




An Update of the Biodiversity in Pulau Ubin, Singapore



Edited by Robert Teo, Geoffrey Davison, Sunshine Sim and Leroy Alphonso

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Foreword

Singapore is widely known as a densely populated, fast-paced city. But we also have a wealth of natural heritage nestled within our small island nation – with Pulau Ubin being one of our finest examples.

At just 1,000 hectares, the island has a remarkable mix of habitats, from mangroves, rocky shores, forests, old fruit plantations, scrubland to freshwater ponds. Within these habitats, a wide range of flora and fauna call Ubin home.

Much work has gone into understanding and protecting this biodiversity. This includes years of monitoring, habitat enhancement, species recovery initiatives and biodiversity surveys. This publication brings together these findings, including the Comprehensive Ubin Biodiversity Survey, which marked the first time such a survey was conducted across the entire island.

The findings showcase Pulau Ubin as a compelling case study of successful biodiversity conservation efforts, highlighting Ubin's significance in Singapore's conservation landscape.

We are still discovering undescribed species as well as new records of native plants and animals for Singapore, like the Swamp Tiger Butterfly (*Danaus affinis malayanus*) and the Singed Nomad Bee (*Nomada adusta*). These are a reminder of just how much life thrives on this island, and why continued exploration and scientific inquiry matter.

This publication is also a testament to what can be achieved through partnership. It reflects years of collaboration between researchers, citizen scientists, government agencies, and the wider community – each contributing a piece to our growing understanding of Pulau Ubin.

We hope Ubin's story – one of resilience, discovery, and the power of working together – inspires you to play your part in protecting the natural world around us.

Alvin Tan
Minister of State, Ministry of National Development &
Ministry of Trade and Industry
Chairman of the Friends of Ubin Network

Updated inventories highlight importance of Pulau Ubin for biodiversity conservation in Singapore

R.C.H. Teo[1] & G.W.H. Davison[2]

[1]Pulau Ubin Branch, National Parks Board,
61 Pulau Ubin, 508310 Singapore
Robert_Teo@nparks.gov.sg
[2]National Parks Board,
1 Cluny Road, 259569 Singapore

ABSTRACT. We discuss the extent of vegetation clearance on Pulau Ubin from past anthropogenic activities and the recovery of vegetation cover through natural regeneration and restoration efforts. This paper documents key taxonomic groups and demonstrates the importance of restored vegetation cover and corresponding wildlife habitats to the biodiversity value of Pulau Ubin.

Keywords. Assemblage, baseline, biodiversity, conservation, flora, fauna, inventory, survey, vegetation.

Introduction

Pulau Ubin (1°25'N, 103°57'E) is a granite island located northeast of the main island of Singapore. Spanning 1,023.9 hectares (Foo, 2002), the island stretches approximately 8 km in length from east to west and 1.7 km from north to south at its widest point. Two smaller islets, Pulau Ketam and Pulau Sekudu, lie just south of Pulau Ubin. The island's topography is characterised by undulating terrain, with hilly areas concentrated in the east and west. Notable peaks include Bukit Tajam (58 m) and Bukit Tinggi (55 m) in the west. Puaka Hill (50 m) used to be the highest point at 74 m, but the summit had been levelled by granite quarrying activities, possibly between the mid-1980s and early 1990s.

Once a hub of intensive agriculture, aquaculture and granite mining, Pulau Ubin has witnessed the cessation of all large-scale economic activities over the past five decades. Agriculture was a mainstay of the island's economy and included rubber, coconut, coffee, pineapple, and jasmine cultivation. An extensive network of riverine mangroves used to divide Pulau Ubin into five distinct land masses, until the construction of bunds for commercial aquaculture subsequently united those into a single island. Most of the mangrove swamps were converted to ponds for the prawn farming. Granite quarrying emerged as the island's primary economic activity until the last quarry was decommissioned in 1999, leaving behind large, excavated pits that have since filled with rainwater, creating scenic lakes.

In 2014, The Ubin Project (NParks, 2024; Er, 2016) was initiated with a vision for "Ubin to remain as a familiar and rustic getaway, where we can reminisce the past and celebrate the present, where our children can learn about and enjoy thriving biodiversity, where we can come together to enhance its idyllic charm through sustainable means and practices, for future generations of Singaporeans". Today, most of Pulau Ubin is managed by the National Parks Board (NParks) for the conservation of its natural and cultural heritage. The residential population has dwindled to about 30 people, but the island attracts over 300,000 visitors annually from the main island of Singapore. Popular activities include camping, cycling, fishing, hiking, nature appreciation and photography.

Changes in Vegetation and Wildlife Habitats

Turner et al. (1992) presumed that the original vegetation of Pulau Ubin likely comprised lowland dipterocarp forest and mangrove swamps. Much of these pristine habitats had, however, been cleared by the late 19th century for agriculture, aquaculture and granite mining. Only some patches of mangroves at Sungei Besar and Sungei Mamam were largely left untouched. With the decline and phasing out of the key economic activities and the subsequent dwindling of the local population, nature began to reclaim the land with regenerated secondary forest and mangroves. Based on aerial photographs taken by the military and NParks from 1950s to 2000 and satellite imagery from GoogleEarth, there was more natural vegetation cover in 2024 than in the 1950s (Fig. 1). The present vegetation comprises a significant extent of mangroves and associated muddy intertidal areas in the central part of the island through which the main rivers run, as well as fringing mangroves along other creeks. Landwards, secondary forest can be found in various stages of regeneration over former rubber plantations and abandoned fruit orchards and coconut groves. Largely bare areas or “derelict” sites identified by Turner et al. (1992) had also been rehabilitated and planted up by NParks through its habitat enhancement programme. Gaw et al. (2019) classified most of the vegetation on the island as “mangroves” or “vegetation with limited human management (with tree canopy)” (Fig. 2).

The change in vegetation coverage would have invariably led to corresponding changes in habitats for wildlife as well as better connectivity amongst previously fragmented habitats. The increase in forest and mangrove cover, both in extent, structure and maturity, could be expected to favour forest-dependant wildlife and result in an increase in their distribution and abundance. A more vegetated Pulau Ubin could also serve as an ecological sink for wildlife dispersing from surrounding areas and lead to an increase in species assemblage. The island might also serve as an ecological stepping stone providing connectivity for wildlife dispersal to the main island of Singapore.

Flora and Fauna Inventories

Significant post-colonial efforts to document the biodiversity of Pulau Ubin began in the early 1990s when the Nature Society Singapore (NSS) formulated a conservation proposal with a checklist of birds ((Lim, 1992), and the National University of Singapore (NUS) published a paper on vascular plants (Turner et al., 1992). Those were complemented by a preliminary survey of mammals, herptiles (reptiles and amphibians), fish and nocturnal birds in 1993 by NSS (Subaraj, 1996). NParks started managing part of Pulau Ubin in 1997 and partnered NSS on a more extensive survey of vertebrates from 1999–2001. NParks followed up with a survey of the vascular flora of Tanjong Chek Jawa at the south-eastern corner of the island (Lee et al., 2003) and a survey of butterflies from 2003–2005. An intensive survey of vascular flora for the whole island was conducted by NParks from 2007–2015. A “Bioblitz@Ubin” in 2016 (Zhaki Abdullah, 2016) saw researchers and naturalists engaging the public to document 15 taxa (ants, assassin bugs, beetles, orthopterans, moths, butterflies, hymenopterans, spiders, fireflies, odonates, mammals, reptiles, amphibians, birds and fish) within a 24-hour period.

Most recently, NParks commissioned the Comprehensive Ubin Biodiversity Survey (CUBS) from 2018–2022 with surveys of various taxonomic groups by researchers and volunteers from NSS, NUS, and the Nanyang Technological University. The objectives were to update existing inventories and establish new baseline inventories of fauna found on Pulau Ubin. A map was provided to CUBS researchers to standardise the names of locations on the island (Fig. 3). As this was the first large-scale biodiversity survey for Pulau Ubin, researchers were left to employ their preferred survey methodologies without standardising survey transects or plots. Researchers for each taxon were supported by a coordinator appointed by NParks to provide support for scheduling of surveys, arrangements for transport and logistical support, requirements for equipment, and other related tasks.

This publication focuses on the biodiversity of Pulau Ubin, providing updated and new baseline inventories of key taxa of flora and fauna. Though not exhaustive in the coverage of taxa, the studies contributed significantly to our understanding of the island's biodiversity and its role in Singapore's broader conservation efforts. This publication comprises 11 papers (Table 1) that incorporate the findings of CUBS, unpublished data gathered in previous surveys, as well as data from recent surveys that were not part of CUBS (vascular flora and beetles).

Table 1. List of papers.

S/No.	Taxon	Paper	Authors	CUBS Coordinators
1	Vascular plants	An update on the vascular flora of Pulau Ubin, Singapore	Robert Teo, Ali Ibrahim, Bazilah Ibrahim, Ho Boon Chuan, Koh Sin Lan & Lua Hock Keong,	-
2	Bees, wasps and ants	Bees, wasps, and ants of Pulau Ubin, Singapore (Insecta: Hymenoptera)	John Ascher, Zestin Soh, Justin Tan, Vera Lim, John Lee, Liew Qi, Jacqueline Chua, Anya Gajanur, Ong Xin Rui, Eunice Soh, Tan Yong Guang, Lim Yu Jun, Robin Southon & Chui Shao Xiong	Justin Tan
3	Beetles	On the coleopteran fauna of Pulau Ubin, Singapore	Cheong Loong Fah & Sean Yap	-
4	Butterflies	Butterfly survey of Pulau Ubin, Singapore	Khew Sin Khoon	Nur Fatin Salleh
5	Crickets, grasshoppers and katydids	Orthoptera in Pulau Ubin: unravelling diversity using systematic sampling and qualitative boat surveys	Joseph Lin, Rachel Lee & Tan Ming Kai	Joseph Lin
6	Dragonflies and damselflies	Diversity, distribution and habitat characteristics of odonates (Insecta: Odonata) in Pulau Ubin, Singapore	Teo Kah Ming, Alex Figueroa, Robin Ngiam & Germaine Leng	Germaine Leng
7	Leaf insects and stick insects	Stick and leaf insects in Pulau Ubin, Singapore, in 2018–2020	Francis Seow-Choen, Azlin Sani, Eunice Tan & Chua Ee Kiam	Leroy Alphonso
8	Moths	Moths of Pulau Ubin, Singapore – a first assessment highlights many new records for the island and Singapore	Anuj Jain, Jerome Chua & Gan Cheong Weei	Siti Khadijah

Table 1. Continuation.

S/No.	Taxon	Paper	Authors	CUBS Coordinators
9	Spiders	Diversity of Spiders (order Aranae) in Pulau Ubin, Singapore	Paul Ng, Christina Choy, Liew Qi & Chris Ang	Christina Choy
10	Birds	The significance of Pulau Ubin for Singapore's avifauna, with a focus on species of conservation concern	Teo Kah Ming, Lim Kim Chuah, Joseph Lin, Lim Kim Keang, Yong Ding Li, Jacky Soh & Ng Lay Hoon	Jacky Soh
11	Amphibians, reptiles and mammals	Updated Inventory of Amphibians, Reptiles and Mammals of Pulau Ubin, Singapore	Noel Thomas, Nick Baker, Fung Tze Kwang, Chiok Wen Xuan & Robert Teo	Noel Thomas

Summary of Results

Table 2 lays out a summary of the past and updated inventories of flora and fauna of Pulau Ubin (only taxa identified to species level have been included).

Table 2. Summary of results

S/No.	Taxon	Number of Native Species (Year)			Number of Undescribed Species	Number of New Records for Singapore
		Previous Inventory	Updated Inventory	Increase		
1	Vascular plants	301 (2003)	565 (2024)	264	-	2
2	Bees, wasps and ants	-	187 (2022)	-	1	1
3	Beetles	-	187 (2019)	-	3	3
4	Butterflies	134 (2006)	205 (2021)	71	-	1
5	Crickets, grasshoppers and katydids	42 (2018)	52 (2019)	10	-	-
6	Dragonflies and damselflies	55 (2017)	61 (2019)	6	-	1
7	Leaf insects and stick insects	-	4 (2019)	-	1	1
8	Moths	-	194 (2021)	-	-	35
9	Spiders	-	119 (2020)	-	8	14
10	Amphibians	6 (2001)	6 (2021)	-	-	-

Table 2. Continuation.

S/No.	Taxon	Number of Native Species (Year)			Number of Undescribed Species	Number of New Records for Singapore
		Previous Inventory	Updated Inventory	Increase		
11	Reptiles	32 (2001)	45 (2021)	13	-	-
12	Birds	229 (2017)	250 (2022)	21	-	-
13	Mammals	22 (2001)	35 (2021)	13	-	3

New baseline inventories have been established for bees, wasps and ants (Ascher et al., 2025), beetles (Cheong & Yap, 2025), leaf insects and stick insects (Seow-Choen et al., 2025), moths (Jain et al., 2025) and spiders (Ng et al., 2025). The updated checklists for those taxa are in Appendices 1–7, respectively. The checklists of fauna included in the remaining papers in this volume (see below, and References) are predominantly snapshots of the current situation rather than complete lists of all the species that have been recorded historically on Pulau Ubin. In Appendices 8–11, we have compiled both the present survey results from CUBS and the historical records to give as complete lists as we can.

Over 190 species of moths were identified to species level, with over 170 additional taxa determined only to genus, subfamily or family level. Of those, 35 species were new records for Singapore (Jain et al., 2025) and only 32 of them were listed by Davison et al. (2024) in the Singapore Red Data Book, which had 152 species of moths for Singapore.

There were 187 species of beetles identified to species level and in addition, over 130 species were yet to be determined, including three that are potentially new to science (Cheong & Yap, 2025). The Singapore Red Data Book (Davison et al., 2024) has a list of only 85 species of beetles for which a conservation status for Singapore could be assigned. No complete and modern checklist of the national beetle fauna exists.

For Hymenoptera, there were 187 species comprising 61 ant species, 58 bee species and 68 wasp species, including an undescribed bee species (Ascher et al., 2025).

Out of over 190 taxa of spiders documented, 119 were confirmed to species level – 14 species were new to Singapore, including 8 undescribed species. There were 14 species that were recorded in Singapore only from Pulau Ubin (Ng et al., 2025).

The inventory for phasmids comprises only five species, but one is an undescribed species (Seow-Choen, 2025). This was surprising as 40 extant species were listed in the Singapore Red Data Book (Davison et al., 2024). Clearance of primary forest vegetation in past decades is a likely cause of impoverishment.

For taxa with existing inventories compiled prior to CUBS, the most significant change was for vascular flora, where 565 native species were recorded (including two new records for Singapore), an increase of 264 species over the baseline in 2003. This was largely due to sustained surveys (2007–2015) and ad hoc collections of plants by NParks from late 2003 – end 2024. The full list of vascular flora can be found in Teo et al. (2025c), including another 316 species native to Singapore that occur on Pulau Ubin through NParks' habitat enhancement and species recovery efforts. Together these represented about 48% of the extant native vascular flora of Singapore.

The butterfly survey of 2003–2005 established a baseline inventory of 134 species, which has been updated to 205 species (an increase of 71 species) with data from CUBS (Khew, 2025) and records maintained by NParks (Appendix 8). This could be attributed mainly to increased efforts to document and report sightings via social media platforms (www.butterflycircle.com; www.facebook.com/groups/butterflysm).

Sampling from CUBS (Lin et al., 2025) increased the inventory for crickets, grasshoppers and katydids to 52 species with an addition of 10 species (Appendix 9).

The inventory for dragonflies and damselflies saw an increase of six species to 61 species, including a new record for Singapore (Appendix 10).

The composition of amphibians remained unchanged at six native species; this is not surprising due to the dearth of natural freshwater habitats on Pulau Ubin. There was an increase of 13 species for reptiles, primarily from ad hoc records maintained by NParks. The inventory for mammals increased to 13 species, primarily through new records of bats (including three new species for Singapore). The updated checklists for amphibians, reptiles and mammals can be found in Thomas et al. (2025).

For avifauna, there was a significant increase of 21 species to 250 species from surveys carried out (Teo, 2025b) and ad hoc records maintained by NParks (Appendix 11). A significant portion of the latter was a result of reports via social media by the birding and bird photography community.

Where Do We Go from Here?

A significant milestone in cataloguing Pulau Ubin's biodiversity has been achieved through the update of existing inventories and the establishment of new ones. The efforts have yielded new benchmark references for 13 flora and fauna groups, substantially enhancing our understanding of the island's biodiversity richness. The updated inventories, however, offer just a vignette of Pulau Ubin's biodiversity offering a current glimpse of the temporal variation as habitats change over time. The studies have also highlighted areas requiring further investigation.

The limited surveys for insects like bees, wasps and ants, beetles, leaf insects and stick insects, and moths have likely revealed only a fraction of the existing diversity of those taxa in Pulau Ubin. It was clear that moths and beetles were understudied even for the rest of Singapore when inventories for Pulau Ubin were compared to checklists in the Singapore Red Data Book (Davison et al, 2024). More surveys and taxonomic work are needed to uncover additional species and identify species yet to be determined to species level. In addition, information on many other insects including cockroaches, flies, mantids, springtails and true bugs, is practically non-existent for Pulau Ubin. There is impetus to facilitate further research on them to have a more complete understanding of insect diversity for the island. The same can be said for fauna like terrestrial and freshwater annelids, onychophorans, myriapods, arachnids (apart from spiders), crustaceans and molluscs, non-vascular flora (algae and bryophytes) and fungi. Much has been done to document the intertidal biodiversity of Pulau Ubin, especially at Chek Jawa Wetlands, through citizen science efforts (https://wildshores.blogspot.com) and these could be supplemented with systematic in-depth surveys.

These knowledge gaps underscore the need for continued research to better understand and conserve Pulau Ubin's biodiversity. Future studies focusing on the under-represented groups could reveal previously undiscovered species and information crucial for formulating conservation strategies and management plans. The papers presented in this volume mark a significant milestone in documenting Pulau Ubin's biodiversity while also highlighting the importance of sustained biodiversity research for the long-term conservation of Singapore's natural heritage.

Pulau Ubin – a Core Area for Biodiversity Conservation in Singapore

Singapore developed a Nature Conservation Master Plan in 2015, with subsequent revisions, as part of the nation's commitments under international agreements as well as helping to fulfil national aspirations. The Master Plan identifies four thrusts, on the conservation of key habitats; on habitat enhancement, restoration and species recovery; on applied research in biodiversity conservation and planning; and on community stewardship and outreach. Pulau Ubin forms part of the Northern Core for nature conservation (together with Pulau Tekong and nearby parts of the main island. Pulau Ubin has the largest contiguous area of mangroves in Singapore and is also designated as a Nature Area under the Parks and Waterbodies Plan prepared by the Urban Redevelopment Authority. A policy decision has been made to retain the atmosphere of Pulau Ubin as a rustic and natural environment. The catalogues of species included in this volume's papers confirm Pulau Ubin's importance as a core area for biodiversity.

Numerous projects have been carried out to enhance habitats and biodiversity, including reforestation and mangrove restoration to extend or improve connectivity of habitats, creation of butterfly habitats and floating wetlands, repeated censuses of rare and interesting species, and species-specific actions such as provision of artificial bat roosts, hornbill nesting boxes and artificial otter holts. Herons, red junglefowl, straw-headed bulbuls, white-rumped shamas, leopard cats, otters, migrant wading birds and others have all been subjects for repeated surveys to track their population size and distribution. These have been accompanied by applied research, by staff of NParks, academics and members of the nature community. Pulau Ubin is also a centre for public nature-based activities and outreach, throughout the island but notably at Chek Jawa Wetlands and in the vicinity of the NParks offices.

Pulau Ubin represents a unique microcosm of Singapore's natural heritage, showcasing the resilience of ecosystems and the potential for biodiversity recovery in landscapes highly impacted by past anthropogenic activities. As large tracts of land were left to regenerate, refugia for wildlife formed increasing the populations and distribution of existing species and possibly also attracting others to colonise from neighbouring areas around Pulau Ubin. The ongoing transformation from a highly exploited island to a biodiversity haven offers valuable lessons in conservation and sustainable land management within the context of a highly urbanised nation.

The importance of Pulau Ubin to nature conservation in Singapore is highlighted by discovery of numerous species new to Singapore in this volume, as well as the many undescribed species that are potentially new to Singapore or even to science. Notwithstanding these, the island's significance can also be seen in the distribution of many threatened species in Singapore. Populations of several species in Singapore including two bats (*Hypsugo macrotis* and *Taphozous longimanus*), a butterfly (*Celaenorrhinus asmara*) and several plants (*Ficus subulata*, *Hoya obtusifolia*, *Pterospermum diversifolium*, *Actinoscirpus grossus* and *Blumea balsamifera*) are restricted to Pulau Ubin. The main populations of three mammals (*Aonyx cinereus*, *Hipposideros cineraceus* and *Tragulus napu*), two snakes (*Bungarus fasciatus* and

Dryophiops rubescens), a bird (*Pycnonotus zeylanicus*), a butterfly (*Euploea tulliolus*) and two plants (*Knema corticosa* and *Neuwiedia veratrifolia*) are found in Pulau Ubin. In addition, the key populations of a bat (*Megaderma spasma*), two birds (*Copsychus malabaricus* and *Pitta megarhyncha*) and a plant (*Utania nervosa*) reside in Pulau Ubin and Pulau Tekong.

To conserve the vast biodiversity of Pulau Ubin, NParks is cognizant of the need to safeguard a good balance of ecosystems including mangroves and mudflats, intertidal shoreline habitats, secondary forest and the limited number for freshwater streams, as well as to main transient habitats like open scrub and grassland. Efforts have been underway to enhance habitats at areas heavily impacted by past anthropogenic activities like agriculture, aquaculture and granite mining and human settlements. Many species are, however, dependent on open scrub and grassland as well as open mudflats for their survival and NParks has intentionally maintained such habitats instead of converting them into forest or mangrove forest to conserve the associated species assemblage. With careful management, Pulau Ubin will continue to be a stronghold for many species of plants and animals and host an important component of Singapore's biodiversity.

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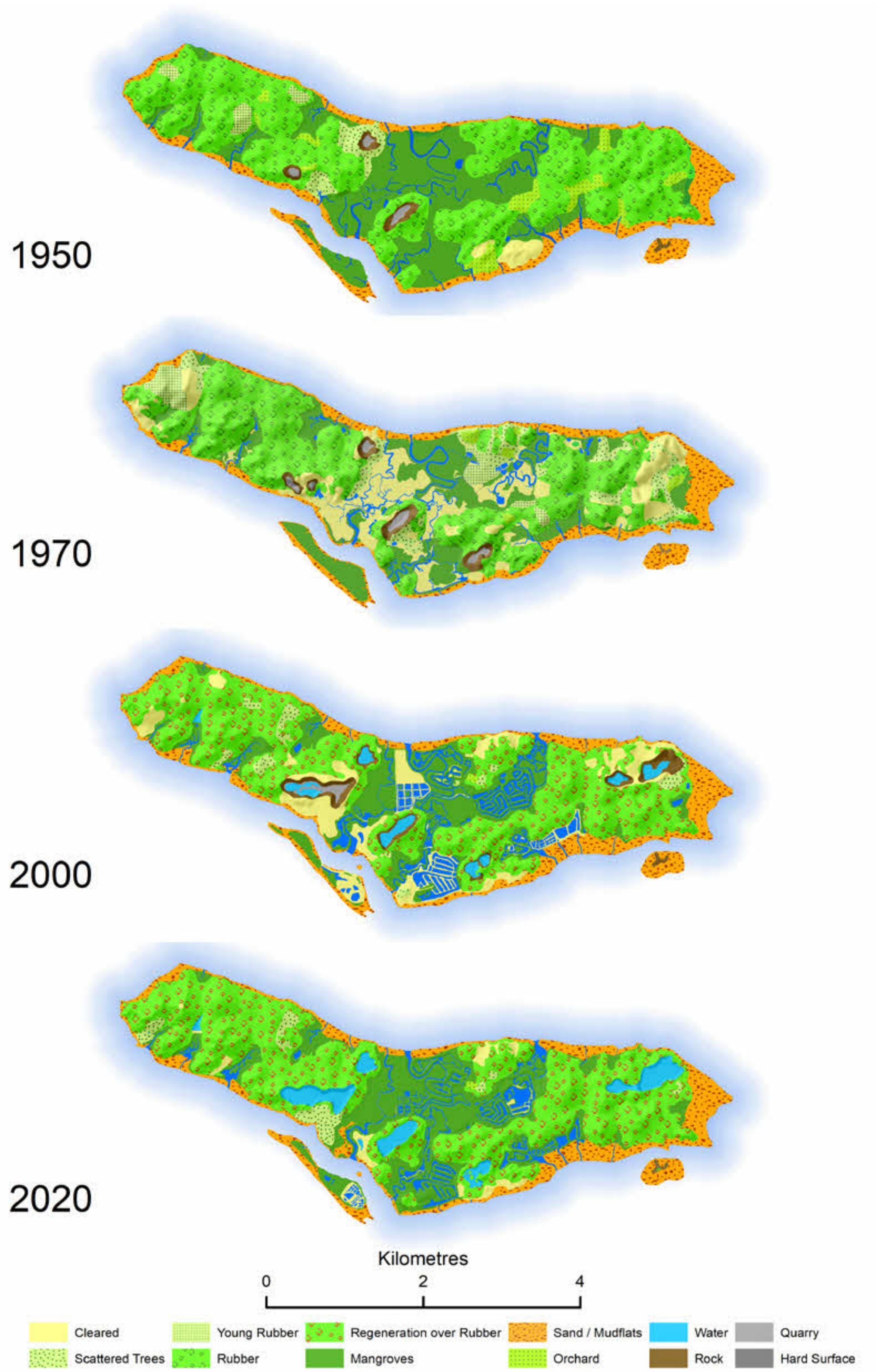

Fig. 1 Vegetation coverage in Pulau Ubin in 1950, 1970, 2000 and 2020 (derived from aerial photographs from the Ministry of Defence, Singapore, National Parks Board and satellite imagery from GoogleEarth).

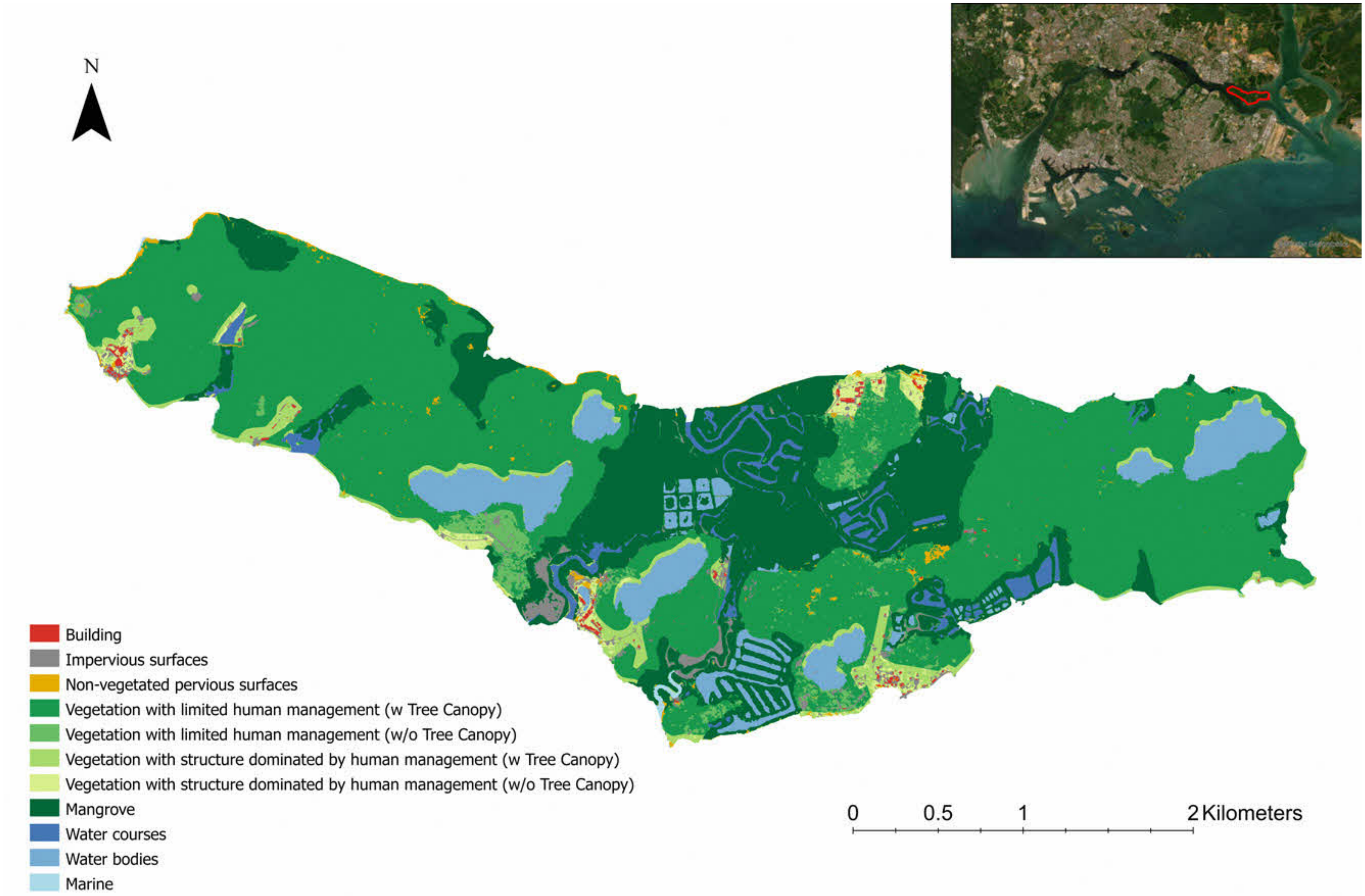

Fig. 2 Present-day vegetation of Pulau Ubin (extracted from Gaw et al (2019)).

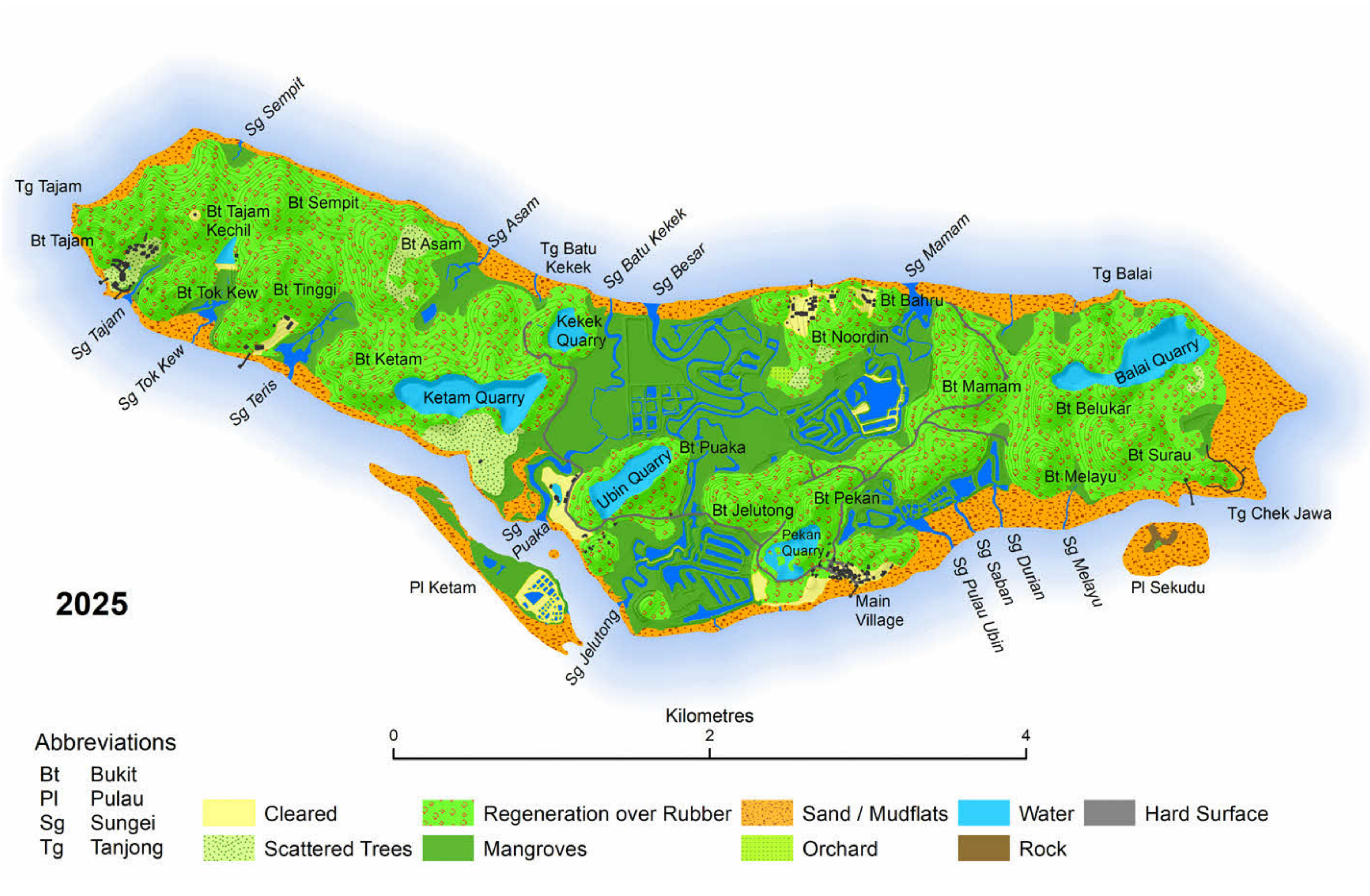

Fig. 3 Map of Pulau Ubin with location names.

Appendix 1. List of Bees of Pulau Ubin (identified to at least genus)

S/No.	Family	Scientific Name
1	Colletidae	*Hylaeus* (*Nesoprosopis*) *penangensis*
2	Colletidae	*Hylaeus* (*Nesoprosopis*) *transversalis*
3	Colletidae	*Hylaeus* (*Nesoprosopis*) sp. 2
4	Colletidae	*Hylaeus* (new subgenus nr. *Prosopisteron*) aff. *jacobsoni*
5	Halictidae	*Austronomia takauensis*
6	Halictidae	*Lipotriches* (*Rhopalomelissa*) *ceratina*
7	Halictidae	*Nomia* (*Acunomia*) *iridescens*
8	Halictidae	*Nomia* (*Acunomia*) *lusoria*
9	Halictidae	*Nomia* (*Acunomia*) *strigata*
10	Halictidae	*Nomia* (*Gnathonomia*) *thoracica*
11	Halictidae	*Nomia* (*Hoplonomia*) *incerta*
12	Halictidae	*Nomia (Maculonomia) terminata* Smith, 1875
13	Halictidae	*Pseudapis* (*Pseudapis*) *siamensis*
14	Halictidae	*Eupetersia* (*Nesoeupetersia*) *malayensis*
15	Halictidae	*Lasioglossum* (*Ctenonomia*) *albescens albescens*
16	Halictidae	*Lasioglossum* (*Ctenonomia*) *deliense*
17	Halictidae	*Lasioglossum* (*Ctenonomia*) *halictoides*
18	Halictidae	*Lasioglossum (Ctenonomia)* sp. 1 [nr. *vagans*]
19	Halictidae	*Lasioglossum* (*Ctenonomia*) sp. 2 [nr. v*agans*]
20	Halictidae	*Lasioglossum* (*Ctenonomia*) sp. 3 [nr. v*agans*]
21	Halictidae	*Lasioglossum* (*Homalictus*) *adonidiae*
22	Halictidae	*Lasioglossum* (*Homalictus*) aff. *Latitarse*
23	Halictidae	*Lasioglossum* (*Homalictus*) *singapurellum*
24	Halictidae	*Patellapis* (*Pachyhalictus*) *murbanus*
25	Halictidae	*Sphecodes* sp. 4 [cf. *kershawi*]
26	Megachilidae	*Lithurgus* sp. 1 [smaller]
27	Megachilidae	*Lithurgus* sp. 2 [cf. *collaris*]
28	Megachilidae	*Anthidiellum* (*Pycnanthidium*) *smithii smithii*
29	Megachilidae	*Euaspis polynesia*
30	Megachilidae	*Heriades* (*Michenerella*) *othonis*
31	Megachilidae	*Coelioxys* (*Callosarissa*) *confusus*
32	Megachilidae	*Coelioxys* (*Allocoelioxys*) sp. 3
33	Megachilidae	*Megachile* (*Aethomegachile*) *conjuncta*
34	Megachilidae	*Megachile* (*Aethomegachile*) *laticeps*
35	Megachilidae	*Megachile* (*Aethomegachile*) sp. 1 nr. *borneana*

Appendix 1. Continuation

S/No.	Family	Scientific Name
36	Megachilidae	*Megachile* (*Aethomegachile*) sp. 2 [*fusciventris group*]
37	Megachilidae	*Megachile* (*Paracella*) *tricincta*
38	Megachilidae	*Megachile* (*Callomegachile*) *disjuncta*
39	Megachilidae	*Megachile (Callomegachile) fulvipennis*
40	Megachilidae	*Megachile* (*Chelostomoda*) *moera*
41	Megachilidae	*Megachile* (*Creightonella*) *atrata*
42	Megachilidae	*Megachile* (*Eutricharaea*) *subrixator*
43	Apidae	*Xylocopa* (*Biluna*) *iridipennis*
44	Apidae	*Xylocopa (Cyaneoderes) caerulea*
45	Apidae	*Xylocopa* (*Maiella*) *aestuans*
46	Apidae	*Xylocopa* (*Maiella*) *flavonigrescens*
47	Apidae	*Xylocopa* (*Platynopoda*) *latipes latipes*
48	Apidae	*Ceratina* (*Ceratinidia*) *accusator accusator*
49	Apidae	*Ceratina* (*Ceratinidia*) *collusor*
50	Apidae	*Ceratina* (*Ceratinidia*) *lieftincki*
51	Apidae	*Ceratina* (*Ceratinidia*) *nigrolateralis incerta*
52	Apidae	*Ceratina* (*Neoceratina*) *dentipes dentipes*
53	Apidae	*Ceratina* (*Pithitis*) *smaragdula smaragdula*
54	Apidae	*Ceratina* (*Pithitis*) *unimaculata palmerii*
55	Apidae	*Ceratina* (*Xanthoceratina*) *fuliginosa*
56	Apidae	*Ceratina* (*Xanthoceratina*) *metaria*
57	Apidae	*Braunsapis clarihirta*
58	Apidae	*Braunsapis cupulifera*
59	Apidae	*Braunsapis hewitti*
60	Apidae	*Braunsapis puangensis*
61	Apidae	*Nomada adusta*
62	Apidae	*Amegilla* (*Zonamegilla*) *andrewsi*
63	Apidae	*Thyreus himalayensis*
64	Apidae	*Thyreus lilacinus lilacinus*
65	Apidae	*Apis* (*Apis*) *cerana javana*
66	Apidae	*Apis* (*Megapis*) *dorsata dorsata*
67	Apidae	*Apis* (*Micrapis*) *andreniformis*
68	Apidae	*Apis* (*Micrapis*) *florea*
69	Apidae	*Heterotrigona* (*Heterotrigona*) *itama*
70	Apidae	*Lepidotrigona terminata*
71	Apidae	*Tetragonula* (*Tetragonula*) *valdezi*

Appendix 2. List of Wasps (identified to at least genus)

S/No.	Family	Scientific Name
1	Ampulicidae	*Ampulex compressa*
2	Crabronidae	*Bembecinus littoralis*
3	Crabronidae	*Bembecinus borneanus*
4	Crabronidae	*Bembecinus reversus*
5	Crabronidae	*Bembecinus insularis*
6	Crabronidae	*Bembix melancholica*
7	Crabronidae	*Nysson* sp.
8	Crabronidae	*Carinostigmus* cf. *maior*
9	Crabronidae	*Cerceris pictiventris*
10	Crabronidae	*Dasyproctus pentheri*
11	Crabronidae	*Dicranorhina ruficollis*
12	Crabronidae	*Liris subtesselatus*
13	Crabronidae	*Liris* sp.1
14	Crabronidae	*Liris* sp. 2
15	Crabronidae	*Liris* sp. 3
16	Crabronidae	*Liris* sp. 5 [red legs]
17	Crabronidae	*Nitela* sp.1
18	Crabronidae	*Nitela* sp. 2 (cf. *maxima*)
19	Crabronidae	*Oxybelus malaysianus*
20	Crabronidae	*Pison* cf. *argentatum*
21	Crabronidae	*Psenulus crabroniformis sumatranus*
22	Crabronidae	*Psenulus yoshimotoi*
23	Crabronidae	*Psenulus* sp.[orange metasoma]
24	Crabronidae	*Tachytes modestus*
25	Crabronidae	*Tachytes* sp. [dark legs]
26	Crabronidae	*Trypoxylon petiolatum*
27	Crabronidae	*Trypoxylon* cf. *schmiedeknechti*
28	Crabronidae	*Vechtia rugosa*
29	Sphecidae	*Chalybion bengalense*
30	Sphecidae	*Chalybion sumatranum*
31	Sphecidae	*Chlorion lobatum*
32	Sphecidae	*Isodontia diodon*
33	Sphecidae	*Isodontia severini*
34	Sphecidae	*Prionyx viduatus*
35	Sphecidae	*Sceliphron coromandelicum*

Appendix 2. Continuation

S/No.	**Family**	**Scientific Name**
36	Sphecidae	*Sceliphron javanumpetiolare*
37	Sphecidae	*Sphex diabolicus*
38	Sphecidae	*Sphex madasummae*
39	Sphecidae	*Sphex subtruncatus*
40	Sphecidae	*Sphex sericeus*
41	Chrysididae	*Stilbum cyanurum*
42	Mutillidae	Trogaspidiini [tribe] [cf. *Trogaspidia*] sp. [T1 red, T6 black]
43	Mutillidae	Trogaspidiini [tribe] [cf. *Trogaspidia*] sp. [T1 black, T6 red]]
44	Mutillidae	*Yamanetilla* sp.
45	Mutillidae	Mutillidae [genus undet] sp.1 [red propodeum, T1 red]
46	Mutillidae	Mutillidae [genus undet] sp.2 [red metasoma base]
47	Mutillidae	*Odontomutilla* sp.
48	Pompilidae	*Auplopus* sp.[cf. *blandus*]
49	Pompilidae	*Ceropales* sp.
50	Pompilidae	*Episyron* sp.
51	Pompilidae	*Macromeris violacea*
52	Pompilidae	*Paragenia* sp.
53	Pompilidae	*Tachypompilus analis*
54	Pompilidae	Pepsinae sp. 1 [cf. Java]
55	Pompilidae	Pepsinae [black body, green and bronze wings]
56	Pompilidae	Pompilidae [bicoloured wing, grey head and thorax, bluish tapering abdomen]
57	Pompilidae	Pompilidae [genus undet] sp.1 [small; yellowish on legs in T1]
58	Pompilidae	Pompilidae [genus undet.] sp. 2 [large, orange legs, head, and thoracic dorsum]
59	Scoliidae	*Campsomeriella collaris*
60	Scoliidae	*Megascolia azurea*
61	Scoliidae	*Megascolia capitata*
62	Scoliidae	*Phalerimeris phalerata*
63	Scoliidae	*Sericocampsomeris rubromaculata*
64	Scoliidae	*Sericocampsomeris stygia*
65	Scoliidae	*Microscolia* sp. 1
66	Scoliidae	*Scolia* sp. 1 [large, orange-tipped antennae]
67	Scoliidae	*Scolia* sp. 2 [orange head and pronotum and antennae]
68	Scoliidae	*Scolia* sp. 3 [orange head, antennae orange but dark-tipped]
69	Tiphiidae	*Tiphia* sp. 1 [partly red mid and hind legs]

Appendix 2. Continuation

S/No.	Family	Scientific Name
70	Vespidae	*Allorhynchium argentatum*
71	Vespidae	*Allorhynchium snelleni*
72	Vespidae	*Antepipona bipustulata*
73	Vespidae	*Apodynerus troglodytes*
74	Vespidae	*Delta campaniforme*
75	Vespidae	*Delta pyriforme circinale*
76	Vespidae	*Eumenes* aff. *punctatus*
77	Vespidae	*Eustenogaster hauxwellii*
78	Vespidae	*Eustenogaster micans*
79	Vespidae	*Labus amoenus*
80	Vespidae	*Liostenogaster varipicta*
81	Vespidae	*Omicroides* sp.
82	Vespidae	*Paraleptomenes communis*
83	Vespidae	*Parapolybia varia*
84	Vespidae	*Parischnogaster mellyi*
85	Vespidae	*Parischnogaster nigricans*
86	Vespidae	*Phimenes flavopictus*
87	Vespidae	*Phimenes* sp. [all black]
88	Vespidae	*Polistes sagittarrius*
89	Vespidae	*Polistes stigma*
90	Vespidae	*Polistes tenebris*
91	Vespidae	*Polistes tenebricosus*
92	Vespidae	*Rhynchium haemorrhoidale*
93	Vespidae	*Ropalidia fasciata*
94	Vespidae	*Ropalidia stigma*
95	Vespidae	*Ropalidia timida*
96	Vespidae	*Stenodyneriellus guttulatus*
97	Vespidae	*Stenodyneriellus* sp. 1
98	Vespidae	*Subancistrocerus sichelii*
99	Vespidae	*Subancistrocerus* sp. 1 [red legs, white spotted metanotum]
100	Vespidae	*Subancistrocerus* sp. 2 [larger terminal flagellar segment]
101	Vespidae	*Subancistrocerus* sp. 3 [smaller terminal flagellar segment]
102	Vespidae	*Vespa affinis*
103	Vespidae	*Vespa analis*
104	Vespidae	*Vespa tropica*

Appendix 2. Continuation

S/No.	Family	Scientific Name
105	Vespidae	*Zethus* sp. 1 [black]
106	Vespidae	*Zethus* sp. 2 [red tegulae]
107	Ceraphronidae	Ceraphronidae sp. 1
108	Aphelinidae	Aphelinidae sp. 1
109	Chalcididae	*Antrocephalus* sp. 1
110	Chalcididae	*Antrocephalus* sp. 2
111	Chalcididae	*Brachymeria* sp. 1 cf. *euploeae*
112	Chalcididae	*Brachymeria* sp. 2
113	Chalcididae	*Brachymeria* sp. 3
114	Chalcididae	*Hockeria* sp. 1
115	Chalcididae	*Trigonura* sp.1
116	Encyrtidae	Encyrtidae sp. 1
117	Eucharitidae	*Chalcura* sp. 1
118	Eucharitidae	*Stilbula* sp. 1
119	Eucharitidae	*Schizaspidia* sp.1
120	Eulophidae	Eulophidae sp. 1
121	Leucospidae	*Leucospis bakeri*
122	Leucospidae	*Leucospis* [*elegans* group] sp. 1
123	Leucospidae	*Leucospis petiolata* Fabricius, 1787
124	Mymaridae	Mymaridae sp. 1
125	Perilampidae	Perilampidae [genus undet] sp.1
126	Perilampidae	Perilampidae [genus undet] sp.2
127	Pteromalidae	Pteromalidae sp. 1
128	Trichogrammatidae	Trichogrammatidae sp. 1
129	Torymidae	*Podagrion* sp. 1
130	Evaniidae	*Evania appendigaster*
131	Evaniidae	*Prosevania* sp.1
132	Gasteruptiidae	*Gasteruption* sp. 1
133	Braconidae	Agathidinae [genus undet] sp. 1 [black wings]
134	Braconidae	cf. *Shelfordia foveata* sp. 1
135	Braconidae	Braconinae [genus undet] sp. 2 [orange-and-black wings]
136	Braconidae	Braconinae [genus undet] sp. 3 [yellow-and-black wings]
137	Braconidae	Braconinae [genus undet] sp. 4 [small, black]
138	Braconidae	Braconinae [genus undet] sp. 5 [large; orange wings]
139	Braconidae	Cardiochilinae [genus undet] sp.1

S/No.	Family	Scientific Name
140	Braconidae	Cheloninae [genus undet] sp. 1
141	Braconidae	Doryctinae [cf. Zombrus] sp. 1
142	Braconidae	*Choeras* sp.
143	Braconidae	Microgastrinae [genus undet] sp. 1
144	Braconidae	Rogadinae [genus undet] sp. 1
145	Ichneumonidae	*Astomaspis* sp. 1
146	Ichneumonidae	Camplopleginae sp. 1
147	Ichneumonidae	Cryptini sp. 1
148	Ichneumonidae	Cryptinae [tribe undet] sp. 1
149	Ichneumonidae	*Leptobatopsis* sp.
150	Ichneumonidae	*Nematopodius* sp.
151	Ichneumonidae	Ophiinae [genus undet] sp. 1
152	Ichneumonidae	Pimplinae [*Theronia* genus group] sp. 1
153	Ichneumonidae	*Xanthopimpla* sp. 1
154	Platygastridae	Scelioninae [genus undet] sp.1
155	Stephanidae	*Pseudomegischus* cf. *sulcifrons*

Appendix 3. List of Ants (identified to at least genus)

S/No.	Family	Scientific Name
1	Formicidae	*Myopopone castanea*
2	Formicidae	*Dolichoderus thoracicus*
3	Formicidae	*Dolichoderus* sp. 1
4	Formicidae	*Iridomyrmex anceps*
5	Formicidae	*Philidris* sp. 1
6	Formicidae	*Tapinoma melanocephalum*
7	Formicidae	*Technomyrmex albipes*
8	Formicidae	*Technomyrmex kraepelini*
9	Formicidae	*Anoplolepis gracilipes*
10	Formicidae	*Camponotus* (*Myrmamblys*) *bedoti*
11	Formicidae	*Camponotus* (*Myrmosericus*) sp. 1
12	Formicidae	*Camponotus* (*Tanaemyrmex*) sp. 1
13	Formicidae	*Colobopsis vitrea*
14	Formicidae	*Colobopsis* sp. 1
15	Formicidae	*Echinopla lineata*
16	Formicidae	*Nylanderia bourbonica*

Appendix 3. Continuation

S/No.	Family	Scientific Name
17	Formicidae	*Nylanderia kraepelini*
18	Formicidae	*Oecophylla smaragdina*
19	Formicidae	*Paraparatrechina* sp. 1
20	Formicidae	*Paratrechina longicornis*
21	Formicidae	*Polyrachis* (*Myrma*) sp. 1
22	Formicidae	*Polyrhachis* (*Myrmhopla*) *abdominalis*
23	Formicidae	*Polyrhachis* (*Myrmhopla*) *saevissima*
24	Formicidae	*Carebara affinis*
25	Formicidae	*Carebara castanea*
26	Formicidae	*Carebara diversa*
27	Formicidae	*Carebara overbecki*
28	Formicidae	*Crematogaster sewardi*
29	Formicidae	*Crematogaster subnuda discinodis*
30	Formicidae	*Crematogaster treubi*
31	Formicidae	*Crematogaster* (*Orthocrema*) *quadriruga*
32	Formicidae	*Liomyrmex gestroi*
33	Formicidae	*Lordomyrma* sp. 1
34	Formicidae	*Mayriella transfuga*
35	Formicidae	*Meranoplus bicolor*
36	Formicidae	*Monomorium floricola*
37	Formicidae	*Myrmicaria luteiventris*
38	Formicidae	*Pheidole plagiaria*
39	Formicidae	*Pheidole umbonata*
40	Formicidae	*Pheidole* sp. 1
41	Formicidae	*Pheidole* sp. 2
42	Formicidae	*Pheidole* sp. 3
43	Formicidae	*Pristomyrmex brevispinosus*
44	Formicidae	*Proatta butteli*
45	Formicidae	*Rhopalomastix johorensis*
46	Formicidae	*Solenopsis overbecki*
47	Formicidae	*Strumigenys eggersi*
48	Formicidae	*Strumigenys emmae*
49	Formicidae	*Strumigenys rofocala*
50	Formicidae	*Strumigenys rogeri*
51	Formicidae	*Tetramorium aptum*

Appendix 3. Continuation

S/No.	Family	Scientific Name
52	Formicidae	*Tetramorium curtulum*
53	Formicidae	*Tetramorium meshena*
54	Formicidae	*Tetramorium tonganum*
55	Formicidae	*Vollenhovia escherichi*
56	Formicidae	*Vollenhovia* sp. 1
57	Formicidae	*Anochetus graeffei*
58	Formicidae	*Brachyponera* sp. 1
59	Formicidae	*Buniapone amblyops*
60	Formicidae	*Centromyrmex hamulatus*
61	Formicidae	*Diacamma rugosum*
62	Formicidae	*Diacamma* sp. 1
63	Formicidae	*Ectomomyrmex overbecki*
64	Formicidae	*Euponera sharpi*
65	Formicidae	*Hypoponera* sp. 1
66	Formicidae	*Leptogenys kraepelini*
67	Formicidae	*Odontomachus litoralis*
68	Formicidae	*Odontomachus rixosus*
69	Formicidae	*Odontomachus simillimus*
70	Formicidae	*Odontoponera denticulata*
71	Formicidae	*Platythyrea parallela*
72	Formicidae	*Proceratium papuanum*
73	Formicidae	*Tetraponera difficilis*
74	Formicidae	*Tetraponera extenuata*
75	Formicidae	*Tetraponera nitida*
76	Formicidae	*Tetraponera pilosa*

Appendix 4. List of Coleoptera (identified to at least genus)

S/No.	Family	Scientific Name
1	Carabidae	*Andrewesia obesa*
2	Carabidae	*Anomotarus sericeus*
3	Carabidae	*Calleida tenuis*
4	Carabidae	*Callytron doriai*
5	Carabidae	*Calomera angulata*
6	Carabidae	*Catascopus borneensis*
7	Carabidae	*Catascopus elegans*
8	Carabidae	*Catascopus facialis basalis*
9	Carabidae	*Chlaenius tetragonoderus*
10	Carabidae	*Colpodes obscuritarsis*
11	Carabidae	*Coptodera* (*Coptoderina*) *flexuosa*
12	Carabidae	*Cosmodela aurulenta*
13	Carabidae	*Cylindera discreta*
14	Carabidae	*Dicraspeda brunnea*
15	Carabidae	*Dolichoctis rotundata*
16	Carabidae	*Endynomena pradieri*
17	Carabidae	*Euplynes* cf. *aurocinctus*
18	Carabidae	*Mochtherus tetraspilotus*
19	Carabidae	*Neocollyris* (*Neocollyris*) *bonellii*
20	Carabidae	*Orthogonius hopei*
21	Carabidae	*Orthogonius* nr. *rufiventris*
22	Carabidae	*Pentagonica eurodes*
23	Carabidae	*Pentagonica pallipes*
24	Carabidae	*Pentagonica parapapua*
25	Carabidae	*Tachys delicatus*
26	Carabidae	*Tachys* cf. *plagiatus*
27	Scirtidae	*Scirtes* sp. 1 (blackish)
28	Scirtidae	*Scirtes* sp. 2 (orange with 2 dots)
29	Staphylinidae	*Cafius nauticus*
30	Staphylinidae	*Orsunius* sp.
31	Staphylinidae	*Oxytelus or Anotylus* sp.
32	Staphylinidae	*Platydracus* sp.
33	Staphylinidae	*Remus corallicola*
34	Staphylinidae	*Stenus* sp.
35	Scarabaeidae	*Adoretini* sp. (=NS 2004 sp.)

Appendix 4. Continuation

S/No.	Family	Scientific Name
36	Scarabaeidae	*Apogonia* cf. *expeditionis*
37	Scarabaeidae	*Apogonia* cf. *orbitalis*
38	Scarabaeidae	*Anomala* cf. *matricula* (sp. nov.)
39	Scarabaeidae	*Anomala* cf. *pallida*
40	Scarabaeidae	*Caccobius unicornis*
41	Scarabaeidae	*Catharsius renaudpauliani*
42	Scarabaeidae	cf. *Diastictus* sp.
43	Scarabaeidae	*Glycyphana binotata laterimarginata*
44	Scarabaeidae	*Ixorida regia* ssp. *sumatrana*
45	Scarabaeidae	*Lepivalgus pygmaeus*
46	Scarabaeidae	*Leucopholis* sp.
47	Scarabaeidae	*Maladera* sp.
48	Scarabaeidae	*Onthophagus babirussa*
49	Scarabaeidae	*Onthophagus crassicollis*
50	Scarabaeidae	*Onthophagus denticollis*
51	Scarabaeidae	*Onthophagus orientalis*
52	Scarabaeidae	*Onthophagus papulatus*
53	Scarabaeidae	*Onthophagus phanaeides*
54	Scarabaeidae	*Onthophagus proletarius*
55	Scarabaeidae	*Onthophagus rutilans*
56	Scarabaeidae	*Onthophagus semifex*
57	Scarabaeidae	*Onthophagus trituber*
58	Scarabaeidae	*Onthophagus waterstradti*
59	Scarabaeidae	*Oryctes rhinoceros*
60	Scarabaeidae	*Sericini* sp., greyish, 3-segmented club
61	Scarabaeidae	*Xylotrupes gideon*
62	Dascillidae	*Petalon* sp.
63	Buprestidae	*Agrilus subconsularis*
64	Buprestidae	*Aphanisticus* nr. *aureocupreus*
65	Buprestidae	*Aphanisticus cochinchinae* ssp. *seminulum*
66	Buprestidae	*Belionota prasina*
67	Buprestidae	*Chrysobothris indica*
68	Buprestidae	*Chrysobothris nigripennis*
69	Buprestidae	*Endelus coeruleus*
70	Buprestidae	*Habroloma* cf. *conscriptum*

Appendix 4. Continuation

S/No.	Family	Scientific Name
71	Buprestidae	*Habroloma gentilis*
72	Buprestidae	*Habroloma lepidoptera*
73	Buprestidae	*Melobasis trifasciata*
74	Buprestidae	*Trachys furnius*
75	Buprestidae	*Trachys mendicus*
76	Callirhipidae	*Callirhipis* cf. *javanica*
77	Elateridae	*Abelater* cf. *pusillarius*
78	Elateridae	*Adelocera* sp. 1
79	Elateridae	*Adelocera* sp. 2
80	Elateridae	*Cardiophorus* sp.
81	Elateridae	*Cryptalaus* sp.
82	Elateridae	*Elaterinae* sp. 1
83	Elateridae	*Elaterinae* sp. 2
84	Elateridae	*Elaterinae* sp. 3
85	Elateridae	*Elaterinae* sp. 4
86	Elateridae	*Melanoxanthus bifasciatus*
87	Elateridae	*Priopus* cf. *waterstradti*
88	Elateridae	cf. *Priopus* sp.
89	Elateridae	cf. *Procraerus corpusculus*
90	Elateridae	*Xanthopenthes* cf. *baumi*
91	Elateridae	*Xanthopenthes* sp.
92	Lycidae	*Plateros* sp.
93	Rhagophthalmidae	cf. *Diplocladon* sp.
94	Lampyridae	*Colophotia praeusta*
95	Lampyridae	*Curtos* sp.
96	Lampyridae	*Diaphanes* sp.
97	Lampyridae	cf. *Flabellotreta* sp.
98	Lampyridae	*Pteroptyx* cf. *valida*
99	Lampyridae	cf. *Stenocladius* sp.
100	Dermestidae	*Orphinus* cf. *fulvipes*
101	Ptinidae	*Ptinus* cf. *rugosithorax*
102	Lymexylidae	*Atractocerus* sp.
103	Trogossitidae	*Anacypta* cf. *punctata*
104	Trogossitidae	*Ancyrona* sp.
105	Cleridae	*Callimerus fuscitarsus*

Appendix 4. Continuation

S/No.	Family	Scientific Name
106	Cleridae	*Clytomadius louwerensi*
107	Cleridae	*Omadius bifasciatus*
108	Melyridae	cf. *Balanophorus* sp.
109	Melyridae	*Intybia* or *Dicranolaius* sp.
110	Erotylidae	*Amblyopus* cf. *vittatus*
111	Erotylidae	*Aulacochilus quadripustulatus*
112	Erotylidae	*Episcapha quadrimacula*
113	Erotylidae	*Micrencaustes* cf. *wunderlichi*
114	Erotylidae	*Pseudotritoma* sp.
115	Erotylidae	*Tetraphala elongata*
116	Erotylidae	*Tritoma* sp.
117	Monomatidae	*Monomma* cf. *glyphysternum*
118	Silvanidae	*Psammoecus* sp.
119	Silvanidae	*Psammoecus* sp. nov.?
120	Nitidulidae	*Carpophilus delkeskampi*
121	Nitidulidae	*Epuraea* (*Haptoncurina*) cf. *paulula*
122	Discolomatidae	cf. *Aphanocephalus* sp.
123	Endomychidae	*Endomychidae* sp.
124	Endomychidae	*Eumorphus assamensis subguttatus*
125	Endomychidae	*Eumorphus sybarita*
126	Endomychidae	*Stenotarsus* sp.
127	Endomychidae	*Trochoideus desjardinsi*
128	Coccinellidae	*Cheilomenes sexmaculata*
129	Coccinellidae	*Cryptogonus* sp.
130	Coccinellidae	*Epilachna vigintioctopunctata*
131	Coccinellidae	*Harmonia sedecimnotata*
132	Coccinellidae	*Heteroneda* cf. *reticulata*
133	Coccinellidae	*Illeis* sp.
134	Coccinellidae	*Micraspis discolor*
135	Coccinellidae	*Ortalia* sp.
136	Coccinellidae	*Phrynocaria deficiens*
137	Coccinellidae	*Sticholotis* cf. *quadriguttata*
138	Mordellidae	*Glipa malaccana*
139	Zopheridae	*Microvonus* (*Anovonus*) *bouchardi*
140	Zopheridae	*Nematidium* sp.

Appendix 4. Continuation

S/No.	Family	Scientific Name
141	Tenebrionidae	*Alphitobius* cf. *laevigatus*
142	Tenebrionidae	*Amarygmus aeneus*
143	Tenebrionidae	*Amarygmus burckhardti*
144	Tenebrionidae	*Amarygmus cupriarus*
145	Tenebrionidae	*Amarygmus micans*
146	Tenebrionidae	*Amarygmus recordativus*
147	Tenebrionidae	*Amarygmus* cf. *rivalis* sp. 2
148	Tenebrionidae	*Amarygmus splendidulus*
149	Tenebrionidae	*Anaedus forticornis*
150	Tenebrionidae	*Androsus corporaali*
151	Tenebrionidae	*Aulonogria concolor*
152	Tenebrionidae	*Bolbostetha baumi*
153	Tenebrionidae	*Bolbostetha* cf. *socia*
154	Tenebrionidae	*Caedius* cf. *aspericollis*
155	Tenebrionidae	*Ceropria adelpha*
156	Tenebrionidae	*Ceropria induta*
157	Tenebrionidae	*Cistelopsis* cf. *brunnea*
158	Tenebrionidae	*Derosphaerus aeruginosus*
159	Tenebrionidae	*Eucyrtus anthracinus*
160	Tenebrionidae	*Eucyrtus pretiosus*
161	Tenebrionidae	*Euhemicera hayashii*
162	Tenebrionidae	*Euhemicera kaszabi*
163	Tenebrionidae	*Gonocephalum* cf. *moluccanum*
164	Tenebrionidae	*Hemicera minutissima*
165	Tenebrionidae	*Hemicera splendens*
166	Tenebrionidae	*Palorus andrewesi*
167	Tenebrionidae	*Palorus* sp. nov.
168	Tenebrionidae	*Phaedis purpureostriatus*
169	Tenebrionidae	*Phaedis superbus*
170	Tenebrionidae	*Platydema marseuli*
171	Tenebrionidae	*Platydema nuciferae*
172	Tenebrionidae	*Platydema* cf. *planum*
173	Tenebrionidae	*Platydema subfascium*
174	Tenebrionidae	*Platydema waterhousei*
175	Tenebrionidae	*Postandrosus maculipennis*

Appendix 4. Continuation

S/No.	Family	Scientific Name
176	Tenebrionidae	*Strongylium erythrocephalum*
177	Tenebrionidae	*Strongylium insigne*
178	Tenebrionidae	*Strongylium* sp., *aciculatum* group
179	Tenebrionidae	*Tetraphyllus* cf. *foveolatus*
180	Tenebrionidae	*Tetraphyllus laevicollis*
181	Tenebrionidae	*Toxicum quadricorne*
182	Oedemeridae	*Oedemeridae* sp. (pink)
183	Salpingidae	*Inopeplus* cf. *malanoleucus*
184	Anthicidae	*Macratria* sp. 1
185	Anthicidae	*Macratria* sp. 2
186	Aderidae	*Phytobaenus* sp.
187	Aderidae	*Zonantes* sp.
188	Vesperidae	*Philus* sp.
189	Cerambycidae	*Abryna regispetri*
190	Cerambycidae	*Anancylus griseatus*
191	Cerambycidae	*Apriona flavescens*
192	Cerambycidae	*Batocera rubus*
193	Cerambycidae	*Ceresium raripilum*
194	Cerambycidae	*Choeromorpha albofasciata*
195	Cerambycidae	*Cleptometopus* sp.
196	Cerambycidae	*Coptops lichenea*
197	Cerambycidae	*Cylindroeme* sp.
198	Cerambycidae	*Dejanira quadripunctata*
199	Cerambycidae	*Egesina fusca fusca*
200	Cerambycidae	*Egesina ornata*
201	Cerambycidae	*Eoporis elegans*
202	Cerambycidae	*Epepeotes luscus*
203	Cerambycidae	*Glenea quadrinotata*
204	Cerambycidae	*Imantocera plumosa*
205	Cerambycidae	*Mispilodes* cf. *borneensis*
206	Cerambycidae	*Nupserha fricator*
207	Cerambycidae	*Olenecamptus bilobus*
208	Cerambycidae	*Pothyne variegata*
209	Cerambycidae	*Pseudiphra* sp.
210	Cerambycidae	*Pterolophia* cf. *kalimantana*

Appendix 4. Continuation

S/No.	Family	Scientific Name
211	Cerambycidae	*Pterolophia* sp.
212	Cerambycidae	*Rondibilis lineaticollis*
213	Cerambycidae	*Ropicagris eosparsa*
214	Cerambycidae	*Ropica honesta*
215	Cerambycidae	*Similosodus* cf. *flavicornis*
216	Cerambycidae	*Similosodus verticalis*
217	Cerambycidae	*Sybra donckieri*
218	Cerambycidae	*Thranius bimaculatus*
219	Cerambycidae	*Xenolea tomentosa*
220	Cerambycidae	*Xylotrechus javanicus*
221	Chrysomelidae	*Altica aenea*
222	Chrysomelidae	*Aulacophora indica*
223	Chrysomelidae	*Basilepta* sp. 6a
224	Chrysomelidae	*Basilepta* sp. 15
225	Chrysomelidae	*Cassida circumdata*
226	Chrysomelidae	*Chaetocnema* (*Chaetocnema*) *sabahensis*
227	Chrysomelidae	*Cleorina aeneomicans*
228	Chrysomelidae	*Coenobius* sp.
229	Chrysomelidae	*Colaspoides* cf. *inornata*
230	Chrysomelidae	cf. *Colaspoides* sp.
231	Chrysomelidae	*Colasposoma viridicoeruleum*
232	Chrysomelidae	*Dercetisoma concolor*
233	Chrysomelidae	*Dercetisoma* sp.
234	Chrysomelidae	*Erystus saundersi*
235	Chrysomelidae	*Haplosomoides plicatus*
236	Chrysomelidae	*Hemipyxis* cf. *flava/badia*
237	Chrysomelidae	*Hemipyxis lusca*
238	Chrysomelidae	cf. *Hesperopenna* sp.
239	Chrysomelidae	*Hyphasis parvula*
240	Chrysomelidae	*Lanka* sp.
241	Chrysomelidae	*Lema coromandeliana*
242	Chrysomelidae	*Lema rufotestacea*
243	Chrysomelidae	*Longitarsus suturellinus*
244	Chrysomelidae	*Monolepta laticornis*
245	Chrysomelidae	*Monolepta* cf. *zonula*

Appendix 4. Continuation

S/No.	Family	Scientific Name
246	Chrysomelidae	*Monolepta murphyi*
247	Chrysomelidae	*Monolepta* cf. *pectoralis*
248	Chrysomelidae	*Monolepta* cf. *rubricollis*or allied genera
249	Chrysomelidae	*Monolepta* sp. 2 (black pronotum rim)
250	Chrysomelidae	*Monolepta* sp. 3 (pronotum red/black)
251	Chrysomelidae	cf. *Monolepta* sp. 7
252	Chrysomelidae	*Nisotra chrysomeloides*
253	Chrysomelidae	*Notosacantha rufa*
254	Chrysomelidae	*Oncocephala feae*
255	Chrysomelidae	*Pagriain gibbosa*
256	Chrysomelidae	*Paradibolia ruficollis*
257	Chrysomelidae	*Parheminodes* cf. *pulcher*
258	Chrysomelidae	*Phyllotreta chotanica*
259	Chrysomelidae	*Phyllotreta striolata*
260	Chrysomelidae	*Phytorus pinguis*
261	Chrysomelidae	*Psylliodes balyi*or *brettinghami*
262	Chrysomelidae	*Rhyparida spiridonovi*
263	Chrysomelidae	*Rhyparida* sp.
264	Chrysomelidae	*Scelodonta granulosa*
265	Chrysomelidae	*Spermophagus* sp.
266	Chrysomelidae	*Sphaeroderma antennata*
267	Chrysomelidae	*Sumatrasia tibialis*
268	Chrysomelidae	*Tricliona trimaculata*
269	Anthribidae	*Acorynus disclusus*
270	Anthribidae	*Apolectella corporaali*
271	Anthribidae	*Araecerus areolatus*
272	Anthribidae	*Autropis* cf. *modesta*
273	Anthribidae	*Deropygus* cf. *giton*
274	Anthribidae	*Eucorynus crassicornis*
275	Anthribidae	*Euparius modicus*
276	Anthribidae	*Exechesops* cf. *lituratus*
277	Anthribidae	*Exechesops phodinus*
278	Anthribidae	*Exillis* sp. (finely streaked)
279	Anthribidae	*Hucus ovinus*
280	Anthribidae	*Hypseus argutus*

Appendix 4. Continuation

S/No.	Family	Scientific Name
281	Anthribidae	*Litocerus figuratus*
282	Anthribidae	*Litocerus humeralis*
283	Anthribidae	*Litocerus pollionis*
284	Anthribidae	*Litotropis icon*
285	Anthribidae	*Melanopsacus subglaber*
286	Anthribidae	*Mucronianus ellipticus*
287	Anthribidae	*Phloeobius pallipes*
288	Anthribidae	*Platystomos wallacei*
289	Anthribidae	*Rhaphitropis gracilis*
290	Anthribidae	*Rhaphitropis vittata*
291	Anthribidae	*Sphinctotropis paviei*
292	Anthribidae	*Uncifer* cf. *rectangulus*
293	Attelabidae	cf. *Auletobius*sp.
294	Attelabidae	*Byctiscidius* cf. *insularis*
295	Brentidae	*Cerobates sexsulcatus*
296	Brentidae	*Cylas formicarius*
297	Brentidae	*Higonius crux*
298	Curculionidae	*Acicnemis* sp.
299	Curculionidae	*Acicnemis ambigua*
300	Curculionidae	*Alcidodes pulchellus*
301	Curculionidae	cf. *Colobodes* sp.
302	Curculionidae	*Euthyrhinus* sp. 1
303	Curculionidae	*Euthyrhinus* sp. 2
304	Curculionidae	*Lobotrachelus angulatus*
305	Curculionidae	cf. *Parapries sumatranus*
306	Curculionidae	*Parimera* sp.
307	Curculionidae	*Platypus parallelus*
308	Curculionidae	*Rhynchophorus vulneratus*
309	Curculionidae	*Telephae* sp.
310	Curculionidae	cf. *Telephae paryphanta*
311	Curculionidae	cf. *Xenotrupis* sp.

Appendix 5. List of Phasmids (identified to at least genus)

S/No.	Family	Scientific Name
1	Heteropterygidae	*Orestes draegeri*
2	Lonchodidae	*Lonchodes brevipes*
3	Lonchodidae	*Sipyloidea sipylus*
4	Lonchodidae	*Trachythorax* sp.
5	Phylliidae	*Cryptophyllium chrisangi*

Appendix 6. List of Moths (identified to at least genus)

S/No.	Family	Scientific Name
1	Bombycidae	*Trilocha* sp.
2	Bombycidae	*Trilocha varians*
3	Brachodidae	*Nigilgia anactis*
4	Callidulidae	*Tetragonus catamitus*
5	Choreutidae	*Brenthia* sp.
6	Choreutidae	*Choreutis amethystodes*
7	Choreutidae	*Choreutis orthogona*
8	Choreutidae	*Choreutis* sp.
9	Choreutidae	*Saptha beryllitis*
10	Choreutidae	*Saptha* sp.
11	Crambidae	*"Syllepte" vagalis*
12	Cosmopterigidae	*Ascalenia thoracista*
13	Cosmopterigidae	*Cosmopterix* sp.
14	Cossidae	*Neurozerra conferta*
15	Cossidae	*Zeuzera conferta*
16	Cossidae	*Zeuzera indica*
17	Crambidae	*Aetholix flavibasalis*
18	Crambidae	*Agrioglypta itysalis*
19	Crambidae	*Agrioglypta* zelimalis
20	Crambidae	*Balaenifrons ochrochroa*
21	Crambidae	*Bocchoris inspersalis*
22	Crambidae	*Bocchoris* sp.
23	Crambidae	*Boeotarcha martinalis*
24	Crambidae	*Conogethes* sp.
25	Crambidae	*Culladia hastiferalis*
26	Crambidae	*Culladia* sp.

Appendix 6. Continuation

S/No.	Family	Scientific Name
27	Crambidae	*Dichocrocis* sp.
28	Crambidae	*Eristena* sp.
29	Crambidae	*Glaucocharis margretella*
30	Crambidae	*Glyphodes canthusalis*
31	Crambidae	*Glyphodes multilinealis*
32	Crambidae	*Haritalodes derogata*
33	Crambidae	*Hemiscopis sanguinea*
34	Crambidae	*Herpetogramma* sp.
35	Crambidae	*Hymenoptychis sordida*
36	Crambidae	*Ischnurges gratiosalis*
37	Crambidae	*Lamprosema tampiusalis*
38	Crambidae	*Lepidoplaga sp.*
39	Crambidae	*Nacoleia* sp.
40	Crambidae	*Omiodes diemenalis*
41	Crambidae	*Pachynoa sabelialis*
42	Crambidae	*Pagyda* sp.
43	Crambidae	*Patania iopasalis*
44	Crambidae	*Physematia* sp.
45	Crambidae	*Piletocera* sp.
46	Crambidae	*Prophantis adusta*
47	Crambidae	*Pylartes subcostalis*
48	Crambidae	*Sameodes cancellalis*
49	Crambidae	*Spoladea recurvalis*
50	Crambidae	*Sufetula* sp.
51	Crambidae	*Symmoracma minoralis*
52	Crambidae	*Symphonia multipictalis*
53	Crambidae	*Taurometopa pyrometalla*
54	Crambidae	*Tetridia vinacealis*
55	Drepanidae	*Callidrepana micacea*
56	Drepanidae	*Callidrepana* sp.
57	Drepanidae	*Oreta carnea*
58	Erebidae	*Achaea serva*
59	Erebidae	*Adrapsa ablualis*
60	Erebidae	*Adrapsa ereboides*
61	Erebidae	*Arctornis egerina*

Appendix 6. Continuation

S/No.	Family	Scientific Name
62	Erebidae	*Arctornis obtusa*
63	Erebidae	*Argina astrea*
64	Erebidae	*Artaxa* sp.
65	Erebidae	*Asota egens*
66	Erebidae	*Asota paphos*
67	Erebidae	*Asota plana*
68	Erebidae	*Asota subsimilis*
69	Erebidae	*Avatha bubo*
70	Erebidae	*Avatha garthei*
71	Erebidae	*Barsilene pallinflexa*
72	Erebidae	*Bocana manifestalis*
73	Erebidae	*Brunia antica*
74	Erebidae	*Brunia* sp.
75	Erebidae	*Cerynea* sp.
76	Erebidae	*Chalciope mygdon*
77	Erebidae	*Clethrogyna turbata*
78	Erebidae	*Corgatha pseudominor*
79	Erebidae	*Corgatha* sp.
80	Erebidae	*Corgatha* sp. nr. *nigripalpis*
81	Erebidae	*Creatonotos transiens*
82	Erebidae	*Cyana conclusa*
83	Erebidae	*Cyana dudgeoni*
84	Erebidae	*Cyana flavalba*
85	Erebidae	*Cyana perornata*
86	Erebidae	*Cyana* sp.
87	Erebidae	*Dasychira* sp.
88	Erebidae	*Didigua vexilla*
89	Erebidae	*Dinumma combusta*
90	Erebidae	*Dinumma oxygrapha*
91	Erebidae	*Enispa elataria*
92	Erebidae	*Enispa* sp.
93	Erebidae	*Eressa confinis*
94	Erebidae	*Ericeia inangulata*
95	Erebidae	*Ericeia* sp. nr. *sobria*
96	Erebidae	*Eublemma abrupta*

Appendix 6. Continuation

S/No.	Family	Scientific Name
97	Erebidae	*Eublemma ignefusa*
98	Erebidae	*Eublemma pudica*
99	Erebidae	*Eublemma* sp1
100	Erebidae	*Eublemma* sp2
101	Erebidae	*Eudocima phalonia*
102	Erebidae	*Eudocima* sp.
103	Erebidae	*Eugoa* sp.
104	Erebidae	*Eurosia melanopera*
105	Erebidae	*Gesonia obeditalis*
106	Erebidae	*Gesonia* sp.
107	Erebidae	*Hadennia hypenalis*
108	Erebidae	*Heliohemonia monosticta*
109	Erebidae	*Homodes crocea*
110	Erebidae	*Homodes vivida*
111	Erebidae	*Hulodes caranea*
112	Erebidae	*Hydrillodes lentalis*
113	Erebidae	*Hypena robustalis*
114	Erebidae	*Hypospila* sp.
115	Erebidae	*Hywoolla* sp.
116	Erebidae	*Ilema* sp.
117	Erebidae	*Ischyja ferrifracta*
118	Erebidae	*Ischyja marapok*
119	Erebidae	*Lacera* sp.
120	Erebidae	*Laspeyria ruficeps*
121	Erebidae	*Lithosiina* sp.
122	Erebidae	*Loxioda* sp.
123	Erebidae	*Macotasa lacrima*
124	Erebidae	*Macotasa tetraspila*
125	Erebidae	*Macotasa tortricoides*
126	Erebidae	*Mecodina metagrapta*
127	Erebidae	*Mesosciera orientalis*
128	Erebidae	*Metaemene atrigutta*
129	Erebidae	*Miltochrista falciseriata*
130	Erebidae	*Miltochrista irregularis*
131	Erebidae	*Miltochrista* sp.

Appendix 6. Continuation

S/No.	Family	Scientific Name
132	Erebidae	*Mocis undata*
133	Erebidae	*Naarda* sp.
134	Erebidae	*Nanarsine porphyrea*
135	Erebidae	*Nechesia albodentata*
136	Erebidae	*Nyctemera baulus*
137	Erebidae	*Nygmiini* sp.
138	Erebidae	*Ophiusa discriminans*
139	Erebidae	*Ophiusa trapezium*
140	Erebidae	*Oruza* sp.
141	Erebidae	*Oxyodes scrobiculata*
142	Erebidae	*Perina sunda*
143	Erebidae	*Polydesma boarmoides*
144	Erebidae	*Pterocyclophora ridleyi*
145	Erebidae	*Rusicada nigritarsis*
146	Erebidae	*Saroba pansa*
147	Erebidae	*Serrodes partita*
148	Erebidae	*Simplicia* sp.
149	Erebidae	*Spirama* sp.
150	Erebidae	*Stenocarsia sthenoptera*
151	Erebidae	*Stictane* sp.
152	Erebidae	*Tamba basiscripta*
153	Erebidae	*Tamsia hieroglyphica*
154	Erebidae	*Throana amyntoralis*
155	Erebidae	*Thyas coronata*
156	Erebidae	*Tigrioides puncticollis*
157	Erebidae	*Tipasa nebulosella*
158	Erebidae	*Tipasa* sp.
159	Erebidae	*Tiruvaca subcostalis*
160	Erebidae	*Tochara creberrima*
161	Erebidae	*Trigonodes hyppasia*
162	Erebidae	*Trischalis* sp.
163	Erebidae	*Veslema flavifrons*
164	Erebidae	*Zurobata vacillans*
165	Euteliidae	*Penicillaria jocosatrix*
166	Euteliidae	*Stictoptera* sp.

Appendix 6. Continuation

S/No.	Family	Scientific Name
167	Gelechiidae	*Dichomeris* sp.
168	Gelechiidae	*Thiotricha* sp.
169	Geometridae	*Argyrocosma inductaria*
170	Geometridae	*Berta chrysolineata*
171	Geometridae	*Berta* sp.
172	Geometridae	*Biston* sp. nr. *inouei*
173	Geometridae	*Biston suppressaria*
174	Geometridae	*Bulonga schistacearia*
175	Geometridae	*Calletarea* sp.
176	Geometridae	*Calletarea subexpressa*
177	Geometridae	*Chiasmia* sp.
178	Geometridae	*Cleora injectaria*
179	Geometridae	*Cleora repetita*
180	Geometridae	*Comibaena attenuata*
181	Geometridae	*Comibaena cassidara*
182	Geometridae	*Comibaena* sp.
183	Geometridae	*Comostola laesaria*
184	Geometridae	*Comostola* sp. nr. *quantula*
185	Geometridae	*Derambila* sp.
186	Geometridae	*Dysphania bivexillata*
187	Geometridae	*Dysphania* sp.
188	Geometridae	*Eucyclodes* sp.
189	Geometridae	*Eumelea* sp.
190	Geometridae	*Eupitheciini* sp.
191	Geometridae	*Fascellina castanea*
192	Geometridae	*Gonodontis clelia*
193	Geometridae	*Heterostegane* sp.
194	Geometridae	*Heterostegane tritocampsis*
195	Geometridae	*Hyperythra lutea*
196	Geometridae	*Hyposidra infixaria*
197	Geometridae	*Hyposidra talaca*
198	Geometridae	*Idaea purpurea*
199	Geometridae	*Idaea* sp.
200	Geometridae	*Luxiaria sp.*
201	Geometridae	*Macariini sp.*

Appendix 6. Continuation

S/No.	Family	Scientific Name
202	Geometridae	*Oenospila flavifusata*
203	Geometridae	*Orothalassodes leucoceraea*
204	Geometridae	*Orothalassodes* sp.
205	Geometridae	*Pingasa rubimontana*
206	Geometridae	*Plutodes* sp.
207	Geometridae	*Scopula* sp.
208	Geometridae	*Semiothisa drepanata*
209	Geometridae	*Somatina* sp.
210	Geometridae	*Traminda aventiaria*
211	Geometridae	*Zeheba aureatoides*
212	Immidae	*Imma mackwoodii*
213	Immidae	*Imma* sp.
214	Immidae	*Imma transversella*
215	Immidae	*Moca* sp.
216	Lacturidae	*Anticrates* sp. 1
217	Lacturidae	*Anticrates* sp. 2
218	Lasiocampidae	*Streblote helpsi*
219	Lecithoceridae	*Lecithocera* sp.
220	Lecithoceridae	*Lecitholaxa* sp.
221	Lecithoceridae	*Torodora* sp.
222	Lecithoceridae	*Torodora* sp. nr. *claustrata*
223	Limacodidae	*Chalcocelis albiguttatus*
224	Limacodidae	*Hyphorma margaritacea*
225	Limacodidae	*Mambarona congrua*
226	Limacodidae	*Narosa* sp. nr. *concinna*
227	Limacodidae	*Orthocraspeda trima*
228	Limacodidae	*Oxyplax pallivitta*
229	Limacodidae	*Parasa lepida*
230	Limacodidae	*Thosea* sp.
231	Limacodidae	*Thosea vetusta*
232	Limacodidae	*Trichogyia* sp.
233	Noctuidae	*Aedia lichenea*
234	Noctuidae	*Amyna* sp.
235	Noctuidae	*Aucha* sp.
236	Noctuidae	*Belciana biformis*

Appendix 6. Continuation

S/No.	Family	Scientific Name
237	Noctuidae	*Borbotana nivifascia*
238	Noctuidae	*Callopistria emiliusalis*
239	Noctuidae	*Condica illecta*
240	Noctuidae	*Cyclodes omma*
241	Noctuidae	*Elusa* sp.
242	Noctuidae	*Mudaria luteileprosa*
243	Noctuidae	*Plusiopalpa adrasta*
244	Nolidae	*Aiteta musculina*
245	Nolidae	*Earias* sp.
246	Nolidae	*Erizada lichenaria*
247	Nolidae	*Gyrtothripa* sp.
248	Nolidae	*Maurilia* sp.
249	Nolidae	*Nolini* sp.
250	Nolidae	*Risoba diversipennis*
251	Nolidae	*Sarbena* sp.
252	Nolidae	*Westermannia* sp.
253	Nolidae	*Westermannia superba*
254	Notodontidae	*Ambadra* sp.
255	Notodontidae	*Chadisra basivacua*
256	Notodontidae	*Neodrymonia* sp.
257	Notodontidae	*Syntypistis pallidifascia*
258	Phaudidae	*Phauda* sp.
259	Plutellidae	*Plutella* sp.
260	Psychidae	*Amatissa* sp.
261	Psychidae	*Pagodiella hekmeyeri*
262	Pterophoridae	*Diacrotricha fasciola*
263	Pterophoridae	*Exelastis* sp.
264	Pterophoridae	*Hellinsia* sp.
265	Pterophoridae	*Pterophorus lacteipennis*
266	Pyralidae	*Arivaca* sp.
267	Pyralidae	*Endotricha mesenterialis*
268	Pyralidae	*Endotricha* sp.
269	Pyralidae	*Epicrocis* sp.
270	Pyralidae	*Etiella* sp.
271	Pyralidae	*Hypsopygia* sp. 1

Appendix 6. Continuation

S/No.	Family	Scientific Name
272	Pyralidae	*Hypsopygia* sp. 2
273	Pyralidae	*Hypsopygia* sp. 3
274	Pyralidae	*Hypsopygia* sp. 4
275	Pyralidae	*Orthaga* sp.
276	Pyralidae	*Stericta* sp.
277	Saturniidae	*Attacus atlas*
278	Sphingidae	*Acherontia* sp.
279	Sphingidae	*Ambulyx moorei*
280	Sphingidae	*Ambulyx pryeri*
281	Sphingidae	*Daphnusa ocellaris*
282	Sphingidae	*Elibia dolichus*
283	Sphingidae	*Enpinanga borneensis*
284	Sphingidae	*Enpinanga vigens*
285	Sphingidae	*Hippotion rosetta*
286	Sphingidae	*Macroglossum corythus*
287	Sphingidae	*Macroglossum* sp.
288	Sphingidae	*Pergesa acteus*
289	Sphingidae	*Psilogramma menephron*
290	Sphingidae	*Theretra latreillii*
291	Sphingidae	*Theretra suffusa*
292	Stathmopodidae	*Stathmopoda* sp.
293	Thyrididae	*Banisia myrsusalis*
294	Thyrididae	*Banisia* sp.
295	Thyrididae	*Epaena* sp.
296	Thyrididae	*Striglina* sp.
297	Tineidae	*Dasyses* sp.
298	Tineidae	*Gerontha* sp.
299	Tineidae	*Harmaclona* sp.
300	Tineidae	*Opogona* sp.
301	Tortricidae	*Adoxophyes privatana*
302	Tortricidae	*Adoxophyes* sp.
303	Tortricidae	*Archipini* sp.
304	Tortricidae	*Cryptaspasma* sp.
305	Tortricidae	*Cryptophlebia ombrodelta*
306	Tortricidae	*Cryptophlebia* sp.

Appendix 6. Continuation

S/No.	Family	Scientific Name
307	Tortricidae	*Dactylioglypha pallens*
308	Tortricidae	*Homona* sp.
309	Tortricidae	*Ophiorrhabda mormopa*
310	Tortricidae	*Ophiorrhabda scaristis*
311	Tortricidae	*Sorolopha* sp.
312	Tortricidae	*Statherotis* sp.
313	Tortricidae	*Sycacantha inodes*
314	Uraniidae	*Acropteris* sp.
315	Uraniidae	*Dysaethria plicata*
316	Uraniidae	*Europlema semibrunnea*
317	Uraniidae	*Lyssa zampa*
318	Uraniidae	*Monobolodes* sp.
319	Xyloryctidae	*Metathrinca* sp.
320	Zygaenidae	*Phacusa* sp. nr. *crawfurdi*
321	Zygaenidae	*Pompelon marginata*
322	Zygaenidae	*Trypanophora* sp.

