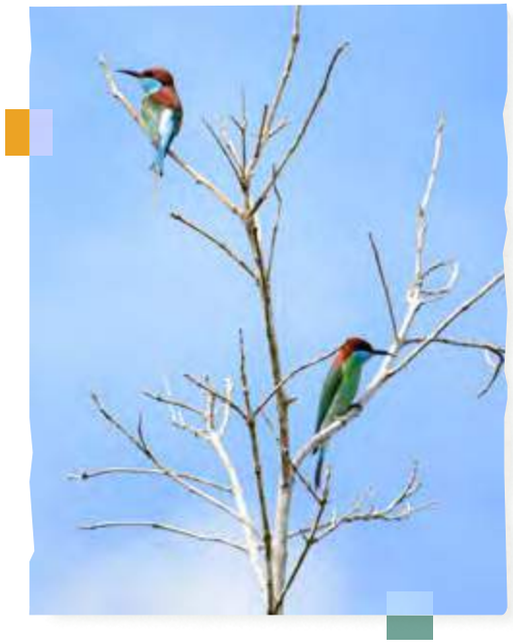

Figure 2

The Barn Swallow (*Hirundo rustica*) is a migrant and abundant in open habitat frequently observed near forest edges of Bukit Durang.
© Photo: Badiozaman Sulaiman

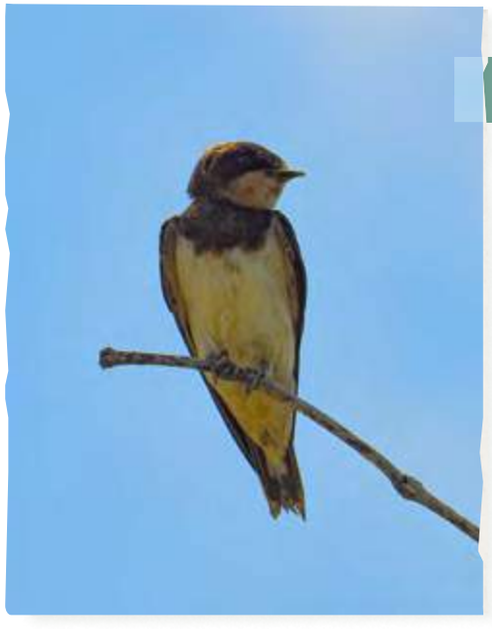

Figure 3

White-rumped Shama (*Kittacincla malabaricus*).

This insectivore species has been recorded in various habitats such as mangroves, plantations, including oil palm, swamp forest, primary and secondary mixed dipterocarp forest. This bird is highly sought after for Its powerful and beautiful song and frequently exploited for caged bird trade. This species is protected under the Sarawak Wild Life Ordinance, 1998.
© Photo: Badiozaman Sulaiman

Methodology

Three mist-netting surveys were conducted non-continuously from November 2014 to April 2015 and point count surveys from February 2015 to February 2016 in Bukit Durang HCVF. A total of 18 mist nets (9 m × 12.6 m, with 36 mm mesh) were set up along nine transects in Bukit Durang, HCVF throughout three sessions accumulated a total of 1,769 net hours while the non-consecutive point count survey totalled up to 286 observational hours where species were identified via visual observation. Point count observation was conducted at 15 observation points and done in a 20m^2 plot with an observation radius of 20m. The study was undertaken in the morning (0630-1030) and evening (1600-1830). Birds were observed by using binocular MEADE 8x 42 glacier. At any one mist-net sampling session, nine nets were set up with an interval of one hundred meters between each transect. The mist-nets were set up using a five-meter long aluminium pole. The mist nets were checked every two hours, daily from 0600 to 1800 hours. Occasionally, some birds were opportunistically recorded by the camera traps set for terrestrial mammals and were included in the inventory (Table 1). The birds were identified to species level based on morphological characteristics and mist-netted birds were banded with a UNIMAS metal ring on the tarsus before releasing back to the captured sites (Phillipps & Phillipps, 2014).

Results & Discussion

The surveys yielded a total of 569 individuals from 90 species belonging to 31 families with two endemic species (Dusky Munia and Golden-naped Barbet). These recorded approximately 15% of Bornean birds (90/600). Most bird species caught and observed were insectivorous, while the piscivorous/insectivorous and insectivorous/carnivorous guilds were represented by two species, respectively (Table 1). Common Hill Myna (n=39) and White-rumped Shama (n=39) were the most abundant species recorded in Bukit Durang HCVF. Five species (7.78%) are categorised as Totally Protected and 13 species (17.78%) as Protected under the Wild Life Protection Ordinance (1998) in Sarawak. While under the Red List of the International Union for Conservation of Nature, three species are categorised as Endangered (3.34%), four Vulnerable (4.44%), 18 Near Threatened (20%), and 65 of them are the Least Concern (72.22%). **The understory bird species richness is higher than that recorded in Gunung Gading National Park (62 species) which is also mostly surrounded by oil palm plantations** (Arif and Mohd-Azlan, 2014).

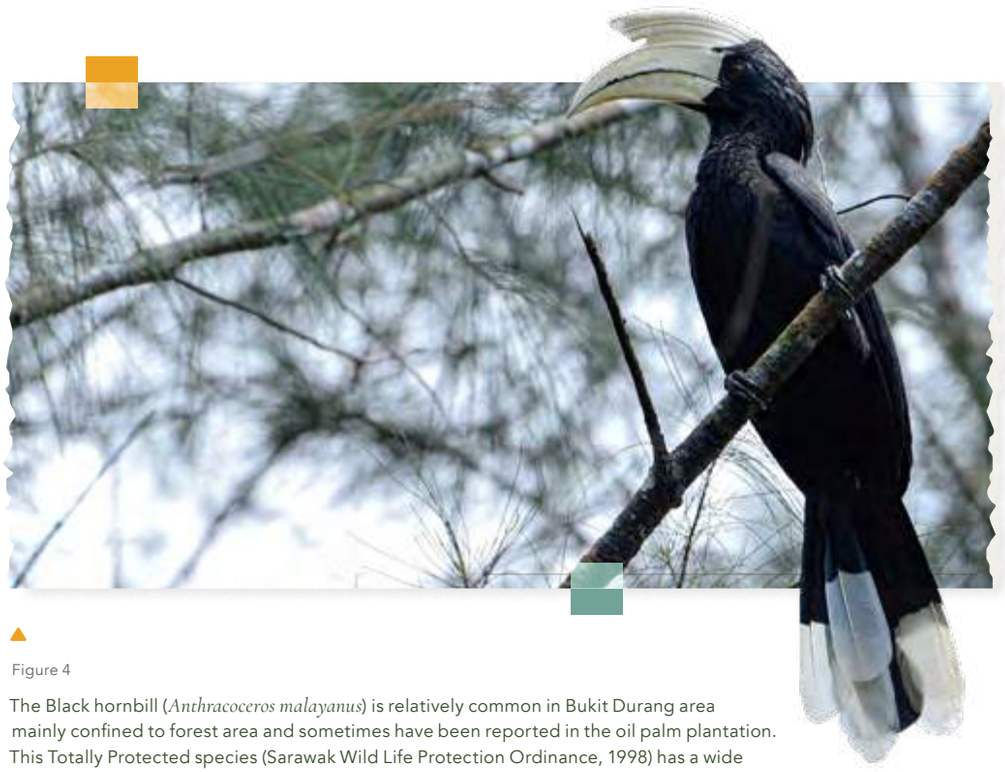

Figure 4

The Black hornbill (*Anthracoceros malayanus*) is relatively common in Bukit Durang area mainly confined to forest area and sometimes have been reported in the oil palm plantation. This Totally Protected species (Sarawak Wild Life Protection Ordinance, 1998) has a wide distribution in Sarawak. This omnivorous species forage mainly in the lower and middle storey.
© Photo: Badiozaman Sulaiman

Figure 5

A White-crowned Hornbill (*Berenicornis comatus*) peaking at the infra red sensored camera in Bukit Durang. Known as Sentuku by the Iban people, due to its unique call, this species forages at the middle and lower story and frequently descends down to the ground where it got camera-trapped. Past studies have shown that the White-crowned Hornbill can use up to 10 km^2 of forest area. This species is Totally Protected under the Sarawak Wild Life Ordinance, 1998.
© Photo: Jayasilan mohd-Azlan

The frontier of HCVF is presumed to play an essential role for birds, where these habitats support species diversity in an area (Koh, 2008; Clough *et al.*, 2007). Native plant species, epiphytes, and leguminous planted near forest edges can potentially improve hospitability towards birds (Koh, 2008). Habitats with higher complexity are presumed to sustain a higher concentration of species richness across taxa (Mohd-Azlan & Lawes, 2011). Hence, replanting some of these plant species could improve the ecological function of HCVF, and create significant differences with surrounding oil palm landscapes.