Appendix 7. List of Spiders (identified to at least genus)

S/No.	Family	Scientific Name
1	Araneidae	*Arachnura* sp.
2	Araneidae	*Araneus mitificus*
3	Araneidae	*Araneus nox*
4	Araneidae	*Argiope catenulata*
5	Araneidae	*Argiope* sp.
6	Araneidae	*Argiope versicolor*
7	Araneidae	*Chorizopesoides orientalis*
8	Araneidae	*Chorizopesoides wulingensis*
9	Araneidae	*Cyclosa bifida*
10	Araneidae	*Cyclosa insulana*
11	Araneidae	*Cyphalanotus selangor*
12	Araneidae	*Cyrtarachne inaequalis*
13	Araneidae	*Cyrtophora beccarii*
14	Araneidae	*Cyrtophora cylindroides*
15	Araneidae	*Cyrtophora unicolor*
16	Araneidae	*Eriovixia* cf. *pseudocentrodes*

Appendix 7. Continuation

S/No.	Family	Scientific Name
17	Araneidae	*Eriovixia laglaizei*
18	Araneidae	*Eriovixia pseudocentrodes*
19	Araneidae	*Eriovixia* sp.
20	Araneidae	*Gea spinipes*
21	Araneidae	*Herennia multipuncta*
22	Araneidae	*Neoscona vigilans*
23	Araneidae	*Nephila pilipes*
24	Araneidae	*Nephilengys malabarensis*
25	Araneidae	*Parawixia dehaani*
26	Araneidae	*Poltys illepidus*
27	Araneidae	*Singa perpolita*
28	Araneidae	*Zygiella calyptrata*
29	Clubionidae	*Clubiona* sp.
30	Clubionidae	*Clubiona* sp. RB “Robust Bronze”
31	Clubionidae	*Clubiona* sp. TY (Translucent Yellow)
32	Clubionidae	*Nusatidia camouflata*
33	Corinnidae	*Aetius* sp.
34	Corinnidae	*Corinnomma javanum*
35	Corinnidae	*Corinnomma severum*
36	Corinnidae	*Corinnomma* sp.
37	Corinnidae	*Echinax oxyopides*
38	Corinnidae	*Medmassa* sp.
39	Corinnidae	*Serendib muadai*
40	Deinopidae	*Asianopis* cf. *liukuensis*
41	Gnaphosidae	*Hitobia* sp. WT “Wavy Tapir”
42	Hersilidae	*Hersilia* sp.
43	Hersilidae	*Hersilia sundaica*
44	Liocranidae	*Oedignatha scrobiculata*
45	Lycosidae	*Hippasa holmerae*
46	Lycosidae	*Pardosa pusiola*
47	Lycosidae	*Pardosa* sp.
48	Lycosidae	*Pardosa sumatrana*
49	Lycosidae	*Venonia coruscans*
50	Oonopidae	*Ischnothyreus brunneus*
51	Oonopidae	*Ischnothyreus tectorius*

Appendix 7. Continuation

S/No.	Family	Scientific Name
52	Oxyopidae	*Hamadruas* sp.
53	Oxyopidae	*Hamadruas* sp. JB "Jogya Batik"
54	Oxyopidae	*Hamataliwa incompta*
55	Oxyopidae	*Hamataliwa* sp.
56	Oxyopidae	*Oxyopes birmanicus*
57	Oxyopidae	*Oxyopes lineatipes*
58	Oxyopidae	*Oxyopes quadridentatus*
59	Oxyopidae	*Tapponia micans*
60	Pholcidae	*Belisana* sp. PS (Pond Spotted)
61	Pholcidae	*Cantikus ubin*
62	Pholcidae	*Crossopriza lyoni*
63	Pholcidae	*Leptopholcus borneensis*
64	Pholcidae	*Leptopholcus podophthalmus*
65	Pholcidae	*Nipisa phyllicola*
66	Pholcidae	*Pholcus gracillimus*
67	Pholcidae	*Pholcus ubin*
68	Pisauridae	*Dendrolycosa* cf. *robusta*
69	Pisauridae	*Hygropoda* sp. ML (Mangrove Large)
70	Pisauridae	*Nilus* sp. VP (Variegated Pattern)
71	Psechridae	*Fecenia ochracea*
72	Psechridae	*Psechrus singaporensis*
73	Salticidae	*Anarrhotus fossulatus*
74	Salticidae	*Anarrhotus* sp. BH "Bronze Hairy"
75	Salticidae	*Bavia sexpunctata*
76	Salticidae	*Carrhotus* cf. *xanthogramma*
77	Salticidae	*Chalcotropis* sp. HB "House Big"
78	Salticidae	*Cocalus murinus*
79	Salticidae	*Cosmophasis thalassina*
80	Salticidae	*Cytaea oreophila*
81	Salticidae	*Epeus flavobilineatus*
82	Salticidae	*Epeus* sp.
83	Salticidae	*Epocilla calcarata*
84	Salticidae	*Harmochirus brachiatus*
85	Salticidae	*Hyllus diardi*
86	Salticidae	*Junxattus* sp. GD "Golden Stripe"

Appendix 7. Continuation

S/No.	Family	Scientific Name
87	Salticidae	*Ligurra latidens*
88	Salticidae	*Menemerus bivittatus*
89	Salticidae	*Myrmarachne acromegalis*
90	Salticidae	*Myrmarachne cornuta*
91	Salticidae	*Myrmarachne melanocephala*
92	Salticidae	*Myrmarachne* sp.
93	Salticidae	*Orcevia* sp. GD "Golden Bark"
94	Salticidae	*Pancorius* sp.
95	Salticidae	*Parabathippus* sp.
96	Salticidae	*Phaeacius malayensis*
97	Salticidae	*Phintella bifurcilinea*
98	Salticidae	*Phintella debilis*
99	Salticidae	*Phintella lepidus*
100	Salticidae	*Phintella* sp.
101	Salticidae	*Phintella vittata*
102	Salticidae	*Piranthus kohi*
103	Salticidae	*Portia labiata*
104	Salticidae	*Psenuc* sp. MP "Mangrove Painted"
105	Salticidae	*Ptocasius weyersi*
106	Salticidae	*Rhene flavigera*
107	Salticidae	*Siler semiglaucus*
108	Salticidae	*Spartaeus spinimanus*
109	Salticidae	*Telamonia festiva*
110	Salticidae	*Telamonia* sp.
111	Salticidae	*Thiania bhamoensis*
112	Salticidae	*Toxeus* cf. *maxillosus*
113	Salticidae	*Toxeus maxillosus*
114	Salticidae	*Viciria praemandibularis*
115	Scytodidae	*Scytodes fusca*
116	Scytodidae	*Scytodes pallida*
117	Scytodidae	*Scytodes* sp.
118	Sparassidae	*Gnathopalystes* sp.
119	Sparassidae	*Heteropoda* sp.
120	Sparassidae	*Heteropoda* sp. SB "Small Banded"
121	Sparassidae	*Heteropoda venatoria*

Appendix 7. Continuation

S/No.	Family	Scientific Name
122	Sparassidae	*Olios* sp. CY "Common Yoga"
123	Sparassidae	*Pandercetes* sp. A
124	Sparassidae	*Pandercetes* sp. HB "Hairy Brown"
125	Sparassidae	*Pandercetes* sp. LG "Lichen Green"
126	Sparassidae	*Thelcticopis* sp.
127	Tetrablemmidae	*Brignoliella besutensis*
128	Tetragnathidae	*Guizygiella nadleri*
129	Tetragnathidae	*Leucauge fastigata*
130	Tetragnathidae	*Leucauge* sp.
131	Tetragnathidae	*Tetragnatha ceylonica*
132	Tetragnathidae	*Tetragnatha hasselti*
133	Tetragnathidae	*Tetragnatha josephi*
134	Tetragnathidae	*Tetragnatha* sp.
135	Tetragnathidae	*Tylorida ventralis*
136	Theridiidae	*Allothymoites* sp. CO "Cushion Abdomen"
137	Theridiidae	*Anelosimus kohi*
138	Theridiidae	*Anelosimus* sp. FP "Former *parvulus*"
139	Theridiidae	*Argyrodes fissifrons*
140	Theridiidae	*Argyrodes flavescens*
141	Theridiidae	*Argyrodes* sp.
142	Theridiidae	*Ariamnes flagellum*
143	Theridiidae	*Ariamnes* sp. GT "Green Twig"
144	Theridiidae	*Chrysso* sp.
145	Theridiidae	*Coscinida* sp. GO "Ground Orange"
146	Theridiidae	*Dipoena turriceps*
147	Theridiidae	*Emertonella* sp. SS "Small Silver"
148	Theridiidae	*Janula* sp.
149	Theridiidae	*Janula* sp. MF "Monkey Face"
150	Theridiidae	*Janula triangularis*
151	Theridiidae	*Meotipa picturata*
152	Theridiidae	*Nihonhimea mundula*
153	Theridiidae	*Parasteatoda* sp.
154	Theridiidae	*Parasteatoda* sp. OM "Orange Male"
155	Theridiidae	*Parasteatoda triangula*
156	Theridiidae	*Phoroncidia* sp. CJ "Creamy Gemstone"

Appendix 7. Continuation

S/No.	Family	Scientific Name
157	Theridiidae	*Phycosoma hana*
158	Theridiidae	*Platnickina mneon*
159	Theridiidae	*Platnickina* sp. BN "Black Ninja"
160	Theridiidae	*Propostira* sp. FT "Four Tubercles"
161	Theridiidae	*Rhomphaea labiata*
162	Theridiidae	*Theridion* sp. RA "Red Abdomen"
163	Theridiidae	*Theridion t-notatum*
164	Theridiidae	*Thwaitesia* sp. MS "Mirror Spider"
165	Theridiidae	*Yunohamella* sp. WL "White Line"
166	Thomisidae	*Alcimocthes* sp. TG "Tall Green"
167	Thomisidae	*Amyciaea forticeps*
168	Thomisidae	*Boliscus tuberculatus*
169	Thomisidae	*Camaricus maugei*
170	Thomisidae	*Henriksenia hilaris*
171	Thomisidae	*Lycopus rubropictus*
172	Thomisidae	*Monaeses* sp. CB "Common Brown"
173	Thomisidae	*Oxytate virens*
174	Thomisidae	*Platythomisus octomaculatus*
175	Thomisidae	*Platythomisus* sp.
176	Thomisidae	*Pycnaxis krakatuaensis*
177	Thomisidae	*Runcinia* sp.
178	Thomisidae	*Spilosynema* sp. CG "Common Green"
179	Thomisidae	*Strigoplus albostriatus*
180	Thomisidae	*Tarrocanus* sp. OT "Ocular Tubercles"
181	Thomisidae	*Thomisus callidus*
182	Thomisidae	*Thomisus* sp.
183	Thomisidae	*Tmarus* sp. TS "Triple Streaked"
184	Trachelidae	*Utivarachna phyllicola*
185	Uloboridae	*Miagrammopes oblongus*
186	Uloboridae	*Miagrammopes* sp. BC "Brown Cigar"
187	Uloboridae	*Philoponella raffrayi*
188	Uloboridae	*Uloborus plumipes*
189	Uloboridae	*Uloborus* sp. CO "Chocolate Orange"
190	Zodariidae	*Asceua* sp. FS "Five Stripes"
191	Zodariidae	*Mallinella allorostrata*
192	Zodariidae	*Mallinella annulipes*

Appendix 8. List of Butterflies

S/No.	Family	Scientific Name
1	Papilionidae	*Troides amphrysus ruficollis*
2	Papilionidae	*Troides helena cerberus*
3	Papilionidae	*Atrophanera varuna varuna*
4	Papilionidae	*Pachliopta aristolochiae asteris*
5	Papilionidae	*Chilasa clytia clytia*
6	Papilionidae	*Papilio demoleus malayanus*
7	Papilionidae	*Papilio demolion demolion*
8	Papilionidae	*Papilio memnon agenor*
9	Papilionidae	*Papilio polytes romulus*
10	Papilionidae	*Graphium sarpedon luctatius*
11	Papilionidae	*Graphium evemon eventus*
12	Papilionidae	*Graphium doson evemonides*
13	Papilionidae	*Graphium agamemnon agamemnon*
14	Papilionidae	*Graphium antiphates itamputi*
15	Pieridae	*Delias hyparete metarete*
16	Pieridae	*Leptosia nina malayana*
17	Pieridae	*Cepora iudith malaya*
18	Pieridae	*Appias libythea olferna*
19	Pieridae	*Catopsilia pyranthe pyranthe*
20	Pieridae	*Catopsilia pomona pomona*
21	Pieridae	*Catopsilia scylla cornelia*
22	Pieridae	*Pareronia valeria*
23	Pieridae	*Eurema hecabe contubernalis*
24	Pieridae	*Eurema simulatrix tecmessa*
25	Pieridae	*Eurema blanda snelleni*
26	Pieridae	*Eurema andersonii andersonii*
27	Pieridae	*Eurema sari sodalis*
28	Pieridae	*Gandaca harina distanti*
29	Nymphalidae	*Danaus chrysippus chrysippus*
30	Nymphalidae	*Danaus genutia genutia*
31	Nymphalidae	*Danaus melanippus hegesippus*
32	Nymphalidae	*Parantica agleoides agleoides*
33	Nymphalidae	*Parantica aspasia aspasia*
34	Nymphalidae	*Ideopsis juventa sitah*
35	Nymphalidae	*Ideopsis vulgaris macrina*

Appendix 8. Continuation

S/No.	Family	Scientific Name
36	Nymphalidae	*Idea leuconoe chersonesia*
37	Nymphalidae	*Euploea crameri bremeri*
38	Nymphalidae	*Euploea camaralzeman malayica*
39	Nymphalidae	*Euploea eyndhovii gardineri*
40	Nymphalidae	*Euploea mulciber mulciber*
41	Nymphalidae	*Euploea phaenareta castelnaui*
42	Nymphalidae	*Euploea tulliolus ledereri*
43	Nymphalidae	*Euploea radamanthus radamanthus*
44	Nymphalidae	*Melanitis leda leda*
45	Nymphalidae	*Elymnias panthera panthera*
46	Nymphalidae	*Elymnias hypermnestra agina*
47	Nymphalidae	*Elymnias penanga penanga*
48	Nymphalidae	*Lethe europa malaya*
49	Nymphalidae	*Mydosama fuscum*
50	Nymphalidae	*Mycalesis perseus cepheus*
51	Nymphalidae	*Mycalesis perseoides perseoides*
52	Nymphalidae	*Mycalesis mineus macromalayana*
53	Nymphalidae	*Mycalesis visala phamis*
54	Nymphalidae	*Orsotria enamedus*
55	Nymphalidae	*Ypthima huebneri*
56	Nymphalidae	*Ypthima newboldi*
57	Nymphalidae	*Ypthima pandocus corticaria*
58	Nymphalidae	*Faunis canens arcesilas*
59	Nymphalidae	*Amathusia phidippus phidippus*
60	Nymphalidae	*Zeuxidia amethystus amethystus*
61	Nymphalidae	*Discophora sondaica despoliata*
62	Nymphalidae	*Ariadne ariadne ariadne*
63	Nymphalidae	*Hypolimnas anomala anomala*
64	Nymphalidae	*Hypolimnas bolina bolina/jacintha*
65	Nymphalidae	*Doleschallia bisaltide bisaltide/pratipa*
66	Nymphalidae	*Junonia hedonia ida*
67	Nymphalidae	*Junonia atlites atlites*
68	Nymphalidae	*Junonia almana javana*
69	Nymphalidae	*Junonia orithya wallacei*
70	Nymphalidae	*Acraea terpsicore*

Appendix 8. Continuation

S/No.	**Family**	**Scientific Name**
71	Nymphalidae	*Cethosia hypsea hypsina*
72	Nymphalidae	*Cethosia penthesilea methypsea*
73	Nymphalidae	*Cethosia cyane*
74	Nymphalidae	*Dryas iulia modesta*
75	Nymphalidae	*Phalanta phalantha phalantha*
76	Nymphalidae	*Cupha erymanthis lotis*
77	Nymphalidae	*Vindula dejone erotella*
78	Nymphalidae	*Moduza procris milonia*
79	Nymphalidae	*Lebadea martha malayana/parkeri*
80	Nymphalidae	*Athyma asura idita*
81	Nymphalidae	*Athyma nefte subrata*
82	Nymphalidae	*Pandita sinope sinope*
83	Nymphalidae	*Neptis hylas papaja*
84	Nymphalidae	*Neptis leucoporos cresina*
85	Nymphalidae	*Phaedyma columella singa*
86	Nymphalidae	*Lasippa heliodore dorelia*
87	Nymphalidae	*Pantoporia paraka paraka*
88	Nymphalidae	*Tanaecia pelea pelea*
89	Nymphalidae	*Tanaecia iapis puseda*
90	Nymphalidae	*Euthalia monina monina*
91	Nymphalidae	*Euthalia aconthea gurda*
92	Nymphalidae	*Euthalia adonia pinwilli*
93	Nymphalidae	*Polyura hebe plautus*
94	Nymphalidae	*Polyura moori*
95	Nymphalidae	*Polyura schreiber*
96	Riodinidae	*Abisara geza niya*
97	Riodinidae	*Abisara savitri savitri*
98	Riodinidae	*Abisara saturata kausambioides*
99	Lycaenidae	*Miletus biggsii biggsii*
100	Lycaenidae	*Allotinus unicolor unicolor*
101	Lycaenidae	*Logania marmorata damis*
102	Lycaenidae	*Spalgis epius epius*
103	Lycaenidae	*Curetis saronis sumatrana*
104	Lycaenidae	*Everes lacturnus rileyi*
105	Lycaenidae	*Megisba malaya sikkima*

Appendix 8. Continuation

S/No.	Family	Scientific Name
106	Lycaenidae	*Acytolepis puspa lambi*
107	Lycaenidae	*Zizina otis lampa*
108	Lycaenidae	*Zizula hylax pygmaea*
109	Lycaenidae	*Zizeeria maha serica*
110	Lycaenidae	*Chilades pandava pandava*
111	Lycaenidae	*Euchrysops cnejus cnejus*
112	Lycaenidae	*Catochrysops strabo strabo*
113	Lycaenidae	*Catochrysops panormus exiguus*
114	Lycaenidae	*Lampides boeticus*
115	Lycaenidae	*Jamides bochus nabonassar*
116	Lycaenidae	*Jamides alecto ageladas*
117	Lycaenidae	*Jamides celeno aelianus*
118	Lycaenidae	*Jamides malaccanus malaccanus*
119	Lycaenidae	*Nacaduba berenice icena*
120	Lycaenidae	*Nacaduba biocellata*
121	Lycaenidae	*Nacaduba kurava nemana*
122	Lycaenidae	*Ionolyce helicon merguiana*
123	Lycaenidae	*Prosotas aluta nanda*
124	Lycaenidae	*Prosotas nora superdates*
125	Lycaenidae	*Prosotas dubiosa lumpura*
126	Lycaenidae	*Catopyrops ancyra*
127	Lycaenidae	*Petrelaea dana dana*
128	Lycaenidae	*Anthene emolus goberus*
129	Lycaenidae	*Anthene lycaenina miya*
130	Lycaenidae	*Spindasis syama terana*
131	Lycaenidae	*Spindasis lohita senama*
132	Lycaenidae	*Arhopala centaurus nakula*
133	Lycaenidae	*Arhopala amphimuta amphimuta*
134	Lycaenidae	*Arhopala major major*
135	Lycaenidae	*Arhopala abseus abseus*
136	Lycaenidae	*Flos apidanus saturatus*
137	Lycaenidae	*Surendra vivarna amisena*
138	Lycaenidae	*Catapaecilma major emas*
139	Lycaenidae	*Loxura atymnus fuconius*
140	Lycaenidae	*Eooxylides tharis distanti*

Appendix 8. Continuation

S/No.	Family	Scientific Name
141	Lycaenidae	*Horaga syrinx maenala*
142	Lycaenidae	*Pratapa deva relata*
143	Lycaenidae	*Tajuria cippus maxentius*
144	Lycaenidae	*Tajuria mantra mantra*
145	Lycaenidae	*Rachana jalindra burbona*
146	Lycaenidae	*Neocheritra amrita amrita*
147	Lycaenidae	*Hypolycaena thecloides thecloides*
148	Lycaenidae	*Hypolycaena erylus teatus*
149	Lycaenidae	*Zeltus amasa maximinianus*
150	Lycaenidae	*Deudorix elioti*
151	Lycaenidae	*Rapala cowani*
152	Lycaenidae	*Rapala domitia domitia*
153	Lycaenidae	*Rapala pheretima sequeira*
154	Lycaenidae	*Rapala iarbus iarbus*
155	Lycaenidae	*Rapala manea chozeba*
156	Lycaenidae	*Rapala varuna orseis*
157	Hesperiidae	*Burara etelka*
158	Hesperiidae	*Burara harisa consobrina*
159	Hesperiidae	*Hasora chromus chromus*
160	Hesperiidae	*Hasora taminatus malayana*
161	Hesperiidae	*Hasora badra badra*
162	Hesperiidae	*Hasora vitta vitta*
163	Hesperiidae	*Badamia exclamationis*
164	Hesperiidae	*Celaenorrhinus asmara asmara*
165	Hesperiidae	*Tagiades japetus atticus*
166	Hesperiidae	*Tagiades gana gana*
167	Hesperiidae	*Odontoptilum angulatum angulatum*
168	Hesperiidae	*Ampittia dioscorides camertes*
169	Hesperiidae	*Iambrix salsala salsala*
170	Hesperiidae	*Psolos fuligo fuligo*
171	Hesperiidae	*Astictopterus jama jama*
172	Hesperiidae	*Ancistroides nigrita maura*
173	Hesperiidae	*Notocrypta paralysos*
174	Hesperiidae	*Udaspes folus*
175	Hesperiidae	*Suastus gremius gremius*

Appendix 8. Continuation

S/No.	Family	Scientific Name
176	Hesperiidae	*Zographetus doxus*
177	Hesperiidae	*Hyarotis adrastus praba*
178	Hesperiidae	*Plastingia naga*
179	Hesperiidae	*Matapa aria*
180	Hesperiidae	*Erionota acroleuca apicalis*
181	Hesperiidae	*Erionota torus*
182	Hesperiidae	*Erionota thrax thrax*
183	Hesperiidae	*Erionota hiraca apicalis*
184	Hesperiidae	*Hidari irava*
185	Hesperiidae	*Taractrocera archias quinta*
186	Hesperiidae	*Potanthus omaha omaha*
187	Hesperiidae	*Potanthus serina*
188	Hesperiidae	*Potanthus trachala tytleri*
189	Hesperiidae	*Potanthus ganda*
190	Hesperiidae	*Cephrenes acalle niasicus*
191	Hesperiidae	*Cephrenes trichopepla*
192	Hesperiidae	*Salanoemia tavoyana*
193	Hesperiidae	*Telicota colon stinga*
194	Hesperiidae	*Telicota besta bina*
195	Hesperiidae	*Telicota augias augias*
196	Hesperiidae	*Telicota linna*
197	Hesperiidae	*Pelopidas mathias mathias*
198	Hesperiidae	*Borbo cinnara cinnara*
199	Hesperiidae	*Pelopidas conjunctus conjunctus*
200	Hesperiidae	*Polytremis lubricans lubricans*
201	Hesperiidae	*Baoris oceia*
202	Hesperiidae	*Baoris farri farri*
203	Hesperiidae	*Caltoris bromus*
204	Hesperiidae	*Caltoris cormasa*
205	Hesperiidae	*Caltoris malaya*

Appendix 9. List of Orthoptera (identified to at least genus)

S/No.	Family	Scientific Name
1	Acrididae	*Acrida willemsei*
2	Acrididae	*Aiolopus thalassinus tamulus*
3	Acrididae	*Apalacris varicornis*
4	Acrididae	*Epistaurus aberrans*
5	Acrididae	*Oxya hyla intricata*
6	Acrididae	*Oxya japonica japonica*
7	Acrididae	*Phlaeoba antennata*
8	Acrididae	*Phlaeoba infumata*
9	Acrididae	*Pseudoxya diminuta*
10	Acrididae	*Spathosternum prasiniferum*
11	Acrididae	*Traulia azureipennis*
12	Acrididae	*Trilophidia annulata*
13	Acrididae	*Valanga nigricornis*
14	Acrididae	*Xenocatantops humilis*
15	Gryllacrididae	*Caustogryllacris* sp.
16	Gryllacrididae	*Gryllacris signifera*
17	Gryllacrididae	*Gryllacris* sp.
18	Gryllacrididae	*Larnaca* sp.
19	Gryllidae	*Aphonoides* sp.
20	Gryllidae	*Aphonoides* sp. 2
21	Gryllidae	*Cardiodactylus singapura*
22	Gryllidae	*Endodrelanva jimini*
23	Gryllidae	*Euscyrtus concinnus*
24	Gryllidae	*Gryllus bimaculatus*
25	Gryllidae	*Gymnogryllus* sp.
26	Gryllidae	*Gymnogryllus sylvestris*
27	Gryllidae	*Lebinthus luae*
28	Gryllidae	*Loxoblemmus* sp.
29	Gryllidae	*Patiscus malayanus*
30	Gryllidae	*Pteronemobius* sp.
31	Gryllidae	*Sclerogryllus* sp. 1
32	Gryllidae	*Sclerogryllus* sp. 2
33	Gryllidae	*Teleogryllus* sp.
34	Gryllidae	*Velarifictorus aspersus*
35	Mogoplistidae	*Apterornebius* sp.

Appendix 9. Continuation

S/No.	Family	Scientific Name
36	Mogoplistidae	*Cycloptiloides* sp.
37	Mogoplistidae	*Micrornebius* sp.
38	Mogoplistidae	*Ornebius pullus*
39	Mogoplistidae	*Ornebius rufonigrus*
40	Mogoplistidae	*Ornebius* sp.
41	Mogoplistidae	*Ornebius tampines*
42	Pyrgomorphidae	*Atractomorpha psittacina psittacina*
43	Pyrgomorphidae	*Tagasta marginella*
44	Tetrigidae	*Coptotettix* sp.
45	Tetrigidae	*Euparatettix* sp.
46	Tetrigidae	*Euparatettix variabilis*
47	Tetrigidae	*Thoradonta nodulosa*
48	Tettigoniidae	*Alloteratura lamella*
49	Tettigoniidae	*Alloteratura subanalis*
50	Tettigoniidae	*Asiophlugis thaumasia*
51	Tettigoniidae	*Carliphisis leontopolites*
52	Tettigoniidae	*Casigneta bisinuata*
53	Tettigoniidae	*Conocephalus longipennis*
54	Tettigoniidae	*Conocephalus maculatus*
55	Tettigoniidae	*Conocephalus melaenus*
56	Tettigoniidae	*Ducetia japonica*
57	Tettigoniidae	*Hexacentrus unicolor*
58	Tettigoniidae	*Holochlora bilobata*
59	Tettigoniidae	*Holochlora obtusa*
60	Tettigoniidae	*Mecopoda elongata*
61	Tettigoniidae	*Nahlaksia bidadari*
62	Tettigoniidae	*Neophisis siamensis*
63	Tettigoniidae	*Oxylakis singaporensis*
64	Tettigoniidae	*Phaneroptera brevis*
65	Tettigoniidae	*Phaulula malayica*
66	Tettigoniidae	*Stictophaula* sp.
67	Trigonidiidae	*Amusurgus* sp. 1
68	Trigonidiidae	*Amusurgus* sp. 2
69	Trigonidiidae	*Homoeoxipha lycoides*
70	Trigonidiidae	*Metioche pallipes*

Appendix 9. Continuation

S/No.	Family	Scientific Name
71	Trigonidiidae	*Natula longipennis*
72	Trigonidiidae	*Svistella chekjawa*
73	Trigonidiidae	*Svistella* sp.

Appendix 10. List of Odonata

S/No.	Family	Scientific Name
1	Coenagrionidae	*Agriocnemis femina*
2	Coenagrionidae	*Archibasis viola*
3	Coenagrionidae	*Argiocnemis rubescens*
4	Coenagrionidae	*Ceriagrion cerinorubellum*
5	Coenagrionidae	*Ischnura senegalensis*
6	Coenagrionidae	*Mortonagrion arthuri*
7	Coenagrionidae	*Pseudagrion microcephalum*
8	Coenagrionidae	*Teinobasis ruficollis*
9	Lestidae	*Lestes praemorsus*
10	Platycnemididae	*Copera marginipes*
11	Platycnemididae	*Copera vittata*
12	Platycnemididae	*Onychargia atrocyana*
13	Aeshnidae	*Anax guttatus*
14	Aeshnidae	*Anax panybeu*s
15	Aeshnidae	*Gynacantha dohrni*
16	Aeshnidae	*Gynacantha subinterrupta*
17	Aeshnidae	*Heliaeschna uninervulata*
18	Gomphidae	*Heliogomphus kelantanensis*
19	Gomphidae	*Ictinogomphus decoratus*
20	Macromiidae	*Epophthalmia vittiger*a
21	Libellulidae	*Acisoma panorpoides*
22	Libellulidae	*Aethriamanta brevipennis*
23	Libellulidae	*Aethriamanta gracilis*
24	Libellulidae	*Agrionoptera insignis*
25	Libellulidae	*Agrionoptera sexlineata*
26	Libellulidae	*Brachydiplax chalybea*
27	Libellulidae	*Brachythemis contaminata*
28	Libellulidae	*Camacinia gigantea*
29	Libellulidae	*Chalybiothemis fluviatilis*

Appendix 10. Continuation

S/No.	Family	Scientific Name
30	Libellulidae	*Cratilla lineata*
31	Libellulidae	*Cratilla metallica*
32	Libellulidae	*Crocothemis servilia*
33	Libellulidae	*Diplacodes trivialis*
34	Libellulidae	*Hydrobasileus croceus*
35	Libellulidae	*Indothemis carnatica*
36	Libellulidae	*Lathrecista asiatica*
37	Libellulidae	*Macrodiplax cora*
38	Libellulidae	*Nannophya pygmaea*
39	Libellulidae	*Neurothemis fluctuans*
40	Libellulidae	*Orchithemis pulcherrima*
41	Libellulidae	*Orthetrum chrysis*
42	Libellulidae	*Orthetrum glaucum*
43	Libellulidae	*Orthetrum sabina*
44	Libellulidae	*Orthetrum testaceum*
45	Libellulidae	*Pantala flavescens*
46	Libellulidae	*Pornothemis starrei*
47	Libellulidae	*Potamarcha congener*
48	Libellulidae	*Pseudothemis jorina*
49	Libellulidae	*Raphismia bispina*
50	Libellulidae	*Rhodothemis rufa*
51	Libellulidae	*Rhyothemis obsolescens*
52	Libellulidae	*Rhyothemis phyllis*
53	Libellulidae	*Rhyothemis triangularis*
54	Libellulidae	*Tholymis tillarga*
55	Libellulidae	*Tramea transmarina*
56	Libellulidae	*Trithemis aurora*
57	Libellulidae	*Trithemis festiva*
58	Libellulidae	*Trithemis pallidinervis*
59	Libellulidae	*Urothemis signata*
60	Libellulidae	*Zyxomma obtusum*
61	Libellulidae	*Zyxomma petiolatum*

Appendix 11. List of Birds

S/No.	Family	Scientific Name
1	Acanthizidae	*Gerygone sulphurea*
2	Accipitridae	*Accipiter gularis*
3	Accipitridae	*Accipiter soloensis*
4	Accipitridae	*Accipiter trivirgatus*
5	Accipitridae	*Aquila heliaca*
6	Accipitridae	*Aviceda jerdoni*
7	Accipitridae	*Aviceda leuphotes*
8	Accipitridae	*Butastur indicus*
9	Accipitridae	*Buteo buteo*
10	Accipitridae	*Circus melanoleucos*
11	Accipitridae	*Circus spilonotus*
12	Accipitridae	*Elanus caeruleus*
13	Accipitridae	*Haliaeetus ichthyaetus*
14	Accipitridae	*Haliaeetus leucogaster*
15	Accipitridae	*Haliastur indus*
16	Accipitridae	*Hieraaetus pennatus*
17	Accipitridae	*Milvus migrans*
18	Accipitridae	*Nisaetus cirrhatus*
19	Accipitridae	*Pernis ptilorhyncus*
20	Accipitridae	*Spilornis cheela*
21	Acrocephalidae	*Acrocephalus bistrigiceps*
22	Acrocephalidae	*Acrocephalus orientalis*
23	Aegithinidae	*Aegithina tiphia*
24	Alcedinidae	*Alcedo atthis*
25	Alcedinidae	*Alcedo meninting*
26	Alcedinidae	*Ceyx erithaca*
27	Alcedinidae	*Halcyon coromanda*
28	Alcedinidae	*Halcyon pileata*
29	Alcedinidae	*Halcyon smyrnensis*
30	Alcedinidae	*Pelargopsis capensis*
31	Alcedinidae	*Todirhamphus chloris*
32	Anatidae	*Dendrocygna javanica*
33	Anhingidae	*Anhinga melanogaster*
34	Apodidae	*Aerodramus germani*
35	Apodidae	*Aerodramus maximus*

Appendix 11. Continuation

S/No.	Family	Scientific Name
36	Apodidae	*Apus nipalensis*
37	Apodidae	*Apus pacificus*
38	Apodidae	*Cypsiurus balasiensis*
39	Apodidae	*Hirundapus giganteus*
40	Ardeidae	*Ardea alba*
41	Ardeidae	*Ardea cinerea*
42	Ardeidae	*Ardea intermedia*
43	Ardeidae	*Ardea purpurea*
44	Ardeidae	*Ardea sumatrana*
45	Ardeidae	*Ardeola bacchus*
46	Ardeidae	*Bubulcus coromandus*
47	Ardeidae	*Butorides striatus*
48	Ardeidae	*Egretta eulophotes*
49	Ardeidae	*Egretta garzetta*
50	Ardeidae	*Egretta sacra*
51	Ardeidae	*Gorsachius melanolophus*
52	Ardeidae	*Ixobrychus cinnamomeus*
53	Ardeidae	*Ixobrychus eurhythmus*
54	Ardeidae	*Ixobrychus flavicollis*
55	Ardeidae	*Ixobrychus sinensis*
56	Ardeidae	*Nycticorax nycticorax*
57	Bucerotidae	*Anthracoceros albirostris*
58	Calyptomenidae	*Calyptomena viridis*
59	Campephagidae	*Lalage nigra*
60	Campephagidae	*Pericrocotus divaricatus*
61	Caprimulgidae	*Caprimulgus affinis*
62	Caprimulgidae	*Caprimulgus macrurus*
63	Charadriidae	*Charadrius alexandrinus*
64	Charadriidae	*Charadrius dubius*
65	Charadriidae	*Charadrius leschenaultii*
66	Charadriidae	*Charadrius mongolus*
67	Charadriidae	*Charadrius peronii*
68	Charadriidae	*Charadrius veredus*
69	Charadriidae	*Pluvialis fulva*
70	Charadriidae	*Pluvialis squatarola*
71	Charadriidae	*Vanellus indicus*

Appendix 11. Continuation

S/No.	Family	Scientific Name
72	Chloropseidae	*Chloropsis cochinchinensis*
73	Ciconiidae	*Anastomus oscitans*
74	Ciconiidae	*Leptoptilos javanicus*
75	Cisticolidae	*Cisticola juncidis*
76	Cisticolidae	*Orthotomus atrogularis*
77	Cisticolidae	*Orthotomus ruficeps*
78	Cisticolidae	*Orthotomus sericeus*
79	Cisticolidae	*Orthotomus sutorius*
80	Cisticolidae	*Prinia flaviventris*
81	Columbidae	*Chalcophaps indica*
82	Columbidae	*Ducula aenea*
83	Columbidae	*Ducula badia*
84	Columbidae	*Ducula bicolor*
85	Columbidae	*Geopelia striata*
86	Columbidae	*Ptilinopus jambu*
87	Columbidae	*Spilopelia chinensis*
88	Columbidae	*Treron curvirostra*
89	Columbidae	*Treron fulvicollis*
90	Columbidae	*Treron olax*
91	Columbidae	*Treron vernans*
92	Coraciidae	*Eurystomus orientalis*
93	Corvidae	*Corvus macrorhynchus*
94	Cuculidae	*Cacomantis merulinus*
95	Cuculidae	*Cacomantis sepulcralis*
96	Cuculidae	*Cacomantis sonneratii*
97	Cuculidae	*Centropus bengalensis*
98	Cuculidae	*Centropus sinensis*
99	Cuculidae	*Chrysococcyx basalis*
100	Cuculidae	*Chrysococcyx maculatus*
101	Cuculidae	*Chrysococcyx minutillus*
102	Cuculidae	*Chrysococcyx xanthorhynchus*
103	Cuculidae	*Clamator coromandus*
104	Cuculidae	*Cuculus micropterus*
105	Cuculidae	*Cuculus saturatus*
106	Cuculidae	*Eudynarnys scolopacea*
107	Cuculidae	*Hierococcyx niscicolor*

Appendix 11. Continuation

S/No.	Family	Scientific Name
108	Cuculidae	*Hierococcyx sparverioides*
109	Cuculidae	*Phaenicophaeus sumatranus*
110	Cuculidae	*Surniculus lugubris*
111	Dicaeidae	*Dicaeum cruentatum*
112	Dicaeidae	*Dicaeum trigonostigma*
113	Dicaeidae	*Prionochilus thoracicus*
114	Dicruridae	*Dicrurus annectans*
115	Dicruridae	*Dicrurus paradiseus*
116	Estrildidae	*Lonchura maja*
117	Estrildidae	*Lonchura malacca*
118	Estrildidae	*Lonchura punctulata*
119	Estrildidae	*Lonchura striata*
120	Eurylaimidae	*Cymbirhynchus macrorhynchos*
121	Falconidae	*Falco peregrinus*
122	Falconidae	*Falco severus*
123	Falconidae	*Falco subbuteo*
124	Fregatidae	*Fregata andrewsi*
125	Glareolidae	*Glareola maldivarum*
126	Hirundinidae	*Hirundo daurica*
127	Hirundinidae	*Hirundo rustica*
128	Hirundinidae	*Hirundo tahitica*
129	Hirundinidae	*Riparia riparia*
130	Hydrobatidae	*Hydrobates monorhis*
131	Irenidae	*Irena puella*
132	Laniidae	*Lanius cristatus*
133	Laniidae	*Lanius scach*
134	Laniidae	*Lanius tigrinus*
135	Laridae	*Chlidonias hybridus*
136	Laridae	*Chlidonias leucopterus*
137	Laridae	*Gelochelidon nilotica*
138	Laridae	*Larus ridibundus*
139	Laridae	*Sterna anaethetus*
140	Laridae	*Sterna hirundo*
141	Laridae	*Sterna sumatrana*
142	Laridae	*Sternula albifrons*

Appendix 11. Continuation

S/No.	Family	Scientific Name
143	Laridae	*Thalasseus bengalensis*
144	Laridae	*Thalasseus bergii*
145	Locustellidae	*Helopsaltes certhiola*
146	Locustellidae	*Locustella lanceolata*
147	Megalaimidae	*Psilopogon haemacephalus*
148	Meropidae	*Merops philippinus*
149	Meropidae	*Merops viridis*
150	Monarchidae	*Hypothymis azurea*
151	Monarchidae	*Terpsiphone affinis*
152	Monarchidae	*Terpsiphone incei*
153	Motacillidae	*Anthus rufulus*
154	Motacillidae	*Dendronanthus indicus*
155	Motacillidae	*Motacilla alba*
156	Motacillidae	*Motacilla cinerea*
157	Motacillidae	*Motacilla tschutschensis*
158	Muscicapidae	*Copsychus malabaricus*
159	Muscicapidae	*Copsychus saularis*
160	Muscicapidae	*Cyornis rufigastra*
161	Muscicapidae	*Ficedula mugimaki*
162	Muscicapidae	*Ficedula zanthopygia*
163	Muscicapidae	*Larvivora cyane*
164	Muscicapidae	*Muscicapa dauurica*
165	Muscicapidae	*Muscicapa ferruginea*
166	Nectariniidae	*Aethopyga siparaja*
167	Nectariniidae	*Anthreptes malacensis*
168	Nectariniidae	*Arachnothera chrysogenys*
169	Nectariniidae	*Arachnothera longirostra*
170	Nectariniidae	*Chalcoparia singalensis*
171	Nectariniidae	*Cinnyris jugularis*
172	Nectariniidae	*Leptocoma brasiliana*
173	Nectariniidae	*Leptocoma calcostetha*
174	Oriolidae	*Oriolus chinensis*
175	Pachycephalidae	*Pachycephala cinerea*
176	Pandionidae	*Pandion haliaetus*
177	Passeridae	*Passer montanus*

Appendix 11. Continuation

S/No.	Family	Scientific Name
178	Pellorneidae	*Malacocincla abbotti*
179	Pellorneidae	*Pellorneum rostratum*
180	Phasianidae	*Gallus gallus*
181	Phasianidae	*Synoicus chinensis*
182	Phylloscopidae	*Phylloscopus borealis*
183	Phylloscopidae	*Phylloscopus borealoides*
184	Phylloscopidae	*Phylloscopus coronatus*
185	Phylloscopidae	*Phylloscopus inornatus*
186	Picidae	*Chrysophlegma miniaceum*
187	Picidae	*Dinopium javanense*
188	Picidae	*Meiglyptes tristis*
189	Picidae	*Micropternus brachyurus*
190	Picidae	*Picus vittatus*
191	Picidae	*Yungipicus moluccensis*
192	Pittidae	*Pitta megarhyncha*
193	Pittidae	*Pitta moluccensis*
194	Pittidae	*Pitta sordida*
195	Ploceidae	*Ploceus philippinus*
196	Podicipedidae	*Tachybaptus ruficollis*
197	Psittaculidae	*Loriculus galgulus*
198	Psittaculidae	*Psittacula longicauda*
199	Psittaculidae	*Psittinus cyanurus*
200	Pycnonotidae	*Hemixos cinereus*
201	Pycnonotidae	*Ixos malaccensis*
202	Pycnonotidae	*Pycnonotus atriceps*
203	Pycnonotidae	*Pycnonotus goiavier*
204	Pycnonotidae	*Pycnonotus plumosus*
205	Pycnonotidae	*Pycnonotus zeylanicus*
206	Rallidae	*Amaurornis phoenicurus*
207	Rallidae	*Gallicrex cinerea*
208	Rallidae	*Gallinula chloropus*
209	Rallidae	*Lewinia striata*
210	Rallidae	*Rallina fasciata*
211	Rallidae	*Zapornia fusca*
212	Recurvirostridae	*Himantopus leucocephalus*

Appendix 11. Continuation

S/No.	Family	Scientific Name
213	Rhipiduridae	*Rhipidura javanica*
214	Scolopacidae	*Actitis hypoleucos*
215	Scolopacidae	*Arenaria interpres*
216	Scolopacidae	*Calidris alba*
217	Scolopacidae	*Calidris canutus*
218	Scolopacidae	*Calidris falcinellus*
219	Scolopacidae	*Calidris ferruginea*
220	Scolopacidae	*Calidris minuta*
221	Scolopacidae	*Calidris ruficollis*
222	Scolopacidae	*Calidris subminuta*
223	Scolopacidae	*Calidris tenuirostris*
224	Scolopacidae	*Gallinago stenura*
225	Scolopacidae	*Limnodromus semipalmatus*
226	Scolopacidae	*Limosa lapponica*
227	Scolopacidae	*Limosa limosa*
228	Scolopacidae	*Numenius arquata*
229	Scolopacidae	*Numenius phaeopus*
230	Scolopacidae	*Tringa brevipes*
231	Scolopacidae	*Tringa glareola*
232	Scolopacidae	*Tringa nebularia*
233	Scolopacidae	*Tringa stagnatilis*
234	Scolopacidae	*Tringa totanus*
235	Scolopacidae	*Xenus cinereus*
236	Strigidae	*Bubo sumatranus*
237	Strigidae	*Ketupa ketupu*
238	Strigidae	*Ninox scutulata*
239	Strigidae	*Otus lempiji*
240	Strigidae	*Otus sunia*
241	Strigidae	*Strix leptogrammica*
242	Strigidae	*Strix seloputo*
243	Sturnidae	*Acridotheres tristis*
244	Sturnidae	*Agropsar sturninus*
245	Sturnidae	*Aplonis panayensis*
246	Sturnidae	*Gracula religiosa*
247	Sturnidae	*Sturnus sinensis*

Appendix 11. Continuation

S/No.	Family	Scientific Name
248	Timaliidae	*Mixornis gularis*
249	Turdidae	*Geokichla citrina*
250	Turdidae	*Turdus obscurus*
251	Turnicidae	*Turnix suscitator*
252	Tytonidae	*Tyto alba*
253	Vangidae	*Hemipus hirundinaceus*
254	Vangidae	*Tephrodonis virgatus*
255	Zosteropidae	*Zosterops simplex*

An update on the vascular flora of Pulau Ubin, Singapore

R.C.H. Teo[1], Ali Ibrahim[2], Bazilah Ibrahim[3], B.C. Ho[3], S.L. Koh[3], H.K. Lua[4]

[1]Pulau Ubin Branch, National Parks Board,
61 Pulau Ubin, 508310 Singapore
Robert_Teo@nparks.gov.sg
[2]c/o Herbarium, Singapore Botanic Gardens, National Parks Board,
1 Cluny Road, 259569 Singapore
[3]Herbarium, Singapore Botanic Gardens, National Parks Board,
1 Cluny Road, 259569 Singapore
[4]National Biodiversity Centre, National Parks Board,
1 Cluny Road, 259569 Singapore

ABSTRACT. The baseline inventory of the vascular flora of Pulau Ubin was updated through the collation of records from the past three decades. We recorded 569 indigenous morphospecies, belonging to 122 families for the island. Over 315 species are threatened with extinction in Singapore, and some species are currently known only from Pulau Ubin. The results highlight the importance of Pulau Ubin for the long-term conservation of Singapore's natural heritage.

Keywords. baseline inventory, conservation, mangroves, Pulau Ubin, secondary forest, regeneration, vascular flora

Introduction

There have only been two modern accounts of the vascular flora of Pulau Ubin – Turner et al. (1992) and Lee et al. (2003), with the latter focusing on the flora at Tanjong Chek Jawa. Apart from these, much field work has, however, been conducted to survey and collect plants on the island. Here, we collate the data gathered over the past three decades for a comprehensive update of the vascular flora of Pulau Ubin. The new baseline is expected to see a significant increase in the number of indigenous species for the island and will serve as a useful resource for future management and monitoring for the long-term conservation of Pulau Ubin's vascular flora, as well as the fauna that it supports.

Materials and Methods

Field surveys targeting specific areas were carried out from 2002 to 2004 (key mangrove areas), 2006 to 2008 (Bukit Belukar, Bukit Melayu, Bukit Surau) and 2014 to 2015 (other areas, apart from Chek Jawa Wetlands), while ad hoc collections were made from 1998 to 2024. Plants grown in premises being occupied by villagers were not included.

Representative voucher specimens were collected and deposited in the Herbarium of Singapore Botanic Gardens (SING). Where no fertile material was available for collection as voucher specimens, identification was either made in the field or through cross-referencing non-fertile material against available voucher specimens in SING.

Voucher specimens collected by Turner et al. (1992), Lee et al. (2003) and other researchers or collectors were included and updated as the taxonomy and conservation status of many species had been redetermined by the Flora of Singapore project (Lindsay et al., 2022). Records of species planted by the National Parks Board (NParks) were also referenced and incorporated in the results (up until 31 December 2024).

The names of species used follow that of Lindsay et al. (2022), or available literature in consultation with SING.

Results

The compilation of vascular plant species found growing in the wild in Pulau Ubin included 569 native morphospecies, including 4 natural hybrids (Appendix I), as well as 44 cryptogenic species and 445 non-native or cryptogenic species and hybrids (Appendix II). There were also 316 native species planted by NParks but not found in the wild in Pulau Ubin (Appendix III). Out of 184 indigenous species recorded before 1960, 105 species (about 57%) were found to be still extant (Appendix IV).

The indigenous flora was represented by 1 lycophyte, 48 ferns, 6 gymnosperms and 514 angiosperms. The species assemblage was spread across 122 families, and was dominated by Fabaceae (39 species), Poaceae (32 species), Rubiaceae (32 species), Cyperaceae (30 species), Moraceae (27 species) and Apocynaceae (24 species).

The most common native tree species recorded in dryland habitats were *Adinandra dumosa*, *Arthrophyllum jackianum*, *Champereia manillana*, *Cinnamomum iners*, *Claoxylon indicum*, *Clausena excavata*, *Clerodendrum disparifolium*, *Cyrtophyllum fragrans*, *Elaeocarpus pedunculatus*, *Ficus fistulosa*, *Ficus variegata*, *Ficus vasculosa*, *Knema corticosa*, *Litsea elliptica*, *Macaranga gigantea*, *Macaranga heynei*, *Macaranga hypoleuca*, *Litsea umbellata*, *Oncosperma tigillarium*, *Planchonella obovata*, *Rhodamnia cinerea*, *Syzygium syzygioides*, *Syzygium zeylanicum*, *Terminalia catappa*, *Timonius wallichianus*, *Triadica cochinchinensis* and *Vitex pinnata*.

The native flora included 32 of the 34 extant 'true' mangrove species for Singapore (Yang et al., 2011 recognized 35 species, but *Bruguiera hainesii* is excluded here as Ono et al., 2016 determined it to be a hybrid, *Bruguiera × hainesii*) – *Avicennia marina* and *Kandelia candel* were not recorded in the wild. The most common species in the mangrove community were *Avicennia alba*, *A. officinalis*, *A. rumphiana*, *Bruguiera cylindrica*, *B. gymnorhiza*, *Ceriops tagal*, *C. zippeliana*, *Hibiscus tiliaceus, Rhizophora apiculata*, *R. mucronata*, *Sonneratia alba* and *Xylocarpus granatum.* There were records of up to a few trees of *Aegiceras corniculatum*, *Bruguiera sexangula*, *Dolichandrone spathacea* and *Sonneratia caseolaris*. A few sizeable stands of *Nypa fruticans* and *Sonneratia ovata* were located. A small population of *Brownlowia tersa* was found within the *Nypa fruticans* stand upstream of Sungei Durian, while a large population of *Bruguiera parviflora* was recorded at Sungei Besar.

Of the 11 species of seagrass found in Singapore, nine species were recorded, primarily within Chek Jawa Wetlands. The most common species were *Cymodocea rotundata*, *Halodule uninervis* and *Halophila ovalis*. Apart from Chek Jawa Wetlands, the latter was recorded in small, scattered populations along the southern coast.

Common naturalised species included trees and palms, like *Acacia auriculiformis*, *Cocos nucifera*, *Hevea brasiliensis*, *Leucaena leucocephala* and *Ptychosperma macarthurii*, as well as shrubs and herbs, like *Adiantum latifolium*, *Asystasia gangetica*, *Mikania micrantha* and *Sieruela rutidosperma*.

Discussion

Changes in Vegetation
The original vegetation and flora of Pulau Ubin had undergone drastic changes due to the historical land use of the island. Changes in the vegetation can be easily detected by comparison of aerial photographs and satellite imagery over the past decades (Fig. 3).

Most of the terrestrial vegetation had been cleared for activities such as granite mining, cultivation of crops (largely rubber and coconut) or human settlements. Except for a few areas, much of the mangroves had also been removed to facilitate aquaculture, typically prawn farming – in some areas this included the excavation of the original mangrove substrate to construct aquaculture ponds.

With the cessation of key economic activities and the resettlement of most of the settlements from the 1980s to early 2000s, a period of regeneration of forests and mangroves followed, and much of the island is now covered in vegetation.

Composition of Present-day Vegetation
The present-day terrestrial vegetation was expected to be dominated by secondary forest species due to past anthropogenic activities, and this was indeed reflected by the composition of the most common species found. Not surprisingly, there were very few records of species typical of primary lowland forest. In particular, there were no records of Dipterocarpaceae, and few representatives of Burseraceae, Meliaceae, Myristicaceae and Zingiberaceae.

The granite mining areas had largely been clear-felled of trees and then overlaid with granite aggregates and compacted to facilitate operations. Regrowth over those areas was characterised by open scrub and woodland species including many which are naturalised, such as *Acacia auriculiformis*, *Falcataria falcata*, *Lantana camara*, *Leucaena leucocephala*, *Mikania micrantha*, *Mimosa pudica*, *Muntingia calabura*, *Spathodea campanulata*, *Stachytarpheta jamaicensis* and *Urena lobata*. Native early successional species found in such areas included *Caryota mitis*, *Claoxylon indicum*, *Clausena excavata*, *Commersonia bartramia*, *Dicranopteris linearis* var. *linearis, Dillenia suffruticosa*, *Imperata cylindrica*, *Leea indica*, *Macaranga heynei*, *Melastoma malabathricum*, *Terminalia catappa*, *Trema cannabina*, *Vernonia cinerea* and *Vitex pinnata*.

The species assemblage across regenerating rubber plantations, apart from relic and regrowth of *Hevea brasiliensis* itself, included pioneer species like *Adinandra dumosa*, *Angelesia splendens*, *Arthrophyllum jackianum*, *Clausena excavata*, *Clerodendrum disparifolium*, *Cyrtophyllum fragrans*, *Eurya acuminata*, *Ficus fistulosa*, *Macaranga gigantea*, *Macaranga heynei*, *Macaranga hypoleuca*, *Morella esculenta*, *Planchonella obovata*, *Rhodamnia cinerea*, *Syzygium syzygioides*, *Syzygium zeylanicum* and *Vitex pinnata*, as well as species of later succession, for example, *Alstonia angustifolia*, *Archidendron clypearia var. clypearia*, *Buchanania arborescens*, *Campnosperma auriculata*, *Champereia manillana*, *Diospyros lanceifolia, Elaeocarpus pedunculatus*, *Ixonanthes reticulata*, *Ixora congesta*, *Litsea elliptica*, *Timonius wallichianus*, *Palaquium obovatum var. obovatum* and *Sloetia elongata*.

Areas formerly used for settlements were easily identified through relic mixed plantings comprising species commonly planted in traditional villages or *kampungs*. Examples include fruit trees and crops like *Areca catechu*, *Artocarpus heterophyllus*, *A. integer*, *Averrhoa carambola*, *Baccaurea motleyana*, *Carica papaya*, *Cocos nucifera*, *Durio zibethinus*, *Garcinia mangostana* var. *mangostana*, *Mangifera* x *odorata*, *Nephelium lappaceum var. lappaceum*, *Pandanus amaryllifolius*, *Psidium guajava*, *Syzygium aqueum*, *S. jambos*, *S. malaccense*, *Theobroma cacao*, and ornamentals like *Adiantum latifolium*, *Allamanda cathartica*, *Clerodendrum paniculatum, Codiaeum variegatum*, *Cordyline fruticosa*, *Dieffenbachia seguine*, *Dracaena aubryana*, *D. fragrans*, *Epipremnum aureum*, *Ixora chinensis*, *Justicia gendarussa*, *Leuenbergeria bleo*, and *Wrightia religiosa*.

Yang et al. (2013) reported 149 ha of mangrove forests for Pulau Ubin (over 20% of mangrove forests in Singapore), but due to rapid and substantial regeneration of mangrove areas cleared in the past, the current mangrove forest coverage is estimated to be over 200 ha. Out of 34 extant 'true' mangrove species for Singapore, 32 have been recorded. A large population of *Bruguiera parviflora* can be found at Sungei Besar, and good populations of *Nypa fruticans* are located at Chek Jawa Wetlands and the headwaters of Sungei Durian.

Chek Jawa Wetlands is the key site for nine species of seagrass found in Pulau Ubin, with the primary habitat being the 6.5 ha seagrass meadow within a natural lagoon (Yaakub, 2013).

Noteworthy Species

Leong & Lua (2021) reported the first and only records of *Ficus subulata* from Singapore from several small patches of secondary forest on Pulau Ubin.

Rodda & Lai (2018) indicated that *Hoya obtusifolia* is presently known only from a single plant in Pulau Ubin.

Ganesan (2013) reported the rediscovery and presence of a self-recruiting population of *Pterospermum diversifolium* on Pulau Ubin – the only known localities are at Bukit Jelutong and Bukit Pekan.

Actinoscirpus grossus was listed as Presumed Nationally Extinct by both Simpson, D.A. (2019) and Lindsay et al. (2022). The species has been found growing in a freshwater pond along Jalan Ubin, and the Conservation Status has been updated to Critically Endangered in NParks (2023).

There were two vouchered specimens of *Blumea balsamifera* which is listed as Presumed Nationally Extinct in Lindsay et al. (2022). The Conservation Status has been updated to Critically Endangered in NParks (2023).

Sugumaran & Wong (2014) redetermined *Fagraea racemosa* collected from Pulau Ubin to be misidentified, and recognised it as a new species to science, *Utania nervosa*. The species is restricted to the southern half of the Malay Peninsula, with Singapore records only from Pulau Ubin and Pulau Tekong.

Yeo et al. (2012) indicated that *Ficus stricta* is found only in Changi and Pulau Ubin, with less than 20 sizeable individuals.

A small population of the Critically Endangered orchid, *Thrixspermum amplexicaule*, was recorded in the west, at the foothills of Bukit Tock Kew, near a mangrove stream.

Another Critically Endangered orchid, *Neuwiedia veratrifolia*, has been found at the foothills of Bukit Tock Kew and Bukit Tinggi, as well as Bukit Bahru.

Good populations of *Capparis micracantha* subsp. *korthalsiana*, *Ixora lobbii*, *Knema corticosa*, *Lasianthus hirsutus* and *Utania nervosa* were found predominantly in the east, although *Knema corticosa* has been spreading westwards over the past two decades, probably through dispersal by birds and other animals.

Other interesting finds included disparately located examples of *Albizia splendens*, *Alstonia pneumatophora*, *Cerbera manghas*, *Ficus crassiramea*, *Mangifera griffithii*, as well as single locality records of *Aglaia cucullata*, *Antiaris toxicaria*, *Artocarpus griffithii*, *Barringtonia reticulata*, *Senegalia kekapur* and *Xylocarpus rumphii*.

Restoration Efforts
In 2001, the National Parks Board initiated the first large scale reforestation project in Pulau Ubin, along Jalan Endut Senin. Since then, many other areas that had been impacted by past anthropogenic activities have been restored. These efforts include both reforestation and mangrove restoration initiatives. In addition, species recovery projects to reintroduce threatened species of shrubs, herbs and climbers were carried out. The species listed in Appendix III will serve as a baseline reference for researchers carrying out botanical work on Pulau Ubin, to take cognizance that not all native species found on the island occur naturally.

Significance of the Flora of Pulau Ubin
The updated baseline has about 2.5 times the number of indigenous species listed by Turner et al. (1992), which recorded only about 220 native species. The 569 morphospecies recorded for Pulau Ubin represents about 24% of the over 2,400 native species of vascular plant species estimated by Middleton (2019) to occur in Singapore. Out of this, 319 species are listed as threatened in the Singapore Red Data List (1 Presumed Nationally Extinct, 133 Critically Endangered, 92 Endangered, 89 Vulnerable and 4 Data Deficient) and as elaborated previously, some species are found only in Pulau Ubin. The results underscore the importance of Pulau Ubin for the conservation of Singapore's flora. Additionally, the vegetation of Pulau Ubin is a key driver of its environment and microclimate, as well as a primary component of the island's varied habitats. Both the naturally occurring flora and that resulting from restoration efforts are important as they support the rich diversity of wildlife, and ultimately the conservation of Pulau Ubin's natural heritage. This new baseline inventory will provide an important updated reference for future land use planning and management, environmental impact studies, and research and monitoring.

Conclusion

This update of the vascular flora of Pulau Ubin is the most comprehensive one since Turner et al. (1992), with a very significant increase in the number of native species recorded. Pulau Ubin's vascular flora is a significant part of Singapore's natural heritage due to the large number of threatened species recorded, with some found only on the island. Management measures should continue to be taken to conserve key habitats so that the flora can be conserved and allowed to thrive.

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Appendix I. List of native vascular plants growing in the wild in Pulau Ubin
Abbreviations: **LC**: Least Concern **VU**: Vulnerable **EN**: Endangered **CR**: Critically Endangered **NEx**: Presumed Nationally Extinct **DD**: Data Deficient

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
LYCOPHYTES			
Family Lycopodiaceae			
Palhinhaea cernua (L.) Franco & Vasc.	LC	Bukit Asam, Bukit Ketam, Bukit Tajam Kechil	SING0164192; SING0338806; SING0338826
FERNS			
Family Aspleniaceae			
Asplenium longissimum Blume	LC	Bukit Belukar, Bukit Ketam, Bukit Surau, Tanjong Chek Jawa	SING0047406
Asplenium nidus L. var. *musifolium* (Mett.) C.Chr.	LC	Jalan Jelutong, Sensory Trail	
Asplenium nidus L. var. *nidus*	LC	Bukit Asam, Bukit Bahru, Bukit Belukar, Bukit Ketam, Bukit Puaka, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Kekek Quarry, Sensory Trail, Ubin Quarry; planted at Bukit Mamam	SING0153665; SING0335010; SING0335011; SING0336789; SING0336808; SING0337495; SING0337497
Asplenium nitidum Sw.	CR	Bukit Jelutong	SING0190189
Family Athyriaceae			
Diplazium fraxinifolium C.Presl	CR	Bukit Jelutong	SING0190193
Family Blechnaceae			
Blechnopsis finlaysoniana (Wall. ex Hook. & Grev.) C.Presl	LC	Bukit Belukar, Bukit Noordin, Bukit Tajam Kechil, Kekek Quarry	SING0387148; SING0387149
Blechnopsis orientalis (L.) C.Presl	LC	Bukit Jelutong, Bukit Ketam, Bukit Puaka, Bukit Tajam, Bukit Tinggi, Tanjong Chek Jawa	SING0042932; SING0337519
Stenochlaena palustris (Burm.f.) Bedd.	LC	Bukit Asam, Bukit Bahru, Bukit Belukar, Bukit Jelutong, Bukit Ketam, Bukit Mamam, Bukit Pekan, Bukit Puaka, Bukit Surau, Bukit Tajam, Bukit Tinggi, Jalan Endut Senin, Kekek Quarry, Sensory Trail, Tanjong Chek Jawa	SING0043118; SING0336826; SING0336849; SING0336854
Telmatoblechnum indicum (Burm.f.) Perrie et al.	CR	Sungei Jelutong, Sungei Mamam	SING0289044

Appendix I. Continuation

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Family Cyatheaceae			
Alsophila latebrosa Wall. ex Hook.	LC	Bukit Mamam, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi; planted at Jalan Jelutong & Sensory Trail Pond	SING0387154; SING0387155
Family Davalliaceae			
Davallia denticulata (Burm.f.) Mett. ex Kuhn var. *denticulata*	LC	Bukit Belukar, Bukit Jelutong, Bukit Ketam, Bukit Noordin, Bukit Pekan, Bukit Puaka, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Jalan Endut Senin, Kekek Quarry, Tanjong Chek Jawa; planted at Jalan Batu Ubin	SING0042365; SING0336263; SING0336264
Family Dennstaedtiaceae			
Histiopteris incisa (Thunb.) J.Sm.	CR	Bukit Mamam near mouth of Sungei Mamam	SING0059420
Microlepia speluncae (L.) T.Moore	VU	Southern foothill of Bukit Asam	SING0190190
Pteridium semihastatum (Wall. ex J.Agardh) S.B.Andrews	EN	Tanjong Chek Jawa	SING0045119; SING0333587; SING0333590
Family Dryopteridaceae			
Pleocnemia irregularis (C.Presl) Holttum	LC	Bukit Jelutong	SING0182013; SING0182014; SING0182015
Family Gleicheniaceae			
Dicranopteris curranii Copel.	LC	Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Bukit Tock Kew	SING 2024-270
Dicranopteris linearis (Burm.f.) Underw. var. *linearis*	LC	Bukit Asam, Bukit Bahru, Bukit Belukar, Bukit Mamam, Bukit Noordin, Bukit Puaka, Bukit Sempit, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Kekek Quarry	SING0153688; SING0336307; SING0336318; SING0336358
Family Lindsaeaceae			
Lindsaea ensifolia Sw. var. *ensifolia*	LC	Bukit Asam, Bukit Ketam, Bukit Mamam, Bukit Noordin, Bukit Pekan, Bukit Puaka, Bukit Sempit, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi	SING0203125; SING0338234; SING0338240; SING0338243

Appendix I. Continuation

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Family Lygodiaceae			
Lygodium flexuosum (L.) Sw.	LC	Bukit Bahru, Bukit Ketam, Bukit Noordin, Bukit Puaka, Bukit Tajam Kechil, Jalan Endut Senin, Jalan Jelutong, Tanjong Chek Jawa	SING0110334; SING0146633; SING0343160; SING0343161; SING0343164; SING0343165; SING0343166
Lygodium longifolium (Willd.) Sw.	LC	Bukit Asam, Bukit Bahru, Bukit Ketam, Bukit Mamam, Bukit Noordin, Bukit Puaka, Bukit Tajam, Bukit Tajam Kechil, Kekek Quarry	SING0040367; SING0047400; SING0343190
Lygodium microphyllum (Cav.) R.Br.	LC	Bukit Asam, Bukit Bahru, Bukit Belukar, Bukit Puaka, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil	SING0203119; SING0343931; SING0343948; SING0343952
Family Marattiaceae			
Angiopteris evecta (G.Forst.) Hoffm.	VU	Bukit Jelutong, Bukit Pekan, Bukit Tajam, Bukit Tajam Kechil; planted at Jalan Endut Senin, Jalan Jelutong, Jalan Wat Siam, Tanjong Chek Jawa	SING0114759; SING0182019
Family Nephrolepidaceae			
Nephrolepis biserrata (Sw.) Schott	LC	Bukit Bahru, Bukit Belukar, Bukit Jelutong, Bukit Ketam, Bukit Mamam, Bukit Noordin, Bukit Pekan, Bukit Puaka, Bukit Surau, Bukit Tajam, Jalan Batu Ubin, Jalan Endut Senin, Jalan Jelutong, Kekek Quarry, Tanjong Chek Jawa; planted at Bukit Melayu	SING0042394; SING0043361; SING0338267
Family Polypodiaceae			
Drynaria quercifolia (L.) J.Sm.	LC	Bukit Belukar, Bukit Pekan, Bukit Surau, Bukit Tajam, Tanjong Chek Jawa; planted at Bukit Belukar, Jalan Noordin	SING0042397; SING0336373; SING0336374; SING0336378
Goniophlebium percussum (Cav.) W.H.Wagner & Grether	VU	Bukit Mamam, Bukit Puaka, Sensory Trail	SING0190198
Microsorum punctatum (L.) Copel.	LC	Kekek Quarry, north of Ketam Quarry	SING0146664
Microsorum scolopendria (Burm.f.) Copel.	LC	Bukit Tajam, Kekek Quarry, Tanjong Chek Jawa	SING0030099; SING0042938; SING0338374; SING0338375

Appendix I. Continuation

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Platycerium coronarium (J.Koenig) Desv.	EN	Bukit Belukar, Bukit Mamam, Bukit Sempit, Bukit Surau	SING0222197
Pyrrosia angustata (Sw.) Ching	EN	Bukit Tinggi; planted at Bukit Belukar, Jalan Noordin	SING 2024-504
Pyrrosia longifolia (Burm.f.) C.V.Morton	LC	Bukit Pekan, Bukit Jelutong, Bukit Tajam Kechil, Jalan Jelutong, Tanjong Chek Jawa	SING0203173; SING0338420
Pyrrosia piloselloides (L.) M.G.Price	LC	Bukit Asam, Bukit Jelutong, Bukit Jelutong, Bukit Ketam, Bukit Puaka, Bukit Tajam, Bukit Tajam Kechil, Kekek Quarry, Tanjong Chek Jawa	SING0043183; SING0047419; SING0338563
Family Psilotaceae			
Psilotum nudum (L.) P.Beauv.	LC	Bukit Melayu, Jalan Ubin, Sensory Trail	SING0202314
Family Pteridaceae			
Acrostichum aureum L.	LC	Bukit Tajam, Kekek Quarry, Pekan Quarry, Sensory Trail, Tanjong Chek Jawa; planted at Sungei Puaka	SING0042890; SING0335111; SING0335113; SING0336899
Acrostichum speciosum Willd.	LC	Bukit Asam, Bukit Ketam, Bukit Tajam, Tanjong Chek Jawa; planted at Sungei Puaka	SING0043546; SING0335125; SING0335127; SING0335155
Cheilanthes tenuifolia (Burm.f.) Sw.	VU	Bukit Ketam, Bukit Puaka, Kekek Quarry	SING0114751
Haplopteris elongata (Sw.) E.H.Crane	LC	Bukit Belukar, Bukit Jelutong, Bukit Puaka, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Jalan Wat Siam	SING0047407; SING0146640; SING0164191; SING0202323
Taenitis blechnoides (Willd.) Sw.	LC	Bukit Asam, Bukit Bahru, Bukit Belukar, Bukit Jelutong, Bukit Ketam, Bukit Noordin, Bukit Sempit, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Tanjong Chek Jawa; planted at Tanjong Chek Jawa	SING0042952; SING0338671; SING0338678; SING0338702; SING0338703
Family Schizaeaceae			
Actinostachys digitata (L.) Wall.	EN	Bukit Surau, Bukit Tajam Kechil, Tanjong Chek Jawa	SING0043555; SING0333613; SING0333614
Schizaea dichotoma (L.) Sm.	EN	Bukit Surau, Tanjong Chek Jawa	SING0047405; SING0101339; SING0101340; SING0197771

Appendix I. Continuation

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Family Tectariaceae			
Tectaria semipinnata (Roxb.) C.V.Morton	EN	Bukit Jelutong, Bukit Pekan, Jalan Ubin; planted at Tanjong Chek Jawa	SING0116836; SING0182021; SING0182022; SING0190200; SING0193758; SING0193759
Family Thelypteridaceae			
Amblovenatum opulentum (Kaulf.) J.P.Roux	LC	Bukit Pekan, Bukit Tajam, Tanjong Chek Jawa	SING0046145; SING0182007; SING0387160; SING0387162
Christella arida (D.Don) Holttum	LC	Jalan Noordin	SING0185153; SING0185154
Christella dentata (Forssk.) Brownsey & Jermy	LC	Bukit Mamam, Bukit Puaka, Bukit Tajam Kechil	SING0337434
Christella parasitica (L.) H.Lév.	VU	Bukit Asam, Bukit Belukar, Bukit Tajam	SING0146627
Christella subpubescens (Blume) Holttum	LC	Tanjong Chek Jawa	SING0182009; SING0337450; SING0337451
Cyclosorus interruptus (Willd.) H.Ito	LC	Kekek Quarry, Tanjong Chek Jawa; planted at Jalan Endut Senin	SING0274405
Grypothrix triphylla (Sw.) S.E.Fawc. & A.R.Sm.	LC	Bukit Belukar, Bukit Jelutong, Bukit Surau, Bukit Tinggi; planted at Jalan Endut Senin	SING0153674
Mesophlebion motleyanum (Hook.) Holttum	CR	Sensory Trail	SING0046196
Sphaerostephanos heterocarpos (Blume) Holttum	LC	Bukit Jelutong, Sensory Trail	SING0046144; SING0046197; SING0146638; SING0182008
GYMNOSPERMS			
Family Gnetaceae			
Gnetum gnemon L. var. *gnemon*	CR	Bukit Bahru, Bukit Belukar, Bukit Mamam, Bukit Noordin, Bukit Surau, Bukit Tinggi, Kampong Sungei Durian, Tanjong Chek Jawa; planted at Balai Quarry, Jalan Jelutong, Jalan Ubin, Ketam Quarry, Sungei Asam, Tanjong Chek Jawa	SING0040362; SING0350336; SING0350339
Gnetum gnemonoides Brongn.	CR	Bukit Bahru	SING0295476

Appendix I. Continuation

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Gnetum latifolium Blume	CR	Bukit Belukar, Bukit Mamam, Bukit Noordin, Bukit Puaka, Bukit Surau, Tanjong Chek Jawa	SING0042881; SING0043349
Gnetum macrostachyum Hook.f.	CR	Bukit Belukar, Bukit Surau	SING0146634; SING0350359; SING0350360; SING0383053
Gnetum microcarpum Blume	EN	Bukit Jelutong, Bukit Noordin, Tanjong Chek Jawa; planted at Jalan Jelutong	SING0042369; SING0042370; SING0351691; SING0383051
Family Podocarpaceae			
Podocarpus polystachyus R.Br. ex Endl.	EN	Bukit Sempit, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi; planted at Balai Quarry, Bukit Belukar, Bukit Noordin, Bukit Tajam, Jalan Endut Senin, Jalan Jelutong, Jalan Wat Siam, Kekek Quarry, Ketam Quarry, Sensory Trail Pond, Sungei Asam, Sungei Puaka, Sungei Pulau Ubin, Tanjong Chek Jawa	SING0203126
ANGIOSPERMS			
Family Acanthaceae			
Acanthus ebracteatus Vahl	VU	Bukit Tajam; planted at Sensory Trail Pond, Sungei Puaka, Tanjong Chek Jawa	SING0011381; SING0011382; SING0348489; SING0348494; SING0348510; SING0348511; SING0348525; SING0348527; SING0348528; SING0348529; SING0348530; SING0348531
Acanthus ilicifolius L.	EN	Tanjong Chek Jawa; planted at Sensory Trail Pond, Sungei Puaka, Tanjong Chek Jawa	SING0011387; SING0011388; SING0011391; SING0348543; SING0348545; SING0348578; SING0348579
Acanthus volubilis Nees	EN	Sungei Besar; planted at Sungei Puaka	SING0205806; SING0348630; SING0348635; SING0348645

Appendix I. Continuation

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Avicennia alba Blume	LC	Sungei Asam, Sungei Batu Kekek, Sungei Besar, Sungei Durian, Sungei Jelutong, Sungei Mamam, Sungei Puaka, Sungei Tajam, Tanjong Chek Jawa; planted at Sungei Durian, Sungei Puaka	SING0153634; SING0347812; SING0347834; SING0042676
Avicennia officinalis L.	LC	Sungei Asam, Sungei Batu Kekek, Sungei Besar, Sungei Durian, Sungei Jelutong, Sungei Mamam, Sungei Puaka, Sungei Tajam, Tanjong Chek Jawa; planted at Sungei Puaka	SING0043502; SING0347950; SING0347956; SING0347958; SING0347967
Avicennia rumphiana Hallier f.	LC	Sungei Asam, Sungei Batu Kekek, Sungei Besar, Sungei Durian, Sungei Jelutong, Sungei Mamam, Sungei Puaka, Sungei Tajam, Tanjong Chek Jawa; planted at Jalan Jelutong, Sungei Durian, Sungei Jelutong, Sungei Puaka, Sungei Pulau Ubin	SING0043351; SING0043535; SING0158570; SING0347998; SING0348474; SING0349983; SING0349987; SING0349990
Strobilanthes brunelloides (Lam.) J.R.I.Wood	EN	Between Bukit Mamam & Sungei Mamam	SING0038955; SING0042874; SING0047414
Family Aizoaceae			
Sesuvium portulacastrum (L.) L.	LC	Jalan Endut Senin, Tanjong Chek Jawa; planted at Jalan Jelutong, Sungei Puaka	SING0043501; SING0349443; SING0349460
Family Amaranthaceae			
Cyathula prostrata (L.) Blume	LC	Jalan Endut Senin, Jalan Jelutong, Tanjong Chek Jawa	SING0047415; SING0349527
Family Amaryllidaceae			
Crinum asiaticum L.	CR	Bukit Melayu, near mouth of Sungei Asam; planted at Jalan Endut Senin, Jalan Jelutong, Tanjong Chek Jawa	SING0202325
Family Anacardiaceae			
Bouea oppositifolia (Roxb.) Meisn.	CR	Kekek Quarry, near Sungei Asam; planted at Balai Quarry, Bukit Noordin, Jalan Wat Siam, Sungei Pulau Ubin, Tanjong Chek Jawa	SING0145305

Appendix I. Continuation

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Buchanania arborescens (Blume) Blume	LC	Bukit Bahru, Bukit Belukar, Bukit Mamam, Bukit Noordin, Bukit Sempit, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tock Kew; planted at Balai Quarry, Bukit Belukar, Bukit Noordin, Bukit Surau, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Ketam Quarry, Sungei Asam, Sungei Teris	SING0042949; SING0153672; SING0382993
Buchanania sessifolia Blume	EN	Tanjong Chek Jawa; planted at Balai Quarry, Jalan Noordin, Ketam Quarry	SING0042949
Campnosperma auriculatum (Blume) Hook.f.	LC	Bukit Belukar, Bukit Mamam, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Bukit Tock Kew; planted at Jalan Batu Ubin, Sungei Asam	SING0190188; SING0350462
Mangifera foetida Lour.	CR	Bukit Bahru, Bukit Belukar, Bukit Surau, Bukit Tock Kew; planted at Jalan Jelutong, Jalan Noordin, Jalan Sam Heng, Kekek Quarry, Sungei Asam, Sungei Teris	
Mangifera griffithii Hook.f.	CR	Between Bukit Melayu & Bukit Belukar, Bukit Bahru, Bukit Surau, Jalan Durian, Kampong Sungei Durian	SING0043358; SING0263728; SING0341601
Family Ancistrocladiaceae			
Ancistrocladus tectorius (Lour.) Merr.	CR	Bukit Melayu, Bukit Pekan; planted at Jalan Jelutong	SING0153671; SING0182042
Family Anisophyllaceae			
Anisophyllea disticha (Jack) Baill.	LC	Bukit Bahru, Bukit Belukar, Bukit Noordin, Bukit Surau	SING0166409
Family Annonaceae			
Artabotrys suaveolens (Blume) Blume	LC	Bukit Bahru, Bukit Belukar, Bukit Mamam, Bukit Noordin, Bukit Sempit, Bukit Surau, Tanjong Chek Jawa	SING0042948; SING0043506; SING0354666
Dasymaschalon dasymaschalum (Blume) I.M.Turner	EN	Bukit Bahru, Bukit Belukar, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Tanjong Chek Jawa; planted at Jalan Endut Senin	SING0042356; SING0043511; SING0065721
Dasymaschalon wallichii (Hook.f. & Thomson) Jing Wang & R.M.K.Saunders	EN		SING0241758

Appendix I. Continuation

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Maasia sumatrana (Miq.) Mols et al.	CR		SING0222173
Phaeanthus intermedius (P.Parm.) I.M.Turner & Veldkamp	VU	Bukit Belukar, Bukit Surau, Tanjong Chek Jawa	SING0042671; SING0043539; SING0174126
Polyalthia angustissima Ridl.	VU	Bukit Pekan	SING0165831
Uvaria grandiflora Roxb. ex Hornem.	VU	Tanjong Chek Jawa; planted at Jalan Jelutong, Pekan Quarry	SING0047733
Uvaria griffithii L.L.Zhou et al.	VU	Tanjong Chek Jawa	SING0043940; SING0179376
Uvaria hirsuta Jack	VU	Bukit Surau, Bukit Tajam Kechil, Tanjong Chek Jawa	SING0003359; SING0047402
Uvaria micrantha (A.DC.) Hook.f. & Thomson	CR	Tanjong Chek Jawa	SING0043106; SING0047715
Family Apiaceae			
Centella asiatica (L.) Urb.	LC	Bukit Noordin, Bukit Tajam; also planted at Pekan Quarry	SING0380579
Family Apocynaceae			
Alstonia angustifolia Wall. ex A.DC.	LC	Bukit Asam, Bukit Sempit, Bukit Tajam Kechil, Bukit Tinggi	SING0226775; SING0354525
Alstonia angustiloba Miq.	LC	Bukit Bahru, Bukit Belukar, Bukit Jelutong, Bukit Mamam, Bukit Pekan, Bukit Puaka, Bukit Sempit, Bukit Surau, Bukit Tinggi; planted at Balai Quarry, Jalan Endut Senin, Jalan Jelutong, Jalan Wat Siam, Ketam Quarry	SING0045118; SING0153675
Alstonia pneumatophora Backer ex Den Berger	CR	Bukit Jelutong, Bukit Tinggi	SING0185162; SING0190199
Alstonia spatulata Blume	EN	Bukit Belukar, Bukit Ketam; planted at Jalan Endut Senin, Sensory Trail Pond	SING0146636
Alyxia reinwardti Blume	LC	Bukit Bahru, Bukit Mamam, Bukit Noordin, Bukit Sempit, Bukit Tajam Kechil, Bukit Tinggi; planted at Balai Quarry, Pekan Quarry, Ubin Quarry	SING0153599; SING0258524; SING0383046
Cerbera manghas L.	CR	Bukit Asam, Bukit Puaka, Tanjong Chek Jawa; planted at Balai Quarry, Jalan Endut Senin, Sensory Trail Pond, Sungei Asam	SING0043544

Appendix I. Continuation

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Cerbera odollam Gaertn.	VU	Bukit Asam, Bukit Noordin, Bukit Tajam, Bukit Tajam Kechil, Sungei Durian; planted at Balai Quarry, Jalan Jelutong, Jalan Noordin, Kekek Quarry, Sensory Trail Pond, Sungei Pulau Ubin, Sungei Asam, Sungei Teris	SING0258521
Cynanchum ovalifolium Wight	CR	Bukit Tajam Kechil; planted at Pekan Quarry	Photographic Record
Dischidia major (Vahl) Merr.	LC	Bukit Bahru, Bukit Belukar, Bukit Jelutong, Bukit Pekan, Bukit Puaka, Bukit Sempit, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Jalan Endut Senin, Kekek Quarry	SING0353012
Dischidia nummularia R.Br.	LC	Bukit Puaka, Jalan Endut Senin, Tanjong Chek Jawa	SING0038954; SING0353039
Finlaysonia obovata Wall.	CR	Sungei Jelutong, Sungei Mamam, Tanjong Chek Jawa	SING0153644; SING0166676
Gymnanthera oblonga (Burm.f.) P.S.Green	CR	Sungei Mamam; planted at Jalan Jelutong, Jalan Noordin, Pekan Quarry, Sungei Pulau Ubin	SING0114769; SING0182044
Hoya diversifolia Blume	VU	Sungei Asam, Sungei Jelutong, Tanjong Chek Jawa; planted at Jalan Jelutong	SING0116837
Hoya latifolia G.Don	LC	Jalan Pekan Ubin; planted at Jalan Jelutong, Tanjong Chek Jawa	
Hoya obtusifolia Wight	CR	Jalan Batu Ubin	SING0202925; SING0253454; SING0312888
Hoya verticillata (Vahl) G.Don	LC	Bukit Bahru, Bukit Jelutong, Bukit Pekan, Bukit Surau, Bukit Tajam, Kekek Quarry, Tanjong Chek Jawa	SING0042359; SING0043727; SING0045121; SING0174109; SING0353058
Micrechites serpyllifolius (Blume) Kosterm.	EN	Bukit Jelutong; planted at Balai Quarry, Jalan Endut Senin, Jalan Jelutong, Pekan Quarry	SING0194941
Parsonsia alboflavescens (Dennst.) Mabb.	CR	Planted at Pekan Quarry	SING0286218
Strophanthus caudatus (L.) Kurz	EN	Bukit Pekan; planted at Balai Quarry, Kekek Quarry, Ketam Quarry, Pekan Quarry, Jalan Jelutong, Jalan Noordin, Sensory Trail Pond, Sungei Pulau Ubin	SING0171394

Appendix I. Continuation

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Vincetoxicum flexuosum (R.Br.) Kuntze var. *tenuis* (Blume) Schneidt et al.	LC	Bukit Tajam, Kekek Quarry, Sensory Trail, Sungei Puaka Ponds; planted at Jalan Jelutong, Jalan Noordin, Pekan Quarry, Sungei Pulau Ubin	SING0114771; SING0353092; SING0353093
Vincetoxicum globiferum (Hook.f.) Kuntze	CR	Tanjong Chek Jawa; planted at Jalan Jelutong, Jalan Noordin, Pekan Quarry, Sungei Pulau Ubin	
Willughbeia coriacea Wall.	LC	Tanjong Chek Jawa	SING0042673; SING0171426; SING0182049
Willughbeia edulis Roxb.	CR	Tanjong Chek Jawa	SING0042357; SING0043941; SING0171429
Willughbeia tenuiflora Dyer ex Hook.f.	CR	Tanjong Chek Jawa	SING0182050
Family Aquifoliaceae			
Ilex cymosa Blume	LC	Bukit Bahru, Bukit Belukar, Bukit Mamam, Bukit Melayu, Bukit Noordin, Bukit Puaka, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Jalan Noordin, Tanjong Chek Jawa; planted at Balai Quarry, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Jalan Sam Heng, Ketam Quarry, Sungei Pulau Ubin	SING0043115
Family Araceae			
Alocasia longiloba Miq.	LC	Bukit Jelutong, Bukit Pekan; planted at Bukit Melayu, Bukit Surau, Jalan Endut Senin	SING0185161
Epipremnum giganteum (Roxb.) Schott	LC	Bukit Ketam, Tanjong Tajam; planted at Bukit Belukar, Jalan Endut Senin, Jalan Noordin, Sungei Pulau Ubin, Tanjong Chek Jawa	SING0193760
Homalomena griffithii (Schott) Hook.f.	DD	Sungei Tock Kew (upstream)	SING0003646
Schismatoglottis lowiae S.Y.Wong & P.C.Boyce	VU	Jalan Ubin; planted at Tanjong Chek Jawa	SING0114761

Appendix I. Continuation

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Family Araliaceae			
Arthrophyllum jackianum (G.Don) Frodin	LC	Bukit Asam, Bukit Bahru, Bukit Mamam, Bukit Pekan, Bukit Puaka, Bukit Sempit, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Kekek Quarry; planted at Jalan Noordin	SING0153670; SING0349345; SING0349346; SING0349347; SING0349355; SING0349366; SING0383044
Heptapleurum ellipticum (Blume) Seem.	EN	Mamam Beach, Noordin Beach, Sensory Trail; planted at Bukit Mamam, Jalan Endut Senin, Jalan Jelutong, Pekan Quarry	SING0114762; SING0349388
Hydrocotyle sibthorpioides Lam.	LC	Sensory Trail	SING0165832
Family Arecaceae			
Calamus erinaceus (Becc.) Becc. subsp. e*rinaceus*	LC	Bukit Asam, Bukit Bahru, Bukit Belukar, Bukit Ketam, Bukit Mamam, Bukit Melayu, Bukit Noordin, Bukit Puaka, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Sungei Tajam, Sungei Tock Kew, Tanjong Chek Jawa	SING0016958; SING0016959; SING0042395
Calamus melanochaetes (Blume) Miq.	VU	Tanjong Chek Jawa	SING0047409
Caryota mitis Lour.	LC	Bukit Bahru, Bukit Belukar, Bukit Jelutong, Bukit Ketam, Bukit Mamam, Bukit Noordin, Bukit Pekan, Bukit Puaka, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Kekek Quarry; planted at Jalan Jelutong	SING0153655
Licuala spinosa Wurmb	LC	Bukit Bahru, Bukit Belukar, Bukit Jelutong, Bukit Mamam, Bukit Noordin, Bukit Pekan, Bukit Puaka, Bukit Surau, Kekek Quarry, Tanjong Chek Jawa; planted at Balai Quarry, Bukit Jelutong, Jalan Endut Senin, jalan Jelutong, Ketam Quarry, Sensory Trail Pond	SING0038953; SING0382987; SING0382988
Nypa fruticans Wurmb	VU	Balai Quarry, Bukit Asam, Kekek Quarry, Sungei Durian, Sungei Mamam, Sungei Pulau Ubin, Tanjong Chek Jawa; planted at Sungei Puaka	SING0045120

Appendix I. Continuation

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Oncosperma tigillarium (Jack) Ridl.	LC	Bukit Asam, Bukit Bahru, Bukit Belukar, Bukit Jelutong, Bukit Ketam, Bukit Mamam, Bukit Melayu, Bukit Noordin, Bukit Sempit, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Kekek Quarry, Tanjong Chek Jawa; planted at Balai Quarry, Jalan Endut Senin, Jalan Jelutong, Kekek Quarry, Ketam Quarry, Sungei Pulau Ubin, Sungei Teris	SING0047732
Family Asparagaceae			
Dracaena maingayi Hook.f.	EN	Bukit Bahru, Bukit Noordin, Bukit Surau, Bukit Tinggi, Bukit Tock Kew, Tanjong Chek Jawa; planted at Jalan Endut Senin, Tanjong Chek Jawa	SING0042366; SING0043954; SING0054008
Dracaena porteri Baker	LC	Bukit Melayu; planted at Jalan Endut Senin, Jalan Jelutong, Ketam Quarry, Tanjong Chek Jawa	SING0203172
Family Asphodelaceae			
Dianella ensifolia (L.) Redouté	LC	Bukit Asam, Bukit Bahru, Bukit Belukar, Bukit Ketam, Bukit Mamam, Bukit Noordin, Bukit Puaka, Bukit Sempit, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Kekek Quarry, Tanjong Chek Jawa; planted at Bukit Mamam, Jalan Batu Ubin, Jalan Endut Senin, Jalan Jelutong, Tanjong Chek Jawa	SING0047397; SING0047703
Family Asteraceae			
Blumea balsamifera (L.) DC.	CR		SING0355931; SING0355932
Emilia sonchifolia (L.) DC.	LC	Jalan Jelutong	Ho & Sim 15, SINU
Pluchea indica (L.) Less.	LC	Bukit Puaka, Jalan Ubin; planted at Jalan Endut Senin, Jalan Jelutong, Ketam Quarry	SING0043505; SING0043516; SING0356240
Vernonia arborea Buch.-Ham.	CR	Bukit Belukar; planted at Jalan Endut Senin, Sungei Asam	SING0145303
Vernonia cinerea (L.) Less.	LC	Jalan Jelutong	SING0356642