While most generalist species can adapt to human-modified landscapes, a recent study by Mohd-Azlan *et al.*, (2019a) showed higher bird composition between forest and oil palm plantation edge. This further illustrates that bird species in the oil palm plantation result from a spill-over and that they are dependent on the available forest fragments. Hence, **HCVFs in an oil palm plantation, regardless of their size, are an irreplaceable habitat for birds, where an increase in 1–10% area of forests will increase the bird compositions by 2.5 species** (Koh, 2008). Taking lessons from Bukit Durang HCVF, oil palm plantations are encouraged to maintain large patches of forest wherever possible within the plantations.

Table 1

LIST OF BIRD SPECIES AND ITS LOCAL ABUNDANCES RECORDED IN BUKIT DURANG HCVF THROUGH MIST-NETS (MN) AND POINT COUNTS (PC).

Diet behaviour of each species:

- C CARNIVOROUS
- O OMNIVOROUS
- I INSECTIVOROUS
- F FRUGIVOROUS
- G GRANIVOROUS
- P PISCIVOROUS
- N NECTIVOROUS

IUCN – International Union for Conservation of Nature

- EN ENDANGERED
- VU VULNERABLE
- NT NEAR THREATENED
- LC LEAST CONCERN

SWLPO – Sarawak Wild Life Protection Ordinance 1998 with their protection status:

- P PROTECTED
- TP TOTALLY PROTECTED
- N/P NOT PROTECTED

* Recorded by camera traps

\# Bornean endemic.

Family	Species	MN	PC	Total (MN+PC	Diet	SWLPO	IUCN
Accipitridae	Crested Serpent-eagle *Spilornis cheela* (Latham, 1790)	1	17	18	C	N/P	LC
	Crested Goshawk* *Accipiter trivirgatus* (Temminck, 1824)	-	-	-	C	N/P	LC
	Lesser Fish Eagle* *Icthyophaga humilis* (Müller & Schlegel, 1841)	-	-	-	C	N/P	NT
Alcedinidae	Blue-eared Kingfisher *Alcedo meninting* Horsfield, 1821	1	2	3	C	P	LC
	Rufous-backed Kingfisher *Ceyx rufidorsa* Strickland, 1847	11	14	25	P/I	P	LC
	Rufous-collared Kingfisher* *Actenoides concretus* (Temminck, 1825)	3	0	3	P/I	P	NT
Apodidae	Black-nest Swiftlet *Aerodramus maximus* (Hume, 1878)	2	0	2	I	P	LC
	Glossy Swiftlet *Collocalia esculenta* (Linnaeus, 1758)	7	1	8	I	P	LC
Bucerotidae	Black Hornbill* *Anthracoceros malayanus* (Raffles, 1822)	0	7	7	F/I	TP	VU
	Bushy-crested Hornbill *Anorrhinus galeritus* (Temminck, 1831)	0	9	9	F/I	TP	NT
	Oriental Pied Hornbill *Anthracoceros albirostris* (Shaw & Nodder, 1807)	0	21	21	O	TP	LC
	Wreathed Hornbill *Rhyticeros undulatus* (Shaw, 1811)	0	4	4	O	TP	VU
	Wrinkled Hornbill *Rhabdotorrhinus corrugatus* (Temminck, 1832)	0	4	4	O	TP	EN
	White-crowned Hornbill *Berenicornis comatus* (Raffles, 1822)	-	-	-	O	TP	EN
Chloropseidae	Lesser Green Leafbird *Chloropsis cyanopogon* (Temminck, 1829)	0	2	2	F/I	N/P	NT
Cisticolidae	Yellow-bellied Prinia *Prinia flaviventris* (Delessert, 1840)	1	2	3	I	N/P	LC
Columbidae	Grey-capped Emerald Dove *Chalcophaps indica* (Linnaeus, 1758)	7	7	14	O	N/P	LC
	Eastern Spotted Dove *Spilopelia chinensis* (Scopoli, 1786)	0	1	1	F/G	N/P	LC
Corvidae	Slender-billed Crow *Corvus enca* (Horsfield, 1822)	0	17	17	F/I	N/P	LC
Cuculidae	Black-bellied Malkoha *Phaenicophaeus diardi* (Lesson, 1830)	0	1	1	I	N/P	NT
	Chestnut-breasted Malkoha *Phaenicophaeus curvirostris* (Shaw, 1810)	0	2	2	I	N/P	LC
	Greater Coucal *Centropus sinensis* (Stephens, 1815)	0	11	11	I	N/P	LC
	Lesser Coucal *Centropus bengalensis* (Gmelin, 1788)	0	1	1	I	N/P	LC
	Oriental Cuckoo *Cuculus saturatus* Blyth, 1843	0	1	1	I	N/P	LC

Diet behaviour of each species:

- **C** CARNIVOROUS
- **O** OMNIVOROUS
- **I** INSECTIVOROUS
- **F** FRUGIVOROUS
- **G** GRANIVOROUS
- **P** PISCIVOROUS
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- **P** PROTECTED
- **TP** TOTALLY PROTECTED
- **N/P** NOT PROTECTED

* Recorded by camera traps # Bornean endemic.

Family	Species	MN	PC	Total (MN+PC	Diet	SWLPO	IUCN
Dicaeidae	Brown-backed Flowerpecker *Dicaeum everetti* (Sharpe, 1877)	0	1	1	I	N/P	NT
	Crimson-breasted Flowerpecker *Prionochilus percussus* (Temminck & Laugier, 1826)	1	0	1	O	N/P	LC
	Orange-bellied Flowerpecker *Dicaeum trigonostigma* (Scopoli, 1786)	1	2	3	N/I/F	N/P	LC
	Yellow-breasted Flowerpecker *Prionochilus maculatus* (Temminck & Laugier, 1836)	0	4	4	N/I/F	N/P	LC
	Yellow-rumped Flowerpecker# *Prionochilus xanthopygius* Salvadori, 1868	2	3	5	N/I/F	N/P	LC
Estrildidae	Dusky Munia # *Lonchura fuscans* (Cassin, 1852)	5	1	6	F/G	N/P	LC
Eurylaimidae	Banded Broadbill *Eurylaimus harterti* Horsfield, 1821	0	5	5	F/I	N/P	LC
	Green Broadbill *Calyptomena viridis* Raffles, 1822	1	0	1	F/G	N/P	NT
	Black-and-yellow Broadbill *Eurylaimus ochromalus* Raffles, 1822	0	6	6	F/I	N/P	NT
Hirundinidae	Barn Swallow *Hirundo rustica* Linnaeus, 1758	0	9	9	I	N/P	LC
Locustellidae	Striated Grassbird *Megalurus palustris* Horsfield, 1821	1	0	1	1	N/P	LC
Megalaimidae	Blue-eared Barbet *Psilopogon cyanotis* (Blyth, 1847)	0	14	14	F/G	N/P	LC
	Golden-naped Barbet # *Psilopogon pulcherrimus* (Sharpe, 1888)	0	2	2	F/G	N/P	LC
	Golden-whiskered Barbet *Psilopogon chrysopogon* (Temminck, 1824)	0	1	1	F/G	N/P	LC
	Red-crowned Barbet *Psilopogon rafflesii* (Lesson, 1839)	0	16	16	F/G	N/P	NT
	Red-throated Barbet *Psilopogon mystacophanos* (Temminck, 1824)	1	6	7	O	N/P	NT
	Yellow-crowned Barbet *Psilopogon henricii* (Temminck, 1831)	0	3	3	F/G	N/P	NT
Meropidae	Blue-throated Bee-Eeter *Merops viridis* Linnaeus, 1758	0	2	2	I	N/P	LC
Muscicapidae	Dark-sided Flycatcher *Muscicapa sibirica* Gmelin, 1789	0	2	2	I	N/P	LC
	Hill Blue Flycatcher *Cyornis banyumas* (Horsfield, 1821)	0	1	1	I	N/P	LC
	Snowy-browed Flycatcher *Ficedula hyperythra* (Blyth, 1843)	0	3	3	I	N/P	LC
Nectariniidae	Brown-throated Sunbird *Anthreptes malacensis* (Scopoli, 1786)	2	1	3	N/I/F	N/P	LC
	Crimson Sunbird *Aethopyga siparaja* (Raffles, 1822)	0	1	1	N/I/F	N/P	LC
	Little Spiderhunter *Arachnothera longirostra* (Latham, 1790)	23	13	36	O	N/P	LC