Appendix I. Continuation

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Wollastonia biflora (L.) DC.	LC	Bukit Asam, Bukit Noordin, Bukit Surau, Bukit Tajam, Jalan Jelutong, Kekek Quarry, Tanjong Chek Jawa; planted at Jalan Endut Senin, Jalan Jelutong	SING0040373; SING0165829; SING0356663; SING0356697; SING0356698
Family Bignoniaceae			
Dolichandrone spathacea (L.f.) K.Schum.	CR	Bukit Tajam Kechil, Kekek Quarry, Sungei Asam, Sungei Durian, Sungei Tajam; planted at Balai Quarry, Jalan Batu Ubin, Sensory Trail Pond, Sungei Asam, Sungei Durian, Sungei Puaka, Sungei Pulau Ubin, Sungei Teris, Tanjong Chek Jawa	SING0004021; SING0065742
Family Bonnetiaceae			
Ploiarium elegans Korth.	LC	Bukit Sempit, Bukit Tajam Kechil, Bukit Tinggi, Tanjong Chek Jawa; planted at Balai Quarry, Bukit Belukar, Bukit Noordin, Bukit Surau, Bukit Tajam, Jalan Endut Senin, Jalan Jelutong, Ketam Quarry, Sensory Trail Pond	SING0153689
Family Burseraceae			
Canarium littorale Blume	EN	Bukit Tinggi; planted at Balai Quarry, Bukit Noordin, Bukit Surau, Jalan Noordin, Tanjong Chek Jawa	
Canarium pilosum A.W.Benn.	VU	Bukit Tinggi; planted at Jalan Batu Ubin	SING0387156
Family Calophyllaceae			
Calophyllum inophyllum L.	EN	Bukit Asam, Bukit Mamam, Bukit Noordin, Bukit Puaka, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Jalan Durian, Sungei Besar, Tanjong Chek Jawa; planted at Balai Quarry, Jalan Endut Senin, Ketam Quarry	SING0153690
Calophyllum pulcherrimum Wall. ex Choisy	LC	Bukit Bahru, Bukit Noordin; planted at Balai Quarry, Jalan Endut Senin, Sungei Asam	SING0166407
Family Cannabaceae			
Trema cannabina Lour.	LC	Bukit Mamam, Bukit Tajam Kechil	SING0165602; SING0182031
Trema tomentosum (Roxb.) H.Hara	VU	Bukit Ketam, Bukit Mamam, Bukit Pekan, Bukit Puaka, Bukit Surau, Tanjong Chek Jawa	SING0040365

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Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Family Capparaceae			
Capparis micracantha DC. subsp. *korthalsiana* (Miq.) M.Jacobs	CR	Bukit Jelutong, Bukit Melayu, Bukit Pekan; planted at Balai Quarry, Jalan Jelutong, Pekan Quarry	SING0065737; SING0065738; SING0116839
Family Cardiopteridaceae			
Gonocaryum gracile Miq.	CR	Tanjong Chek Jawa	SING0042714
Family Casuarinaceae			
Casuarina equisetifolia L.	LC	Bukit Ketam, Bukit Tajam; planted at Jalan Jelutong, Ketam Quarry	SING0016521
Family Celastraceae			
Loeseneriella macrantha (Korth.) A.C.Sm.	CR	Bukit Asam, Bukit Tock Kew; planted at Balai Quarry, Jalan Jelutong	SING0203174; SING0203175
Salacia chinensis L.	CR	Bukit Tajam Kechil, Tanjong Chek Jawa	SING0004346; SING0043717; SING0046147
Salacia grandiflora Kurz	CR	Tanjong Chek Jawa; planted Balai Quarry, Pekan Quarry, Ubin Quarry	SING0174101
Salacia korthalsiana Miq.	CR	Tanjong Chek Jawa	SING0042360; SING0047734
Family Centroplacaceae			
Bhesa paniculata Arn.	LC	Bukit Bahru, Bukit Melayu; planted at Bukit Belukar, Bukit Noordin, Bukit Surau, Bukit Tajam, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Jalan Wat Siam, Tanjong Chek Jawa	SING0289046
Bhesa robusta (Roxb.) Ding Hou	VU	Bukit Bahru, Bukit Melayu, Bukit Surau; planted at Bukit Belukar, Jalan Batu Ubin, Jalan Jelutong, Kekek Quarry, Ketam Quarry, Sungei Asam	
Family Chrysobalanaceae			
Angelesia splendens Korth.	VU	Bukit Belukar, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Tanjong Chek Jawa	SING0043942; SING0383047

Appendix I. Continuation

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Maranthes corymbosa Blume	VU	Bukit Surau, Tanjong Chek Jawa; planted at Balai Quarry, Bukit Belukar, Bukit Surau, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Kekek Quarry, Ketam Quarry, Sungei Asam, Sungei Teris, Tanjong Chek Jawa	SING0045123
Parastemon urophyllus (Wall. ex A.DC.) A.DC.	CR	Bukit Asam, Bukit Surau	SING0146655
Family Clusiaceae			
Garcinia atroviridis Griff. ex T.Anderson	CR	Tanjong Chek Jawa; planted at Bukit Surau, Jalan Jelutong, Ketam Quarry, Sensory Trail, Tanjong Chek Jawa	SING0043538
Garcinia celebica L.	EN	Bukit Surau, Bukit Tajam, Tanjong Chek Jawa; planted at Balai Quarry, Bukit Noordin, Bukit Surau, Bukit Tajam, Jalan Endut Senin, Jalan Jelutong, Ketam Quarry, Sungei Asam, Sungei Teris, Tanjong Chek Jawa	SING0008130; SING0042710
Garcinia nervosa (Miq.) Miq.	CR	Bukit Surau; planted at Bukit Belukar	SING0145349; SING0174125
Garcinia nigrolineata Planch. ex T.Anderson	CR	Bukit Melayu, Bukit Noordin, Tanjong Chek Jawa; planted at Balai Quarry, Bukit Noordin, Bukit Surau, Bukit Tajam, Jalan Batu Ubin, Jalan Endut Senin, Jalan Noordin, Kekek Quarry, Ketam Quarry, Sungei Asam	SING0241761
Garcinia parvifolia (Miq.) Miq.	LC	Tanjong Chek Jawa; planted at Balai Quarry, Jalan Endut Senin, Jalan Noordin, Kekek Quarry, Sungei Asam	SING0043537
Family Combretaceae			
Lumnitzera littorea (Jack) Voigt	EN	Bukit Tajam, Bukit Tajam Kechil, Sungei Asam, Sungei Besar, Sungei Jelutong, Sungei Puaka, Sungei Pulau Ubin, Tanjong Chek Jawa; planted at Sensory Trail Pond, Sungei Puaka, Tanjong Chek Jawa	SING0008181; SING0043550; SING0153636; SING0355724
Lumnitzera racemosa Willd.	EN	Sungei Jelutong, Sungei Puaka; planted at Sensory Trail Pond, Sungei Puaka, Sungei Pulau Ubin, Tanjong Chek Jawa	SING0114770; SING0355762

Appendix I. Continuation

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Terminalia catappa L.	LC	Bukit Asam, Bukit Bahru, Bukit Ketam, Bukit Mamam, Bukit Melayu, Bukit Noordin, Bukit Pekan, Bukit Puaka, Bukit Surau, Bukit Tajam, Bukit Tinggi, Jalan Endut Senin, Jalan Jelutong, Kekek Quarry, Sensory Trail, Tanjong Chek Jawa; planted at Balai Quarry, Jalan Endut Senin, Jalan Jelutong, Kekek Quarry, Ketam Quarry	SING0016498; SING0046231; SING0355843
Family Connaraceae			
Agelaea cf. *macrophylla* (Zoll.) Leenh.	LC	Bukit Tinggi	SING0383049
Cnestis palala (Lour.) Merr.	VU	Bukit Jelutong, Bukit Mamam, Bukit Melayu, Bukit Pekan, Bukit Surau, Tanjong Chek Jawa	SING0042686; SING0043943; SING0356753
Rourea aspleniifolia (G.Schellenb.) Jongkind	LC	Bukit Sempit, Bukit Tajam	SING0047721
Rourea fulgens Planch.	EN	Tanjong Chek Jawa; planted at Jalan Jelutong	SING0042363; SING0042687; SING0382995
Rourea minor (Gaertn.) Merr.	VU	Bukit Noordin, Bukit Tajam Kechil, Tanjong Chek Jawa; planted at Jalan Jelutong	SING0065720
Family Convolvulaceae			
Erycibe leucoxyloides King ex Ridl.	VU	Bukit Tinggi	SING0356875; SING0383050; SING0387157
Erycibe malaccensis C.B.Clarke	CR	Tanjong Chek Jawa	SING0043540
Erycibe tomentosa Blume	LC	Bukit Asam, Bukit Bahru, Bukit Belukar, Bukit Jelutong, Bukit Ketam, Bukit Mamam, Bukit Noordin, Bukit Pekan, Bukit Puaka, Bukit Sempit, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Kekek Quarry; planted at Jalan Jelutong, Pekan Quarry, Ubin Quarry	SING0042364; SING0171424; SING0356884; SING0356900; SING0356901; SING0356902; SING0356903; SING0356904; SING0356905; SING0356906; SING0356930
Ipomoea aquatica Forssk.	LC	Ketam Quarry; planted at Pekan Quarry	SING0356949; SING0356955
Ipomoea obscura (L.) Ker Gawl.	LC	Bukit Bahru, Bukit Ketam, Bukit Noordin, Ketam Quarry; planted at Jalan Jelutong	SING 2015-237

Appendix I. Continuation

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Ipomoea pes-caprae (L.) R.Br.	LC	Jalan Jelutong, Sungei Besar; planted at Jalan Endut Senin, Jalan Jelutong	SING0080620; SING0153663
Ipomoea pes-tigridis L.	CR	Bukit Jelutong, Jalan Jelutong	SING0046198
Merremia hederacea (Burm.f.) Hallier f.	LC	Jalan Jelutong	SING0164189
Xenostegia tridentata (L.) D.F.Austin & Staples	LC	Bukit Noordin, Bukit Pekan, Bukit Puaka	SING0258570; SING0274424; SING0357099; SING0357108
Family Cornaceae			
Alangium griffithii (C.B.Clarke) Harms	EN	Bukit Jelutong, Bukit Tajam Kechil	SING0185177
Family Costaceae			
Cheilocostus speciosus (J.Koenig) C.D.Specht	CR	Bukit Sempit, Tanjong Chek Jawa; planted at Jalan Endut Senin, Jalan Jelutong, Kampong Sungei Durian, Pekan Quarry, Sensory Trail Pond	SING0203127
Family Cucurbitaceae			
Gymnopetalum scabrum (Lour.) W.J.de Wilde & Duyfjes	LC	Ketam Quarry	SING0231962; SING0349932
Family Cymodoceaceae			
Cymodocea rotundata Asch. & Schweinf.	CR	Chek Jawa Wetlands	SING0045959; SING0048235
Cymodocea serrulata (R.Br.) Asch. & Magnus	EN	Pulau Sekudu, Chek Jawa Wetlands	SING0203137; SING0203141; SING0274407
Halodule uninervis (Forssk.) Asch.	VU	Chek Jawa Wetlands	SING0045957; SING0048230; SING0048231; SING0048233; SING0078968
Family Cyperaceae			
Actinoscirpus grossus (L.f.) Goetgh. & D.A.Simpson	CR	Sensory Trail Pond; planted at Sensory Trail Pond	SING0295843
Bulbostylis barbata (Rottb.) C.B.Clarke	CR		Roslina 21, SINU
Bulbostylis thouarsii (Roem. & Schult.) Lye ex Veldkamp & Verloove	VU		SING0182053

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Species	**Conservation Status**	**Location**	**Barcode No./Voucher Specimen No./ Photographic Record**
Cyperus brevifolius (Rottb.) Hassk.	VU	Bukit Asam, Bukit Jelutong	
Cyperus compactus Retz.	LC	Planted at Sensory Trail Pond	Loo et al PS218, SINU; Latifah & Neo 2, SINU
Cyperus compressus L.	VU		SING0057423
Cyperus cyperinus (Retz.) Valck.Sur.	EN	Bukit Puaka, Tanjong Chek Jawa	SING0042361
Cyperus diffusus Vahl	CR	Bukit Bahru, Tanjong Chek Jawa	SING0182054; SING0387172
Cyperus haspan L.	LC	Planted at Sensory Trail Pond	SING0059415; SING0171408
Cyperus imbricatus Retz.	LC	Tanjong Chek Jawa	SING0042879
Cyperus javanicus Houtt.	LC	Tanjong Chek Jawa; planted at Sensory Trail Pond	SING0043723; SING0182003; SING0201477
Cyperus mindorensis (Steud.) Huygh	LC		Latifah 18, SINU
Cyperus polystachyos Rottb.	LC	Bukit Puaka, Tanjong Chek Jawa	SING0201467
Cyperus rotundus L.	LC		SING0182055
Cyperus trialatus (Boeckeler) J.Kern	LC	Balai Quarry, Bukit Jelutong, Tanjong Chek Jawa	SING0042955; SING0059178; SING0146635; SING0182002; SING0295471; SING0341211
Fimbristylis acuminata Vahl	LC		SING0173929
Fimbristylis complanata (Retz.) Link	VU		SING0171396
Fimbristylis cymosa R.Br.	LC	Sungei Teris	SING0205587
Fimbristylis dichotoma (L.) Vahl	LC	Planted at Ketam Quarry, Senosry Trail Pond	Roslina 4, SINU
Fimbristylis ferruginea (L.) Vahl	LC	Tanjong Chek Jawa	SING0043722; SING0080195
Fimbristylis griffithii Boeckeler	CR		Chan 10, SINU
Fimbristylis polytrichoides (Retz.) Vahl	VU	Sungei Mamam	SING0289043; SING0383264
Fimbristylis schoenoides (Retz.) Vahl	LC		Neo 204, SINU
Fuirena umbellata Rottb.	LC	Tanjong Chek Jawa	SING0113782

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Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Hypolytrum nemorum (Vahl) P.Beauv. var. *nemorum*	LC	Bukit Asam, Bukit Bahru, Bukit Jelutong, Bukit Ketam, Bukit Mamam, Bukit Pekan, Bukit Puaka, Bukit Sempit, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Bukit Tock Kew, Kekek Quarry, Tanjong Chek Jawa	SING0042362; SING0171395; SING0387150; SING0387151
Scleria ciliaris Nees	LC	Bukit Mamam, Bukit Noordin, Bukit Puaka, Bukit Sempit, Bukit Tajam Kechil, Bukit Tinggi, Tanjong Chek Jawa	SING0043561; SING0174124; SING0387171
Scleria levis Retz.	LC		SING0387152; SING0393848
Scleria oblata S.T.Blake ex J.Kern	LC		
Scleria rugosa R.Br.	CR		SING0383263
Scleria sumatrensis Retz.	LC	Sungei Teris, Tanjong Chek Jawa	SING 2014-266
Family Dilleniaceae			
Dillenia suffruticosa (Griff. ex Hook.f. & Thomson) Martelli	LC	Balai Quarry, Bukit Asam, Bukit Bahru, Bukit Belukar, Bukit Jelutong, Bukit Ketam, Bukit Mamam, Bukit Noordin, Bukit Puaka, Bukit Sempit, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Jalan Endut Senin, Jalan Ubin, Jalan Wat Siam, Kekek Quarry, Sensory Trail Pond; planted at Ketam Quarry, Sensory Trail Pond	SING0153691; SING0349242; SING0349243; SING0349249; SING49276; SING0349280
Tetracera akara (Burm.f.) Merr.	VU	Bukit Sempit, Bukit Tock Kew, Tanjong Chek Jawa	SING0042691
Tetracera arborescens Jack	CR	Between Bukit Asam & Bukit Tinggi, Bukit Tajam Kechil, Tanjong Chek Jawa	SING0171416; SING0185310
Tetracera fagifolia Blume var. *borneensis* (Miq.) Hoogland	CR	Bukit Tinggi	SING0182058
Tetracera indica (Christm. & Panz.) Merr.	LC	Bukit Asam, Bukit Bahru, Bukit Belukar, Bukit Jelutong, Bukit Ketam, Bukit Mamam, Bukit Noordin, Bukit Pekan, Bukit Puaka, Bukit Sempit, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Jalan Endut Senin, Jalan Ubin, Kekek Quarry, Tanjong Chek Jawa; planted at Jalan Jelutong, Pekan Quarry, Sungei Pulau Ubin	SING0038949; SING0350215; SING0350216; SING0350224; SING0350226; SING0350227; SING0350231; SING0350256
Tetracera macrophylla Wall. ex Hook.f. & Thomson	VU	Bukit Tinggi, Tanjong Chek Jawa	SING0043944

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Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Tetracera maingayi Hoogland	VU	Tanjong Chek Jawa	SING0173373
Family Dioscoreaceae			
Dioscorea laurifolia Wall. ex Hook.f.	LC		Chua & Tan 437, SINU
Dioscorea stenomeriflora Prain & Burkill	CR	Bukit Tinggi	SING0226781
Dioscorea tenuifolia Ridl.	VU	Bukit Tinggi; planted at Jalan Jelutong	SING0381704
Family Ebenaceae			
Diospyros lanceifolia Roxb.	LC	Bukit Bahru, Bukit Noordin, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Tanjong Chek Jawa; planted at Bukit Belukar, Bukit Noordin, Bukit Surau, Jalan Endut Senin, Jalan Noordin	SING0042367; SING0042942; SING0043547; SING0047723; SING0182030; SING0185312; SING0387153
Family Elaeocarpaceae			
Elaeocarpus ferrugineus (Jack) Steud. subsp. *ferrugineus*	VU	Bukit Tajam Kechil	SING0146645; SING0358478
Elaeocarpus mastersii King	LC	Bukit Asam, Bukit Ketam, Bukit Surau, Bukit Tinggi; planted at Balai Quarry, Bukit Belukar, Bukit Noordin, Bukit Surau, Bukit Tajam, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Kekek Quarry, Ketam Quarry, Sungei Asam	SING0274417; SING0358507
Elaeocarpus pedunculatus Wall. ex Mast.	LC	Bukit Asam, Bukit Bahru, Bukit Belukar, Bukit Jelutong, Bukit Ketam, Bukit Mamam, Bukit Noordin, Bukit Pekan, Bukit Puaka, Bukit Sempit, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Tanjong Chek Jawa; planted at Bukit Noordin	SING0042880; SING0358423; SING0358445; SING0358450
Elaeocarpus petiolatus (Jack) Wall.	LC	Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi; planted at Jalan Jelutong, Jalan Noordin, Ketam Quarry, Sungei Asam, Sungei Teris	SING0258561
Family Eriocaulaceae			
Eriocaulon truncatum Buch.-Ham. ex Mart. var. *truncatum*	LC	Between Bukit Asam & Bukit Tinggi	

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Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Family Erythroxylaceae			SING0393590
Erythroxylum cuneatum (Miq.) Kurz	LC	Bukit Bahru, Bukit Melayu, Bukit Puaka, Bukit Surau, Bukit Tajam, Bukit Tock Kew, Tanjong Chek Jawa; planted at Balai Quarry, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Jalan Wat Siam, Ketam Quarry, Sensory Trail Pond	SING0047412; SING0339890; SING0339893
Family Euphorbiaceae			
Claoxylon indicum (Reinw. ex Blume) Hassk.	LC	Bukit Asam, Bukit Bahru, Bukit Belukar, Bukit Jelutong, Bukit Ketam, Bukit Mamam, Bukit Noordin, Bukit Pekan, Bukit Puaka, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Jalan Endut Senin, Jalan Jelutong, Kekek Quarry	SING0202315; SING0343074; SING0343077
Excoecaria agallocha L.	LC	Bukit Tajam, Kekek Quarry, Sungei Asam, Sungei Besar, Sungei Durian, Sungei Jelutong, Sungei Mamam, Sungei Puaka, Sungei Pulau Ubin, Sungei Tajam, Tanjong Chek Jawa; planted at Jalan Jelutong, Sungei Puaka	SING0043500; SING0339963; SING0339974; SING0339982
Macaranga bancana (Miq.) Müll.Arg.	LC	Bukit Asam, Bukit Ketam, Bukit Mamam, Bukit Puaka, Bukit Sempit, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Kekek Quarry	SING0202318; SING0340383; SING0340431; SING0340432; SING0340449
Macaranga conifera (Rchb.f. & Zoll.) Müll.Arg.	LC	Bukit Asam, Bukit Ketam, Bukit Sempit, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi; planted at Bukit Surau	SING0185175; SING0340304
Macaranga gigantea (Rchb.f. & Zoll.) Müll.Arg.	LC	Bukit Asam, Bukit Jelutong, Bukit Ketam, Bukit Mamam, Bukit Pekan, Bukit Puaka, Bukit Sempit, Bukit Surau, Bukit Tajam Kechil, Bukit Tinggi, Kekek Quarry; planted at Jalan Endut Senin, Jalan Noordin	SING0274418; SING0340318
Macaranga griffithiana Müll.Arg.	VU	Bukit Asam, Bukit Belukar, Bukit Ketam, Bukit Mamam, Bukit Sempit, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi	SING0042954; SING0162392; SING0202317

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Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Macaranga heynei I.M.Johnst.	LC	Bukit Asam, Bukit Bahru, Bukit Belukar, Bukit Jelutong, Bukit Ketam, Bukit Mamam, Bukit Noordin, Bukit Puaka, Bukit Sempit, Bukit Surau, Bukit Tajam Kechil, Bukit Tinggi, Jalan Endut Senin, Jalan Ubin, Kekek Quarry, Tanjong Chek Jawa	SING0038950; SING0340331; SING0340341; SING0340343; SING0340344; SING0340376
Macaranga hypoleuca (Rchb.f. & Zoll.) Müll.Arg.	LC	Bukit Asam, Bukit Belukar, Bukit Jelutong, Bukit Ketam, Bukit Mamam, Bukit Melayu, Bukit Noordin, Bukit Puaka, Bukit Surau, Bukit Tajam Kechil, Bukit Tinggi, Kekek Quarry, Tanjong Chek Jawa	SING0340395; SING0340409
Macaranga lowii King ex Hook.f.	VU	Tanjong Chek Jawa	SING0042368; SING0047730; SING0052090
Mallotus paniculatus (Lam.) Müll.Arg.	LC	Bukit Asam, Bukit Ketam, Bukit Mamam, Bukit Pekan, Bukit Puaka, Bukit Tinggi, Kekek Quarry	SING0164190; SING0340458
Suregada glomerulata (Blume) Baill.	CR	Bukit Belukar, Bukit Jelutong, Bukit Mamam, Bukit Pekan, Bukit Sempit, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Jalan Ubin, Tanjong Chek Jawa	SING0013058; SING0013060; SING0042929; SING0158556; SING0341790; SING0341791
Triadica cochinchinensis Lour.	LC	Bukit Asam, Bukit Bahru, Bukit Belukar, Bukit Ketam, Bukit Mamam, Bukit Noordin, Bukit Puaka, Bukit Surau, Bukit Tajam Kechil, Bukit Tinggi, Kekek Quarry, Tanjong Chek Jawa; planted at Ketam Quarry	SING0042705; SING0341792
Family Fabaceae			
Adenanthera malayana Kosterm. subsp. *malayana*	EN	Tanjong Chek Jawa; planted at Bukit Noordin	SING0047727; SING0047728
Aganope heptaphylla (L.) Polhill	CR	Bukit Bahru, Bukit Jelutong, Bukit Noordin, Bukit Pekan, Noordin Beach; planted at Jalan Jelutong, Jalan Noordin, Pekan Quarry	SING0201443
Aganope thyrsiflora (Benth.) Polhill	EN	Bukit Bahru, Bukit Noordin, Tanjong Chek Jawa	SING0042373; SING0047783; SING0387167
Albizia splendens Miq.	EN	Bukit Bahru, Bukit Surau	SING0258527

Appendix I. Continuation

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Alysicarpus vaginalis (L.) DC.	LC	Bukit Bahru, Bukit Pekan, Bukit Puaka, Kekek Quarry, Ketam Quarry	SING0346314; SING0346320
Archidendron clypearia (Jack) I.C.Nielsen var. *clypearia*	LC	Bukit Bahru, Bukit Mamam, Bukit Noordin, Bukit Sempit, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Bukit Tock Kew	SING0153656; SING0345420; SING0346881; SING0346882
Archidendron contortum (Mart.) I.C.Nielsen	EN	Bukit Belukar, Bukit Mamam, Bukit Noordin, Bukit Sempit, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Tanjong Chek Jawa	SING0042787; SING0047709; SING0182037; SING0199207; SING0232154
Archidendron ellipticum (Blume) I.C.Nielsen subsp. *ellipticum*	EN	Bukit Jelutong, Jalan Durian, Sensory Trail, Tanjong Chek Jawa	SING0274413
Archidendron globosum (Blume) I.C.Nielsen	CR	Tanjong Chek Jawa	SING0043947; SING0047737
Archidendron jiringa (Jack) I.C.Nielsen	VU	Bukit Bahru, Bukit Noordin, Bukit Surau, Tanjong Chek Jawa; planted at Jalan Endut Senin, Jalan Jelutong, Ketam Quarry, Sungei Asam	SING0043108; SING0387168
Archidendron microcarpum (Benth.) I.C.Nielsen	EN		SING0162393
Brachypterum scandens (Roxb.) Benth. ex Miq.	CR	Bukit Belukar, Bukit Jelutong, Sensory Trail, Sungei Jelutong, Tanjong Chek Jawa; planted at Jalan Jelutong	SING0030085; SING0030086; SING0043120; SING0047738; SING0114757
Canavalia cathartica Thouars	LC	Bukit Ketam, Bukit Noordin, Bukit Surau, Jalan Jelutong, Tanjong Chek Jawa	SING0016831; SING0043119; SING0047786; SING0158552
Canavalia rosea (Sw.) DC.	LC	Bukit Asam, Jalan Jelutong, Kekek Quarry, Ketam Quarry, Sungei Mamam, Tanjong Chek Jawa; planted at Jalan Endut Senin, Jalan Jelutong, Ketam Quarry	SING0043360; SING0345627; SING0345628
Cynometra ramiflora L.	CR	West of Sungei Mamam; planted at Balai Quarry, Bukit Surau, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Kekek Quarry, Ketam Quarry, Sensory Trail Pond, Sungei Asam, Sungei Teris, Sungei Pulau Ubin, Tanjong Chek Jawa	SING0182051; SING0345400; SING0345401; SING0345402; SING0345403; SING0345404

Appendix I. Continuation

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Dalbergia candenatensis (Dennst.) Prain	LC	Bukit Puaka, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Kekek Quarry, Sensory Trail, Tanjong Chek Jawa; planted at Jalan Jelutong	SING0008143; SING0008144; SING0042944; SING0345461; SING0345462; SING0345463; SING0345668
Dalbergia rostrata Hassk.	LC	Bukit Noordin, Bukit Surau, Bukit Tajam, Tanjong Chek Jawa	SING0042790
Dendrolobium umbellatum (L.) Benth.	LC	Bukit Belukar, Bukit Mamam, Bukit Noordin, Bukit Surau, Jalan Jelutong, Jalan Endut Senin, Tanjong Chek Jawa; planted at Balai Quarry, Jalan Endut Senin, Jalan Jelutong, Ketam Quarry	SING0016908; SING0036722; SING0042791; SING0042931; SING0047720; SING0346952
Derris amoena Benth.	LC	Bukit Noordin, Bukit Tajam, Bukit Tajam Kechil, Tanjong Chek Jawa; planted at Jalan Jelutong, Pekan Quarry	SING0047704; SING0346956; SING0346957; SING0346958
Derris trifoliata Lour.	LC	Bukit Asam, Bukit Noordin, Bukit Puaka, Bukit Surau, Bukit Tajam, Kekek Quarry, Tanjong Chek Jawa; planted at Jalan Jelutong, Jalan Noordin, Sungei Pulau Ubin	SING0036411; SING0042926; SING0043551; SING0344471; SING0344472; SING0344473; SING0047782; SING0344514; SING0344520; SING0344522
Entada spiralis Ridl.	VU	Bukit Asam, Bukit Bahru, Bukit Noordin, Bukit Sempit, Bukit Tajam, Bukit Tinggi, Bukit Tock Kew, Tanjong Chek Jawa	SING0038952; SING0043948; SING0171427; SING0344418; SING0344426; SING0344427
Flemingia strobilifera (L.) W.T.Aiton	CR	Bukit Ketam, Bukit Melayu; planted at Balai Quarry, Jalan Endut Senin, Jalan Jelutong, Ketam Quarry	SING0008151
Grona heterocarpos (L.) H.Ohashi & K.Ohashi var. *strigosa* (Meeuwen) H.Ohashi & K.Ohashi	VU		SING0046199; SING0347648
Grona heterophylla (Willd.) H.Ohashi & K.Ohashi	LC	Bukit Tajam, Tanjong Chek Jawa	Chan & Roslina 31, SINU
Grona triflora (L.) H.Ohashi & K.Ohashi	LC	Jalan Jelutong, Jalan Ubin	
Intsia bijuga (Colebr.) Kuntze	CR	Bukit Asam, Bukit Bahru, Bukit Sempit, Bukit Surau, near Sungei Saban, Sungei Teris, Tanjong Chek Jawa; planted at Balai Quarry, Jalan Endut Senin, Jalan Jelutong, Kekek Quarry, Sungei Asam, Sungei Puaka, Sungei Pulau Ubin, Sungei Teris	SING0008152; SING0018459; SING0042784

Appendix I. Continuation

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Kunstleria ridleyi Prain	EN	Tanjong Chek Jawa; planted at Balai Quarry, Jalan Jelutong	SING0179378
Millettia pinnata (L.) Panigrahi	EN	Bukit Asam, Bukit Ketam, Bukit Surau, Kekek Quarry, Tanjong Chek Jawa; planted at Balai Quarry, Bukit Tajam, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Kekek Quarry, Ketam Quarry, Sensory Trail Pond, Sungei Pulau Ubin, Sungei Teris, Tanjong Chek Jaw	SING0036418; SING0043117; SING0043354
Ormocarpum cochinchinense (Lour.) Merr.	CR	Sungei Asam; planted at Balai Quarry, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Ketam Quarry, Sensory Trail Pond, Sungei Jelutong, Sungei Pulau Ubin, Sungei Teris, Tanjong Chek Jawa	SING0054740; SING0054741; SING0114752; SING0114776; SING0226782
Ormosia bancana (Miq.) Prain	CR	Bukit Noordin, Bukit Tajam, Bukit Tajam Kechil; planted atJalan Endut Senin, Jalan Jelutong, Jalan Noordin	
Padbruggea dasyphylla Miq.	CR	Bukit Jelutong	SING0232155
Parkia speciosa Hassk.	VU	Bukit Belukar, Kampong Sungei Durian, Sungei Mamam, Tanjong Chek Jawa; Balai Quarry, Bukit Belukar, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Ketam Quarry, Sungei Asam	SING0153709
Peltophorum pterocarpum (DC.) Backer ex K.Heyne	CR	Bukit Asam, Bukit Bahru, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Jalan Jelutong, Jalan Pekan Ubin, Kekek Quarry, Sungei Saban, Tanjong Chek Jawa, west of Sungei Pulau Ubin; planted at Balai Quarry, Jalan Endut Senin, Jalan Jelutong, Jalan Ubin, Kekek Quarry, Ketam Quarry, Sensory Trail Pond, Sungei Asam, Sungei Pulau Ubin	SING0258526; SING274412
Senegalia kekapur (I.C.Nielsen) Maslin et al.	CR	Bukit Jelutong	SING0185178; SING0208536; SING0208537; SING0208538; SING0208539; SING0208540; SING0208543

Appendix I. Continuation

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Serianthes grandiflora Benth.	CR	Sungei Asam; planted at Balai Quarry, Bukit Noordin, Bukit Surau, Jalan Endut Senin, Jalan Wat Siam, Kekek Quarry, Ketam Quarry, Sungei Asam, Tanjong Chek Jawa	SING 2012-515
Spatholobus ferrugineus (Zoll. & Moritzi) Benth. var. *ferrugineus*	LC	Bukit Tajam	SING0182056
Ticanto crista (L.) R.Clark & Gagnon	LC	Balai Quarry, Bukit Asam, Bukit Noordin, Bukit Surau, Bukit Tajam, Kekek Quarry, Sungei Besar	SING0205812; SING0344405; SING0344406; SING0344407; SING0387174
Vigna marina (Burm.) Merr.	LC	East of Sungei Jelutong, near Sungei Asam, Noordin Beach	SING0241756
Whitfordiodendron erianthum (Benth.) Dunn	CR	Tanjong Chek Jawa; planted at Jalan Jelutong, Kekek Quarry, Ketam Quarry	
Family Flagellariaceae			
Flagellaria indica L.	LC	Bukit Asam, Bukit Bahru, Bukit Belukar, Bukit Jelutong, Bukit Ketam, Bukit Mamam, Bukit Noordin, Bukit Puaka, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Jalan Endut Senin, Kekek Quarry, Sensory Trail Pond, Sungei Pulau Ubin, Tanjong Chek Jawa	SING0042957; SING0047787; SING0255832; SING0267180; SING0267181; SING0267182
Family Gentianaceae			
Cyrtophyllum fragrans (Roxb.) DC.	LC	Bukit Asam, Bukit Bahru, Bukit Belukar, Bukit Ketam, Bukit Mamam, Bukit Melayu, Bukit Noordin, Bukit Puaka, Bukit Sempit, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Kekek Quarry, Tanjong Chek Jawa; planted at Balai Quarry, Jalan Jelutong, Kekek Quarry, Ketam Quarry, Sungei Teris	SING0042374
Fagraea auriculata Jack	CR	Bukit Tajam, Bukit Tinggi; planted at Bukit Surau, Jalan Endut Senin, Jalan Jelutong, Jalan Wat Siam, Sensory Trail Pond, Tanjong Chek Jawa	SING0165833; SING0215131; SING0363008

Appendix I. Continuation

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Limahlania crenulata (Maingay ex C.B.Clarke) K.M.Wong & Sugumaran	NEx	Sungei Teris; planted at Jalan Endut Senin, Kekek Quarry, Sungei Teris	
Utania nervosa K.M.Wong & Sugumaran	VU	Bukit Bahru, Bukit Belukar, Bukit Mamam, Bukit Melayu, Bukit Surau, Bukit Tinggi, Kekek Quarry, Tanjong Chek Jawa; planted at Balai Quarry	SING0008241; SING0008242; SING0013341; SING0047404; SING0166278; SING0166279; SING0179374; SING0258595
Family Goodeniaceae			
Scaevola taccada (Gaertn.) Roxb.	LC	Balai Quarry, Bukit Asam, Bukit Ketam, Bukit Noordin, Bukit Tajam, Tanjong Chek Jawa; planted at Balai Quarry, Bukit Tajam, Jalan Endut Senin, Jalan Jelutong, Jalan Ubin	SING0047707; SING0341713; SING0358540; SING0358553
Family Hanguanaceae			
Hanguana neglecta Škorničk. & Niissalo	EN	Planted at Jalan Endut Senin, Jalan Jelutong, Tanjong Chek Jawa	SING0043566
Family Hydrocharitaceae			
Enhalus acoroides (L.f.) Royle	CR	Chek Jawa Wetlands	Photographic Record
Halophila beccarii Asch.	EN	Chek Jawa Wetlands	SING0048229
Halophila minor (Zoll.) Hartog	CR	Chek Jawa Wetlands	SING0274406
Halophila ovalis (R.Br.) Hook.f.	LC	Chek Jawa Wetlands, intertidal area off Jalan Jelutong & Jalan Pekan Ubin, Sungei Durian Ponds	SING0045956; SING0045960; SING0045961; SING0048226; SING0048232; SING0048236; SING0048237; SING0061124; SING0078966; SING0078967; SING0137230; SING0144310; SING0144311
Halophila spinulosa (R.Br.) Asch.	CR	Chek Jawa Wetlands	SING0045954; SING0048228; SING0078965
Thalassia hemprichii (Ehrenb.) Asch.	EN	Chek Jawa Wetlands	SING0048225
Family Hypericaceae			

Appendix I. Continuation

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Cratoxylum formosum (Jack) Benth. & Hook.f. ex Dyer	EN	Bukit Sempit, Kekek Quarry; planted at Balai Quarry, Jalan Jelutong, Ketam Quarry, Sungei Asam, Sungei Teris, Tanjong Chek Jawa	
Family Hypoxidaceae			
Curculigo latifolia W.T.Aiton	VU	Bukit Asam, Bukit Bahru, Bukit Ketam, Bukit Mamam, Bukit Tinggi, Tanjong Chek Jawa	SING0042354
Family Icacinaceae			
Iodes ovalis Blume	VU	Bukit Jelutong, Bukit Melayu	SING0165821
Family Ixonanthaceae			
Ixonanthes icosandra Jack	VU	Bukit Melayu, Bukit Surau, Bukit Tajam Kechil, Bukit Tinggi, Tanjong Chek Jawa; planted at Bukit Surau, Jalan Noordin	SING0043554; SING0174105
Ixonanthes reticulata Jack	LC	Bukit Asam, Bukit Bahru, Bukit Belukar, Bukit Ketam, Bukit Mamam, Bukit Melayu, Bukit Sempit, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi	SING0153658
Family Lamiaceae			
Anisomeles indica (L.) Kuntze	CR	Sensory Trail	SING0120374
Callicarpa longifolia Lam.	VU	Bukit Tinggi, Sensory Trail; planted at Balai Quarry, Jalan Jelutong, Jalan Ubin, Ketam Quarry, Sensory Trail Pond, Sungei Asam	SING0046146; SING0182028
Clerodendrum deflexum Wall.	LC	Bukit Sempit	SING0222174
Clerodendrum disparifolium Blume	LC	Bukit Asam, Bukit Bahru, Bukit Belukar, Bukit Jelutong, Bukit Ketam, Bukit Noordin, Bukit Pekan, Bukit Puaka, Bukit Sempit, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Bukit Tock Kew, Kekek Quarry, Sensory Trail, Tanjong Chek Jawa; planted at Balai Quarry, Jalan Jelutong	SING0042413; SING0042747

Appendix I. Continuation

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Clerodendrum villosum Blume	LC	Bukit Belukar, Bukit Noordin, Bukit Pekan, Bukit Puaka, Bukit Tinggi, Tanjong Chek Jawa; planted at Balai Quarry, Jalan Jelutong	SING0212354
Premna serratifolia L.	LC	Bukit Surau, Bukit Tajam, Kekek Quarry, Sungei Pulau Ubin, Tanjong Chek Jawa; planted at Balai Quarry, Jalan Jelutong, Bukit Mamam, Ketam Quarry, Sungei Asam	SING0043209; SING0205811; SING0008142; SING0026772; SING0042774
Vitex pinnata L.	LC	Bukit Asam, Bukit Bahru, Bukit Belukar, Bukit Jelutong, Bukit Ketam, Bukit Mamam, Bukit Melayu, Bukit Noordin, Bukit Puaka, Bukit Sempit, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Jalan Endut Senin, Jalan Jelutong, Kekek Quarry, Tanjong Chek Jawa	SING0042414; SING0042415; SING0043542
Vitex trifolia L.	CR	Sensory Trail	KS Tan 52, SINU
Volkameria inermis L.	LC	Bukit Ketam, Bukit Noordin, Bukit Tajam, Jalan Pekan Ubin, Sungei Besar, Tanjong Chek Jawa; planted at Balai Quarry, Jalan Endut Senin, Jalan Jelutong, Ketam Quarry	SING0043184; SING0043357; SING0153587
Family Lauraceae			
Cassytha filiformis L.	LC	Bukit Ketam, Bukit Puaka, Kekek Quarry	SING0165924
Cinnamomum iners (Reinw. ex Nees & T.Nees) Blume	LC	Bukit Asam, Bukit Bahru, Bukit Belukar, Bukit Jelutong, Bukit Ketam, Bukit Mamam, Bukit Noordin, Bukit Pekan, Bukit Puaka, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Kekek Quarry, Tanjong Chek Jawa; planted at Bukit Noordin, Jalan Jelutong	SING0042371; SING0153596
Litsea elliptica Blume	LC	Bukit Asam, Bukit Bahru, Bukit Belukar, Bukit Jelutong, Bukit Ketam, Bukit Mamam, Bukit Noordin, Bukit Puaka, Bukit Sempit, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Bukit Tok Kew, Tanjong Chek Jawa; planted at Bukit Belukar, Bukit Noordin, Jalan Endut Senin, Kekek Quarry	SING0042953; SING0383045

Appendix I. Continuation

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Litsea myristicifolia (Wall. ex Nees) Hook.f.	CR	Bukit Bahru, Bukit Jelutong, Bukit Mamam, Bukit Melayu, Bukit Noordin, Bukit Surau, Tanjong Chek Jawa, west of Sungei Pulau Ubin; planted at Bukit Jelutong, Bukit Surau, Sungei Asam, Sungei Teris	SING0042950; SING0047708
Litsea umbellata (Lour.) Merr.	VU	Bukit Asam, Bukit Bahru, Bukit Belukar, Bukit Jelutong, Bukit Ketam, Bukit Mamam, Bukit Melayu, Bukit Noordin, Bukit Pekan, Bukit Puaka, Bukit Sempit, Bukit Surau, Jalan Jelutong, Jalan Noordin, Kekek Quarry, Sensory Trail, Tanjong Chek Jawa; planted at Jalan Jelutong	SING0042372; SING0042884; SING0165603; SING0312887; SING0388397
Machilus declinata (Blume) de Kok	CR	Bukit Belukar	SING0397364
Neolitsea cassia (L.) Kosterm.	LC	Bukit Bahru, Bukit Belukar, Bukit Jelutong, Bukit Noordin, Bukit Pekan, Bukit Puaka, Bukit Surau, Kekek Quarry, Tanjong Chek Jawa; planted at Balai Quarry, Bukit Jelutong, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Ketam Quarry, Sensory Trail Pond, Sungei Teris	SING0040361; SING0042781; SING0043946; SING0045663
Phoebe grandis (Nees) Merr.	CR	Bukit Melayu	SING0065659
Family Lecythidaceae			
Barringtonia asiatica (L.) Kurz	CR	Bukit Asam, Sungei Asam; planted at Balai Quarry, Jalan Endut Senin, Jalan Jelutong, Ketam Quarry	SING 2015-236
Barringtonia racemosa (L.) Spreng.	CR	Sungei Durian, Bukit Surau; planted at Balai Quarry, Jalan Batu Ubin, Jalan Endut Senin, Jalan Noordin, Kekek Quarry, Ketam Quarry, Sensory Trail Pond, Sungei Pulau Ubin, Sungei Teris, Sungei Pulau Ubin, Tanjong Chek Jawa	SING0153661
Barringtonia reticulata (Blume) Miq.	CR	Bukit Bahru, Bukit Noordin; planted at Jalan Endut Senin, Kekek Quarry	SING0166408

Appendix I. Continuation

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Family Linaceae			
Indorouchera griffithiana (Planch.) Hallier f.	LC	Bukit Asam, Bukit Bahru, Bukit Belukar, Bukit Jelutong, Bukit Ketam, Bukit Mamam, Bukit Noordin, Bukit Pekan, Bukit Puaka, Bukit Sempit, Bukit Surau, Bukit Tajam Kechil, Bukit Tinggi, Kekek Quarry, Tanjong Chek Jawa; planted at Pekan Quarry	SING0038946
Family Loganiaceae			
Strychnos ignatii P.J.Bergius	LC	Tanjong Chek Jawa	SING0042375; SING0042376
Strychnos maingayi C.B.Clarke	CR	Tanjong Chek Jawa	SING0043548; SING0182034
Family Loranthaceae			
Dendrophthoe pentandra (L.) Miq.	LC	Bukit Jelutong, Bukit Mamam, Bukit Pekan	SING0241755
Macrosolen cochinchinensis (Lour.) Tiegh.	LC	Bukit Bahru	SING0153666
Scurrula parasitica L.	CR	Bukit Bahru	SING0043498
Family Lythraceae			
Sonneratia alba Sm.	LC	Bukit Surau, Bukit Tajam, Jalan Pekan Ubin, Kekek Quarry, Sungei Asam, Sungei Batu Kekek, Sungei Besar, Sungei Durian, Sungei Jelutong, Sungei Mamam, Sungei Melayu, Sungei Puaka, Sungei Tajam, Sungei Pulau Ubin, Tanjong Chek Jawa; planted at Jalan Jelutong, Sungei Puaka	SING0042745; SING0043515; SING0052180; SING0263722
Sonneratia caseolaris (L.) Engl.	CR	Sungei Puaka, west of Sungei Asam, Tanjong Chek Jawa; planted at Sungei Puaka, Tanjong Chek Jawa	SING0205578; SING0263725
Sonneratia ovata Backer	CR	Sungei Asam, Sungei Besar, Sungei Durian, Sungei Mamam, Sungei Teris, Tanjong Chek Jawa; planted at Sungei Puaka, Sungei Pulau Ubin	SING0046233; SING0263724
Family Malpighiaceae			
Aspidopterys concava (Wall.) A.Juss.	EN	Bukit Bahru, Tanjong Chek Jawa	SING0047722; SING0174102

Appendix I. Continuation

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Tristellateia australasiae A.Rich.	EN	Sensory Trail; planted at Balai Quarry, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Kekek Quarry, Ketam Quarry, Pekan Quarry, Sensory Trail Pond, Sungei Pulau Ubin	SING0182035
Family Malvaceae			
Brownlowia tersa (L.) Kosterm.	CR	Sungei Durian; planted at Sungei Puaka	SING0065741; SING0153673
Commersonia bartramia (L.) Merr.	LC	Bukit Noordin, Bukit Puaka, Bukit Surau, Kekek Quarry	SING0052632
Heritiera littoralis Aiton	EN	Bukit Asam, Sungei Besar, Sungei Jelutong, Sungei Teris, Tanjong Chek Jawa; planted at Bukit Surau, Jalan Batu Ubin, Jalan Endut Senin, Jalan Noordin, Jalan Wat Siam, Kekek Quarry, Ketam Quarry, Sensory Trail Pond, Sungei Puaka, Sungei Asam, Sungei Pulau Ubin	SING0043714; SING0145059
Hibiscus tiliaceus L.	LC	Bukit Asam, Bukit Bahru, Bukit Ketam, Bukit Noordin, Bukit Puaka, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Jalan Endut Senin, Jalan Jelutong, Jalan Pekan Ubin, Kekek Quarry, Sensory Trail, Sungei Asam, Sungei Besar, Sungei Jelutong, Sungei Mamam, Sungei Puaka, Sungei Teris, Sungei Pulau Ubin, Tanjong Chek Jawa; planted at Sungei Puaka	SING0165600
Pterospermum diversifolium Blume	CR	Bukit Jelutong, Bukit Pekan; planted at Balai Quarry, Bukit Surau, Jalan Endut Senin, Jalan Noordin, Ketam Quarry, Sungei Asam	SING0114753; SING0185182; SING0185183; SING0185184; SING0185311
Scaphium affine (Mast.) Pierre	EN	Tanjong Chek Jawa; planted at Bukit Belukar, Bukit Surau, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Ketam Quarry, Sungei Asam, Sungei Teris	SING0008042; SING0042943
Sida rhombifolia L. subsp. *rhombifolia*	LC	Bukit Belukar, Jalan Jelutong, Kekek Quarry, Tanjong Chek Jawa	SING0042797
Sterculia coccinea Jack	EN	Bukit Belukar, Bukit Tinggi; planted at Balai Quarry, Bukit Noordin, Jalan Endut Senin, Sungei Asam, Tanjong Chek Jawa	SING0043563; SING0205796

Appendix I. Continuation

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Sterculia rubiginosa Vent.	VU	Tanjong Chek Jawa; planted at Balai Quarry, Bukit Belukar, Bukit Ketam, Bukit Noordin, Bukit Surau, Jalan Batu Ubin, Jalan Durian, Jalan Endut Senin, Jalan Noordin, Kekek Quarry, Ketam Quarry, Sungei Asam, Sungei Teris	SING0205524
Thespesia populnea (L.) Sol. ex Corrêa	LC	Bukit Surau, Jalan Jelutong, Kekek Quarry; planted at Balai Quarry, Jalan Endut Senin, Jalan Noordin, Jalan Wat Siam, Sungei Puaka, Sungei Asam, Sungei Pulau Ubin, Tanjong Chek Jawa	SING0052461
Family Maranthaceae			
Donax canniformis (G.Forst.) K.Schum.	CR	Bukit Jelutong	SING0185160
Family Melastomataceae			
Dissochaeta biligulata Korth.	CR	Tanjong Chek Jawa	SING0047714
Dissochaeta gracilis (Jack) Blume	VU	Bukit Surau, Tanjong Chek Jawa	SING0146654; SING0153598
Melastoma malabathricum L.	LC	Bukit Asam, Bukit Bahru, Bukit Belukar, Bukit Jelutong, Bukit Ketam, Bukit Mamam, Bukit Noordin, Bukit Puaka, Bukit Surau, Bukit Sempit, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Kekek Quarry; planted at Balai Quarry, Jalan Endut Senin, Jalan Jelutong, Jalan Ubin, Kampong Sungei Durian, Ketam Quarry, Sensory Trail Pond, Sungei Asam, Tanjong Chek Jawa	SING0052341
Memecylon edule Roxb. var. *edule*	EN	Bukit Bahru, Bukit Mamam, Bukit Noordin, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Kekek Quarry, Tanjong Chek Jawa; planted at Balai Quarry, Bukit Belukar, Bukit Noordin, Bukit Surau, Bukit Tajam, Jalan Endut Senin, Jalan Jelutong, Ketam Quarry, Sensory Trail Pond, Sungei Pulau Ubin	SING0146644
Memecylon lilacinum Zoll. & Moritzi	CR	Tanjong Chek Jawa; planted at Jalan Endut Senin	SING0182029; SING0383052

Appendix I. Continuation

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Memecylon ovatum Sm.	EN	Bukit Noordin, Tanjong Chek Jawa; planted at Balai Quarry, Bukit Ketam, Bukit Surau, Bukit Tajam, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Ketam Quarry, Sensory Trail Pond, Sungei Asam	SING0008214; SING0030095; SING0042379; SING0042380; SING0042800; SING0043536; SING0043549; SING0047403; SING0158551
Pachycentria pulverulenta (Jack) Clausing	CR	Tanjong Chek Jawa	SING0008185
Family Meliaceae			
Aglaia cucullata (Roxb.) Pellegr.	CR	Bukit Tajam Kechil, Sungei Asam; planted at Sensory Trail Pond, Tanjong Chek Jawa	SING0054737; SING0054738; SING0054739; SING0205467
Aphanamixis polystachya (Wall.) R.Parker	LC	Bukit Mamam, Bukit Pekan, Jalan Jelutong; planted at Bukit Tajam, Jalan Jelutong, Bukit Noordin, Ketam Quarry, Sensory Trail Pond, Sungei Pulau Ubin, Tanjong Chek Jawa	
Sandoricum koetjape (Burm.f.) Merr.	VU	Bukit Belukar, Bukit Mamam, Bukit Surau, Jalan Durian, Tanjong Chek Jawa; planted at Balai Quarry, Jalan Jelutong, Jalan Pekan Ubin, Jalan Ubin, Ketam Quarry	SING0045122
Xylocarpus granatum J.Koenig	LC	Bukit Noordin, Bukit Tajam, Kekek Quarry, Sungei Asam, Sungei Batu Kekek, Sungei Besar, Sungei Durian, Sungei Jelutong, Sungei Mamam, Sungei Melayu, Sungei Puaka, Sungei Pulau Ubin, Tanjong Chek Jawa; planted at Ketam Quarry, Sungei Durian, Sungei Puaka	SING0018760; SING0042801; SING0043718
Xylocarpus moluccensis (Lam.) M.Roem.	EN	Bukit Tajam, Kekek Quarry, Sungei Asam, Sungei Besar, Sungei Jelutong, Sungei Mamam, Sungei Puaka, Tanjong Chek Jawa; planted at Bukit Tajam, Jalan Noordin, Ketam Quarry, Sungei Puaka, Sungei Pulau Ubin	SING0043513; SING0043713
Xylocarpus rumphii (Kostel.) Mabb.	CR	Sungei Puaka; planted at Jalan Endut Senin, Sensory Trail Pond, Sungei Puaka, Tanjong Chek Jawa	SING0258593

Appendix I. Continuation

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Family Menispermaceae			
Coscinium fenestratum (Gaertn.) Colebr.	EN		SING0043949
Fibraurea tinctoria Lour.	LC	Bukit Asam, Bukit Bahru, Bukit Belukar, Bukit Jelutong, Bukit Ketam, Bukit Melayu, Bukit Noordin, Bukit Puaka, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Tanjong Chek Jawa; planted at Jalan Jelutong, Pekan Quarry	SING0042377; SING0043950; SING0357398; SING0357606; SING0357607; SING0357608
Hypserpa nitida Miers	EN	Tanjong Chek Jawa	SING0171428; SING0173346; SING0176990
Limacia scandens Lour.	LC	Bukit Asam, Bukit Bahru, Bukit Jelutong, Bukit Mamam, Bukit Melayu, Bukit Puaka, Bukit Surau, Jalan Jelutong	SING0153668; SING0258545; SING0357634
Family Moraceae			
Antiaris toxicaria (Pers.) Lesch.	CR	Bukit Jelutong; planted at Balai Quarry, Bukit Jelutong, Bukit Surau, Bukit Mamam, Jalan Endut Senin, Kekek Quarry, Sungei Asam	SING0193763
Artocarpus dadah Miq.	EN	Bukit Bahru, Bukit Melayu, Tanjong Chek Jawa; planted at Balai Quarry, Bukit Belukar, Jalan Batu Ubin, Jalan Endut Senin, Jalan Noordin, Kekek Quarry, Sungei Asam	SING0042672; SING0042946; SING0043346; SING0043350; SING0043951; SING0182060; SING0222183
Artocarpus elasticus Reinw. ex Blume	LC	Bukit Jelutong, Bukit Pekan, Jalan Jelutong; planted at Balai Quarry, Bukit Belukar, Bukit Noordin, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Ketam Quarry	SING0165823
Artocarpus griffithii (King) Merr.	CR	Bukit Bahru, Bukit Melayu, Tanjong Chek Jawa; planted at Bukit Noordin, Bukit Tajam	SING0043558
Ficus aurata (Miq.) Miq.	LC	Bukit Asam, Bukit Ketam, Bukit Sempit, Bukit Tajam Kechil, Bukit Tinggi, Jalan Batu Ubin; planted at Balai Quarry, Jalan Endut Senin, Ketam Quarry	SING0153669
Ficus binnendijkii (Miq.) Miq.	CR	Tanjong Chek Jawa; planted at Bukit Tajam, Jalan Noordin, Tanjong Chek Jawa	SING0174103

Appendix I. Continuation

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Ficus caulocarpa (Miq.) Miq.	EN	Bukit Mamam, Sensory Trail, Tanjong Chek Jawa; planted at Sungei Asam	SING0008049; SING0042025; SING0042381; SING0042382; SING0043352; SING0146659; SING0315285
Ficus crassiramea (Miq.) Miq. subsp. *crassiramea*	CR	Bukit Ketam, Jalan Pekan Ubin, Sungei Pulau Ubin; planted at Balai Quarry, Bukit Noordin, Bukit Surau, Jalan Batu Ubin, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Ketam Quarry, Sensory Trail Pond, Sungei Asam, Sungei Teris, Tanjong Chek Jawa	SING0008056; SING0042887; SING0046148; SING0299542
Ficus deltoidea Jack	CR	Off Tanjong Tajam	SING0360066; SING0360067; SING0360068; SING0360069
Ficus fistulosa Reinw. ex Blume	LC	Bukit Asam, Bukit Bahru, Bukit Belukar, Bukit Jelutong, Bukit Ketam, Bukit Mamam, Bukit Noordin, Bukit Pekan, Bukit Puaka, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Jalan Endut Senin, Kekek Quarry; planted at Jalan Jelutong	SING0162391
Ficus globosa Blume	VU	Tanjong Chek Jawa; planted at Bukit Noordin, Jalan Batu Ubin, Jalan Endut Senin, Jalan Noordin, Jalan Wat Siam	SING0159057
Ficus grossularioides Burm.f. var. *grossularioides*	LC	Bukit Asam, Bukit Bahru, Bukit Belukar, Bukit Ketam, Bukit Noordin, Bukit Pekan, Bukit Puaka, Bukit Sempit, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Kekek Quarry, Tanjong Chek Jawa	SING0042384; SING0042385
Ficus heteropleura Blume	LC	Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Jalan Jelutong, Tanjong Chek Jawa; planted at Ketam Quarry	SING0043112
Ficus kerkhovenii Koord. & Valeton	EN	Bukit Bahru, Bukit Melayu, Bukit Tinggi, Sensory Trail, Tanjong Chek Jawa; planted at Balai Quarry, Kekek Quarry, Jalan Jelutong	SING0042383; SING0043728; SING0052002
Ficus microcarpa L.f.	LC	Bukit Pekan, Bukit Surau, Bukit Tajam, Jalan Jelutong, Jalan Noordin, Jalan Ubin, Sensory Trail, Sungei Jelutong, Tanjong Chek Jawa	SING0042386; SING0042934; SING0153662; SING0315284

Appendix I. Continuation

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Ficus microsyce Ridl.	CR	Bukit Sempit; planted at Balai Quarry, Bukit Surau, Jalan Jelutong, Kekek Quarry, Sensory Trail Pond, Sungei Asam, Sungei Teris	SING0205795
Ficus punctata Thunb.	LC	Bukit Bahru, Bukit Jelutong, Bukit Melayu, Bukit Noordin, Bukit Pekan, Bukit Puaka, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Jalan Sam Heng, Tanjong Chek Jawa; planted at Bukit Belukar, Bukit Mamam, Jalan Noordin	SING0043113
Ficus sagittata Vahl	EN	Bukit Bahru, Bukit Jelutong; planted at Bukit Mamam, Jalan Endut Senin, Jalan Wat Siam	SING0193761
Ficus sinuata Thunb.	CR	Sensory Trail; planted at Balai Quarry, Bukit Belukar, Bukit Mamam, Jalan Noordin	SING0182012
Ficus stricta (Miq.) Miq.	CR	Bukit Melayu, Jalan Jelutong, Jalan Noordin, near Sungei Pulau Ubin estuary, Sensory Trail; planted at Balai Quarry, Bukit Tajam, Jalan Batu Ubin, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Kekek Quarry, Ketam Quarry, Sungei Asam, Sungei Pulau Ubin, Sungei Teris, Tanjong Chek Jawa	SING0179372; SING0299541; SING0299543
Ficus subulata Blume	CR	Jalan Batu Ubin, Jalan Ubin; planted at Balai Quarry, Bukit Mamam, Pekan Quarry	SING0065725; SING0065726; SING0164193; SING0295063; SING0310297; SING0387165
Ficus variegata Blume	LC	Bukit Bahru, Bukit Belukar, Bukit Jelutong, Bukit Ketam, Bukit Mamam, Bukit Noordin, Bukit Pekan, Bukit Puaka, Bukit Surau, Bukit Tinggi, Jalan Endut Senin, Jalan Ubin, Kekek Quarry, Sensory Trail, Tanjong Chek Jawa	SING0042805
Ficus vasculosa Wall. ex Miq.	VU	Bukit Asam, Bukit Bahru, Bukit Belukar, Bukit Ketam, Bukit Mamam, Bukit Noordin, Bukit Puaka, Bukit Sempit, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Tanjong Chek Jawa	SING0042387; SING0222178

Appendix I. Continuation

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Ficus villosa Blume	EN	Tanjong Chek Jawa; planted at Bukit Belukar, Bukit Mamam, Jalan Jelutong, Jalan Noordin, Tanjong Chek Jawa	SING0043107
Ficus virens Aiton	EN	planted at Bukit Surau	SING0043719; SING0315286
Malaisia scandens (Lours.) Planch.	CR	Jalan Jelutong; Jalan Pekan Ubin; Tanjong Chek Jawa; planted at Jalan Jelutong	SING0030487; SING0030195; SING0043510; SING0312886
Sloetia elongata (Miq.) Koord.	LC	Bukit Jelutong, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Bukit Tock Kew, Kekek Quarry; planted at Balai Quarry, Bukit Tajam, Jalan Batu Ubin, Jalan Jelutong, Jalan Noordin, Ketam Quarry, Sensory Trail Pond, Sungei Asam, Sungei Teris	SING0114772
Family Myricaceae			
Morella esculenta (Buch.-Ham. ex D.Don) I.M.Turner	LC	Bukit Bahru, Bukit Ketam, Bukit Sempit, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi	SING0153660
Family Myristicaceae			
Knema corticosa Lour.	VU	Bukit Bahru, Bukit Belukar, Bukit Jelutong, Bukit Ketam, Bukit Mamam, Bukit Melayu, Bukit Noordin, Bukit Pekan, Bukit Puaka, Bukit Surau, Jalan Jelutong, Jalan Noordin, Kekek Quarry, Sensory Trail, Tanjong Chek Jawa; planted at Balai Quarry, Bukit Belukar, Bukit Noordin, Bukit Tajam, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Ketam Quarry, Sensory Trail Pond, Sungei Asam, Sungei Pulau Ubin, Sungei Teris, Sungei Pulau Ubin	SING0008158; SING0008159; SING0038948; SING0042388; SING0042808; SING0046374; SING0158546; SING0158547; SING0231967; SING0231969
Knema laurina (Blume) Warb. var. *laurina*	EN	Tanjong Chek Jawa; planted at Bukit Surau	SING0179375

Appendix I. Continuation

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Family Myrtaceae			
Rhodamnia cinerea Jack	LC	Bukit Asam, Bukit Bahru, Bukit Belukar, Bukit Jelutong, Bukit Ketam, Bukit Mamam, Bukit Noordin, Bukit Puaka, Bukit Sempit, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Kekek Quarry, Tanjong Chek Jawa; planted at Bukit Belukar, Bukit Noordin, Bukit Tajam, Jalan Noordin, Ketam Quarry	SING0042389
Rhodomyrtus tomentosa (Aiton) Hassk.	VU	Bukit Puaka; planted at Balai Quarry, Bukit Mamam, Jalan Endut Senin, Jalan Jelutong, Ketam Quarry, Sensory Trail Pond	SING0114768
Syzygium cerasiforme (Blume) Merr. & L.M.Perry	LC	Bukit Belukar, Bukit Ketam, Bukit Noordin, Bukit Puaka, Bukit Surau, Bukit Tinggi, Jalan Jelutong, Tanjong Chek Jawa; planted at Balai Quarry, Bukit Belukar, Bukit Surau, Jalan Endut Senin, Ketam Quarry, Sungei Asam	SING0042390; SING0042947
Syzygium chloranthum (Duthie) Merr. & L.M.Perry	EN	Bukit Ketam; planted at Jalan Wat Siam	
Syzygium formosum (Wall.) Mason	CR	Between Bukit Asam & Bukit Tinggi; planted at Bukit Surau, Jalan Endut Senin, Jalan Noordin, Kekek Quarry, Sungei Asam	SING 2013-070
Syzygium glaucum (King) Chantar. & J.Parn.	VU	Bukit Tajam, Bukit Tajam Kechil, Sungei Asam; planted at Balai Quarry, Bukit Belukar, Bukit Noordin, Bukit Surau, Bukit Tajam, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Jalan Wat Siam, Kekek Quarry, Ketam Quarry, Sungei Asam, Sungei Pulau Ubin	SING0182005
Syzygium grande (Wight) Walp.	LC	Bukit Mamam, Bukit Noordin, Bukit Surau, Bukit Tinggi; planted at Balai Quarry, Jalan Endut Senin, Jalan Jelutong, Sungei Asam	SING0212353
Syzygium palembanicum Miq.	VU	Bukit Asam, Bukit Bahru, Bukit Noordin, Bukit Tajam Kechil; planted at Balai Quarry, Bukit Belukar, Bukit Noordin, Bukit Tajam, Jalan Batu Ubin, Jalan Endut Senin, Ketam Quarry, Sungei Teris	SING0182016; SING0182017; SING0182018; SING0387170

Appendix I. Continuation

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Syzygium polyanthum (Wight) Walp.	LC	Bukit Jelutong, Bukit Ketam, Bukit Mamam, Bukit Noordin, Bukit Pekan, Bukit Puaka, Bukit Tinggi, Jalan Jelutong, Kekek Quarry; planted at Balai Quarry, Bukit Tajam, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Kekek Quarry, Ketam Quarry, Sungei Asam, Sungei Pulau Ubin, Tanjong Chek Jawa	SING0153657
Syzygium pycnanthum Merr. & L.M.Perry	CR	Bukit Noordin; planted at Bukit Belukar, Bukit Noordin, Bukit Surau, Jalan Jelutong, Jalan Noordin	
Syzygium syzygioides (Miq.) Merr. & L.M.Perry	LC	Bukit Asam, Bukit Bahru, Bukit Belukar, Bukit Jelutong, Bukit Ketam, Bukit Mamam, Bukit Melayu, Bukit Noordin, Bukit Pekan, Bukit Puaka, Bukit Sempit, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Kekek Quarry, Sungei Pulau Ubin, Tanjong Chek Jawa; planted at Balai Quarry, Bukit Belukar, Bukit Noordin, Bukit Surau, Bukit Tajam, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Kekek Quarry, Ketam Quarry, Sungei Asam, Sungei Teris, Sungei Pulau Ubin	SING0042391; SING0043359; SING0194926; SING0203108; SING0241762; SING0382994
Syzygium zeylanicum (L.) DC.	LC	Bukit Asam, Bukit Bahru, Bukit Jelutong, Bukit Mamam, Bukit Noordin, Bukit Puaka, Bukit Sempit, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Kekek Quarry, Tanjong Chek Jawa; planted at Balai Quarry, Bukit Belukar, Bukit Noordin, Bukit Surau, Bukit Tajam, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Ketam Quarry, Sungei Asam, Sungei Teris	SING0371781
Tristaniopsis whiteana (Griff.) Peter G.Wilson & J.T.Waterh.	EN	Bukit Noordin, Bukit Tajam, Bukit Tock Kew; planted at Balai Quarry, Bukit Noordin, Bukit Tajam, Jalan Endut Senin, Jalan Jelutong, Kekek Quarry, Ketam Quarry, Sensory Trail Pond, Sungei Asam, Sungei Puaka, Sungei Teris	SING0116843
Family Nepenthaceae			
Nepenthes ampullaria Jack	VU	Bukit Tajam Kechil, Bukit Tinggi, Bukit Tock Kew	SING0093674; SING0093675; SING0093676; SING0146657

Appendix I. Continuation

Species	**Conservation Status**	**Location**	**Barcode No./Voucher Specimen No./ Photographic Record**
Nepenthes gracilis Korth.	LC	Bukit Ketam, Bukit Puaka, Bukit Sempit, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Kekek Quarry, Tanjong Chek Jawa	SING0093671; SING0093672; SING0093673; SING0192201; SING0203128
Nepenthes rafflesiana Jack	VU	Bukit Tinggi	SING0388832; SING0390132
Nepenthes x *trichocarpa* Miq.		Tanjong Chek Jawa	SING0093669; SING0093670
Family Ochnaceae			
Brackenridgea elegantissima (Wall.) Kanis	EN	Bukit Noordin	
Campylospermum serratum (Gaertn.) Bittrich & M.C.E.Amaral	VU	Bukit Bahru, Bukit Belukar, Bukit Mamam, Bukit Noordin, Bukit Surau, Tanjong Chek Jawa; planted at Bukit Belukar, Bukit Noordin, Jalan Endut Senin	SING0014538; SING0042392; SING0043541
Family Olacaceae			
Ximenia americana L.	LC	Bukit Asam, Kekek Quarry, Sungei Durian, Sungei Pulau Ubin, Tanjong Chek Jawa	SING0043356; SING0042813; SING0056604
Family Oleaceae			
Chionanthus ramiflorus Roxb.	CR	Bukit Surau, Tanjong Chek Jawa	SING0274425
Jasminum elongatum (P.J.Bergius) Willd.	EN	Bukit Bahru, Bukit Mamam, Bukit Puaka, Tanjong Chek Jawa; planted at Jalan Jelutong, Balai Quarry, Jalan Noordin, Kekek Quarry, Ketam Quarry, Pekan Quarry, Sungei Pulau Ubin, Ubin Quarry	SING0040366; SING0166592; SING0171425
Olea brachiata (Lour.) Merr.	VU	Bukit Bahru, Bukit Belukar, Bukit Mamam, Bukit Noordin, Bukit Surau, Tanjong Chek Jawa; planted at Balai Quarry, Bukit Ketam, Jalan Endut Senin, Jalan Jelutong, Ketam Quarry, Sungei Asam, Sungei Pulau Ubin, Sungei Teris	SING0042393; SING0042815; SING0043545; SING0047726; SING0222964
Family Opiliaceae			
Cansjera rheedei J.F.Gmel.	LC	Bukit Asam, Bukit Bahru, Bukit Belukar, Bukit Mamam, Bukit Noordin, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Sensory Trail	SING0014609

Appendix I. Continuation

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Champereia manillana (Blume) Merr.	LC	Bukit Asam, Bukit Bahru, Bukit Belukar, Bukit Ketam, Bukit Mamam, Bukit Noordin, Bukit Pekan, Bukit Puaka, Bukit Sempit, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Jalan Noordin, Kekek Quarry, Tanjong Chek Jawa	SING0042205; SING0042818
Lepionurus sylvestris Blume	CR	Bukit Tinggi, Tanjong Chek Jawa	SING0258525
Family Orchidaceae			
Arachnis x *maingayi* (Hook.f.) Schltr.		Jalan Wat Siam; planted at Jalan Jelutong	SING0310292
Arundina graminifolia (D.Don) Hochr.	VU	Balai Quarry; planted at Ketam Quarry, Pekan Quarry, Sensory Trail Pond	SING0222187
Bromheadia finlaysoniana (Lindl.) Miq.	LC	Bukit Mamam, Bukit Sempit, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil	SING0274409
Bulbophyllum vaginatum (Lindl.) Rchb.f.	VU	Bukit Melayu, Jalan Noordin; planted at Jalan Jelutong, Tanjong Chek Jawa	SING0201442
Dendrobium crumenatum Sw.	LC	Bukit Bahru, Bukit Belukar, Bukit Jelutong, Bukit Mamam, Bukit Noordin, Bukit Pekan, Bukit Puaka, Bukit Tajam, Bukit Tajam Kechil, Tanjong Chek Jawa	SING0042936
Didymoplexis pallens Griff.	DD	Bukit Tock Kew (near Sungei Tajam)	SING0146653
Eulophia nuda Lindl.	CR	Bukit Sempit, near Tanjong Balai	SING0116758
Neuwiedia veratrifolia Blume	EN	Bukit Bahru, Bukit Sempit, Bukit Tajam Kechil, Bukit Tock Kew (near Sungei Tajam)	SING0010896; SING0226784
Robiquetia spathulata (Blume) J.J.Sm.	CR	Bukit Melayu; planted at Jalan Jelutong, Tanjong Chek Jawa	SING0099054; SING0215125
Spathoglottis plicata Blume	LC	Between Bukit Ketam & Sungei Teris, Bukit Tajam; planted at Pekan Quarry	SING0166385
Thrixspermum amplexicaule (Blume) Rchb.f.	CR	Sungei Tajam	SING0010988; SING0162830
Vanilla griffithii Rchb.f.	EN	Bukit Ketam, Bukit Tajam Kechil, Bukit Tock Kew; planted at Jalan Jelutong, Tanjong Chek Jawa	SING0011013; SING0033281

Appendix I. Continuation

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Zeuxine clandestina Blume	CR		SING0043564
Family Pandaceae			
Galearia fulva (Tul.) Miq.	VU	Bukit Melayu, Bukit Pekan	SING0043565; SING0065722; SING0171409; SING0171410
Microdesmis caseariifolia Planch. ex Hook.	VU	Bukit Jelutong, Bukit Pekan, Bukit Surau, Tanjong Chek Jawa	SING0042838; SING0165830; SING0174108; SING0295477
Family Pandanaceae			
Benstonea ornata (Kurz) Callm. & Buerki	EN	Bukit Tock Kew, Tanjong Chek Jawa; planted at Tanjong Chek Jawa	SING0047739; SING0146658; SING0172409; SING0172410; SING0386509
Pandanus odorifer (Forssk.) Kuntze	LC	Bukit Asam, Bukit Noordin, Bukit Tajam, Jalan Jelutong, Sungei Pulau Ubin, Tanjong Chek Jawa; planted at Jalan Endut Senin, Jalan Jelutong, Sungei Pulau Ubin	SING0043724
Pandanus yvanii Solms	CR		SING0387898
Family Passifloraceae			
Adenia macrophylla var. *singaporiana* (Wall. ex G.Don) W.J.de Wilde	EN	Bukit Tinggi, Tanjong Chek Jawa; planted at Balai Quarry, Jalan Jelutong, Pekan Quarry, Ubin Quarry	SING0174107
Family Pentaphylaceae			
Adinandra dumosa Jack	LC	Bukit Asam, Bukit Bahru, Bukit Belukar, Bukit Ketam, Bukit Mamam, Bukit Noordin, Bukit Pekan, Bukit Puaka, Bukit Sempit, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Kekek Quarry; planted at Jalan Jelutong, Jalan Noordin, Ketam Quarry, Sungei Asam	SING0116842; SING0226785
Eurya acuminata DC.	LC	Bukit Asam, Bukit Belukar, Bukit Ketam, Bukit Puaka, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi	SING0153693

Appendix I. Continuation

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Family Phyllanthaceae			
Antidesma velutinosum Blume	EN	Bukit Bahru, Bukit Jelutong, Bukit Mamam, Bukit Noordin, Bukit Pekan, Bukit Puaka, Jalan Ubin, Tanjong Chek Jawa; planted at Jalan Endut Senin	SING0035239; SING0158557; SING0194922; SING0341914; SING0341915; SING0388391
Aporosa frutescens Blume	LC	Bukit Surau, Tanjong Chek Jawa	SING0043559
Baccaurea motleyana (Müll.Arg.) Müll.Arg.	CR	Bukit Belukar, Bukit Jelutong, Bukit Mamam, Bukit Melayu, Bukit Puaka, Bukit Surau, Jalan Durian; planted at Jalan Ubin, Sensory Trail Pond, Sungei Teris	SING0153694; SING0341992; SING0341993; SING0341994; SING0341995
Breynia androgyna (L.) Chakrab. & N.P.Balakr.	VU	Bukit Belukar, Tanjong Chek Jawa	SING0038951
Breynia discigera Müll.Arg.	EN		SING0182048
Breynia racemosa (Blume) Müll.Arg.	LC	Bukit Tajam, Bukit Tajam Kechil, Kekek Quarry, Tanjong Chek Jawa	SING0043114; SING0146637; SING0342841; SING0342842; SING0342843
Bridelia pustulata Hook.f.	CR		
Bridelia stipularis (L.) Blume	LC	Bukit Asam, Bukit Jelutong, Bukit Puaka	SING0185152; SING0222175; SING0342888
Bridelia tomentosa Blume	LC	Bukit Noordin; planted at Jalan Jelutong	
Cleistanthus myrianthus (Hassk.) Kurz	CR	Off Jalan Batu Ubin, between Bukit Jelutong & Bukit Pekan	SING0185157; SING0185158; SING0185159; SING0193764; SING0241759
Glochidion borneense (Müll.Arg.) Boerl.	CR	Tanjong Chek Jawa	SING0179379
Glochidion littorale Blume	EN	Tanjong Chek Jawa; planted at Balai Quarry, Bukit Noordin, Jalan Endut Senin, Jalan Jelutong, Ketam Quarry, Sensory Trail Pond, Sungei Asam, Sungei Teris, Sungei Pulau Ubin	SING0043560
Glochidion superbum Baill.	LC	Bukit Asam, Bukit Tajam Kechil, Bukit Tinggi, Tanjong Chek Jawa; planted at Bukit Belukar, Bukit Noordin	SING0042701; SING0043945; SING0342939; SING0342941; SING0342942

Appendix I. Continuation

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Glochidion zeylanicum (Gaertn.) A.Juss. var. *zelyanicum*	VU	Bukit Noordin, Bukit Surau, Sungei Durian	SING0387166
Synostemon bacciformis (L.) G.L.Webster	CR	Jalan Pekan Ubin, Tanjong Chek Jawa	SING0041494; SING0114758; SING0182006
Family Piperaceae			
Piper lanatum Roxb.	VU	Between Bukit Asam & Bukit Tinggi	SING0171415
Piper ramipilum C.DC.	EN	Jalan Ubin; planted at Jalan Jelutong	SING0213818
Piper sarmentosum Roxb.	LC	Bukit Jelutong, Bukit Pekan, Bukit Puaka, Bukit Surau, Jalan Endut Senin, Jalan Jelutong; planted at Bukit Melayu, Jalan Batu Ubin, Jalan Jelutong, Jalan Pekan Ubin, Jalan Ubin, Sensory Trail Pond	SING0153659
Family Plantaginaceae			
Limnophila sessiliflora Blume	LC		Chua & Tan 431, SINU
Family Poaceae			
Centotheca lappacea (L.) Desv.	LC	Bukit Asam, Bukit Bahru, Bukit Belukar, Bukit Jelutong, Bukit Ketam, Bukit Mamam, Bukit Noordin, Bukit Pekan, Bukit Puaka, Bukit Sempit, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Jalan Endut Senin, Kekek Quarry, Tanjong Chek Jawa	SING0042882; SING0059327; SING0182057
Chrysopogon aciculatus (Retz.) Trin.	LC		SING0171407
Cyrtococcum accrescens (Trin.) Stapf	VU	Bukit Jelutong, Bukit Mamam, Bukit Puaka, Kekek Quarry	SING0384736
Cyrtococcum patens (L.) A.Camus	VU	Bukit Mamam, Bukit Pekan, Bukit Puaka, Bukit Surau, Kekek Quarry, Tanjong Chek Jawa	SING0059186; SING0059188; SING0146631; SING0182045; SING0231211; SING0341212
Dactyloctenium aegyptium (L.) Willd.	LC	Bukit Ketam	SING0174120; SING0231217
Digitaria bicornis (Lam.) Roem. & Schult.	CR		SING0059192
Digitaria setigera Roth var. *setigera*	LC	Bukit Puaka	SING0384822; SING0384823

Appendix I. Continuation

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Echinochloa colona (L.) Link	LC		SING0384862
Eleusine indica (L.) Gaertn.	LC	Bukit Ketam, Bukit Puaka	SING0059580; SING0174121
Eragrostis cumingii Steud.	LC		SING0059572; SING0384979
Eragrostis tenella (L.) P.Beauv.	LC		SING0231216
Eragrostis unioloides (Retz.) Nees ex Steud.	LC	Kekek Quarry, Jalan Pekan Ubin	SING0174119
Eriochloa procera (Retz.) C.E.Hubb.	LC	Bukit Puaka, Ketam Quarry	SING0059615; SING0179377; SING0231215
Gigantochloa ligulata Gamble	CR	Bukit Asam, Tanjong Chek Jawa	SING0229593
Imperata cylindrica (L.) P.Beauv.	LC	Bukit Jelutong, Bukit Ketam, Jalan Jelutong, Ketam Quarry	SING0385168
Ischaemum barbatum Retz.	LC	Balai Quarry, Kekek Quarry	SING0179447; SING0388460
Ischaemum ciliare Retz.	LC	Bukit Noordin	SING0174853
Ischaemum muticum L.	LC	Bukit Ketam, Bukit Noordin, Bukit Puaka, Bukit Tajam, Jalan Ubin, Kekek Quarry, Sensory Trail Pond	SING0059606; SING0153667
Ischaemum timorense Kunth	LC	Jalan Ubin	SING0231213
Lepturus repens (G.Forst.) R.Br.	LC	Noordin Beach	SING0059675; SING0059676; SING0182001
Lophatherum gracile Brongn.	LC	Bukit Melayu, Bukit Sempit, Bukit Surau, Bukit Tajam Kechil, Bukit Tinggi, Kekek Quarry	SING0153696
Mnesithea glandulosa (Trin.) de Koning & Sosef	VU	Bukit Belukar, Bukit Surau, Tanjong Chek Jawa	SING0042883; SING0047398; SING0064171
Ottochloa nodosa (Kunth) Dandy	LC	Balai Quarry, Bukit Tajam, Tanjong Chek Jawa	SING0038956; SING0295470
Panicum sarmentosum Roxb.	DD	Between Bukit Asam & Bukit Tinggi	SING 2013-068
Paspalum orbiculare G.Forst.	LC		SING0047788; SING0059668; SING0059669; SING0385756

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Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Paspalum vaginatum Sw.	LC	Jalan Jelutong	SING0059661; SING0231212
Pogonatherum crinitum (Thunb.) Kunth	LC	Bukit Puaka, Sungei Asam; planted at Jalan Batu Ubin, Jalan Jelutong, Sensory Trail Pond	SING0205586; SING0179373
Saccharum arundinaceum Retz.	LC		SING0385825
Sporobolus indicus (L.) R.Br. var. *flaccidus* (Roth) Veldkamp	LC	Bukit Bahru, Bukit Tajam	SING0182059; SING0295764; SING0385942
Sporobolus indicus (L.) R.Br. var. *major* (Buse) Baaijens	LC		SING00177821
Urochloa subquadripara (Trin.) R.D.Webster	LC		SING0059709; SING0059710
Zoysia matrella (L.) Merr.	LC	Noordin Beach; planted at Jalan Endut Senin, Jalan Jelutong, Jalan Pekan Ubin, Mamam Beach	SING0202319
Family Primulaceae			
Aegiceras corniculatum (L.) Blanco	CR	Sungei Batu Kekek, Sungei Besar, Sungei Jelutong, Sungei Mamam; planted at Sungei Puaka	SING0114773; SING0153637; SING0182011
Ardisia crenata Sims	CR	Bukit Bahru, Bukit Mamam, Bukit Melayu, Bukit Surau, Tanjong Chek Jawa; planted at Bukit Noordin, Jalan Endut Senin, Jalan Jelutong, Ketam Quarry	SING0038947; SING0042495; SING0043111; SING0214505
Ardisia elliptica Thunb.	LC	Bukit Asam, Bukit Bahru, Bukit Jelutong, Bukit Mamam, Bukit Noordin, Bukit Pekan, Bukit Puaka, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Jalan Batu Ubin, Kekek Quarry; planted at Balai Quarry, Bukit Ketam, Bukit Noordin, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Kekek Quarry, Ketam Quarry, Sensory Trail Pond, Sungei Asam, Sungei Pulau Ubin, Sungei Teris, Tanjong Chek Jawa	SING0153697
Embelia ribes Burm.f.	LC	Bukit Asam, Bukit Belukar, Bukit Jelutong, Bukit Ketam, Bukit Mamam, Bukit Noordin, Bukit Pekan, Bukit Puaka, Bukit Sempit, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Kekek Quarry, Tanjong Chek Jawa; planted at Balai Quarry, Kekek Quarry, Ketam Quarry, Pekan Quarry, Ubin Quarry	SING0040364; SING0043499; SING0047716

Appendix I. Continuation

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Maesa sumatrana Scheff.	VU	Bukit Puaka, Bukit Tinggi	SING0164561
Myrsine capitellata Wall.	EN	Bukit Tinggi, Jalan Noordin, Sungei Mamam, Sungei Puaka; planted at Balai Quarry, Jalan Batu Ubin, Jalan Endut Senin, Jalan Jelutong, Kekek Quarry, Sensory Trail Pond, Sungei Asam, Sungei Puaka, Sungei Pulau Ubin, Tanjong Chek Jawa	SING0165920
Family Rhamnaceae			
Colubrina asiatica (L.) Brongn.	LC	Bukit Noordin, Bukit Tajam, Jalan Jelutong, Kekek Quarry, Noordin Beach, Tanjong Chek Jawa; planted at Jalan Jelutong	SING0025120; SING0043355; SING0043514; SING0043721; SING0266644
Smythea lanceata (Tul.) Summerh.	CR	Noordin Beach	SING0116840; SING0182043
Ventilago malaccensis Ridl.	VU	Bukit Jelutong, Tanjong Chek Jawa; planted at Balai Quarry, Pekan Quarry	SING0145350; SING0193762
Family Rhizophoraceae			
Bruguiera cylindrica (L.) Blume	LC	Sungei Asam, Sungei Batu Kekek, Sungei Besar, Sungei Durian, Sungei Jelutong, Sungei Mamam, Sungei Puaka, Sungei Tajam, Sungei Pulau Ubin, Tanjong Chek Jawa; planted at Jalan Jelutong, Sungei Durian, Sungei Jelutong, Sungei Puaka, Sungei Pulau Ubin, Tanjong Chek Jawa	SING0042937; SING0043161; SING0043348
Bruguiera gymnorhiza (L.) Lam. ex Savigny	LC	Sungei Asam, Sungei Batu Kekek, Sungei Besar, Sungei Durian, Sungei Jelutong, Sungei Mamam, Sungei Puaka, Sungei Tajam, Sungei Pulau Ubin, Tanjong Chek Jawa; planted at Jalan Jelutong, Sungei Puaka, Sungei Pulau Ubin, Tanjong Chek Jawa	SING0025170; SING0043160
Bruguiera x *hainesii* C.G.Rogers		Sungei Besar (behind Noordin Beach), Sungei Jelutong; planted at Sungei Puaka, Sungei Pulau Ubin, Tanjong Chek Jawa	SING0054734; SING0054735; SING0153633
Bruguiera parviflora (Roxb.) Wight & Arn. ex Griff.	EN	Sungei Asam, Sungei Besar, Sungei Jelutong, Tanjong Chek Jawa; planted at Jalan Jelutong, Sungei Puaka, Sungei Pulau Ubin	SING0046195

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Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Bruguiera sexangula (Lour.) Poir.	CR	Sungei Pulau Ubin; planted at Sungei Puaka, Sungei Pulau Ubin, Tanjong Chek Jawa	SING0165827
Carallia brachiata (Lour.) Merr.	VU	Bukit Tajam Kechil, Tanjong Chek Jawa; planted at Bukit Noordin, Bukit Tajam, Jalan Endut Senin, Jalan Jelutong, Ketam Quarry, Sungei Asam	SING0047724
Ceriops tagal (Perr.) C.B.Rob.	VU	Sungei Besar, Sungei Durian, Sungei Jelutong, Sungei Puaka, Tanjong Chek Jawa; planted at Jalan Jelutong, Sungei Puaka, Tanjong Chek Jawa	SING0043720
Ceriops zippeliana Blume	EN	Sungei Asam, Sungei Besar, Sungei Jelutong, Sungei Mamam, Sungei Puaka, Tanjong Chek Jawa; planted at Jalan Jelutong, Sungei Puaka, Sungei Pulau Ubin	SING0025189; SING0043715; SING0043716; SING0153632
Gynotroches axillaris Blume	LC	Between Bukit Asam & Bukit Tinggi, Bukit Sempit, Bukit Surau, Bukit Tajam Kechil; planted at Bukit Noordin, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Kekek Quarry, Sensory Trail Pond	SING0171414; SING0182010
Rhizophora apiculata Blume	LC	Bukit Tajam, Kekek Quarry, Sungei Asam, Sungei Besar, Sungei Durian, Sungei Jelutong, Sungei Mamam, Sungei Puaka, Sungei Tajam, Sungei Pulau Ubin, Tanjong Chek Jawa; planted at Jalan Jelutong, Sungei Jelutong, Sungei Puaka, Sungei Pulau Ubin, Tanjong Chek Jawa	SING0043512
Rhizophora x *lamarckii* Montr.		Jalan Noordin, Sungei Jelutong (Jalan Jelutong)	SING0165290
Rhizophora mucronata Poir.	LC	Bukit Tajam, Kekek Quarry, Sungei Asam, Sungei Besar, Sungei Durian, Sungei Jelutong, Sungei Mamam, Sungei Puaka, Sungei Tajam, Sungei Pulau Ubin, Tanjong Chek Jawa; planted at Sungei Jelutong, Sungei Puaka, Sungei Pulau Ubin, Tanjong Chek Jawa	SING0042718; SING0043182; SING0043507
Rhizophora stylosa Griff.	VU	Sungei Besar, Sungei Batu Kekek, Sungei Jelutong, Sungei Mamam, Sungei Puaka, Tanjong Chek Jawa; planted at Jalan Jelutong, Sungei Puaka, Sungei Pulau Ubin	SING0043725; SING0153635

Appendix I. Continuation

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Family Rubiaceae			
Aidia densiflora (Wall.) Masam.	LC	Bukit Belukar, Bukit Ketam, Bukit Melayu, Bukit Surau, Tanjong Chek Jawa	SING0042941; SING0047705
Canthium malayense K.M.Wong	CR	Tanjong Chek Jawa; planted at Pekan Quarry	SING0047729
Canthiumera robusta K.M.Wong & X.Y.Ng	EN	Bukit Tajam; planted at Bukit Noordin, Bukit Surau, Jalan Endut Senin, Jalan Noordin	SING0042891
Chassalia curviflora (Wall.) Thwaites	VU	Bukit Melayu, Bukit Sempit, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Tanjong Chek Jawa; planted at Bukit Surau, Jalan Endut Senin	SING0065657; SING0114778
Dibridsonia conferta (Korth.) K.M.Wong	EN	Bukit Tock Kew, Tanjong Chek Jawa; planted at Jalan Jelutong	SING0146646
Discospermum malaccense (Hook.f.) Kuntze	CR	Tanjong Chek Jawa; planted at Jalan Jelutong	SING0042400; SING0042401; SING0179380
Guettarda speciosa L.	EN	Balai Quarry, Sungei Asam, Tanjong Chek Jawa; planted at Balai Quarry, Jalan Endut Senin, Jalan Jelutong, Jalan Wat Siam, Kekek Quarry, Ketam Quarry, Sungei Asam, Sungei Pulau Ubin, Tanjong Chek Jawa	SING0042927; SING0042928
Gynochthodes coriacea Blume	LC	Bukit Belukar, Bukit Mamam, Bukit Surau, Tanjong Chek Jawa; planted at Pekan Quarry, Ubin Quarry	SING0043109; SING0171377
Gynochthodes rigida (Miq.) Razafim. & B.Bremer	VU	Bukit Bahru, Bukit Belukar, Bukit Mamam, Bukit Melayu, Bukit Sempit, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Tanjong Chek Jawa; planted at Jalan Jelutong, Pekan Quarry	SING0045124; SING0090231; SING0153597
Gynochthodes umbellata (L.) Razafim. & B.Bremer	LC	Bukit Asam, Bukit Bahru, Bukit Belukar, Bukit Jelutong, Bukit Ketam, Bukit Mamam, Bukit Noordin, Bukit Pekan, Bukit Puaka, Bukit Sempit, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Kekek Quarry, Tanjong Chek Jawa	SING0040363; SING0042208; SING0047418
Hedyotis affinis Roem. & Schult.	LC	Jalan Jelutong	SING0241760

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Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Hedyotis corymbosa (L.) Lam.	LC	Bukit Jelutong, Bukit Sempit, Bukit Tock Kew	Law & Ng 61, SINU
Hedyotis prostrata Blume	VU	Bukit Bahru, Bukit Puaka, Bukit Sempit, Bukit Tajam, Bukit Tinggi	SING0241753
Ixora congesta Roxb.	LC	Bukit Asam, Bukit Bahru, Bukit Belukar, Bukit Jelutong, Bukit Ketam, Bukit Mamam, Bukit Melayu, Bukit Noordin, Bukit Puaka, Bukit Sempit, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Tanjong Chek Jawa; planted at Balai Quarry, Bukit Belukar, Bukit Mamam, Jalan Endut Senin, Jalan Jelutong, Jalan Wat Siam, Ketam Quarry, Sungei Asam, Tanjong Chek Jawa	SING0040360
Ixora lobbii Loudon ex King & Gamble var. *lobbii*	EN	Bukit Mamam, Bukit Melayu, Bukit Pekan, Bukit Surau, Bukit Tajam Kechil, Jalan Durian, Tanjong Chek Jawa; planted at Balai Quarry, Bukit Belukar, Bukit Tajam, Jalan Endut Senin, Jalan Jelutong, Kekek Quarry, Ketam Quarry, Sungei Asam	SING0030251
Ixora pendula Jack var. *pendula*	EN	Tanjong Chek Jawa; planted at Jalan Jelutong	SING0043556
Lasianthus hirsutus (Roxb.) Merr.	EN	Bukit Bahru, Bukit Belukar, Bukit Melayu, Bukit Surau, Tanjong Chek Jawa	SING0040368; SING0043562; SING0065740; SING0145351; SING0387173
Morinda citrifolia L.	LC	Bukit Bahru, Bukit Jelutong, Bukit Ketam, Bukit Pekan, Bukit Puaka, Bukit Surau, Bukit Tajam, Kekek Quarry, Sungei Pulau Ubin, Tanjong Chek Jawa	SING0043353
Morinda elliptica (Hook.f.) Ridl.	EN	Bukit Tajam	SING0222188
Nauclea officinalis (Pierre ex Pit.) Merr. & Chun	EN	Bukit Bahru, Bukit Pekan	SING0153685; SING0171411
Oxyceros longiflorus (Lam.) T.Yamaz.	LC	Bukit Asam, Bukit Belukar, Bukit Jelutong, Bukit Ketam, Bukit Mamam, Bukit Pekan, Bukit Puaka, Bukit Sempit, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Kekek Quarry, Tanjong Chek Jawa; planted at Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Pekan Quarry	SING0030415; SING0042726; SING0047706; SING0146652; SING0153585; SING0182039; SING0182040; SING0298600

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Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Prismatomeris tetrandra (Roxb.) K.Schum. subsp. *malayana* (Ridl.) J.T.Johanss.	CR		SING0146642
Psydrax approximatus (Korth.) Mahyuni & K.M.Wong	VU	Tanjong Chek Jawa	SING0045689; SING0182032; SING0182033
Scyphiphora hydrophylacea C.F.Gaertn.	EN	Bukit Noordin, Bukit Tajam, Jalan Jelutong, Sungei Besar, Sungei Durian, Sungei Jelutong, Sungei Puaka, Sungei Mamam; planted Tanjong Chek Jawa	SING0042935; SING0303471; SING0043509
Tarenna costata (Miq.) Merr.	CR	Bukit Tajam	SING0222189
Tarenna fragrans (Blume) Koord. & Valeton	EN	Bukit Ketam, Bukit Tajam, Bukit Tock Kew; planted at Balai Quarry, Bukit Noordin, Bukit Surau, Bukit Tajam, Jalan Endut Senin, Jalan Jelutong, Jalan Wat Siam, Ketam Quarry, Pekan Quarry, Sensory Trail Pond, Sungei Asam, Tanjong Chek Jawa	SING0008179; SING0030622; SING0030623; SING0258596
Timonius finlaysonianus (Wall. ex G.Don) Hook.f.	CR	Bukit Tajam, Bukit Tock Kew, Ketam Quarry; planted at Jalan Endut Senin, Jalan Noordin, Ketam Quarry, Sensory Trail Pond, Sungei Pulau Ubin	SING0030654; SING0203132
Timonius flavescens (Jack) Baker	CR	Tanjong Chek Jawa	SING0090725; SING0383048
Timonius wallichianus Valeton	LC	Bukit Bahru, Bukit Belukar, Bukit Ketam, Bukit Mamam, Bukit Noordin, Bukit Puaka, Bukit Sempit, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Tanjong Chek Jawa; planted at Balai Quarry, Kekek Quarry	SING0042729; SING0047736
Uncaria cordata (Lour.) Merr.	EN	Bukit Belukar, Bukit Tajam Kechil	SING0182004; SING0182062
Uncaria lanosa Wall. var. *glabrata* (Blume) Ridsdale	CR		SING0185299
Urophyllum glabrum Wall.	VU		SING0146650

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Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Family Rutaceae			
Clausena excavata Burm.f.	LC	Bukit Bahru, Bukit Belukar, Bukit Jelutong, Bukit Ketam, Bukit Mamam, Bukit Noordin, Bukit Pekan, Bukit Puaka, Bukit Sempit, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Jalan Jelutong, Kekek Quarry, Tanjong Chek Jawa; planted at Jalan Jelutong, Sungei Teris	SING0042402; SING0357245
Glycosmis chlorosperma (Blume) Spreng. var. *chlorosperma*	VU	Tanjong Chek Jawa	SING0182036; SING0042403; SING0043952; SING0047735
Melicope glabra (Blume) T.G.Hartley	EN	Bukit Tajam	SING0357292; SING0357294
Melicope lunu-ankenda (Gaertn.) T.G.Hartley	EN	Bukit Asam, Bukit Belukar, Bukit Mamam, Bukit Noordin, Bukit Puaka, Bukit Surau, Bukit Tinggi, Sungei Durian, Tanjong Chek Jawa; planted at Balai Quarry, Jalan Endut Senin, Ketam Quarry, Sungei Pulau Ubin	SING0043557; SING0043557; SING0153664; SING0357297; SING0357314
Family Salicaceae			
Flacourtia rukam Zoll. & Moritzi	VU	Bukit Surau, Jalan Durian; planted at Jalan Jelutong	SING0274421
Family Santalaceae			
Dendrotrophe buxifolia (Blume) Miq.	CR	Bukit Bahru, Bukit Noordin, Bukit Sempit, Bukit Tajam, Bukit Tinggi	
Dendrotrophe varians (Blume) Miq.	EN	Bukit Tajam Kechil, Bukit Tinggi	SING0025397
Viscum articulatum Burm.f.	EN	Jalan Endut Senin	SING0114754
Viscum ovalifolium Wall. ex DC.	EN	Jalan Jelutong	SING0205794
Family Sapindaceae			
Allophylus cobbe (L.) Forsyth f.	LC	Bukit Puaka, Bukit Tajam, Jalan Noordin, Sensory Trail, Sungei Besar, Sungei Jelutong, Sungei Pulau Ubin, Tanjong Chek Jawa; planted at Jalan Endut Senin, Sungei Puaka	SING0025411; SING0046232; SING0047711

Appendix I. Continuation

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Dimocarpus lichi Lour.	DD	Bukit Puaka, Jalan Noordin; planted at Jalan Jelutong, Jalan Ubin	
Guioa pleuropteris (Blume) Radlk.	LC	Bukit Asam, Bukit Bahru, Bukit Mamam, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Sensory Trail; planted at Balai Quarry, Bukit Tajam, Jalan Endut Senin, Jalan Jelutong, Kekek Quarry, Ketam Quarry, Sensory Trail, Sungei Asam, Sungei Pulau Ubin	SING0165822
Guioa pubescens (Zoll. & Moritzi) Radlk.	LC	Bukit Asam, Bukit Ketam, Bukit Sempit, Bukit Surau, Bukit Tajam Kechil, Bukit Tinggi, Tanjong Chek Jawa	SING0042405
Lepisanthes rubiginosa (Roxb.) Leenh.	LC	Bukit Bahru, Bukit Belukar, Bukit Jelutong, Bukit Melayu, Bukit Noordin, Bukit Pekan, Bukit Puaka, Bukit Surau, Bukit Tinggi, Jalan Jelutong, Jalan Ubin, Kekek Quarry, Tanjong Chek Jawa; planted at Balai Quarry, Jalan Jelutong, Kekek Quarry, Ketam Quarry, Sungei Asam, Sungei Teris	SING0042404; SING0042930; SING0043503; SING0158563; SING0388399
Mischocarpus sundaicus Blume	CR	Bukit Jelutong, Bukit Puaka, Bukit Tajam Kechil, Tanjong Chek Jawa; planted at Balai Quarry, Bukit Belukar, Bukit Noordin, Bukit Tajam, Jalan Batu Ubin, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Ketam Quarry, Sensory Trail Pond	SING0036341; SING0042940; SING0043553
Family Sapotaceae			
Palaquium obovatum (Griff.) Engl. var. *obovatum*	VU	Bukit Bahru, Bukit Noordin, Bukit Tajam, Bukit Tajam Kechil; planted at Balai Quarry, Bukit Noordin, Bukit Surau, Bukit Tajam, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Jalan Wat Siam, Ketam Quarry, Sungei Asam, Sungei Teris	SING0153686
Planchonella chartacea (F.Muell. ex Benth.) H.J.Lam	CR	Tanjong Chek Jawa; planted at Balai Quarry, Bukit Noordin, Jalan Endut Senin, Jalan Jelutong, Jalan Wat Siam, Sensory Trail Pond	SING0042093; SING0042407; SING0042408; SING0042736; SING0043552; SING0096386
Planchonella maingayi (C.B.Clarke) P.Royen	CR	Jalan Noordin, Tanjong Chek Jawa	SING0174104
Planchonella malaccensis (C.B.Clarke) Swenson	EN	Bukit Asam, Tanjong Chek Jawa	SING0047725

Appendix I. Continuation

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Planchonella obovata (R.Br.) P	LC	Bukit Asam, Bukit Bahru, Bukit Belukar, Bukit Jelutong, Bukit Ketam, Bukit Mamam, Bukit Noordin, Bukit Pekan, Bukit Puaka, Bukit Sempit, Bukit Surau, Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Kekek Quarry, Tanjong Chek Jawa; planted at Balai Quarry, Bukit Belukar, Bukit Tajam, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Jalan Wat Siam, Kekek Quarry, Ketam Quarry, Sungei Asam, Sungei Teris, Sungei Pulau Ubin	SING0025836; SING0158566
Family Simaroubaceae			
Brucea javanica (L.) Merr.	CR	Bukit Puaka, Jalan Jelutong, Tanjong Chek Jawa; planted at Jalan Jelutong	SING0008021; SING0047710; SING0153586; SING0341528
Eurycoma longifolia Jack	EN	Tanjong Chek Jawa; planted at Balai Quarry, Bukit Belukar, Bukit Jelutong, Bukit Noordin, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Jalan Wat Siam, Ketam Quarry, Sungei Asam	SING0042409
Family Smilacaceae			
Smilax megacarpa A.DC.	EN	Tanjong Chek Jawa	SING0042410
Smilax myosotiflora A.DC.	VU	Bukit Asam, Bukit Ketam, Bukit Tajam Kechil, Bukit Tinggi	SING0274408
Smilax setosa Miq.	LC	Bukit Tajam, Bukit Tajam Kechil, Bukit Tinggi, Tanjong Chek Jawa	SING0042411
Family Symplocaceae			
Symplocos fasciculata Zoll.	VU	Bukit Bahru, Bukit Belukar, Bukit Jelutong, Bukit Mamam, Bukit Surau, Bukit Tajam Kechil, Tanjong Chek Jawa	SING0043110; SING0043347; SING0146656
Family Thymelaeaceae			
Aquilaria malaccensis Lam.	VU	Bukit Surau; planted at Balai Quarry, Bukit Belukar, Bukit Noordin, Bukit Tajam, Jalan Batu Ubin, Jalan Noordin, Jalan Wat Siam, Kekek Quarry, Ketam Quarry, Sungei Asam, Sungei Teris	SING0114774

Appendix I. Continuation

Species	Conservation Status	Location	Barcode No./Voucher Specimen No./ Photographic Record
Linostoma pauciflorum Griff.	EN	Balai Quarry, Bukit Bahru, Bukit Noordin, Bukit Surau, Bukit Tajam, Bukit Tinggi, Tanjong Chek Jawa; planted at Pekan Quarry	SING0042412; SING0053987; SING0158565
Family Urticaceae			
Laportea interrupta (L.) Chew	LC	Jalan Jelutong	
Poikilospermum suaveolens (Blume) Merr.	VU	Jalan Pekan Ubin; planted at Jalan Jelutong, Jalan Wat Siam, Ketam Quarry, Pekan Quarry	SING0274414
Family Vitaceae			
Ampelocissus elegans Gagnep.	VU	Bukit Bahru, Bukit Noordin, Jalan Noordin, Tanjong Chek Jawa; planted at Jalan Jelutong	SING0043953; SING0046171; SING0046172; SING0174263
Cissus hastata Miq.	LC	Bukit Bahru, Bukit Ketam, Bukit Mamam, Bukit Noordin, Bukit Puaka, Bukit Tajam, Jalan Jelutong, Kekek Quarry	SING0379593
Cissus repens Lam.	VU	Tanjong Chek Jawa, Sensory Trail	SING0042416; SING0057827
Leea indica (Burm.f.) Merr.	LC	Bukit Belukar, Bukit Jelutong, Bukit Ketam, Bukit Mamam, Bukit Pekan, Bukit Puaka, Bukit Surau, Jalan Wat Siam, Kekek Quarry, Ketam Quarry; planted at Bukit Noordin, Bukit Tajam, Jalan Endut Senin, Jalan Jelutong, Ketam Quarry, Sensory Trail Pond	SING0042470; SING0042471; SING0042472; SING0042473; SING0042474
Family Zingiberaceae			
Alpinia aquatica (Retz.) Roscoe	CR	Between Bukit Mamam & Sungei Mamam, Bukit Bahru; planted at Bukit Ketam, Jalan Endut Senin, Jalan Sam Heng, Jalan Jelutong, Pekan Quarry, Sensory Trail Pond, Tanjong Chek Jawa	SING0165825
Zingiber griffithii Baker	CR	Tanjong Chek Jawa	SING0042892

Appendix II. List of non-native or cryptogenic vascular plants growing wild in Pulau Ubin

Species	**Category**
LYCOPHYTES	
Family Selaginellaceae	
Selaginella plana (Desv. ex Poir.) Hieron.	Cryptogenic
FERNS	
Family Dryopteridaceae	
Pleocnemia conjugata (Blume) C.Presl	Naturalised
Family Nephrolepidaceae	
Nephrolepis cordifolia (L.) C.Presl	Cultivated
Nephrolepis falciformis J.Sm.	Cultivated
Family Pteridaceae	
Adiantum latifolium Lam.	Naturalised
Ceratopteris thalictroides (L.) Brongn.	Cryptogenic
Pityrogramma calomelanos (L.) Link	Naturalised
Pteris semipinnata L.	Naturalised
Pteris tripartita Sw.	Cryptogenic
Pteris vittata L.	Cryptogenic
GYMNOSPERMS	
Family Araucariaceae	
Agathis dammara (Lamb.) Poir.	Cultivated
Agathis robusta (C.Moore ex F.Muell.) F.M.Bailey	Cultivated
Araucaria columnaris (G.Forst.) Hook.	Cultivated
Araucaria heterophylla (Salisb.) Franco	Cultivated
Family Cupressaceae	
Juniperus chinensis L.	Cultivated
Platycladus orientalis (L.) Franco	Cultivated
Family Cycadaceae	
Cycas revoluta Thunb.	Cultivated
Family Podocarpaceae	
Nageia motleyi (Parl.) de Laub.	Cultivated
Podocarpus macrophyllus (Thunb.) Sweet	Cultivated
Podocarpus rumphii Blume	Cultivated
ANGIOSPERMS	
Family Acanthaceae	
Andrographis paniculata (Burm.f.) Wall. ex Nees	Naturalised
Asystasia gangetica (L.) T.Anderson subsp. *micrantha* (Nees) Ensermu	Naturalised

Appendix II. Continuation

Species	Category
Asystasia nemorum Nees	Casual
Clinacanthus nutans (Burm.f.) Lindau	Cultivated
Justicia gendarussa Burm.f.	Naturalised
Nelsonia canescens (Lam.) Spreng.	Cryptogenic
Nicoteba betonica (L.) Lindau	Cultivated
Peristrophe bivalvis (L.) Merr.	Cryptogenic
Pseuderanthemum maculatum (G.Lodd.) I.M.Turner	Cultivated
Pseuderanthermum laxiflorum (A.Gray) F.T.Hubb.	Cultivated
Ruellia prostrata Poir.	Naturalised
Strobilanthes reptans (G.Forst.) Moylan ex Y.F.Deng & J.R.I.Wood	Naturalised
Strobilanthes scabra Nees	Cultivated
Thunbergia fragrans Roxb.	Naturalised
Thunbergia grandiflora Roxb.	Casual
Thunbergia hawtayneana Wall.	Cultivated
Family Achariaceae	
Pangium edule Reinw.	Cultivated
Family Acoraceae	
Acorus calamus L.	Casual
Family Alismataceae	
Aquarius palifolius (Nees & Mart.) Christenh. & Byng	Cultivated
Limnocharis flava (L.) Buchenau	Naturalised
Sagittaria lancifolia L.	Cultivated
Family Aloaceae	
Aloe vera (L.) Burm.f.	Cultivated
Family Amaranthaceae	
Achyranthes aspera L.	Cryptogenic
Alternanthera sessilis (L.) DC.	Cryptogenic
Amaranthus blitum L. subsp. *oleraceus* (L.) Costea	Naturalised
Amaranthus spinosus L.	Naturalised
Celosia argentea L.	Casual
Gomphrena globosa L.	Cultivated
Family Amaryllidaceae	
Hippeastrum Herb. hybrids	Cultivated
Hymenocallis littoralis (Jacq.) Salisb.	Cultivated

Appendix II. Continuation

Species	Category
Family Anacardiaceae	
Anacardium occidentale L.	Casual
Bouea macrophylla Griff.	Cultivated
Mangifera caesia Jack	Casual
Mangifera indica L.	Casual
Mangifera x *odorata* Griff.	Casual
Spondias dulcis Parkinson	Cultivated
Family Annonaceae	
Annona cherimola Mill.	Cultivated
Annona mucosa Jacq.	Cultivated
Annona muricata L.	Cultivated
Annona reticulata L.	Casual
Annona squamosa L.	Cultivated
Cananga odorata (Lam.) Hook.f. & Thomson var. *fruticosa* (Craib.) J.Sinclair	Cultivated
Cananga odorata (Lam.) Hook.f. & Thomson var. *odorata*	Cryptogenic
Desmos chinensis Lour.	Casual
Mitrephora maingayi Hook.f. & Thomson	Casual
Family Apiaceae	
Eryngium foetidum L.	Casual
Family Apocynaceae	
Allamanda cathartica L.	Naturalised
Alstonia macrophylla Wall. ex G.Don	Naturalised
Alstonia scholaris (L.) R.Br.	Naturalised
Asclepias curassavica L.	Casual
Calotropis gigantea (L.) W.T.Aiton	Casual
Catharanthus roseus (L.) G.Don	Naturalised
Cynanchum tunicatum (Retz.) Alston	Naturalised
Nerium oleander L.	Cultivated
Plumeria obtusa L.	Cultivated
Plumeria rubra L.	Cultivated
Tabernaemontana divaricata (L.) R.Br. ex Roem. & Schult.	Cultivated
Wrightia religiosa (Teijsm. & Binn.) Benth. ex Kurz	Cultivated
Family Araceae	
Alocasia macrorrhizos (L.) G.Don	Naturalised
Amorphophallus paeoniifolius (Dennst.) Nicolson	Cultivated

Appendix II. Continuation

Species	Category
Caladium bicolor (Aiton) Vent.	Cultivated
Colocasia esculenta (L.) Schott	Casual
Dieffenbachia seguine (Jacq.) Schott	Casual
Epipremnum aureum (Linden ex André) G.S.Bunting	Casual
Epipremnum pinnatum (L.) Engl.	Naturalised
Lemna aequinoctialis Welw.	Naturalised
Typhonium trilobatum (L.) Schott	Naturalised
Family Araliaceae	
Heptapleurum actinophyllum (Endl.) Lowry & G.M.Plunkett	Casual
Hydrocotyle verticillata Thunb.	Casual
Polyscias fruticosa (L.) Harms	Cultivated
Family Arecaceae	
Areca catechu L.	Casual
Arenga pinnata (Wurmb) Merr.	Naturalised
Borassus flabellifer L.	Cultivated
Cocos nucifera L.	Naturalised
Dendrocalamus asper (Schult. f.) Backer	Cultivated
Dypsis lutescens (H.Wendl.) Beentje & J.Dransf.	Cultivated
Elaeis guineensis Jacq.	Casual
Livistona chinensis (Jacq.) R.Br. ex Mart.	Cultivated
Metroxylon sagu Rottb.	Naturalised
Ptychosperma macarthurii (H.Wendl. ex H.J.Veitch) H.Wendl. ex Hook.f.	Naturalised
Salacca zalacca (Gaertn.) Voss	Cultivated
Saribus rotundifolius (Lam.) Blume	Casual
Family Aristolochiaceae	
Aristolochia acuminata Lam.	Casual
Family Asparagaceae	
Cordyline fruticosa (L.) A.Chev.	Casual
Dracaena angustifolia (Medik.) Roxb.	Naturalised
Dracaena aubryana Brongn. ex É.Morren	Naturalised
Dracaena fragrans (L.) Ker Gawl.	Casual
Dracaena trifasciata (Prain) Mabb.	Casual
Family Asteraceae	
Acmella uliginosa (Sw.) Cass.	Naturalised
Ageratum conyzoides L.	Naturalised

Appendix II. Continuation

Species	Category
Artemisia lactiflora Wall ex DC.	Cultivated
Artemisia vulgaris L.	Cultivated
Bidens alba (L.) DC.	Cultivated
Bidens pilosa L.	Naturalised
Centratherum punctatum Cass.	Cultivated
Chromolaena odorata (L.) R.M.King & H.Rob.	Naturalised
Conyza bonariensis (L.) Cronquist	Naturalised
Crassocephalum crepidioides (Benth.) S.Moore	Naturalised
Eclipta prostrata (L.) L.	Naturalised
Elephantopus mollis Kunth	Naturalised
Elephantopus scaber L.	Naturalised
Eleutheranthera ruderalis (Sw.) Sch.Bip.	Naturalised
Erechtites valerianifolius (Link ex Spreng.) DC.	Naturalised
Eupatorium capillifolium Waldst. & Kit.	Cultivated
Mikania micrantha Kunth	Naturalised
Porophyllum ruderale (Jacq.) Cass.	Naturalised
Sphagneticola trilobata (L.) Pruski	Naturalised
Struchium sparganophorum (L.) Kuntze	Naturalised
Synedrella nodiflora (L.) Gaertn.	Naturalised
Tagetes erecta L.	Casual
Tridax procumbens L.	Naturalised
Youngia japonica (L.) DC.	Naturalised
Family Balsaminaceae	
Impatiens balsamina L.	Cultivated
Family Bignoniaceae	
Mansoa alliacea (Lam.) A.H.Gentry	Cultivated
Oroxylum indicum (L.)	Cultivated
Spathodea campanulata P.Beauv.	Naturalised
Tecoma stans (L.) Juss. ex Kunth	Cultivated
Family Bixaceae	
Bixa orellana L.	Casual
Family Boraginaceae	
Heliotropium indicum L.	Naturalised
Varronia cylindrostachya Ruiz & Pav.	Cultivated

Appendix II. Continuation

Species	Category
Family Bromeliaceae	
Ananas comosus (L.) Merr.	Cultivated
Family Burseraceae	
Canarium album (Lour.) DC.	Cultivated
Canarium vulgare Leenh.	Cultivated
Family Cactaceae	
Epiphyllum oxypetalum (DC.) Haw.	Cultivated
Leuenbergeria bleo (Kunth) Lodé	Cultivated
Family Calophyllaceae	
Calophyllum soulattri Burm.f.	Cultivated
Family Cannaceae	
Canna indica L.	Naturalised
Family Caricaceae	
Carica papaya L.	Casual
Family Casuarinaceae	
Gymnostoma nobile (Whitmore) L.A.S.Johnson	Cultivated
Gymnostoma rumphianum (Miq.) L.A.S.Johnson	Cultivated
Family Cleomaceae	
Sieruela rutidosperma (DC.) Roalson & J.C.Hall	Naturalised
Family Clusiaceae	
Garcinia intermedia (Pittier) Hammel	Cultivated
Garcinia mangostana L. var. *mangostana*	Casual
Garcinia xanthochymus Hook.f. ex T.Anderson	Cultivated
Family Colchicaceae	
Gloriosa superba L.	Casual
Family Combretaceae	
Combretum indicum (L.) DeFilipps	Casual
Terminalia calamansanai (Blanco) Rolfe	Cultivated
Family Commelinaceae	
Commelina diffusa Burm.f.	Cryptogenic
Murdannia nudiflora (L.) Brenan	Cryptogenic
Tradescantia spathacea Sw.	Cultivated
Family Convolvulaceae	
Cuscuta campestris Yunck	Naturalised
Evolvulus nummularius (L.) L.	Naturalised

Appendix II. Continuation

Species	Category
Ipomoea batatas (L.) Lam.	Casual
Ipomoea cairica (L.) Sweet	Naturalised
Ipomoea triloba L.	Naturalised
Family Crassulaceae	
Kalanchoe pinnata (Lam.) Pers.	Casual
Family Cucurbitaceae	
Coccinia grandis (L.) Voigt	Naturalised
Cucumis sativa L.	Casual
Gymnopetalum chinense (Lour.) Merr.	Cryptogenic
Luffa acutangula (L.) Roxb.	Cultivated
Melothria pendula L.	Naturalised
Momordica charantia L. f. *abbreviata* (Ser.) W.J.de Wilde & Duyfjes	Cryptogenic
Mukia maderaspatana (L.) M.Roem.	Cryptogenic
Family Cyperaceae	
Cyperus aromaticus (Ridl.) Mattf. & Kük.	Naturalised
Cyperus papyrus L.	Cultivated
Cyperus prolifer Lam.	Cultivated
Family Dilleniaceae	
Dillenia indica L.	Cultivated
Family Dioscoreaceae	
Dioscorea alata L.	Cultivated
Dioscorea bulbifera L.	Cryptogenic
Family Dipterocarpaceae	
Hopea odorata Roxb.	Cultivated
Shorea glauca King	Cultivated
Family Ebenaceae	
Diospyros blancoi A.DC.	Cultivated
Family Elaeocarpaceae	
Elaeocarpus obtusus Blume	Cultivated
Family Euphorbiaceae	
Acalypha amentacea Roxb.	Cultivated
Acalypha arvensis Poepp.	Naturalised
Acalypha hispida Burm.f.	Casual
Acalypha indica L.	Cryptogenic
Acalypha wilkesiana Müll.Arg.	Cultivated

Appendix II. Continuation

Species	**Category**
Aleurites moluccanus (L.) Willd.	Casual
Codiaeum variegatum (L.) A.Juss.	Casual
Croton hirtus L'Hér.	Naturalised
Croton tiglium L.	Cultivated
Elateriospermum tapos Blume	Casual
Euphorbia heterophylla L.	Naturalised
Euphorbia hirta L.	Naturalised
Euphorbia pulcherrima Willd. Ex Klotzsch	Cultivated
Euphorbia thymifolia L.	Naturalised
Hevea brasiliensis (Willd. ex A.Juss.) Müll.Arg.	Naturalised
Hura crepitans L.	Cultivated
Jatropha curcas L.	Casual
Macaranga caladiifolia Becc.	Cultivated
Manihot carthagenensis (Jacq.) Müll.Arg. subsp. *glaziovii* (Müll.Arg.) Allem	Naturalised
Manihot esculenta Crantz	Naturalised
Microstachys chamaelea (L.) Müll.Arg.	Cryptogenic
Ricinus communis L.	Naturalised
Suregada multiflora (A.Juss.) Baill.	Cultivated
Family Fabaceae	
Abrus precatorius L.	Naturalised
Acacia auriculiformis A.Cunn. ex Benth.	Naturalised
Acacia x *mangiiformis* Maslin & L.A.J.Thomson	Casual
Acacia mangium Willd.	Naturalised
Adenanthera pavonina L.	Naturalised
Adinobotrys atropurpureus (Wall.) Dunn	Naturalised
Aeschynomene americana L.	Naturalised
Andira inermis (W.Wright) Kunth ex DC.	Casual
Arachis hypogaea L.	Cultivated
Baphia nitida G.Lodd.	Casual
Bauhinia x *blakeana* Dunn	Cultivated
Caesalpinia pulcherrima (L.) Sw.	Cultivated
Calopogonium mucunoides Desv.	Naturalised
Cassia fistula L.	Casual
Cassia javanica L.	Cultivated
Centrosema molle Mart. ex Benth.	Naturalised

Appendix II. Continuation

Species	**Category**
Chamaecrista leschenaultiana (DC.) O.Deg.	Naturalised
Clitoria laurifolia Poir.	Naturalised
Clitoria ternatea L.	Naturalised
Crotalaria pallida Aiton	Naturalised
Crotalaria retusa L.	Cryptogenic
Cynometra cauliflora L.	Cultivated
Derris elliptica (Roxb.) Benth.	Naturalised
Desmanthus virgatus (L.) Willd.	Naturalised
Falcataria falcata (L.) Greuter & R.Rankin	Naturalised
Indigofera suffruticosa Mill.	Naturalised
Leucaena leucocephala (Lam.) de Wit subsp. *leucocephala*	Naturalised
Macroptilium atropurpureum (DC.) Urb.	Naturalised
Mimosa diplotricha C.Wright var. *diplotricha*	Naturalised
Mimosa pigra L.	Naturalised
Mimosa pudica L.	Naturalised
Neptunia plena (L.) Benth.	Naturalised
Ohwia caudata (Thunb.) H.Ohashi	Naturalised
Parkia timoriana (DC.) Merr.	Cultivated
Phanera kockiana var. *kockiana*	Cultivated
Psophocarpus tetragonolobus (L.) DC.	Cultivated
Pterocarpus indicus Willd.	Casual
Pueraria lobata (Lour.) Merr. *var. montana* (Lour.) Maesen	Cultivated
Samanea saman (Jacq.) Merr.	Casual
Senna alata (L.) Roxb.	Naturalised
Senna occidentalis (L.) Link	Naturalised
Senna siamea (Lam.) H.S.Irwin & Barneby	Cultivated
Senna surattensis (Burm.f.) H.S.Irwin & Barneby	Casual
Senna tora (L.) Roxb.	Casual
Sesbania cannabina (Retz.) Poir.	Naturalised
Sesbania grandiflora (L.) Poir.	Cultivated
Stylosanthes guianensis (Aubl.) Sw.	Naturalised
Tamarindus indica L.	Casual
Tephrosia noctiflora Bojer ex Baker	Naturalised
Uraria crinita (L.) Desv. ex DC.	Naturalised

Appendix II. Continuation

Species	Category
Family Gentianaceae	
Utania racemosa (Jack ex Wall.) Sugumaran	Cultivated
Family Hanguanaceae	
Hanguana anthelminthica (Blume ex Schult. & Schult.f.) Masam.	Cultivated
Family Heliconiaceae	
Heliconia rostrata Ruiz & Pav.	Casual
Family Hydrocharitaceae	
Hydrilla verticillata (L.f.) Royle	Cryptogenic
Family Hypericaceae	
Cratoxylum glaucum Korth.	Cultivated
Family Iridaceae	
Trimezia martinicensis (Jacq.) Herb.	Casual
Family Lamiaceae	
Clerodendrum chinense (Osbeck) Mabb.	Naturalised
Clerodendrum paniculatum L.	Naturalised
Clerodendrum thomsoniae Balf.	Casual
Coleus amboinicus Lour.	Cultivated
Coleus monostachyus (P.Beauv.) A.J.Paton	Naturalised
Coleus scutellarioides (L.) Benth. cultivar	Cultivated
Gmelina asiatica L.	Naturalised
Hyptis brevipes Poit.	Naturalised
Hyptis capitata Jacq.	Naturalised
Leucas zeylanica (L.) W.T.Aiton	Naturalised
Mesosphaerum suaveolens (L.) Kuntze	Naturalised
Ocimum basilicum L.	Naturalised
Ocimum tenuiflorum L.	Cryptogenic
Orthosiphon aristatus (Blume) Miq.	Casual
Pogostemon auricularius (L.) Hassk.	Cryptogenic
Tectona grandis L.f.	Cultivated
Family Lauraceae	
Cinnamomum aromaticum Nees	Cultivated
Persea americana Mill.	Cultivated
Family Lentibulariaceae	
Utricularia bifida L.	Cryptogenic

Appendix II. Continuation

Species	Category
Family Linderniaceae	
Legazpia polygonoides (Benth.) T.Yamaz.	Cryptogenic
Lindernia antipoda (L.) Alston	Cryptogenic
Lindernia crustacea (L.) F.Muell.	Cryptogenic
Lindernia sessiliflora (Benth.) Wettst.	Cryptogenic
Family Lythraceae	
Ammannia baccifera L.	Naturalised
Cuphea hyssopifolia Kunth	Cultivated
Lagerstroemia speciosa (L.) Pers.	Cultivated
Lawsonia inermis L.	Naturalised
Punica granatum L.	Cultivated
Family Magnoliaceae	
Magnolia champaca (L.) Baill. ex Pierre	Cultivated
Magnolia x *alba* (DC.) Figlar	Cultivated
Family Malpighiaceae	
Hiptage benghalensis (L.) Kurz	Cultivated
Family Malvaceae	
Abelmoschus esculentus (L.) Moench	Cultivated
Ceiba pentandra (L.) Gaertn.	Casual
Corchorus aestuans L.	Naturalised
Durio graveolens Becc.	Cultivated
Durio oxleyanus Griff.	Cultivated
Durio zibethinus L.	Casual
Hibiscus mutabilis L.	Cultivated
Hibiscus rosa-sinensis L.	Casual
Hibiscus sabdariffa L.	Cultivated
Hibiscus surattensis L.	Naturalised
Pachira aquatica Aubl.	Cultivated
Pterospermum lanceifolium Roxb. ex DC.	Cultivated
Sida acuta Burm.f.	Naturalised
Sterculia foetida L.	Cultivated
Sterculia monosperma Vent.	Cultivated
Theobroma cacao L.	Cultivated
Triumfetta rhomboidea Jacq.	Naturalised

Appendix II. Continuation

Species	Category
Urena lobata L.	Naturalised
Waltheria indica L.	Naturalised
Family Maranthaceae	
Schumannianthus dichotomus Gagnep.	Cultivated
Thaumatococcus daniellii (Benn.) Benth. ex Eichler	Naturalised
Family Melastomataceae	
Heterotis rotundifolia (Sm.) Jacq.-Fél.	Cultivated
Macrolenes nemorosa (Jack) Bakh.f.	Cultivated
Memecylon coeruleum Jack	Casual
Memecylon pauciflorum Blume	Cultivated
Miconia crenata (Vahl) Michelang	Naturalised
Family Meliaceae	
Aglaia odorata Lour.	Cultivated
Azadirachta indica A.Juss.	Casual
Lansium domesticum Corrêa	Casual
Melia azedarach L.	Cultivated
Family Menispermaceae	
Tinospora crispa (L.) Hook.f. & Thomson	Casual
Family Menyanthaceae	
Nymphoides indica (L.) Kuntze	Cryptogenic
Family Monimiaceae	
Kibara coriacea (Blume) Hook.f. & Thomson	Cryptogenic
Family Moraceae	
Artocarpus altilis (Parkinson) Fosberg	Casual
Artocarpus camansi Blanco	Cultivated
Artocarpus heterophyllus Lam.	Casual
Artocarpus integer (Thunb.) Merr. var. *integer*	Cryptogenic
Artocarpus odoratissimus Blanco	Cultivated
Ficus auriculata Lour.	Cultivated
Ficus benjamina L.	Cryptogenic
Ficus elastica Roxb. ex Hornem.	Casual
Ficus pumila L.	Casual
Ficus religiosa L.	Naturalised
Morus alba L.	Cultivated

Appendix II. Continuation

Species	Category
Family Moringaceae	
Moringa oleifera Lam.	Cultivated
Family Muntingiaceae	
Muntingia calabura L.	Naturalised
Family Musaceae	
Musa L. cultivars	Cultivated
Family Myristicaceae	
Myristica fragrans Houtt.	Cultivated
Family Myrtaceae	
Eucalyptus camaldulensis Dehnh.	Cultivated
Psidium cattleyanum Sabine	Casual
Psidium guajava L.	Casual
Syzygium aqueum (Burm.f.) Alston	Cultivated
Syzygium claviflorum (Roxb.) Wall. ex Steud.	Cultivated
Syzygium cumini (L.) Skeels	Naturalised
Syzygium jambos (L.) Alston	Casual
Syzygium malaccense (L.) Merr. & L.M.Perry	Casual
Family Nelumbonaceae	
Nelumbo nucifera Gaertn.	Casual
Family Nyctaginaceae	
Bougainvillea Comm. ex Juss. hybrids	Cultivated
Family Nymphaceae	
Nymphaea hybrids	Cultivated
Family Ochnaceae	
Ochna kirkii Oliv.	Naturalised
Family Oleaceae	
Jasminum sambac (L.) Aiton	Cultivated
Family Onagraceae	
Ludwigia adscendens (L.) H.Hara	Cryptogenic
Ludwigia hyssopifolia (G.Don) Exell	Cryptogenic
Ludwigia octovalvis (Jacq.) P.H.Raven	Cryptogenic
Family Orchidaceae	
Eulophia graminea Lindl.	Cryptogenic
Family Orobanchaceae	
Striga asiatica (L.) Kuntze	Cryptogenic

Appendix II. Continuation

Species	Category
Family Oxalidaceae	
Averrhoa bilimbi L.	Casual
Averrhoa carambola L.	Casual
Oxalis barrelieri L.	Naturalised
Oxalis corniculata L.	Naturalised
Family Pandanaceae	
Pandanus amaryllifolius Roxb. ex Lindl.	Casual
Family Passifloraceae	
Passiflora foetida L.	Naturalised
Passiflora laurifolia L.	Naturalised
Passiflora suberosa L.	Naturalised
Piriqueta racemosa (Jacq.) Sweet	Naturalised
Turnera ulmifolia L.	Naturalised
Family Pedaliaceae	
Sesamum radiatum Thonn. ex Hornem.	Naturalised
Family Phyllanthaceae	
Antidesma bunius (L.) Spreng.	Casual
Baccaurea lanceolata (Miq.) Müll.Arg.	Cultivated
Cleistanthus maingayi Hook.f.	Cultivated
Emblica urinaria (L.) R.W.Bouman	Naturalised
Moeroris amara (Schumac. & Thonn.) R.W.Bouman	Naturalised
Moeroris debilis (J.G.Klein ex Willd.) R.W.Bouman	Naturalised
Phyllanthus acidus (L.) Skeels	Cultivated
Family Phytolaccaceae	
Phytolacca octandra L.	Cultivated
Family Piperaceae	
Peperomia pellucida (L.) Kunth	Naturalised
Piper aduncum L.	Naturalised
Piper betle L.	Casual
Piper nigrum L.	Cultivated
Family Plantaginaceae	
Bacopa caroliniana (Walter) B.L.Rob.	Naturalised
Plantago major L.	Naturalised
Scoparia dulcis L.	Naturalised

Appendix II. Continuation

Species	Category
Family Poaceae	
Arundo donax L.	Casual
Axonopus compressus (Sw.) P.Beauv.	Naturalised
Axonopus fissifolius (Raddi) Kuhlm.	Naturalised
Bambusa balcooa Roxb.	Cultivated
Bambusa lako Widjaja	Cultivated
Bambusa multiplex (Lour.) Raeusch. ex Schult.f.	Cultivated
Bothriochloa bladhii (Retz.) S.T.Blake	Cryptogenic
Cenchrus brownii Roem. & Schult.	Naturalised
Cenchrus x *cupreus* (Thorpe) Govaerts	Cultivated
Cenchrus setosus Sw.	Naturalised
Chloris barbata Sw.	Naturalised
Chrysopogon zizanioides (L.) Roberty	Cultivated
Coix lacryma-jobi L.	Naturalised
Cymbopogon citratus (DC.) Stapf	Cultivated
Cymbopogon flexuosus (Nees ex Steud.) W.Watson	Cultivated
Cymbopogon nardus (L.) Rendle	Cultivated
Cynodon dactylon (L.) Pers.	Naturalised
Gigantochloa levis (Blanco) Merr.	Cultivated
Gigantochloa thoi K.M.Wong	Cultivated
Gigantochloa wrayi Gamble	Cultivated
Melinis repens (Willd.) Zizka	Naturalised
Panicum repens L.	Naturalised
Paspalum conjugatum P.J.Bergius	Naturalised
Phragmites karka (Retz.) Trin. ex Steud. cultivar	Cultivated
Saccharum spontaneum L.	Naturalised
Schizostachyum brachycladum (Kurz ex Munro) Kurz	Cultivated
Stenotaphrum secundatum (Walter) Kuntze	Naturalised
Thysanolaena latifolia (Roxb. ex Hornem.) Honda	Naturalised
Urochloa maxima (Jacq.) R.D.Webster	Naturalised
Urochloa mutica (Forssk.) T.Q.Nguyen	Naturalised
Family Polygalaceae	
Polygala paniculata L.	Naturalised

Appendix II. Continuation

Species	Category
Family Polygonaceae	
Antigonon leptopus Hook. & Arn.	Casual
Muehlenbeckia platyclada (F.Muell.) Meisn.	Cultivated
Persicaria hydropiper (L.) Delarbre	Casual
Family Pontederiaceae	
Monochoria hastata (L.) Solms	Cryptogenic
Pontederia cordata L.	Cultivated
Family Portulacaceae	
Portulaca grandiflora Hook.	Cultivated
Portulaca oleracea L.	Naturalised
Portulaca pilosa L. var. *pilosa*	Naturalised
Family Proteaceae	
Grevillea robusta A.Cunn. ex R.Br.	Cultivated
Macadamia integrifolia Maiden & Betche	Cultivated
Family Rhamnaceae	
Ziziphus mauritiana Lam.	Cultivated
Family Rosaceae	
Rhaphiolepis bibas (Lour.) Galasso & Banfi	Cultivated
Family Rubiaceae	
Coffea liberica W.Bull ex Hiern	Casual
Gardenia coronaria Banks	Cultivated
Gardenia jasminoides J.Ellis	Cultivated
Ixora chinensis Lam.	Cultivated
Ixora javanica (Blume) DC. var. *javanica*	Cultivated
Mussaenda Burm. ex L. '*Dona Eva*'	Cultivated
Mussaenda erythrophylla Schumach. & Thonn.	Cultivated
Mussaenda philippica A.Rich. var. *aurorae* Sulit	Cultivated
Spermacoce exilis (L.O.Williams) C.D.Adams ex W.C.Burger & C.M.Taylor	Naturalised
Spermacoce latifolia Aubl.	Naturalised
Spermacoce ocymifolia Willd.	Naturalised
Spermacoce remota Lam.	Naturalised
Family Rutaceae	
Bergera koenigii L.	Casual
Citrus x *aurantifolia* (Christm.) Swingle	Cultivated
Citrus x *aurantium* L.	Cultivated

Appendix II. Continuation

Species	Category
Citrus hystrix DC.	Cultivated
Citrus x *limon* (L.) Osbeck	Casual
Citrus maxima (Burm.) Merr.	Cultivated
Citrus medica L.	Cultivated
Citrus x *microcarpa* Bunge	Cultivated
Murraya paniculata (L.) Jack	Cultivated
Triphasia trifolia (Burm.f.) P.Wilson	Cultivated
Family Salicaceae	
Flacourtia inermis Roxb.	Cultivated
Flacourtia jangomas (Lour.) Raeusch.	Naturalised
Salix babylonica L.	Cultivated
Family Sapindaceae	
Arfeuillea arborescens Pierre ex Radlk.	Cultivated
Cardiospermum halicacabum L.	Naturalised
Dimocarpus longan Lour.	Cultivated
Litchi chinensis Sonn.	Cultivated
*Lepisanthes alata (*Blume) Leenh.	Cultivated
Nephelium lappaceum L. *var. lappaceum*	Cryptogenic
Nephelium ramboutan-ake (Labill.) Leenh.	Cryptogenic
Family Sapotaceae	
Chrysophyllum cainito L.	Cultivated
Manilkara zapota (L.) P.Royen	Cultivated
Mimusops elengi L.	Casual
Palaquium formosanum Hayata	Cultivated
Palaquium leiocarpum Boerl.	Cultivated
Pouteria campechiana (Kunth) Baehni	Cultivated
Family Solanaceae	
Brugmansia x *candida* Pers.	Cultivated
Capsicum frutescens L.	Cultivated
Physalis minima L.	Cryptogenic
Solanum mammosum L.	Cultivated
Solanum melongena L.	Cultivated
Solanum torvum Sw.	Naturalised
Family Talinaceae	
Talinum paniculatum (Jacq.) Gaertn.	Naturalised

Appendix II. Continuation

Species	**Category**
Family Typhaceae	
Typha angustifolia L.	Naturalised
Family Umbelliferae	
Oenanthe javanica (Blume) DC.	Cultivated
Family Urticaceae	
Boehmeria nivea (L.) Gaudich.	Naturalised
Cecropia pachystachya Trécul	Naturalised
Pilea microphylla (L.) Liebm.	Naturalised
Pipturus argenteus (G.Forst.) Wedd.	Cryptogenic
Family Verbenaceae	
Aloysia virgata (Ruiz & Pav.) Juss.	Cultivated
Citharexylum flexuosum (Ruiz & Pav.) D.Don	Cultivated
Lantana camara L.	Naturalised
Phyla nodiflora (L.) Greene	Naturalised
Stachytarpheta indica (L.) Vahl	Cultivated
Stachytarpheta jamaicensis (L.) Vahl	Naturalised
Family Zingiberaceae	
Alpinia galanga (L.) Willd.	Cryptogenic
Alpinia zerumbet (Pers.) B.L.Burtt & R.M.Sm.	Cultivated
Etlingera elatior (Jack) R.M.Sm.	Cryptogenic
Zingiber ottensii Valeton	Cryptogenic

Appendix III. List of native vascular plants introduced by NParks but not found growing wild in Pulau Ubin
Abbreviations: **LC**: Least Concern **VU**: Vulnerable **EN**: Endangered **CR**: Critically Endangered **NEx**: Presumed Nationally Extinct **DD**: Data Deficient

Species	Conservation Status	Location of Planting
LYCOPHYTES		
Family Selaginellaceae		
Selaginella willdenowii (Desv.) Baker	VU	Jalan Endut Senin, Jalan Jelutong
FERNS		
Family Nephrolepidaceae		
Nephrolepis acutifolia (Desv.) Christ	EN	Bukit Mamam, Jalan Endut Senin, Jalan Jelutong, Jalan Wat Siam, Tanjong Chek Jawa
Family Tectariaceae		
Tectaria vasta (Blume) Copel.	CR	Jalan Endut Senin, Jalan Jelutong
Family Thelypteridaceae		
Sphaerostephanos polycarpos (Blume) Copel.	LC	Jalan Jelutong
GYMNOSPERMS		
Family Cycadaceae		
Cycas edentata de Laub.	CR	Jalan Endut Senin, Jalan Jelutong, Tanjong Chek Jawa
ANGIOSPERMS		
Family Acanthaceae		
Avicennia marina (Forssk.) Vierh.	CR	Sungei Puaka
Family Anacardiaceae		
Dracontomelon dao (Blanco) Merr. & Rolfe	CR	Balai Quarry, Jalan Jelutong
Gluta wallichii (Hook.f.) Ding Hou	EN	Sungei Asam
Mangifera pentandra Hook.f.	CR	Balai Quarry, Bukit Belukar, Bukit Noordin, Bukit Surau, Jalan Batu Ubin, Jalan Endut Senin, Jalan Noordin, Kekek Quarry, Ketam Quarry, Sungei Asam
Parishia insignis Hook.f.	CR	Balai Quarry, Bukit Surau, Jalan Batu Ubin, Jalan Noordin, Jalan Wat Siam, Kekek Quarry, Ketam Quarry, Sungei Asam
Swintonia schwenkii (Teijsm. & Binn.) Teijsm. & Binn.	CR	Balai Quarry, Jalan Jelutong, Jalan Noordin

Appendix III. Continuation

Species	Conservation Status	Location of Planting
Family Annonaceae		
Anaxagorea javanica Blume var. *javanica*	CR	Jalan Endut Senin, Sensory Trail, Tanjong Chek Jawa
Fissistigma ovoideum (King) Merr.	EN	Pekan Quarry
Friesodielsia borneensis (Miq.) Steenis var. *sumatrana* (Miq.) I.M.Turner	VU	Balai Quarry, Kekek Quarry, Pekan Quarry
Friesodielsia latifolia (Hook.f. & Thomson) Steenis	LC	Pekan Quarry
Goniothalamus tapis Miq.	EN	Balai Quarry
Monocarpia maingayi (Hook.f. & Thomson) I.M.Turner	CR	Jalan Endut Senin, Bukit Noordin, Bukit Surau
Monoon lateriflorum (Blume) Miq.	CR	Jalan Jelutong, Jalan Noordin
Monoon sclerophyllum (Hook.f. & Thomson) B.Xue & R.M.K.Saunders	CR	Jalan Noordin, Sensory Trail Pond
Uvaria littoralis (Blume) Blume	LC	Balai Quarry, Jalan Jelutong, Kekek Quarry, Ketam Quarry, Pekan Quarry, Ubin Quarry
Family Apocynaceae		
Anodendron candolleanum Wight	DD	Jalan Jelutong
Chonemorpha fragrans (Moon) Alston	CR	Balai Quarry, Jalan Jelutong, Kekek Quarry, Ketam Quarry, Pekan Quarry, Ubin Quarry
Dischidia acutifolia Maingay ex Hook.f.	CR	Jalan Jelutong
Dyera costulata (Miq.) Hook.f.	VU	Balai Quarry, Bukit Jelutong, Bukit Noordin, Jalan Endut Senin, Jalan Jelutong, Ketam Quarry, Sungei Asam, Sungei Teris
Gongreos wallichii (Wight) Rodda et al.	CR	Kekek Quarry, Ketam Quarry, Pekan Quarry, Ubin Quarry
Kopsia singapurensis Ridl.	CR	Balai Quarry, Jalan Batu Ubin, Jalan Endut Senin, Jalan Jelutong, Kekek Quarry, Sensory Trail Pond, Tanjong Chek Jawa
Leuconotis griffithii Hook.f.	LC	Balai Quarry, Pekan Quarry
Ochrosia oppositifolia (Lam.) K.Schum.	NEx	Balai Quarry, Bukit Surau, Jalan Endut Senin, Kekek Quarry, Ketam Quarry, Sungei Asam, Tanjong Chek Jawa

Appendix III. Continuation

Species	Conservation Status	Location of Planting
Tabernaemontana corymbosa Roxb. ex Wall.	EN	Balai Quarry, Bukit Jelutong, Bukit Noordin, Jalan Endut Senin, Sungei Asam
Family Araceae		
Aglaonema nebulosum N.E.Br.	EN	Tanjong Chek Jawa
Aglaonema nitidum (Jack) Kunth	VU	Bukit Ketam, Jalan Endut Senin, Jalan Ubin, Jalan Wat Siam, Tanjong Chek Jawa
Aglaonema simplex Blume	VU	Tanjong Chek Jawa
Amydrium medium (Zoll. & Moritzi) Nicolson	EN	Tanjong Chek Jawa
Anadendrum montanum (Blume) Schott	VU	Balai Quarry, Pekan Quarry, Ubin Quarry
Rhaphidophora lobbii Schott	VU	Jalan Jelutong
Schismatoglottis pantiensis S.Y.Wong et al.	VU	Jalan Endut Senin, Jalan Wat Siam, Tanjong Chek Jawa
Scindapsus hederaceus Miq.	LC	Jalan Jelutong, Jalan Endut Senin, Jalan Wat Siam
Scindapsus lucens Bogner & P.C.Boyce	CR	Jalan Jelutong, Tanjong Chek Jawa
Scindapsus pictus Hassk.	EN	Tanjong Chek Jawa
Family Arecaceae		
Cyrtostachys renda Blume	CR	Bukit Surau, Jalan Endut Senin, Kekek Quarry, Sensory Trail Pond, Tanjong Chek Jawa
Licuala triphylla Griff.	NEx	Bukit Ketam, Tanjong Chek Jawa
Nenga pumila H.Wendl. ex Schaedtler var. *pachystachya* (Blume) Fernando	CR	Bukit Belukar, Jalan Noordin, Jalan Wat Siam
Oncosperma horridum (Griff.) Scheff.	VU	Bukit Noordin, Jalan Jelutong, Ketam Quarry
Orania sylvicola (Griff.) H.E.Moore	CR	Jalan Endut Senin
Pinanga disticha (Roxb.) Blume ex H.Wendl.	NEx	Jalan Wat Siam, Tanjong Chek Jawa
Rhopaloblaste singaporensis (Becc.) Benth. & Hook.f.	CR	Jalan Endut Senin, Jalan Jelutong
Family Asparagaceae		
Dracaena cantleyi Baker	EN	Jalan Endut Senin

Appendix III. Continuation

Species	**Conservation Status**	**Location of Planting**
Dracaena brachystachys Hook.f.	CR	Bukit Noordin, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Sensory Trail Pond, Tanjong Chek Jawa
Family Bignoniaceae		
Radermachera quadripinnata (Blanco) Seem. subsp. *lobbii* (Teijsm. & Binn.) I.M.Turner	CR	Balai Quarry, Bukit Noordin, Jalan Batu Ubin, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Jalan Wat Siam, Kekek Quarry, Sensory Trail Pond, Sungei Asam
Family Boraginaceae		
Cordia dichotoma G.Forst.	NEx	Balai Quarry, Bukit Belukar, Bukit Noordin, Bukit Tajam, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Kekek Quarry, Ketam Quarry, Sensory Trail Pond, Sungei Asam, Sungei Pulau Ubin, Sungei Teris, Tanjong Chek Jawa
Cordia subcordata Lam.	CR	Balai Quarry, Bukit Surau, Jalan Endut Senin, Jalan Jelutong, Jalan Wat Siam, Kekek Quarry, Ketam Quarry, Sensory Trail Pond, Sungei Asam, Sungei Teris, Tanjong Chek Jawa
Family Burseraceae		
Canarium patentinervium Miq.	EN	Sungei Asam
Family Calophyllaceae		
Calophyllum ferrugineum Ridl. var. *ferrugineum*	LC	Balai Quarry, Bukit Belukar, Bukit Noordin, Bukit Tajam, Jalan Endut Senin
Calophyllum macrocarpum Hook.f.	CR	Bukit Noordin
Calophyllum teysmannii Miq. var. *teysmannii*	VU	Jalan Sam Heng, Ketam Quarry
Family Cannabaceae		
Gironniera nervosa Planch.	LC	Jalan Wat Siam
Family Celastraceae		
Gymnosporia littoralis (Backer) Jordaan	CR	Jalan Jelutong
Kokoona reflexa (M.A.Lawson) Ding Hou	CR	Balai Quarry, Jalan Batu Ubin, Sungei Asam
Lophopetalum wightianum Arn.	EN	Bukit Noordin, Bukit Surau, Jalan Endut Senin, Jalan Noordin, Jalan Wat Siam, Tanjong Chek Jawa

Appendix III. Continuation

Species	Conservation Status	Location of Planting
Family Chrysobalanaceae		
Atuna excelsa (Jack) Kosterm. subsp. e*xcelsa*	CR	Bukit Noordin, Bukit Tajam, Tanjong Chek Jawa; planted at Bukit Noordin, Bukit Tajam
Family Clusiaceae		
Garcinia brevirostris Scheff.	VU	Balai Quarry, Bukit Belukar, Ketam Quarry, Tanjong Chek Jawa
Garcinia forbesii King	EN	Jalan Jelutong, Jalan Noordin, Sungei Teris
Garcinia scortechinii King	EN	Bukit Surau
Family Combretaceae		
Terminalia phellocarpa King	NEx	Balai Quarry, Bukit Belukar, Bukit Noordin, Jalan Endut Senin, Jalan Wat Siam, Kekek Quarry, Sensory Trail Pond, Sungei Teris, Tanjong Chek Jawa
Terminalia subspathulata King	CR	Balai Quarry, Bukit Surau, Jalan Endut Senin, Jalan Noordin, Jalan Wat Siam, Kekek Quarry, Ketam Quarry, Sensory Trail Pond
Family Convolvulaceae		
Bonamia semidigyna (Roxb.) Hallier f.	CR	Pekan Quarry
Erycibe festiva Prain	CR	Pekan Quarry
Ipomoea mauritiana Jacq.	LC	Jalan Jelutong
Ipomoea violacea L.	DD	Jalan Jelutong, Jalan Noordin, Pekan Quarry, Sungei Pulau Ubin
Family Costaceae		
Cheilocostus globosus (Blume) C.D.Specht	CR	Bukit Mamam, Jalan Durian, Jalan Endut Senin, Jalan Jelutong, Jalan Wat Siam, Tanjong Chek Jawa
Family Cucurbitaceae		
Trichosanthes elmeri Merr.	EN	Balai Quarry, Jalan Jelutong, Kekek Quarry, Ketam Quarry, Pekan Quarry
Family Cyperaceae		
Eleocharis dulcis (Burm.f.) Trin. ex Hensch.	VU	Sensory Trail Pond
Lepironia articulata (Retz.) Domin	CR	Pekan Quarry, Sensory Trail Pond

Appendix III. Continuation

Species	Conservation Status	Location of Planting
Mapania cuspidata (Miq.) Uittien	VU	Tanjong Chek Jawa
Schoenoplectiella mucronata (L.) J.Jung & H.K.Choi	NEx	Sensory Trail Pond
Family Dilleniaceae		
Dillenia excelsa (Jack) Gilg var. *excelsa*	CR	Balai Quarry, Bukit Noordin, Bukit Surau, Jalan Endut Senin, Kekek Quarry, Sensory Trail Pond, Sungei Asam
Dillenia grandifolia Wall. ex Hook.f. & Thomson	EN	Jalan Endut Senin
Dillenia reticulata King	CR	Bukit Belukar, Sungei Asam, Tanjong Chek Jawa
Family Dioscoreaceae		
Dioscorea polyclades Hook.f.	CR	Jalan Jelutong
Family Dipterocarpaceae		
Anthoshorea bracteolata (Dyer) P.S.Ashton & J.Heck.	CR	Balai Quarry, Bukit Noordin, Kekek Quarry, Sungei Asam
Anisoptera megistocarpa Slooten	CR	Bukit Belukar, Bukit Noordin, Bukit Surau, Jalan Endut Senin, Kekek Quarry, Sungei Asam, Tanjong Chek Jawa
Dipterocarpus chartaceus Symington	CR	Balai Quarry, Kekek Quarry, Sungei Asam
Dipterocarpus cornutus Dyer	CR	Balai Quarry, Sungei Asam
Dipterocarpus grandiflorus (Blanco) Blanco	CR	Balai Quarry, Jalan Endut Senin, Kekek Quarry, Sungei Asam
Dipterocarpus kunstleri King	EN	Balai Quarry, Bukit Surau, Jalan Endut Senin, Kekek Quarry, Sungei Asam, Tanjong Chek Jawa
Hopea ferruginea Parijs	CR	Bukit Noordin, Jalan Batu Ubin, Jalan Endut Senin, Jalan Wat Siam, Kekek Quarry, Sungei Asam
Hopea griffithii Kurz	EN	Bukit Noordin, Jalan Endut Senin
Hopea mengarawan Miq.	EN	Balai Quarry, Bukit Belukar, Bukit Noordin, Jalan Endut Senin, Tanjong Chek Jawa
Hopea sangal Korth.	CR	Balai Quarry, Bukit Ketam, Bukit Surau, Jalan Endut Senin, Tanjong Chek Jawa
Neobalanocarpus heimii (King) P.S.Ashton	NEx	Balai Quarry, Jalan Endut Senin, Jalan Jelutong, Kekek Quarry, Sungei Asam
Richetia gibbosa (Brandis) P.S.Ashton & J.Heck.	CR	Bukit Noordin, Bukit Surau, Tanjong Chek Jawa

Appendix III. Continuation

Species	Conservation Status	Location of Planting
Rubroshorea curtisii (Dyer ex King) P.S.Ashton & J.Heck. subsp. *curtisii*	EN	Balai Quarry, Jalan Endut Senin, Sungei Asam
Rubroshorea leprosula (Miq.) P.S.Ashton & J.Heck.	EN	Balai Quarry, Jalan Endut Senin, Sungei Asam
Rubroshorea ovalis (Korth.) P.S.Ashton & J.Heck. subsp. *ovalis*	CR	Bukit Noordin, Jalan Endut Senin, Sungei Asam
Rubroshorea pauciflora (King) P.S.Ashton & J.Heck.	EN	Bukit Noordin, Kekek Quarry, Ketam Quarry
Rubroshorea platycarpa (F.Heim) P.S.Ashton & J.Heck.	CR	Balai Quarry, Jalan Endut Senin, Sungei Teris
Vatica odorata (Griff.) Symington subsp. *odorata*	CR	Sungei Asam, Sungei Teris
Family Ebenaceae		
Diospyros argentea Griff.	CR	Kekek Quarry, Sungei Asam
Diospyros buxifolia (Blume) Hiern	CR	Balai Quarry, Bukit Noordin, Bukit Surau, Jalan Jelutong, Jalan Noordin, Kekek Quarry, Ketam Quarry, Sungei Asam, Tanjong Chek Jawa
Diospyros ferrea (Willd.) Bakh.	NEx	Bukit Belukar, Bukit Noordin, Bukit Surau, Jalan Endut Senin, Sungei Asam
Family Elaeocarpaceae		
Elaeocarpus stipularis Blume var. *stipularis*	VU	Tanjong Chek Jawa
Family Euphorbiaceae		
Agrostistachys sessilifolia (Kurz) Pax & K.Hoffm.	LC	Jalan Endut Senin, Jalan Wat Siam
Croton adumbratus Croizat	NEx	Bukit Belukar, Bukit Noordin, Bukit Tajam, Jalan Endut Senin, Jalan Noordin, Jalan Sam Heng, Sungei Asam, Sungei Teris, Tanjong Chek Jawa
Neoscortechinia sumatrensis S.Moore	CR	Bukit Noordin, Bukit Surau, Jalan Batu Ubin, Jalan Endut Senin, Jalan Wat Siam, Sungei Asam
Ptychopyxis costata Miq. var. *oblanceolata* Airy Shaw	CR	Bukit Ketam, Bukit Noordin, Jalan Endut Senin, Jalan Noordin
Family Fabaceae		
Dialium indum L. var. *indum*	CR	Tanjong Chek Jawa
Dalbergia velutina Benth. var. *maingayi* Prain	EN	Jalan Jelutong
Dialium platysepalum Baker	CR	Jalan Endut Senin

Appendix III. Continuation

Species	Conservation Status	Location of Planting
Guilandina bonduc L.	CR	Balai Quarry, Jalan Endut Senin, Jalan Jelutong, Tanjong Chek Jawa
Indigofera zollingeriana Miq.	CR	Jalan Jelutong
Intsia palembanica Miq.	CR	Bukit Belukar, Bukit Surau, Jalan Noordin, Ketam Quarry, Sungei Asam, Sungei Teris
Koompassia malaccensis Maingay ex Benth.	EN	Balai Quarry, Bukit Belukar, Bukit Noordin, Bukit Surau, Jalan Endut Senin, Jalan Noordin, Sungei Asam
Mucuna biplicata Teijsm. & Binn. ex Kurz	CR	Balai Quarry, Jalan Jelutong, Pekan Quarry, Ubin Quarry
Mucuna gigantea (Willd.) DC. subsp. *gigantea*	CR	Balai Quarry, Jalan Jelutong, Kekek Quarry, Pekan Quarry, Ubin Quarry
Ormosia sumatrana (Miq.) Prain	CR	Jalan Endut Senin, Bukit Surau
Phanera semibifida (Roxb.) Benth. var. *semibifida*	LC	Balai Quarry, Jalan Jelutong, Pekan Quarry, Ubin Quarry
Sindora wallichii Benth.	CR	Balai Quarry, Bukit Belukar, Bukit Noordin, Bukit Surau, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Jalan Wat Siam, Ketam Quarry, Sungei Asam, Sungei Teris, Tanjong Chek Jawa
Sindora echinocalyx Prain	CR	Bukit Jelutong
Sophora tomentosa L.	CR	Jalan Endut Senin, Jalan Jelutong, Tanjong Chek Jawa
Family Fagaceae		
Castanopsis inermis (Lindl.) Benth. & Hook.f.	CR	Balai Quarry, Bukit Ketam, Jalan Endut Senin, Jalan Noordin, Jalan Sam Heng, Sungei Asam
Family Gelsemiaceae		
Pteleocarpa lamponga (Miq.) Bakh. ex K.Heyne	NEx	Balai Quarry, Bukit Belukar, Bukit Noordin, Bukit Tajam, Jalan Endut Senin, Jalan Noordin, Jalan Sam Heng, Kekek Quarry, Ketam Quarry, Sungei Asam, Tanjong Chek Jawa
Family Gentianaceae		
Fagraea splendens Blume	CR	Jalan Jelutong, Tanjong Chek Jawa
Utania volubilis (Wall.) Sugumaran var. *volubilis*	EN	Jalan Endut Senin
Family Gesneriaceae		
Aeschynanthus albidus (Blume) Steud.	CR	Jalan Endut Senin, Jalan Jelutong, Tanjong Chek Jawa

Appendix III. Continuation

Species	Conservation Status	Location of Planting
Aeschynanthus pulcher (Blume) G.Don	CR	Jalan Endut Senin, Jalan Jelutong
Cyrtandra pendula Blume	CR	Bukit Mamam, Jalan Endut Senin, Jalan Jelutong, Jalan Wat Siam, Tanjong Chek Jawa
Family Hanguanaceae		
Hanguana rubinea Škorničk. & P.C.Boyce	CR	Jalan Endut Senin, Jalan Jelutong
Family Hernandiaceae		
Hernandia nymphaeifolia (C.Presl) Kubitzki	NEx	Balai Quarry, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Jalan Wat Siam, Sungei Teris, Tanjong Chek Jawa
Family Hypericaceae		
Cratoxylum arborescens (Vahl) Blume	EN	Balai Quarry, Ketam Quarry
Cratoxylum cochinchinense (Lour.) Blume	EN	Balai Quarry, Bukit Belukar, Bukit Noordin, Bukit Tajam, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Jalan Sam Heng, Kekek Quarry, Ketam Quarry, Sensory Trail Pond, Sungei Asam, Sungei Teris, Tanjong Chek Jawa
Cratoxylum maingayi Dyer	CR	Balai Quarry, Bukit Surau, Jalan Jelutong, Jalan Noordin, Ketam Quarry, Tanjong Chek Jawa
Family Icacinaceae		
Phytocrene bracteata Wall.	VU	Jalan Jelutong
Family Irvingiaceae		
Irvingia malayana Oliv. ex A.W.Benn.	CR	Balai Quarry, Bukit Tajam, Jalan Noordin, Sungei Teris
Family Lamiaceae		
Peronema canescens Jack	NEx	Bukit Ketam, Bukit Noordin, Bukit Surau, Jalan Endut Senin, Tanjong Chek Jawa
Teijsmanniodendron pteropodum (Miq.) Bakh.	CR	Jalan Endut Senin
Family Lauraceae		
Alseodaphne nigrescens (Gamble) Kosterm.	NEx	Jalan Endut Senin
Beilschmiedia madang (Blume) Blume	VU	Balai Quarry, Jalan Endut Senin
Litsea castanea Hook.f.	EN	Kekek Quarry

Appendix III. Continuation

Species	Conservation Status	Location of Planting
Litsea resinosa Blume	CR	Bukit Belukar, Bukit Noordin, Bukit Surau, Jalan Endut Senin, Ketam Quarry
Nothaphoebe umbelliflora (Blume) Blume	LC	Bukit Belukar, Bukit Noordin, Bukit Surau, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Jalan Wat Siam, Sungei Teris, Tanjong Chek Jawa
Family Lecythidaceae		
Barringtonia macrostachya (Jack) Kurz	CR	Jalan Batu Ubin, Jalan Endut Senin, Kekek Quarry, Sensory Trail Pond, Sungei Asam, Sungei Teris, Tanjong Chek Jawa
Family Lythraceae		
Pemphis acidula J.R.Forst. & G.Forst.	CR	Jalan Endut Senin, Jalan Jelutong, Sungei Puaka, Sensory Trail Pond, Tanjong Chek Jawa
Family Magnoliaceae		
Magnolia elegans (Blume) H.Keng	CR	Bukit Belukar, Bukit Ketam, Bukit Noordin
Family Malvaceae		
Byttneria maingayi Mast.	EN	Jalan Jelutong
Grewia laevigata Vahl	VU	Balai Quarry, Jalan Jelutong, Ketam Quarry, Pekan Quarry, Sungei Asam
Heritiera elata Ridl.	CR	Balai Quarry, Bukit Belukar, Bukit Noordin, Sungei Asam
Heritiera simplicifolia (Mast.) Kosterm.	EN	Balai Quarry, Bukit Noordin, Sungei Asam
Kleinhovia hospita L.	NEx	Bukit Belukar, Bukit Noordin, Bukit Tajam, Jalan Endut Senin, Jalan Jelutong, Ketam Quarry
Melochia umbellata (Houtt.) Stapf	CR	Bukit Noordin, Jalan Endut Senin, Jalan Jelutong, Kekek Quarry, Ketam Quarry, Sungei Asam
Microcos latifolia Burret	EN	Bukit Surau
Pentace triptera Mast.	EN	Balai Quarry, Bukit Belukar, Bukit Ketam, Bukit Noordin, Bukit Surau, Bukit Tajam, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Ketam Quarry, Sungei Teris, Tanjong Chek Jawa
Pterospermum sumatranum Miq.	CR	Bukit Noordin, Jalan Endut Senin, Tanjong Chek Jawa
Scaphium linearicarpum (Mast.) Pierre	CR	Bukit Belukar, Bukit Noordin, Tanjong Chek Jawa

Appendix III. Continuation

Species	Conservation Status	Location of Planting
Sida cordifolia L.	LC	Jalan Jelutong
Sterculia cordata Blume	CR	Balai Quarry, Bukit Belukar, Bukit Noordin, Bukit Surau, Bukit Tajam, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Ketam Quarry, Sungei Asam, Sungei Teris
Sterculia macrophylla Vent.	CR	Bukit Belukar, Bukit Noordin, Bukit Surau, Jalan Batu Ubin, Jalan Endut Senin, Jalan Noordin, Jalan Sam Heng, Kekek Quarry, Ketam Quarry, Sensory Trail Pond, Tanjong Chek Jawa
Sterculia parviflora Roxb. ex G.Don	CR	Balai Quarry, Bukit Belukar, Bukit Noordin, Bukit Surau, Bukit Tajam, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Jalan Sam Heng, Kekek Quarry, Ketam Quarry, Sungei Asam, Sungei Teris, Tanjong Chek Jawa
Family Maranthaceae		
Stachyphrynium parvum Ridl.	CR	Jalan Jelutong, Tanjong Chek Jawa
Family Melastomataceae		
Memecylon oleifolium Blume	CR	Bukit Noordin, Tanjong Chek Jawa
Memecylon paniculatum Jack	CR	Jalan Endut Senin
Family Meliaceae		
Chisocheton patens Blume	CR	Jalan Noordin
Epicharis densiflora Blume	CR	Bukit Noordin
Family Menispermaceae		
Arcangelisia flava (L.) Merr.	CR	Jalan Jelutong, Pekan Quarry
Cyclea laxiflora Miers	CR	Balai Quarry, Jalan Jelutong, Kekek Quarry
Nephroia orbiculata (L.) Lian Lian & Wei Wang	CR	Jalan Jelutong
Stephania capitata (Blume) Spreng.	CR	Jalan Jelutong, Pekan Quarry
Tinomiscium petiolare Miers ex Hook.f. & Thomson	VU	Jalan Jelutong, Pekan Quarry
Tinospora macrocarpa Diels	VU	Jalan Jelutong
Family Monimiaceae		
Matthaea sancta Blume	EN	Bukit Noordin, Jalan Endut Senin

Appendix III. Continuation

Species	Conservation Status	Location of Planting
Family Moraceae		
Artocarpus hispidus F.M.Jarrett	CR	Bukit Surau
Artocarpus lanceifolius Roxb.	EN	Balai Quarry, Bukit Jelutong, Sungei Asam, Tanjong Chek Jawa
Artocarpus rigidus Blume	EN	Jalan Endut Senin
Ficus apiocarpa (Miq.) Miq.	EN	Balai Quarry, Jalan Endut Senin, Pekan Quarry, Ubin Quarry
Ficus consociata Blume	CR	Balai Quarry, Jalan Jelutong, Jalan Noordin, Jalan Sam Heng, Ketam Quarry, Sungei Teris, Tanjong Chek Jawa
Ficus delosyce Corner	CR	Balai Quarry
Ficus kochummeniana C.C.Berg	CR	Balai Quarry, Ketam Quarry
Ficus laevis Blume	CR	Balai Quarry, Pekan Quarry, Ubin Quarry
Ficus recurva Blume var. *ribesioides* (Miq.) King	EN	Bukit Mamam, Bukit Noordin
Ficus subgelderi Corner	CR	Balai Quarry, Ketam Quarry, Sungei Asam
Ficus sundaica Blume	CR	Balai Quarry, Bukit Surau, Bukit Tajam, Jalan Batu Ubin, Sensory Trail Pond
Ficus superba (Miq.) Miq.	EN	Balai Quarry, Bukit Surau, Jalan Jelutong, Jalan Endut Senin, Jalan Wat Siam, Mamam Campsite
Ficus trichocarpa Blume	CR	Ketam Quarry
Ficus xylophylla (Miq.) Wall. ex Miq.	CR	Balai Quarry, Bukit Belukar, Bukit Noordin, Bukit Surau, Jalan Jelutong, Jalan Noordin, Ketam Quarry, Sungei Teris, Tanjong Chek Jawa
Family Myristicaceae		
Endocomia canarioides (King) W.J.de Wilde	CR	Balai Quarry, Bukit Belukar, Bukit Jelutong, Bukit Surau, Jalan Endut Senin, Ketam Quarry, Sungei Asam
Horsfieldia crassifolia (Hook.f. & Thomson) Warb.	CR	Bukit Ketam, Bukit Noordin, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Sungei Asam, Sungei Teris
Horsfieldia irya (Gaertn.) Warb.	CR	Balai Quarry, Bukit Belukar, Bukit Noordin, Bukit Surau, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Jalan Wat Siam, Kekek Quarry, Ketam Quarry, Sensory Trail Pond, Sungei Asam, Sungei Teris, Tanjong Chek Jawa

Appendix III. Continuation

Species	Conservation Status	Location of Planting
Horsfieldia polyspherula (Hook.f.) J.Sinclair var. *polyspherula*	VU	Balai Quarry, Bukit Tajam, Jalan Endut Senin, Jalan Noordin, Jalan Wat Siam, Kekek Quarry, Sungei Asam
Horsfieldia punctatifolia J.Sinclair	EN	Bukit Noordin, Jalan Endut Senin
Horsfieldia sparsa W.J.de Wilde	EN	Jalan Noordin
Horsfieldia superba (Hook.f. & Thomson) Warb.	CR	Jalan Endut Senin, Jalan Noordin, Kekek Quarry, Ketam Quarry, Sungei Asam
Knema communis J.Sinclair	VU	Jalan Endut Senin
Knema curtisii (King) Warb. var. *paludosa* J.Sinclair	CR	Ketam Quarry, Sungei Asam, Sungei Teris
Knema intermedia (Blume) Warb.	EN	Bukit Noordin, Jalan Endut Senin
Knema latericia Elmer subsp. *ridleyi* (Gand.) W.J.de Wilde	EN	Bukit Noordin, Bukit Surau, Tanjong Chek Jawa
Knema laurina (Blume) Warb. var. *laurina*	EN	Bukit Noordin
Myristica elliptica Wall. ex Hook.f. & Thomson	CR	Tanjong Chek Jawa
Family Myrtaceae		
Melaleuca cajuputi Maton & Sm. ex R.Powell	DD	Balai Quarry, Jalan Endut Senin, Jalan Jelutong, Jalan Wat Siam, Kekek Quarry, Ketam Quarry, Sensory Trail Pond, Sungei Pulau Ubin, Tanjong Chek Jawa
Syzygium acuminatissimum (Blume) DC.	EN	Jalan Endut Senin, Jalan Noordin, Jalan Sam Heng, Ketam Quarry
Syzygium borneense (Miq.) Miq.	LC	Balai Quarry, Bukit Belukar, Bukit Noordin, Bukit Tajam, Jalan Batu Ubin, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Jalan Sam Heng, Jalan Wat Siam, Kekek Quarry, Ketam Quarry, Sensory Trail Pond, Sungei Asam, Sungei Teris
Syzygium claviflorum (Roxb.) Wall. ex Steud.	CR	Bukit Noordin, Jalan Endut Senin, Sungei Teris
Syzygium incarnatum (Elmer) Merr. & L.M.Perry	EN	Bukit Tajam, Jalan Endut Senin
Syzygium leucoxylon Korth.	NEx	Balai Quarry, Jalan Batu Ubin, Jalan Endut Senin, Jalan Jelutong, Kekek Quarry, Ketam Quarry, Sungei Asam, Sungei Teris
Syzygium myrtifolium Walp.	CR	Bukit Jelutong, Bukit Noordin, Jalan Endut Senin, Jalan Jelutong, Jalan Mamam, Kekek Quarry, Ketam Quarry, Sensory Trail Pond, Sungei Asam, Sungei Pulau Ubin
Syzygium oblatum (Roxb.) Wall. ex A.M.Cowan & Cowan var. *oblatum*	CR	Bukit Noordin, Jalan Endut Senin, Jalan Noordin, Jalan Sam Heng, Jalan Wat Siam, Ketam Quarry

Appendix III. Continuation

Species	Conservation Status	Location of Planting
Syzygium pachyphyllum (Kurz) Merr. & L.M.Perry	CR	Balai Quarry, Jalan Endut Senin, Kekek Quarry, Ketam Quarry, Sensory Trail Pond, Sungei Teris
Syzygium pyrifolium (Blume) DC.	EN	Bukit Surau, Jalan Noordin, Jalan Sam Heng
Tristaniopsis merguensis (Griff.) Peter G.Wilson & J.T.Waterh.	CR	Balai Quarry, Jalan Noordin, Sungei Asam
Tristaniopsis obovata (Benn.) Peter G.Wilson & J.T.Waterh.	CR	Balai Quarry, Bukit Surau, Jalan Endut Senin, Jalan Jelutong, Kekek Quarry, Ketam Quarry, Sungei Asam, Sungei Puaka, Tanjong Chek Jawa
Family Olacaceae		
Ochanostachys amentacea Mast.	VU	Balai Quarry, Bukit Noordin, Bukit Surau, Jalan Endut Senin, Sungei Asam
Scorodocarpus borneensis (Baill.) Becc.	CR	Balai Quarry, Sungei Asam
Strombosia ceylanica Gardner	LC	Bukit Noordin, Jalan Endut Senin, Jalan Noordin
Strombosia javanica Blume	VU	Balai Quarry, Bukit Noordin, Bukit Surau, Jalan Batu Ubin, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Kekek Quarry, Ketam Quarry, Sungei Asam, Sungei Teris, Tanjong Chek Jawa
Family Orchidaceae		
Appendiculata uncata Ridl.	NEx	Jalan Jelutong
Brachypeza pallida (Blume) Kocyan & Schuit.	CR	Jalan Jelutong
Bulbophyllum clandestinum Lindl.	CR	Jalan Jelutong
Bulbophyllum lepidum (Blume) J.J.Sm.	CR	Jalan Jelutong
Bulbophyllum limbatum Lindl.	NEx	Jalan Jelutong
Bulbophyllum lobbii Lindl.	NEx	Jalan Jelutong, Tanjong Chek Jawa
Bulbophyllum macranthum Lindl.	NEx	Tanjong Chek Jawa
Bulbophyllum maxillare (Lindl.) Rchb.f.	CR	Jalan Jelutong, Tanjong Chek Jawa
Bulbophyllum medusae (Lindl.) Rchb.f.	CR	Jalan Endut Senin, Jalan Jelutong, Jalan Wat Siam, Tanjong Chek Jawa
Bulbophyllum membranaceum Teijsm. & Binn.	CR	Jalan Jelutong
Bulbophyllum pileatum Lindl.	NEx	Jalan Jelutong, Tanjong Chek Jawa

Appendix III. Continuation

Species	Conservation Status	Location of Planting
Bulbophyllum praetervisum J.J.Verm.	CR	Jalan Jelutong, Tanjong Chek Jawa
Bulbophyllum trigonopus (Rchb.f.) P.T.Ong	CR	Jalan Jelutong, Tanjong Chek Jawa
Callostylis pulchella (Lindl.) S.C.Chen & Z.H.Tsi	CR	Jalan Jelutong
Claderia viridiflora Hook.f.	CR	Jalan Jelutong
Coelogyne mayeriana Rchb.f.	NEx	Jalan Jelutong, Tanjong Chek Jawa
Coelogyne rochussenii de Vriese	CR	Jalan Endut Senin, Jalan Jelutong, Tanjong Chek Jawa
Cymbidium bicolor Lindl. subsp. *pubescens* (Lindl.) Du Puy & P.J.Cribb	CR	Jalan Jelutong, Sungei Teris, Tanjong Chek Jawa
Cymbidium finlaysonianum Lindl.	EN	Jalan Endut Senin, Jalan Jelutong, Jalan Wat Siam, Tanjong Chek Jawa
Dendrobium acerosum Lindl.	NEx	Jalan Jelutong
Dendrobium aloifolium (Blume) Rchb.f.	CR	Jalan Jelutong, Tanjong Chek Jawa
Dendrobium lamellatum (Blume) Lindl.	NEx	Jalan Jelutong
Dendrobium lobatum (Blume) Miq.	NEx	Jalan Jelutong
Dendrobium lobbii Teijsm. & Binn.	CR	Tanjong Chek Jawa
Grammatophyllum speciosum Blume	NEx	Bukit Mamam, Bukit Melayu, Jalan Jelutong, Jalan Wat Siam, Sungei Mamam, Sungei Teris
Hetaeria oblongifolia Blume	CR	Jalan Endut Senin, Jalan Jelutong
Phalaenopsis cornu-cervi (Breda) Blume & Rchb.f.	NEx	Jalan Endut Senin, Jalan Jelutong, Jalan Wat Siam, Tanjong Chek Jawa
Pinalia tenuiflora (Ridl.) J.J.Wood	NEx	Jalan Jelutong, Tanjong Chek Jawa
Family Pandanaceae		
Benstonea affinis (Kurz) Callm. & Buerki	CR	Jalan Endut Senin, Tanjong Chek Jawa
Benstonea parva (Ridl.) Callm. & Buerki	EN	Jalan Endut Senin, Jalan Jelutong
Freycinetia javanica Blume	CR	Jalan Jelutong, Tanjong Chek Jawa
Pandanus houlletii Carrière	CR	Jalan Jelutong, Tanjong Chek Jawa

Appendix III. Continuation

Species	Conservation Status	Location of Planting
Family Passifloraceae		
Adenia cordifolia (Blume) Engl.	EN	Jalan Jelutong
Family Philydraceae		
Philydrum lanuginosum Banks ex Gaertn.	CR	Sensory Trail Pond
Family Phyllanthaceae		
Baccaurea bracteata Müll.Arg.	VU	Bukit Tajam, Jalan Batu Ubin, Kekek Quarry, Sungei Asam
Baccaurea brevipes Hook.f.	CR	Bukit Belukar, Bukit Noordin, Bukit Surau, Jalan Endut Senin, Jalan Noordin, Sensory Trail Pond, Tanjong Chek Jawa
Baccaurea parviflora (Müll.Arg.) Müll.Arg.:	LC	Bukit Surau, Jalan Endut Senin, Jalan Noordin, Jalan Wat Siam, Sungei Teris
Baccaurea polyneura Hook.f.	VU	Jalan Noordin
Baccaurea racemosa (Reinw.) Müll.Arg.	CR	Bukit Noordin, Jalan Noordin, Sensory Trail Pond
Cleistanthus malaccensis Hook.f.	NEx	Balai Quarry, Bukit Belukar, Bukit Noordin, Bukit Surau, Bukit Tajam, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Ketam Quarry, Sungei Asam, Sungei Teris
Cleistanthus sumatranus (Miq.) Müll.Arg.	VU	Bukit Surau
Emblica officinalis Gaertn.	CR	Jalan Jelutong, Ketam Quarry, Sensory Trail Pond, Sungei Teris
Margaritaria indica (Dalzell) Airy Shaw	CR	Kekek Quarry
Family Piperaceae		
Piper baccatum Blume	CR	Jalan Jelutong
Family Pittosporaceae		
Pittosporum ridleyi L.W.Cayzer & G.Chandler	VU	Balai Quarry, Bukit Surau, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Kekek Quarry, Ketam Quarry, Sungei Asam
Family Poaceae		
Thuarea involuta (G.Forst.) R.Br. ex Sm.	LC	Tanjong Chek Jawa
Family Polygalaceae		
Xanthophyllum obscurum A.W.Benn.	CR	Bukit Ketam, Bukit Noordin, Jalan Endut Senin, Jalan Noordin

Appendix III. Continuation

Species	Conservation Status	Location of Planting
Family Primulaceae		
Ardisia complanata Wall.	LC	Jalan Endut Senin, Jalan Jelutong
Labisia pumila (Blume) Fern.-Vill.	VU	Jalan Endut Senin, Jalan Jelutong, Jalan Wat Siam
Family Rhamnaceae		
Ziziphus elegans Wall.	CR	Balai Quarry, Kekek Quarry, Ketam Quarry
Family Rhizophoraceae		
Kandelia candel (L.) Druce	CR	Sungei Puaka, Tanjong Chek Jawa
Family Rosaceae		
Rubus moluccanus L. var. *angulosus* Kalkman	VU	Jalan Jelutong, Tanjong Chek Jawa
Family Rubiaceae		
Gardenia tubifera Wall.	NEx	Balai Quarry, Bukit Belukar, Bukit Noordin, Bukit Surau, Jalan Noordin, Jalan Wat Siam, Kekek Quarry, Ketam Quarry
Hedyotis capitellata Wall. ex G.Don	LC	Jalan Jelutong
Ixora grandifolia Zoll. & Moritzi var. *grandifolia*	NEx	Tanjong Chek Jawa
Morinda elliptica (Hook.f.) Ridl.	EN	Jalan Endut Senin
Mussaenda glabra Vahl	EN	Jalan Jelutong
Oxyceros bispinosus (Griff.) Tirveng.	LC	Jalan Jelutong, Pekan Quarry
Paederia foetida L.	LC	Jalan Jelutong
Psychotria maingayi Hook.f.	EN	Balai Quarry, Pekan Quarry, Ubin Quarry
Psychotria ovoidea Wall. ex Hook.f.	EN	Jalan Jelutong
Singaporandia macrophylla (Hook.f.) K.M.Wong	VU	Balai Quarry, Bukit Noordin, Ketam Quarry
Uncaria acida (W.Hunter) W.Hunter ex Roxb. var. *acida*	EN	Balai Quarry, Pekan Quarry
Uncaria attenuata Korth.	CR	Balai Quarry, Jalan Jelutong, Kekek Quarry
Uncaria elliptica R.Br. ex G.Don	CR	Balai Quarry, Pekan Quarry