Diet behaviour of each species:

- **C** CARNIVOROUS
- **O** OMNIVOROUS
- **I** INSECTIVOROUS
- **F** FRUGIVOROUS
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- **N/P** NOT PROTECTED

* Recorded by camera traps # Bornean endemic.

Family	Species	MN	PC	Total (MN+PC	Diet	SWLPO	IUCN
Oriolidae	Plain Sunbird *Anthreptes simplex* (Müller, 1843)	0	1	1	N/I/F	N/P	LC
	Purple-naped Sunbird *Kurochkinegramma hypogrammicum* (Müller, 1843)	0	1	1	N/I/F	N/P	LC
	Black-hooded Oriole *Oriolus xanthornus* (Linnaeus, 1758)	0	1	1	N/I/F	N/P	LC
	Black-naped Oriole *Oriolus chinensis* Linnaeus, 1766	0	1	1	N/I/F	N/P	LC
Pellorneidae	Ferruginous Babbler *Trichastoma bicolor* (Lesson, 1839)	0	1	1	I	N/P	LC
	Scaly-crowned Babbler *Malacopteron cinereum* Eyton, 1839	1	1	2	O	N/P	LC
	Short-tailed Babbler *Trichastoma malaccense* (Hartlaub, 1844)	0	1	1	I	N/P	NT
	Chestnut-backed Scimitar-babbler* *Pomatorhinus montanus* Horsfield, 1821	-	-	-	I	N/P	LC
Phasianidae	Bornean Crested Fireback* *Lophura ignita* (Shaw, 1798)	-	-	-	O	P	VU
	Great Argus* *Argusianus argus* (Linnaeus, 1766)	-	-	-	O	TP	VU
Picidae	Maroon Woodpecker *Blythipicus rubiginosus* (Swainson, 1837)	1	4	5	I	P	LC
	Rufous Piculet *Sasia abnormis* (Temminck, 1825)	1	0	1	I	P	LC
Psittacidae	Blue-crowned Hanging-parrot *Loriculus galgulus* (Linnaeus, 1758)	0	3	3	F/G	P	LC
Pycnonotidae	Brown-cheeked Bulbul *Alophoixus bres* (Lesson, 1832)	1	0	1	I	N/P	EN
	Cream-vented Bulbul *Pycnonotus simplex* Lesson, 1839	0	11	11	F/I	N/P	LC
	Hairy-backed Bulbul *Tricholestes criniger* (Blyth, 1845)	4	0	4	F/I	N/P	LC
	Olive-winged Bulbul *Pycnonotus plumosus* Blyth, 1845	8	3	11	F/I	N/P	LC
	Red-eyed Bulbul *Pycnonotus brunneus* Blyth, 1845	3	5	8	F/I	N/P	LC
	Spectacled Bulbul *Ixodia erythropthalmos* (Hume, 1878)	0	1	1	F/I	N/P	LC
	Streaked Bulbul *Ixos malaccensis* (Blyth, 1845)	0	1	1	F/I	N/P	NT
	Yellow-bellied Bulbul *Alophoixus phaeocephalus* (Hartlaub, 1844)	4	11	15	F/I	N/P	LC
	Yellow-vented Bulbul *Pycnonotus goiavier* (Scopoli, 1786)	8	9	17	F/I	N/P	LC
Rallidae	White-breasted Waterhen *Amaurornis phoenicurus* (Pennant, 1769)	1	1	2	O	N/P	LC
Rhipiduridae	Sunda Pied Fantail *Rhipidura javanica* (Sparrman, 1788)	3	0	3	I	N/P	LC

Diet behaviour of each species:

- **C** CARNIVOROUS
- **O** OMNIVOROUS
- **I** INSECTIVOROUS
- **F** FRUGIVOROUS
- **G** GRANIVOROUS
- **P** PISCIVOROUS
- **N** NECTIVOROUS

IUCN – International Union for Conservation of Nature

- **EN** ENDANGERED
- **VU** VULNERABLE
- **NT** NEAR THREATENED
- **LC** LEAST CONCERN

SWLPO – Sarawak Wild Life Protection Ordinance 1998 with their protection status:

- **P** PROTECTED
- **TP** TOTALLY PROTECTED
- **N/P** NOT PROTECTED

* Recorded by camera traps # Bornean endemic.

Family	Species	MN	PC	Total (MN+PC	Diet	SWLPO	IUCN
Sturnidae	Common Hill Myna *Gracula religiosa* Linnaeus, 1758	0	39	39	O	P	LC
Strigidae	Brown Wood-Owl *Strix leptogrammica* Temminck, 1832	1	0	1	C	P	LC
	Collared Scops Owl *Otus lettia* (Hodgson, 1836)	1	0	1	I/C	P	LC
	Oriental Scops Owl *Otus sunia* (Hodgson, 1836)	1	0	1	C	P	LC
	Reddish Scops Owl *Otus rufescens* (Horsfield, 1821)	3	0	3	I/C	P	NT
	Barred-eagle Owl* *Bubo sumatranus* (Raffles, 1822)	-	-	-	I/C	P	LC
Sylviidae	Ashy Tailorbird *Orthotomus ruficeps* (Lesson, 1830)	0	3	3	I	N/P	LC
	Rufous-tailed Tailorbird *Orthotomus sericeus* Temminck, 1836	4	4	8	I	N/P	LC
Timaliidae	Black-capped Babbler *Pellorneum capistratum* (Temminck, 1823)	0	11	11	I	N/P	LC
	Black-throated Babbler *Stachyris nigricollis* (Temminck, 1836)	4	5	9	I	N/P	NT
	Bold Striped Tit-babbler *Mixornis bornensis* Bonaparte, 1850	1	21	22	I	N/P	LC
	Chestnut-rumped Babbler *Stachyris maculata* (Temminck, 1836)	0	2	2	I	N/P	NT
Timaliidae	Chestnut-winged Babbler *Cyanoderma erythropterum* (Blyth, 1842)	0	5	5	I	N/P	LC
	Fluffy-backed Tit-babbler *Macronus ptilosus* (Jardine & Selby, 1835)	0	4	4	I	N/P	NT
	Grey-headed Babbler *Stachyris poliocephala* (Temminck, 1836)	0	2	2	I	N/P	LC
Turdidae	Oriental Magpie-robin* *Copsychus saularis* (Linnaeus, 1758)	25	12	37	I	N/P	LC
	Siberian Blue Robin *Larvivora cyane* (Pallas, 1776)	1	0	1	I	N/P	LC
	White-rumped Shama* *Copsychus malabaricus* (Scopoli, 1788)	12	27	39	I	P	LC
Total Abundance		**158**	**411**	**569**	**2P/I; 3I/C; 6C; 9F/G; 9N/I/F; 13O; 14F/I; 34I**	**7 TP; 16 P**	**3EN, 4VU, 8NT, 65LC**
Total Species		**38**	**69**	**90**			
Number of Families		**20**	**26**	**31**			