Appendix III. Continuation

Species	Conservation Status	Location of Planting
Uncaria longiflora (Poir.) Merr. var. *pteropoda* (Miq.) Ridsdale	EN	Balai Quarry, Pekan Quarry
Family Rutaceae		
Merope angulata (Willd.) Swingle	CR	Sungei Puaka
Family Salicaceae		
Scolopia macrophylla (Wight & Arn.) Clos	CR	Jalan Endut Senin, Sensory Trail Pond
Family Sapindaceae		
Arytera litoralis Blume	CR	Bukit Surau, Jalan Endut Senin, Jalan Noordin, Jalan Sam Heng, Ketam Quarry, Tanjong Chek Jawa; planted at Bukit Belukar
Dodonaea viscosa Jacq.	CR	Balai Quarry, Jalan Batu Ubin, Jalan Endut Senin, Jalan Ubin, Jalan Jelutong, Sensory Trail Pond, Tanjong Chek Jawa
Nephelium cuspidatum Blume var. *eriopetalum*	CR	Sungei Teris
Nephelium laurinum Blume	CR	Balai Quarry
Nephelium maingayi Hiern	CR	Balai Quarry, Jalan Batu Ubin, Jalan Endut Senin, Jalan Ubin, Sungei Asam, Sungei Teris
Paranephelium macrophyllum King	CR	Balai Quarry, Bukit Surau, Jalan Endut Senin, Jalan Noordin, Jalan Wat Siam, Tanjong Chek Jawa
Pometia pinnata J.R.Forst. & G.Forst.	EN	Balai Quarry, Bukit Belukar, Bukit Noordin, Bukit Surau, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Kekek Quarry, Ketam Quarry, Sensory Trail Pond, Sungei Asam, Sungei Teris, Tanjong Chek Jawa
Trigonachras acuta (Hiern) Radlk.	CR	Bukit Noordin, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin
Xerospermum noronhianum (Blume) Blume	EN	Bukit Ketam, Bukit Noordin, Jalan Endut Senin, Jalan Noordin
Family Sapotaceae		
Palaquium gutta (Hook.) Baill.	CR	Balai Quarry, Bukit Belukar, Bukit Noordin, Bukit Surau, Jalan Endut Senin, Ketam Quarry
Palaquium oxleyanum Pierre	CR	Bukit Jelutong, Jalan Endut Senin, Sungei Asam
Palaquium rostratum (Miq.) Burck	CR	Bukit Surau, Tanjong Chek Jawa

Appendix III. Continuation

Species	Conservation Status	Location of Planting
Family Schisandraceae		
Kadsura scandens (Blume) Blume	CR	Jalan Jelutong, Pekan Quarry
Kadsura verrucosa (Gagnep.) A.C.Sm.	CR	Balai Quarry, Pekan Quarry, Ubin Quarry
Family Simaroubaceae		
Ailanthus integrifolia Lam.	CR	Jalan Endut Senin, Jalan Jelutong, Jalan Noordin
Family Styracaceae		
Styrax benzoin Dryand. var. *benzoin*	CR	Bukit Noordin, Bukit Surau, Jalan Noordin
Family Theaceae		
Polyspora penangensis (Ridl.) Niissalo & L.M.Choo	EN	Sungei Asam, Sungei Teris
Family Thymelaeaceae		
Enkleia malaccensis Griff.	CR	Jalan Jelutong
Gonystylus confusus Airy Shaw	EN	Bukit Belukar, Bukit Surau
Family Torricelliaceae		
Aralidium pinnatifidum (Jungh. & de Vriese) Miq.	CR	Tanjong Chek Jawa
Family Violaceae		
Rinorea anguifera (Lour.) Kuntze	CR	Bukit Noordin, Bukit Surau, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Ketam Quarry
Family Vitaceae		
Causonis trifolia (L.) Mabb. & J.Wen	DD	Balai Quarry, Jalan Jelutong, Ketam Quarry, Pekan Quarry
Cissus nodosa Blume	VU	Jalan Jelutong
Leea angulata Korth. ex Miq.	CR	Balai Quarry, Bukit Belukar, Bukit Noordin, Bukit Surau, Jalan Endut Senin, Jalan Jelutong, Jalan Noordin, Ketam Quarry, Tanjong Chek Jawa
Leea rubra Blume ex Spreng.	NEx	Jalan Jelutong
Tetrastigma leucostaphylum (Dennst.) Alston	CR	Balai Quarry, Jalan Jelutong, Ketam Quarry, Pekan Quarry, Ubin Quarry

Appendix III. Continuation

Species	Conservation Status	Location of Planting
Family Zingiberaceae		
Amomum latiflorum (Ridl.) Škorničk. & Hlavatá	EN	Jalan Endut Senin, Jalan Jelutong
Etlingera maingayi (Baker) R.M.Sm.	CR	Jalan Endut Senin, Jalan Jelutong
Etlingera punicea (Roxb.) R.M.Sm.	CR	Jalan Endut Senin
Globba leucantha Miq. var. *peninsularis* Holttum	CR	Jalan Endut Senin, Jalan Jelutong
Globba pendula Roxb.	CR	Jalan Endut Senin, Jalan Jelutong
Hornstedtia scyphifera (J.Koenig) Steud. var. *scyphifera*	VU	Jalan Endut Senin, Jalan Jelutong
Sundamomum hastilabium (Ridl.) A.D.Poulsen & M.F.Newman	CR	Jalan Endut Senin
Zingiber puberulum Ridl. var. *puberulum*	EN	Jalan Endut Senin
Zingiber singapurense Škorničk.	CR	Jalan Endut Senin, Jalan Jelutong, Jalan Wat Siam

Appendix IV. List of native vascular plants recorded from Pulau Ubin before 1960
Abbreviations: **x**: Presumed extirpated from Pulau Ubin **r**: Still extant in Pulau Ubin

	Species	**Barcode No. or Reference for Historical Records**
	LYCOPHYTES	
	Family Selaginellaceae	
x	*Selaginella willdenowii* (Desv.) Baker	SING0033608
	FERNS	
	Family Aspleniaceae	
x	*Asplenium macrophyllum* Sw.	(Ridley 1900)
	Family Davalliaceae	
r	*Davallia denticulata* (Burm.f.) Mett. ex Kuhn var. *denticulata*	SING0031476
x	*Davallia heterophylla* Sm.	SING0031485
	Family Dryopteridaceae	
r	*Pleocnemia irregularis* (C.Presl) Holttum	SING0031616
	Family Lindsaeaceae	
x	*Lindsaea divergens* Hook. & Grev.	(Johnson 1977)
	Family Polypodiaceae	
x	*Drynaria sparsisora* (Desv.) T.Moore	SING0032659
r	*Microsorum scolopendria* (Burm.f.) Copel.	SING0031538
x	*Pyrrosia lanceolata* (L.) Farw.	SING0033545; SING0103088
	Family Pteridaceae	
x	*Adiantum flabellulatum* L.	SING0032334; SING0032336
r	*Cheilanthes tenuifolia* (Burm.f.) Sw.	SING0031222
x	*Haplopteris ensiformis* (Sw.) E.H.Crane	SING0338621
	Family Tectariaceae	
r	*Tectaria semipinnata* (Roxb.) C.V.Morton	SING0031634; SING0031635
	Family Thelypteridaceae	
r	*Christella dentata* (Forssk.) Brownsey & Jermy	SING0033404
	ANGIOSPERMS	
	Family Acanthaceae	
r	*Avicennia officinalis* L.	(Ridley 1900)
	Family Amaranthaceae	
r	*Cyathula prostrata* (L.) Blume	(Ridley 1900)
	Family Amaryllidaceae	
r	*Crinum asiaticum* L.	(Ridley 1900)
	Family Annonaceae	
r	*Uvaria griffithii* L.L.Zhou et al.	SING0003119

Appendix IV. Continuation

	Species	Barcode No. or Reference for Historical Records
	Family Apocynaceae	
r	*Dischidia nummularia* R.Br.	SING0037666
x	*Urceola lucida* (A.DC.) Benth. & Hook.f. ex Kurz	SING0003495; SING0003496; SING0003499; SING0120132
r	*Willughbeia coriacea* Wall.	SING0003534
x	*Willughbeia flavescens* Dyer ex Hook.f.	SING0037914
	Family Araceae	
x	*Aglaonema simplex* Blume	SING0003597
	Family Araliaceae	
x	*Heptapleurum cephalotes* C.B.Clarke	(Ridley 1900)
x	*Heptapleurum lanceolatum* (Ridl.) Lowry & G.M.Plunkett	SING0003857
	Family Arecaceae	
r	*Caryota mitis* Lour.	SING0090490
r	*Licuala spinosa* Wurmb	SING0014853; SING0014855; SING0014856; SING0014857; SING0014858
x	*Nenga pumila* H.Wendl. ex Schaedtler	SING0014888
x	*Orania sylvicola* (Griff.) H.E.Moore	SING0017045; SING0017046
	Family Asparagaceae	
x	*Dracaena elliptica* Thunb.	(Ridley 1900)
r	*Dracaena maingayi* Hook.f.	SING0002681
r	*Dracaena porteri* Baker	SING0002691
	Family Asphodelaceae	
r	*Dianella ensifolia* (L.) Redouté	SING0160126; SING0160127
	Family Asteraceae	
x	*Adenostemma viscosum* J.R.Forst. & G.Forst.	SING0055665
x	*Blumea riparia* DC.	Ridley s.n. 1894
r	*Pluchea indica* (L.) Less.	SING0004506
r	*Vernonia arborea* Buch.-Ham.	SING0004522
r	*Wollastonia biflora* (L.) DC.	SING0189753
	Family Bignoniaceae	
r	*Dolichandrone spathacea* (L.f.) K.Schum.	(Ridley 1900)
	Family Calophyllaceae	
r	*Calophyllum inophyllum* L.	(Ridley 1900)

Appendix IV. Continuation

	Species	Barcode No. or Reference for Historical Records
	Family Cannabaceae	
x	*Gironniera subaequalis* Planch.	SING0026610
r	*Trema tomentosum* (Roxb.) H.Hara	SING0051996
	Family Celastraceae	
x	*Reissantia indica* (Willd.) N.Hallé	(Ridley 1900)
r	*Salacia chinensis* L.	SING0004347; SING0004349
r	*Salacia grandiflora* Kurz	SING0004365
x	*Salacia viminea* Wall. ex M.A.Lawson	SING0004380
	Family Clusiaceae	
x	*Garcinia brevirostris* Scheff.	SING0017951
r	*Garcinia celebica* L.	SING0017962
r	*Garcinia nervosa* (Miq.) Miq.	SING0018019
	Family Commelinaceae	
x	*Amischotolype gracilis* (Ridl.) I.M.Turner	SING0004470
x	*Pollia secundiflora* (Blume) Bakh.f.	SING0042865
	Family Connaraceae	
x	*Connarus paniculatus* Roxb.	SING0004545
	Family Cucurbitaceae	
x	*Trichosanthes borneensis* Cogn.	SING0037115; SING0037116
	Family Cyperaceae	
x	*Cyperus albescens* (Steud.) Larridon & Govaerts	SING0005033
r	*Fimbristylis ferruginea* (L.) Vahl	SING0004958
x	*Fimbristylis pauciflora* R.Br.	SING0240003
r	*Mapania bancana* (Miq.) Ridl.	SING0240015
x	*Mapania kurzii* C.B.Clarke	SING0005150
r	*Scleria levis* Retz.	SING0059969; SING0059971
r	*Scleria oblata* S.T.Blake ex J.Kern	SING0010017
	Family Dilleniaceae	
r	*Dillenia suffruticosa* (Griff. ex Hook.f. & Thomson) Martelli	SING0121554
	Family Dipterocarpaceae	
x	*Dipterocarpus sublamellatus* Foxw.	SING0000881; SING0000882
	Family Elaeocarpaceae	
r	*Elaeocarpus pedunculatus* Wall. ex Mast.	SING0017273; SING0017274

Appendix IV. Continuation

	Species	Barcode No. or Reference for Historical Records
	Family Euphorbiaceae	
x	*Claoxylon longifolium* (Blume) Endl. ex Hassk.	SING0012720; SING0012721; SING0059733
r	*Macaranga bancana* (Miq.) Müll.Arg.	SING0034955; SING0034960
r	*Macaranga heynei* I.M.Johnst.	SING0034990; SING0034993
r	*Suregada glomerulata* (Blume) Baill.	SING0013057
	Family Fabaceae	
r	*Aganope heptaphylla* (L.) Polhill	SING0011291; SING0011293
x	*Albizia retusa* Benth. subsp. *retusa*	SING0011286
r	*Alysicarpus vaginalis* (L.) DC.	SING0047469
r	*Archidendron ellipticum* (Blume) I.C.Nielsen subsp. *ellipticum*	SING0018327; SING0018330
r	*Canavalia cathartica* Thouars	SING0047525
r	*Dalbergia candenatensis* (Dennst.) Prain	SING0018377; SING0098103
x	*Dalbergia junghuhnii* Benth.	SING0018397
r	*Derris amoena* Benth.	SING0035200
r	*Derris trifoliata* Lour.	SING0035195; SING0035207; SING0035208; SING0035209
r	*Entada spiralis* Ridl.	SING0045197
r	*Intsia bijuga* (Colebr.) Kuntze	SING0018461; SING0018466
r	*Millettia pinnata* (L.) Panigrahi	SING0047497
	Family Fagaceae	
x	*Lithocarpus elegans* (Blume) Hatus. ex Soepadmo	(Ridley 1900)
x	*Lithocarpus wallichianus* (Lindl. ex Hance) Rehder	SING0011126
	Family Flagellariaceae	
r	*Flagellaria indica* L.	(Ridley 1900)
	Family Gentianaceae	
r	*Fagraea auriculata* Jack	SING0011367
r	*Utania nervosa* K.M.Wong & Sugumaran	SING0013341
	Family Goodeniaceae	
r	*Scaevola taccada* (Gaertn.) Roxb.	(Ridley 1900)
	Family Hanguanaceae	
x	*Hanguana triangulata* Škorničk. & P.C.Boyce	SING0018121
	Family Lamiaceae	
r	*Premna serratifolia* L.	SING0026765
r	*Vitex pinnata* L.	SING0043293

Appendix IV. Continuation

	Species	Barcode No. or Reference for Historical Records
r	*Vitex trifolia* L.	(Keng 1990)
r	*Volkameria inermis* L.	SING0026688
	Family Lauraceae	
x	*Actinodaphne maingayi* Hook.f.	SING0013092
r	*Litsea umbellata* (Lour.) Merr.	SING0229003
r	*Neolitsea cassia* (L.) Kosterm.	SING0045662
r	*Phoebe grandis* (Nees) Merr.	(Keng 1990)
	Family Linaceae	
r	*Indorouchera griffithiana* (Planch.) Hallier f.	SING0013331; SING0013332
	Family Malpighiaceae	
r	*Tristellateia australasiae* A.Rich.	(Ridley 1900)
	Family Malvaceae	
x	*Abutilon indicum* (L.) Sweet	SING0013418
x	*Microcos hirsuta* (Korth.) Burret	SING0026467
r	*Pterospermum diversifolium* Blume	SING0061614; SING0061615
r	*Sterculia coccinea* Jack	SING0026043
r	*Thespesia populnea* (L.) Sol. ex Corrêa	SING0013438
	Family Melastomataceae	
x	*Diplectria stipularis* (Blume) Kuntze	SING0011643
x	*Diplectria viminalis* (Jack) Kuntze	SING0013463; SING0013465
r	*Memecylon lilacinum* Zoll. & Moritzi	SING0013562
x	*Ochthocharis javanica* Blume	SING0011669
r	*Pachycentria pulverulenta* (Jack) Clausing	SING0013603
	Family Meliaceae	
x	*Aglaia meliosmoides* Craib	SING0011686
x	*Chisocheton erythrocarpus* Hiern	(Ridley 1900)
x	*Chisocheton macrophyllus* King subsp. *macrophyllus*	SING0046121
x	*Epicharis cuneata* (Hiern) Harms	SING0018644; SING0018645
r	*Sandoricum koetjape* (Burm.f.) Merr.	SING0018728
r	*Xylocarpus granatum* J.Koenig	SING0018749
	Family Menispermaceae	
x	*Cyclea laxiflora* Miers	SING0013693
r	*Fibraurea tinctoria* Lour.	SING0013715

Appendix IV. Continuation

	Species	Barcode No. or Reference for Historical Records
	Family Moraceae	
r	*Artocarpus dadah* Miq.	SING0013788
x	*Ficus callophylla* Blume	SING0042022
r	*Ficus fistulosa* Reinw. ex Blume	SING0052101
r	*Ficus kerkhovenii* Koord. & Valeton	SING0014026; SING0042064
x	*Ficus laevis* Blume	(Ridley 1900)
x	*Ficus pellucidopunctata* Griff.	(Ridley 1900)
x	*Ficus scaberrima* Blume	SING0014038; SING0014042
x	*Ficus scortechinii* King	SING0014069
r	*Ficus variegata* Blume	SING0042057
r	*Malaisia scandens* (Lours.) Planch.	SING0030487
	Family Myristicaceae	
r	*Knema corticosa* Lour.	SING0011774
x	*Knema rubens* (J.Sinclair) W.J.de Wilde	(Ridley 1900)
	Family Myrtaceae	
x	*Syzygium leucoxylon* Korth.	Ridley 9486
r	*Syzygium pycnanthum* Merr. & L.M.Perry	SING0019268
r	*Tristaniopsis whiteana* (Griff.) Peter G.Wilson & J.T.Waterh.	SING0019829
	Family Ochnaceae	
r	*Campylospermum serratum* (Gaertn.) Bittrich & M.C.E.Amaral	SING0014530
	Family Oleaceae	
r	*Olea brachiata* (Lour.) Merr.	SING0222966
	Family Orchidaceae	
x	*Bulbophyllum medusae* (Lindl.) Rchb.f.	(Ridley 1900)
x	*Corymborkis veratrifolia* (Reinw.) Blume	SING0010635; SING0010637
x	*Cymbidium finlaysonianum* Lindl.	Goodenough s.n. 1894
x	*Grammatophyllum speciosum* Blume	(Ridley 1900)
x	*Phalaenopsis cornu-cervi* (Breda) Blume & Rchb.f.	SING0042613
x	*Renanthera elongata* (Blume) Lindl.	(Ridley 1900)
r	*Spathoglottis plicata* Blume	SING0041487
x	*Thrixspermum calceolus* (Lindl.) Rchb.f.	SING0010994
r	*Vanilla griffithii* Rchb.f.	(Ridley 1900)
	Family Pandaceae	
r	*Galearia fulva* (Tul.) Miq.	SING0035983

Appendix IV. Continuation

	Species	Barcode No. or Reference for Historical Records
	Family Pandanaceae	
x	*Benstonea parva* (Ridl.) Callm. & Buerki	SING0059863
r	*Pandanus odorifer* (Forssk.) Kuntze	(Ridley 1900)
	Family Phyllanthaceae	
r	*Antidesma velutinosum* Blume	SING0012411; SING0012414
r	*Glochidion borneense* (Müll.Arg.) Boerl.	SING0012892
	Family Piperaceae	
r	*Piper lanatum* Roxb.	SING0014974; SING0014977
	Family Plantaginaceae	
x	*Adenosma indiana* (Lour.) Merr.	SING0025844
	Family Poaceae	
x	*Digitaria ciliaris* (Retz.) Koeler	SING0058861
x	*Digitaria longiflora* (Retz.) Pers.	SING0017736
x	*Digitaria violascens* Link	Ridley s.n. 1894
r	*Eragrostis tenella* (L.) P.Beauv.	SING0302447
r	*Eriochloa procera* (Retz.) C.E.Hubb.	SING0058863
r	*Ischaemum muticum* L.	SING0041297
r	*Mnesithea glandulosa* (Trin.) de Koning & Sosef	SING0064541; SING0064542
x	*Scrotochloa urceolata* (Roxb.) Judz.	SING0201741
	Family Primulaceae	
r	*Aegiceras corniculatum* (L.) Blanco	SING0014244
x	*Ardisia cymosa* Blume	SING0014338; SING0014339; SING0014340; SING0206997
r	*Ardisia elliptica* Thunb.	SING0014281; SING0014293
x	*Ardisia villosa* Roxb.	(Ridley 1900)
	Family Rhamnaceae	
r	*Ventilago malaccensis* Ridl.	SING0025134
	Family Rhizophoraceae	
r	*Bruguiera cylindrica* (L.) Blume	SING0025155; SING0025164
r	*Gynotroches axillaris* Blume	SING0025197
	Family Rubiaceae	
x	*Coelospermum truncatum* (Wall.) Baill. ex K.Schum.	SING0019999
x	*Eumachia rostrata* (Blume) I.M.Turner	SING0012159
x	*Gaertnera viminea* Hook.f. ex C.B.Clarke	SING0046192
r	*Gynochthodes coriacea* Blume	SING0051237

Appendix IV. Continuation

	Species	Barcode No. or Reference for Historical Records
r	*Gynochthodes rigida* (Miq.) Razafim. & B.Bremer	SING0030357
r	*Gynochthodes umbellata* (L.) Razafim. & B.Bremer	SING0255818
r	*Ixora congesta* Roxb.	SING0298503
r	*Lasianthus hirsutus* (Roxb.) Merr.	SING0012069; SING0012072
x	*Ophiorrhiza singapurensis* Ridl.	SING0030393; SING0030397
r	*Oxyceros longiflorus* (Lam.) T.Yamaz.	SING0030410
x	*Psychotria griffithii* Hook.f.	SING0012133; SING0012138; SING0012139
x	*Spermacoce hispida* L.	SING0072453
x	*Uncaria acida* (W.Hunter) W.Hunter ex Roxb. var. *acida*	SING0030706; SING0030716
r	*Uncaria lanosa* Wall. var. *glabrata* (Blume) Ridsdale	Goodenough, J.S. s.n. 1891; Ridley H.N. 5671
x	*Urophyllum streptopodium* Wall. ex Hook.f.	SING0231909
	Family Rutaceae	
r	*Clausena excavata* Burm.f.	SING0025296
	Family Sapindaceae	
r	*Lepisanthes rubiginosa* (Roxb.) Leenh.	SING0025463
r	*Mischocarpus sundaicus* Blume	SING0025474
	Family Sapotaceae	
r	*Planchonella obovata* (R.Br.) P	SING0259634
	Family Urticaceae	
x	*Poikilospermum cordifolium* (Barg.-Petr.) Merr.	(Ridley 1900)
r	*Poikilospermum suaveolens* (Blume) Merr.	SING0026639
	Family Zingiberaceae	
x	*Hornstedtia leonurus* (J.Koenig) Retz.	SING0034091

Diversity of spiders (Araneae) in Pulau Ubin, Singapore

Paul Ng[1], Christina Choy[2], Liew Qi[2]* & Chris Ang[3]

[1]205 River Valley Road, #16-53, Singapore 238274
[2]National Parks Board, Singapore Botanic Gardens, 1 Cluny Road, Singapore 259569
[3]chris_angsp@yahoo.com.sg
* Corresponding author: liew_qi@nparks.gov.sg

ABSTRACT. Spider fauna was surveyed across different habitats within Pulau Ubin from June 2018 to February 2020. Sampling was conducted by visual searches of foliage over a fixed duration both by day and by night and was supplemented with the shaking of foliage to dislodge spiders which may otherwise have been well hidden in foliage. A total of 173 morphospecies were distinguished from this survey, of which 91 were identifiable to a published binomial while others were assigned to an informal species-level category matching names used for other collections in the region. Six are new records to Singapore. Eleven specimens are not yet identified to the species level and have the potential to represent eight new records to science. The total spider fauna on Pulau Ubin is likely to be much greater with increased sampling as well as use of other sampling methods such as leaf litter sieving to obtain ground spider specimens.

Keywords. Arachnida, biodiversity, conservation

Introduction

There is no equivalent catalogue of spider diversity on Pulau Ubin. Records so far have been based on opportunistic hand sampling and mentioned briefly in a field manual on Singapore spiders (Koh 1989). Other than spider diversity, only the mating and ballooning behaviours for nephilid spiders from Pulau Ubin have been studied in detail by Kuntner et al. (2009) and Lee et al. (2015).

Despite the lack of consistent long-term sampling efforts, it is hypothesised that there would be considerable diversity of spiders on Pulau Ubin, since it comprises many different habitats. In addition, casual collections of spiders have yielded new species. For instance, *Cantikus ubin* has been newly described from Pulau Ubin (Huber et al. 2016, 2018).

This survey to sample the spiders of Pulau Ubin was therefore organised as part of the Comprehensive Ubin Biodiversity Survey (CUBS) initiated by the National Parks Board. The main objective of the survey was to establish a preliminary checklist to highlight the diversity of spiders on Pulau Ubin and to allow future temporal and spatial comparisons for long-term monitoring.

Materials and Methods

Sampling sites

Although much of the island's original 'lowland rain forest and mature mangrove forest' (Turner et al. 1992) was initially cleared for granite quarrying, prawn farming and growing rubber, coconut, fruits and other cash crops in the early 20th century, many areas have been reclaimed by secondary forest regrowth with the reduction of local populace and cessation of human disturbance (Tan 2018, Yong et al. 2017). The island's rustic nature has not only attracted much wildlife but is also well-liked by visitors for nature recreational activities at managed trails such as the Sensory Trail, Butterfly Hill and Murai Trail. With these different habitats across Pulau Ubin, eleven sites ranging from mangrove forest, grassland, rubber plantation, brackish pond, managed vegetation to secondary forest (Fig. 1) were selected for sampling. At one of the sites, Chek Jawa, three sub-plots (1, 2 and 3) were sampled, making a total of 13 sampling sites.

Sampling sessions and methods

The survey used an adapted protocol employed in a similar study on the spider diversity at Bukit Timah Nature Reserve, Singapore (Koh & Court, 2019). Between June 2018 and February 2020, a total of 23 sampling sessions were carried out at the sampling sites. Of the 13 sampling sites, ten were sampled once each in a day session (between 0900 hrs and 1200 hrs) and a night session (between 1900 hrs and 2200 hrs). During each sampling session, the survey leader ensured the availability of a minimum of four Surveyors, and Surveyors worked in either pairs or trios. Bukit Melayu, and Chek Jawa sites 2 and 3 were only sampled in the day session because of delays caused by manpower constraints and wet weather.

Methods such as fogging and sweep netting were not utilised in this survey as they are indiscriminate and more impactful. Leaf litter sieving was also not utilised due to time constraints; hence, spiders were only collected at ground level and above using the following repeatable and consistent steps.

- Visual search (day session): Surveyors searched for and collected specimens along a linear transect for a 30-minute period.

- Vegetation shaking over an inverted umbrella (day session): Surveyors shook 20 clusters of foliage and branches and collected specimens which were dislodged and fell into the inverted umbrella.

- Visual search (night session): Surveyors, aided with headlamps and/or torch lights, searched and collected specimens along a linear transect for a 30-minute period.

Other than highly recognisable adult specimens which can be confidently identified to species level on site, Surveyors collected most of the spiders including juveniles in individual containers and vials for subsequent identification.

Identification and field records

Collected specimens were identified to the lowest possible taxonomic level by Paul Ng, Chris Ang and Liew Qi at either the Ubin Volunteer Hub or Ubin Living Lab, whereas specimens which required closer examination or to be photographed were taken back to mainland Singapore for identification by Joseph K.H. Koh. The names used in Appendix I follow those listed in the volume by Koh et al. (2022).

For undetermined adult specimens, the following nomenclature procedures were adopted for addition to the spider master database maintained by Joseph Koh:

- Where a morphologically distinct adult specimen could not be positively identified down to the species level, but where its generic affiliation was clear, it was counted as a morphospecies of that genus, e.g., "*Clubiona* sp. PU" where PU is a double-letter code of its nickname or locality, e.g., "Pulau Ubin".

- Where even the generic affiliation could not be determined, then it was counted as a morphospecies of a particular family, usually with a nickname.

- While identification of juveniles in many cases was difficult, juveniles in the samples were still counted to obtain a better sense of abundance and species diversity. This was important as juveniles often made up a large component of many of the samples. In addition, some juveniles could be determined down to species level, and to leave them out would have distorted abundance figures. The possibility of matching juveniles with identified adults using molecular analysis techniques is being explored.

Custody of Specimens
All specimens brought to Joseph Koh for identification were preserved in 70% ethyl alcohol. After processing, all specimens will be deposited at the Lee Kong Chian Natural History Museum, National University of Singapore.

Results

Overall family diversity and species richness
A total of 173 species from 21 families were identified. These are shown in the checklist in Appendix I. All the families have been previously recorded from elsewhere in Singapore (Song et al., 2002).

Notable finds
Among the specimens identified so far, six are new records to Singapore. The six species are *Serendib muadai*, *Hersilia sundaica, Phintella lepidus, Tetragnatha ceylonica, Dipoena turriceps,* and *Meotipa picturata*. These are pictured in Fig. 2.

Piranthus kohi is a new species of jumping spider which was described based on a specimen collected in Pulau Ubin. The female is notable for the bright reddish-orange colour on its front two pairs of legs. The species was first collected in Brunei in 2012 and has since been found in coastal areas of Singapore such as Sungei Buloh Wetland Reserve and mangroves in Lim Chu Kang. At the time of those earlier sightings, the spider was thought to belong to the genus *Bavia*. Upon closer examination it was discovered that the Ubin specimen was an entirely new species.

Eleven spider specimens cannot be identified to species level at this stage of investigation. Of these, eight cannot be placed under any of the species already described or recorded from Singapore or nearby countries. These specimens may be new to science and will be investigated further. Some of them are pictured in Fig. 3.

Similarities and differences across sampling sites
There were no striking associations between total captures versus habitat, nor between total species versus habitat. Old rubber plantation sites included the highest number of species per site (57 species) but also the equal lowest (27 species, in common with the grassland site). The three sites in old rubber plantation yielded 28, 42 and 63 individuals, with respectively 27, 31 and 57 species, while three sites in mangroves yielded 36, 41 and 65 individuals with respectively 31, 36 and 43 species. Three habitat types (brackish ponds, grasslands and

managed shrubs) were each represented by only one site, offering minimal scope for habitat comparisons. Evidently, sampling intensity was insufficient to distinguish overall species richness between habitats.

Many species were represented by only one (67 species), two (36 species) or three individuals each (24 species). Together, these formed 127 or more than 73% of all the 173 species found. Only three species (fewer than 2%) were represented by more than ten individuals each. With such under-sampling, it is only at the species level that there are hints of habitat specialisation. For example, there was good representation across the three mangrove sites of species such as *Araneus mitificus* (Simon, 1886), *Asianopis* cf. *liukuensis* (Yin, Griswold & Yan, 2002), *Hygropoda* sp. ML (Mangrove Large), *Nilus* sp. VP (Variegated Pattern), *Tetragnatha josephi* Okuma, 1998, *Lycopus rubropictus* (Workman, 1896) and *Uloborus plumipes* (Lucas, 1846) – even if more intensive sampling in future might show that they are not completely confined to a single habitat type.

Fig. 4 suggests no geographical pattern in the richness of the spider fauna across sites. The richest site was in old rubber in the extreme east of Pulau Ubin, followed by mangroves at nearby Chek Jawa and managed shrubs in the centre of Pulau Ubin at Butterfly Hill. But Chek Jawa was more intensively sampled than the other ten localities (four surveys at three sub-plots, compared with the usual two surveys at one locality) so the results are not exactly comparable.

Discussion

The survey provides an interim and provisional assessment of the spider fauna in Pulau Ubin; the list remains to be expanded with ongoing taxonomic work and much greater sampling intensity. Due to manpower constraints, we were unable to sample all habitats and all strata within each habitat. Among the work to be done are the following tasks:

- Using leaf litter sieving and fogging to sample specimens in the leaf litter and higher canopy respectively

- Having more sampling sites

The more intensive study of the spider fauna in Bukit Timah Nature Reserve (Koh & Court, 2019) yielded more than 3,000 specimens of at least 317 species and morphospecies, with 25 new species records for Singapore. The sampling there was done by greater manpower over a longer period, yielding a far greater series of duplicates (average 9.5 individuals per species found). The sampling therefore yielded more statistically robust results when analysed across only three habitat types (primary forest, old secondary forest, maturing secondary forest) rather than the smaller sample (492 individuals of 173 morphospecies) across six habitat types in Pulau Ubin. While acknowledging the intrinsic interest of a primary rainforest fauna, the two studies cannot be used to imply a poorer fauna in Pulau Ubin. On the contrary, the comparison indicates the scope and value of further studies to be done.

Some species that are new to science have been found in this survey, and some others are rare. Finding six new records for Singapore within a sample of fewer than 500 specimens, compared with 25 new records among 3,000 from Bukit Timah, suggests that there is great potential for finding more. The implications for management and conservation include (a) the importance of conserving examples of multiple habitat types, each of which is likely to support a partially distinct fauna, and (b) the importance of a network of sites that may conserve genetic diversity and allow the management of interconnected populations.

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Table 1. Coordinates and habitat types of sites in Pulau Ubin selected for sampling. The sequence of listing follows the arrangement of columns in the checklist in the Appendix.

Location	Coordinates		Habitat type	Survey dates
	N	E		
Butterfly Hill	01.402053	103.967837	Managed shrubs	27 Aug 2018, 28 Sep 2018
Chek Jawa	01.411040	103.990419	Mangrove	5 Jun 2018, 24 Aug 2018, 25 Mar 2019, 21 Feb 2020
Jalan Noordin ponds	01.414385	103.969064	Brackish ponds	27 Aug 2018, 28 Sep 2018
Murai Trail	01.412902	103.974439	Rubber plantation	5 Jun 2018, 24 Aug 2018
Western forest	01.422626	103.936271	Secondary forest	22 Oct 2018, 22 Feb 2019
Ubin Living Lab (ULL)	01.408084	103.955069	Grassland	22 Oct 2018, 22 Feb 2019
Sensory Trail	01.404566	103.972942	Back mangroves	25 Mar 2019, 31 May 2019
Noordin Bridge	01.411941	103.966290	Mangrove	31 May 2019, 14 Jun 2019
Bukit Melayu	01.409399	103.982564	Rubber plantation	14 Jun 2019
Puaka Hill	01.406978	103.958433	Secondary forest	19 Jul 2019, 24 Sep 2019
Balai Quarry	01.417610	103.987150	Rubber plantation	19 Jul 2019, 24 Sep 2019

Figures

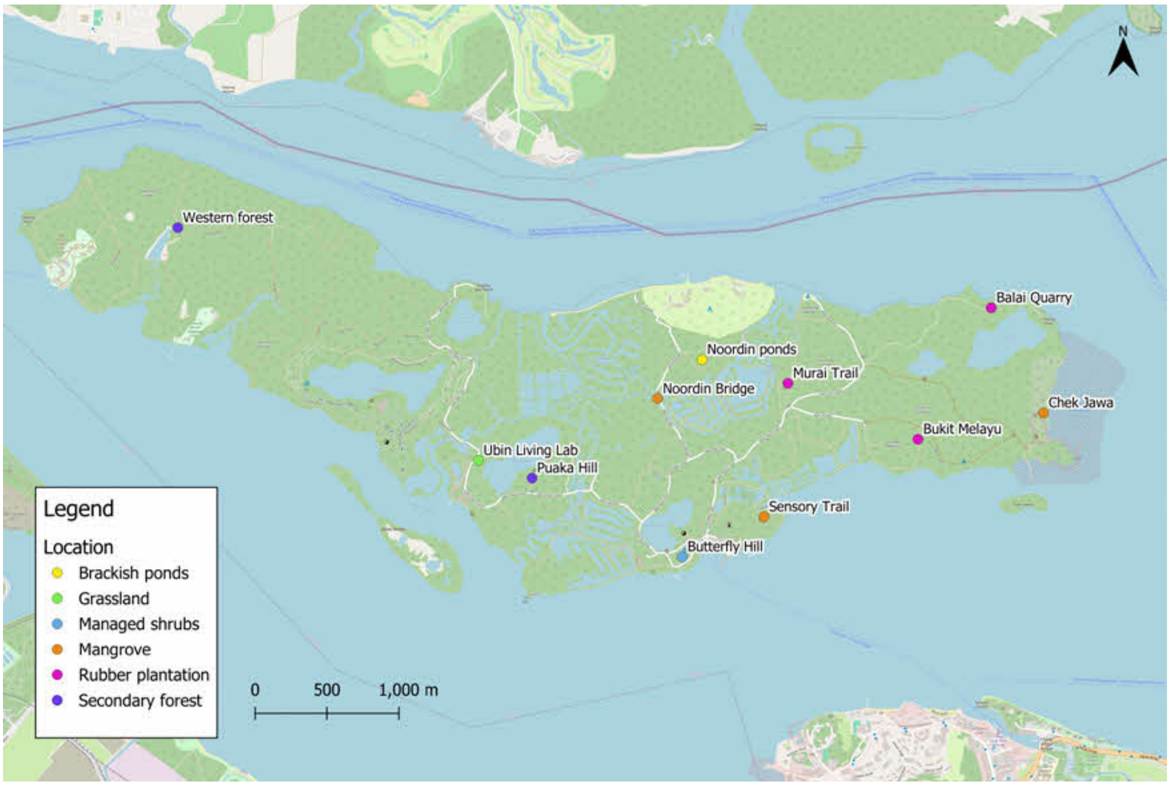

Fig. 1 Map of the sites in Pulau Ubin selected for sampling of the spider fauna.

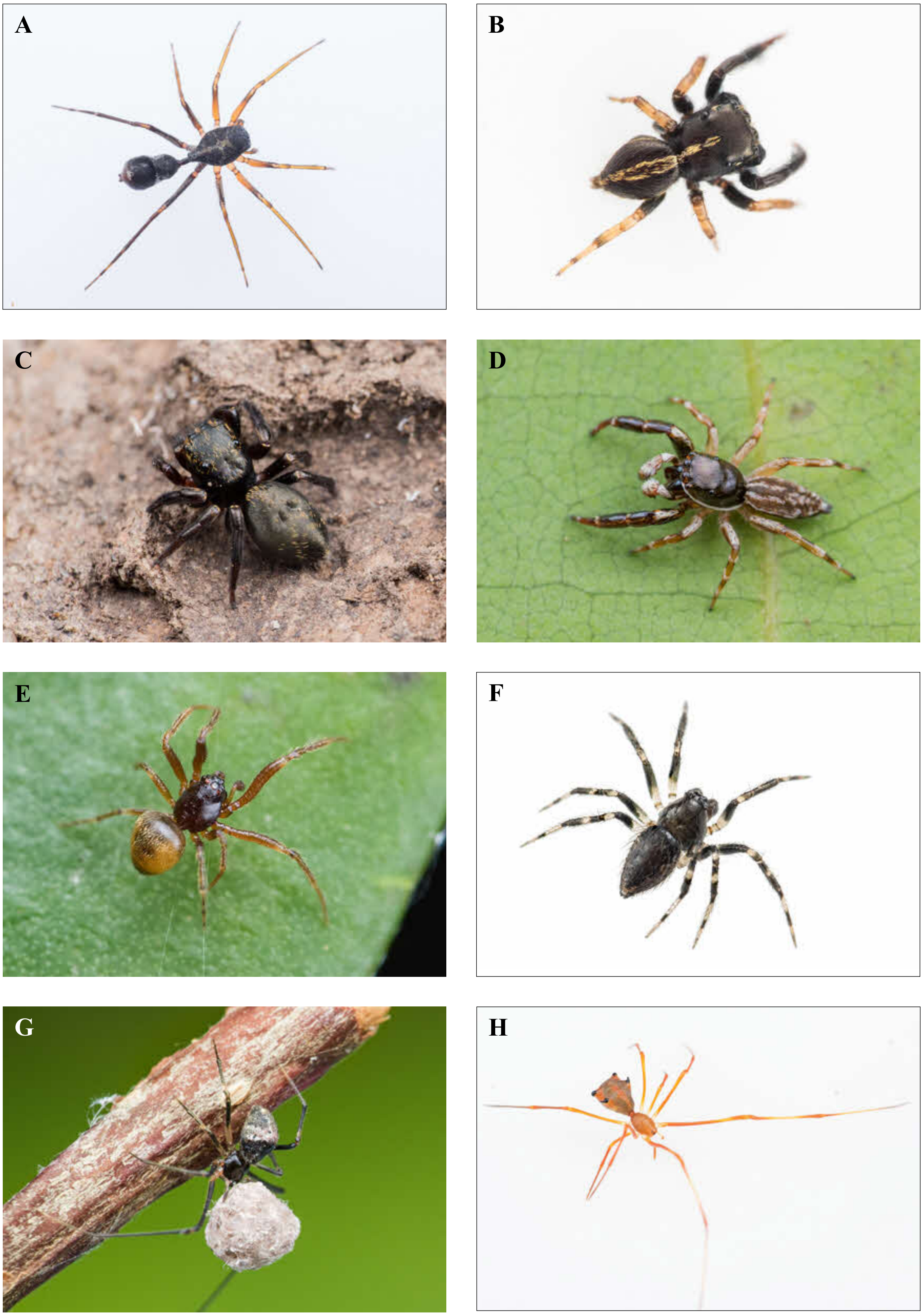

Fig. 2 Examples of some species possibly new to science from the survey. **A.** *Aetius* sp. **B.** *Junxattus* sp. GD "Golden Stripe" **C.** *Orcevia* sp. GD "Golden Bark" **D.** *Psenuc* sp. **E.** *Allothymoites* sp. CO "Cushion Abdomen" **F.** *Emertonella* sp. *SS* "Small Silver" **G.** *Platnickina* sp. BN "Black Ninja" **H.** *Propostira* sp. FT "Four Tubercles" (Photos: Ng, P. & Ang, C.)

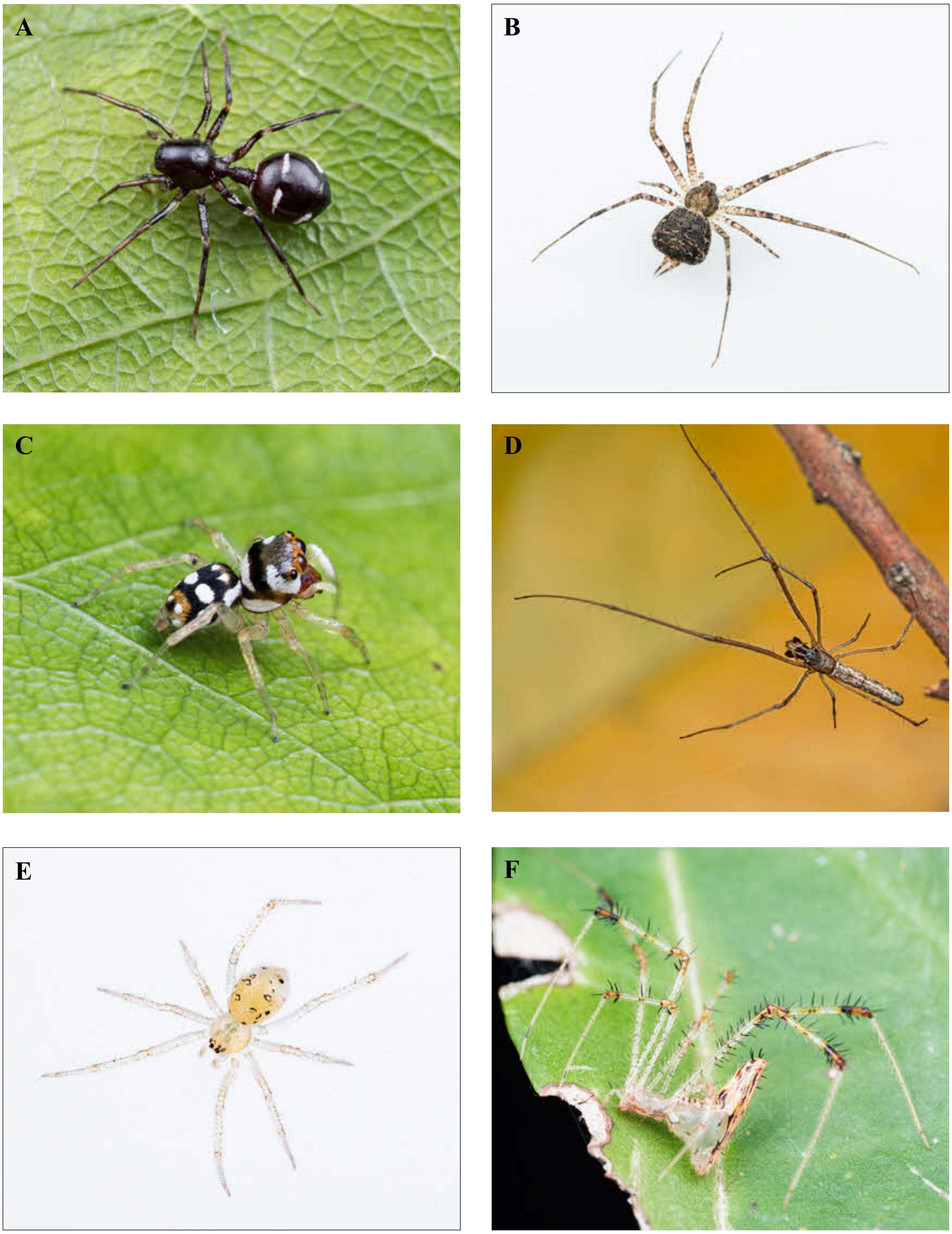

Fig. 3 Examples of some new records for Singapore from the survey. **A.** *Serendib muadai* **B.** *Hersilia sundaica* **C.** *Phintella lepidus* **D.** *Tetragnatha ceylonica* **E.** *Dipoena turriceps* **F.** *Meotipa picturata* (Photos: Ng, P. & Ang, C.)

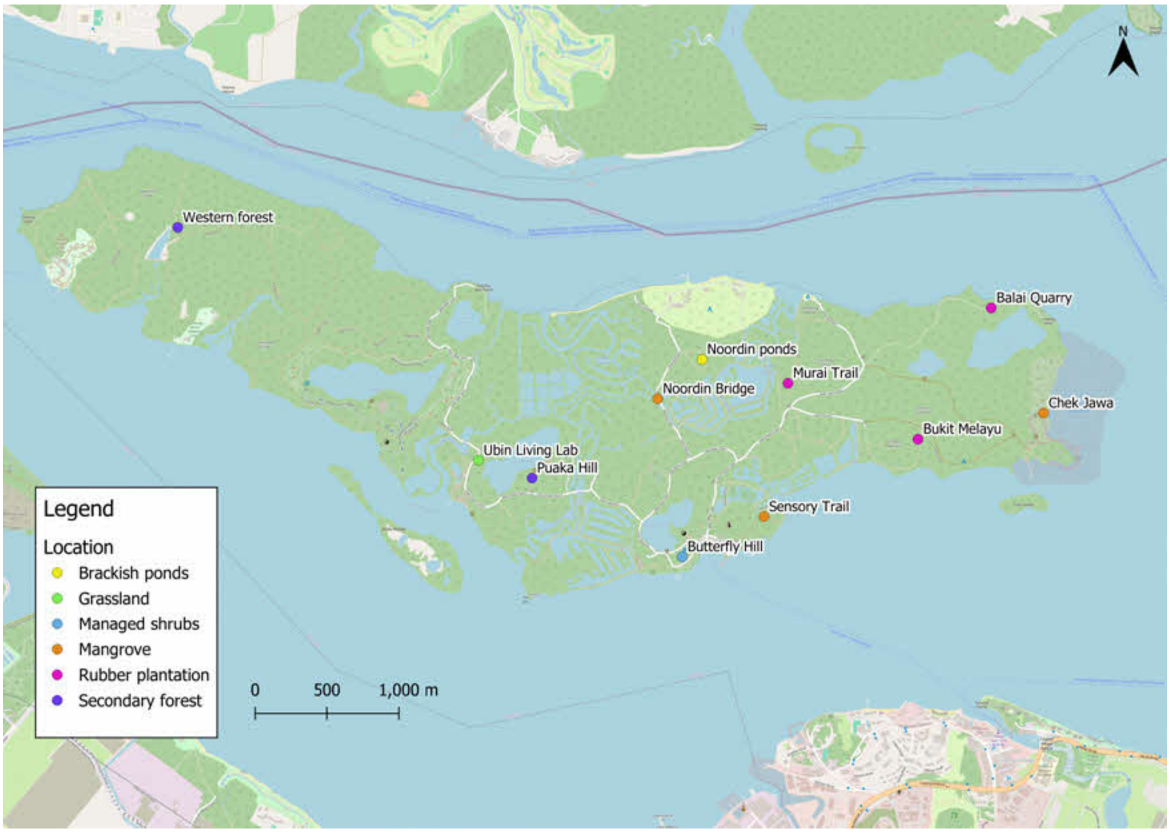

Fig. 4 Species abundance at sites.

Appendix I. List of spiders in Pulau Ubin

Family	**Genus, Species** (day and night sampling, including immature)	**New record for Singapore?**	**Survey site and survey dates**											**No. of specimens collected**	**No. of sites recorded**
			Butterfly Hill	**Chek Jawa**	**Jalan Noordin**	**Murai Trail**	**Western forest**	**ULL**	**Sensory Trail**	**Noordin Bridge**	**Bukit Melayu**	**Puaka Hill**	**Balai Quarry**		
			Managed shrubs	Man-grove	Brackish ponds	Rubber	Second-ary forest	Grass	Man-grove	Man-grove	Rubber	Sec-ondary forest	Rubber		
Araneidae	*Araneus mitificus* (Simon, 1886)			2					1	1				4	3
	Araneus nox (Simon, 1877)										1			1	1
	Arachnura sp.												1	1	1
	Argiope versicolor (Doleschall, 1859)					1		1						2	2
	Argiope sp. (juveniles or unidentifiable)							1				1	1	3	3
	Chorizopesoides wulingensis (Yin, Wang &Xie, 1994)							1						1	1
	Cyphalanotus selangor (Dzulhelmi, 2015)		1											1	1
	Cyrtarachne inaequalis Thorell, 1895		2											2	1
	Cyrtophora cylindroides (Walckenaer, 1841)			1										1	1

Appendix I. Continuation

Family	**Genus, Species** (day and night sampling, including immature)	**New record for Singapore?**	**Survey site and survey dates**											**No. of specimens collected**	**No. of sites recorded**
			Butterfly Hill	**Chek Jawa**	**Jalan Noordin**	**Murai Trail**	**Western forest**	**ULL**	**Sensory Trail**	**Noordin Bridge**	**Bukit Melayu**	**Puaka Hill**	**Balai Quarry**		
			Managed shrubs	Man-grove	Brackish ponds	Rubber	Second-ary forest	Grass	Man-grove	Man-grove	Rubber	Sec-ondary forest	Rubber		
	Cyrtophora unicolor (Doleschall, 1857)						1							1	1
	Cyrtophora beccarii (Thorell, 1878)						1							1	1
	Eriovixia laglaizei (Simon, 1877)		1		1	1	1		1	1		1	1	8	8
	Eriovixia pseudocentrodes (Bösenberg & Strand, 1906)						1		1	1				3	3
	Eriovixia cf. *pseudocentrodes*							1						1	1
	Eriovixia sp. (juveniles or unidentifiable)		2	1	1			1	1	1		1	1	9	8
	Gea spinipes (C. L. Koch, 1843)										1			1	1
	Herennia multipuncta (Doleschall, 1859)			1					1		1			3	3
	Neoscona vigilans (Blackwall, 1865)		2				1		1				1	5	4

Appendix I. Continuation

Family	Genus, Species (day and night sampling, including immature)	New record for Singapore?	Survey site and survey dates											No. of specimens collected	No. of sites recorded
			Butterfly Hill	**Chek Jawa**	**Jalan Noordin**	**Murai Trail**	**Western forest**	**ULL**	**Sensory Trail**	**Noordin Bridge**	**Bukit Melayu**	**Puaka Hill**	**Balai Quarry**		
			Managed shrubs	Man-grove	Brackish ponds	Rubber	Second-ary forest	Grass	Man-grove	Man-grove	Rubber	Sec-ondary forest	Rubber		
	Nephilengys malabarensis (Walckenaer, 1841)			2	1					1	1			5	4
	Nephila pilipes (Fabricius, 1793)					1	1	1						3	3
	Singa perpolita (Thorell, 1892)						1							1	1
	Parawixia dehaani (Doleschall, 1859)							1	1				2	4	3
	Poltys illepidus (C.L. Koch, 1843)		1					1	1	1		1	2	7	6
	Zygiella calyptrata (Workman & Workman, 1894)		2	1									1	4	4
Clubionidae			1	1		2	1				1		1	7	6
	Clubiona sp. (juvenile or unidentifiable)		1		2									3	2
	Clubiona sp. RB “Robust Bronze”									1				1	1
	Clubiona sp. TY (Translucent Yellow)									1				1	1

Appendix I. Continuation

Family	**Genus, Species** (day and night sampling, including immature)	**New record for Singapore?**	**Survey site and survey dates**											**No. of specimens collected**	**No. of sites recorded**
			Butterfly Hill	**Chek Jawa**	**Jalan Noordin**	**Murai Trail**	**Western forest**	**ULL**	**Sensory Trail**	**Noordin Bridge**	**Bukit Melayu**	**Puaka Hill**	**Balai Quarry**		
			Managed shrubs	Man-grove	Brackish ponds	Rubber	Second-ary forest	Grass	Man-grove	Man-grove	Rubber	Sec-ondary forest	Rubber		
Corinnidae	*Aetius* sp.	Likely undescribed										1		1	1
	Corinnomma sp. (juveniles or unidentifiable)		1						3	1		1	1	7	5
	Corinnomma javanum (Simon, 1905)					2								2	1
	Corinnomma severum (Thorell, 1877)											1	1	2	2
	Echinax oxyopides (Deeleman-Reinhold, 1995)										1	1		2	2
	Medmassa (juveniles or unidentifiable)					1								1	1
	Serendib muadai Jäger, Nophaseud & Praxaysombath, 2012	New record											1	1	1
Deinopidae	*Asianopis* cf. *liukuensis* (Yin, Griswold & Yan, 2002)			1					1	1				3	3

Appendix I. Continuation

Family	**Genus, Species** (day and night sampling, including immature)	**New record for Singapore?**	**Survey site and survey dates**											**No. of specimens collected**	**No. of sites recorded**
			Butterfly Hill	**Chek Jawa**	**Jalan Noordin**	**Murai Trail**	**Western forest**	**ULL**	**Sensory Trail**	**Noordin Bridge**	**Bukit Melayu**	**Puaka Hill**	**Balai Quarry**		
			Managed shrubs	Man-grove	Brackish ponds	Rubber	Second-ary forest	Grass	Man-grove	Man-grove	Rubber	Sec-ondary forest	Rubber		
Gnaphosidae	*Hitobia* sp. WT "Wavy Tapir"									1				1	1
Hersilidae	*Hersilia sundaica* (Baehr & Baehr, 1993)	New record	1			1								2	2
	Hersilia sp. (juveniles or unidentifiable)			1		1					1			3	3
Liocranidae	*Oedignatha scrobiculata* (Thorell, 1881)					1							1	2	2
Lycosidae	*Hippasa holmerae* (Thorell, 1895)									1			1	2	2
	Pardosa sumatrana (Thorell, 1890)			1	1	2								4	3
	Pardosa pusiola (Thorell, 1891)						1			1				2	2
	Pardosa sp. (juveniles or unidentifiable)		2	1	1	1	1		1		1	1	1	10	9
	Venonia coruscans (Thorell, 1894)				1	1	1							3	3

Appendix I. Continuation

Family	**Genus, Species** (day and night sampling, including immature)	**New record for Singapore?**	**Survey site and survey dates**											**No. of specimens collected**	**No. of sites recorded**
			Butterfly Hill	**Chek Jawa**	**Jalan Noordin**	**Murai Trail**	**Western forest**	**ULL**	**Sensory Trail**	**Noordin Bridge**	**Bukit Melayu**	**Puaka Hill**	**Balai Quarry**		
			Managed shrubs	Man-grove	Brackish ponds	Rubber	Second-ary forest	Grass	Man-grove	Man-grove	Rubber	Sec-ondary forest	Rubber		
Oxyopidae	*Hamataliwa incompta* (Thorell, 1895)		1											1	1
	Hamataliwa (juveniles or unidentifiable)												1	1	1
	Hamadruas sp. JB “Jogya Batik”											1		1	1
	Hamadruas sp. (juveniles or unidentifiable)				2				1		1	1		5	4
	Oxyopes birmanicus (Thorell, 1887)		1						1	1				3	3
	Oxyopes quadridentatus (Thorell, 1895)			6										6	1
	Oxyopes lineatipes (C. L. Koch, 1847)			1				1					1	3	3
Psechridae	*Fecenia ochracea* (Doleschall, 1859)						1					1	1	3	3
Pisauridae	*Dendrolycosa* cf. *robusta* (Thorell, 1895)			1	1		1							3	3

Appendix I. Continuation

Family	**Genus, Species** (day and night sampling, including immature)	**New record for Singapore?**	**Survey site and survey dates**											**No. of specimens collected**	**No. of sites recorded**
			Butterfly Hill	**Chek Jawa**	**Jalan Noordin**	**Murai Trail**	**Western forest**	**ULL**	**Sensory Trail**	**Noordin Bridge**	**Bukit Melayu**	**Puaka Hill**	**Balai Quarry**		
			Managed shrubs	Mangrove	Brackish ponds	Rubber	Secondary forest	Grass	Mangrove	Mangrove	Rubber	Secondary forest	Rubber		
	Hygropoda sp. ML (Mangrove Large)			2							1			3	2
	Nilus sp. VP (Variegated Pattern)			5										5	1
Pholcidae	*Belisana* sp. PS (Pond Spotted)		1			1		1						3	3
	Cantikus ubin (Huber, 2016)								1		1		1	3	3
	Leptopholcus borneensis Deeleman-Reinhold, 1986												1	1	1
	Leptopholcus podophthalmus (Simon, 1893)						1							1	1
	Nipisa phyllicola (Deeleman-Reinhold, 1986)					3								3	1
	Pholcus ubin (Huber, 2016)					1								1	1
	Pholcus gracillimus (Thorell, 1890)				1									1	1
	Pholcidae (juveniles or unidentifiable)				1		1							2	2

Appendix I. Continuation

Family	**Genus, Species** (day and night sampling, including immature)	**New record for Singapore?**	**Survey site and survey dates**											**No. of specimens collected**	**No. of sites recorded**
			Butterfly Hill	**Chek Jawa**	**Jalan Noordin**	**Murai Trail**	**Western forest**	**ULL**	**Sensory Trail**	**Noordin Bridge**	**Bukit Melayu**	**Puaka Hill**	**Balai Quarry**		
			Managed shrubs	Mangrove	Brackish ponds	Rubber	Secondary forest	Grass	Mangrove	Mangrove	Rubber	Secondary forest	Rubber		
Salticidae	*Anarrhotus fossulatus* (Simon, 1902)						1				1	1	1	4	4
	Anarrhotus sp. BH "Bronze Hairy"							1						1	1
	Bavia sexpunctata (Doleschall, 1859)			1	1						1			3	3
	Carrhotus cf. *xanthogramma* (Latreille, 1819)		2										1	3	2
	Chalcotropis sp. HB "House Big"		1					1						2	2
	Cocalus murinus (Simon, 1899)		1											1	1
	Cosmophasis thalassina (C. L. Koch, 1846)		1						1	2			1	5	4
	Cytaea oreophila (Simon, 1902)			1	1			1					1	4	4
	Epeus flavobilineatus (Doleschall, 1859)			2	1		1		1	1	1			7	6
	Epeus sp. (juveniles or unidentifiable)		1				1					3	1	6	4

Appendix I. Continuation

Family	Genus, Species (day and night sampling, including immature)	New record for Singapore?	Survey site and survey dates											No. of specimens collected	No. of sites recorded
			Butterfly Hill	**Chek Jawa**	**Jalan Noordin**	**Murai Trail**	**Western forest**	**ULL**	**Sensory Trail**	**Noordin Bridge**	**Bukit Melayu**	**Puaka Hill**	**Balai Quarry**		
			Managed shrubs	Man-grove	Brackish ponds	Rubber	Second-ary forest	Grass	Man-grove	Man-grove	Rubber	Sec-ondary forest	Rubber		
	Epocilla calcarata (Karsch, 1880)								1					1	1
	Harmochirus brachiatus (Thorell, 1877*)*										1	1		2	2
	Hyllus diardi (Walckenaer, 1837)									1				1	1
	Junxattus sp. GD "Golden Stripe"	Likely undescribed											1	1	1
	Ligurra latidens (Doleschall, 1859)												1	1	1
	Menemerus bivittatus (Dufour, 1831)									1	1			2	2
	Myrmarachne acromegalis (Yamasaki & Ahmad, 2013)			1										1	1
	Myrmarachne cornuta (Badcock, 1917)				1		1					1		3	3
	Myrmarachne melanocephala (MacLeay, 1839)				1						1		1	3	3

Appendix I. Continuation

Family	**Genus, Species** (day and night sampling, including immature)	**New record for Singapore?**	**Survey site and survey dates**											**No. of specimens collected**	**No. of sites recorded**
			Butterfly Hill	**Chek Jawa**	**Jalan Noordin**	**Murai Trail**	**Western forest**	**ULL**	**Sensory Trail**	**Noordin Bridge**	**Bukit Melayu**	**Puaka Hill**	**Balai Quarry**		
			Managed shrubs	Mangrove	Brackish ponds	Rubber	Secondary forest	Grass	Mangrove	Mangrove	Rubber	Secondary forest	Rubber		
	Myrmarachne sp. (juveniles or unidentifiable)		2	3				2	2	3				12	5
	Orcevia sp. GD "Golden Bark"	Likely undescribed										2		2	1
	Pancorius (juvenile or unidentifiable)												1	1	1
	Parabathippus (juvenile or unidentifiable)		1											1	1
	Phaeacius malayensis (Wanless, 1981)					1		1				1		3	3
	Phintella vittata (C.L. Koch, 1846)											1	1	2	2
	Phintella lepidus Cao & Li, 2016	Yes					1						1	2	2
	Phintella (juveniles or unidentifiable)									1				1	1
	Piranthus kohi												1	1	1
	Portia labiata (Thorell, 1887)		1				1		1					3	3
	Ptocasius weyersi (Simon, 1885)					2					1			3	2

Appendix I. Continuation

Family	**Genus, Species** (day and night sampling, including immature)	**New record for Singapore?**	**Survey site and survey dates**											**No. of specimens collected**	**No. of sites recorded**
			Butterfly Hill	**Chek Jawa**	**Jalan Noordin**	**Murai Trail**	**Western forest**	**ULL**	**Sensory Trail**	**Noordin Bridge**	**Bukit Melayu**	**Puaka Hill**	**Balai Quarry**		
			Managed shrubs	Man-grove	Brackish ponds	Rubber	Second-ary forest	Grass	Man-grove	Man-grove	Rubber	Sec-ondary forest	Rubber		
	Psenuc sp. MP "Mangrove Painted"	Likely undescribed								1				1	1
	Siler semiglaucus (Simon, 1901)								1	1			1	3	3
	Spartaeus spinimanus (Thorell, 1878)					1								1	1
	Telamonia festiva (Thorell, 1887)		1											1	1
	Telamonia sp. (Juveniles or unidentifiable)		1					1		1				3	3
	Thiania bhamoensis (Thorell 1887)		1		1		1	1				1	1	6	6
	Toxeus maxillosus C. L. Koch, 1846							1						1	1
	Toxeus cf. *maxillosus*							1						1	1
	Viciria praemandibularis (Hasselt, 1893)		1	1	1	1	1				1	1	1	8	8

Appendix I. Continuation

Family	Genus, Species (day and night sampling, including immature)	New record for Singapore?	Survey site and survey dates											No. of specimens collected	No. of sites recorded
			Butterfly Hill	Chek Jawa	Jalan Noordin	Murai Trail	Western forest	ULL	Sensory Trail	Noordin Bridge	Bukit Melayu	Puaka Hill	Balai Quarry		
			Managed shrubs	Man-grove	Brackish ponds	Rubber	Second-ary forest	Grass	Man-grove	Man-grove	Rubber	Sec-ondary forest	Rubber		
Scytodidae	*Scytodes fusca* (Walckenaer, 1837)			1	1	1			1			1	1	6	6
	Scytodes pallida (Doleschall, 1859)		1			1								2	2
	Scytodes sp. (juveniles or unidentifiable)		1								1	1	2	5	4
Sparassidae	*Gnathopalystes* (juveniles or unidentifiable)					1		1						2	2
	Heteropoda sp. SB "Small Banded"			1										1	1
	Heteropoda (juveniles or unidentifiable)			1	1					1		1	1	5	5
	Heteropoda venatoria (Linnaeus, 1767)		1	1	1				1	1				5	5
	Olios sp. CY "Common Yoga"		1						1	2		1	1	6	5
	Pandercetes sp. LG "Lichen Green"		1		2	1	1		2			1	1	9	7
	Pandercetes sp. HB "Hairy Brown"			1										1	1

Appendix I. Continuation

Family	Genus, Species (day and night sampling, including immature)	New record for Singapore?	Survey site and survey dates											No. of specimens collected	No. of sites recorded
			Butterfly Hill	**Chek Jawa**	**Jalan Noordin**	**Murai Trail**	**Western forest**	**ULL**	**Sensory Trail**	**Noordin Bridge**	**Bukit Melayu**	**Puaka Hill**	**Balai Quarry**		
			Managed shrubs	Man-grove	Brackish ponds	Rubber	Second-ary forest	Grass	Man-grove	Man-grove	Rubber	Sec-ondary forest	Rubber		
	Thelcticopis sp. (juveniles or unidentifiable)				1							1		2	2
Tetragnathidae	*Guizygiella nadleri* (Heimer, 1984)		1											1	1
	Leucauge (juveniles or unidentifiable)				1								1	2	2
	Tetragnatha josephi Okuma, 1998			3						2				5	2
	Tetragnatha (juveniles or unidentifiable)			1				1						2	2
	Tetragnatha hasselti Thorell, 1890				2									2	1
	Tetragnatha ceylonica O. Pickard-Cambridge, 1869	New record		1										1	1
	Tylorida ventralis (Thorell, 1877)		1	1		1	1		1	1				6	6

Appendix I. Continuation

Family	Genus, Species (day and night sampling, including immature)	New record for Singapore?	Survey site and survey dates											No. of specimens collected	No. of sites recorded
			Butterfly Hill	**Chek Jawa**	**Jalan Noordin**	**Murai Trail**	**Western forest**	**ULL**	**Sensory Trail**	**Noordin Bridge**	**Bukit Melayu**	**Puaka Hill**	**Balai Quarry**		
			Managed shrubs	Man-grove	Brackish ponds	Rubber	Second-ary forest	Grass	Man-grove	Man-grove	Rubber	Sec-ondary forest	Rubber		
Theridiidae	*Argyrodes flavescens* (O. Pickard-Cambridge, 1880)						1							1	1
	Argyrodes sp. (juveniles or unidentifiable)						1							1	1
	Allothymoites sp. CO "Cushion Abdomen"	Likely undescribed			1		1							2	2
	Anelosimus kohi (Yoshida, 1993)			1										1	1
	Anelosimus sp. FP "Former *parvulus*"		1										1	2	2
	Ariamnes sp. GT "Green Twig"				1									1	1
	Chrysso (juveniles or unidentifiable)		1	1					1	1	1	1		6	6
	Coscinida sp. GO "Ground Orange"												1	1	1
	Dipoena turriceps (Schenkel, 1936)	New record				1						1		2	2
	Emertonella sp. SS "Small Silver"	Likely undescribed		1			1							2	2

Appendix I. Continuation

Family	Genus, Species (day and night sampling, including immature)	New record for Singapore?	Survey site and survey dates											No. of specimens collected	No. of sites recorded
			Butterfly Hill	**Chek Jawa**	**Jalan Noordin**	**Murai Trail**	**Western forest**	**ULL**	**Sensory Trail**	**Noordin Bridge**	**Bukit Melayu**	**Puaka Hill**	**Balai Quarry**		
			Managed shrubs	Man-grove	Brackish ponds	Rubber	Second-ary forest	Grass	Man-grove	Man-grove	Rubber	Sec-ondary forest	Rubber		
	Janula triangularis (Yoshida & Koh, 2011)						2					1		3	2
	Janula sp. MF "Monkey Face"										2			2	1
	Janula (juveniles or unidentifiable)				1	1								2	2
	Meotipa picturata Simon, 1895	New record				1	1					1	1	4	4
	Nihonhimea mundula (L. Koch, 1872)				1	1	2							4	3
	Parasteatoda triangula (Yoshida, 1993)			2										2	1
	Parasteatoda sp. OM "Orange Male"						1							1	1
	Parasteatoda (juveniles or unidentifiable)			2	1		2		1	1	1		1	9	7
	Platnickina mneon (Boesenberg& Strand, 1906)											1		1	1
	Platnickina sp. BN "Black Ninja"	Likely undescribed			1								1	2	2

Appendix I. Continuation

Family	Genus, Species (day and night sampling, including immature)	New record for Singapore?	Survey site and survey dates											No. of specimens collected	No. of sites recorded
			Butterfly Hill	**Chek Jawa**	**Jalan Noordin**	**Murai Trail**	**Western forest**	**ULL**	**Sensory Trail**	**Noordin Bridge**	**Bukit Melayu**	**Puaka Hill**	**Balai Quarry**		
			Managed shrubs	Man-grove	Brackish ponds	Rubber	Second-ary forest	Grass	Man-grove	Man-grove	Rubber	Sec-ondary forest	Rubber		
	Propostira sp. FT "Four Tubercles"	Likely undescribed						1						1	1
	Phoroncidia sp. CJ "Creamy Gemstone"				1									1	1
	Phycosoma hana (Zhu, 1998)		1								1		2	4	3
	Rhomphaea labiata (Zhu & Song, 1991)		1	3	2	5	1		1		1	1		15	8
	Theridion t-notatum Thorell, 1895		2	1		2						2	1	8	5
	Theridion sp. RA "Red Abdomen"												1	1	1
	Thwaitesia sp. MS "Mirror Spider"						1					1		2	2
	Yunohamella sp. WL "White Line"											1		1	1
Thomisidae	*Amyciaea forticeps* (O.Pickard-Cambridge, 1873)		2		1				1	1				5	4
	Alcimocthes sp. TG "Tall Green"		1											1	1

Appendix I. Continuation

Family	**Genus, Species** (day and night sampling, including immature)	**New record for Singapore?**	**Survey site and survey dates**											**No. of specimens collected**	**No. of sites recorded**
			Butterfly Hill	**Chek Jawa**	**Jalan Noordin**	**Murai Trail**	**Western forest**	**ULL**	**Sensory Trail**	**Noordin Bridge**	**Bukit Melayu**	**Puaka Hill**	**Balai Quarry**		
			Managed shrubs	Man-grove	Brackish ponds	Rubber	Second-ary forest	Grass	Man-grove	Man-grove	Rubber	Sec-ondary forest	Rubber		
	Camaricus maugei (Walckenaer, 1837)						1							1	1
	Henriksenia hilaris (Thorell, 1877)							1						1	1
	Lycopus rubropictus (Workman, 1896)			1						1				2	2
	Monaeses sp. CB "Common Brown"												1	1	1
	Oxytate virens (Thorell, 1891)		1					1			1			3	3
	Pycnaxis krakatuaensis (Bristowe, 1931)							1						1	1
	Platythomisus sp. (unidentifiable or juvenile)											1		1	1
	Runcinia sp.		1											1	1
	Strigoplus albostriatus Simon, 1885				1							1		2	2
	Spilosynema sp. CG "Common Green"				1								1	2	2

Appendix I. Continuation

Family	Genus, Species (day and night sampling, including immature)	New record for Singapore?	Survey site and survey dates											No. of specimens collected	No. of sites recorded
			Butterfly Hill	**Chek Jawa**	**Jalan Noordin**	**Murai Trail**	**Western forest**	**ULL**	**Sensory Trail**	**Noordin Bridge**	**Bukit Melayu**	**Puaka Hill**	**Balai Quarry**		
			Managed shrubs	Man-grove	Brackish ponds	Rubber	Second-ary forest	Grass	Man-grove	Man-grove	Rubber	Sec-ondary forest	Rubber		
	Tarrocanus sp. OT "Ocular Tubercles"			1										1	1
	Thomisus callidus (Thorell, 1890)			1										1	1
	Thomisus sp. (juveniles or unidentifiable)		5							1			1	7	3
	Tmarus sp. TS "Triple Streaked"		5	1				1	2	1	1		2	13	7
Trachelidae	*Utivarachna phyllicola*												1	1	1
Uloboridae	*Uloborus plumipes* (Lucas, 1846)			2						1				3	2
	Uloborus sp. CO "Chocolate Orange"												2	2	1
	Miagrammopes oblongus Yoshida, 1982												1	1	1
	Miagrammopes sp. BC "Brown Cigar"									1			1	2	2
	Miagrammopes (juveniles or unidentifiable)						3	1	1					5	3

Appendix I. Continuation

Family	Genus, Species (day and night sampling, including immature)	New record for Singapore?	Survey site and survey dates											No. of specimens collected	No. of sites recorded
			Butterfly Hill	Chek Jawa	Jalan Noordin	Murai Trail	Western forest	ULL	Sensory Trail	Noordin Bridge	Bukit Melayu	Puaka Hill	Balai Quarry		
			Managed shrubs	Man-grove	Brackish ponds	Rubber	Second-ary forest	Grass	Man-grove	Man-grove	Rubber	Sec-ondary forest	Rubber		
Zodariidae	*Mallinella allorostrata* (Dankittipakul, Jocque & Singtripop, 2012)					1								1	1
	Asceua sp. FS "Five Stripes"				1									1	1
Total no. of specimens at each survey site			62	65	42	42	43	28	36	41	28	42	63		
Total no. of species at each survey site			45	43	37	31	38	27	31	36	27	38	57		

On the coleopteran fauna of Pulau Ubin, Singapore

L.F. Cheong[1] & Sean Yap[2]

[1]Lee Kong Chian Natural History Museum
Conservatory Drive, Singapore 117377
[2]Reproductive Evolution Lab
Department of Biological Sciences, National University of Singapore
16 Science Drive 4, Block S3 Level 4, Singapore 117558
loongfah@gmail.com, seanyapzs@gmail.com

ABSTRACT. This paper reports the results of our inventory of the coleopteran fauna of Pulau Ubin, Singapore. It comprises slightly over 300 species from 39 families, with a significant proportion of species found nowhere else in Singapore, and among them are a few undescribed species. Many of these newly recorded beetles are affiliated with coastal or back-mangrove vegetation, habitats that have been severely reduced on mainland Singapore. We also review the dominant beetle families represented in Pulau Ubin, highlighting important ecological information such as habitat requirements and potential threats, identifying habitats or species that need protection/conservation, and selecting a few potential indicator species.

Introduction

Beetles are important in most natural terrestrial and freshwater ecosystems, playing important roles as pollinators, decomposers, soil engineers, and as regulators of the populations of other organisms. A better understanding of beetle biodiversity is critical to our knowledge of the proper functioning of our natural ecosystems. Towards achieving that goal, we have been conducting inventory surveys of the beetle fauna of Singapore for the past few years.

As part of this inventorying effort, we contributed to the Comprehensive Ubin Biodiversity Survey (CUBS), an initiative led by the National Parks Board, Singapore, to obtain a more rigorous scientific understanding of the natural resources of Pulau Ubin.

The objectives of the beetle survey were:

a. To provide a preliminary synopsis of the coleopteran fauna on Pulau Ubin, highlighting the conservation significance of the island's fauna within the overall context of the Singapore fauna;
b. To sketch a brief profile of various beetle families, highlighting important ecological information such as habitat requirements and potential threats, identifying habitats or species that need protection/conservation;
c. To identify potential surrogate/indicator species that are easy to measure for conservation purposes, and/or that can excite the imagination, thereby raising the general consciousness about beetles among the general public. Clearly, what constitutes a charismatic species to a beetle aficionado would be somewhat different from the ones the general public find attractive. Here we give a personal take on the extra quality that quickens the pulse with a "wow" factor.

Materials and Methods

The first author conducted 11 days of surveys (both diurnal and nocturnal) on Pulau Ubin, spread over the period 2018–2021. For dung beetle sampling, the second author set baited pitfall traps and beetles were collected after 24 hours, with a total of 16 sampling events

(384 hours). Dung beetle species were delimited using DNA barcoding. While we have good estimates for numbers of species, some species have yet to be identified due to lack of morphological taxonomic expertise. The species list compiled in this report is supplemented by records from other entomologists (e.g., the late Prof. D.H. Murphy, National University of Singapore) and other naturalists and photographers, and by the Malaise trap material collected on Pulau Ubin through the Mangrove Insect Project between 2012 and 2019 (Yeo et al., 2021). Nevertheless, the species list is by no means exhaustive, due to the following two main reasons.

Sampling Limitations. Slightly more than 70% of the species listed in the Appendix came from about 100 hours of sampling by the first author. Given the limited number of sampling hours, we are still quite far from obtaining the asymptote of a species accumulation curve. Species that were not previously recorded continued to appear in our sampling in significant numbers; for instance, two days of surveys contributed 43 new records to the list. There is no doubt that the actual beetle fauna is much richer. The present list should therefore be regarded as preliminary.

Only the following sampling modalities have been systematically employed on Pulau Ubin: visual observation and light traps (by the first author), dung bait traps (by the second author), and Malaise traps (from the Mangrove Insect Project). No other specialised collecting methods (e.g. Berlese extraction or sieving of leaf litter, aquatic nets for gathering aquatic beetles) have been systematically employed. Such methods should yield further species.

Taxonomic Challenges. As a rule, of the 170 or so beetle families worldwide (Bouchard et al., 2017), the small families (defined as comprising fewer than ~2,000 species worldwide in the family) have all been omitted from this report, and this happens to preclude most of the minute (size < 3mm) coleopteran fauna. This omission is necessary to limit the scope of the report, as well as for the fact that these families are unlikely to be encountered without some specialised method of collecting (although they were collected where encountered). That leaves seven megadiverse families (defined as comprising more than 20,000 described species worldwide) and 20 or so medium-sized families, listed below in decreasing order of abundance (with number of species worldwide in brackets). From this list, we focus on the megadiverse families (rich enough diversity so that some faunistic patterns emerge for analysis), with a few from the medium-sized families (those of some special interest, specifically Buprestidae, Anthribidae and Attelabidae).

Staphylinidae (56,000)
Curculionidae (51,000)
Carabidae (40,000)
Chrysomelidae (32,500)
Cerambycidae (30,079)
Scarabaeidae (27,000)
Tenebrionidae (20,000)
Buprestidae (14,700)
Elateridae (10,000)

Nitidulidae (4,500)
Histeridae (4,300)
Brentidae (4,000)
Dytiscidae (4,000)
Anthribidae (3,900)
Erotylidae (3,500)
Hydrophilidae (3,400)
Cleridae (3,400)
Meloidae (3,000)

Melyridae (6,000)
Coccinellidae (6,000)
Cantharidae (5,100)
Lycidae (4,600)
Anthicidae (3,000)
Attelabidae (2,500)
Lampyridae (2,200)
Ptinidae (2,200)

Even among these selected families, some significant coleopteran groups have been excluded in this report for various reasons (poor taxonomic knowledge, constraints of time, inaccessibility of some literature).

For Scarabaeidae, it has not been possible to examine within the timeframe required for this report the numerically large number of Melolonthines (especially species from the tribe Sericini and the genus *Apogonia*) and Rutelines (species from the tribe Adoretini) collected in the Malaise traps from the Mangrove Insect Project. Identification of all these species is not possible without genitalia examination.

Staphylinidae probably constituted the most abundant coleopteran material collected in the Malaise traps. Many of these staphylinids belong to the Aleocharinae subfamily, taxonomically one of the most difficult lineages to identify, with probably many new species remaining to be described. At the moment, we lack the taxonomic expertise to deal with this group of beetles. Thus, the family is omitted from this report.

In weevils (superfamily Curculionoidea), only one family is hyperdiverse (Curculionidae, with about 51,000 species worldwide). Due to this sheer diversity, curculionid identification is beset with difficulties. In poorly known groups, it has been inferred that we know as few as 10% of the real species numbers of such groups (Oberprieler et al., 2007). This is based on recent collecting efforts in various tropical or subtropical regions of the world which can yield a staggering ratio of 1 described to 20 (or even more) undescribed species in some genera. Many tribes and subfamilies are poorly studied, including Cryptorhynchini, Curculioninae s. lat., and some groups of Molytinae, with a total lack of monographic works thereon. Therefore, many weevil species collected in this project are yet to be identified to species level. This report instead looks at the more primitive weevil families Anthribidae and Attelabidae, which are quite rich in the Indomalayan region, and are reasonably well-worked.

As a rule, our criterion of eliminating minute beetles of less than 3 mm length also applies to such beetles in those families that we covered (e.g. the small flea beetles in the family Chrysomelidae, and the small carabids and anthribids living among leaf litter).

Definition of terms used

- Mainland fauna: refers to the whole set of Singaporean fauna minus those on outlying islands.
- Endemic fauna: fauna found only on Pulau Ubin
- Subendemic fauna: (1) fauna not found on mainland Singapore but there are records from other outlying islands, or (2) fauna historically recorded on mainland Singapore but no recent records within the last 50 years.

Results

Significant coleopteran diversity is present on Pulau Ubin, many of the species being found nowhere else in Singapore, and a small number of undescribed new species has been found. The resulting list comprises more than 300 species from 39 families (listed in the Appendix).

General Remarks on Beetle Family Diversity and Assemblage Structure

In general, Pulau Ubin includes a high proportion of beetles affiliated with coastal (both sandy and mangrove) or back-mangrove vegetation, habitats that have been severely reduced on mainland Singapore. Thus, even if some of these beetles are present in other coastal or back-mangrove habitats on mainland Singapore, they are not found as abundantly as on Pulau Ubin. Several beetle species are currently known only from localities within Pulau Ubin, though actual endemism is hard to ascertain without a thorough investigation of the beetle fauna on mainland Singapore and adjacent parts of Malaysia.

Table 1. Distribution of rare beetles by localities on Pulau Ubin

Locality	Endemic	Subendemic
Chek Jawa	20	4
Sungei Puaka + Bukit Puaka	7	2
Sungei Jelutong + Bukit Jelutong	4	3
Western forest *	3	0
Noordin Beach	2	0
Other/Unknown Locality	8	4

* There has been uneven sampling effort across sites due to poor accessibility.

In terms of rarity of species found, as Table 1 shows, the Chek Jawa coastal forest contains the highest number of species that are apparently endemic or subendemic to Pulau Ubin, followed by the Sungei Puaka (including Bukit Puaka) and the Sungei Jelutong (including Bukit Jelutong) areas. In fact, Pulau Ubin has the highest number of rare beetles among representative mangroves such as Sungei Buloh, Pulau Semakau, and Pulau Sarimbun (based on an informal comparison of the Malaise trap specimens obtained at the various mangroves). This is not surprising given that Pulau Ubin has the largest mangrove area found in Singapore, and the highest number of mangrove plant species among the various mangrove sites (Yang et al., 2013).

Table 2. Taxonomic composition of the Coleopteran fauna of Pulau Ubin

Family	Total fauna in Singapore	Fauna in Ubin (% of Singapore total)	Endemic	Subendemic
Chrysomelidae	367	48 (13.1%)	14 *	5 *
Tenebrionidae	225	43 (19.1%)	11	2
Cerambycidae	338	32 (9.5%)	6	2
Scarabaeidae	NA	27 (NA)	6	1
Carabidae	193	26 (13.5%)	1	0
Anthribidae	200	24 (12.0%)	2	1

* If we disregard the endemic species found in grassland habitat, which is not well-worked on mainland Singapore, then the corresponding figures are 11 and 3 respectively.

Among the dominant families, six families are each represented by more than 20 species recorded from Pulau Ubin. They are listed in Table 2 in descending order of species richness, with the proportion of the Ubin fauna to the total Singapore fauna shown in parentheses (the total Singapore fauna for Scarabaeidae is not available, due to the aforementioned taxonomic challenge associated with the family). As can be seen, this ratio varies from about 10 to 19%, with an average figure of 13.4%. As the land area of Pulau Ubin is only less than 2% of the total area of Singapore, it is evident that the matrix of coastal forest, sandy shore scrub, grassland, and synanthropic habitats found on Pulau Ubin have provided nature-friendly conditions for beetles (and insects in general). The numbers of endemic/subendemic beetles by family are also tabulated in the same Table (see Appendix for the actual endemic/subendemic species). Note that the sums of endemic/subendemic species in Table 2 may not tally with those in Table 1 because some of these species may be found in more than one locality on Pulau Ubin.

Not surprisingly, species associated with coastal habitats, grassland, synanthropic habitats are over-represented on Pulau Ubin compared to mainland areas, for instance, chrysomelids with coastal plants as hosts, and those carabids preferring more open habitats. On the other hand, those carabids associated with forest are under-represented. One should expect that in general, species associated with freshwater-edge and forest interior would be under-represented, and indeed, the largely forest-dwelling fauna belonging to Attelabidae, Buprestidae and Cerambycidae are under-represented on the island.

Compared with the average proportion of the Pulau Ubin fauna to the mainland fauna, there was an over-representation of Pulau Ubin species associated with fungi (especially tenebrionids associated with macrofungi) and dung (dung beetles). This might be due to the greater mobility required for frequent movements between patchily distributed ephemeral resources conferring a higher probability of establishment success on Pulau Ubin. This is despite the reduced fungal diversity assumed on the island due to its relatively low level of humidity compared with forest on the mainland.

Lastly, as a factor in our account of the beetle fauna composition of Pulau Ubin, Malaysia cannot be ruled out as a potential source of immigration (e.g., the nearest significant patch of mangrove at the mouth of Johor River is less than 10 km away). The northeasterly and northerly winds during the North-East Monsoon may have facilitated arrivals from Malaysia. Some saproxylic fauna closely associated with tree trunks immersed in sea water could have been deposited by the sea from areas further inland (e.g. via Johor River).

Review of Selected Beetle Families

This section is presented in systematic sequence – notionally reflecting a natural phylogeny – of eight families. Each family contains a relatively short synopsis. This is accompanied by some comparative remarks relating to the mainland Singapore fauna, especially with regard to the endemic/subendemic fauna, and species of conservation concern in general. Other remarks summarise potential identification issues such as confusions or errors, or alerts to possible gaps in knowledge.

With regard to conservation threats, our views are stated somewhat dogmatically. As is usually the case for insects, even in the most well-researched regions such as Europe, there is a lack of quantitative data to back up the arguments in the manner of the IUCN Criteria for red-listing a species. This subjectivity is justified since decisions have to be made while there still is something left to protect.

"Selected References" provides key identification references. The literature on the Indomalayan beetles is extensive but highly fragmented. It is therefore necessary to know the first points of reference. Under Selected References we offer a list of publications considered likely to be most helpful to further explore the family under consideration. We also draw attention to the following publications here (not repeated under the family treatments), which provide the basic knowledge of coleopteran taxonomy, especially with regard to the Oriental fauna: Ek-Amnuay, 2008; Hayashi et al., 1984; Kurosawa et al., 1985; Marshall, 2018; Ueno et al., 1985; White 1983.

Carabidae (including Cicindelinae)

A dominant group of terrestrial predators, they are mainly nocturnal but some are diurnal, and not necessarily living on the ground, despite the common name of Ground Beetle. They are mostly carnivores as larvae and adults, although several lineages are herbivores (e.g., Harpalini) or parasitoids (e.g., Brachinini and Lebiini). Among carnivorous carabids, some have evolved specialised diets, such as feeding on ants (many Paussinae).

They are encountered in a variety of habitats ranging from forest litter, old tree trunks, under stones, and long grass to some wet habitats, including riparian and coastal areas. Pulau Ubin, with its interwoven matrix of coastal forest, sandy shore scrub, grassland, mangrove and back mangrove vegetation sustains quite different groups of carabid beetles indeed, with about 26 species in 20 genera.

Of particular interest is the sandy shore Tiger Beetle species (most authorities now treat Tiger Beetles as belonging to the subfamily Cicindelinae of the Carabidae). Besides the ubiquitous *Cosmodela aurulenta*, *Calomera angulata* (synonym: *Lophyridia angulata*) is a much less common sandy shore inhabitant. It was recorded at Noordin Beach in 2004, but now it seems to have disappeared from that locality, possibly due to loss of habitat from erosion. Furthermore, while the beach awaits restoration work to commence, the large amount of plastic debris that has been washed up onto the shore has probably exacerbated the situation. *Calomera angulata* is also recorded elsewhere in Singapore (Sembawang beach, Pulau Semakau). It would be nice to confirm its continued occurrence on Pulau Ubin and monitor its long-term population, especially with regard to its hoped-for recovery after the beach restoration, not to mention the potential long-term threats of climate change to sandy shore habitats.