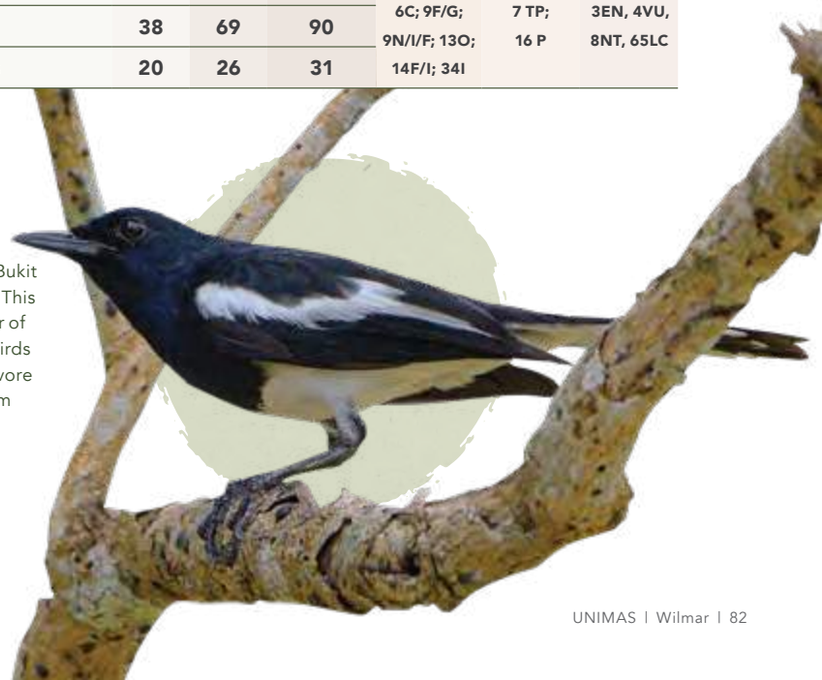

Figure 6

The Oriental Magpie Robin (*Copsychus saularis*) is a common bird in this area, frequently found in the understory of Bukit Durang and in the oil palm plantation. This territorial species is an excellent singer of varied songs and often mimics other birds in the area. This litter-gleaning insectivore probably plays an important ecosystem service in controlling insects in the oil palm plantation.
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Figure 7

White-breasted Waterhen (*Amaurornis phoenicurus*) This omnivorous species appears wide spread in Saremas. The White-breasted Waterhen often seen at wetland areas hiding in long grasses near Bukit Durang. Occasionally seen in open areas crossing roads with long strides.
© Photo: Badiozaman Sulaiman

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Small Mammals

JAYASILAN MOHD-AZLAN, SALLY SOO KAICHEEN,
LISA LOK CHOY HONG, FAISAL A.A. KHAN

Whitehead's Maxomys (***Maxomys whiteheadi***) is the common and smallest ***Maxomys*** species found throughout Sarawak. This s pecies has a spiny body fur with underparts and usually attracted to traps baited with banana. However, they were reported to feed mainly on insects such as ants. Despite commonly found across Borneo, their population trend has declined severely, and their conservation status is listed as Vulnerable in the IUCN red list.

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Introduction

The Bornean tropical rainforests harbour some of the most remarkable diversity of flora and fauna in the world (Jennings ***et al.***, 2015; Sodhi ***et al.***, 2004). Tropical biodiversity is highly threatened by land conversion for agricultural purposes. This calls for greater conservational prioritization (Wilcove & Koh, 2010; Fitzherbert ***et al.***, 2008) as many have become fragmented and disconnected. There are a total of 247 species of mammals recorded in Borneo, and small mammals make up approximately 81%, which can be sub-categorized into bats, shrews, treeshrews, rats, mice, squirrels and flying squirrels (Phillipps & Phillipps, 2016). Borneo is regarded as one of the biodiversity hotspots, sustaining a high concentration of endemism, including approximately 19% of mammals (5% of the 99 bats species and 26 Rodentia), 20% of snakes and 6% of birds (Mohd-Azlan & Lawes, 2011). Small mammals (< 1kg) are extensively studied and are considered to be good indicators of habitat quality (Shazali ***et al.***, 2016; Khan ***et al.***, 2007) as they play significant roles in the sustenance and regeneration of forests through pollination and seed dispersal (Phillipps & Phillipps, 2016). Fruit bats are known to play a keystone role in structuring the forest community by dispersing pioneer tree species. Some small mammals also play important role in regulating insects. Some rodents are abundant in oil palm dominated landscapes, supporting predator populations such as leopard cats, owls and pythons. Therefore identifying species that are available and absent in reserves is crucial for conservation planning as well as in evaluating conservation effectiveness (Jennings, 2000). This chapter aims to describe the small mammals that were recorded in Bukit Durang High Conservation Value (HCV) area during a series of surveys.

“There are a total of 247 species of mammals recorded in Borneo, and small mammals make up approximately 81%, which can be sub-categorized into bats, shrews, treeshrews, rats, mice, squirrels and flying squirrels.

Methodology

Bats and non-volant small mammals were sampled on three different occasions from 2014–2015, totalling 25 days. Traps were set up at three points along three transects with 100m intervals between each trap. A total of 18 mist nets ~1,872 net hours, were deployed throughout three sampling periods; where mist nets were used to capture frugivorous bats and insectivorous bats opportunistically. Mist nets were checked every 30 minutes from 1830 to 2130 to avoid bats from escaping especially the insectivorous bats. Harp traps were set up exclusively for insectivorous bats. The harp traps were moved at 100m intervals every day throughout the sampling periods and were checked twice daily at 1830 hours and 0600 hours, accumulating 360 trap hours.

Wired mesh cage traps baited with bananas, pineapples, peanuts and oil palm fruits were used to catch the non-volant small mammals. These were set on the ground or tree branches along three transects. This study used a total of 36 cage trap sites which accumulated 900 trap hours. The traps were checked twice daily, from 0800 and 1600 and only re-baited when necessary and relocated the trap when there was no capture for two days.

Figure 1

Müller's Sundamys (*Sundamys muelleri*) is common rodent species in disturbed habitat in Malaysia. It is one of the common oil palm pest that causes serious loss in oil palm production. Rodents are omnivorous species and is known to damage fruit branches and prey on the pollinating weevil's larvae. Natural predators such as predatory birds and snakes potentially regulate its population in forested areas such as Bukit Durang.
© Photo: Faisal Ali

Figure 2

Lesser Dog-faced Fruit Bat (*Cynopterus brachyotis*) is one of the most common fruit bats in Borneo. This species is found in most habitat ranging from mangrove forest to mix dipterocarp forest including oil palm area. This species forages on fruits, leaf and nectar where the fibre wad and larger seeds are often discarded under feeding roost. The lesser dog-faced fruit bat is known to forage on over 40 plant species. Fruit bats plays an important role in the maintenance of forest ecosystems as seed dispersers.
© Photo: Jayasilan Mohd-Azlan

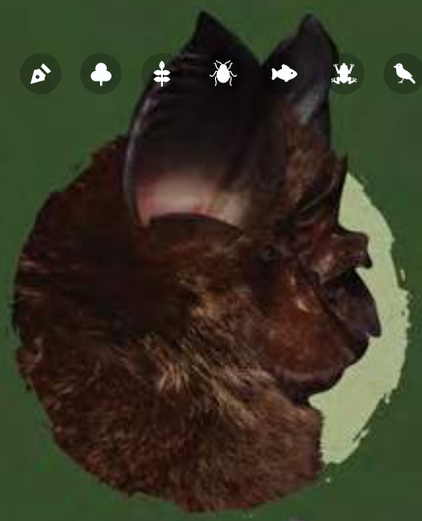

fig. 3

fig. 5

fig. 4

fig. 6

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fig. 9

fig. 8

fig. 10

Figure 3

Bornean Horseshoe Bat (*Rhinolophus borneensis*) is one of the most widespread Horseshoe bat species found both in primary and secondary mix dipterocarp forest. This insectivore species roost inside rock crevices, hollow trees and leaf furls. Insectivore bat species uses echolocation to navigate and to prey on insects and deemed as important insect regulator, including those that are considered pest to agriculture.

Figure 4

Lesser Woolly Horseshoe Bat (*Rhinolophus sedulus*) is a forest-dependent species found mainly in primary forests. This insectivorous species was typically found roosting in hollow trees and recorded from undisturbed culvert, caves, and boulder. Studies had reported that the species was found roosting alone or in a small group along with their larger counterpart Woolly Horseshoe Bat (*Rhinolophus luctus*). *Rhinolophus sedulus* conservation status is listed as Near Threatened with a declining population trend in the IUCN red list given the rate of forest reduction in Southeast Asia.

Figure 5

Trefoil Horseshoe Bat (*Rhinolophus trifoliatus*) is an elegant bat species that can be distinguished from the rest of the species in Malaysia as it has a distinct yellowish noseleaf color. This insectivorous species is a forest-dependent species and mostly found roosting alone in tree branches. Rhinolophus trifoliatus conservation status is listed as Near Threatened with a declining population trend in the IUCN red list given the rate of forest reduction in Southeast Asia.

Figure 6

Spotted-Winged Fruit Bat (*Balionycteris maculata*) is the smallest fruit bat in Borneo. This is the only bat species in Borneo with obvious white to pinkish spots on its wings. This frugivorous bat species is commonly found in lowland dipterocarp forest up to 1500 asl. This forest-dependent species is known to roost in epiphytic ferns, ginger plants, and abandoned ants and termites nets. *Balionycteris maculata* conservation status is listed as Least Concern with a declining population trend in the IUCN red list.

Figure 7

Dayak Fruit Bat (*Dyacopterus spadiceus*) is not commonly recorded across Sarawak, and this may be due to trapping effort that focuses mainly on the lower canopy species. This species was reported from the upper canopy or elevated area where trapping was conducted between valleys. This frugivorous species is known to roost in cave and hollow trees. Their powerful and broader jaw muscle than Cynopterus is probably essential for their specialization feeding on figs. *Dyacopterus spadiceus* conservation status is listed as Near Threatened in the IUCN red list. Their population status trend is unclear as they are high flying species that made them hard to be studied.

Figure 8

Small Asian Sheath-tailed Bat (*Emballonura alecto*) is a common lowland species. This species occurs in multiple different roost types, including boulders, forest buildings, cave mouth, and other underground structures, mostly with a well-lit condition. This insectivorous bat species is a high-flying species and rarely caught under the canopy. *Emballonura alecto* conservation status is listed as Least Concern in the IUCN red list with a stable population given that this species is well adapted to human-made structures.

Figure 9

Fawn-coloured Leaf-nosed Bat (*Hipposideros cervinus*) is a common forest understory species in both primary and secondary forests. This insectivorous species is usually caught in a harp trap fixed across established forest trails where they hunt insects. Studies have documented dorsal fur color variation from bright orange, brown to grey in this species. They have been recorded roosting in a medium to a large colony, mostly in hollow trees and caves. Their conservation status is listed as Least Concern in the IUCN red list with a stable population given their tolerance to habitat disturbance.

Figure 10

Papillose Woolly Bat (*Kerivoula papillosa*) is the largest woolly bat. This insectivorous species is the most common woolly bat in Borneo found in undisturbed lowland to lower montane forest. They were found mostly roosting individually or in small groups on hollow trees and tree branches. This species are usually captured in harp traps fixed across forest trails and small streams. Their conservation status is Least Concern in the IUCN red list, but not much information is known on their population status trend.

Table 1

LIST OF SMALL MAMMALS IDENTIFIED IN BUKIT DURANG HCVF, WITH ITS LOCAL ABUNDANCE, CONSERVATION STATUS IN SARAWAK'S WILD LIFE PROTECTION ORDINANCE 1998 AND INTERNATIONAL UNION FOR CONSERVATION OF NATURE, WHETHER THEY ARE FOREST-DWELLING (PREVIOUSLY RECORDED FROM ANY FORESTS), AND ITS DIET BEHAVIOUR.

P PROTECTED	VU VULNERABLE	I INSECTIVOROUS
LC LEAST CONCERN	U UNKNOWN	O OMNIVOROUS
NT NEAR THREATENED	F FRUGIVOROUS	

Family	Scientific Name	Common Name	Relative Abundance	Consevation Status (C)			Guild
				SWLPO 1998	IUCN 2020	Forest	
Volant Small Mammals (Bats)							
Pteropodidae	*Balionycteris maculata*	Spotted-winged Fruit Bat*	9	P	LC	Yes	F
	Cynopterus brachyotis	Lesser Dog-faced Fruit Bat	25	P	LC	No	F
	Dyacopterus spadiceus	Dayak Fruit Bat	4	P	NT	U	F
Emballonuridae	*Emballonura alecto*	Small Asian Sheath-tailed Bat	1	P	LC	Yes	I
Vespertilionidae	*Kerivoula papillosa*	Papillose Wooly Bat	1	P	LC	Yes	I
Hipposideridae	*Hipposideros cervinus*	Fawn-coloured Leaf-nosed Bat	10	P	LC	No	I
Rhinolophidae	*Rhinolophus borneensis*	Bornean Horseshoe Bat	7	P	LC	No	I
	Rhinolophus sedulus	Lesser Woolly Horseshoe Bat	2	P	NT	No	I
	Rhinolophus trifoliatus	Trefoil Horseshoe Bat	1	P	LC	Yes	I
Nycteridae	*Nycteris tragata*	Hollow-faced Bat	1	P	VU	Yes	I
Relative Abundance			61				
Total Species			10				
Non-volant Small Mammals							
Tupaiidae	*Tupaia dorsalis*	Striped Treeshrew	1	P	LC	U	F/I
	Tupaia picta	Painted Threeshrew	3	p	LC	Yes	F/I
Muridae	*Maxomys rajah*	Rajah Sundaic Maxomys	1	-	VU	Yes	-
	Maxomys whiteheadi	Whitehead's Spiny Rat	1	-	VU	No	I
	Rattus argentiventer	Ricefield Rat	1	-	LC	No	O
	Rattus exulans	Polynesian Rat	1	-	LC	No	O
	Rattus tanezumi	House Rat	2	-	LC	No	O
	Sundamys muelleri	Müller's Sundamys	4	-	LC	No	O
Relative Abundance			14				
Total Species			8				

Results & Discussion

Overall, this study recorded a total of 75 individuals representing 18 species of small mammals. This includes 10 bat species (61 individuals) and eight species (14 individuals) of non-volant small mammals captured within Bukit Durang HCVF (Table 1).

Bats

A total of three frugivorous (38 individuals) and seven insectivorous (23 individuals) bats were recorded throughout this study. This represents approximately 17% of the frugivorous bats family, Pteropodidae. The Lesser Dog-Faced Fruit Bat is the most abundant species (n=25) (Table 1). This species primarily feed on fruits, flowers, and leaf fractions, where it typically roosts in small groups in trees, under banana leaves, palm fronds, and man-made structures. The study also trapped four individuals of the relatively scarce Dayak Fruit Bat, and nine individuals of the Spotted-winged Fruit Bat.

A total of seven insectivorous bats were recorded representing approximately 9% of the insectivorous species.