Calomera angulata could be considered as an indicator as many tiger beetle species are well known for consistent habitat specialisation. The reason for this pattern of narrow habitat use is most likely due to physiological adaptations of the larvae (to soil moisture, soil composition and temperature). Though *Calomera angulata* is likely not very habitat-specific (it is found on sandy shores of oceans, but also inland sandy river banks in other countries), it will still be a good indicator for how the restoration measures at Noordin Beach have helped in restoring its ecosystem components (being a predator, the tiger beetles will be good integrators of a substantial amount of ecological information about the biological communities to which they belong).

The genus *Pentagonica* is particularly well-represented in Pulau Ubin with three species; some of them seem to be ground- or grass-living, whereas others are arboreal, living on foliage. *Pentagonica pallipes* seems to be associated with back-mangroves, being recorded from mangrove forests on the western part of Pulau Ubin, as well as from Pasir Ris, Sungei Buloh and Kranji Marshes on mainland Singapore.

The odacanthine genus *Dicraspeda* has the typical elongate, slender form of the Odacanthini tribe adapted for living (and hiding) among long grass and reeds. However, *Dicraspeda* (at least in New Guinea) is said to deviate in its habit from the many 'normal' hygrophilous, commonly reed-inhabiting odacanthine beetles. Many *Dicraspeda* species were collected well away from water; some specimens were collected at light (Baehr 2003). In particular, *Dicraspeda brunnea* has been collected from rainforest in other countries, but in Singapore this species was collected near coastal mangroves. There have been records from Pulau Ubin (from light traps at Chek Jawa) and Sarimbun (from Malaise traps). Little is known about the habits of this species.

Another genus that is well represented on Pulau Ubin is *Catascopus*, a well-known genus because of their bright colouration and elegant body shape. Of particular interest is *Catascopus borneensis*, by far the least common among the three *Catascopus* species found on the island. This species has been recorded from Pulau Ubin, Western Catchment and Chestnut Nature Park.

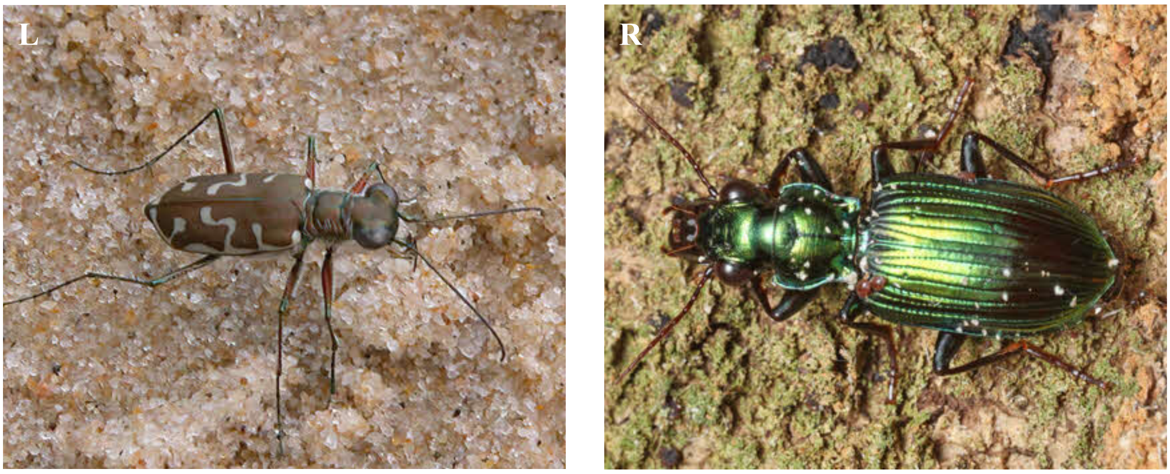

Fig. 1 *Calomera angulata* (**L**) and *Catascopus borneensis* (**R**), being predators, are good integrators of a substantial amount of ecological information about the biological communities to which they belong.

The relatively moist forests found on the granite outcrops of hills (e.g. Bukit Jelutong) as well as the coastal woodlands harbour the forest-living species, especially the arboreal fauna from the tribe Lebiini, though due to the small forest area, the arboreal fauna is far less diverse than that in the mainland forests. Of particular interest is the species identified as *Euplynes* cf. *aurocinctus* Bates, 1889, which constitutes the sole record for Singapore so far. It is difficult to be certain that this species is truly endemic to Pulau Ubin, especially given that arboreal fauna tends to be stochastic in appearance and usually requires repeated sampling to detect their presence. *Euplynes* cf. *aurocinctus* was obtained by sweeping tree foliage in the Chek Jawa forest. Another arboreal species of note in the Chek Jawa forest is *Calleida tenuis*. It is almost possible to detect this species on demand in this patch of forest, while it is generally much harder to do so for other localities on mainland Singapore (though it is by no means rare).

Various genera in Carabidae are in need of revision, including *Coptodera* (one species recorded on Bukit Jelutong), *Egadroma* (not recorded, though likely to be present), and various genera in Pterostichini.

SELECTED REFERENCES. Andrewes (1925, 1931, 1933), Baehr (2012a, 2012b, 2013), Naviaux (1994-1995).

Scarabaeidae

Two major clades occur in the family Scarabaeidae, the dung-beetle clade and the highly diverse phytophagous scarab clade. Members of the phytophagous scarab clade primarily feed on angiosperm plant foliage, flowers, nectar, pollen, or fruit during their adult stage and roots, humus, detritus, or dead wood as larvae. The dung-beetle clade, in their shift to dung feeding, show the second most successful trophic adaptation in the evolution of scarab beetles, after angiosperm plant feeding.

The diversity of this family is significantly under-reported here due to the taxonomic challenges associated with difficult groups such as the genus *Apogonia,* the tribes Adoretini and Sericini. We focus on the dung beetles as a key functional group of which knowledge is rather good compared to other scarab beetles. We then highlight a few scarab beetles of interest.

The term "dung beetles" actually refers to a paraphyletic, functional grouping of beetles with dung feeding behaviour, mostly from the family Scarabaeidae, with the majority of genera and species belonging to the subfamily Scarabaeinae. Dung beetles are considered among some of the most important organisms in terms of ecosystem services in tropical forests, playing major roles in decomposition, seed dispersal, and nutrient recycling (Hanski & Cambefort, 2014; Nichols et al., 2008). In certain parts of the world, including Southeast Asia, where carrion beetles are less abundant and diverse, dung beetles are also known to be carrion feeders, speeding up decomposition of carcasses (Goh, 2014; Hanski, 1983; Hanski & Niemala, 1989). They are also common bioindicator organisms in studies on forest disturbance and vertebrate biodiversity, due to their close relationship with vertebrate dung (Drinkwater et al., 2021; Ong et al., 2020).

In Singapore, there remain four extant genera of scarabaeine dung beetles – *Onthophagus*, *Caccobius*, *Paragymnopleurus* and *Catharsius*. Of these, the genus *Onthophagus* is the most diverse in Singapore, with about 20 known species, while *Caccobius*, *Paragymnopleurus* and *Catharsius* are thus far only represented by one species each. *Paragymnopleurus*, the only genus and species of beetles from the "roller" functional group (dung beetles that roll balls of dung away from dung piles), is so far only recorded from forests in the Central Catchment area of Singapore. The other three genera are all present on Pulau Ubin.

The present study, which includes sampling on mainland Singapore and Pulau Ubin, has recorded 25 species of dung beetles so far, 15 of which occur on Pulau Ubin. Of these 15 species, 14 species are also found on the mainland. As such, the majority of Pulau Ubin's dung beetle diversity appears to be a subset of that of the mainland, and dung beetles are surprisingly well represented on Pulau Ubin, with 60% of species in this study being present on the island. A possible reason for this, as mentioned earlier, is that as a group attracted to ephemeral food sources, dung beetles may have evolved to travel greater distances and thus have the potential to disperse further than other beetle groups, allowing a greater richness of species to establish on offshore islands. Even though species composition on Pulau Ubin appears to be a subset of the mainland's, it may be worth noting that based on community analyses, dung beetle communities on Pulau Ubin appear to be relatively distinct from those of the mainland (see Fig. 2). This could be due to differences in relative abundance, where some species are more common on Pulau Ubin than on the mainland and vice versa.

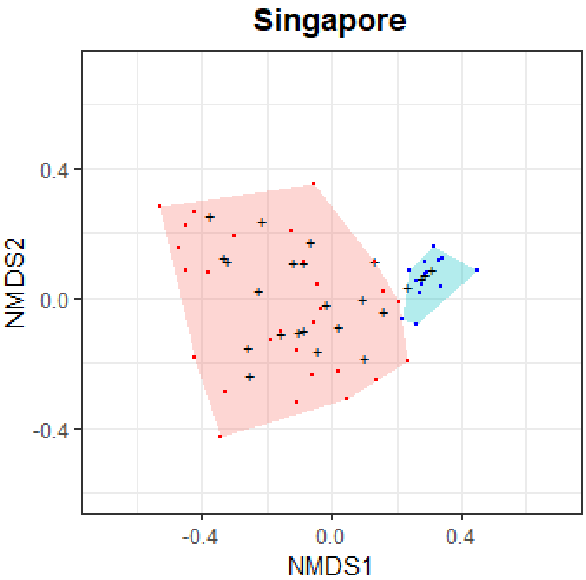

Fig. 2 Non-metric multidimensional scaling (NMDS) analysis of dung beetle communities on mainland Singapore (red) and Pulau Ubin (blue). Each coloured point is a sampling event. The fact that Pulau Ubin sampling event points cluster together, instead of being interspersed with mainland points, suggest that communities at sampling points within Pulau Ubin are more similar to each other than with any of the mainland sampling points, indicating community differences despite overlapping species composition.

Only one species, *Onthophagus waterstradti*, is thus far locally endemic to Pulau Ubin. This species has been recorded in Peninsular Malaysia, but in the context of Singapore has only been found on Pulau Ubin. Either this species has gone extinct on the Singapore mainland, or it is possible that individuals had travelled over from Malaysia in enough numbers for the species to establish itself on Pulau Ubin. Within Pulau Ubin itself, this species was particularly abundant in traps placed at Jalan Sam Heng and Jalan Durian.

Of the species present on Pulau Ubin, *Catharsius* sp. is relatively charismatic for a dung beetle, being of relatively large size and with males that sport impressive horns. This species has mostly been recorded from Pulau Ubin and relatively intact forests on the mainland and may serve as a good indicator species as well. However, the taxonomy of this genus in Singapore still requires some resolution. Historically, *Catharsius* specimens from Singapore had been labelled as the species *Catharsius molossus*, but it is now largely accepted that *Catharsius molossus*, previously recorded from almost all of Asia, is really a species complex consisting of multiple species. Recent publications in the region from Peninsular Malaysia and Borneo refer to the common regional species as *Catharsius renaudpauliani* (Drinkwater et al., 2021; Muhaimin et al., 2015; Niino et al., 2014; Slade et al., 2014), and it is likely that the *Catharsius* found in Singapore also belong to this species. Furthermore, based on molecular evidence from the current study, it is possible that there is a second, cryptic *Catharsius* species present both in Malaysia and in Singapore. In Singapore, both molecular clusters of *Catharsius* are found in the same sampling sites, so in terms of being species indicators, the genus in general still works for now, even if the species level definitions have not yet been resolved.

It is also worth noting that beetles recorded in this study were mainly caught in pitfall traps baited with only one type of bait, and that there is potential for more species to be recorded with the use of a wider variety of animal dung, as with other methods such as flight intercept traps and carrion baited traps.

As for non-dung beetle scarabs, an *Anomala* species collected from Chek Jawa (light trap), identified as *Anomala* cf. *matricula* (sp. nov.), is likely to be a new species. The genus *Anomala* is one of the most species-rich genera of the Rutelinae subfamily. More than 100 described species are known from Peninsular Malaysia and Sumatra alone (including neighbouring small islands). In spite of this, a high number of species remain undiscovered, and knowledge about the way of life and the exact distribution of many species is still very incomplete.

Glycyphana binotata laterimarginata is historically recorded in Singapore, but the only recent record is the 2018 female specimen found in the forest on Bukit Jelutong on Pulau Ubin. The adult has been observed inside decomposing tree trunks (pers. obs.), possibly ovipositing, thereby implying a saproxylic habit of its immature stages. As the common name of flower chafer implies, adults have been recorded feeding on a variety of flowers. This is another attractive beetle that can be used as a flagship species to indicate the ecological health of the environment, possibly through a citizen science approach in view of their popular and charismatic appeal.

Fig. 3 *Catharsius renaudpauliani* (**L**) and *Glycyphana binotata* (**R**) both have good potential as indicator species representative of the coprophagous and saproxylic insects respectively.

Many genera of Scarabaeidae are in need of revision, including the various groups mentioned under the Methods section. *Leucopholis* is another genus that sorely requires a revision.

SELECTED REFERENCES: Endrődi (1985), Krikken (1978), Kuijten (1992), Legrand and Chew (2010), Miksic (1970, 1976), Ohaus (1943). Literature on the Indomalayan *Anomala* is rather fragmentary (see Zorn (1998) for the references therein).

Buprestidae

There are two different modes of life in Buprestidae: the stem and leaf miners and the wood borers. Buprestid species which develop on shrubs and leaf miners are well-represented but species which are directly associated with trees are poorly represented. Many species from the very speciose genus *Agrilus* fall into the latter category, and most of them are not found on Pulau Ubin. So far, only *Agrilus subconsularis* is recorded from the northern shores (e.g. Noordin Beach) of the island. A second *Agrilus* species occurs on the island, but the specimen was collected in 1988 and is in a very poor state of preservation, so its identity cannot be ascertained.

The mangroves of Singapore harbour two attractive, medium-sized jewel beetles, *Chrysobothris nigripennis* and *Chrysodema auroplagiata*. *Chrysobothris nigripennis* now seems to be associated mainly with mangrove habitats, with Pulau Ubin an especially important stronghold given that it has the largest and most diverse mangrove habitat in the country. The species was formerly more widespread, probably, as it was collected by Bryant in 1909 at Bukit Timah forest. Now its population level is probably so low such that the only reliable method to see this beautiful species is through Malaise trapping (especially at the back mangroves of Sungei Puaka). The beauty of this species calls to mind that of a lacquerware finished in sombre black, decorated with flecks of silver and gold. As the Japanese author and novelist J. Tanizaki (2001) wrote in his tribute to the traditional Japanese aesthetics, it has an "inexpressible aura of depth and mystery". It can serve as a flagship species that promotes an aesthetic appreciation of the beauty of beetles while at the same time recognising its ecological functioning.

Chrysodema auroplagiata is the second jewel beetle found in the mangroves of Singapore. It has quite a different kind of beauty, with fiery golden orange spots on a shiny green background. Presently, it is recorded in Sungei Buloh and Pasir Ris, with no records in Pulau Ubin, though it is likely to be present too. It would be nice to confirm its occurrence in Pulau Ubin.

The heterogeneous coastal habitats on Pulau Ubin support a relatively rich set of leaf and stem mining buprestid species, which usually have a high degree of host specificity, confining their attacks to a single genus or family of plant. Five species from the genera *Trachys* and *Habroloma* are recorded, which amounts to 17.2% of the total Singapore fauna of those genera (29 species from *Trachys* and *Habroloma* combined).

Fig. 4 *Agrilus subconsularis* (**L**) and *Chrysobothris nigripennis* (**R**) are two Buprestid species that are more reliably recorded from, respectively, the sandy and back-mangrove vegetation of Pulau Ubin, habitats that have been severely reduced on mainland Singapore.

SELECTED REFERENCES: Deyrolle (1864), Obenberger (1924, 1929a, 1929b)

Tenebrionidae

With 43 species and 23 genera, this family constitutes the second largest beetle family in Pulau Ubin. In terms of habitats and habitus, this family is indeed very diverse. The majority of tenebrionids live in wooded areas with dead wood and fungi, but there are also specialists which feed on lichen, larvae that live in soil, and adventive cosmopolitan pests that infest stored products.

On first thought, it might seem that tenebrionid species feeding on rotten wood and fungi should be under-represented on Pulau Ubin, since only a relatively small area of the island is covered by forests, and these small forests are relatively not saturated with moisture.

Yet, not only is Tenebrionidae the second largest beetle family there, the dominant tenebrionid genera found on the island (*Amarygmus* with seven species and *Platydema* with five species) are rotten wood and fungi feeders. The majority of *Amarygmus* species can be found at night on the bark of living and dead trees, especially when covered or mixed with fungi or lichen, whereas *Platydema* species are usually found on fungi-habitats on old trees and they possess striking, fungus-adapted modifications on the head (in the form of horns or teeth). Not only are these two genera high in absolute number, they are also over-represented in relative terms: the seven *Amarygmus* species in Ubin amount to 25% of the total *Amarygmus* species in Singapore, and the five *Platydema* species amount to 38% of the total *Platydema* species in Singapore. Perhaps, over-representation of species confined to patchily distributed ephemeral microhabitats such as fungi or dung (see also the discussion on dung beetles, above) indicates that a higher mobility, necessary for frequent movements between patches, confers a higher probability of establishment success on Pulau Ubin. It would be nice to further corroborate the presence (or the lack) of other beetles associated with macrofungi, e.g. *Byrsax* (Tenebrionidae) and Ciidae. Some of them would require a more targeted search, especially for those that hide inside decaying fungi.

Of particular interest is the species identified as *Amarygmus* cf. *rivalis* sp. 2, collected from a Malaise trap near the Sungei Teris area. This seems to differ from the specimen that the first author has previously collected from Sungei Buloh. Ascertaining whether both specimens are the same species would require a proper examination, which has to be put on hold awaiting DNA extraction of the Pulau Ubin Malaise trap specimen. Another species of interest is *Platydema nuciferae* collected from Chek Jawa; it constitutes the sole record for this species in Singapore.

Besides *P. nuciferae*, the Chek Jawa forest is the sole locality for three further tenebrionids which have not been recorded on mainland Singapore: *Phaedis purpureostriatus* (on a dead tree), *Derosphaerus aeruginosus* (on a dead tree), and *Euhemicera kaszabi* (on the moss-covered trunk of a back-mangrove tree). It is also the sole recent locality for the Alleculinae species *Bolbostetha baumi* (from light trap); the only other record for this species is of the two syntype specimens collected from Singapore by Baum in 1929. Bukit Jelutong is the sole locality for *Euhemicera hayashii* and a potentially new *Palorus* species.

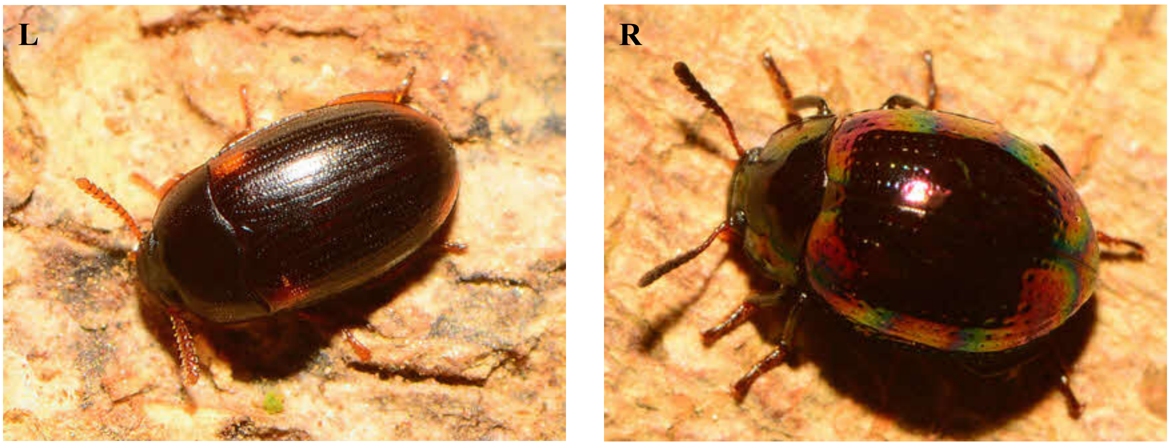

Fig. 5 *Platydema nuciferae* (**L**) and *Euhemicera hayashii* (**R**) are solely recorded from the Chek Jawa forest and Bukit Jelutong respectively, both mature forests with fungi habitats. *Platydema* species are found under the caps of macrofungi, often with multiple *Platydema* species together, whereas *Euhemicera* species are usually observed moving slowly over dead branches at night, probably scraping and consuming microfungi.

SELECTED REFERENCES: Matthews & Bouchard (2008), an excellent book on Tenebrionidae, providing a review of higher level groups. For *Amargymus*, most species were described by H.J. Bremer; to be cited here are Bremer (2001, 2010). For *Platydema*: Schawaller (2004, 2012). For *Phaedis*: Ando (2019a, 2019b). For *Derosphaerus*: Kaszab (1987). For *Hemicera* and allied genera: Ando (2003). For *Bolbostetha*: Novak (2008).

Chrysomelidae

With 48 species, in 35 genera, this family constitutes the largest beetle family in Pulau Ubin. This family is also marked by several species recorded from Pulau Ubin but not recorded so far on the mainland, or not as abundantly as in Pulau Ubin. This phenomenon might have to do with the different distribution of host plants on Pulau Ubin compared to the mainland. For instance, the Chek Jawa coastal forest, though disturbed, still contains elements of the original flora that are rare elsewhere in Singapore. Examples of endemic chrysomelids include *Haplosomoides plicatus* (Allard, 1887) and *Monolepta laticornis* (Jacoby, 1899), both not uncommon on Pulau Ubin but not recorded on the mainland so far.

Traditional orchards/farms and grassland patches also serve as a refuge for various species, especially with increasing urbanisation on mainland Singapore. For instance, flea beetles of the genus *Phyllotreta* are specialist feeders on the Brassicaceae and its related groups, and many of them are considered crop pests. Two *Phyllotreta* species are recorded on Pulau Ubin: *Phyllotreta chotanica* is abundant on the host plant *Cleome rutidosperma*, whereas *Phyllotreta striolata* has been recorded by Saunders in the 1930s on pak-choi in Singapore, after which there has been no further record until this record on Pulau Ubin.

Sandy shore is another vanishing habitat sustaining different groups of leaf beetles. Of particular concern are the leaf beetles associated with sandy shore plants found on Noordin Beach, such as *Oncocephala feae* and *Parheminodes* cf. *pulcher*. It would be nice to have their continued occurrence confirmed, especially *Parheminodes* cf. *pulcher* which is only recorded on Pulau Ubin.

SELECTED REFERENCES: Baly (1867), Maulik (1919, 1926, 1936), Mohamedsaid (2004). Scherer (1969)

Cerambycidae

At 32 species, in 29 genera, the Cerambycidae family is slightly less numerous than the Chrysomelids. However, as the predominant saproxylic beetle family that is particularly representative of the saproxylic invertebrates, it can play an important role in the conservation of this key functional group.

The saproxylic organisms are a wide trophic category that includes not only saproxylophagous (dead wood-eating) species, but also those that feed on fungi that live on dead wood, predators, parasites and parasitoids of all the organisms living together in the same microhabitat, as well as several sap-feeding insects associated with yeasts and bacteria on living trees wounded by xylophagous insects. Of the different trophic categories among the saproxylic insects, it seems that the saproxylophagous category (to which many cerambycids belong) is the feeding habit typical of the most imperilled species due to their specialised requirements. The occurrence of these saproxylophagous beetles is not only dependent on the presence of dead or dying trees at the right time and within the reach of these beetles (increasingly difficult due to habitat fragmentation), but also depends on the microhabitat of the treefall (the tree species (primary/secondary), tree diameter, degree of decay, level of sun exposure/canopy closure, deadwood postures (whether the dead tree is standing or lying), the species of wood-decaying fungi colonising the wood etc.). This specialisation could possibly account for the degree of endemism/subendemism found in the Cerambycidae. However, given that cerambycid species are subject to under-sampling, it is possible that some of them are not as imperilled as they seem. The possible under-sampling is caused by sampling difficulties (e.g. many long-horned beetles from the subfamily Cerambycinae are rather elusive as they tend to visit flowers at the canopy) or by the sedentary habit of some cerambycids (especially those from the subfamily Prioninae).

With this proviso in mind, some cerambycids could certainly be selected as an indicator of habitat quality. One candidate is *Dejanira quadripunctata*, a Cerambycinae that within Singapore is so far recorded only from Pulau Ubin. In Peninsular Malaysia it is not uncommon, often attracted to lights (pers. obs.). In Pulau Ubin, two individuals were recorded at lights in Outward Bound Singapore (OBS) and Ubin Living Lab (ULL). The impact of light pollution on saproxylic beetles is generally limited and affects significantly only a fairly small number of species, especially certain medium- and large-sized long-horned beetles, one example of which could be *Dejanira quadripunctata.* Light pollution harms the insects by impeding communication, changing their physiology, life-history traits and night habits, and limiting mobility and dispersal through its disorienting effect. Whether light pollution has driven the declines of *Dejanira quadripunctata* on mainland Singapore we have no way of ascertaining now, but on Pulau Ubin, with its environment relatively free of light pollution, any future change in the nocturnal illumination regime on the island – or even further afield, as light can scatter in the atmosphere and affects areas tens of kilometres from its source – has to be carefully considered. *Dejanira quadripunctata*, with its big size and easy recognisability, not to mention aesthetic appeal, can be the subject of monitoring with public participation.

Two potentially undescribed species from the subfamily Cerambycinae, *Cylindroeme* sp. and *Pseudiphra* sp., are recorded from Pulau Ubin. *Cylindroeme* is a genus newly defined by Vives (2019), and is so far monotypic with the sole species *C. vietnamica*. The Pulau Ubin specimen collected by the first author appears to belong to this genus but is clearly different from *C. vietnamica.* Besides the Pulau Ubin specimen, there are also a few specimens from Pulau Semakau collected from Malaise traps. It would be interesting to find out if this species also occurs on the mainland or if this is a true island species. The *Pseudiphra* sp. collected by the first author from the coastal forest near Noordin Beach is closest to *P. apicalis* but there are several important differences. This species is also recorded at the Chestnut forest on the mainland. It is difficult to say whether they are rare on the mainland or not, but both species do seem rather rarely collected.

Another species worthy of note is *Rondibilis lineaticollis*, captured in flight among fallen trees in the back mangrove-edge habitat just to the north of Bukit Jelutong. Not only is it a new national record, this record also significantly extends the distribution range of this species, which is so far recorded from Thailand, Laos, Vietnam, Hainan, and Borneo.

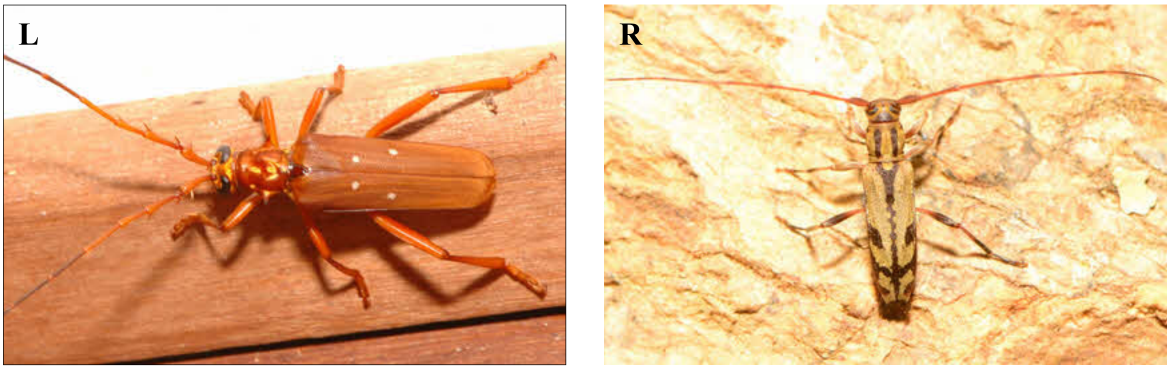

Fig. 6 *Dejanira quadripunctata* (**L**) and *Rondibilis lineaticollis* (**R**) are so far only recorded in Singapore from Pulau Ubin. The former is rather commonly encountered in Peninsular Malaysia, whereas the record for the latter significantly extends the southern range limit of this species.

Choeromorpha albofasciata, based on a specimen collected in 1988, is the only recent record since Wallace recorded it in the 1850s from Bukit Timah. It would be nice to confirm the continued presence of this elegant species on the island. Note that its congeneric species *Choeromorpha polynesus* should be removed from the national checklist. What Pascoe determined as *Choeromorpha polynesus* in the 1850s – 1860s actually contained two species, *C. albofasciata* and *C. polynesus*. Based on the work done in the virtual repatriation of the Wallace specimens, the Singapore specimen in the Pascoe collection is in fact a *Choeromorpha albofasciata*, and there is no *C. polynesus* from Singapore found in the Pascoe collection. Thus, until proven otherwise, *Choeromorpha polynesus* is unknown from Singapore.

Other rare or otherwise interesting records of cerambycids from Pulau Ubin include:

- *Pothyne variegata* (collected 2010, the sole record for Singapore)
- *Pterolophia* cf. *kalimantana* (collected 2011, the sole record for Singapore)
- *Similosodus* cf. *flavicornis* (collected 2020, Chek Jawa coastal forest, the sole record for Singapore)
- *Similosodus verticalis* (historically recorded by Wallace. One record at Pulau Ubin (2020) and one at Venus trail on mainland Singapore (2020))
- *Sybra donckieri* (one record at MacRitchie forest in the Central Catchment (2020), and one at Sungei Teris, Pulau Ubin (2019, Malaise trap))
- *Mispilodes* cf. *borneensis* (one record at Chek Jawa on Pulau Ubin (2019), and two records at Nee Soon forest in the Central Catchment (2014, 2019))

Last but not least, a mention must be made of a species included in the traditional "cerambycoid assemblage", a *Philus* species collected from a Malaise trap at Bukit Puaka, the sole locality for this species. The species belongs to the family Vesperidae, a close relative of Cerambycidae and traditionally placed within Cerambycidae until the work of Svacha & Danilevsky (1987) and Svacha et al. (1997). This *Philus* sp. is rather enigmatic, and is the only Vesperid recorded from Singapore. Its larvae are likely to be subterranean, and are probably feeding on rootlets of various plants.

SELECTED REFERENCES: Pascoe (1864-1869). Bentanachs et al (2012). Breuning (1938, 1939, 1956a, 1956b, 1956c, 1958a, 1958b, 1960-1962).

Curculionoidea: Anthribidae

The anthribid fauna is extraordinarily rich in the Indomalayan region, their success in diversity being linked to mycetophagy. With a few exceptions, the larvae of most anthribids live inside dying branches and stems of angiosperms and gymnosperms. Although direct evidence is lacking at present, it looks as if the larvae depend on plant-parasitic fungi such as Xylariaceae to convert the host tissue into a form that they can assimilate. Most adults are fungal feeders, ingesting fructifications and hyphae that grow on or near the surface of stems, branches, or leaves of higher plants. The fungal material they eat sometimes comes from rusts, but more commonly it originates from Ascomycetes, particularly the Xylariaceae which attack plants of low vitality.

Of the 200 anthribid species recorded from Singapore, 12% of them (24 species from 20 genera) are found on Pulau Ubin. This is not a particularly high figure (compared with 19% for Tenebrionids, and the even higher figures of 25–38% for the mycetophagous genera associated with macrofungi). Maybe this difference stems from the micro- and macrophagy of fungivores and the different ecological processes and factors that influence the respective fungus–insect systems, but more studies are needed before we can offer an explanation.

Mucronianus ellipticus Jordan, 1923, so far recorded from Sungei Puaka area and Kranji Marsh, is thought likely to be the remnants of the saproxylic beetle assemblage of historical riverine mangrove habitat. Of particular interest is the male specimen collected, as the male of this species has not been described. The female of this species has been described twice, first from Sarawak by Jordan (1923), and redescribed again from Rayong, Thailand by Senoh (1997).

SELECTED REFERENCES: Morimoto (1972), Rheinheimer (2004).

Curculionoidea: Attelabidae

Attelabidae are known as the leaf-rolling weevils, because many members of this family construct leaf-rolls of cylindrical, funnel or cigar shapes. This family is well-represented in Singapore by 51 recorded species, though it is poorly represented on Pulau Ubin. Only two species are recorded as of now: *Auletobius* sp. (from Auletini) and *Byctiscidius* cf. *insularis* (from Bytiscini), both from Bukit Puaka. An Auletini species “cf. *Eumetopon* sp.”, recorded from various mainland mangroves with *Sonneratia alba* as host, is likely to be present too. Still, with these two species, the two biological groups, the “stingers” and the “rollers” in Attelabidae are both represented on the island. The former, which are represented by the Auletini and the Rhynchitini, pursue a primitive mode of oviposition: larvae develop within buds, shoots, or fruits, and the female prepares the oviposition hole with its rostrum. In many cases a second hole (“sting”) is made some distance basal to the oviposition site to interrupt the sap flow; this leads the apical plant part to wilt or to rot and sometimes to fall off the plant. The Bytiscini represent the most primitive group of the “rollers”. They sting the petiole of a chosen leaf. After the leaf starts wilting, the female rolls it into a cigar-like object which is used for oviposition. The Deporaini plus the Attelabinae (both unrecorded on Pulau Ubin) are the more sophisticated rollers; they make mathematically precise incision across the leaf surface which allows them to prepare cone- or can-shaped nidi.

The two big tribes Deporaini and Rhynchitini, many of their members being forest inhabitants, are conspicuous in their absence from Pulau Ubin. Perhaps for these attelabids, the requisite inner forest condition is absent in the forest patches found on the island, or the host plants are absent.

SELECTED REFERENCES: Legalov (2007), Voss (1922, 1926, 1927, 1938a, 1938b, 1941, 1969)

Discussion

Conservation

As the preceding sections show, the multitude of habitats found on Pulau Ubin contain many unique (endemic or subendemic) beetles found nowhere else in Singapore. The Chek Jawa wetland together with its coastal forest is the area with the highest species richness and rarity. The Sungei Puaka and Sungei Jelutong areas (riverine mangroves plus the hills) also contain faunas of significant richness and diversity. We do not go further in offering comparative remarks with regard to the irreplaceability or complementarity of sites, as we feel that it would be unwarranted based on the preliminary data that we have. "Rarity" is quite sensitive to incomplete data; new records from more complete surveys could always change such a selection of so-called irreplaceable or complementary sites.

What is the potential for long-term survival of these beetles? First and foremost, it should be noted that these insects on Pulau Ubin are not immune to the general reduction of insect numbers and species richness like what happens on the mainland, via various forms of land use and other indirect effects such as fragmentation or light pollution. This severe decline in abundance is evident from a comparison of what "used to be" and what is no longer the case. Historical collectors such as Wallace and Baum in the 19th and early 20th century could obtain an unimaginable amount of beetle species in a matter of weeks, whereas now it will take decades of collecting efforts to build up similar numbers. Many species are at such a low level of density nowadays that it is almost impossible to find them through general collecting (like that practised by Wallace and Baum) and are only obtainable through various mass trapping methods. Unfortunately, for many species, there is a slippery slope from such a severe dip in population to local or even general extinction. And given that populations associated with small, fragmented communities are always vulnerable, these unique beetle fauna found on Pulau Ubin are in need of long-term conservation management efforts to improve their potential for survival.

Indicator species

- Many endemic/subendemic species reported here are thought likely to be the remnants of the beetle assemblage associated with coastal/mangal environment. A few with high conservation priority and each presumably representative of a group of functionally related taxa (together with their potential for engendering public goodwill) have been chosen as potential bioindicators for the community living in such an environment (see Table 3). They would be useful for monitoring the changes in response to natural factors, human activity or management practices (e.g. to assess the effectiveness of mangrove replanting in restoring these beetle populations).
- A series of beetles from other functional groups would be needed to fully reflect the richness or diversity of beetles. While there are other rare species collected in this project, their specialisation to habitat is not sufficiently known (our project is an inventory study and understanding the biology is not the main focus of our study). Further investigations on how these species are related to a specific attribute of the habitat are recommended so that we can appraise their desirability as indicator species.

Table 3. Recommended indicator species

Indicator species (family, subfamily)	Trophic category	Habitat (locality)
Calomera angulata (Carabidae, Cicindelinae)	Predator	Sandy shore (Noordin Beach)
Catharsius renaudpauliani (Scarabaeidae, Scarabaeinae)	Coprophage	Forest (Chek Jawa, ULL)
Glycyphana binotata (Scarabaeidae, Cetoniinae)	Saproxylic (larval stage)	Forest (Bukit Jelutong)
Chrysobothris nigripennis (Buprestidae, Buprestinae)	Saproxylic	Mangrove (Sungei Puaka)
Dejanira quadripunctata (Cerambycidae, Cerambycinae)	Saproxylic	Forest (Western forest, Bukit Jelutong area)

Habitat protection and improvement

- Coastal forest/riverine mangrove: Retain as much plant material as possible within the habitat and avoid removing fallen trees (including stranded trunks along the coast). If some form of intervention is required for safety reasons, never saw the trees into small stockpiles, which will destroy the richness of the deadwood habitat in its various conditions (branches and twigs of varying thickness, overhanging branches with shady undersides, standing tree trunk with cracks and crevices for the nocturnal fauna, etc.). During mangrove replanting, promote heterogeneity and uneven-aged composition, and if possible, provide decaying wood in the forest understory to increase the abundance of deadwood material and improve deadwood connectivity.
- Sandy shore: Noordin Beach is a critical habitat that is currently severely threatened/degraded by coastal erosion. Plans to restore and safeguard Noordin Beach against erosion will hopefully help sandy shore beetles (and other insects) survive this loss of habitat. Some shoreline protection measures (e.g. armouring of the shoreline using various structural modifications) that might contribute to the decline and loss of habitat themselves should be avoided. Guidelines for recreational use of the habitat should be developed to prevent trampling and compaction of the sandy substrate where the Tiger Beetle larvae are found.
- Grassland/Scrub: Grassland patches and scrub corridors should be preserved both as conduits and as refugia in their own right. Native wild flowers with a more diverse range of floral morphology should be planted to support a more diverse and abundant insect assemblage (e.g. unlike butterflies, beetles typically visit bowl-shaped flowers that are white). As these habitats require maintenance to keep the vegetation structure suitable for grassland wildlife, the intervention should be wildlife-friendly (such as cutting in small compartments).

Conclusions

Pulau Ubin, with its heterogeneous habitats, allows diverse microenvironments to exist. In the case of insects, which typically have small area requirements and narrow but diverse habitat requirements, such networks of microenvironments support a large number of species. Our preliminary inventory for beetles results in more than three hundred species, with several species currently known only from localities within Pulau Ubin, as well as some undescribed new species. Such biological inventory provides important information for conservation planning, and allows a broader range of species to be included in such planning. We have identified the core areas on Pulau Ubin with high species richness and rarity, and a few potential indicator species of different feeding guilds for various representative habitats.

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Appendix 1. Preliminary List of Beetles Collected from Pulau Ubin
The families are presented in systematic sequence. Species as yet unidentified or even undescribed are referred to by informal names or by `sp.'
* refers to species endemic to Pulau Ubin
** refers to species subendemic to Pulau Ubin

Carabidae
1. *Andrewesia obesa*
2. *Anomotarus sericeus*
3. *Calleida tenuis*
4. *Callytron doriai*
5. *Calomera angulata*
6. *Catascopus borneensis*
7. *Catascopus elegans*
8. *Catascopus facialis basalis*
9. *Chlaenius tetragonoderus*
10. *Colpodes obscuritarsis*
11. *Coptodera (Coptoderina) flexuosa*
12. *Cosmodela aurulenta*
13. *Cylindera discreta*
14. *Dicraspeda brunnea*
15. *Dolichoctis rotundata*
16. *Endynomena pradieri*
17. *Euplynes* cf. *aurocinctus**
18. *Mochtherus tetraspilotus*
19. *Neocollyris (Neocollyris) bonellii*
20. *Orthogonius hopei*
21. *Orthogonius* nr. *rufiventris*
22. *Pentagonica eurodes*
23. *Pentagonica pallipes*
24. *Pentagonica parapapua*
25. *Tachys delicatus*
26. *Tachys* cf. *plagiatus*

Scirtidae
27. *Scirtes* sp. 1 (blackish)
28. *Scirtes* sp. 2 (orange with 2 dots)

Staphylinidae
29. *Cafius nauticus*
30. *Orsunius* sp.
31. *Oxytelus or Anotylus* sp.*
32. *Platydracus* sp.
33. *Remus corallicola*
34. Scaphidiinae sp.
35. *Stenus* sp.

Scarabaeidae
36. *Adoretini* sp. (=NS 2004 sp.)
37. *Apogonia* cf. *expeditionis*
38. *Apogonia* cf. *orbitalis*
39. *Anomala* cf. *matricula* (sp. nov.)*
40. *Anomala* cf. *pallida**
41. *Caccobius unicornis*
42. *Catharsius renaudpauliani*
43. cf. *Diastictus* sp.*
44. *Glycyphana binotata laterimarginata***
45. *Ixorida regia* ssp. *sumatrana*
46. *Lepivalgus pygmaeus*
47. *Leucopholis* sp.*
48. *Maladera* sp.
49. *Onthophagus babirussa*
50. *Onthophagus crassicollis*
51. *Onthophagus denticollis* or near (new)
52. *Onthophagus orientalis*
53. *Onthophagus papulatus*
54. *Onthophagus phanaeides*
55. *Onthophagus proletarius*
56. *Onthophagus rutilans*
57. *Onthophagus semifex*
58. *Onthophagus trituber*
59. *Onthophagus waterstradti**
60. *Oryctes rhinoceros*
61. *Sericini* sp., greyish, 3-segmented club*
62. *Xylotrupes gideon*

Dascillidae
63. *Petalon* sp.

Buprestidae
64. *Agrilus subconsularis*
65. *Aphanisticus* nr. *aureocupreus*
66. *Aphanisticus cochinchinae* ssp. *seminulum*
67. *Belionota prasina*
68. *Chrysobothris indica*
69. *Chrysobothris nigripennis*
70. *Endelus coeruleus*
71. *Habroloma* cf. *conscriptum*
72. *Habroloma gentilis**
73. *Habroloma lepidoptera*
74. *Melobasis trifasciata*
75. *Trachys furnius*
76. *Trachys mendicus**

Callirhipidae
77. *Callirhipis* cf. *javanica*

Elateridae
78. *Abelater* cf. *pusillarius*
79. *Adelocera* sp. 1*
80. *Adelocera* sp. 2*
81. *Cardiophorus* sp.
82. *Cryptalaus* sp.
83. *Elaterinae* sp. 1
84. *Elaterinae* sp. 2
85. *Elaterinae* sp. 3
86. *Elaterinae* sp. 4
87. *Melanoxanthus bifasciatus*

Appendix 1. Continuation

88. *Priopus* cf. *waterstradti*
89. cf. *Priopus* sp.
90. cf. *Procraerus corpusculus**
91. *Xanthopenthes* cf. *baumi*
92. *Xanthopenthes* sp.*

Lycidae
93. *Plateros* sp.*

Rhagophthalmidae
94. cf. *Diplocladon* sp.

Lampyridae
95. *Colophotia praeusta*
96. *Curtos* sp.
97. *Diaphanes* sp.
98. cf. *Flabellotreta* sp.
99. *Pteroptyx* cf. *valida*
100. cf. *Stenocladius* sp.

Cantharidae
101. Cantharid sp., long antennomeres

Dermestidae
102. *Orphinus* cf. *fulvipes**

Ptinidae
103. *Ptinus* cf. *rugosithorax*

Lymexylidae
104. *Atractocerus* sp.

Trogossitidae
105. *Anacypta* cf. *punctata*
106. *Ancyrona* sp.*

Cleridae
107. *Callimerus fuscitarsus*
108. *Clytomadius louwerensi*
109. *Omadius bifasciatus*

Melyridae
110. cf. *Balanophorus* sp.
111. *Intybia* or *Dicranolaius* sp.

Erotylidae
112. *Amblyopus* cf. *vittatus*
113. *Aulacochilus quadripustulatus*
114. *Episcapha quadrimacula*
115. *Micrencaustes* cf. *wunderlichi**
116. *Pseudotritoma* sp.
117. *Tetraphala elongata*
118. *Tritoma* sp.

Monomatidae
119. *Monomma* cf. *glyphysternum*

Silvanidae
120. *Psammoecus* sp.
121. *Psammoecus* sp. nov.?*
122. Unidentified s p.*?*

Nitidulidae
123. *Carpophilus delkeskampi**
124. *Epuraea (Haptoncurina)* cf. *paulula*

Discolomatidae
125. cf. *Aphanocephalus* sp.

Endomychidae
126. *Endomychidae* sp.*
127. *Eumorphus assamensis subguttatus*
128. *Eumorphus sybarita*
129. *Stenotarsus* sp.
130. *Trochoideus desjardinsi*

Coccinellidae
131. *Cheilomenes sexmaculata*
132. *Cryptogonus* sp.*
133. *Epilachna vigintioctopunctata*
134. *Harmonia sedecimnotata*
135. *Heteroneda* cf. *reticulata*
136. *Illeis* sp.
137. *Micraspis discolor*
138. *Ortalia* sp.
139. *Phrynocaria deficiens*
140. *Sticholotis* cf. *quadriguttata**

Mordellidae
141. *Glipa malaccana*

Zopheridae
142. *Microvonus (Anovonus) bouchardi*
143. *Nematidium* sp.*

Tenebrionidae
144. Alleculinae: Oedemerid-like*
145. Alleculinae: Lagriinae-like, head quadrate*
146. *Alphitobius* cf. *laevigatus*
147. *Amarygmus aeneus*
148. *Amarygmus burckhardti*
149. *Amarygmus cupriarus*
150. *Amarygmus micans*
151. *Amarygmus recordativus*
152. *Amarygmus* cf. *rivalis* sp. 2*
153. *Amarygmus splendidulus*
154. *Anaedus forticornis*
155. *Androsus corporaali*
156. *Aulonogria concolor*

Appendix 1. Continuation

*157.Bolbostetha baumi***
158.Bolbostetha cf. *socia*
159.Caedius cf. *aspericollis*
160.Ceropria adelpha
161.Ceropria induta
162.Cistelopsis cf. *brunnea*
*163.Derosphaerus aeruginosus**
164.Eucyrtus anthracinus
165.Eucyrtus pretiosus
*166.Euhemicera hayashii**
*167.Euhemicera kaszabi**
168.Gonocephalum cf. *moluccanum*
169.Hemicera minutissima
170.Hemicera splendens
*171.Palorus andrewesi***
172.Palorus sp. nov.*
*173.Phaedis purpureostriatus**
174.Phaedis superbus
175.Platydema marseuli
*176.Platydema nuciferae**
177.Platydema cf. *planum*
178.Platydema subfascium
179.Platydema waterhousei
*180.Postandrosus maculipennis**
181.Strongylium erythrocephalum
182.Strongylium insigne
183.Strongylium sp., *aciculatum* group
184.Tetraphyllus cf. *foveolatus**
185.Tetraphyllus laevicollis
186.Toxicum quadricorne

Oedemeridae
187.Oedemeridae sp. (pink)

Salpingidae
188.Inopeplus cf. *malanoleucus*

Anthicidae
189.Macratria sp. 1*
190.Macratria sp. 2*

Aderidae
191.Phytobaenus sp.
192.Zonantes sp.

Vesperidae
193.Philus sp.*

Cerambycidae
194.Abryna regispetri
195.Anancylus griseatus
196.Apriona flavescens
197.Batocera rubus
198.Ceresium raripilum
*199.Choeromorpha albofasciata***
200.Cleptometopus sp.
201.Coptops lichenea
202.Cylindroeme sp.**
*203.Dejanira quadripunctata**
204.Egesina fusca fusca
205.Egesina ornata
206.Eoporis elegans
207.Epepeotes luscus
208.Glenea quadrinotata
*209.Imantocera plumosa**
210.Mispilodes cf. *borneensis*
211.Nupserha fricator
212.Olenecamptus bilobus
*213.Pothyne variegata**
214.Pseudiphra sp.
215.Pterolophia cf. *kalimantana**
216.Pterolophia sp. (denuded, possibly *subtincta*)
*217.Rondibilis lineaticollis**
218.Ropicagris eosparsa
219.Ropica honesta
220.Similosodus cf. *flavicornis**
221.Similosodus verticalis
222.Sybra donckieri
223.Thranius bimaculatus
224.Xenolea tomentosa
225.Xylotrechus javanicus

Chrysomelidae
226.Altica aenea
227.Aulacophora indica
228.Basilepta sp. 6a
229.Basilepta sp. 15*
230.Cassida circumdata
*231.Chaetocnema (Chaetocnema) sabahensis ***
*232.Cleorina aeneomicans***
233.Coenobius sp.
234.Colaspoides cf. *inornata*
235.cf. *Colaspoides* sp.*
236.Colasposoma viridicoeruleum
237.Dercetisoma concolor
238.Dercetisoma sp.
239.Erystus saundersi
*240.Haplosomoides plicatus**
241.Hemipyxis cf. *flava/badia*
242.Hemipyxis lusca
243.cf. *Hesperopenna* sp.*
244.Hyphasis parvula
245.Lanka sp.*
246.Lema coromandeliana
247.Lema rufotestacea
248.Longitarsus suturellinus
*249.Monolepta laticornis**
250.Monolepta cf. *zonula **
251.Monolepta murphyi
252.Monolepta cf. *pectoralis**

Appendix 1. Continuation

253.*Monolepta* cf. *rubricollis* or allied genera*
254.*Monolepta* sp. 2 (black pronotum rim)
255.*Monolepta* sp. 3 (pronotum red/black)*
256.cf. *Monolepta* sp. 7
257.*Nisotra chrysomeloides***
258.*Notosacantha rufa*
259.*Oncocephala feae*
260.*Pagriain gibbosa*
261.*Paradibolia ruficollis*
262.*Parheminodes* cf. *pulcher**
263.*Phyllotreta chotanica**
264.*Phyllotreta striolata***
265.*Phytorus pinguis*
266.*Psylliodes balyi*or *brettinghami**
267.*Rhyparida spiridonovi*
268.*Rhyparida* sp.*
269.*Scelodonta granulosa*
270.*Spermophagus* sp.*
271.*Sphaeroderma antennata*
272.*Sumatrasia tibialis***
273.*Tricliona trimaculata*

Anthribidae
274.*Acorynus disclusus***
275.*Apolectella corporaali*
276.*Araecerus areolatus*
277.*Autropis* cf. *modesta**
278.*Deropygus* cf. *giton*
279.*Eucorynus crassicornis*
280.*Euparius modicus*
281.*Exechesops* cf. *lituratus**
282.*Exechesops phodinus*
283.*Exillis* sp. (finely streaked)
284.*Hucus ovinus*
285.*Hypseus argutus*
286.*Litocerus figuratus*
287.*Litocerus humeralis*
288.*Litocerus pollionis*
289.*Litotropis icon*
290.*Melanopsacus subglaber*
291.*Mucronianus ellipticus*
292.*Phloeobius pallipes*
293.*Platystomos wallacei*
294.*Rhaphitropis gracilis*
295.*Rhaphitropis vittata*
296.*Sphinctotropis paviei*
297.*Uncifer* cf. *rectangulus*

Attelabidae
298.cf. *Auletobius*sp.*
299.*Byctiscidius* cf. *insularis*

Brentidae
300.*Cerobates sexsulcatus*
301.*Cylas formicarius*
302.*Higonius crux*

Curculionidae
303.*Acicnemis* sp.
304.*Acicnemis ambigua*
305.*Alcidodes pulchellus*
306.Baridinae?
307.cf. *Colobodes* sp.*
308.Cossoninaesp. 1
309.Cossoninae sp. 2
310.*Euthyrhinus* sp. 1
311.*Euthyrhinus* sp. 2
312.*Lobotrachelus angulatus**
313.cf. *Parapries sumatranus*
314.*Parimera* sp.
315.*Platypus parallelus*
316.*Rhynchophorus vulneratus*
317.*Telephae* sp.*
318.cf. *Telephae paryphanta*
319.cf. *Xenotrupis* sp.*

Bees, wasps, and ants of Pulau Ubin, Singapore (Insecta: Hymenoptera)

John S. Ascher[1]*, Zestin W.W. Soh[2], Justin C.H. Tan[2], Vera S.H. Lim[1], John X. Q. Lee[3], Liew Qi[2], Jacqueline L.E. Chua[2], Anya R. Gajanur[1], Ong Xin Rui[1,4], Eunice J.Y. Soh[1], Tan Yong Guang[1], Lim Yu Jun [5], Robin J. Southon[1], Chui Shao Xiong[1]

[1]Insect Diversity Lab, Department of Biological Sciences, National University of Singapore, 16 Science Drive 4 S3 Level 4, 117558, Singapore
[2]National Parks Board, Singapore Botanic Gardens, 1 Cluny Road, Singapore 259569
[3]No. 2, 2/F, Sai Wang Lane, Sai Kung, N.T., Hong Kong
[4]Asian School of the Environment, Nanyang Technological University, 50 Nanyang Avenue, Singapore 639798
[5]Blk 289C Punggol Place, Singapore 823289
*Corresponding author: dbsajs@nus.edu.sg

ABSTRACT. Hymenoptera (bees, wasps, and ants) are major contributors to ecosystem functioning via pollination, predation, and parasitism, but have been historically under-sampled on Pulau Ubin, Singapore's second largest offshore island, compared to the mainland. To rectify this, we compiled occurrence records of bees, wasps, and ants from systematic and opportunistic studies involving fieldwork, museum collections, citizen science, and critical review of scientific literature. We recorded 303 species of Hymenoptera belonging to 34 families for the island, including species known for Singapore only on Pulau Ubin, underscoring the importance of the island as a biodiversity hotspot within Singapore. Bees comprise approximately one-half of the fauna now known from Singapore (71 of the 140 Singaporean species). There are more ant species recorded from Pulau Ubin (76), but these comprise a far smaller proportion (18.6%) of the known Singaporean fauna of 409 species. The 107 species of aculeate wasps and 51 'Parasitica' represent a start towards documenting Singapore's wasp diversity. Highlights of the study include the discovery of several taxa new for Singapore, such as a cleptoparasitic bee from the locally rare genus *Nomada*. Prominent sites for Hymenoptera include Butterfly Hill, restoration plantings of native flora, mangroves, and surrounding sandy beaches. Further integrative taxonomic work on vouchers may assist in cryptic species identification among aculeate bees and wasps, and new species discovery particularly within the largely unknown parasitic wasps. Citizen science platforms, especially iNaturalist, proved to be an important source of data, with 45 of the 71 bees (63.4%) and 57 of 107 (53.3%) all aculeate wasps documented, along with many Parasitica and ants. Several taxa were recorded solely based on expert-identified images, and for common taxa these data sources extended spatiotemporal coverage of records for the island.

Keywords. Aculeata, Anthophila, biodiversity, citizen science, conservation, insects, island biogeography, taxonomy

Introduction

Hymenopterans (bees, wasps, and ants) are globally diverse insects that provide crucial ecological functions for maintaining ecosystem health and stability. Bees are well established as major pollinators of flowering plants worldwide, even within Southeast Asia where they are relatively species poor but highly functional (Corlett, 2004; Orr et al., 2021; Warrit et al., 2023). Wasps, whilst also pollinators at times, are influential regulators of arthropod populations through predation and parasitism (Brock et al., 2021). Ants also perform an array of ecological roles in tropical ecosystems, where their biomass may exceed that of birds and mammals combined (Schultheiss et al., 2022). Given the tremendous importance of Hymenoptera in maintaining natural and managed ecosystems, studies on their biodiversity are vital to direct conservation and research efforts.

The bees of Singapore comprise 140 species (including certainly distinct morphospecies but excluding at least two other potentially distinct morphospecies in the genera *Nomia* and *Braunsapis*) in four families, the taxonomy of which has been largely resolved due to focused review since 2011. Most species are photographed and described in Soh & Ascher (2020), and their conservation status and habitat usage are summarised in a country checklist (Ascher et al., 2022). The ant species of Singapore were very recently reviewed (Wang et al., 2022) and a prior study reported genera and morphospecies found during a rapid assessment of this group for Pulau Ubin (Yong et al., 2017). By contrast, the wasps, a paraphyletic group far exceeding bees and ants in family and species diversity, are still poorly understood in Singapore (Ascher & Lee, 2023). The taxonomy of many wasp species across Southeast Asia remains to be fully resolved, with the best understood taxa being larger-bodied aculeate wasps, in particular the social vespids (Lee et al., 2023) and the thread-waisted wasps of family Sphecidae (Hensen, 1991).

Pulau Ubin is relatively undeveloped and characterised by a range of habitat types such as secondary, coastal & scrub forests, mangroves, grassy fields, and sandy and rocky beaches that potentially host a diverse hymenopteran fauna. Given the short distance between Pulau Ubin and mainland Singapore and Peninsular Malaysia, species richness is unlikely to be lowered by island isolation (Spengler et al., 2011). The island's position as a relatively undisturbed habitat alongside the urbanised metropolis of Singapore provides a unique opportunity to contrast the species richness between nearby areas with divergent land use.

Bees on the offshore islands of Singapore, including Pulau Ubin, were apparently not surveyed by any of the pioneering bee collectors in the 19th or early 20th centuries–with the exception of a historical stingless bee nest collected by H.N. Ridley in 1898 (Ascher et al., 2022; Soh et al., 2022). A.R. Wallace and C.F. Baker collected mostly forested-associated bees (Ascher et al., 20l6, 2022; Soh & Ascher, 2020), but there is no evidence that they captured any coastal or mangrove species. Dennis Hugh ("Paddy") Murphy was an important researcher of insects in mangroves and other habitats (Ng, 2020), but collected on Singapore's outlying islands mostly from Pulau Semakau rather than Pulau Ubin. The ants of Pulau Ubin were poorly known until recently. A rapid assessment of ant diversity at the generic and morphospecies level by Yong et al. (2017; see also Wang et al., 2018) surveyed ants at several sites using various methods, including Winkler extractions. Subsequently, records from Pulau Ubin were included in a review of all ant species of Singapore (Wang et al., 2022), including some pre-2016 samples (see below). This study reported species identifications (some with annotations or qualifications) for 62 species, but did not review all morphospecies cited in the 2017 paper or include taxa recorded for Pulau Ubin in citizen science platforms (e.g. iNaturalist). The history of wasp collecting in Singapore is less well known, but as with bees it is likely that historical collections from Pulau Ubin were sparse, and that most species now known to the island were detected only recently.

Here we provide the first modern checklist of bees, wasps, and ants for Pulau Ubin to serve as a baseline for monitoring and management, for the long-term conservation of Pulau Ubin's natural heritage.

Materials and Methods

Species Database

We compiled a database of bees and wasps comprising label data of available Pulau Ubin

(Singapore; 1°24’37.3”N 103°57’37.0”E) specimens from the National University of Singapore Insect Diversity Lab (IDL) and Lee Kong Chian Natural History Museum Zoological Reference Collection (LKCNHM ZRC), which includes records from students’ research projects and malaise trap specimens from the National University of Singapore Mangrove Insect Project (MIP) (Yeo et al., 2021) together with the authors’ opportunistic observational records on the island documented in notes or photographs between 2006–2022. We also included citizen science records from online platforms such as the “Bees & Wasps of Singapore” Facebook.com group (from 2013–2022) and iNaturalist.org (n=827 Hymenoptera observations from 2009–2022; submitted by 52 observers between 2017–2022) captured in the database. Online citizen science records were only used when the species was identified or verified by experts (including JSA, ZWWS, and experts thanked in Acknowledgements). Identifications by JSA were made with reference to voucher specimens from Singapore in the IDL and LKCNHM ZRC databases, publications on the Singapore bee and wasp fauna (e.g., Soh & Ascher, 2021; Ascher et al., 2022; Lee et al., 2023), and publications on wasps mostly focusing on other regions yet still providing relevant diagnostic information (e.g., van der Vecht, 1949, 1963; van Lith, 1962, 1969; Hensen, 1991; Narendran & van Achterberg, 2016; Ye et al., 2017). Type material of bees in collections such as the Natural History Museum in London (NHMUK) were examined and photographed (by ZWWS, CSX) to ensure accurate species identification. Taxonomic-grade photographs of most species are uploaded to The Biodiversity of Singapore (Singapore.biodiversity.online) along with information on species interactions such as pollinator-floral associations.

Targeted Sampling from 2018–2019

To supplement the above database and ensure coverage of the various habitats across the island, a series of targeted sampling events for bees and wasps was initiated as part of the Comprehensive Ubin Biodiversity Survey (CUBS). A total of nine surveys were carried out from August 2018 to November 2019 in sunny weather by two to four surveyors at a time. Survey transects were spread throughout the island in different habitats (Fig. 1) and lasted from 0830 hours to 1200 hours. Surveyors hiked the transects and captured all bees and wasps using sweep nets, spending additional time at flowering plants in bloom. Specimens that were readily identified to species level in the field were recorded and then released while those requiring detailed examination were collected as vouchers. Specimen vouchers were deposited at the IDL or the LKCNHM ZRC and identified to the lowest possible taxonomic level.

Results and Discussion

Historical and recent records of bees, wasps, and ants at Pulau Ubin were compiled. The bee fauna (Appendix I) comprises all four families known from Singapore, 24 genera (of 27 recorded from Singapore), and 70 species including unnamed morphospecies (50% of the known bee fauna in Singapore of 140 species; this total is derived from Ascher et al. (2022), with addition of *Nomada adusta* as reported herein and by Lim et al. (2022), and the following additions: the recently discovered morphospecies *Megachile* (*Aethomegachile*) sp. 3 and *Lasioglossum* (*Hemihalictus*) *plasunicum* (Blüthgen, 1926), male not female, which had been omitted due to taxonomic issues arising from its likely composite type series; two additional *Sphecodes* morphospecies are now recognised, two additional exotic bee species have been found at Gardens by the Bay; and finally Singaporean ethanol-stored examples of the bee reported by Soh and Ascher (2020) and Ascher et al. (2022), as *Eupetersia* (*Nesoeupetersia*) *yanegai* Pauly proved upon restudy after proper mounting to instead be a third additional *Sphecodes* morphospecies exhibiting exceptional mimicry (bringing the total *Sphecodes* of Singapore to nine species and morphospecies; true *E. yanegai* is correctly identified in the LKCNHM ZRC from nearby Johor) (Table 1). The ants of Pulau Ubin (Appendix II) comprise 62 identified species (Wang et al., 2018, 2022) and 14 additional morphospecies (most reported by Yong et al., 2017), totalling 44 genera in 76 species-level taxa (18.6% of the known Singaporean ant fauna of 409 species). The wasp fauna of Pulau Ubin (Appendix III) comprises 157 species from 29 families including unnamed morphospecies (Tables 2 & 3). The taxonomy of the bees and ants is relatively resolved, with 82.9% and 81.6% respectively of taxa recorded identified to species level, and the remaining 15% and 18.4% identified to morphospecies (with identification resolved to generic or subgeneric level). Aculeate wasps are approaching a similar resolution, with approximately 63% of specimens identified to species level, 29% to morphospecies (subgenus or genus), and 9% to morphospecies (above genus level). However, non-aculeate wasps (referred to as 'Parasitica') are still a 'dark taxon', in that few taxa were identified to species, even equivocally, whilst about one-third identified to genus and the majority remain at family-group rank (tribe, subfamily, or family) only.

Bees of Pulau Ubin

Most of the bee species reported as 'Common' in Singapore (24 of 26) in Soh & Ascher (2020) are now known from Pulau Ubin (Fig. 2). The two such taxa not recorded on the island are the resin bee *Megachile umbripennis*, believed to be non-native in Singapore and occurring widely on the mainland, and the widespread sweat bee *Lasioglossum vagans* even though similar morphospecies in subgenus *Ctenonomia* are recorded. Most 'Moderately Common' species (13 of 17) as reported in Soh & Ascher (2020) are on Pulau Ubin with the exception of the forest-associated *Nomia fuscipennis* and *Tetragonula geissleri*, and two species that are more widely ranging and thus have higher probability of occurrence on Pulau Ubin: *Megachile* (*Eutricharaea*) sp. 1 and *Ceratina perforatrix*.

Apis florea, a species native to monsoonal countries of continental Southeast Asia has recently expanded its range to include Singapore and much of Peninsular Malaysia (Silva et al., 2020). It was first detected in the West Coast area of southern Singapore and until recently was scarce or absent in much of northern Singapore. It is not clear if the first records of *A. florea* for Pulau Ubin, from 2020, represent an extension of its northward spread within Singapore or spread southwards from Johor in Malaysia where the species is now also established.

Most of the 'Uncommon' species (15 of 17, including three newly assessed species) of Singapore also occur on Pulau Ubin. For example, the beach-associated sweat bee *Lasioglossum halictoides* is found at sandy areas on the island where its host plant *Ipomoea pes-caprae* grows.

Of the ten 'Rare' species (two newly assessed), the most conspicuous is *Lepidotrigona terminata*, a stingless bee regularly observed visiting inflorescences of the nipah palms *Nypa fruticans* along the boardwalk at Chek Jawa. Workers and nests of this eusocial species are also recorded elsewhere on Pulau Ubin and on nearby Pulau Tekong, but notably it is not an established species on the mainland of Singapore (although it may occur temporarily when hives are transferred for meliponiculture). Given its limited range and habitat association, this stingless bee is also assessed to be nationally 'Vulnerable' in Singapore (Ascher et al. 2022). Another mangrove-associated 'Rare' species is *Nomia lusoria*, detected on Pulau Ubin in August 2022 visiting *Bruguiera gymnorhiza* at Sungei Mamam. This species (including a potential cryptic morphospecies; see Soh & Ascher, 2020) is known exclusively from mangrove sites in Singapore, including Sungei Buloh Wetland Reserve and Pasir Ris Park. One male of the *Megachile* morphospecies *M.* (*Aethomegachile*) sp. 2 [*fusciventris* group] was photographed visiting *Kleinhovia hospita* along Jalan Noordin. Two 'Rare' cleptoparasites of *Megachile* are found on Pulau Ubin, *Euaspis polynesia* and *Coelioxys* (*Allocoelioxys*) sp. 3. The latter may prove to be a parasite of *Megachile subrixator*, the only *Megachile* (*Eutricharaea*) known so far on Pulau Ubin, while the former likely parasitises resin bees such as *Megachile disjuncta* and *M. fulvipennis* on the island (Soh et al., 2020). The bamboo-nesting carpenter bee *Xylocopa iridipennis* is known from one record in 2011. *Ceratina metaria* is a small-bodied member of a subgenus most often associated with mature forests in the region, and aside from the Central Catchment forests in central Singapore has only been locally recorded from Pulau Ubin at Chek Jawa, although it may be overlooked. This bee was also photographed at the *Pittosporum* at Jalan Noordin. The 'Rare' *Anthidiellum* (*Pycnanthidium*) *smithii smithii* was newly detected on Pulau Ubin on 5 May 2022 where two were observed visiting *Pittosporum ridleyi.* Previous records from Singapore are limited to a few sites on the mainland including Dairy Farm Nature Park and HortPark.

Of greatest interest are eight 'Very Rare' species (three newly assessed), some of which are likely to be coastal specialists. Species recorded only from malaise traps conducted as part of the Mangrove Insects Project at Pulau Ubin (and other sites such as Pulau Semakau) include an unusual metallic blue *Hylaeus* species with affinities to *Hylaeus jacobsoni* of Java that could be new to science, and *Lasioglossum* aff. *latitarse* — although females key to *L. latitarse* in Pauly (1986), males from Singapore lack the namesake broadened front tarsi of male syntypes from New Guinea, so we now think that Singaporean examples pertain to a different taxon, perhaps undescribed, as could putative synonyms of *L. latitarse* from Southeast Asia described from females only). Another *Hylaeus* reported as a morphospecies (sp. 4) by Ascher et al. (2022) has been reidentified as a *Hylaeus* (*Nesoprosopis*) *transversalis* Cockerell male with an unusually sculptured propodeum (known to vary in this species, see Dathe, 2015), while an unidentified *Hylaeus* resembling *H.* (*Nesoprosopis*) sp. 2 [aff. *transversalis*] was photographed visiting *Bruguiera gymnorhiza.* Only distant photos were taken, but the limited yellow markings suggest that it could be that morphospecies. In Jalan Noordin, males of the two 'Very Rare' morphospecies *Megachile* (*Aethomegachile*) sp. 1 nr. *borneana* and *Megachile moera* were observed visiting flowering *Pittosporum ridleyi* (https://www.inaturalist.org/observations/113723799) (Fig. 3). At the same time, the cleptoparasitic bee *Nomada adusta* (Smith, 1875) was discovered visiting a nearby bush of *Premna serratifolia*, representing the first record of this species for Singapore and only known site nationally (Lim et al., 2022) (Fig 3A). The sweat bee *Lasioglossum albescens* was abundant at the site in Pulau Ubin and may be a potential host of *Nomada adusta* given the correspondence in their known geographic ranges (Lim et al., 2022). At Jelutong Bridge, a female *Ceratina* (*Xanthoceratina*) *fuliginosa* was discovered visiting the mangrove *Bruguiera gymnorhiza* in September 2022, representing the first record of this species for Singapore outside of the Central Catchment Nature Reserve, and further evidence that forest-associated bees are able to persist on Pulau Ubin.

Thus, the bee fauna of Pulau Ubin comprises almost all of the common and widespread species of Singapore, many less common species, as well as some rarely detected coastal specialists and forest-associated taxa. It is also noteworthy that three genera of stingless bees (tribe Meliponini) are present on the island, despite them being apparently absent from several other coastal sites in mainland Singapore. These bees may be considered an additional testament to the habitat quality on Pulau Ubin as they construct long-lived nests and are associated with mature forests. Many species are shared between Pulau Ubin and other surveyed islands of Singapore (Tan, 2017) but there are some discrepancies as some species known from the Southern Islands are unrecorded from Pulau Ubin. More bee species may be found on Pulau Ubin when more extensive or targeted surveys of its natural habitats are made.

Ants of Pulau Ubin

The ants (Formicidae) of Pulau Ubin were summarised at the generic level by Yong et al. (2017) who recorded 35 genera and 53 morphospecies from the island, mostly from rapid opportunistic sampling, and provided species-level annotation for selected rare species found. Wang et al. (2018) reported an additional genus *Rhopalomastix* from the island. Images of this genus were also posted on iNaturalist along with those for 16 other identifiable ant taxa that included *Camponotus* (*Tanaemyrmex*) sp. (not recorded from the island in print publications). Wang et al. (2022) recorded 62 named species from Pulau Ubin but did not review the morphospecies records reported by Yong et al. (2017). The ant list reported here of 76 species-level taxa in 44 genera combines non-redundant records from all available sources. In addition to the 2016 rapid biodiversity assessments reported by Yong et al. (2017), we collate information from earlier collections made by the MIP (more than a dozen species of alate ants captured in malaise traps serviced by, J. Puniamoorthy and M. Foo of the R. Meier laboratory, see Yeo et al., 2021) and at least 16 additional ant species captured and subsequently identified to species by taxonomic specialist Seiki Yamane during his visit to the island on 7 January 2014. In all, at least 33 ant species have records pre-dating the rapid assessment of 2016. Noteworthy ant species include *Vollenhovia escherichi* Forel, 1911, which is known in Singapore only from Pulau Ubin (Wang et al., 2022) *and Strumigenys rogeri* Emery, 1890, likely an accidental introduction to Singapore from Africa via human commerce (Wang et al., 2022).

Aculeate Wasps

Apoid wasps are conspicuous on Pulau Ubin, notably *Sphex madasummae* and *Bembix melancholica* which form nesting aggregations at sandy sites including Chek Jawa (Fig. 4). These wasps are localised at accessible sites on mainland Singapore, with most records of the *Bembix* coming from Coney Island and adjacent Punggol just across the Singapore straits from Pulau Ubin. Ampulicidae are represented by the widespread cockroach hunter *Ampulex compressa*. Most of the common Sphecidae known from Singapore (i.e., the species routinely reported on iNaturalist) are recorded from Pulau Ubin, such as *Sphex sericeus* and *Isodontia diodon*, along with the rarely recorded *Prionyx viduatus* (Christ) (new record; this genus is evidently poorly documented in Peninsular Malaysia and the Greater Sundas, see Pulawski, 2023), *Chalybion sumatranum*, and *Chlorion lobatum*. Black *Sphex* are mostly *Sphex madasummae*, but superficially similar dark-legged *Sphex subtruncatus* also occur so critical identifications should be made using keys in Hensen (1991). Crabronidae include several of the more common local taxa and some more unusual species such as the larrine *Dicranorhina ruficollis* and the cleptoparasitic genus *Nysson*. Four *Bembecinus* species including some known beach associates were identified to species with reference to van der

Vecht (1949). Additional study of malaise trap material should reveal additional mangrove-inhabiting species in genera such as *Psenulus*. Two species were identified in that genus, one from images, *Psenulus crabroniformis sumatranus* (Ritsema), and another from specimens, *Psenulus yoshimotoi* van Lith (1969). The latter is a new record from Singapore of a species described from Sabah that is similar to *Psenulus puncticeps* (Cameron), a species known from Singapore (the type locality of its synonym *Diodontus antennatus* Rohwer, 1923) but not from Pulau Ubin.

Vespidae are rather well-represented with 37 species present (78.4% of the 53 species known from Singapore). Most of the common vespid species of Singapore have been found such as all three common local *Vespa* species: *V. affinis*, *V. analis* and *V. tropica* (Lee et al., 2023). In addition, some more rare and localised species were recorded such as *Omicroides* sp., an all-black *Phimenes* species in addition to *P. flavopictus*, two species of *Zethus*, *Ropalidia fasciata*, and the recently described *Polistes tenebris* Nguyen & Lee (Nguyen et al., 2017).

The Pompilidae of Singapore are poorly known, and among several species recorded from Pulau Ubin only *Tachypompilus analis* has been identified to species level. Other taxa present include *Episyron*, *Auplopus*, *Irenangelus*, and *Paragenia*. Mutillidae are also poorly known in Singapore, but generic IDs are available for *Odontomutilla* sp. and *Yamanetilla* sp. based on review by experts of images shared on the biodiversity portal iNaturalist. Two species of tribe Trogaspidiini seem to be the most numerous mutillids. Scoliidae are generally abundant in coastal and mangrove sites in Singapore, and 10 of the 18 species (55.6%) known from Singapore have been detected on Pulau Ubin. Tiphiids and bethylids are present but not identified. Chrysidid cuckoo wasps are represented by the widespread *Stilbum cyanurum*.

Non-Aculeate Wasps of Pulau Ubin

Parasitoid Hymenoptera (an informal group known as 'Parasitica') are poorly studied in Singapore (Ascher & Lee, 2023) and most material from Pulau Ubin is on loan to specialists, with precise identifications not yet available. At least four genera of Chalcididae are recorded along with two species of genus *Leucospis* (Leucospidae) identified by Ng Yu Fei with reference to Ye et al. (2017). Three genera of the ant-associated chalcidoid family Eucharitidae are known. Many braconid and ichneumonid taxa are recorded, several of which were identified to genus by A. Reshchikov from specimens or images.

Future Directions

Pulau Ubin is an important site for Hymenoptera research as it supports populations of bees, wasps, and ants absent from or scarce at other accessible sites. It is also important for the detection, study, and conservation of poorly known coastal and mangrove-associated species. Persistence on Pulau Ubin of diverse cleptoparasitic bees likely indicates relatively large or stable populations of hosts and a more resilient and functionally diverse fauna than may exist at heavily fragmented mainland sites (see Sheffield et al., 2013, regarding the potential of cleptoparasitic bees as indicator species). The diversity of nationally rare bees and wasps visiting restoration plantings of native host flowers at some open sites such as Butterfly Hill and Jalan Noordin demonstrates the potential to restore and enhance pollinator, predator, and parasitoid habitats.

However, even in the better-studied groups such as bees and ants, Hymenoptera known from Pulau Ubin tend to be represented by one or a few specimens only (many examples for ants in Wang et al., 2022). This suggests that many more species remain to be discovered, and there is also much scope to recognise nationally and even globally novel material, especially when extensive samples of 'Parasitica' are fully sorted. Presence of nationally rare species of local conservation interest among bees, the best studied group, and of unusual ants (Wang et al., 2018, 2022) attests to the conservation importance for Hymenoptera of this island. Integrative taxonomic studies including molecular diagnostics (Orr et al., 2021; Yeo et al., 2021) may help to further discover cryptic species among the more well-known bees and ants, improve our understanding of species delimitations in the less well-known aculeate wasps, and help advance our still imprecise identifications of many parasitic wasps to generic level at least.

Pulau Ubin is often visited by insect photographers, and the biodiversity portal iNaturalist proved useful as a source of novel records for various taxa (e.g., Gasteruptiidae, the stephanid genus *Pseudomegischus*, the crabronid *Dicranorhina ruficollis*), and to extend spatiotemporal coverage for the well-known species. Citizen science images on iNaturalist of 121 taxa by 52 observers were a valuable source of new island records and a means to obtain new and further validated identifications from global experts (regarding the benefits of contributing to this platform as an identifier see Callaghan et al., 2022). In addition, these image records extend our temporal coverage by showing persistence of species that have not been collected at the site for many years. By facilitating non-destructive but reliable monitoring for many species we can track small and potentially vulnerable populations of bees, wasps, and ants at sites regularly visited by the public and thus not optimal for intensive research activities.

Conclusion

Bees, wasps, and ants of Pulau Ubin are diverse due to the variety of habitats that include mature terrestrial, coastal, and mangrove forests and availability of both native and planted floral resources. In well-known groups such as bees and vespids, most of the common and widespread species of Singapore are recorded from the island along with a set of more localised species including rarely seen cleptoparasitic bees – many of which have been collected only from mangroves or other coastal habitats. The aculeate fauna – in particular the bees, ants, apoid wasps, and vespid wasps – are relatively well characterized, although discovery is ongoing, and many species are reported as morphospecies. Additional study by taxonomic specialists is required to identify these, and numerous taxa in families such as Pompilidae that are less well studied locally and regionally. Further studies on Hymenoptera along with improvements in taxonomy will certainly uncover more species, especially among small-bodied wasps. In particular, additional integrative study of vouchers obtained using malaise traps from the Mangrove Insect Project should clarify the diversity of parasitoids, which remains poorly characterized beyond the conspicuous chalcids and leucospids. Citizen science image records should continue to document novel and rare taxa from the island fauna and extend temporal, spatial, and species interaction coverage of the better-known species.

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FIGURES & TABLES FOR MAIN TEXT

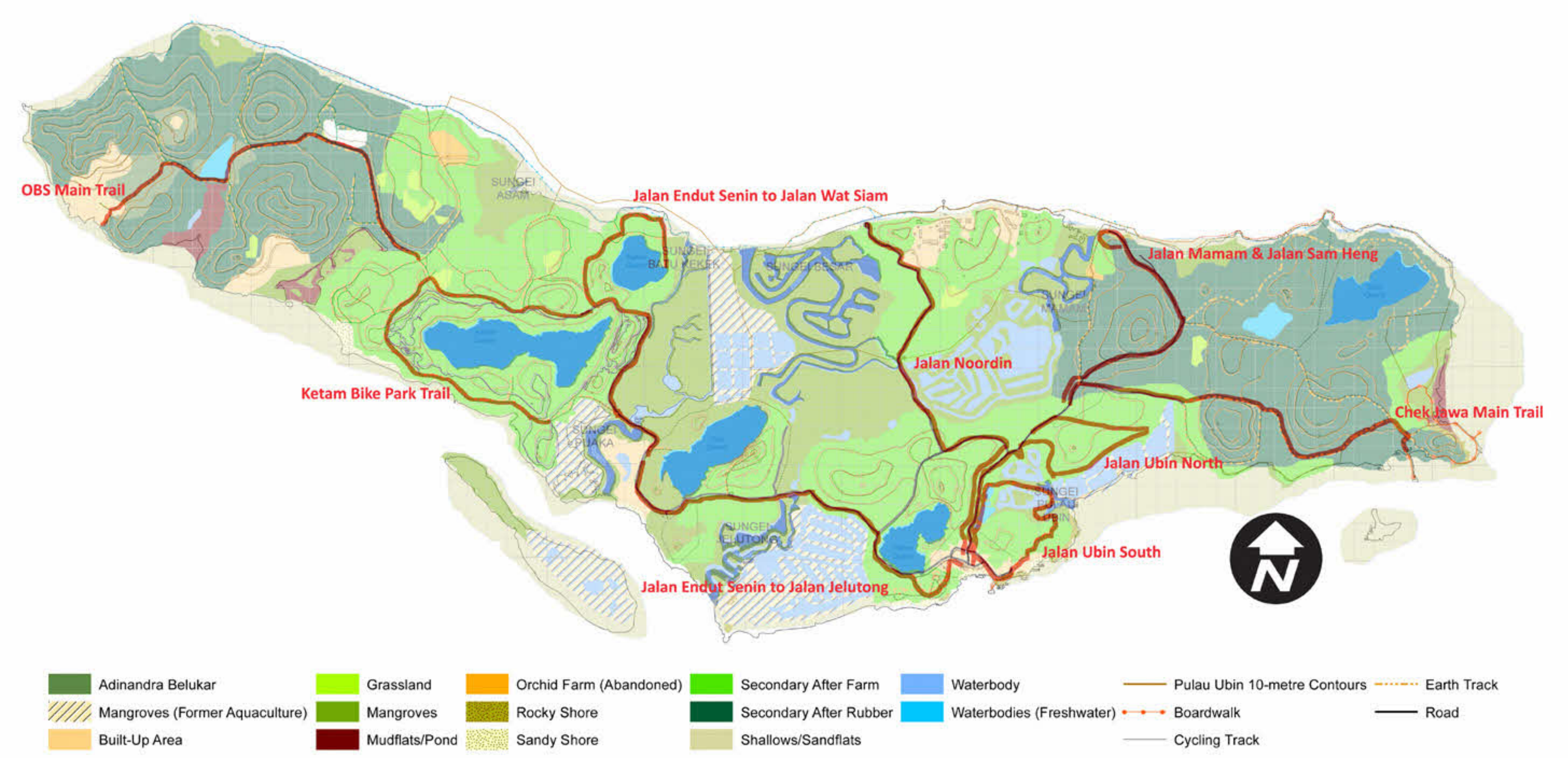

Fig. 1 Map of Pulau Ubin indicating locations and habitats sampled for bees and wasps as part of the Comprehensive Ubin Biodiversity Survey from August 2018 to November 2019.

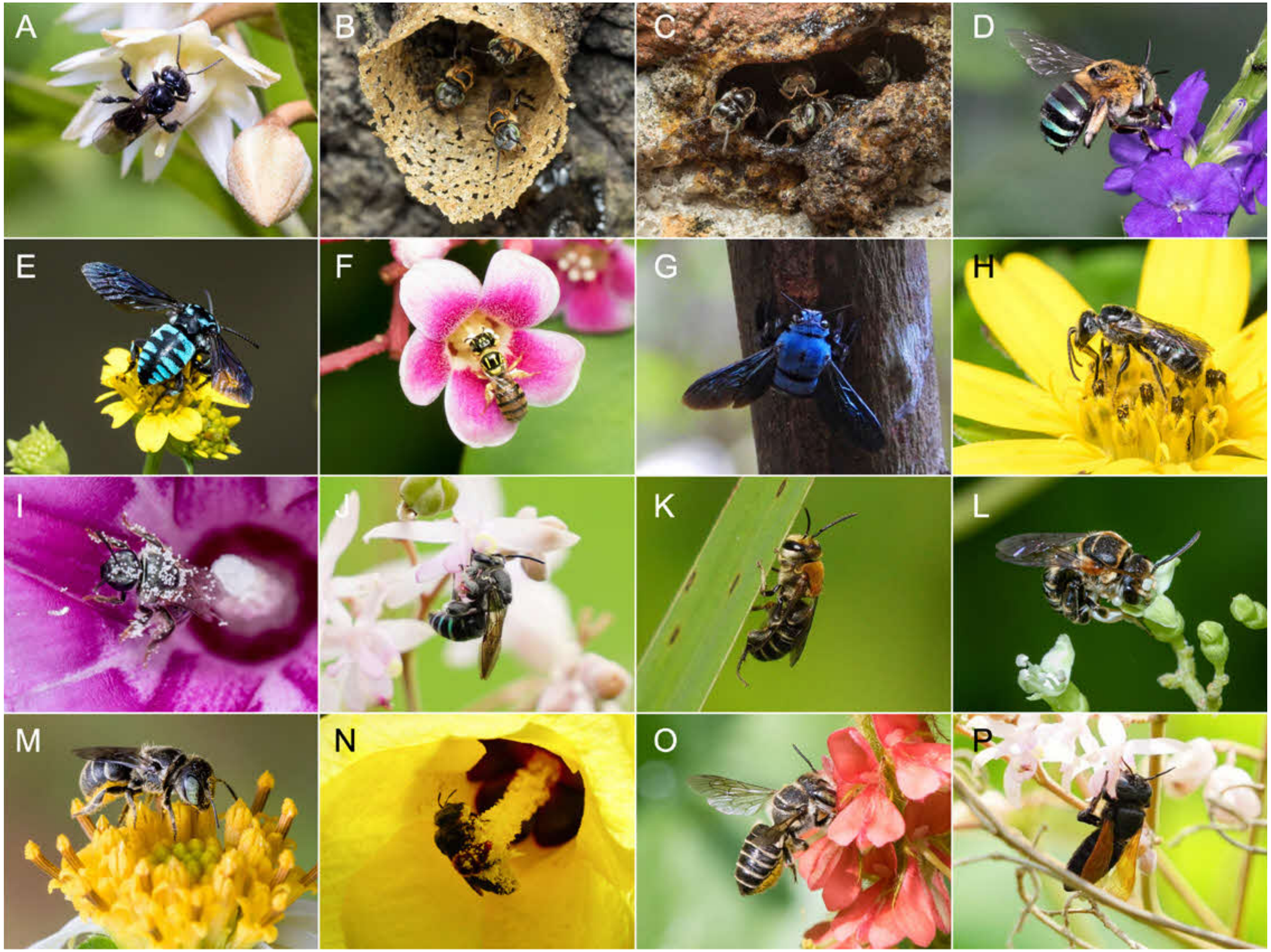

Fig. 2 Examples of the bee fauna on Pulau Ubin. **A.** *Heterotrigona itama* (Apidae); **B.** *Lepidotrigona terminata* (Apidae); **C.** *Tetragonula valdezi* (Apidae); **D.** *Amegilla andrewsi* (Apidae); **E.** *Thyreus lilacinus* (Apidae); **F.** *Ceratina metaria* (Apidae); **G.** *Xylocopa caerulea* (Apidae); **H.** *Lasioglossum albescens* (Halictidae); **I.** *Lasioglossum halictoides* (Halictidae); **J.** *Nomia incerta* (Halictidae); **K.** *Nomia thoracica* (Halictidae); **L.** *Pseudapis siamensis* (Halictidae); **M.** *Heriades othonis* (Megachilidae); **N.** *Lithurgus* sp. (Megachilidae); **O.** *Megachile subrixator* (Megachilidae); **P.** *Megachile fulvipennis* (Megachilidae). Photographs by Catalina Tong (G), Lim Yu Jun (J – K, N, P) and Zestin Soh (all other images).