These species are equipped with sophisticated echolocation abilities for navigating and catching prey. As such, they can evade the mist nets and thus resulting in lower capture rates in mist nets. Four of the forest-dwelling insectivorous species (Small Asian Sheath-tailed Bat, Papillose Woolly Bat, Trefoil Horseshoe Bat, and Hollow-faced Bat), however, were only trapped once throughout the study (Table 1). This is expected as fewer are recorded in forest understory when compared to the forest canopy, probably due to higher distribution and abundance of food resources in the canopy. Some common bat species such as the Dayak Leaf-nosed Bat (*Hipposideros dyacorum*) and the Bicoloured Leaf-nosed bat (*Hipposiderous bicolor*) were also absent from this study, suggesting additional surveys would increase the probability of recording more species. The capture effort concentrated in the understory may not accurately represent the bat diversity present in Bukit Durang forest area. Additionally, all bat species receive protected status following Sarawak Wild Life Protection Ordinance 1998.

Non-volant Small Mammals

The study recorded relatively fewer non-volant small mammals with only 14 individuals from eight species and most were only trapped once (Table 1). The two treeshrews recorded in Bukit Durang represent 22% of the overall recorded non-volant small mammals. Both of the treeshrews are endemic to Borneo and have been recorded in mixed dipterocarp forests. These species feed on fruits and insects, making them omnivores. Whitehead's Spiny Rat has also been frequently recorded from within monoculture vegetation such as rubber trees and oil palm plantations. The Müller's Sundamys is the most abundant species with four captures as it is a synanthropic rodent frequently reported in highly disturbed habitats along streams and close to human settlement. **Among the eight species, only two are forest-dwelling species. The foraging guild of these non-volant small mammals mainly consisted of omnivores and insectivores** (Table 1). Some of these species spend substantial time on the ground while others are arboreal, and a few species are considered fossorial.

Our research indicates that isolated forest patches result in species filtering and are insufficient to support the majority of small mammals of Borneo. However, the importance of maintaining a network of forest patches despite their level of fragmentation in oil palm plantations for conserving small mammals should not be ignored. Corridors of natural vegetation can be established to connect patches of forest in the oil palm landscape to potentially mitigate the adverse effects of extinction debt and forest fragmentation on small mammal conservation.

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Dayak Fruit Bat, *Dycopterus spadecius*.
© Photo: Faisal Ali

Medium to Large Terrestrial Mammals

JAYASILAN MOHD-AZLAN, LISA LOK CHOY HONG,
SALLY SOO KAICHEEN

The Sun bear (*Helarctos malayanus*) is the smallest member of the bear family but one of the largest mammals recorded in Bukit Durang.

Sun bear rely on tropical forest habitat but also have been reported near oil palm plantations and forest edges. Being a forest-dependent species, the Malayan Sun bear is prone to the effects of anthropogenic disturbances and thus signifies the importance of protected forest in Sarawak including Bukit Durang. Sun bear is omnivores, feeding primarily on invertebrates (e.g. termites, ants, larvae and honey) and a large variety of fruit species, especially fruits of the families Moraceae, Burseraceae and Myrtaceae.

Introduction

Mammals are one of the most susceptible taxa to local extinction because of habitat fragmentation and loss (Dirzo *et al.*, 2014). Partly due to their sensitivity to their surrounding, mammals are often used for biodiversity assessments and monitoring programmes around the globe as they are reliable ecosystem quality indicators (Ahumuda *et al.*, 2011). However, as tropical medium to large mammals are often cryptic and elusive in nature (Mohd-Azlan, 2006), they are difficult to study. Therefore comprehension of the persistence of medium to large mammals within forest fragments especially in agricultural landscapes in this region is important as they remain scarce in scientific literature. Remnant forest fragments within the plantation area may potentially provide refugia and support the existence of medium to large mammals as many studies have indicated that oil palm plantation harbours lower diversity of wildlife compared to forested areas.

Many larger mammals (e.g. Bearded Pigs, Deer, Muntjac, Mousedeer) are considered wild meat by local communities. With a long tradition of hunting, they avoid humans and can only be detected with infrared sensor cameras, by identification of footprints, and sometimes by chance on foot. The use of camera traps is a popular tool in this particular research field and is extensively utilised to monitor mammals (Rovero *et al.*, 2014). This method is exceptionally efficient to detect species that are hard to observe such as tropical mammals (Tobler *et al.*, 2008; Mohd-Azlan *et al.*, 2019). Therefore, this camera trap survey is aimed to identify the medium to large mammals that are present in Bukit Durang HCVF.

Materials & Methods

This study was conducted in Bukit Durang High Conservation Value Forest (HCVF, Class 1). Bukit Durang HCVF is the largest forest patch within Wilmar Plantations located in Miri, Sarawak (1.5533°N, 110.3592°E). Bukit Durang HCVF is a secondary forest and is characterised as a long and thin strip of the remaining hill ridge forest that spans a total area of 994.6 ha. The forest is dominated by the Leguminosae, Euphorbiacea, Moraceae and Dipterocarpaceae families.

Three mammalian surveys were undertaken from September 2013–April 2014, April 2014–April 2015 and from November 2018 to February 2020 whereby a total of 47 camera trap sites were established throughout a cumulative period of months. The camera traps utilized Passive Infra-Red (PIR) motion sensors and were composed of a mixture of models (Reconyx Hyperfire HC500, Bushnell Trophy Cam HD and Bushnell Trophy Cam). Cameras were mounted to trees approximately 30-40 cm above the ground, operational for 24 hours. Camera traps were also adjusted to face potential animal pathways and tracks to maximize photographic rates (Ancrenaz *et al.*, 2012; Mohd-Azlan & Engkamat, 2013). To prevent moisture damage cameras were equipped with desiccants packs and were subsequently sealed.

Figure 1

Pig-tail Macaques (*Macaca nemestrina*) are mainly terrestrial, but also active arboreal and often recorded in large groups. The Pig-tail Macaque appears to be dependent on Mix Dipterocarp forest and have been recorded in oil palm plantations. They are omnivorous mammal; they consume fruits, seeds, leaves, but also insects, buds and small animals and can measure up to 80 cm in length. This primate species has been reported outside forested area where its ability to exploit different resources suggest its resilence to human-induced change compared to many other primates.

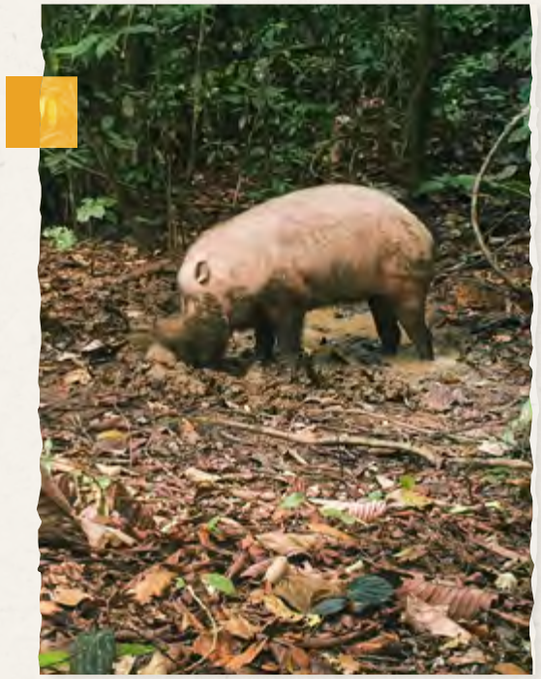

Figure 2

The Bearded Pig (*Sus barbatus*) can be found in coastal lowlands comprising peat swamp and dipterocarp forest with undulating hills and the mountain highlands in Borneo. The bearded pig, frequently detected in Bukit Durang area, is one of the most hunted species in Borneo. The bearded pig is an omnivorous animal that forages mainly on seeds of Dipterocarpaceae, Fagaceae, fruits, roots and invertebrates.

Figure 3

The Totally Protected Marbled Cat (*Pardofelis mamorata*) is partly arboreal and often active primarily during nocturnal and crepuscular times. The Marbled Cat, has similar coat pattern to the clouded leopard *Neofelis diardi*, with cloud-like markings and a very long tail but lacks distinct black-edged blotches on the sides of its body with numerous black spots on the legs. The Marbled Cat is a forest dependent species with good climbing skills. The ability of this species to move in the forest canopy has been partly thought to account for its rarity in Bukit Durang area. This felid species has been reported to be dependent on birds, squirrels and rodents as prey species. Marbled Cat receives Totally Protection status in Sarawak under the Sarawak Wild Life Ordinance 1998.