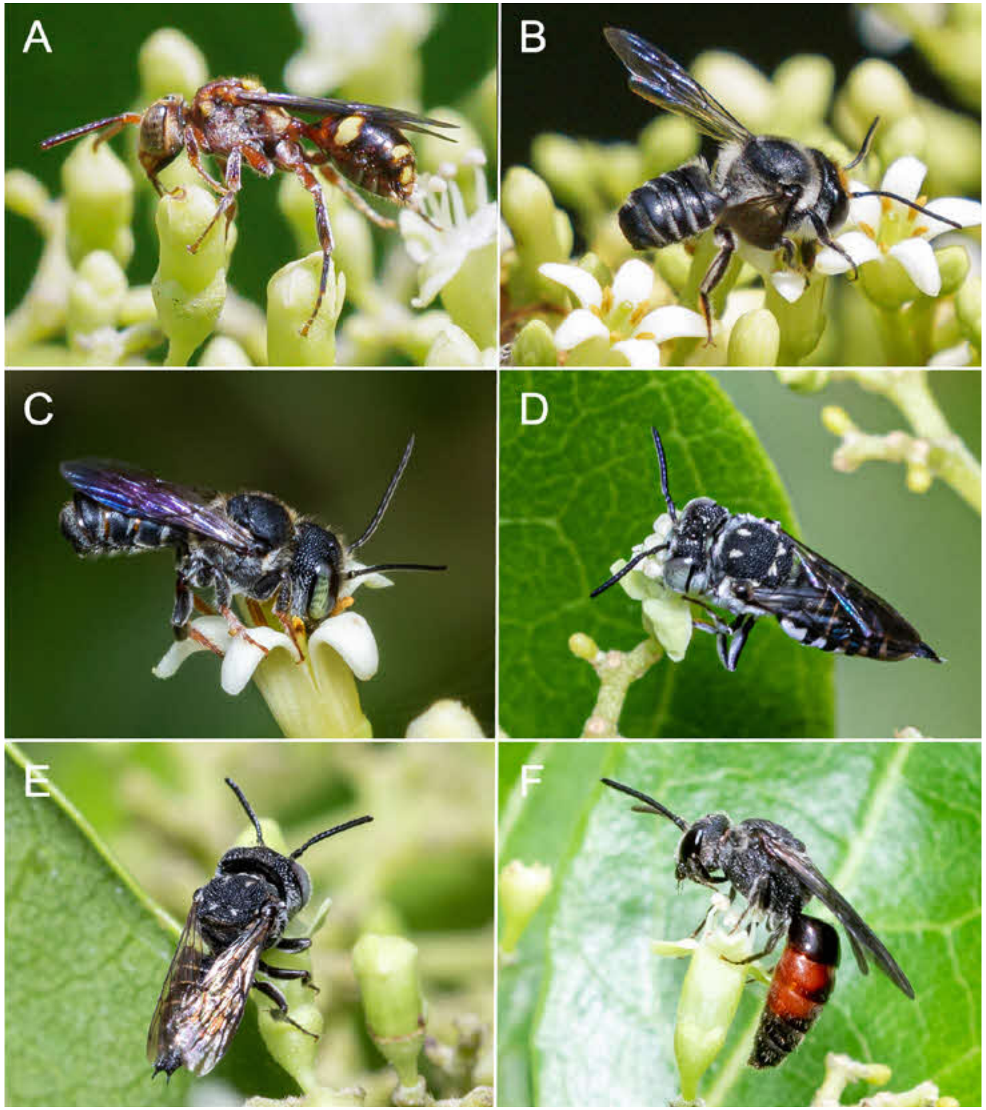

Fig. 3 Scarcely recorded bees in Singapore photographed visiting flowering *Pittosporum ridleyi* (Pittosporaceae) [B–C] and *Premna serratifolia* (Lamiaceae) [A, D, E, F] at Jalan Noordin, Pulau Ubin, in May 2022. **A.** *Nomada adusta* – a first country record for Singapore; **B.** *Megachile* (*Aethomegachile*)sp. 1 nr. *borneana*, male; **C.** *Megachile* (*Chelostomoda*) *moera*, male; **D – E.** *Coelioxys* (*Allocoelioxys*) sp. 3, female and male; **F.** *Sphecodes* sp. 4 [cf. *S. kershawi*]. Morphospecies names follow Ascher et al. (2022). Photographs by Lim Yu Jun (A – B) and Zestin Soh (C – F).

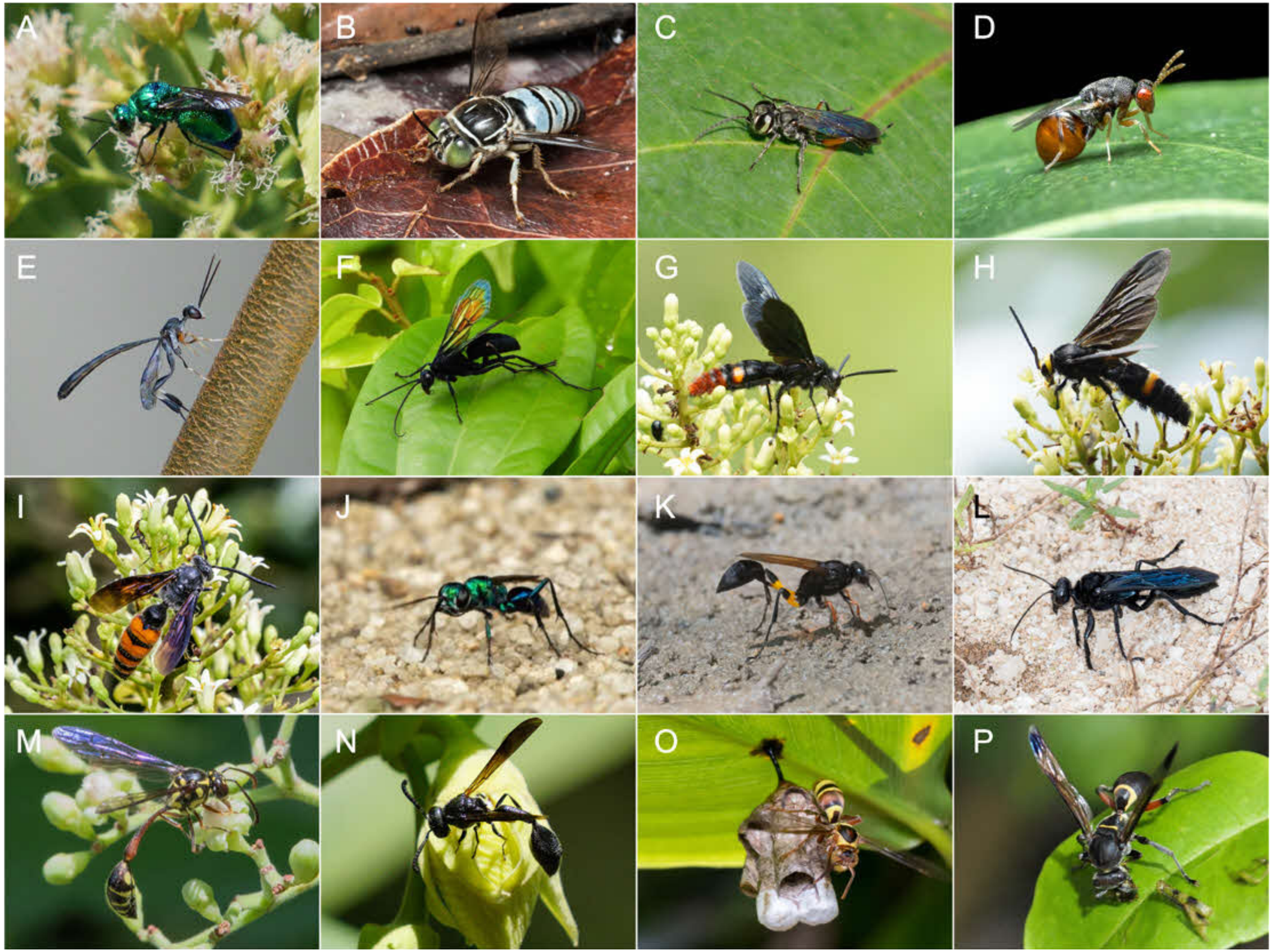

Fig. 4 Examples of wasp fauna on Pulau Ubin. **A.** *Stilbum cyanurum* (Chrysididae); **B.** *Bembix melancholica* (Crabronidae); **C.** *Liris subtesselatus* (Crabronidae); **D.** *Chalcura* sp. (Eucharitidae); **E.** *Gasteruption* sp. (Gasteruptiidae); **F.** Pepsinae sp. (Pompilidae); **G.** *Megascolia azurea* (Scoliidae); **H.** *Megascolia capitata* (Scoliidae); **I.** *Sericocampsomeris rubromaculata* (Scoliidae); **J.** *Chlorion lobatum* (Sphecidae); **K.** *Sceliphron javanum* (Sphecidae); **L.** *Sphex madasummae* (Sphecidae); **M.** *Eustenogaster hauxwellii* (Vespidae): **N.** *Zethus* sp. (Vespidae); **O.** *Polistes stigma* (Vespidae); **P.** *Polistes tenebris* (Vespidae). Photographs by Catalina Tong (F), Jan Tan (J), Lim Yu Jun (A, C, E, G, H, N), Mike Hooper (K, M), Patrick Leong (P), and Zestin Soh (all other images).

Table 1. Summary of bee diversity on Pulau Ubin, and the extent to which they are identified to species, genus (or subgenus in the case of bees), and above genus. Total species refers to both species and morphospecies level. IDL – Insect Diversity Lab database of Singapore bees & wasps at National University of Singapore.

Superfamily	Family	Total # of species	# ID to species	# morpho (genus)	# morpho (above genus)	Min. # of known spp. in SG (from IDL)	%ID to species	% ID to genus only	% of known spp. in SG
Apoidea	Colletidae	4	2	2	0	9	50.0%	50.0%	44.4%
	Halictidae	21	16	5	0	42	76.24%	23.8%	50.0%
	Megachilidae	17	12	5	0	32	70.6%	29.4%	51.6%
	Apidae	29	29	0	0	59	100.0%	0.0%	49.2%

Table 2. Summary of aculeate wasp and ant diversity on Pulau Ubin, and the extent to which they are identified to species, genus (or subgenus), and above genus. Total species refers to both species and morphospecies levels. IDL – Insect Diversity Lab of Singapore bees & wasps at National University of Singapore, Formicidae diversity from Yong et al. (2017) and Wang et al. (2018, 2022).

Superfamily	Family	Total # of species	# ID to species	# morpho (genus)	# morpho (above genus)	Min. # of known spp. in SG	% ID to species	% ID to genus/ subgenus only	% of known spp. in SG
Apoidea	Ampulicidae	1	1	0	0	7	100.0%	0.0%	14.3%
	Crabronidae	27	17	10	0	73	63.0%	37.0%	36.9%
	Sphecidae	12	12	1	0	14	100.0%	0.0%	85.7%
Chrysidoidea	Bethylidae	1	0	0	1	3	0.0%	0.0%	33.3%
	Chrysididae	1	1	0	0	4	100.0%	0.0%	25.0%
	Dryinidae	1	0	0	1	3	0.0%	0.0%	33.3%
Formicoidea	Formicidae	76	62	14	0	409	81.6%	18.4%	18.5%
Pompiloidea	Mutillidae	6	0	2	4	10	0.0%	33.3%	66.7%
	Pompilidae	10	1	4	5	18	10.0%	40.0%	55.6%
Scolioidea	Scoliidae	10	6	4	0	18	60.0%	40.0%	55.6%
Tiphioidea	Tiphiidae	1	0	1	0	3	0.0%	100.0%	33.3%
Vespoidea	Vespidae	37	29	8	0	53	78.4%	21.6%	69.8%

Table 3. Summary parasitic hymenopteran diversity on Pulau Ubin, and extent to which they are identified to species, genus, and above genus. Total species refers to both species and morphospecies level.

Superfamily	Family	Total # of species	# ID to species	# morpho (genus)	# morpho (above genus)	%ID to species	% ID to genus only
Ceraphronoidea	Ceraphronidae	1	0	0	1	0.0%	0.0%
Chalcidoidea	Aphelinidae	1	0	0	1	0.0%	0.0%
	Chalcididae	7	0	7	0	0.0%	100.0%
	Encyrtidae	1	0	0	1	0.0%	0.0%
	Eucharitidae	3	0	3	0	0.0%	100.0%
	Eulophidae	1	0	0	1	0.0%	0.0%
	Leucospidae	2	1	1	0	50.0%	50.0%
	Mymaridae	1	0	0	1	0.0%	0.0%
	Perilampidae	2	0	0	2	0.0%	0.0%
	Pteromalidae	1	0	0	1	0.0%	0.0%
	Trichogrammatidae	1	0	0	1	0.0%	0.0%
	Torymidae	1	0	1	0	0.0%	100.0%
Evanioidea	Evaniidae	2	1	1	0	50.0%	50.0%
	Gasteruptiidae	1	0	1	0	0.0%	100.0%
Ichneumonoidea	Braconidae	12	0	0	12	0.0%	0.0%
	Ichneumonidae	12	0	4	8	0.0%	33.3%
Platygastroidea	Platygastridae	1	0	0	1	0.0%	0.0%
Stephanoidea	Stephanidae	1	0	1	0	0.0%	100.0%

Appendix I. Bees (Apoidea: Anthophila) recorded for Pulau Ubin

S/N	Species	Common Name[#]	PU first	PU last	Rarity[#]	National status assessment[##]	Sources[###]
	Colletidae						
1	*Hylaeus* (*Nesoprosopis*) *penangensis* (Cockerell, 1920)	Penang Masked Bee	2016	2016	UC	LC	IDL
2	*Hylaeus* (*Nesoprosopis*) *transversalis* Cockerell, 1924	Transverse Masked Bee	2016	2016	VR*	DD	IDL
3	*Hylaeus* (*Nesoprosopis*) sp. 2	unknown masked bee	2022	2022	_	DD	iNat
4	*Hylaeus* (new subgenus nr. *Prosopisteron*) aff. *jacobsoni* (Friese. 1914)	Singapore Blue Masked Bee	2016	2016	VR	DD	IDL
	Halictidae						
5	*Austronomia takauensis* (Friese, 1910)	Takau Austral-Nomia	2016	2019	UC	VU	IDL
6	*Lipotriches* (*Rhopalomelissa*) *ceratina* (Smith, 1857)	Red-waisted Grass-Nomia	2012	2012	CO	LC	CUBS, IDL
7	*Nomia* (*Acunomia*) *iridescens* Smith, 1857	Iridescent Nomia	2022	2022	UC	LC	CUBS, iNat
8	*Nomia* (*Acunomia*) *lusoria* Cockerell, 1919	Mangrove Nomia	2022	2022			iNat
9	*Nomia* (*Acunomia*) *strigata* (Fabricius, 1793)	Striped Nomia	2007	2022	CO	LC	CUBS, IDL, iNat, LKCNHM
10	*Nomia* (*Gnathonomia*) *thoracica* Smith, 1875	Felt-topped Nomia	2022	2022	RA	LC	iNat
11	*Nomia* (*Hoplonomia*) *incerta* Gribodo, 1894	Black-waisted Pronged-Nomia	2012	2022	CO	LC	CUBS, IDL
12	*Nomia* (*Maculonomia*) *terminata* Smith, 1875	Spine-thighed Forest-Nomia	2012	2022	MC	NT	CUBS, IDL, iNat
13	*Pseudapis* (*Pseudapis*) *siamensis* (Cockerell, 1929)	Siamese Epaulette-Nomia	2014	2022	MC	LC	CUBS, IDL, iNat

Appendix I. Continuation

S/N	Species	Common Name#	PU first	PU last	Rarity#	National status assessment##	Sources###
14	*Eupetersia* (*Nesoeupetersia*) *malayensis* (Blüthgen, 1927)	Malay Smooth-Blood Bee	2012	2012	VR	DD	IDL, MIP
15	*Lasioglossum* (*Ctenonomia*) *albescens albescens* (Smith, 1853)	White Combed-Sweat Bee	2012	2022	MC	LC	CUBS, IDL, iNat, LKCNHM
16	*Lasioglossum* (*Ctenonomia*) *deliense* (Strand, 1910)	Orange-legged Combed-Sweat Bee	2015	2015	MC	LC	IDL
17	*Lasioglossum* (*Ctenonomia*) *halictoides* (Smith, 1858)	Beach Combed-Sweat Bee	2019	2019	UC	NT	CUBS
18	*Lasioglossum (Ctenonomia)* sp. 1 [nr. *vagans*]	Tan-haired Combed-Sweat Bee	2015	2019	MC	LC	IDL
19	*Lasioglossum* (*Ctenonomia*) sp. 2 [nr. *vagans*]	unknown combed-sweat bee	2017	2018	UC*	DD	IDL
20	*Lasioglossum* (*Ctenonomia*) sp. 3 [nr. *vagans*]	unknown combed-sweat bee	2016	2019	UC*	DD	IDL
21	*Lasioglossum* (*Homalictus*) *adonidiae* (Cockerell, 1919)	Palm Plume-vented Bee	2021	2022	MC	LC	iNat
22	*Lasioglossum* (*Homalictus*) aff. *latitarse* (Friese, 1909)	unknown plume-ventedbee	2012	2016	RA*	LC	IDL
23	*Lasioglossum* (*Homalictus*) *singapurellum* (Blüthgen, 1926)	Singapore Plume-vented Bee	2016	2016	MC	LC	IDL
24	*Patellapis* (*Pachyhalictus*) *murbanus* (Blüthgen, 1931)	Sunda Reticulate-Furrow Bee	2016	2016	MC	DD	IDL
25	*Sphecodes* sp. 4 [cf. *kershawi*]	-	2016	2022	VR*	DD	iNat, MIP
	Megachilidae						
26	*Lithurgus* sp. 1 [smaller]	Lesser Woodborer	2016	2016	UC	LC	IDL

Appendix I. Continuation

S/N	Species	Common Name#	PU first	PU last	Rarity#	National status assessment##	Sources###
27	*Lithurgus* sp. 2 [cf. *collaris* Smith, 1873]	Greater Woodborer	2016	2021	UC*	DD	CUBS, IDL, iNat
28	*Anthidiellum* (*Pycnanthidium*) *smithii smithii* (Ritsema, 1874)	Smith's Rotund-Resin bee	2022	2022	RA	VU	IDL
29	*Euaspis polynesia* Vachal, 1903	Asian Chilli-tail	2012	2019	RA	LC	CUBS, LKCNHM, photo
30	*Heriades* (*Michenerella*) *othonis* Friese, 1914	Indomalayan Armoured-Resin Bee	2016	2019	CO	LC	CUBS, IDL
31	*Coelioxys* (*Callosarissa*) *confusus* Smith, 1875	Confusing Sharptail	2012	2022	CO	LC	Facebook, IDL, iNat
32	*Coelioxys* (*Allocoelioxys*) sp. 3	-	2019	2022	RA*	DD	Facebook, IDL, iNat
33	*Megachile* (*Aethomegachile*) *conjuncta* Smith, 1853	Dimorphic Leafcutter	2014	2014	UC	LC	IDL
34	*Megachile* (*Aethomegachile*) *laticeps* Smith, 1853	Broad-headed Leafcutter	2012	2022	CO	LC	CUBS, IDL, iNat, LKCNHM, iNat
35	*Megachile* (*Aethomegachile*) sp. 1 nr*borneana*	Bright-legged Leafcutter	2022	2022	VR	DD	iNat
36	*Megachile* (*Aethomegachile*) sp. 2 [*fusciventris group*]	White-gloved Leafcutter	2014	2022	RA		Ascher et al., 2016, iNat
37	*Megachile* (*Paracella*) *tricincta* Bingham, 1897	Golden-bellied Leafcutter	2016	2016	MC	LC	IDL
38	*Megachile* (*Callomegachile*) *disjuncta* (Fabricius, 1781)	Disjunct Resin Bee	2010	2022	CO	NN	CUBS, IDL, iNat, LKCNHM, photo
39	*Megachile (Callomegachile) fulvipennis* Smith, 1879	Orange-winged Resin Bee	2017	2022	UC	LC	IDL, iNat, photo

Appendix I. Continuation

S/N	Species	Common Name#	PU first	PU last	Rarity#	National status assessment##	Sources###
40	*Megachile* (*Chelostomoda*) *moera* Cameron, 1902	Orange-thighed Leafcutter	2022	2022	VR	DD	Facebook, iNat
41	*Megachile* (*Creightonella*) *atrata* Smith, 1853	Orange-winged Leafcutter	2011	2016	UC	LC	IDL, LKCNHM
42	*Megachile* (*Eutricharaea*) *subrixator* Cockerell, 1915	Orange-bellied Leafcutter	2012	2022	CO	LC	CUBS, IDL, iNat, LKCNHM
	Apidae						
43	*Xylocopa* (*Biluna*) *iridipennis* Lepeletier, 1841	Purple-winged Bamboo-Carpenter	2011	2011	RA	DD	LKCNHM
44	*Xylocopa (Cyaneoderes) caerulea* (Fabricius, 1804)	Cerulean Carpenter	2018	2021	UC	LC**	CUBS, Facebook, iNat
45	*Xylocopa* (*Maiella*) *aestuans* (Linnaeus, 1758)	White-cheeked Carpenter	2000	2022	CO	LC	CUBS, Facebook, IDL, iNat, LKCNHM
46	*Xylocopa* (*Maiella*) *flavonigrescens* Smith, 1854	Yellow-and-black Carpenter	2000	2022	CO	LC	CUBS, IDL, iNat, LKCNHM
47	*Xylocopa* (*Platynopoda*) *latipes latipes* (Drury, 1773)	Broad-handed Carpenter	2016	2022	CO	LC	CUBS, IDL, iNat
48	*Ceratina* (*Ceratinidia*) *accusator accusator* Cockerell, 1919	Short-nosed Small Carpenter	2016	2022	UC	LC	IDL
49	*Ceratina* (*Ceratinidia*) *collusor* Cockerell, 1919	Companion Small Carpenter	2012	2022	CO	LC	CUBS, IDL, photo
50	*Ceratina* (*Ceratinidia*) *lieftincki* van der Vecht, 1952	Lieftinck's Small Carpenter	2010	2022	CO	LC	CUBS, IDL, iNat, photo
51	*Ceratina* (*Ceratinidia*) *nigrolateralis incerta* Cockerell, 1919	Black-sided Small Carpenter	2014	2022	CO	LC	CUBS, IDL, iNat, photo
52	*Ceratina* (*Neoceratina*) *dentipes dentipes* Friese, 1914	Tooth-legged Small Carpenter	2013	2019	CO	LC	CUBS, IDL

Appendix I. Continuation

S/N	Species	Common Name[#]	PU first	PU last	Rarity[#]	National status assessment[##]	Sources[###]
53	*Ceratina* (*Pithitis*) *smaragdula smaragdula* (Fabricius, 1787)	Emerald Small Carpenter	2010	2020	MC	LC	CUBS, IDL, iNat, photo
54	*Ceratina* (*Pithitis*) *unimaculata palmerii* Cameron, 1908	One-spotted Small Carpenter	2018	2018	MC	LC	CUBS
55	*Ceratina* (*Xanthoceratina*) *fuliginosa*Cockerell, 1916	Dusky-winged Small Carpenter	2022	2022	RA		iNat
56	*Ceratina* (*Xanthoceratina*) *metaria* Cockerell, 1920	Bounded Small Carpenter	2015	2022	RA	DD	IDL, iNat photo
57	*Braunsapis clarihirta* Reyes, 1991	Clear-haired Reed Bee	2012	2022	UC	LC	IDL, iNat, photo
58	*Braunsapis cupulifera* (Vachal, 1895[“1894”])	Cup-legged Reed Bee	2012	2018	CO	LC	IDL, MIP
59	*Braunsapis hewitti* (Cameron, 1908)	Hewitt’s Reed Bee	2012	2016	CO	LC	IDL, MIP
60	*Braunsapis puangensis* (Cockerell, 1929)	Puang Reed Bee	2014	2022	CO	LC	CUBS, IDL
61	*Nomada adusta* Smith, 1875	Singed Nomad bee	2022	2022	VR*	DD	IDL, iNat
62	*Amegilla* (*Zonamegilla*) *andrewsi* (Cockerell, 1910)	Sunda Blue-banded Digger	2012	2022	CO	LC	CUBS, IDL, iNat
63	*Thyreus himalayensis* (Radoszkowski, 1893)	Himalayan Cloak-and dagger Bee	2010	2022	CO	LC	CUBS, IDL, iNat, LKCNHM, photo
64	*Thyreus lilacinus lilacinus* (Cockerell, 1919)	Black-notched Cloak-and dagger Bee	2000	2022	UC	LC	CUBS, IDL, iNat, LKCNHM, photo
65	*Apis* (*Apis*) *cerana javana* Enderlein, 1906	Asian Honey Bee	2012	2022	CO	LC	CUBS, IDL,iNat, photo
66	*Apis* (*Megapis*) *dorsata* Fabricius, 1793	Giant Honey Bee	2000	2022	MC	LC	Facebook, IDL, iNat, LKCNHM

Appendix I. Continuation

S/N	Species	Common Name[#]	PU first	PU last	Rarity[#]	National status assessment[##]	Sources[###]
67	*Apis* (*Micrapis*) *andreniformis* Smith, 1857	Black Dwarf Honey Bee	2010	2016	CO	LC	CUBS, IDL, LKCNHM
68	*Apis* (*Micrapis*) *florea* Fabricius, 1787	Red Dwarf Honey Bee	2020	2022	CO	NN	CUBS
69	*Heterotrigona* (*Heterotrigona*) *itama* (Cockerell, 1918)	Notch-toothed Stingless Bee	1898	2022	MC	LC**	CUBS, IDL, iNat, NHMUK
70	*Lepidotrigona terminata* (Smith, 1878)	Gold-margined Stingless Bee	2015	2022	RA	VU	CUBS, IDL, iNat
71	*Tetragonula* (*Tetragonula*) *valdezi* (Cockerell, 1918)	Valdez's Stingless Bee	2011	2022	CO	LC	CUBS, IDL, iNat, LKCNHM, MIP, photo

from Soh & Ascher (2020)
from Ascher et al. (2022)
IDL refers to the Insect Diversity Lab's collection, iNat refers to the records on the online iNaturalist database, LKCNHM refers to specimens in the Lee Kong Chian Natural History Museum Collection, Facebook refers to pictures posted on the Bees and Wasps of Singapore Group
* under rarity indicates additional assessment newly provided here
** Although LC, this species is relatively scarce or localised.

Appendix II. Ants (Formicidae) recorded for Pulau Ubin

S/N	Species ID	First seen in PU	Last seen in PU	Sources*
	ACULEATA			
	Formicoidea			
	Formicidae **Amblyponinae**			
1	*Myopopone castanea* (Smith, 1860)	2016	2016	Yong et al., 2017
	Dolichoderinae			
2	*Dolichoderus thoracicus* Smith, 1860	2015	2022	iNat
3	*Dolichoderus* sp. 1	2016	2016	Yong et al., 2017
4	*Iridomyrmex anceps* (Roger, 1863)	2014	2014	
5	*Philidris* sp. 1	2016	2016	Yong et al., 2017
6	*Tapinoma melanocephalum* (Fabricius, 1793)	2016	2016	Yong et al., 2017
7	*Technomyrmex albipes* (Smith, 1861)	2014	2014	
8	*Technomyrmex kraepelini* Forel, 1905	2012	2012	
	Formicinae			
9	*Anoplolepis gracilipes* (Smith, 1857)	2016	2022	iNat, Yong et al., 2017
10	*Camponotus* (*Myrmamblys*) *bedoti* Emery, 1893	2016	2016	
11	*Camponotus* (*Myrmosericus*) sp. 1	2014	2019	iNat
12	*Camponotus* (*Tanaemyrmex*) sp. 1	2020	2022	iNat
13	*Colobopsis vitrea* (Smith, 1860)	2012	2012	
14	*Colobopsis* sp. 1	2016	2016	Yong et al., 2017
15	*Echinopla lineata* Mayr, 1862	2016	2016	
16	*Nylanderia bourbonica* (Forel, 1886)	2012	2012	
17	*Nylanderia kraepelini* (Forel, 1905)	2021	2021	
18	*Oecophylla smaragdina* (Fabricius, 1775)	2014	2022	iNat

Appendix II. Continuation

S/N	Species ID	First seen in PU	Last seen in PU	Sources*
19	*Paraparatrechina* sp. 1	2016	2016	Yong et al., 2017
20	*Paratrechina longicornis* (Latreille, 1802)	2014	2016	Yong et al., 2017
21	*Polyrachis* (*Myrma*) sp. 1	2019	2022	iNat
22	*Polyrhachis* (*Myrmhopla*) *abdominalis* Smith, 1858	2018	2018	
23	*Polyrhachis* (*Myrmhopla*) *saevissima* Smith, 1860	2012	2012	
	Myrmicinae			
24	*Carebara affinis* (Jerdon, 1851)	2014	2014	
25	*Carebara castanea* Smith, 1858	2015	2015	
26	*Carebara diversa* (Jerdon, 1851)	2016	2016	
27	*Carebara overbecki* (Viehmeyer, 1916)	2016	2016	
28	*Crematogaster sewardi* Forel, 1901	2014	2014	
29	*Crematogaster subnuda discinodis* Emery, 1893	2012	2012	
30	*Crematogaster treubi* Emery, 1896	2012	2012	
31	*Crematogaster* (*Orthocrema*) *quadriruga* Forel, 1911	2014	2014	
32	*Liomyrmex gestroi* (Emery, 1887)	2016	2016	Yong et al., 2017
33	*Lordomyrma* sp. 1 [cf. sp. 7 of Seiki Yamane] (in Wang et al., 2022)	2015	2015	
34	*Mayriella transfuga* Baroni Urbani, 1977	2016	2016	
35	*Meranoplus bicolor* (Guérin-Méneville, 1844)	2016	2016	
36	*Monomorium floricola* (Jerdon, 1851)	2014	2014	
37	*Myrmicaria luteiventris* Emery, 1900	2016	2016	
38	*Pheidole plagiaria* Smith, 1860	2012	2012	
39	*Pheidole umbonata* Mayr, 1870	2012	2012	

Appendix II. Continuation

S/N	Species ID	First seen in PU	Last seen in PU	Sources*
40	*Pheidole* sp. 1	2016	2016	Yong et al., 2017
41	*Pheidole* sp. 2	2016	2016	Yong et al., 2017
42	*Pheidole* sp. 3	2016	2016	Yong et al., 2017
43	*Pristomyrmex brevispinosus* Emery, 1887	2016	2016	
44	*Proatta butteli* Forel, 1912	2016	2016	
45	*Rhopalomastix johorensis* Wheeler, 1929	2012	2020	iNat; see also Wang et al., 2018
46	*Solenopsis overbecki* Viehmeyer, 1916	2021	2021	
47	*Strumigenys eggersi* Emery, 1890	2016	2016	
48	*Strumigenys emmae* (Emery, 1890)	2014	2014	
49	*Strumigenys rofocala* Bolton, 2000	2016	2016	
50	*Strumigenys rogeri* Emery, 1890	2016	2016	
51	*Tetramorium aptum* Bolton, 1977	2021	2021	
52	*Tetramorium curtulum* Emery, 1895	2014	2014	
53	*Tetramorium meshena* (Bolton, 1976)	2014	2014	
54	*Tetramorium tonganum* Mayr, 1870	2014	2014	
55	*Vollenhovia escherichi* Forel, 1911	2016	2016	
56	*Vollenhovia* sp. 1	2016	2016	
	Ponerinae			
57	*Anochetus graeffei* Mayr, 1870	2012	2012	
58	*Brachyponera* sp. 1	2016	2016	
59	*Buniapone amblyops* (Emery, 1887)	2016	2016	Yong et al., 2017
60	*Centromyrmex hamulatus* (Karavaiev, 1925)	2019	2019	
61	*Diacamma rugosum* (Le Guillou, 1842) [sensu lato]	2016	2022	iNat
62	*Diacamma* sp. 1	2016	2016	Yong et al., 2017

Appendix II. Continuation

S/N	Species ID	First seen in PU	Last seen in PU	Sources*
63	*Ectomomyrmex overbecki* (Viehmeyer, 1916)	2019	2019	
64	*Euponera sharpi* Forel, 1901	2014	2014	
65	*Hypoponera* sp. 1	2016	2016	
66	*Leptogenys kraepelini* Forel, 1905	2016	2016	
67	*Odontomachus litoralis* Wang, Yamada & Yamane, 2020	2012	2012	
68	*Odontomachus rixosus* Smith, 1857	2012	2012	
69	*Odontomachus simillimus* Smith, 1858	2016	2016	
70	*Odontoponera denticulata* (Smith, 1858)	2016	2022	iNat
71	*Platythyrea parallela* (Smith, 1859)	2016	2016	
	Proceratiinae			
72	*Proceratium papuanum* Emery, 1897	2016	2018	
	Pseudomyrmecinae			
73	*Tetraponera difficilis* (Emery, 1900)	2014	2014	
74	*Tetraponera extenuata* Ward, 2001	2013	2013	
75	*Tetraponera nitida* (Smith, 1860)	2014	2014	
76	*Tetraponera pilosa* (Smith, 1858)	2012	2012	

***** Species identifications, as well as the *Lordomyrma* morphospecies, were obtained from Wang et al. (2022) from the "Localities" of species accounts. In addition, a minimum number of certainly additional morphospecies and species are cited from two other sources prior, namely: the generic treatment of ants in Yong et al. (2017) and iNaturalist (captured as of Dec 2022). The morphospecies from Yong et al. (2017) were based the number of morphospecies reported from Pulau Ubin (N column in the Appendix) subtracting the number of named species reported by Wang et al. (2022) to obtain the minimal number of certainly additional morphospecies. These additional morphospecies have been renumbered here starting with 1.

Appendix III. Wasps recorded for Pulau Ubin

S/N	Species ID	First seen in PU	Last seen in PU	Sources*
	ACULEATA			
	Apoidea Anthophila (bees): see Appendix I			
	Ampulicidae			
1	*Ampulex compressa* (Fabricius, 1781)	2011	2018	LKCNHM, IDL
	Crabronidae			
2	*Bembecinus littoralis* van der Vecht, 1949	2018	2022	IDL, iNat
3	*Bembecinus borneanus* (Cameron, 1903)	2016	2022	IDL, iNat
4	*Bembecinus reversus* (F. Smith, 1856)	2014	2014	IDL
5	*Bembecinus insularis* (Handlirsch, 1892)	2013	2022	IDL, iNat
6	*Bembix melancholica* F. Smith,1856	2011	2022	CUBS, IDL, iNat, MIP
7	*Nysson* sp. 1	2022	2022	iNat
8	*Carinostigmus* sp. [cf. *maior* (Maidl,1925)]	2014	2018	IDL
9	*Cerceris pictiventris* Dahlbom, 1845	2014	2017	IDL
10	*Dasyproctus pentheri* Leclercq, 1956	2016	2016	IDL
11	*Dicranorhina ruficollis* (Cameron, 1904)	2020	2020	iNat
12	*Liris subtesselatus* (F. Smith, 1856)	2020	2022	CUBS, IDL, iNat
13	*Liris* sp.1	2013	2018	IDL
14	*Liris* sp. 2	2014	2014	IDL
15	*Liris* sp. 3	2016	2016	IDL
16	*Liris* sp. 5 [red legs]	2022	2022	iNat
17	*Nitela* sp.1	2012	2019	IDL, MIP
18	*Nitela* sp. 2	2018	2019	CUBS, IDL
19	*Oxybelus malaysianus* Tsuneki, 1974	2016	2016	IDL

Appendix III. Continuation

S/N	Species ID	First seen in PU	Last seen in PU	Sources*
20	*Pison argentatum* Shuckard, 1838	2015	2015	IDL
21	*Psenulus crabroniformis sumatranus* (Ritsema, 1880)	2020	2020	iNat
22	*Psenulus yoshimotoi* van Lith, 1969	2016	2016	IDL
23	*Psenulus* sp. [orange metasoma]	2016	2020	IDL, iNat
24	*Tachytes modestus* F. Smith, 1856	2018	2022	IDL, iNat
25	*Tachytes* sp. 1 [dark legs]	2018	2018	IDL
26	*Trypoxylon petiolatum* F. Smith, 1858	2016	2016	IDL
27	*Trypoxylon schmiedeknechti* Kohl, 1906	2014	2014	IDL
28	*Vechtia rugosa* (F. Smith, 1858)	2014	2014	IDL
	Sphecidae			
29	*Chalybion bengalense* (Dahlbom, 1845)	2014	2022	CUBS, IDL, iNat
30	*Chalybion sumatranum* (Kohl, 1884)	2010	2020	LKCNHM
31	*Chlorion lobatum* (Fabricius, 1775)	2021	2021	CUBS
32	*Isodontia diodon* (Kohl, 1890)	2018	2022	CUBS, IDL, iNat
33	*Isodontia severini* (Kohl, 1898)	2020	2020	IDL
34	*Prionyx viduatus* (Christ, 1791)	2014	2014	IDL
35	*Sceliphron coromandelicum* (Lepeletier de Saint Fargeau, 1845)	2016	2016	IDL
36	*Sceliphron javanum petiolare* Kohl, 1918	2016	2021	IDL,iNat
37	*Sphex diabolicus* F. Smith, 1858	2017	2021	CUBS, IDL, iNat
38	*Sphex madasummae* van der Vecht, 1973	2011	2022	CUBS, iNat, LKCNHM,
39	*Sphex subtruncatus* Dahlbom, 1843	2016	2022	CUBS, IDL, iNat, LKCNHM
40	*Sphex sericeus* (Fabricius, 1804)	2020	2022	CUBS, IDL,iNat

Appendix III. Continuation

S/N	Species ID	First seen in PU	Last seen in PU	Sources*
	Chrysidoidea			
	Bethylidae			
41	Bethylidae [genus undet] sp. 1	2016	2016	IDL
	Chrysididae			
42	*Stilbum cyanurum* (Förster, 1771)	2015	2017	IDL
	Dryinidae			
43	Anteoninae [genus undet] sp. 1	2016	2016	IDL
	Formicoidea			
-	Formicidae: see Appendix II	-		
	Pompiloidea			
	Mutillidae			
44	Trogaspidiini [tribe] [cf. *Trogaspidia*] sp. [T1 red, T6 black]	2016	2022	IDL, iNat
45	Trogaspidiini [tribe] [cf. *Trogaspidia*] sp. [T1 black, T6 red]]	2016	2022	IDL, iNat
46	Mutillidae [genus undet] sp.1 [red propodeum, T1 red]	2016	2016	IDL
47	Mutillidae [genus undet] sp.2 [red metasoma base]	2016	2016	IDL
48	*Yamanetilla* sp. 1	2016	2022	iNat
49	*Odontomutilla* sp. 1	2018	2018	iNat
	Pompilidae			
50	*Auplopus* sp. 1 [cf. *blandus* (Guerin, 1830)]	2021	2022	CUBS, iNat
51	*Irenangelus* sp. 1	2022	2022	iNat
52	*Episyron* sp. 1	2018	2018	IDL, iNat
53	Pepsinae sp. 1 [cf. *Java*]	2010	2021	LKCNHM, iNat
54	*Paragenia* sp. 1	2016	2022	IDL, iNat

Appendix III. Continuation

S/N	Species ID	First seen in PU	Last seen in PU	Sources*
55	*Tachypompilus analis* (Fabricius, 1781)	2009	2018	LKCNHM, iNat
56	Pepsinae [black body, green and bronze wings]	2020	2020	iNat
57	Pompilidae [bicoloured wing, grey head and thorax, bluish tapering abdomen]	2021	2021	iNat
58	Pompilidae [genus undet] sp.1 [small; yellowish on legs in T1]	2016	2016	IDL
59	Pompilidae [genus undet.] sp. 2 [large, orange legs, head, and thoracic dorsum]	2019	2022	iNat
	Scolioidea			
	Scoliidae			
60	*Campsomeriella collaris (*Fabricius, 1775)	2017	2022	CUBS
61	*Megascolia azurea* (Christ, 1791)	2016	2022	IDL, iNat
62	*Megascolia capitata* (Fabricius, 1804)	2011	2022	LKCNHM, IDL, iNat
63	*Phalerimeris phalerata* (de Saussure, 1858)	2017	2022	CUBS, IDL, iNat
64	*Sericocampsomeris rubromaculata* (Smith, 1855)	2022	2022	IDL. iNat
65	*Sericocampsomeris stygia* (Illiger, 1802)	2015	2022	IDL
66	*Microscolia* sp. 1	2021	2021	IDL
67	*Scolia* sp. 1 [large, orange-tipped antennae]	2021	2022	Facebook
68	*Scolia* sp. 2 [orange head and pronotum and antennae]	2020	2022	IDL, iNat
69	*Scolia* sp. 3 [orange head, antennae orange but dark-tipped]	2022	2022	IDL
	Tiphioidea			
	Tiphiidae			
70	*Tiphia* sp. 1 [partly red mid and hind legs]	2018	2021	CUBS, iNat
	Vespoidea			
	Vespidae			
71	*Allorhynchium argentatum* (Fabricius, 1804)	2011	2022	CUBS, IDL, iNat, LKCNHM, MIP

Appendix III. Continuation

S/N	Species ID	First seen in PU	Last seen in PU	Sources*
72	*Allorhynchium snelleni* (de Saussure, 1862)	2012	2016	IDL, MIP
73	*Antepipona bipustulata* (de Saussure, 1855)	2014	2022	CUBS, IDL, iNat
74	*Apodynerus troglodytes* (de Saussure, 1855	2016	2018	CUBS, IDL
75	*Delta campaniforme* (Fabricius, 1775)	2017	2017	CUBS, IDL, LKCNHM
76	*Delta pyriforme circinale* (Fabricius, 1804)	2019	2022	CUBS, IDL, iNat
77	*Eumenes* sp. 1 [aff. *punctatus*]	2016	2022	IDL, iNat
78	*Eustenogaster hauxwellii* (Bingham, 1893)	2021	2021	iNat
79	*Eustenogaster micans* (de Saussure, 1852)	2016	2016	LKCNHM
80	*Labus amoenus* van der Vecht, 1935	2009	2009	IDL
81	*Liostenogaster varipicta* (Rohwer 1919)	2016	2017	IDL, MIP
82	*Omicroides* sp. 1	2014	2022	IDL, iNat
83	*Paraleptomenes communis* Giordani Soika, 1994	2009	2022	IDL, iNat
84	*Parapolybia varia* (Fabricius, 1787)	2021	2022	iNat
85	*Parischnogaster mellyi* (de Saussure, 1852)	2018	2022	CUBS, IDL, iNat, LKCNHM
86	*Parischnogaster nigricans* (du Buysson, 1905)	2019	2019	CUBS, IDL
87	*Phimenes flavopictus* (Blanchard, 1849)	2012	2018	CUBS, IDL, LKCNHM
88	*Phimenes* sp. 1 [all black]	2022	2022	iNat
89	*Polistes sagittarrius* de Saussure, 1853	2018	2018	CUBS
90	*Polistes stigma* (Fabricius, 1793)	2016	2022	IDL, iNat
91	*Polistes tenebris* Nguyen & Lee, 2017	2020	2020	Facebook
92	*Polistes tenebricosus* Lepeletier, 1836	2007	2007	LKCNHM, Facebook
93	*Rhynchium haemorrhoidale* (Fabricius, 1775)	2019	2022	CUBS, IDL, iNat
94	*Ropalidia fasciata* (Fabricius, 1804)	2014	2014	IDL

Appendix III. Continuation

S/N	Species ID	First seen in PU	Last seen in PU	Sources*
95	*Ropalidia stigma* (Smith, 1858)	2018	2022	CUBS, IDL, iNat
96	*Ropalidia timida* Vecht, 1962	2012	2017	IDL, LKCNHM
97	*Stenodyneriellus guttulatus* (de Saussure, 1862)	2018	2022	CUBS, IDL, iNat, LKCNHM
98	*Stenodyneriellus* sp. 1	2014	2014	IDL
99	*Subancistrocerus sichelii* (de Saussure, 1856)	2016	2016	CUBS, IDL
100	*Subancistrocerus* sp. 1 [red legs, white spotted metanotum]	2016	2016	IDL
101	*Subancistrocerus* sp. 2 [larger terminal flagellar segment]	2014	2022	IDL, iNat
102	*Subancistrocerus* sp. 3 [smaller terminal flagellar segment]	2016	2016	IDL
103	*Vespa affinis* (Linnaeus, 1764)	2012	2022	CUBS, IDL, iNat, MIP, LKCNHM
104	*Vespa analis* Fabricius, 1775	2018	2022	CUBS, IDL, iNat, MIP, LKCNHM
105	*Vespa tropica* (Linnaeus, 1758)	2012	2022	IDL, iNat, LKCNHM
106	*Zethus* sp. 1 [black]	2021	2021	iNat
107	*Zethus* sp. 2 [red tegulae]	2021	2021	iNat
	‘PARASITICA’			
	Ceraphronoidea			
	Ceraphronidae			
108	Ceraphronidae sp. 1	2019	2019	MIP
	Chalcidoidea			
	Aphelinidae			
109	Aphelinidae sp. 1	2019	2019	MIP
	Chalcididae			
110	*Antrocephalus* sp. 1	2017	2017	IDL

Appendix III. Continuation

S/N	Species ID	First seen in PU	Last seen in PU	Sources*
111	*Antrocephalus* sp. 2	2016	2016	IDL
112	*Brachymeria* sp. 1 cf. *euploeae*	2016	2022	IDL, iNat
113	*Brachymeria* sp. 2	2019	2019	IDL
114	*Brachymeria* sp. 3	2015	2015	IDL
115	*Hockeria* sp. 1	2016	2016	IDL
116	*Trigonura* sp. 1	2016	2016	IDL
	Encyrtidae			
117	Encyrtidae sp. 1	2019	2019	MIP
	Eucharitidae			
118	*Chalcura* sp. 1	2014	2014	IDL
119	*Stilbula* sp. 1	2016	2016	IDL
120	*Schizaspidia* sp. 1	2016	2022	IDL, iNat
	Eulophidae			
121	Eulophidae sp. 1	2019	2019	MIP
	Leucospidae			
122	*Leucospis petiolata* Fabricius, 1787	2022	2022	IDL
123	*Leucospis* sp. 1 [cf. *japonica* Walker, 1871]	2013	2013	IDL
	Mymaridae			
124	Mymaridae sp. 1	2019	2019	MIP
	Perilampidae			
125	Perilampidae[genus undet] sp.1	2016	2016	IDL
126	Perilampidae[genus undet] sp.2	2016	2016	IDL
	Pteromalidae			
127	Pteromalidae sp. 1	2019	2019	MIP

Appendix III. Continuation

S/N	Species ID	First seen in PU	Last seen in PU	Sources*
	Trichogrammatidae			
128	Trichogrammatidae sp. 1	2019	2019	MIP
	Torymidae			
129	*Podagrion* sp. 1	2019	2019	Facebook
	Evanioidea			
	Evaniidae			
130	*Evania appendigaster* (Linnaeus, 1758)	2022	2022	iNat
131	*Prosevania* sp.1	2020	2020	iNat
	Gasteruptiidae			
132	*Gasteruption* sp. 1	2021	2021	iNat
	Ichneumonoidea			
	Braconidae			
133	Agathidinae [genus undet] sp. 1 [black wings]	2016	2016	IDL
134	Braconinae [cf. *Shelfordia foveata* (F. Smith, 1858)] sp. 1	2016	2016	IDL
135	Braconinae [genus undet] sp. 2 [orange-and-black wings]	2016	2016	IDL
136	Braconinae [genus undet] sp. 3 [yellow-and-black wings]	2015	2016	IDL
137	Braconinae [genus undet] sp. 5 [large; orange wings]	2016	2016	IDL
138	Braconinae [genus undet] sp. 4 [small, black]	2016	2016	IDL
139	Cardiochilinae [genus undet] sp.1	2016	2016	IDL
140	Cheloninae [genus undet] sp. 1	2016	2016	IDL
141	Doryctinae [cf. *Zombrus*] sp. 1	2016	2016	IDL
142	Microgastrinae [*cf. Choeras*] sp. 1	2018	2019	MIP
143	Microgastrinae [genus undet] sp. 1	2016	2016	IDL

Appendix III. Continuation

S/N	Species ID	First seen in PU	Last seen in PU	Sources*
144	Rogadinae [genus undet] sp. 1	2017	2017	IDL
	Ichneumonidae			
145	*Astomaspis* sp. 1	2016	2016	IDL
146	Camplopleginae sp. 1	2022	2022	iNat
147	Cryptini sp. 1	2021	2021	iNat
148	Cryptinae [tribe undet] sp. 1	2016	2016	IDL
149	*Leptobatopsis* sp. 1	2021	2021	iNat
150	*Nematopodius* sp. 1	2022	2022	iNat
151	Ophiinae [genus undet] sp. 1	2016	2016	IDL
152	Pimplinae [*Theronia* genus group] sp. 1	2016	2017	IDL
153	*Xanthopimpla* sp. 1	2016	2017	IDL
154	Ichneumonidae [genus undet] sp.1	2016	2016	IDL
155	Ichneumonidae [genus undet] sp.2	2016	2016	IDL
156	Ichneumonidae [genus undet] sp.3	2016	2016	IDL
	Platygastroidea			
	Platygastridae			
157	Scelioninae [genus undet] sp.1	2013	2013	IDL
	Stephanoidea			
	Stephanidae			
158	*Pseudomegischus* (*Pseudomegischus*) cf. *sulcifrons* (Schletterer).	2019	2019	iNat

* CUBS refers to Comprehensive Ubin Biodiversity Survey sampling events, IDL refers to the Insect Diversity Lab's collection, iNat refers to the records on the online iNaturalist database, LKCNHM refers to specimens in the Lee Kong Chian Natural History Museum Collection, Facebook refers to pictures posted on the Bees and Wasps of Singapore Group; MIP refers to the Mangrove Insect Project.

Butterfly survey of Pulau Ubin, Singapore

Khew Sin Khoon[1]

[1]Lee Kong Chian Natural History Museum, National University of Singapore,
2 Conservatory Drive, Singapore 117377

ABSTRACT. A two-year biodiversity survey was conducted on Pulau Ubin, a small island of 10km^2 off the northeastern coast of Singapore. Sampling was mainly through field observations and photographic records along nine selected transects on the island. The transects, each about 300m in length, were grouped into three main categories by habitat – 1) secondary forest regenerated after rubber plantations had been abandoned; 2) secondary forest regenerated after general farming activities had ceased; and 3) mangrove and back-mangrove forest. More butterfly species were recorded at the transects with secondary forest after farming activities ceased (37) as compared to the secondary forest that was previously occupied by rubber plantations (20). The mangrove forest habitat transects yielded 24 species. It is likely that the secondary forest transects which were previously occupied by farms had a higher diversity of butterflies due to the open and sunnier nature of the transects. There was also a higher diversity of roadside wildflowers, nectar-producing plants and caterpillar host plants found along the transects in secondary forest following farming.

Keywords. Biodiversity surveys, butterfly conservation, Lepidoptera, Pulau Ubin, mangroves.

Introduction

Despite its small size, Pulau Ubin is known for its rich biodiversity and rustic environment to which many weekend visitors flock to get away from Singapore's hectic urban lifestyle. Over the years, butterfly sightings have been recorded by enthusiasts and the total number of species recorded stands close to 175 species.

Butterflies are a well-studied taxonomic group in Singapore and in the region. Most species of butterflies are readily identifiable in the field, and they are an excellent group for monitoring environmental and botanical changes by making repeated site-specific surveys. The Comprehensive Biodiversity Survey of Pulau Ubin was the first opportunity to survey and document the butterfly diversity of the island systematically over a long period. Although each transect was planned to be surveyed at two different times of the year, to detect seasonality, the COVID-19 pandemic reduced the number of surveys due to restrictions on field outings. Fortunately, enough data on each transect were gathered to give a good baseline information on the butterfly diversity across the selected range of habitats on Pulau Ubin.

Materials and Methods

The surveys along nine selected transects (F1–F3, M1–M3, R1–R3), each about 300m long, were based on visual observations and photographic records (where possible) of the butterfly species seen. Transects F1–F3 were in forest regrowth after farming, transects M1–M3 in back mangroves, and transects R1–R3 in forest regrowth after rubber plantation. The surveys were conducted mostly in the mornings and in fairly good weather conditions. At some of the transects, appropriate baits (e.g. over-ripe fruits or fermented shrimp paste) were laid to attract certain species of butterflies. Data on the butterfly species that were sighted along these transects were recorded. In some instances, there were interesting sightings of butterflies beyond the transects and these were recorded for discussion. As these areas are in the immediate vicinity of the selected transects, the presence/absence of aerial organisms like butterflies should be considered of relevance to a wider context for the study of butterfly diversity on Pulau Ubin.

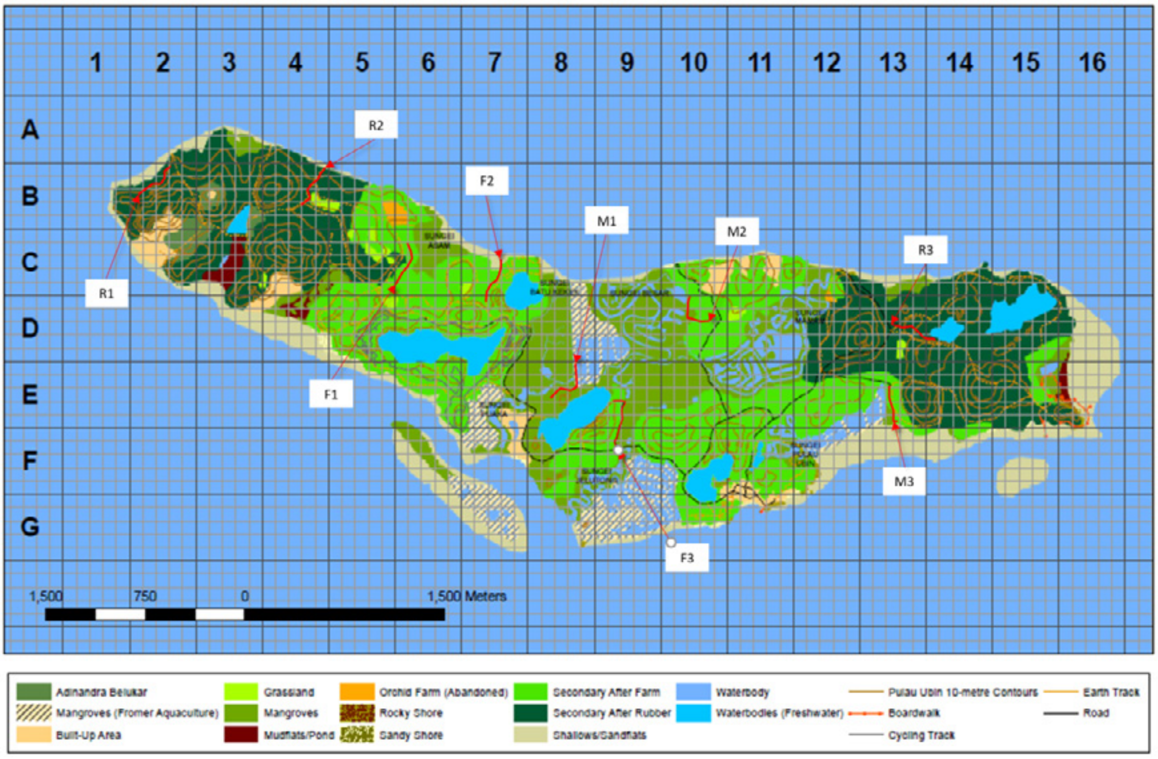

Fig. 1 Survey transects on Pulau Ubin and their relationship to available habitats

Results

Butterfly diversity on Pulau Ubin

Over 360 species of butterflies have been recorded in Singapore. Butterfly diversity on Pulau Ubin has been relatively well studied over the past few decades. From observations through casual field data collected from many individuals and nature enthusiasts, we can estimate the total number of butterfly species recorded at around 175 species. However, this is the first time a systematic survey based on nine selected transects has been done to establish a baseline for future surveys on Pulau Ubin.

From a total of 15 field outings conducted along the nine selected transects across Pulau Ubin, 71 species were recorded. All the six locally occurring butterfly families (Papilionidae, Pieridae, Nymphalidae, Riodinidae, Lycaenidae and Hesperiidae) were represented. As the nine selected transects were mainly in forested areas with a general paucity of flowering, the number of species sighted was not unexpected. Compared to a specialised location like Butterfly Hill on Pulau Ubin, where specific butterfly-attracting plants have been intentionally cultivated, the survey transects did not yield as diverse a range or number of butterfly species. The survey transect F1, which had more open areas and wild flowers growing at certain stretches, had the highest number of species recorded (37 species or 52.9% of the observed total) over two surveys.

Although baiting with overripe fruit and fermented prawn paste was done at four of the nine transects, the effectiveness of the baits in attracting butterflies was somewhat unproductive.

From the survey records, none of the species occurred in all nine transects. However, two species, the Common Mormon (*Papilio polytes*) and the Knight (*Lebadea martha*) were found in eight of the nine transects. These are considered the most common species observed due mainly to the widespread occurrence of their respective caterpillar host plants, *Murraya* sp. (Rutaceae) and *Ixora congesta* (Rubiaceae) on Pulau Ubin.

Out of the 71 species observed, 37 (or 52%) were single sighting observations across the nine transects. Whilst some of these species prefer more sunny and open habitats, some of them are of conservation relevance as they are more likely to be associated with a specific location or habitat where their hitherto unknown caterpillar host plants may be found. An example is the White Banded Flat (*Celaenorrhinus asmara*), known only from Puaka Hill ever since it was first discovered at this location in 2011. In recent years, it has also been spotted at Butterfly Hill and along the roadside shrubbery along Jalan Jelutong and Jalan Batu Ubin.

Table 1. Number of butterfly species that were confined to one of the selected habitats and not found in the other two habitats

Family/Subfamily	Secondary forests after rubber plantations R1, R2, R3	Secondary forests after farming F1, F2, F3	Mangrove and back-mangroves M1, M2, M3	Total species recorded across all 3 habitats
Papilionidae		2	1	5
Pieridae				
Pierinae			1	3
Coliadinae		1		3
Nymphalidae				
Danainae	2		1	6
Satyrinae	2	2	2	9
Heliconiinae			1	1
Nymphalinae			2	3
Limenitidinae	3	1	1	9
Charaxinae			1	1
Riodinidae				
Nemeobiinae		1		1
Lycaenidae				
Miletinae	1	1	1	3
Polyommatinae		4	3	8
Aphnaeinae		1		1
Theclinae		3	1	4
Hesperiidae				
Coeliadinae			1	3

Table 1. Continuation

Family/Subfamily	**Secondary forests after rubber plantations R1, R2, R3**	**Secondary forests after farming F1, F2, F3**	**Mangrove and back-mangroves M1, M2, M3**	**Total species recorded across all 3 habitats**
Pyrginae		1		1
Hesperiinae	1	7		10
TOTAL	**9**	**24**	**16**	**71**
Surveys conducted	4	6	5	

Table 1 shows the number of species that occur exclusively in only one of the habitats and not observed in the other two during the surveys. Although too much should not be read into this, there is a general trend that the forested areas (after farms were vacated) have a higher number of species that are not observed in the other two habitats. The transects designated F1, F2 and F3 yielded a total of 24 species or 33.8% of the total number of species recorded in the surveys.

The forested areas (after rubber plantations were abandoned) yielded the least number of species exclusively found there – only 9 species or 12.7% of the total number of species observed. The mangrove or back mangrove habitats yielded 16 species or 22.5% that were recorded from only that habitat during the surveys.

Species of notable interest

Whilst the diversity of the butterfly species observed during the Pulau Ubin survey was not unexpected, the following genera/species are worthy of special mention and further comment.

1) The Common Birdwing (*Troides helena*) (C & R Felder, 1865)

The Common Birdwing is one of two butterflies recorded in Singapore that are protected under the CITES convention on international trade. It is a large butterfly, with a wingspan usually exceeding 140mm. Although it was observed at only one transect (M1 – Puaka East) this species has often been seen on Pulau Ubin. At times, several individuals are seen at Butterfly Hill and its vicinity due to the planting of its non-native caterpillar host plant, *Aristolochia* *acuminata*, in the surrounding areas. With its large flight range, it is expected to be able to fly around the island, looking for mates and foraging for food. It is a spectacular and iconic species that should continue to thrive on Pulau Ubin, as long as its caterpillar host plant is found on the island.

2) The Dwarf Crow (*Euploea tulliolus*) (C & R Felder, 1860)

The Dwarf Crow was first re-discovered on Pulau Ubin in 2002. It was earlier thought to be extinct from Singapore until that sighting. Subsequently it continued to be observed on Pulau Ubin and is sometimes even considered common. Only in recent years has it been seen on the northern parts of Singapore island, e.g. Coney Island and Pasir Ris Park. The species continues to thrive on Pulau Ubin where sightings of this species have been regularly reported. Its caterpillar host plant is *Malaisia scandens*, (Moraceae, syn: *Trophis scandens*, common name: Burny Vine). This plant should be cultivated urgently so that this species can be conserved through continued availability of its caterpillar host plant.

3) The Saturn (*Zeuxidia amethystus*) (Butler, 1865)

The Saturn is a large butterfly usually associated with palms. It prefers shaded habitats and can usually be found foraging amongst leaf litter on the forest floor and sometimes feeding on overripe fallen fruits. This was an unexpected find on Pulau Ubin and so far it has only been seen in the forested areas in the west. A single male was seen at Transect R2. The caterpillar host plant of the Saturn is believed to be a species of palm or rattan.

4) The Knight (*Lebadea martha*) (C & R Felder, 1860)

The Knight is a common species found on Pulau Ubin. It was observed at eight of the nine selected transects and often, several individuals were sighted. The occurrence of its caterpillar host plant, *Ixora congesta* which is widely distributed around the island, is probably a reason for its abundance on Pulau Ubin. However, what is interesting about the Knight is that the Malaysian subspecies *malayana* has previously been recorded on Pulau Ubin. Although none of that subspecies were sighted in the course of the survey, it is an interesting aspect of the convergence of two subspecies of butterflies in the ongoing evolution of the dominance of one subspecies and the eventual disappearance of the other.

5) The Malayan Plum Judy (*Abisara saturata*) (Butler, 1870)

The Malayan Plum Judy is the only representative of its family Riodinidae found on Pulau Ubin. Whilst it is quite regularly observed, usually within its preferred habitat of shady forested areas, the butterfly is not common. It depends on the availability of its caterpillar host plant, *Ardisia elliptica* to sustain its population on the island.

6) The Two Spotted Line Blue (*Nacaduba biocellata*) (C & R Felder, 1865)

The Two Spotted Line Blue was a new taxon for Singapore when it was first discovered on Singapore island in 2008. It appears to be highly seasonal, where it can even be abundant for several days, and then mysteriously disappears for long periods. The species is known from the South Pacific, and is common in Australia. Its caterpillar host plant is the invasive *Acacia auriculiformis* (Leguminosae, common name: Earleaf Acacia, Black Wattle), *Acacia mangium* (Leguminosae, common name: Silver Wattle).

7) The White Banded Flat (*Celaenorrhinus asmara) (Butler, 1879*)

The White Banded Flat was first re-discovered at Puaka Hill in 2011, after being presumed extinct in Singapore. However, its existence in that very localised area on Pulau Ubin remains to this day. Although regularly seen, it is considered Critically Endangered and if its preferred habitat and caterpillar host plant is removed, this species will most likely be extirpated from Singapore once again. Its caterpillar host plant, *Jasminum elongatum* (Oleaceae, common name: Common Malayan Jasmine) should be cultivated on Pulau Ubin to ensure this species' continued survival.

Discussion

General situation for butterflies on Pulau Ubin

Very little of the original primary forests and native vegetation of Pulau Ubin remain today. Due to a variety of economic and non-economic activities like vegetable farming, rubber and other cash crop plantations, prawn and fish farming, quarrying, recreational and residential developments in the past, much of the flora we see today would be considered secondary forests and regrowth.

However, a number of Singapore's butterfly species were first discovered or re-discovered on Pulau Ubin. That this small island of only slightly more than 1,000 ha can yield such discoveries is intriguing. Some theories that may account for this observation are:

1) The island has been left relatively undisturbed by the aggressive urbanisation that the Singapore mainland has experienced since its independence. The developments on Pulau Ubin have been minimal and thus far, done sensitively in keeping with the rustic and natural environment with as little disruption as possible.
2) The variety of plants on the island is probably a remnant of the original diversity that was found on the island lying between Peninsular Malaysia and Singapore. More than 1,000 plant species have been found on Pulau Ubin, some of them rare or absent in mainland Singapore.
3) Certain habitats on the island, combined with the caterpillar host plants of certain species of butterflies are uniquely conducive for the survival of a small colony of these species of butterflies.
4) The proximity to the southernmost state of Johor in Peninsular Malaysia makes Pulau Ubin a very convenient "pit-stop" for butterfly species that are strong enough to fly across the Straits of Johor or other smaller species that may be carried on prevailing winds that blow towards Singapore during certain months of the year.

Whilst the diversity of butterflies observed during the two-year CUBS is relatively low, this may be because a number of species that have been observed during the surveys of the transects prefer shaded forest habitats. The relatively low abundance of free-flowering shrubs at the selected transects and habitats could have a contributory effect on the perceived lower butterfly diversity and abundance.

It is a known fact that there is a close correlation between the diversity of plants and the diversity of butterflies. This is because the caterpillars of butterflies are very particular about the host plants that they feed on. Many butterfly species are known to feed on host plants that are specific to that butterfly species. It is therefore important that a comprehensive inventory of the flora is continuously updated for Pulau Ubin, and any species that is unique to Pulau Ubin be highlighted. Where a host plant is lost or becomes extinct, there is a potential loss of the related butterfly species whose caterpillar requires that host plant to survive.

Similar to the natureways and park connectors strategy on the Singapore mainland, it is also important to study the feasibility of connectivity corridors on Pulau Ubin. Sites of concentration of high biodiversity should be conserved, and plans put in place to connect these areas to ensure that there is no significant fragmentation of these habitats.

Butterfly species of conservation significance

Of the butterflies observed during CUBS, two species are of conservation significance. The first is the Dwarf Crow (*Euploea tulliolus*). Believed to be extinct in Singapore, the Dwarf

Crow was re-discovered on Pulau Ubin and reinstated to the Singapore Butterfly Checklist in 2002. Since then, it has been regularly observed on Pulau Ubin, and only in recent years has it also been spotted at Coney Island and Pasir Ris Park. There is a colony surviving on Pulau Ubin, and it is important to establish its caterpillar host plant, *Malaisia scandens* (Moraceae, syn: *Trophis scandens*, common name: Burny Vine), so that this species continues to survive in Singapore.

The second is the White Banded Flat (*Celaenorrhinus asmara*). This very rare skipper is classified Critically Endangered in Singapore in the Singapore Red Data Book 3rd Edition (2024). Described as "uncommon" in Malaysia, this species has so far been reliably recorded within Singapore territory only on Pulau Ubin. The area on and around Puaka Hill should be sensitively conserved. Its caterpillar host plant, *Jasminum elongatum* (Oleaceae, common name: Common Malayan Jasmine) should be cultivated to ensure the continued survival of this species.

Conservation strategies and recommendations

Habitats and host plants on Pulau Ubin need to be conserved. Butterfly biodiversity on Pulau Ubin is remarkably high, considering the size of the island. Its forested habitats should be conserved. Any proposed development should not exert significant environmental impact to the plant diversity of the island. There are a number of species that were originally discovered or re-discovered on Pulau Ubin and the importance of the island as a pit stop that is within some butterfly species' flying distance from Malaysia should be reiterated in any conservation plans. The cultivation of key caterpillar host plants in the northern coasts of Pulau Ubin should be considered as this may attract some of the species that are able to make the journey across the Johor Straits to fly over and establish a viable colony on Pulau Ubin.

A healthy diversity of nectaring and other food sources needs to be maintained in various habitats. Whilst it is important to maintain a healthy population of caterpillar host plants to sustain viable colonies of the butterfly species that depend on them, it is also as important to provide relevant nectaring sources for the adult butterflies. Judicious planting and management of nectaring plants will also help the nature community observe and enjoy the butterflies as they feed on the nutritious nectar from key flowering plants. The Butterfly Hill on Pulau Ubin is an excellent example of intentional planting of relevant plants to attract butterflies to a specific location where they can be safely and easily observed.

An inventory of the caterpillar host plants in various habitats should also be maintained, and these plants cultivated and conserved so that there is a sustainable supply of these plants for the caterpillars of the various species of butterflies that depend on these host plants.

A network of connectors needs to be maintained between sites of high biodiversity. Whilst it is much easier to establish nature connectivity across Pulau Ubin, a management strategy to ensure that connectivity is maintained should be put in place. Fragmented and isolated areas may cause certain species to be extirpated –due to disease outbreaks, unduly high predation or loss of caterpillar host plants. Cultivating alternative sites with known host plants of various species will give a contingency plan to minimise the likelihood of a population of butterflies that only depend on a single site for survival from being extirpated.

Non-native vegetation should be managed judiciously. The vegetation of Pulau Ubin is generally less manicured than in other urban parks in Singapore. Being considered a rustic nature area, much of the landscaping of the island is left natural without over-maintenance. However, non-forest or non-native vegetation is often considered of limited conservation value in Singapore. However, for butterflies, many of these plants that are often classified as 'weeds' are as important for their survival as many of their rarer caterpillar host plants. Even the humble grasses and Lalang (*Imperata cylindrica*) support several species of Hesperiidae (Skippers). The removal of any plants on Pulau Ubin should be done judiciously and after due consideration of its rich biodiversity, such that there is minimal impact to the fauna that depend on these plants.

Conclusion

Pulau Ubin has a rich diversity of butterflies due to its rustic and largely undeveloped nature. Despite its small size, there is a relatively good number of species that have been discovered or re-discovered on the island. Due to its proximity to neighbouring Johor, we will likely continue to observe Malaysian butterfly species coming from across the Johor Straits in the coming years.

Any future developments to the built environment should be sensitively done to minimise the impact to the biodiversity of the island. Areas of high biodiversity should be conserved, and adequately linked via green connectors to ensure that there is no fragmentation.

Further research and surveys should continue to document the butterfly biodiversity of the island as well as the critical caterpillar host plants that various butterfly species depend on for their continued survival on Pulau Ubin.

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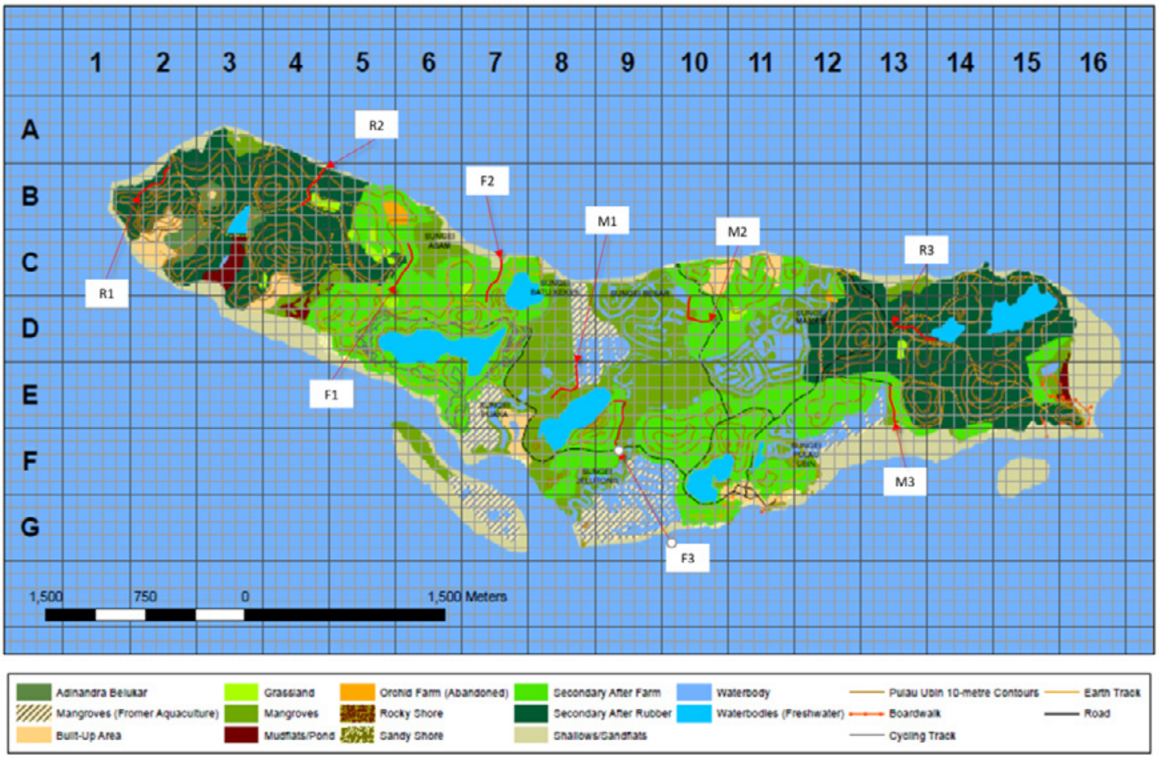
Web Resources

Butterflies of Singapore Blogspot: www.butterflycircle.blogspot.com
Flora & Fauna Web. National Parks Board: https://florafaunaweb.nparks.gov.sg

Appendix 1. Butterfly species recorded from Pulau Ubin transect surveys and some adjacent areas over the period 10 Mar 2018 to 17 Oct 2020. For each butterfly species, the location and number of the sightings are shown for each of the nine selected transects



The surveys at the selected transects on Pulau Ubin conducted over the period Mar 2018 to Oct 2020 were as follows :

Year	Month	R1 : Bukit Tajam	R2 : OBS Evac Point	R3: Balai Quarry	F1 : Aunty Lian's	F2: Kekek Quarry	F3: Puaka Hill	M1 : Puaka East	M2 : Sungei Besar	M3: Sungei Durian
2018	Mar	10th								
	April				21st					
	May							26th		
	June		9th							
	July					8th				
	August								5th	
	September			8th						
	October						28th			
2019	March									24th
	May				11th					
	June									8th
	July						20th			
	August					17th				
	September								21st	

Appendix 1. Continuation

Year	Month	R1 : Bukit Tajam	R2 : OBS Evac Point	R3: Balai Quarry	F1 : Aunty Lian's	F2: Kekek Quarry	F3: Puaka Hill	M1 : Puaka East	M2 : Sungei Besar	M3: Sungei Durian
2020	October			17th						

			Survey Transects									
S/N	**Scientific Name**	**Common Name**	**R1**	**R2**	**R3**	**F1**	**F2**	**F3**	**M1**	**M2**	**M3**	**Total**
Family: Papilionidae												
1	*Troides helena*	Common Birdwing								√		1
2	*Papilio polytes*	Common Mormon		√	√	√	√	√	√	√	√	8
3	*Papilio memnon*	Great Mormon				√						1
4	*Graphium sarpedon*	Common Bluebottle				√		√				2
5	*Graphium agamemnon*	Tailed Jay				√						1
Family: Pieridae **Subfamily: Pierinae**												
6	*Delias hyparete*	Painted Jezebel		√	√	√	√	√			√	6
7	*Leptosia nina*	Psyche			√				√			2
8	*Appias olferna*	Striped Albatross								√		1
Family: Pieridae **Subfamily: Coliadinae**												
9	*Eurema hecabe*	Common Grass Yellow		√	√	√	√	√			√	6
10	*Eurema blanda*	Three Spot Grass Yellow				√			√			2
11	*Eurema sari*	Chocolate Grass Yellow					√					1
Family: Nymphalidae **Subfamily: Danainae**												
12	*Euploea crameri*	Spotted Black Crow			√	√						2
13	*Euploea tulliolus*	Dwarf Crow							√		√	2
14	*Danaus melanippus*	Black Veined Tiger			√							1

Appendix 1. Continuation

			Survey Transects									
S/N	**Scientific Name**	**Common Name**	**R1**	**R2**	**R3**	**F1**	**F2**	**F3**	**M1**	**M2**	**M3**	**Total**
15	*Danaus chrysippus*	Plain Tiger			√							1
16	*Ideopsis vulgaris*	Blue Glassy Tiger	√		√	√		√	√	√	√	7
17	*Parantica agleoides*	Dark Glassy Tiger				√	√	√	√	√		5
Family: Nymphalidae Subfamily: Satyrinae												
18	*Melanitis leda*	Common Evening Brown									√	1
19	*Elymnias hypermnestra*	Common Palmfly			√	√	√	√	√		√	6
20	*Mydosama fuscum*	Malayan Bush Brown	√	√								2
21	*Mycalesis mineus*	Dark Brand Bush Brown				√	√			√		3
22	*Mycalesis perseoides*	Burmese Bush Brown				√	√					2
23	*Orsotria enamedus*	Dark Grass Brown				√	√		√	√		4
24	*Ypthima newboldi*	Common Five Ring				√						1
25	*Amathusia phidippus*	Palm King								√	√	2
26	*Zeuxidia amethystus*	Saturn		√								1
Family: Nymphalidae Subfamily: Heliconiinae												
27	*Acraea terpsicore*	Tawny Coster								√		1
Family: Nymphalidae Subfamily: Nymphalinae												
28	*Doleschallia bisaltide*	Autumn Leaf							√			1
29	*Junonia hedonia*	Chocolate Pansy			√	√	√		√		√	5
30	*Junonia almana*	Peacock Pansy							√			1

Appendix 1. Continuation

			Survey Transects								
S/N	**Scientific Name**	**Common Name**	**R1**	**R2**	**R3**	**F1**	**F2**	**F3**	**M1**	**M2**	**M3**	**Total**
Family: Nymphalidae Subfamily: Limenitidinae												
31	*Neptis hylas*	Common Sailor							√	√		2
32	*Pantoporia paraka*	Perak Lascar				√			√		√	3
33	*Phaedyma columella*	Short Banded Sailor			√	√		√	√	√		5
34	*Lebadea martha*	Knight	√	√	√	√		√	√	√	√	8
35	*Athyma asura*	Studded Sergeant			√							1
36	*Moduza procris*	Commander				√					√	2
37	*Tanaecia pelea*	Malay Viscount	√		√	√						3
38	*Tanaecia iapis*	Horsfield's Baron			√							1
39	*Euthalia monina*	Malay Baron			√			√				2
Family: Nymphalidae Subfamily: Charaxinae												
40	*Charaxes schreiber*	Blue Nawab							√			1
Family: Riodinidae Subfamily: Nemeobiinae												
41	*Abisara saturata*	Malayan Plum Judy						√				1
Family: Lycaenidae Subfamily: Miletinae												
42	*Miletus biggsii*	Biggs' Brownwing		√	√							2
43	*Allotinus unicolor*	Lesser Darkwing				√						1
44	*Logania marmorata*	Pale Mottle							√	√	√	3
Family: Lycaenidae Subfamily: Polymmatinae												
45	*Acytolepis puspa*	Common Hedge Blue						√				1
46	*Zizula hylax*	Pygmy Grass Blue			√	√			√			3

Appendix 1. Continuation

			Survey Transects									
S/N	**Scientific Name**	**Common Name**	**R1**	**R2**	**R3**	**F1**	**F2**	**F3**	**M1**	**M2**	**M3**	**Total**
47	*Jamides celeno*	Common Caerulean									√	1
48	*Jamides bochus*	Dark Caerulean							√			1
49	*Nacaduba biocellata*	Two Spotted Line Blue					√					1
50	*Prosotas nora*	Common Line Blue				√						1
51	*Prosotas dubiosa*	Tailless Line Blue				√	√					2
52	*Petrelaea dana*	Dingy Line Blue							√			1

Family: Lycaenidae
Subfamily: Aphnaeinae

53	*Spindasis syama*	Club Silverline					√					1

Family: Lycaenidae
Subfamily: Theclinae

54	*Arhopala centaurus*	Centaur Oak Blue				√						1
55	*Tajuria mantra*	Felder's Royal				√						1
56	*Hypolycaena thecloides*	Dark Tit				√						1
57	*Rapala manea*	Slate Flash							√			1

Family: Hesperiidae
Subfamily: Coeliadinae

58	*Burara harisa*	Orange Awlet	√	√					√			3
59	*Hasora taminatus*	White Banded Awl							√			1
60	*Hasora badra*	Common Awl	√								√	2

Family: Hesperiidae
Subfamily: Pyrginae

61	*Celaenorrhinus asmara*	White Banded Flat						√				1

Family: Hesperiidae
Subfamily: Hesperiinae

62	*Iambrix salsala*	Chestnut Bob		√	√	√	√		√			5
63	*Notocrypta paralysos*	Banded Demon				√						1

Appendix 1. Continuation

			Survey Transects									
S/N	**Scientific Name**	**Common Name**	**R1**	**R2**	**R3**	**F1**	**F2**	**F3**	**M1**	**M2**	**M3**	**Total**
64	*Suastus gremius*	Palm Bob			√							1
65	*Plastingia naga*	Chequered Lancer				√						1
66	*Hidari irava*	Coconut Skipper				√				√		2
67	*Potanthus omaha*	Lesser Dart				√	√					2
68	*Telicota colon*	Common Palm Dart				√						1
69	*Telicota besta*	Besta Palm Dart				√						1
70	*Pelopidas mathias*	Small Branded Swift				√						1
71	*Polytremis lubricans*	Contiguous Swift				√	√					2
	TOTAL		**6**	**9**	**20**	**37**	**16**	**13**	**24**	**14**	**15**	
	Surveys conducted		1	1	2	2	2	2	1	2	2	

Moths of Pulau Ubin, Singapore – A first assessment highlights many new records for the island and Singapore

Anuj Jain[1,2], Jerome Chua[1] & C. W. Gan[1]

[1]Nature Society (Singapore), 510 Geylang Rd, Singapore 389466
[2]bioSEA Pte. Ltd., 68 Chestnut Avenue, Singapore 679521

ABSTRACT. Seven moth surveys were conducted from September 2018 to January 2021 as part of a Comprehensive Ubin Biodiversity Survey (CUBS) across three habitat types in Pulau Ubin, Singapore. The habitats were mangrove edges, secondary forest that was previously farmland and secondary forest that was previously rubber plantation. The surveys recorded a total of 236 moth species of which 176 species (75%) are considered new records for Pulau Ubin and 32 species (13.6%) are considered new records for Singapore. The high rate of species discovery (new records) is indicative of the poorly sampled moth fauna and the high moth diversity in Singapore and particularly in Pulau Ubin.

Keywords. Endemic, island biodiversity, Lepidoptera, light trap, species discovery, tropical insects

Introduction

While butterflies have garnered much research and public interest in Singapore, moths are relatively poorly known. After Murphy's (1990) seminal work on mangrove insects which included moths, ad hoc surveys have since been conducted around Singapore (e.g., Koh, 2007; Leong & Tay, 2011; Karam & Chong, 2019; Nature Society (Singapore) unpublished data). These have provided vital information about our moth fauna. Unfortunately, many of these datasets, though extensive, have a significant proportion of unidentified specimens. This is made more complicated by the fact that moth taxonomy in the region is still undergoing active revision (Kawahara et al., 2019). In recent years, our biggest source of knowledge on Singapore's moths comes from citizen scientists (Singapore Moths Project on iNaturalist, 2021). To date, there is no consolidated checklist of moths of Singapore but our preliminary compilations suggest in excess of 1,500 moth species extant in Singapore.

The state of moths on Pulau Ubin mirrors that of mainland Singapore. Opportunistic and/or localized surveys have been conducted on Pulau Ubin in the past (Gan C.W. unpublished data that are uploaded on iNaturalist). However, no checklist of moths from Pulau Ubin has been published to our knowledge.

The objective of this study was to produce a checklist of moths recorded from Pulau Ubin to date. The surveys were part of the Comprehensive Ubin Biodiversity Survey (CUBS) facilitated by the National Parks Board from 2018 to 2021. We compared our survey results with moths already known from Pulau Ubin (non-CUBS records) and produced a comprehensive checklist of moths for the island. CUBS records were compared with our existing compilation of moth records from Singapore (as described below) to identify potential new records for Pulau Ubin and for Singapore.

Materials & Methods

Moth surveys were conducted on days of clear weather conditions from 19:30–21:30. A 500W blended mercury bulb (Philips) and a white screen were used at each site. The light bulbs were operated by a portable 3kVA generator (model ETS950) that was provided by the National Parks Board. Two white screens were placed at each location typically placed about 20m apart from each other and facing in different directions to record moths flying from different directions and differing forest topography.

The surveyors checked the white screens frequently and photographed all the moths that landed on or around the screens. Trails in the vicinity of 100m from the screens were typically walked and searched for moths that had settled elsewhere, and these were photographed where possible.

Limited surveys were carried out at the start of CUBS because substantial time was spent coordinating and negotiating with contractors in 2017 and 2018 to manufacture Robinson light traps that could be left overnight on site. The traps could, in theory, be visited the next morning and moths collected for identification, processing and analysis and would, therefore, allow us to deploy many traps concurrently across multiple locations in Ubin. However, this plan did not materialize due to logistic and cost constraints. We resorted to non-invasive methods, i.e., light bulb and white sheet with no specimens collected during the surveys.

Of the seven surveys conducted during the study, three were at the mangrove edge, two were at secondary forest that had previously been farmland and two were at secondary forest that had previously been rubber plantations (Table 1). Gan C.W. and Jain A. led the field surveys along with National Parks Board staff and volunteers while J. Chua provided crucial expertise in moth species identification.

Table 1. Moth surveys conducted in Pulau Ubin as part of the study.

S/No	Survey locations	Habitat type	Date
1	Chek Jawa Bungalow	Mangrove edge	29 September 2018
2	Butterfly Hill Pavilion	Secondary forest (prior farmland)	6 July 2019
3	Five-way Junction	Secondary forest (prior rubber)	31 Aug 2019
4	Sungei Mamam	Mangrove edge	28 September 2019
5	Sungei Durian	Secondary forest (prior farmland)	6 March 2020
6	Bukit Tajam	Secondary forest (prior rubber)	10 October 2020
7	Sungei Asam	Mangrove edge	15 Jan 2021

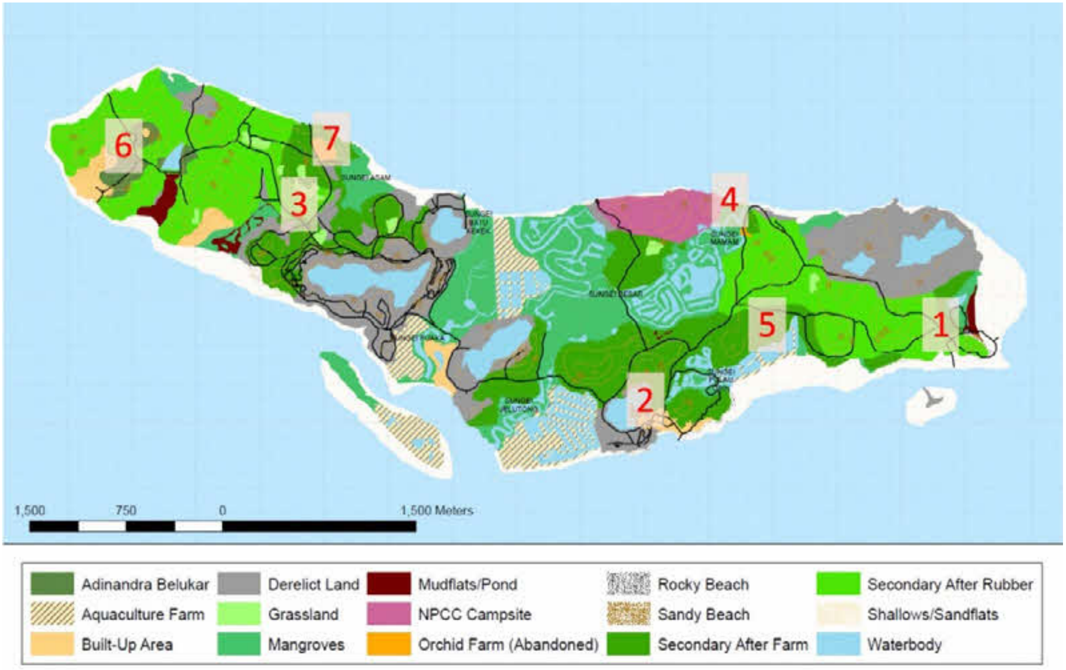


Fig. 1 Moth survey locations classified by habitat types. See Table 1 for the description of survey locations and dates. Basemap provided by NParks.

Fig. 2 Field set-up showing two white sheets erected to face in different directions at Bukit Tajam in Pulau Ubin. Similar light bulbs were used for both sheets. Photo credit: Anuj Jain

To compare results from CUBS surveys with the Singapore moth checklist as a whole, we collated past records in Singapore known from checklists by Murphy (1990), past biodiversity records published in *Nature in Singapore*, Karam & Chong (2019), iNaturalist records as well as unpublished records by the authors that have been collated for the purposes of updating the Singapore Red Data Book.

Results

A total of 236 moth species were recorded from the seven surveys in Pulau Ubin (Appendix 1). We also reviewed checklists from previous non-CUBS surveys in Pulau Ubin including a BioBlitz citizen science exercise held by the National Parks Board in 2016, and report 195 moth species from them. When combined, the two checklists total 372 moth species known from Pulau Ubin to date. There was a high degree of uniqueness between the two lists such that CUBS surveys added 177 new species records for Pulau Ubin. This implies that 75% of species (177 out of 236 species) recorded during CUBS surveys were new records for Pulau Ubin. Out of 39 families represented, the three families Erebidae (112 species), Geometridae (48 species) and Crambidae (43 species) accounted for 54% of the moth taxa identified to date.

When classified by habitat types, mangrove edge had the highest moth diversity with 127 species, while the two types of secondary forests i.e. regenerated from prior farmland (91 species) or from prior rubber (89 species) had nearly an equal number of species (Table 2). However, the species totals might also reflect that three survey sessions were conducted in the mangrove edge, compared with two surveys each in the secondary forest habitats. Of the 236 moth species recorded during CUBS surveys, 188 species (80%) could be identified to species or genus level. The remaining species could only be identified to family or subfamily level but the photographs remain on file with the authors so that they might be identified to species level in the future.

Of the 177 new records for Ubin, 32 species are possibly new records for Singapore (Table 3, Appendix 1).

Discussion

Three-quarters (75%) of the species recorded during CUBS surveys were new records for Pulau Ubin. This is expected because few systematic moth surveys had ever been conducted on Pulau Ubin before. Additionally, our surveys yielded an unexpectedly high number of new records (32 species) for Singapore. This is both a testament to the poorly known moth fauna of Singapore and the taxonomic challenges to moth identification in the tropics.

The authors were meticulous in identifying species recorded in CUBS surveys. However, because the non-CUBS dataset has not been identified to the same rigour, we may find some CUBS species currently identified as new Ubin records or new national records as also present in the non-CUBS dataset once the latter have been identified with the same rigour.