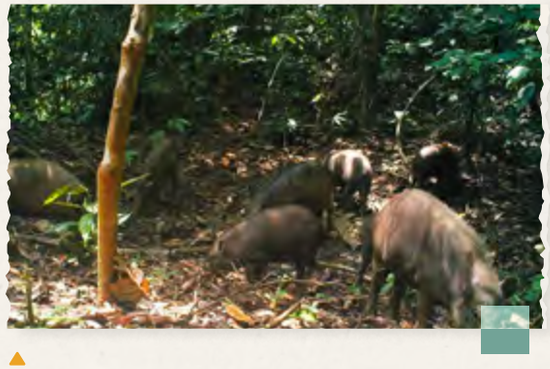

Figure 4

This generalist species is known to utilize a wide variety of habitat types but lives in one location in a stable group for the majority part of the year. The bearded pig has been reported to be mobile and exhibit a variety of aggregation strategies, ranging from solitary and sedentary to mass aggregation with wide ranging migration. This species is active during the day except in times of migration or human disturbance, when it has been reported to being more active at night. The ability of the bearded pig to utilize a variety of habitats makes them an interesting subject in understanding effects of habitat changes and disturbance on this species.

Observations—Results & Discussion

Bukit Durang HCVF recorded a total of 22 species (Table 1) throughout the three survey periods which cumulated to 5,485 camera trap days.

The Sunda Pangolin (*Manis javanica*), Sun Bear (*Helarctos malayanus*), Beaded Pig (*Sus barbatus*), Pig-tailed Macaque (*Macaca nemestrina*), Sambar Deer (*Rusa unicolor*) are of high conservation importance. These species are listed under the IUCN Red List of Threatened Species as Critically Endangered (Sunda Pangolin) and Vulnerable (Sun Bear, Bearded Pig, Pig-tailed Macaque, Sambar Deer) (IUCN, 2019).

Eight species were listed under the Convention of International Trade in Endangered Species of Wild Fauna and Flora (CITES); Appendix 1=Sunda Pangolin (*Manis javanica*), Marbled Cat (*Pardofelis mamorata*), Appendix II=Leopard Cat (*Prionailurus bengalensis*), Long-tailed Macaque (*Macaca fascicularis*), Pig-tailed Macaque (*Macaca nemestrina*), Banded Palm Civet (*Hemigalus derbyanus*), Appendix III=Common Palm Civet (*Paradoxurus hemaphroditus*), Masked Palm Civet (*Paguma larvata*), (CITES, 2019). Two species; Maroon Langur (*Presbytis rubicunda*) and Marbled Cat (*Pardofelis marmorata*) are categorized as Totally Protected under the Sarawak Wild Life Protection Ordinance 1998, while 14 other species are considered Protected (SWLPO, 1998).

The majority of the species were consistently recorded throughout the three surveys suggesting that Bukit Durang HCVF is able to support the long-term persistence of these species. **Bukit Durang HCVF has also proven to retain a substantial amount of species (22), comparable to several Protected Areas within Sarawak (eg. Gunung Pueh National Park (22 species) Gunung Gading National Park (20 species)**.

Table 1.

LIST OF MEDIUM TO LARGE MAMMAL SPECIES RECORDED IN WILMAR OIL PALM PLANTATION FROM 2013- 2020.

P PROTECTED
TP TOTALLY PROTECTED
N/A NOT PROTECTED*
LC LEAST CONCERN

NT NEAR THREATENED
VU VULNERABLE
CR CRITICALLY ENDANGERED**

(Convention of International Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendices)

I APPENDIX I
II APPENDIX II
III APPENDIX III

* Wild Life Protection Ordinance, 1998

** IUCN Red List of Threatened Species

Order/Family	Scientific Name	Common Name	Consevation Status (C)		
			SWLPO 1998	IUCN 2020	CITES
Artiodactyla					
Cervidae	*Rusa unicolor*	Sambar deer	N/A	VU	N/A
Suidae	*Sus barbatus*	Bearded pig	N/A	VU	N/A
	*Sus scrofa**	Domestic pig	N/A	N/A	N/A
Tragulidae	*Tragulus napu*	Greater Oriental Chevrotain	N/A	LC	N/A
	Tragulus kanchil	Lesser Oriental Chevrotain	N/A	LC	N/A
Carnivora					
Felidae	*Prionailurus bengalensis*	Leopard cat	P	LC	II
	Pardofelis mamorata	Marbled cat	TP	NT	I
Viverridae	*Hemigalus derbyanus*	Banded palm civet	P	NT	II
	Paguma larvata	Masked palm civet	P	LC	III
	Paradoxurus hermaphroditus	Common palm civet	P	LC	III
	Viverra tangalunga	Malay civet	P	LC	N/A
Ursidae	*Helarctos malayanus*	Sun bear	P	VU	I
Prionodontidae	*Prionodon linsang*	Banded Linsang	P	LC	N/A
Herpestidae	*Herpestes semitorquatus*	Collared Mongoose	P	NT	N/A
Pholidota					
Manidae	*Manis javanica*	Pangolin	P	CR	I
Primate					
Cercopithecidae	*Macaca fascicularis*	Long tailed macaque	P	LC	II
	Macaca nemestrina	Pig-tailed macaque	P	VU	II
	Presbytis rubicunda	Maroon leaf monkey	TP	LC	N/A
Eulipotyphla					
Erinaceidae	*Echinosorex gymnura*	Moonrat	N/A	LC	N/A
Rodentia					
Hystricidae	*Hystrix brachyura*	Common porcupine	P	LC	N/A
	Hystrix crassispinis	Thick-spined porcupine	P	LC	N/A
	Trichys fasciculata	Long-tailed porcupine	P	LC	N/A
Total number of species					**22**

Malay civets (*Viverra tangalunga*) are considered dietary generalists where plantations likely provide supplemental food resources including rodents.
© Photo: Jayasilan Mohd-Azlan

The Long-tailed Macaque (*Macaca fascicularis*) is an omnivorous animal that can be found in a variety of habitats, ranging from primary to secondary forest, plantations and the outskirts of human settlements.
© Photo: Jayasilan Mohd-Azlan

Leopard cats (*Prionailurus bengalensis*) are known to persist and reproduce well in oil palm plantation and deemed as good biological controllers.
© Photo: Jayasilan Mohd-Azlan

The Malayan porcupine (*Hystrix brachyura*) is a generalist species that utilizes various types of forest habitats and also agricultural areas. This burrowing animal is an omnivorous species that feeds on roots, fallen fruits, insects and even bones!
© Photo: Jayasilan Mohd-Azlan

Bornean biodiversity is disappearing at an alarming rate therefore remnant forests such as Bukit Durang HCVF serve as a refuge for biodiversity and should be regarded as critical habitats that contribute to the sustainability of ecosystem functions in this agricultural landscape. Initiatives such as replanting native trees through reforestation programs and allowing selected areas of old palm patches near forest edges to function as corridors to facilitate movement and gene flow. This study recommends continuous law enforcement, ranger patrolling and monitoring via camera traps to identify core areas of conservational importance as encroachment in the forms of extraction of timber and non-timber resources, intrusion and hunting were detected on several occasions during the study.

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Figure 5

The Vulnerable Sambar Deer (*Rusa unicolor*) has been frequently recorded at night in secondary forest feeding on a wide variety of vegetation, including grasses, bark, foliage, fruit, and water plants. This ungulate species is common in secondary mix dipterocarp forests, in swamp forests and often recorded near salt licks. The Sambar Deer has been thought to be important seed dispersers in tropical rainforest. Adult males grow large antlers that are shed and regrown.
© Photo: Jayasilan Mohd-Azlan

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Forest fragments such as Bukit Durang potentially increase the permeability of oil palm plantations for biodiversity and assist in the maintenance of ecosystem functions important to agricultural landscapes, such as pollination, hydrological functions, soil health, seed dispersal and biological control.

© Photo: Wilmar

The People of Saremas

JAMES WONG, CHIN SING YUN AND MARCIE ELENE MARCUS JOPONY

Sarawak, the largest state in Malaysia, is the land of myriad traditions and cultures with more than 45 recognised ethnic groups of indigenous communities. The multi-ethnicity natives consisting of Iban, Bidayuh, Kayan, Kenyah, Lun Bawang, Kelabit, Penan, Melanau and many more, have diverse customs, traditions, cultures, languages and identities. The Iban, known as "sea Dayak", make up the largest percentage of the Sarawak ethnic population and traditionally resided in longhouses.

Figure 1

Local communities in Saremas play an active role in the protection of our conservation areas including riparian area.
© Photo: Wilmar

Within Wimar's Saremas Plantation, there are more than four native ethnic groups, mainly Penan, Kedayan, Bugis and Iban. **Saremas used to be the roaming area of the Penans but now the Ibans make up most of the community that has settled in Saremas.** Since the 1970s, the Ibans have lived around Saremas and Suai river, working as loggers for Sarawak Land Development Board (SLDB). The upper reaches of the Suai river were originally the foraging grounds for the Penan people who occasionally returned to fish and forage for wild fruits. The Penan groups were from Kg. Ogos, Kg. Mareang and from around the Jambatan Suai-lower Suai River. Before public roads were available, the main mode of transportation was either through Suai River or the logging roads. As accessibility to the nearest township posed to be a challenge, the local communities used to hunt and forage instead for food. In the 1980s, palm oil operations were expanded further by the concession owners – BLD and later Saremas Plantations.

The majority of Ibans in Saremas are Christians but like most other ethnic groups in Sarawak, they have maintained their traditional beliefs and cultural identities. They have settled in the longhouses built within Saremas while making a living as independent oil palm smallholders. They also cultivate home gardens around the longhouse for food security. Many rear livestock like chickens and pigs. While subsistence livelihood practiced by the community has minimal impact on conservation areas, especially Bukit Durang, it should be noted that hunting activity is still practised by the local communities, albeit on a smaller scale compared to before. The communities in Saremas still depend on small-scale fishing for their protein needs and extra income.

Within Wimar's Saremas Plantation, High Conservation Value (HCV) assessment and Social Impact Assessment (SIA) were conducted in 2008 to identify valuable areas to be protected for environmental and social-cultural purposes. As the ancestral beliefs and cultural traditions of the Ibans are evident within Saremas, HCV 6 which covers the function of forests to the traditional cultural identities of local communities is present. Old burial sites which were identified as sacred grounds are conserved and will not be disturbed for any development or planting activities as the land rights of the community are respected. The burial grounds and tombs which are found outside the plantation areas are still used for the local community's rituals.

With time, some traditional practices began to wane. At present with better access to modern healthcare facilities and education, the practice of traditional medicine has declined as many of the younger people prefer modern medications and treatments. The younger generation no longer as dependent as their ancestors were on the forests for food resources and medicinal needs. The weaving practice or basketry is still practised by the communities, mostly by women. However, they do not rely on the forests around the area like Bukit Durang for Non-Timber Forest Products (NTFP) sources such as *Calamus* spp or rattan for their handicraft works. The community prefers to use synthetic raw materials for their weaving as there is a wide variety of materials available at a cheaper cost. The community is an important partner in supporting the monitoring of Wilmar's conservation areas to ensure the biodiversity area is protected.

Today, the communities within Saremas live together in the longhouses with many employed in the companies nearby including Wilmar. From planting fruit trees and vegetables in their land plots, many are now oil palm smallholders. The water catchment around the area, like lakes and ponds, are water sources for the community's daily needs, especially during the dry season. It is also a source to supplement protein needs for the communities making it crucial for the water sources to be conserved.

> The community is an important partner in supporting the monitoring of Wilmar's conservation areas to ensure the biodiversity is protected.

Figure 2

Local community involvement in Black Pepper plantation to boost their monthly income inside Saremas Estate.
© Photo: Wilmar

Way Forward

MOHD-AZLAN JAYASILAN, JAMES WONG AND CHIN SING YUN

Figure 1

It is important to incorporate the management of biodiversity and ensure a sustainable oil palm production where management strategies to increase biodiversity in agricultural landscapes could be considered.
© Photo: Jayasilan Mohd-Azlan

Agricultural expansion is one of the main drivers of deforestation, biodiversity losses, and environmental degradation across the regions of Borneo (Gaveau *et al.*, 2016). Oil palm monocultures support a low account of species diversity mainly due to the absence of forest vegetation and reduced heterogeneity. Thus, forest remnants and HCV forests in oil palm plantations such as Bukit Durang are of great conservation importance and managed accordingly.

Studying various aspects of biodiversity, such as species richness and composition, and physical structures of ecosystems and processes, could be demanding in terms of resources but essential in maintaining healthy biodiversity within agricultural dominated landscapes. Understanding diversity and ecology is crucial to biodiversity management, as it provides fundamental information about the habitat, niches and the way each species utilise the resources in the landscape. For example, forest specialists are of the greatest conservation concern when compared to non-forest or pioneer species (Aratrakorn *et al.*, 2006; Sheldon *et al.*, 2010). Distribution and abundance models for these species can serve as a tool for evaluating conservation opportunities (Alexander *et al.*, 2017). This will help to identify the gaps and pragmatic approach to improve the management of the fragmented forests in the plantation landscape. Managing isolated small populations in forest fragments such as Bukit Durang as part of larger metapopulation to prevent their local extinction is the way forward. Accurate estimates of population size are critical to conservation efforts as reliable abundance estimates can enable the prioritisation of critically endangered populations and secure resources for immediate and future conservation work (Brooks *et al.*, 2006). Additionally, with reliable estimates of species abundance, whether in response to conservation management or baseline studies, a management plan can be adapted and improved to meet the dynamic biodiversity conditions.

The level of disturbance in fragmented forests can partly influence species diversity. This includes invasive, domestic and introduced species. Therefore, when designing the oil palm plantation management plan, it is crucial to incorporate the management of these threats to safeguard biodiversity and ensure a sustainable ecosystem. The local community and plantation workers need to be educated and made aware of the importance of conservation. Pets and domestic animals should not be encouraged near forest edges as some of these species can compete for resources, transmit zoonotic disease and prey on wildlife. Wildlife in isolated populations such as those in Bukit Durang (especially the endemic species and habitat specialists) are highly vulnerable to localized extinction processes. In view of this, the HCV management unit needs to monitor the distribution and population of species present in this area as the density of invasive species can influence other species that utilize the same resource.

Expansion and intensification of agriculture remain one of the greatest threats to many of the Bornean biodiversity. Hence, wildlife monitoring can provide a measure for conservation success.

Figure 2

Water management is an important aspect of oil palm plantation and Bukit Durang can play an important catchment role in this area.
© Photo: Wilmar

Biodiversity monitoring will enable managers to better predict and prevent threats that correspond to a species' response in which alternative solutions can be implemented for comprehensive management of Bukit Durang within the oil palm landscape. Future research on population and community structure must be continued where sustainability is concerned and minimize negative edge impacts on biodiversity in Bukit Durang area. Our study showed that many species of conservation importance are thriving in Bukit Durang (e.g. Sun bear, Pangolin, Marbled cat). Improving habitat connectivity and buffers will facilitate the persistence and perhaps slow the decline of various flora and fauna communities in the plantation landscape mosaic. As the only remaining forest landscape within the plantation landscape, protecting and conserving Bukit Durang is crucial in sustaining the biodiversity in the Ulu Suai District which in turn shall preserve the cultural heritage of the local communities.

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Bukit Durang plays a crucial role in Saremas as refugia for biodiversity and ecosystem services.

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Bukit Durang Conservation Area provides opportunities for research and education for better understanding the ecology and to create awareness among stakeholders in Sarawak.

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