The total of 372 moth species now known from Pulau Ubin may still be an underestimate. Separately, the authors note that at least 184 butterfly species are known from Pulau Ubin (A.J. unpublished data), equivalent to 55% of Singapore's total 334 butterfly species, and the butterfly fauna of the island has also been estimated as at least 175 species (Khew, this volume). Given that over 1500 moth species are known from Singapore, which is nearly 4.5

times that of the Singapore butterfly fauna, it is possible that the moth diversity of Ubin may be over 800 species. This suggests that less than half of the actual number of moth species present in Ubin may have been recorded so far.

We suggest more systematic moth surveys be conducted in Pulau Ubin to document the island's rich moth diversity. Additionally, this may continue to yield unexpected new discoveries for Ubin and Singapore. Finally, we hope the moth checklist presented in this paper will provide further impetus to the invertebrate conservation efforts in Pulau Ubin.

Table 2. Number of moth species recorded in each survey and classified by habitat types

Habitat types	Date	Number of surveys	Number of species observed
Secondary forest (prior farmland)			
Butterfly Hill Pavilion	6 July 2019		47
Sungei Durian	6 March 2020		53
Subtotal		2	91
Secondary forest (prior rubber)			
Five-way Junction OBS	31 Aug 2019		46
Bukit Tajam OBS	10 October 2020		56
Subtotal		2	89
Mangrove edge			
Chek Jawa Bungalow	29 September 2018		36
Sungei Mamam	28 September 2019		58
Sungei Asam	15 January 2021		50
Subtotal		3	126
Total		7	236

Table 3. List of potential 32 new moth records for Singapore found during the CUBS surveys (see Appendix 1 for photos)

SN	Family	Subfamily	Scientific name	Location
1	Psychidae	Oiketicinae	*Amatissa sp.*	Butterfly Hill
2	Lacturidae	-	*Anticrates sp. 1*	Bukit Tajam
3	Lacturidae	-	*Anticrates sp. 2*	Sungei Asam
4	Pyralidae	Phycitinae	*Arivaca sp.*	Sungei Mamam
5	Erebidae	Erebinae	*Avatha garthei*	Bukit Tajam
6	Choreutidae	Choreutinae	*Choreutis sp.*	Butterfly Hill
7	Geometridae	Geometrinae	*Comostola quantula*	Sungei Asam
8	Erebidae	Boletobiinae	*Corgatha* sp. nr. *nigripalpis*	Butterfly Hill
9	Tortricidae	Olethreutinae	*Dactylioglypha pallens*	Sungei Durian
10	Pyralidae	Phycitinae	*Etiella sp.*	Chek Jawa

Table 3. Continuation

SN	**Family**	**Subfamily**	**Scientific name**	**Location**
11	Erebidae	Boletobiinae	*Eublemma ignefusa*	Bukit Tajam
12	Geometridae	Geometrinae	*Eucyclodes sp.*	Sungei Asam
13	Crambidae	Crambinae	*Glaucocharis margretella*	Sungei Durian
14	Tineidae	Harmacloninae	*Harmaclona sp.*	Five-way Junction OBS
15	Pyralidae	Pyralinae	*Hypsopygia sp.*	Sungei Mamam, Sungei Durian
16	Erebidae	Arctiinae	*Macotasa tetraspila*	Butterfly Hill, Sungei Durian
17	Nolidae	Chloephorinae	*Maurilia sp.*	Five-way Junction OBS
18	Uraniidae	Epipleminae	*Monobolodes sp.*	Butterfly Hill
19	Brachodidae	-	*Nigilgia anactis*	Sungei Asam, Chek Jawa
20	Tortricidae	Olethreutinae	*Ophiorrhabda scaristis*	Sungei Asam, Five-way Junction OBS
21	Geometridae	Sterrhinae	*Somatina sp.*	Five-way Junction OBS
22	Cosmopterigidae	Chrysopeleiinae	*Sp.*	Sungei Durian
23	Tineodidae	-	*Sp.*	Sungei Durian
24	Lecithoceridae	Torodorinae	*Torodora* sp. nr. *claustrata*	Chek Jawa
25	Cosmopterigidae	-	*Sp.*	Sungei Durian
26	Oecophoridae	-	*Sp.*	Sungei Durian
27	Erebidae	Boletobiinae	*Tamba basiscripta*	Bukit Tajam
28	Crambidae	Pyraustinae	*Tetridia vinacealis*	Sungei Asam
29	Erebidae	Boletobiinae	*Tipasa nebulosella*	Bukit Tajam
30	Erebidae	Boletobiinae	*Tipasa sp.*	Bukit Tajam
31	Limacodidae	-	*Trichogyia sp.*	Chek Jawa
32	Cossidae	Zeuzerinae	*Zeuzera indica*	Butterfly Hill

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Appendix

Table A1. List of moths recorded from Pulau Ubin, Singapore, as part of CUBS or other studies

SN	Scientific name	Family	Subfamily	CUBS	Non CUBS	Status
1	*Achaea serva*	Erebidae	Erebinae	1		New Ubin Record
2	*Acherontia* sp.	Sphingidae	Sphinginae		1	
3	*Acropteris* sp.	Uraniidae	Microniinae		1	
4	*Adoxophyes* sp.	Tortricidae	Tortricinae	1		New Ubin Record
5	*Adoxophyes privatana*	Tortricidae	Tortricinae		1	
6	*Adrapsa* ereboides	Erebidae	Herminiinae	1		New Ubin Record
7	*Adrapsa ablualis*	Erebidae	Herminiinae		1	
8	*Aedia lichenea*	Noctuidae	Aediinae		1	
9	*Aetholix flavibasalis*	Crambidae	Spilomelinae	1	1	
10	*Agrioglypta* zelimalis	Crambidae	Spilomelinae		1	
11	*Agrioglypta itysalis*	Crambidae	Spilomelinae	1		New Ubin Record
12	*Aiteta musculina*	Nolidae			1	
13	*Amatissa* sp.	Psychidae	Oiketicinae	1		New Ubin Record
14	*Ambadra* sp.	Notodontidae	Spataliinae	1	1	
15	*Ambulyx moorei*	Sphingidae	Smerinthinae	1	1	
16	*Ambulyx pryeri*	Sphingidae	Smerinthinae		1	
17	*Amyna* sp.	Noctuidae	Bagisarinae	1		New Ubin Record
18	*Anticrates* sp. 1	Lacturidae		1		New Ubin Record
19	*Anticrates* sp. 2	Lacturidae		1		New Ubin Record
20	*Archipini* sp.	Tortricidae			1	
21	*Arctiinae* sp.	Erebidae	Arctiinae	1	1	
22	*Arctornis egerina*	Erebidae	Lymantriinae	1	1	
23	*Arctornis obtusa*	Erebidae	Lymantriinae	1		New Ubin Record
24	*Argina astrea*	Erebidae	Arctiinae		1	
25	*Argyrocosma inductaria*	Geometridae	Geometrinae	1		New Ubin Record
26	*Arivaca* sp.	Pyralidae	Phycitinae	1		New Ubin Record

Table A1. Continuation

SN	Scientific name	Family	Subfamily	CUBS	Non CUBS	Status
27	*Artaxa* sp.	Erebidae	Lymantriinae		1	
28	*Ascalenia thoracista*	Cosmopterigidae	Chrysopeleiinae	1		New Ubin Record
29	*Asota egens*	Erebidae	Aganainae		1	
30	*Asota paphos*	Erebidae	Aganainae		1	
31	*Asota plana*	Erebidae	Aganainae	1		New Ubin Record
32	*Asota subsimilis*	Erebidae	Aganainae	1	1	
33	*Attacus atlas*	Saturniidae			1	
34	*Aucha* sp.	Noctuidae	Noctuinae	1		New Ubin Record
35	*Avatha bubo*	Erebidae	Erebinae		1	
36	*Avatha garthei*	Erebidae	Erebinae	1		New Ubin Record
37	*Balaenifrons ochrochroa*	Crambidae	Odontiinae	1		New Ubin Record
38	*Banisia* sp.	Thyrididae	Striglininae	1		New Ubin Record
39	*Banisia myrsusalis*	Thyrididae	Striglininae		1	
40	*Barsilene pallinflexa*	Erebidae	Arctiinae	1		New Ubin Record
41	*Belciana biformis*	Noctuidae	Pantheinae	1		New Ubin Record
42	*Berta* sp.	Geometridae	Geometrinae		1	
43	*Berta chrysolineata*	Geometridae	Geometrinae		1	
44	*Biston* sp. nr. *inouei*	Geometridae	Ennominae		1	
45	*Biston suppressaria*	Geometridae	Ennominae		1	
46	*Bocana manifestalis*	Erebidae	Herminiinae		1	
47	*Bocchoris* sp.	Crambidae	Spilomelinae	1		New Ubin Record
48	*Bocchoris inspersalis*	Crambidae	Spilomelinae	1		New Ubin Record
49	*Boeotarcha martinalis*	Crambidae	Odontiinae	1		New Ubin Record
50	*Boletobiinae* sp.	Erebidae	Boletobiinae	1		New Ubin Record
51	*Borbotana nivifascia*	Noctuidae	Noctuinae	1		New Ubin Record
52	*Brenthia* sp.	Choreutidae	Brenthiinae		1	

Table A1. Continuation

SN	Scientific name	Family	Subfamily	CUBS	Non CUBS	Status
53	*Brunia* sp.	Erebidae	Arctiinae	1		New Ubin Record
54	*Brunia antica*	Erebidae	Arctiinae	1		New Ubin Record
55	*Bulonga schistacearia*	Geometridae	Ennominae	1		New Ubin Record
56	*Calletarea* sp.	Geometridae	Ennominae		1	
57	*Calletarea subexpressa*	Geometridae	Ennominae	1	1	
58	*Callidrepana* sp.	Drepanidae	Drepaninae		1	
59	*Callidrepana micacea*	Drepanidae	Drepaninae	1		New Ubin Record
60	*Callopistria emiliusalis*	Noctuidae	Eriopinae		1	
61	*Cerynea* sp.	Erebidae	Boletobiinae	1	1	
62	*Chadisra basivacua*	Notodontidae	Periergosinae		1	
63	*Chalciope mygdon*	Erebidae	Erebinae	1	1	
64	*Chalcocelis albiguttatus*	Limacodidae		1	1	New Ubin Record
65	*Chiasmia* sp.	Geometridae	Ennominae	1		New Ubin Record
66	*Choreutidae* sp.	Choreutidae			1	
67	*Choreutis* sp.	Choreutidae	Choreutinae	1		New Ubin Record
68	*Choreutis amethystodes*	Choreutidae	Choreutinae		1	
69	*Choreutis orthogona*	Choreutidae	Choreutinae		1	
70	*Chrysopeleiinae* sp.	Cosmopterigidae	Chrysopeleiinae	1		New Ubin Record
71	*Cleora injectaria*	Geometridae	Ennominae		1	
72	*Cleora repetita*	Geometridae	Ennominae	1		New Ubin Record
73	*Clethrogynaturbata*	Erebidae	Lymantriinae		1	
74	*Comibaena* sp.	Geometridae	Geometrinae	1		New Ubin Record
75	*Comibaena attenuata*	Geometridae	Geometrinae	1	1	
76	*Comibaena cassidara*	Geometridae	Geometrinae		1	
77	*Comostola laesaria*	Geometridae	Geometrinae	1		New Ubin Record
78	*Comostola* sp. nr. *quantula*	Geometridae	Geometrinae	1		New Ubin Record

Table A1. Continuation

SN	Scientific name	Family	Subfamily	CUBS	Non CUBS	Status
79	*Condica illecta*	Noctuidae	Condicinae	1		New Ubin Record
80	*Conogethes* sp.	Crambidae	Spilomelinae	1		New Ubin Record
81	*Corgatha* sp.	Erebidae	Boletobiinae	1	1	
82	*Corgatha nigripalpis*	Erebidae	Boletobiinae	1		New Ubin Record
83	*Corgatha pseudominor*	Erebidae	Boletobiinae		1	
84	*Cosmopterix* sp.	Cosmopterigidae	Cosmopteriginae	1		New Ubin Record
85	*Creatonotos transiens*	Erebidae	Arctiinae	1	1	
86	*Cryptaspasma* sp.	Tortricidae	Olethreutinae	1		New Ubin Record
87	*Cryptophlebia* sp.	Tortricidae	Olethreutinae	1	1	
88	*Cryptophlebia ombrodelta*	Tortricidae	Olethreutinae		1	
89	*Culladia* sp.	Crambidae	Crambinae		1	
90	*Culladia hastiferalis*	Crambidae	Crambinae	1		New Ubin Record
91	*Cyana* sp.	Erebidae	Arctiinae		1	
92	*Cyana conclusa*	Erebidae	Arctiinae	1		New Ubin Record
93	*Cyana dudgeoni*	Erebidae	Arctiinae		1	
94	*Cyana flavalba*	Erebidae	Arctiinae		1	
95	*Cyana perornata*	Erebidae	Arctiinae		1	
96	*Cyclodes omma*	Noctuidae	Dyopsinae	1	1	
97	*Dactylioglypha pallens*	Tortricidae	Olethreutinae	1		New Ubin Record
98	*Daphnusa ocellaris*	Sphingidae	Smerinthinae	1	1	
99	*Orthocraspeda trima*	Limacodidae		1		New Ubin Record
100	*Dasychira* sp.	Erebidae	Lymantriinae	1		New Ubin Record
101	*Dasyses* sp.	Tineidae	Hapsiferinae	1		New Ubin Record
102	*Derambila* sp.	Geometridae	Desmobathrinae	1		New Ubin Record
103	*Diacrotricha fasciola*	Pterophoridae	Pterophorinae		1	
104	*Dichocrocis* sp.	Crambidae	Spilomelinae	1	1	
105	*Dichomeris* sp.	Gelechiidae	Dichomeridinae	1	1	

Table A1. Continuation

SN	Scientific name	Family	Subfamily	CUBS	Non CUBS	Status
106	*Didigua vexilla*	Erebidae	Chloephorinae	1		New Ubin Record
107	*Dinumma combusta*	Erebidae	Scoliopteryginae	1		New Ubin Record
108	*Dinumma oxygrapha*	Erebidae	Scoliopteryginae		1	
109	*Dysaethria plicata*	Uraniidae	Epipleminae		1	
110	*Dysphania* sp.	Geometridae	Geometrinae		1	
111	*Dysphania bivexillata*	Geometridae	Geometrinae	1	1	
112	*Earias* sp.	Nolidae	Eariadinae	1		New Ubin Record
113	*Elibia dolichus*	Sphingidae	Macroglossinae		1	
114	*Elusa* sp	Noctuidae		1	1	
115	*Endotricha* sp.	Pyralidae	Pyralinae	1		New Ubin Record
116	*Endotricha mesenterialis*	Pyralidae	Pyralinae	1		New Ubin Record
117	*Enispa* sp.	Erebidae	Boletobiinae	1		New Ubin Record
118	*Enispa elataria*	Erebidae	Boletobiinae		1	
119	*Ennominae* sp.	Geometridae	Ennominae		1	
120	*Enpinanga borneensis*	Sphingidae	Macroglossinae		1	
121	*Enpinanga vigens*	Sphingidae	Macroglossinae	1		New Ubin Record
122	*Epaena* sp.	Thyrididae			1	
123	*Epicrocis* sp.	Pyralidae	Phycitinae	1		New Ubin Record
124	*Epipaschiinae* sp.	Pyralidae	Epipaschiinae	1	1	
125	*Erebidae* sp.	Erebidae		1	1	
126	*Eressa confinis*	Erebidae	Arctiinae	1		New Ubin Record
127	*Ericeia inangulata*	Erebidae	Erebinae	1		New Ubin Record
128	*Ericeia sp. nr. sobria*	Erebidae	Erebinae	1		New Ubin Record
129	*Eriocottidae* sp.	Eriocottidae			1	
130	*Eristena* sp.	Crambidae	Acentropinae	1	1	
131	*Erizada lichenaria*	Nolidae	Chloephorinae	1		New Ubin Record

Table A1. Continuation

SN	Scientific name	Family	Subfamily	CUBS	Non CUBS	Status
132	*Etiella* sp.	Pyralidae	Phycitinae	1		New Ubin Record
133	*Eublemma sp. 1*	Erebidae	Boletobiinae	1		New Ubin Record
134	*Eublemma sp. 2*	Erebidae	Boletobiinae	1		New Ubin Record
135	*Eublemma abrupta*	Erebidae	Boletobiinae	1		New Ubin Record
136	*Eublemma ignefusa*	Erebidae	Boletobiinae	1		New Ubin Record
137	*Eublemma pudica*	Erebidae	Boletobiinae	1		New Ubin Record
138	*Eucyclodes* sp.	Geometridae	Geometrinae	1		New Ubin Record
139	*Eudocima* sp.	Erebidae	Calpinae	1	1	
140	*Eudocima phalonia*	Erebidae	Calpinae	1	1	
141	*Eugoa* sp.	Erebidae	Arctiinae	1		New Ubin Record
142	*Eumelea* sp.	Geometridae	Desmobathrinae		1	
143	*Eupitheciini* sp.	Geometridae	Larentiinae		1	
144	*Europlema semibrunnea*	Uraniidae	Epipleminae	1	1	
145	*Eurosia melanopera*	Erebidae	Arctiinae	1		New Ubin Record
146	*Exelastis* sp.	Pterophoridae	Pterophorinae		1	
147	*Fascellina castanea*	Geometridae	Ennominae	1		New Ubin Record
148	*Gelechiidae* sp.	Gelechiidae		1		New Ubin Record
149	*Gelechioidea* sp.				1	
150	*Geometridae* sp.	Geometridae		1	1	
151	*Geometrinae* sp.	Geometridae	Geometrinae		1	
152	*Gerontha* sp.	Tineidae		1		New Ubin Record
153	*Gesonia* sp.	Erebidae	Boletobiinae	1	1	
154	*Gesonia obeditalis*	Erebidae	Boletobiinae		1	
155	*Glaucocharis margretella*	Crambidae	Crambinae	1		New Ubin Record
156	*Glyphodes canthusalis*	Crambidae	Spilomelinae		1	

Table A1. Continuation

SN	Scientific name	Family	Subfamily	CUBS	Non CUBS	Status
157	*Glyphodes multilinealis*	Crambidae	Spilomelinae	1		New Ubin Record
158	*Gonodontis clelia*	Geometridae	Ennominae		1	
159	*Gracillariidae* sp.	Gracillariidae		1	1	
160	*Gyrtothripa* sp.	Nolidae	Chloephorinae	1		New Ubin Record
161	*Hadennia hypenalis*	Erebidae	Herminiinae		1	
162	*Hapsiferinae* sp.	Tineidae	Hapsiferinae	1		New Ubin Record
163	*Haritalodes derogata*	Crambidae	Spilomelinae		1	
164	*Harmaclona* sp.	Tineidae	Harmacloninae	1		New Ubin Record
165	*Heliohemonia monosticta*	Erebidae	Arctiinae	1	1	
166	*Hellinsia* sp.	Pterophoridae	Pterophorinae		1	
167	*Hemiscopis sanguinea*	Crambidae	Spilomelinae	1		New Ubin Record
168	*Herpetogramma* sp.	Crambidae	Spilomelinae		1	
169	*Heterostegane* sp.	Geometridae	Ennominae	1	1	
170	*Heterostegane tritocampsis*	Geometridae	Ennominae	1		New Ubin Record
171	*Hippotion rosetta*	Sphingidae	Macroglossinae		1	
172	*Homodes crocea*	Erebidae	Boletobiinae		1	
173	*Homodes vivida*	Erebidae	Boletobiinae	1		New Ubin Record
174	*Homona* sp.	Tortricidae	Tortricinae	1		New Ubin Record
175	*Hulodes caranea*	Erebidae	Erebinae		1	
176	*Hydrillodes lentalis*	Erebidae	Herminiinae	1		New Ubin Record
177	*Hymenoptychis sordida*	Crambidae	Spilomelinae	1		New Ubin Record
178	*Hypena robustalis*	Erebidae	Hypeninae	1		New Ubin Record
179	*Hypenodinae* sp.	Erebidae	Hypenodinae	1		New Ubin Record
180	*Hyperythra lutea*	Geometridae	Ennominae		1	
181	*Hyphorma margaritacea*	Limacodidae		1		New Ubin Record

Table A1. Continuation

SN	Scientific name	Family	Subfamily	CUBS	Non CUBS	Status
182	*Hyposidra infixaria*	Geometridae	Ennominae		1	
183	*Hyposidra talaca*	Geometridae	Ennominae	1	1	
184	*Hypospila* sp.	Erebidae	Erebinae		1	
185	*Hypsopygia* sp. 1	Pyralidae	Pyralinae	1		New Ubin Record
186	*Hypsopygia* sp. 2	Pyralidae	Pyralinae	1		New Ubin Record
187	*Hypsopygia* sp. 3	Pyralidae	Pyralinae	1		New Ubin Record
188	*Hypsopygia* sp. 4	Pyralidae	Pyralinae	1		New Ubin Record
189	*Hywoolla sp.*	Erebidae	Herminiinae	1		New Ubin Record
190	*Idaea* sp.	Geometridae	Sterrhinae	1		New Ubin Record
191	*Idaea purpurea*	Geometridae	Sterrhinae	1		New Ubin Record
192	*Ilema* sp.	Erebidae	Lymantriinae	1		New Ubin Record
193	*Imma* sp.	Immidae		1	1	
194	*Imma mackwoodii*	Immidae		1		New Ubin Record
195	*Imma transversella*	Immidae			1	
196	*Ischnurges gratiosalis*	Crambidae	Spilomelinae		1	
197	*Ischyja ferrifracta*	Erebidae	Erebinae		1	
198	*Ischyja marapok*	Erebidae	Erebinae	1	1	
199	*Lacera* sp.	Erebidae	Erebinae		1	
200	*Lamprosema tampiusalis*	Crambidae	Spilomelinae		1	
201	*Larentiinae* sp.	Geometridae	Larentiinae	1		New Ubin Record
202	*Lasiocampidae* sp.	Lasiocampidae			1	
203	*Laspeyria ruficeps*	Erebidae	Boletobiinae		1	
204	*Lathrotelinae* sp.	Crambidae	Lathrotelinae	1		New Ubin Record
205	*Lecithocera* sp.	Lecithoceridae	Lecithocerinae	1		New Ubin Record
206	*Lecithoceridae* sp.	Lecithoceridae		1		New Ubin Record
207	*Lecithocerinae sp.*	Lecithoceridae	Lecithocerinae	1		New Ubin Record

Table A1. Continuation

SN	Scientific name	Family	Subfamily	CUBS	Non CUBS	Status
208	*Lecitholaxa sp.*	Lecithoceridae	Lecithocerinae	1		New Ubin Record
209	*Lepidoplaga sp.*	Crambidae	Pyraustinae	1		New Ubin Record
210	*Limacodidae sp.*	Limacodidae		1	1	
211	*Lithosiina sp.*	Erebidae	Arctiinae		1	
212	*Loxioda sp.*	Erebidae	Boletobiinae		1	
213	*Luxiaria sp.*	Geometridae	Ennominae	1		New Ubin Record
214	*Lymantriinae sp.*	Erebidae	Lymantriinae	1	1	
215	*Lyssa zampa*	Uraniidae	Uraniinae		1	
216	*Macariini sp.*	Geometridae	Ennominae		1	
217	*Macotasa tetraspila*	Erebidae	Arctiinae	1		New Ubin Record
218	*Macotasa lacrima*	Erebidae	Arctiinae		1	
219	*Macotasa tortricoides*	Erebidae	Arctiinae		1	
220	*Macroglossinae* sp.	Sphingidae	Macroglossinae		1	
221	*Macroglossum* sp.	Sphingidae	Macroglossinae	1	1	
222	*Macroglossum corythus*	Sphingidae	Macroglossinae	1		New Ubin Record
223	*Mambarona congrua*	Limacodidae		1		New Ubin Record
224	*Maurilia* sp.	Nolidae	Chloephorinae	1		New Ubin Record
225	*Mecodina metagrapta*	Erebidae	Aganainae		1	
226	*Mesosciera orientalis*	Erebidae			1	New Ubin Record
227	*Metaemene atrigutta*	Erebidae	Boletobiinae	1		New Ubin Record
228	*Metathrinca* sp.	Xyloryctidae		1		New Ubin Record
229	*Miltochrista* sp.	Erebidae	Arctiinae	1		New Ubin Record
230	*Miltochrista falciseriata*	Erebidae	Arctiinae	1		New Ubin Record
231	*Miltochrista irregularis*	Erebidae	Arctiinae		1	
232	*Moca* sp.	Immidae		1		New Ubin Record
233	*Mocis undata*	Erebidae	Erebinae		1	

Table A1. Continuation

SN	Scientific name	Family	Subfamily	CUBS	Non CUBS	Status
234	*Monobolodes* sp.	Uraniidae	Epipleminae	1		New Ubin Record
235	*Mudaria luteileprosa*	Noctuidae	Noctuinae		1	
236	*Naarda* sp.	Erebidae	Lymantriinae	1	1	
237	*Nacoleia* sp.	Crambidae	Spilomelinae	1		New Ubin Record
238	*Nanarsine porphyrea*	Erebidae	Arctiinae	1	1	
239	*Narosa* sp. nr. *concinna*	Limacodidae		1		New Ubin Record
240	*Nechesia albodentata*	Erebidae	Boletobiinae	1		New Ubin Record
241	*Neodrymonia* sp.	Notodontidae	Notodontinae		1	
242	*Neurozerra conferta*	Cossidae		1		New Ubin Record
243	*Nigilgia anactis*	Brachodidae		1	1	
244	*Noctuidae* sp.	Noctuidae		1	1	
245	*Noctuinae* sp.	Noctuidae	Noctuinae	1	1	
246	*Noctuoidea* sp.				1	
247	*Nolidae* sp.	Nolidae		1	1	
248	*Nolinae* sp.	Nolidae	Nolinae	1		New Ubin Record
249	*Nolini* sp.	Nolidae			1	
250	*Notodontidae* sp.	Notodontidae			1	
251	*Nyctemera baulus*	Erebidae	Arctiinae		1	
252	*Nygmiini* sp.	Erebidae	Lymantriinae		1	
253	*Odontiinae* sp.	Crambidae	Odontiinae	1		New Ubin Record
254	*Oecophoridae* sp.	Oecophoridae		1		New Ubin Record
255	*Oenospila flavifusata*	Geometridae	Geometrinae	1		New Ubin Record
256	*Olethreutinae* sp.	Tortricidae	Olethreutinae	1		New Ubin Record
257	*Omiodes diemenalis*	Crambidae	Spilomelinae	1		New Ubin Record
258	*Ophiorrhabda mormopa*	Tortricidae	Olethreutinae	1		New Ubin Record
259	*Ophiorrhabda scaristis*	Tortricidae	Olethreutinae	1		New Ubin Record

Table A1. Continuation

SN	Scientific name	Family	Subfamily	CUBS	Non CUBS	Status
260	*Ophiusa discriminans*	Erebidae	Erebinae	1		New Ubin Record
261	*Ophiusa trapezium*	Erebidae	Erebinae	1	1	
262	*Opogona* sp.	Tineidae	Hieroxestinae	1		New Ubin Record
263	*Oreta carnea*	Drepanidae	Drepaninae		1	
264	*Orothalassodes* sp.	Geometridae	Geometrinae		1	
265	*Orothalassodes leucoceraea*	Geometridae	Geometrinae		1	
266	*Orthaga* sp.	Pyralidae	Epipaschiinae	1		New Ubin Record
267	*Oruza* sp.	Erebidae	Boletobiinae	1		New Ubin Record
268	*Oxyodes scrobiculata*	Erebidae	Erebinae	1	1	
269	*Oxyplax pallivitta*	Limacodidae		1	1	
270	*Pachynoa sabelialis*	Crambidae	Spilomelinae	1		New Ubin Record
271	*Pagodiella hekmeyeri*	Psychidae			1	
272	*Pagyda* sp.	Crambidae	Pyraustinae		1	
273	*Parasa lepida*	Limacodidae			1	
274	*Patania iopasalis*	Crambidae	Spilomelinae		1	
275	*Penicillaria jocosatrix*	Euteliidae	Euteliinae		1	
276	*Pergesa acteus*	Sphingidae	Macroglossinae		1	
277	*Perina sunda*	Erebidae	Lymantriinae	1		New Ubin Record
278	*Phauda* sp.	Phaudidae	Phaudinae		1	
279	*Phacusa sp. nr. crawfurdi*	Zygaenidae			1	
280	*Phycitinae* sp.	Pyralidae	Phycitinae	1	1	
281	*Physematia* sp.	Crambidae	Spilomelinae	1		New Ubin Record
282	*Piletocera* sp.	Crambidae	Spilomelinae	1		New Ubin Record
283	*Pingasa rubimontana*	Geometridae	Geometrinae		1	
284	*Plusiopalpa adrasta*	Noctuidae	Plusiinae		1	
285	*Plutella* sp.	Plutellidae		1		New Ubin Record
286	*Plutodes* sp.	Geometridae	Ennominae		1	

Table A1. Continuation

SN	Scientific name	Family	Subfamily	CUBS	Non CUBS	Status
287	*Polydesma boarmoides*	Erebidae	Erebinae		1	
288	*Pompelon marginata*	Zygaenidae	Chalcosiinae		1	
289	*Prophantis adusta*	Crambidae	Spilomelinae	1		New Ubin Record
290	*Psilogramma menephron*	Sphingidae	Sphinginae		1	
291	*Psychidae* sp.	Psychidae			1	
292	*Pterocyclophora ridleyi*	Erebidae	Erebinae	1	1	
293	*Pterophoridae* sp.	Pterophoridae			1	
294	*Pterophorus lacteipennis*	Pterophoridae		1	1	
295	*Pylartes subcostalis*	Crambidae	Spilomelinae	1		New Ubin Record
296	*Pyralidae* sp.	Pyralidae		1		New Ubin Record
297	*Pyralinae* sp.	Pyralidae	Pyralinae	1	1	
298	*Pyraloidea* sp.				1	
299	*Pyraustinae* sp.	Crambidae	Pyraustinae	1		New Ubin Record
300	*Risoba diversipennis*	Nolidae	Risobinae	1		New Ubin Record
301	*Rusicada nigritarsis*	Erebidae	Scoliopteryginae	1		New Ubin Record
302	*Sameodes cancellalis*	Crambidae	Spilomelinae	1	1	
303	*Saptha* sp.	Choreutidae	Choreutinae		1	
304	*Saptha beryllitis*	Choreutidae	Choreutinae	1	1	
305	*Sarbena* sp.	Nolidae	Nolinae		1	
306	*Saroba pansa*	Erebidae	Boletobiinae	1		New Ubin Record
307	*Scopula* sp.	Geometridae	Sterrhinae	1	1	
308	*Semiothisa drepanata*	Geometridae	Ennominae		1	
309	*Serrodes partita*	Erebidae	Erebinae		1	
310	*Sesiidae* sp.	Sesiidae			1	
311	*Simplicia* sp.	Erebidae	Herminiinae		1	
312	*Somatina obscuriciliata*	Geometridae	Sterrhinae	1		New Ubin Record
313	*Sorolopha* sp.	Tortricidae	Olethreutinae	1		New Ubin Record

Table A1. Continuation

SN	Scientific name	Family	Subfamily	CUBS	Non CUBS	Status
314	*Spilomelinae* sp.	Crambidae	Spilomelinae	1	1	
315	*Spirama* sp.	Erebidae	Erebinae		1	
316	*Spoladea recurvalis*	Crambidae	Spilomelinae		1	
317	*Statherotis* sp.	Tortricidae	Olethreutinae	1		New Ubin Record
318	*Stathmopoda* sp.	Stathmopodidae		1		New Ubin Record
319	*Stenocarsia sthenoptera*	Erebidae		1		New Ubin Record
320	*Stericta* sp.	Pyralidae	Epipaschiinae	1		New Ubin Record
321	*Sterrhinae* sp.	Geometridae	Sterrhinae	1	1	
322	*Stictane* sp.	Erebidae	Arctiinae	1	1	
323	*Stictoptera* sp.	Euteliidae	Stictopterinae		1	
324	*Stictopterinae* sp.	Euteliidae	Stictopterinae	1		New Ubin Record
325	*Streblote helpsi*	Lasiocampidae			1	
326	*Striglina* sp.	Thyrididae		1		New Ubin Record
327	*Sufetula* sp.	Crambidae	Lathrotelinae	1		New Ubin Record
328	*Sycacantha inodes*	Tortricidae	Olethreutinae	1		New Ubin Record
329	*"Syllepte" vagalis*	Crambidae	Spilomelinae	1		New Ubin Record
330	*Symmoracma minoralis*	Crambidae	Spilomelinae	1		New Ubin Record
331	*Symphonia multipictalis*	Crambidae	Spilomelinae	1		New Ubin Record
332	*Syntypistis pallidifascia*	Notodontidae	Notodontinae	1		New Ubin Record
333	*Tamba basiscripta*	Erebidae	Boletobiinae	1		New Ubin Record
334	*Tamsia hieroglyphica*	Erebidae	Tinoliinae		1	
335	*Taurometopa pyrometalla*	Crambidae	Odontiinae	1		New Ubin Record
336	*Tetragonus catamitus*	Callidulidae			1	
337	*Tetridia vinacealis*	Crambidae	Pyraustinae	1		New Ubin Record
338	*Theretra latreillii*	Sphingidae	Macroglossinae		1	

Table A1. Continuation

SN	Scientific name	Family	Subfamily	CUBS	Non CUBS	Status
339	*Theretra suffusa*	Sphingidae	Macroglossinae		1	
340	*Thiotricha* sp.	Gelechiidae	Thiotrichinae	1		New Ubin Record
341	*Thosea* sp.	Limacodidae		1		New Ubin Record
342	*Thosea vetusta*	Limacodidae			1	
343	*Throana amyntoralis*	Erebidae	Calpinae	1		New Ubin Record
344	*Thyas coronata*	Erebidae	Erebinae	1		New Ubin Record
345	*Thyrididae* sp.	Thyrididae			1	
346	*Tigrioides puncticollis*	Erebidae	Arctiinae		1	
347	*Tineidae* sp.	Tineidae		1		New Ubin Record
348	*Tineinae* sp.	Tineidae	Tineinae	1		New Ubin Record
349	*Tineodidae* sp.	Tineodidae		1		New Ubin Record
350	*Tipasa* sp.	Erebidae	Boletobiinae	1		New Ubin Record
351	*Tipasa nebulosella*	Erebidae	Boletobiinae	1		New Ubin Record
352	*Tiruvaca subcostalis*	Erebidae	Boletobiinae	1		New Ubin Record
353	*Tochara creberrima*	Erebidae	Erebinae		1	
354	*Torodora* sp.	Lecithoceridae	Torodorinae	1		New Ubin Record
355	*Torodora* sp. nr. *claustrata*	Lecithoceridae	Torodorinae	1		New Ubin Record
356	*Tortricidae* sp.	Tortricidae		1		New Ubin Record
357	*Tortricinae* sp.	Tortricidae	Tortricinae	1		New Ubin Record
358	*Traminda aventiaria*	Geometridae	Sterrhinae	1	1	
359	*Trichogyia* sp.	Limacodidae		1		New Ubin Record
360	*Trigonode hyppasia*	Erebidae	Erebinae	1		New Ubin Record
361	*Trilocha* sp.	Bombycidae	Bombycinae		1	
362	*Trilocha varians*	Bombycidae	Bombycinae	1		New Ubin Record

Table A1. Continuation

SN	Scientific name	Family	Subfamily	CUBS	Non CUBS	Status
363	*Trischalis* sp.	Erebidae	Arctiinae	1	1	
364	*Trypanophora* sp.	Zygaenidae	Chalcosiinae		1	
365	*Veslema flavifrons*	Erebidae	Arctiinae		1	
366	*Westermannia* sp.	Nolidae	Westermanniinae		1	
367	*Westermannia superba*	Nolidae	Westermanniinae		1	
368	*Zeheba aureatoides*	Geometridae	Ennominae	1		New Ubin Record
369	*Zeuzera conferta*	Cossidae	Zeuzerinae	1	1	
370	*Zeuzera indica*	Cossidae	Zeuzerinae	1	1	New Ubin Record
371	*Zurobata vacillans*	Erebidae	Boletobiinae		1	

Appendix 1. A photo gallery of 32 potential new records for Singapore found during the CUBS surveys. All moth photos except *Eublemma ignefusa* are by Gan Cheong Weei. *Eublemma ignefusa* photo by Anuj Jain.

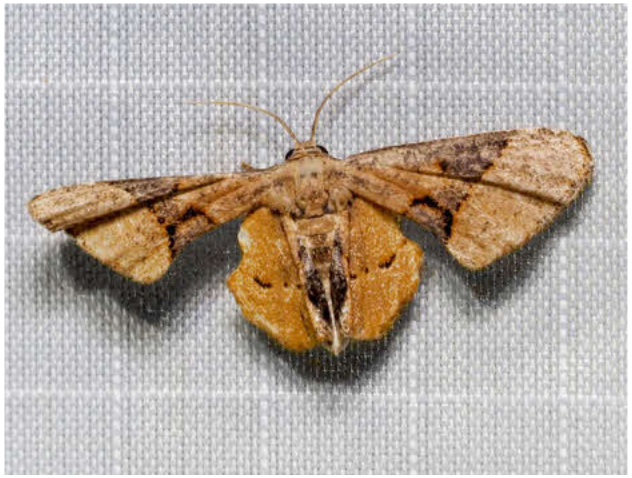
Habitat: Secondary forest (prior farmland)
Location: Ubin Butterfly Hill

Amatissa sp.

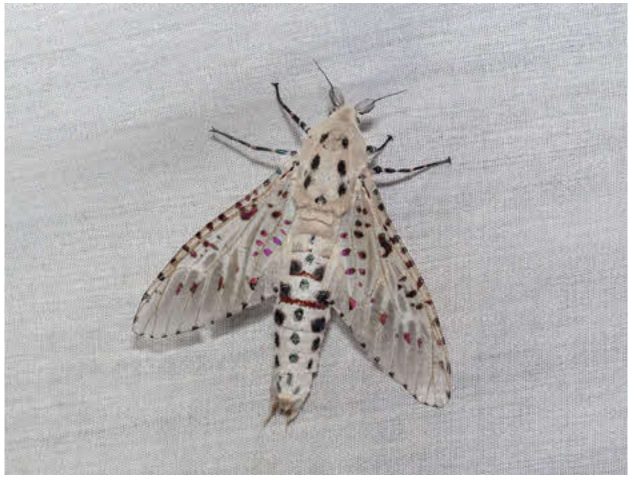
Corgatha sp. nr. *nigripalpis*

Choreutis sp.

Macotasa tetraspila



Monobolodes sp.



Zeuzera indica

Appendix 1. Continuation

Location: Sungei Durian

Glaucocharis margretella

Dactylioglypha pallens

Family Cosmopterigidae sp.

Family Oecophoridae sp.

Family Tineodidae

Subfamily Chrysopeleiinae

Appendix 1. Continuation

Location: Outward Bound Singapore (Five-way Junction)

Harmaclona sp.

Maurilia sp.

Somatina sp.

Appendix 1. Continuation

Location: Bukit Tajam

Avatha garthei

Tamba basiscripta

Eublemma ignefusa

Anticrates sp.1

Tipasa sp.

Tipasa nebulosella

Appendix 1. Continuation

Location: Chek Jawa

Etiella sp.

Trichogyia sp.

Torodora sp. nr. *claustrata*

Location: Sungei Mamam

Arivaca sp.

Hypsopygia sp. (also seen in Sungei Durian)

Appendix 1. Continuation

Location: Sungei Asam

Anticrates sp. 2

Tetridia vinacealis

Comostola sp. nr. *quantula*

Eucyclodes sp.

Ophiorrhabda sp. nr. *caristis*
(also recorded from OBS Five-way Junction)

Nigilgia sp. nr. *anactis*
(also recorded in Chek Jawa)

Diversity, distribution and habitat characteristics of odonates (Insecta: Odonata) in Pulau Ubin, Singapore

Kah Ming Teo[1,5], Alex Figueroa[2], Robin Ngiam[3,5] & Germaine Leng[4]

[1]National Parks Board, 61 Pulau Ubin, Singapore 508310.
E-mail: TEO_Kah_Ming@nparks.gov.sg
[2]165 Bedok South Rd, Singapore 460165. E-mail: afigueroa21@gmail.com
[3]Block 539 Ang Mo Kio Avenue 10, Singapore 560539. E-mail: yanrobin@hotmail.com
[4]National Parks Board, 61 Pulau Ubin, Singapore 508310.
Email: germaine_leng@nparks.gov.sg
[5]Authors for correspondence
E-mail: TEO_Kah_Ming@nparks.gov.sg
E-mail: yanrobin@hotmail.com

ABSTRACT. Pulau Ubin supports a rich diversity of Odonata due to its mosaic landscape containing different types of freshwater and mangrove habitats. A total of 1032 individuals comprising 45 species from 39 genera and six families were recorded during the Comprehensive Ubin Biodiversity Survey. Six species had not previously been recorded in Pulau Ubin. The estimated odonate diversity on Pulau Ubin is between 54 and 70 species. Areas with both the highest estimated abundance and species richness are Sensory Trail Pond and the area between Ubin Living Lab Pond and the edge of Ubin Quarry. Among the habitat characteristics studied, four aquatic characteristics (conductivity, turbidity, salinity, and dissolved oxygen) characterise the first principal component. The second principal component is strongly negatively correlated with canopy cover and strongly positively correlated with water pH and ambient temperature. Open habitats were found to support a high abundance of common sun-loving species, while ponds in shadier conditions provided refuge for uncommon and rare species. The PCA results have shown that some key environmental variables drive the distribution pattern of odonates in Pulau Ubin.

Keywords. Odonata, Pulau Ubin island, Singapore, rural villages, disused quarries, young secondary forests

Introduction

Dragonflies and damselflies (Insecta: Odonata) form a flagship taxon for freshwater conservation. In Singapore, 133 odonate species have been recorded including nine that are now considered nationally extinct (Soh et al., 2019). Pulau Ubin has a variety of habitats conducive for odonates such as open freshwater ponds, forest streams and back mangroves. A history of quarrying for granite on the island has added the presence of freshwater lakes in the defunct quarries. Prior to the Comprehensive Ubin Biodiversity Surveys (CUBS), 54 odonate species were known from Pulau Ubin (Teo, 2014). The list was derived mainly from incidental sightings and anecdotal observations. Two species occurring in Singapore, *Zyxomma obtusum* Albarda 1881 and *Indothemis carnatica* (Fabricius 1798), have only been recorded on Pulau Ubin (Ngoi et al., 2011; Soh et al., 2019). Moreover, the proximity of Pulau Ubin to Peninsular Malaysia provides a potential source for new species to Singapore.

Despite an abundance of suitable habitat for odonates throughout Pulau Ubin, a comprehensive and systematic odonate survey has never been conducted there. This contrasts with other parts of Singapore where odonates have been surveyed extensively, e.g. Cai et al. (2018) who surveyed Nee Soon Swamp Forest, and Cai et al. (2019) at Bukit Timah Nature Reserve. Aside from establishing species richness and abundance, Cai et al. (2018, 2019) also investigated the environmental drivers of odonate community and spatial distribution patterns. Such knowledge is important in formulating conservation strategies. Therefore, as part of CUBS we had the following objectives:

1. Establish a new baseline inventory for odonates and identify key hotspots.
2. Elucidate how the environment influences odonate diversity and spatial distribution.
3. From the findings, recommend long-term odonate conservation steps for Pulau Ubin.

Materials and Methods

Odonate sampling

Species richness and abundance data were collected over a total of 33 surveys on 16 days at 33 locations (Table 1, Fig. 1), totalling about 54 survey hours between April 2018 and September 2019. We employed visual encounter surveys by walking slowly either along terrestrial transects or around water bodies. Each survey was performed by a team of two to four surveyors with the aid of cameras and binoculars. Insect nets were used to capture specimens should closer inspection be required for confirming a species identity. Terrestrial transects were along vehicular roads, tracks, boardwalks, and forest trails found across Pulau Ubin (Fig. 2). Sites with known freshwater and brackish habitats, such as the abandoned ponds formerly used by villagers or back mangroves, were also surveyed (Fig. 2). Boat surveys were conducted at three quarry lakes, namely Pekan Quarry, Ubin Quarry, and Kekek Quarry on a rowboat. The boat was rowed as close as possible to vegetation along water edges for visual searches. This included the periphery of the quarry lakes, as well as the edges of floating vegetation like that in Pekan Quarry. Surveys were generally conducted from 0900 hrs to 1700 hrs, with each survey lasting between one to three hours depending on the transect length and size of waterbodies. Sites were only surveyed once, except for the two ponds at Balai Quarry, where one dusk survey was conducted. The dusk survey at Balai Quarry was primarily to confirm the continued existence of the crepuscular *Z. obtusum* where it was last observed (Ngoi et al., 2011).

Environmental Parameter Sampling

For each odonate observation at or alongside a water body, the following eight environmental parameters were recorded: canopy cover (%), pH, dissolved oxygen (%), conductivity (µs/cm), total dissolved solids (ppm TDS), salinity (PSU), turbidity (FNU), and water temperature (°C). These parameters were measured using Hanna Instruments HI9829 Multiparameter Meter. For observations away from any water body, e.g. forest trails, only canopy cover (%) was measured. Canopy cover was recorded using the mobile application, CanopyApp, developed by University of New Hampshire. A picture of the canopy would be taken with the phone camera being held parallel to the ground. Colours of the canopy were selected and confirmed by the user. Using the selection, the software then distinguished the canopy cover in the image and determined the percentage (University of New Hampshire, 2018).

Statistical Analyses

All statistical analyses were conducted in R Studio Version 1.4.1717 (R Studio T 2015) using R v4.10 (R Development Core Team, 2018). Species accumulation curve was plotted using the function ‘specaccum’ in the vegan package version 2.5-6 (Oksanen et al. 2019) with method ‘random’, which adds data in random order without replacement, and permutation of 1000 to measure the adequacy of the survey effort in capturing the species richness. Four estimators, Chao, Jackknife1, Jackknife2, and Bootstrap, in the 'specpool' function were used to estimate the actual number of species.

For abundance of individuals, Heatmap (Kernel Density Estimation) Function was used to generate a heatmap for abundance in QGIS 3.4.15, by estimating a density function from each recorded point, of a radius of 250 m. For species richness, Count Points in Polygon Function with colour-graduated points was used to generate a hotspot map of richness, given that clear boundaries are required to dictate the area within which the occurrence of a unique species is counted. Areas with higher species richness are indicated with darker colours, and areas with fewer than four species were not displayed on the map at all. A grid of hexagons with long diagonal of 500 m was used to match the radius of the abundance heatmap. The distance chosen is to allow aggregation of species richness of nearby areas, while still allowing some level of granularity in distinguishing different areas and habitats.

To evaluate how the environmental variables influence odonate habitat use, we performed a principal components analysis (PCA) using the *psych* v2.1.3 (Revelle 2015) and *GPArotation* v2014.11-1 (Bernaards & Jennrich 2015) packages to reduce the dimensionality of the data. Each of the environmental variables was log-transformed to achieve normality, except for canopy cover and dissolved oxygen, which were arc-sine transformed since they were percentages. The principal components (PC) to be retained were chosen by selecting the PCs with eigenvalues > 1 (Ricklefs and Travis, 1980). Observations without water parameters, i.e., not found near water bodies, were excluded from the PCA.

Results

Species Richness and Abundance

A total of 1032 odonate individuals comprising 45 species from 39 genera and six families were recorded during the CUBS survey period. They included 792 individuals of 35 species from four families of Anisoptera (dragonflies), and 240 individuals of ten species from two families of Zygoptera (damselflies). The most abundant damselfly species was *Pseudagrion microcephalum* (Rambur 1842) (n = 178 individuals), while the most common dragonfly species was *Neurothemis fluctuans* (Fabricius 1793) (n = 164 individuals). Of the 45 odonate species recorded, six species were previously not recorded in Pulau Ubin (Table 2). They are *Brachythemis contaminata* (Fabricius 1793), *Argiocnemis rubescens* Selys 1877, *Copera marginipes* (Rambur 1842), *Hydrobasileus croceus* (Brauer 1867), *Onychargia atrocyana* Selys 1865, and lastly *Indothemis carnatica* which is a new record to both Pulau Ubin and Singapore, when it was first recorded in Pulau Ubin. While it was not spotted during an actual CUBS survey, its picture was taken by an odonate enthusiast (Soh et al., 2019) during the period in which CUBS survey was conducted. Hence, we regarded it as part of the CUBS findings. More recently, *I. carnatica* has been recorded in some sites on mainland Singapore (Ngiam & Ng 2022).

The previous Pulau Ubin odonate checklist (Teo 2014) catalogued a total of 54 species and was increased to 55 species when *Anax panybeus* Hagen 1867 was discovered in 2017 (Soh et al., 2018). Together with the six new species recorded in CUBS, the total number of species ever recorded from Pulau Ubin has increased to 61.

Species Accumulation Curve and Sampling Adequacy

The shape of the species accumulation curve is logarithmic showing a steady increase in the number of new species with sampling effort and does not reach an asymptote. Based on the data collected, the four species richness estimators (Chao, Jackknife1, Jackknife2, and Bootstrap) supported the species accumulation curve results by estimating the odonate diversity on Pulau Ubin to be between 52±3 to 67 species (Table 3). On the contrary, the number of species that we detected in our sampling effort of 33 surveys is 45 species. Hence, the sampling effort conducted during CUBS was not sufficient to capture the complete species richness of odonates in Pulau Ubin (Fig. 3).

Conservation Status of Pulau Ubin Odonate Species

The most recent local conservation status based on Singapore Red Data Book 3rd Edition (NParks, 2024) is shown for each species in Table 2. Of the 45 species recorded, ten species are of conservation significance. Three are Vulnerable, four are Near-threatened, and three are Critically Endangered at national level (Fig. 4). The three Critically Endangered species include *Z. obtusum* which only occurs in Pulau Ubin within Singapore territory. The other Critically Endangered species are *I. carnatica* and *Heliogomphus kelantanensis* (Laidlaw 1902). It is noteworthy that the locally vulnerable *Mortonagrion arthuri* Fraser 1942, is recognised as Near-threatened under the IUCN Red List due to loss and degradation of coastal habitats throughout most of its known range (Dow, 2020). This species inhabits brackish habitats, which are extensive in Pulau Ubin. Therefore, Pulau Ubin is its stronghold within Singapore.

Odonate Hotspots

Using the species richness hotspot and abundance heatmap, the areas with the highest diversity and abundance are indicated in Figures 5 and 6. Areas with the highest estimated abundance of odonates are Sensory Trail Pond (STP), the area in which Ubin Living Lab (ULL) Pond and part of Ubin Quarry were previously, Kekek Quarry, and the abandoned ponds at Bukit Surau (Fig. 5). The species richness hotspots appear to coincide with some of the areas with high abundance. These areas include Sensory Trail Pond, the area between ULL Pond and the edge of Ubin Quarry, and the abandoned pond in Noordin forest (Fig. 6). The highest species richness of 19 was recorded at Sensory Trail Pond, followed by 17 species in the abandoned pond in Noordin forest, and 15 species recorded in the area with ULL Pond and Ubin Quarry (Fig. 6).

Species Composition and Habitat Parameters

The first two principal components of the PCA explained 73.8% of the variation in the environmental variables, and were nearly equal, with PC1 accounting for 39.3% and PC2 accounting for 34.5% of the total variation (Table 3). The first PC represents four aquatic characteristics, specifically conductivity, turbidity, salinity, and dissolved oxygen, with the first two loading the highest (Table 3). The second PC is strongly negatively correlated with canopy cover and strongly positively correlated with water pH and water temperature (Table 4; Fig. 7). The loadings on the PCA graph are scattered throughout the plot, with a small clustering of species that loaded high on PC1 (Fig. 7). On the left side of the graph are three indistinct clusters of species that were separated based on loadings on PC2 and each loaded low on PC1 (Fig. 7).

Discussion

Definitively, Pulau Ubin supports a rich diversity of odonates. This is due mainly to its mosaic landscape containing different freshwater and mangrove habitats. Among the freshwater habitats, there are many open environments such as the big quarry lakes, and the smaller Sensory Trail Pond, as well as swampy water bodies in forested areas. The prevalence of open habitats on the island supports a high abundance of common sun-loving species, which is evident from the top three species recorded, namely *Pseudagrion microcephalum*, *Ictinogomphus decoratus* and *Neurothemis fluctuans*. Unsurprisingly, open habitats exemplified by the Sensory Trail Pond are generally both high in abundance and in species richness. Among the open habitats with high species richness, a noteworthy site is Ubin Quarry, where most individuals of the vulnerable *C. fluviatilis* were recorded. Ponds in shadier conditions such as the abandoned ponds at Bukit Surau and Noordin forest have lower species richness but are important refuge for uncommon and rare species like *Copera vittata* (Selys 1863), *Argiocnemis rubescens rubeola* Selys 1877 and *Teinobasis ruficollis* (Selys 1877). Correspondingly, habitats in these locations are identified as odonate hotspots in our spatial analysis.

The total of 61 species now recorded from Pulau Ubin represents 49.19% of Singapore's 126 odonate species (less 10 that are considered to be nationally extirpated). More importantly, of the 61 species, 10 are of conservation significance (3 Vulnerable, 4 Near-threatened, 3 Critically Endangered) (Fig. 4), including *Z. obtusum* which is still only known from Pulau Ubin. Moreover, the island remains a stronghold for brackish back mangrove specialists which are Near-threatened due to scarcity and loss of such habitats in Singapore. Therefore, Pulau Ubin is a refuge and vital site for Singapore's odonate conservation.

Pulau Ubin's odonates generally display a clear distribution pattern that is influenced by certain environmental variables important in their ecology (Table 4; Fig. 5). Closed canopy cover is favoured by species such as *Agrionoptera insignis* (Rambur 1842), *Cratilla lineata* (Brauer 1878) and *C. vittata*. During our surveys, several individuals of *A. insignis* and *C. lineata* were observed perching along forest trails in an ambush foraging mode. Other species like *Orthetrum chrysis* (Selys 1891) and *Mortonagrion arthuri* Fraser 1942 prefer shaded streams and ponds characterised by low temperature and low pH. On the other hand, the open lentic habitats, especially those rich in macrophytes, are favourable for many common sun-loving species. The water chemistry (higher temperature, conductivity, TDS and salinity) is typical of these habitats, in particular those situated nearer to high human activities. This finding corroborates the growing knowledge that vegetation types and canopy cover which directly influence water quality are main drivers of odonate community assemblages in urban as well as forest landscapes (De Marco Junior et al., 2015; Cai et al., 2018; Cai et al., 2019; Johansson et al., 2019; Perron et al., 2021). In conclusion, our findings indicate unequivocally that Pulau Ubin is an odonate hotspot in Singapore. The island's matrix of natural and rural landscape supports an impressive diversity of common and threatened species. This, together with empirical evidence on localised sites of high diversity and abundance, and environmental drivers of spatial distribution, should be useful in formulating conservation strategies for Ubin's odonates.

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Fig. 1 Odonate survey sites (transects, quarries and water bodies) covered during the Comprehensive Ubin Biodiversity Survey (CUBS).

Fig. 2 (**A.**) forest pond at Balai Quarry (E13), (**B.**) forest pond, S1, (**C.**) forest pond, N4

Fig. 2 Continued (**D.**) pond at Wei Tuo Fa Gong Temple, (**E, F.**) terrestrial transect along gravel track towards Chek Jawa and tarmac road, (**G, H.**) streams near OBS gate, (**I.**) Pekan Quarry.

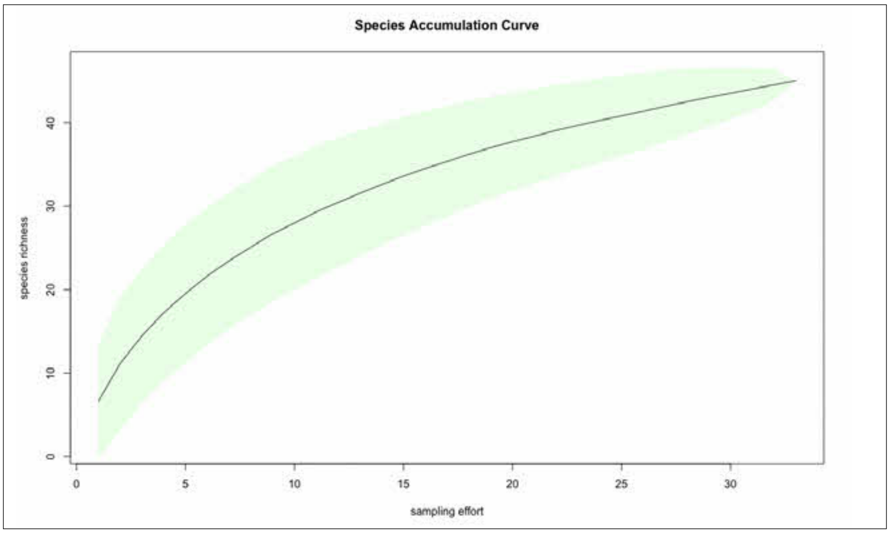

Fig. 3 Species accumulation curve for sampling effort during CUBS survey.

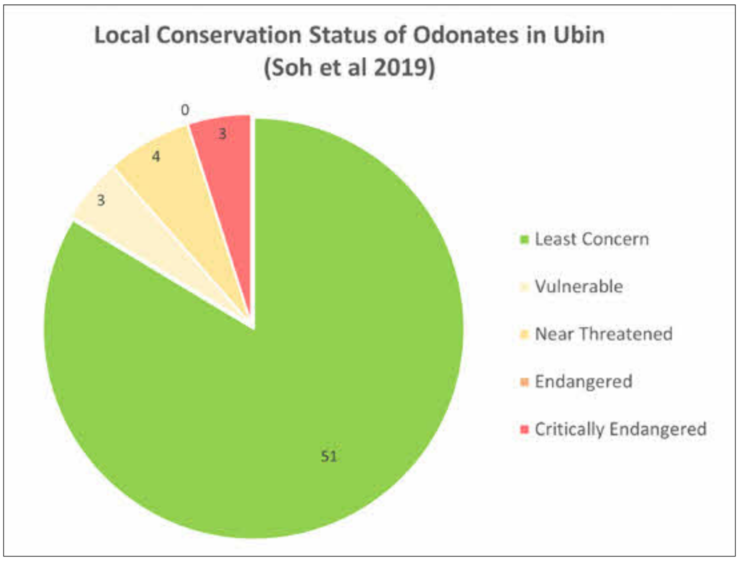

Fig. 4 National Conservation Status of Odonates recorded in CUBS.

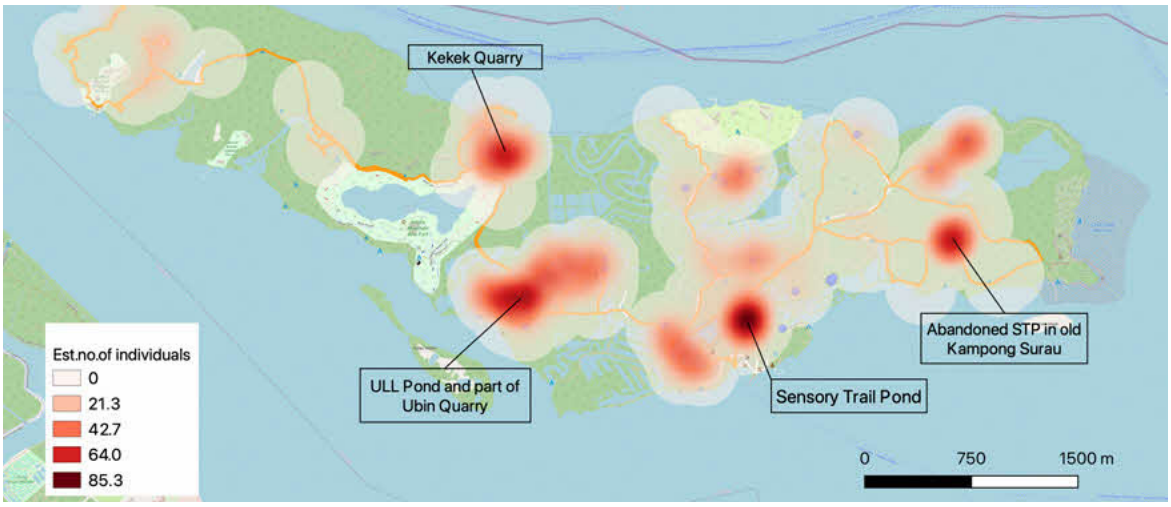

Fig. 5 Abundance heatmap of odonates in Pulau Ubin recorded during CUBS.

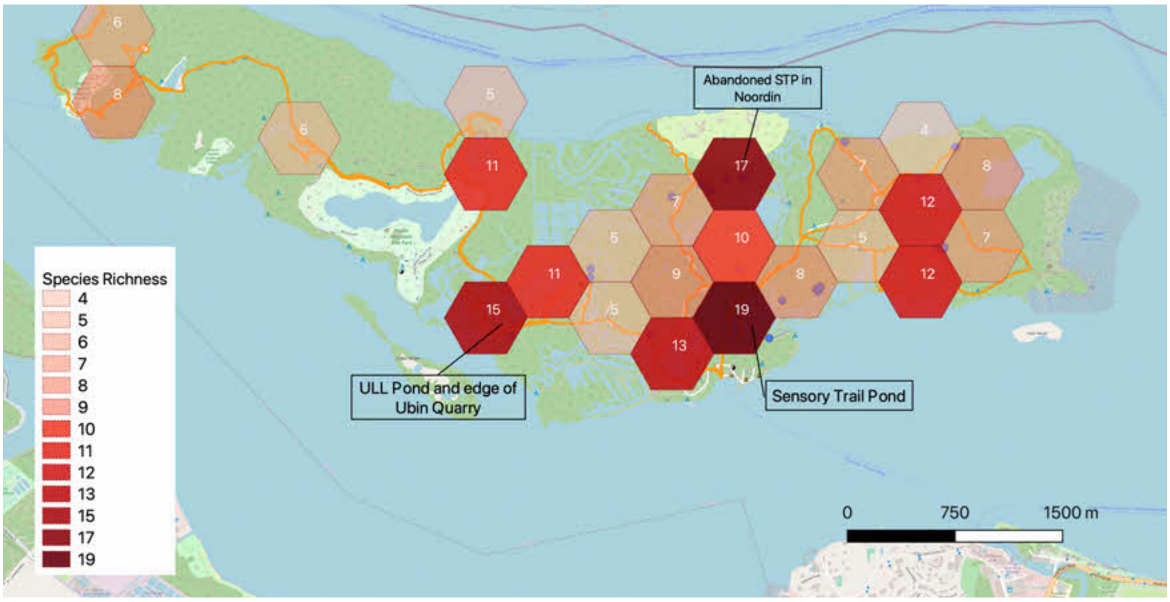

Fig. 6 Species richness hotspot map of odonates in Pulau Ubin recorded during CUBS.

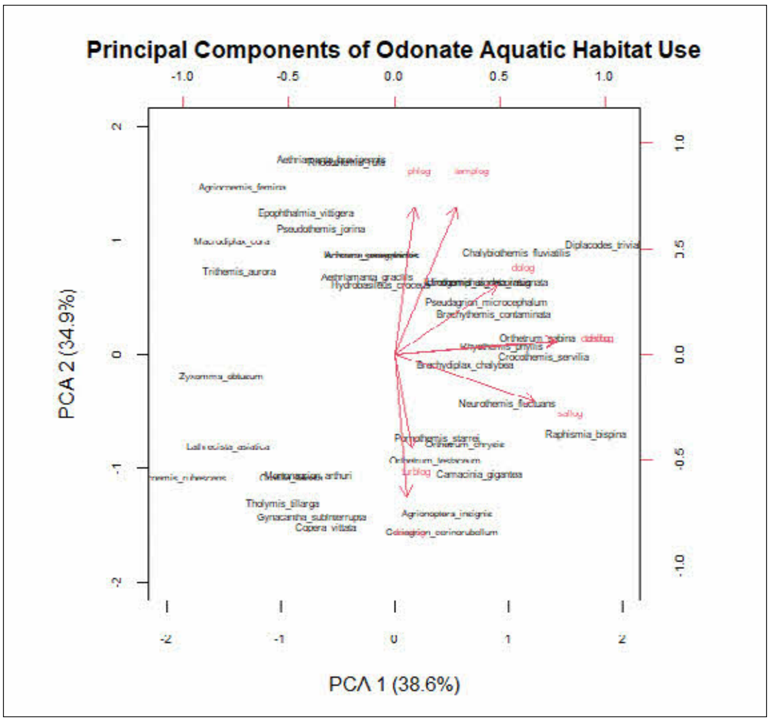

Fig. 7 Principal components analysis plot showing the loadings for eight environmental variables on the first two principal components.

Table 1. List of 33 locations conducted over 33 surveys, and the type of survey conducted.

Location	**Survey**
Jalan Batu Ubin	Transect
Jalan Endut Senin	Transect
Jalan Mamam	Transect
Jalan Wat Siam	Transect
Jalan Noordin	Transect
Jalan Jelutong	Transect
Trail to Wei Tuo Fa GongTemple	Transect
Puaka Hill	Transect
OBS Camp 1 and Forest	Transect
OBS – Gate – 5-way junction – canal	Transect
Bukit Tajam	Transect
Bukit Surau	Transect
Track back to Jalan Sam Heng	Transect
To Pekakak Hut	Transect
Path between E13 and E14	Transect
ULL Pond	Water body perimeter
Pond next to Jalan Sam Heng	Water body perimeter
Sensory Trail Pond	Water body perimeter
Forest Ponds – N11	Water body perimeter
Forest Ponds – N12	Water body perimeter
Forest Ponds – S1	Water body perimeter
Forest Ponds – W1	Water body perimeter
Forest Ponds – W2	Water body perimeter
Forest Ponds – E1–12	Water body perimeter
Forest Ponds – E13 (Balai Quarry)	Water body perimeter
Forest Ponds – E14 (Balai Quarry)	Water body perimeter
Forest Ponds – N1	Water body perimeter
Forest Ponds – N2–4	Water body perimeter
Forest Ponds – N5	Water body perimeter
Forest Ponds – N7–9	Water body perimeter
Kekek Quarry	Boat
Pekan Quarry	Boat
Ubin Quarry	Boat

Table 2. List of species recorded in Pulau Ubin from 2014 checklist and from CUBS survey with distribution and rarity, and national conservation status from Singapore Red Data Book (3rd Edition).

Scientific Name	**Common Name**	**2014 Checklist**	**CUBS**	**Distribution & Rarity Soh et al (2019)**	**Conservation Status Soh et al (2019)**
Suborder Zygoptera					
Family Coenagrionidae					
Agriocnemis femina	Variable Wisp	✓	✓	Widespread & Common	Least Concern
Archibasis viola	Violet Sprite	✓		Widespread & Common	Least Concern
Argiocnemis rubescens	**Variable Sprite**		✓	**Widespread but Uncommon**	**Least Concern**
Ceriagrion cerinorubellum	Ornate Coraltail	✓	✓	Widespread & Common	Least Concern
Ischnura senegalensis	Common Bluetail	✓	✓	Widespread & Common	Least Concern
Mortonagrion arthuri	Arthur's Midget	✓	✓	Restricted & Rare	Vulnerable
Pseudagrion microcephalum	Blue Sprite	✓	✓	Widespread & Common	Least Concern
Teinobasis ruficollis	Red-tailed Sprite	✓	✓	Widespread but Rare	Near Threatened
Family Lestidae					
Lestes praemorsus	Crenulated Spreadwing	✓		Widespread but Uncommon	Least Concern
Family Platycnemididae					
Copera marginipes	**Yellow Featherlegs**		✓	**Widespread & Common**	**Least Concern**
Copera vittata	Variable Featherlegs	✓	✓	Restricted & Rare	Vulnerable
Onychargia atrocyana	**Shorttail**		✓	**Widespread but Uncommon**	**Least Concern**
Suborder Anisoptera					
Family Aeshnidae					
Anax guttatus	Emperor	✓	✓	Widespread but Uncommon	Least Concern
Anax panybeus[1]	Arrow Emperor			Widespread but Rare	Least Concern
Gynacantha dohrni	Spear-tail Duskhawker	✓		Widespread but Uncommon	Least Concern

[1]*Anax panybeus* was first recorded in Ubin on 10 October 2017 (Soh et al 2018). However, it was not recorded in 2014 checklist as well as in CUBS survey.

Table 2. Continuation

Scientific Name	Common Name	2014 Checklist	CUBS	Distribution & Rarity Soh et al (2019)	Conservation Status Soh et al (2019)
Gynacantha subinterrupta	Dingy Duskhawker	✓	✓	Widespread but Uncommon	Least Concern
Heliaeschna uninervulata	Lesser Nighthawker	✓		Widespread but Rare	Near Threatened
Family Gomphidae					
Heliogomphus kelantanensis	Malayan Grappletail	✓		Restricted & Rare	Critically Endangered
Ictinogomphus decoratus	Common Flangetail	✓	✓	Widespread & Common	Least Concern
Family Macromiidae					
Epophthalmia vittigera	Pond Cruiser	✓	✓	Widespread & Common	Least Concern
Family Libellulidae					
Acisoma panorpoides	Trumpet Tail	✓	✓	Widespread & Common	Least Concern
Aethriamanta brevipennis	Scarlet Adjudant	✓	✓	Widespread but Uncommon	Least Concern
Aethriamanta gracilis	Pond Adjutant	✓	✓	Widespread & Common	Least Concern
Agrionoptera insignis	Grenadier	✓	✓	Widespread & Common	Least Concern
Agrionoptera sexlineata	Handsome Grenadier	✓		Widespread but Uncommon	Least Concern
Brachydiplax chalybea	Blue Dasher	✓	✓	Widespread & Common	Least Concern
Brachythemis contaminata	**Common Amberwing**		✓	**Widespread & Common**	**Least Concern**
Camacinia gigantea	Sultan	✓	✓	Widespread but Uncommon	Least Concern
Chalybiothemis fluviatilis	Green-eyed Percher	✓	✓	Restricted & Uncommon	Vulnerable
Cratilla lineata	Lined Forest Skimmer	✓	✓	Widespread but Uncommon	Least Concern
Cratilla metallica	Dark-tipped Forest Skimmer	✓	✓	Widespread & Common	Least Concern
Crocothemis servilia	Common Scarlet	✓	✓	Widespread & Common	Least Concern
Diplacodes trivialis	Blue Percher	✓	✓	Widespread & Common	Least Concern
Hydrobasileus croceus	**Water Monarch**		✓	**Widespread & Common**	**Least Concern**

Table 2. Continuation

Scientific Name	**Common Name**	**2014 Checklist**	**CUBS**	**Distribution & Rarity Soh et al (2019)**	**Conservation Status Soh et al (2019)**
Indothemis carnatica	**White-tipped Demon**[2]		✓	**Restricted & Very Rare**	**Critically Endangered**
Lathrecista asiatica	Scarlet Grenadier	✓	✓	Widespread & Common	Least Concern
Macrodiplax cora	Coastal Glider	✓	✓	Widespread & Common	Least Concern
Nannophya pygmaea	Scarlet Pygmy	✓		Widespread & Common	Least Concern
Neurothemis fluctuans	Common Parasol	✓	✓	Widespread & Common	Least Concern
Orchithemis pulcherrima	Variable Sentinel	✓		Widespread & Common	Least Concern
Orthetrum chrysis	Spine-tufted Skimmer	✓	✓	Widespread & Common	Least Concern
Orthetrum glaucum	Blue Skimmer	✓		Widespread & Common	Least Concern
Orthetrum sabina	Variegated Green Skimmer	✓	✓	Widespread & Common	Least Concern
Orthetrum testaceum	Scarlet Skimmer	✓	✓	Widespread & Common	Least Concern
Pantala flavescens	Wandering Glider	✓	✓	Widespread & Common	Least Concern
Pornothemis starrei	Mangrove Marshal	✓	✓	Widespread but Uncommon	Near Threatened
Potamarcha congener	Common Chaser	✓		Widespread & Common	Least Concern
Pseudothemis jorina	Banded Skimmer	✓	✓	Widespread but Uncommon	Least Concern
Raphismia bispina	Mangrove Dwarf	✓	✓	Widespread but Uncommon	Near Threatened
Rhodothemis rufa	Common Redbolt	✓	✓	Widespread & Common	Least Concern
Rhyothemis obsolescens	Bronze Flutterer	✓	✓	Widespread but Uncommon	Least Concern
Rhyothemis phyllis	Yellow-barred Flutterer	✓	✓	Widespread & Common	Least Concern
Rhyothemis triangularis	Sapphire Flutterer	✓		Widespread but Uncommon	Least Concern
Tholymis tillarga	White-barred Duskhawk	✓	✓	Widespread & Common	Least Concern
Tramea transmarina	Saddlebag Glider	✓		Widespread & Common	Least Concern

[2]*I. carnatica* was not spotted during an actual CUBS survey. However, as its picture was taken by an odonate enthusiast (Soh et al., 2019) during the period in which CUBS survey was conducted, it was regarded as part of the CUBS findings.

Table 2. Continuation

Scientific Name	**Common Name**	**2014 Checklist**	**CUBS**	**Distribution & Rarity Soh et al (2019)**	**Conservation Status Soh et al (2019)**
Trithemis aurora	Crimson Dropwing	✓	✓	Widespread & Common	Least Concern
Trithemis festiva	Indigo Dropwing	✓		Widespread & Common	Least Concern
Trithemis pallidinervis	Dancing Dropwing	✓		Widespread but Uncommon	Least Concern
Urothemis signata insignata	Scarlet Basker	✓	✓	Widespread & Common	Least Concern
Zyxomma obtusum	White Duskdarter	✓	✓	Restricted & Uncommon	Critically Endangered
Zyxomma petiolatum	Slender Duskdarter	✓		Widespread & Common	Least Concern

Table 3. Total actual species recorded during CUBS compared to Estimated Species Richness using Chao, Jackknife1, Jackknife2, and Bootstrap. The values are represented by mean ± standard error (SE).

	Species Estimator			
Actual Species Recorded	Chao	Jackknife1	Jackknife2	Bootstrap
45	60.6± 10.7	59.5± 5.62	67.3	51.6±3.11

Table 4. Principal component loadings on eight environmental variables describing odonate habitat use. The first two principal components accounted for 73.6% of the total variation.

Variable	PC1	PC2
Densiometer		**-0.840**
pH	0.118	**0.870**
Dissolved Oxygen	**0.611**	0.413
Conductivity	**0.964**	
TDS	**0.963**	
Salinity	**0.833**	-0.281
Turbidity	0.105	-0.555
Temperature	0.370	**0.874**
Eigenvalues	3.441	2.445
% Variation Explained	38.6%	34.9%

Orthoptera in Pulau Ubin: unravelling diversity using systematic sampling and qualitative boat surveys

J. Lin[1], R.S.K. Lee[2] & M.K. Tan[3*]

[1]Conservation Division, National Parks Board,
1 Cluny Road, Singapore 259569, Singapore
Joseph_LIN@nparks.gov.sg
[2]National Institute of Education, Nanyang Technological University,
1 Nanyang Walk, Singapore 637616, Singapore
rachelleesk@gmail.com
[3]Institut de Systématique, Evolution et Biodiversité (ISYEB),
Muséum national d'Histoire naturelle, CNRS, SU, EPHE, UA,
57 rue Cuvier, CP 50, 75231 Paris Cedex 05, France
orthoptera.mingkai@gmail.com
[*] corresponding author

ABSTRACT. Orthoptera are highly diversified in form, behaviour and ecological niches, and this is true for species in Singapore. Studying these insects can help to understand how the ecosystem functions. However, systematic study on orthopteran community ecology remains rare in Singapore. The Comprehensive Ubin Biodiversity Survey offered us the opportunity to understand how an orthopteran community can be shaped by environment and habitat. Twenty-six randomised transects across the island were surveyed for orthopterans. Environmental predictors (including the plant community) were also sampled. To create a comprehensive checklist of Orthoptera on Pulau Ubin, Singapore, boat surveys were also conducted during high tides to sample the mangrove canopy which would otherwise be inaccessible. Fifty species of Orthoptera were recorded, including seven from the mangroves. Fewer species (alpha-diversity) were observed at higher mean daily temperature and higher canopy, but the orthopteran assemblage (beta-diversity) was homogeneous and independent of the park management scheme (i.e., sites), land history and plant assemblages. Using orthopterans as a model, we demonstrate that we can study how their diversity is influenced and shaped in Pulau Ubin to help understand the roles of invertebrates in the ecosystem in the context of Singapore and/or beyond.

Keywords. Crickets, ecology, grasshoppers, katydids, mangrove, richness

Introduction

Orthoptera refers to the order of insects generally known as the grasshoppers, crickets and katydids. There are more than 28,000 described species globally, and they are diverse in their form, behaviour and ecological niches (Cigliano et al., 2018). In Singapore, orthopterans can be found in most terrestrial habitats, some aquatic habitats (including seashores, streams) and urban habitats (Tan 2012a, 2012b, 2013, 2020; Tan et al., 2017a). These insects play a wide variety of ecological roles in the ecosystem. These include being prey to larger animals, predators of smaller insects, pollinators and detritivores (Tan et al., 2017b; Fung et al., 2018; Tan & Tan, 2018). Hence, studying Orthoptera can enhance our general understanding of how biodiversity functions in a highly complex ecosystem in the tropics, especially in an era where biodiversity loss is at an unprecedented rate.

In Singapore, there is a dearth of published literature looking into the community ecology of orthopterans, in contrast to other popular insect groups, such as butterflies and dung beetles (e.g., Jain et al., 2017, 2020; Ong et al., 2020). For orthopterans, systematic studies on their community ecology are limited specifically to pygmy grasshoppers found in the Nee Soon freshwater swamp forests (Tan et al., 2017a) and crickets in the urban landscape

(Tan, 2020). The majority of studies looking into the orthopteran community are qualitative checklists (Tan, 2012, 2013; Tan et al., 2012, 2015).

In a study on the pygmy grasshoppers found in the Nee Soon freshwater swamp forests, it was found that pygmy grasshoppers in general are associated with wetter microhabitat conditions (specifically wet leaf litter) rather than water bodies (e.g., forest streams) (Tan et al., 2017a). It was suggested that orthopterans can be used as a bioindicator owing to their sensitivity to their microhabitat conditions. Extending similar studies to other parts of Singapore and/or different habitats will enhance the more generalisable understanding of how the habitat and environment can predict the diversity and community of orthopterans. This in turn can potentially be useful for conservation managements of natural areas in Singapore.

The National Parks Board, Singapore (NParks) took the initiative to better manage natural areas in Singapore and mould Singapore as a 'City in Nature' by initiating biodiversity surveys. For the terrestrial habitats of Singapore, NParks recently concluded a series of biodiversity surveys in Bukit Timah Nature Reserve (Chan & Davison, 2019), which also included a census of the literature and collection of Orthoptera there (Tan, 2019). Recently, the Comprehensive Ubin Biodiversity Survey (CUBS) offered us an opportunity to understand how the orthopteran community can be shaped by environment and habitat, in addition to creating a comprehensive checklist of orthopteran on Pulau Ubin.

Pulau Ubin is an island in the Johor Straits comprising secondary forests with different land use histories and it is one of the few remaining rural areas in Singapore. A few studies have looked into the diversity of orthopterans there (Tan, 2010, 2013; Fung et al., 2018) and these provide a baseline to conduct a systematic study on the community ecology of orthopterans there. Specifically we sampled orthopterans in randomised transects around Pulau Ubin and quantified environmental and habitat parameters to investigate the following questions: (1) what predicts the orthopteran species richness (alpha-diversity) in Pulau Ubin and (2) how does the orthopteran community (beta-diversity) differ across different habitats within the island? Specifically, we are interested to examine if land use history of the forest, understorey plant community and canopy cover can influence orthopteran diversity, since these variables are likely to influence microhabitats suited for different orthopteran community members. Additionally, we also compared how the orthopteran community may differ between the publicly-accessible sites and western forest sites that are closed to public access, since frequent human presence may possibly also alter species behaviour (Tan & Tan, 2021) and consequently, species diversity.

About 24.4% of Pulau Ubin is covered by mangrove forests (Friess et al., 2016), and it is therefore essential to sample this habitat to have a comprehensive understanding of the orthopteran diversity on the island. However, mangrove-associated orthopterans tend to reside among the canopy (Tan, 2013). As such, we cannot employ the same terrestrial methodology to sample for orthopterans as the ones used for other habitats. Instead, we employed qualitative sampling of the mangrove canopy using a boat during high tides so that we could collect orthopterans in the canopy. This methodology has been employed in Siargao, Philippines (Tan et al., 2019) but has not been carried out until now in Singapore. For the first time, we attempted this sampling technique in Pulau Ubin to understand mangrove-associated orthopterans.

Materials and Methods

Study area
The study was carried out between August 2018 and August 2019 on Pulau Ubin, an offshore island to the north of Singapore along the Straits of Johor. The island consisted of a mixture of *Adinandra* belukar (forest dominated by the tree *Adinandra dumosa* on degraded soils), and secondary forest regrowth after use as either farmland, rubber plantations or fruit orchards. Twenty-six 10-metre line-transects were laid randomly across the island (Fig. 1A). The transects were distinguished by two categories of use: (1) publicly accessible sites, and (2) western forest sites that are closed to public access. Being a closed area, the western forest may support a different species community with the forest regeneration after the departure of villagers, as has been observed among fireflies (Tan, 2018).

Although mangrove forest is an important habitat on Pulau Ubin, it was not feasible to carry out terrestrial-style surveys due to the terrain. Furthermore, mangrove-associated orthopterans tend to be found on the canopy, rather than the ground. As such, we conducted two night boat surveys within the mangroves in Pulau Ubin during high tide on 22 March (Sungei Jelutong and Sungei Puaka) and 2 August 2019 (Sungei Besar and Sungei Pulau Ubin). The aim of this qualitative survey was to supplement the orthopteran inventory collected based on the line-transect sampling of the other forest types.

Orthopteran sampling and identification
Sampling for orthopterans was conducted after last light (i.e., after approximately 1930 hrs) along the randomised transects. Within each transect, orthopterans were opportunistically sought and collected by three trained surveyors for 30 minutes to standardise sampling effort (Figs. 1B, 1C). The same surveyors conducted the collections. Each surveyor was allowed to sample 5 m away on both sides of the line transect. Understorey plants, leaf litter, branches and foliage within the reach of a human were sampled. To minimise effect of tiredness, only two transects were sampled on each sampling night. To avoid double-counting, all orthopterans, adults and nymphs, were collected and kept in small containers. After 30 minutes, the orthopterans were identified by Ming Kai Tan, whenever possible. Orthopteran identification was based on Tan (2011, 2012a, 2012b, 2014a), Ingrisch & Tan (2012), Tan & Robillard (2012), Tan & Ingrisch (2013), Tan & Kamaruddin (2016) and Tan & Artchawakom (2017). Thereafter, the orthopterans were released back into the transect. Species in need of further identification were brought back to the laboratory. Each transect was only sampled once. Based on the sampling, we counted the number of individuals collected for each species and quantified the observed richness (Richness) for each transect.

Vegetation survey and identification
To examine whether vegetation can predict orthopteran diversity, the understorey plants were sampled during the day, after the orthopteran surveys were completed. Joseph Lin identified the plants whenever possible. Species in need of further identification were brought to herbarium at the Singapore Botanic Gardens. The vegetation survey involved determining the presence of the plant species in each transect, and abundance for each species was not quantified. From the vegetation survey, the understorey plant community was determined based on the absence/presence of different plant species from the 26 transects (see below on how the beta-diversity of plants was quantified statistically). The number of understorey

species (PlantRichness) was quantified for each transect. Owing that many herbivorous orthopterans may have different preferred hosts (sometimes specific), we predict that more species can be found in plots with higher PlantRichness or presence of different understorey plant community. We also identified the dominant understorey plant species. Based on the mature trees, we identified the land history types (LandHistory) as (1) after rubber plantation, (2) after fruit plantation, (3) after managed land for each transect. Different land history can influence both the plant community and microhabitat conditions, which in turn may support different orthopteran species. Two plots were considered *Adinandra* belukar and back mangrove and were excluded for the modelling.

During the vegetation survey, the canopy cover was also quantified using a smartphone application CanopyApp (University of New Hampshire, version 1.0.4). This was done three times along each transect to obtain an average (CanopyCover) for each transect. It can be expected that the amount of CanopyCover can influence the orthopteran community in the understorey since canopy cover is likely to alter microhabitat conditions that are suited for specific species.

Other environmental parameters

To examine whether environmental parameters can predict orthopteran diversity, data on total rainfall and mean temperature were obtained from National Environmental Agency, Singapore (http://www.weather.gov.sg/climate-historical-daily/). Specifically, total rainfall (TotalRain) and mean temperature (MeanTemp) for the day and (TotalRain7, MeanTemp7, respectively) for the previous seven days collected from the Pulau Ubin weather station were used. We postulate that the orthopteran community in the understorey can be influenced by immediate weather conditions (hence the use of daily values) but also a local short-term climatic conditions (hence the use of 7 days average values).

Statistical analyses

All statistical analyses were done in the R software version 3.5.1 (R Development Core Team 2019).

Firstly, to estimate the completeness of sampling, species accumulation curve was calculated based on rarefaction and 1,000 permutations, using ‘specaccum’ in R package ‘vegan’. We also used species estimators to estimate the extrapolated species richness in a species pool by accounting for the number of unobserved species using the ‘specpool’ function in the package ‘vegan’ (Oksanen et al. 2015).

Next, to quantify beta-diversity of plants, non-metric multidimensional scaling (NMDS) using Jaccard distance was performed using the ‘metaMDS’ function in the package ‘vegan’ (Oksanen et al. 2015). Stress values of 0.20 and below are deemed acceptable for interpretation of patterns (Clarke 1993). Jaccard distance was used since the plant data is absence/presence. Excluding joint absence was also preferred because two sites are not considered more similar when they both lack certain species (Anderson et al. 2011). The first two NMDS axes representing the assemblages were used for univariate correlations (mds1, mds2).

To investigate what predicts orthopteran richness in Pulau Ubin, the orthopteran observed richness (Richness) was fitted as generalised linear models with Poisson error structure. We proposed ten models containing single effects each with these variables: (1) Site, (2) LandHistory, (3) CanopyCover, (4) PlantRichness, (5) TotalRain, (6) MeanTemp, (7) TotalRain7, (8) MeanTemp7, (9) mds1 and (10) mds2. Prior to analyses, all continuous explanatory variables were scaled to zero mean. Another 46 biologically meaningful models containing either additive or multiplicative interaction of two viable variables were proposed. We ensured that correlated variables were not placed in the same models to avoid collinearity problems. For the environmental variables, only TotalRain and MeanTemp were used correlates positively and negatively with MeanTemp7 and TotalRain7, respectively. Only models with a maximum of two terms were fitted to avoid over-fitting. Lastly, a null model without any predictor (i.e., ~ 1) was also proposed. In total, 57 proposed models were ranked according to the small sample-size corrected version of the Akaike information criterion (AICc) using the 'MuMIn' package (Barton & Barton 2015). Models with delta (difference between the AICc of a particular model and that of the best model) less than 2.0 (Burnham & Anderson 2002) were interpreted together. For each model, heteroscedasticity and overdispersion (by comparing the residual deviance to the degree of freedom) were also checked.

Distance-based methods were used to examine whether the orthopteran beta-diversity is different between plots from different Sites, LandHistory and plant assemblages. The Bray-Curtis dissimilarity matrix was calculated using the function 'vegdist' in the package 'vegan' (Oksanen et al. 2015). Permutational Multivariate Analysis of Variance (PERMANOVA) was conducted against the dissimilarity matrix to examine the statistical significance of Site, LandHistory and the two plant assemblages axes (mds1 and mds2). The number of permutations used was 9,999. Terms with p-values < 0.05 are considered significant. The differences in the orthopteran community across Sites and LandHistory were also visualised through a two-dimensional NMDS plot. The other aspect of beta-diversity examined was community dispersion, which looks at the variation in communities within a group, e.g., within a single Site. Pairwise permutational F-tests were performed to test if communities from across Sites had significantly different community dispersion, calculated using the function 'betadisper'. These multivariate analyses were conducted using the community package vegan (Oksanen et al. 2015).

Results

What is the diversity of Orthoptera on Pulau Ubin?

Based on the systematic sampling of 26 transects, we documented 50 species of 40 genera from eight families of Orthoptera (Table 1, Fig. 2A). Species estimators extrapolated that Pulau Ubin has a probable range of 60±4 to 88±21 species based on bootstrap and Chao estimators respectively. The two boat surveys, each lasting about two hours, led to the documentation of seven species from the mangrove; of which *Svistella chekjawa* Tan & Robillard 2012 and *Holochlora bilobata* (Karny 1926) were not documented in the systematic sampling.

What predicts the diversity?

Based on the model selection process, five models with delta<2.0 containing CanopyCover, MeanTemp and mds2 were useful for predicting observed species richness (Richness) (Table 2). Both canopy cover (estimate = −0.15±0.07, 95% CI[−0.29, −0.01]) and the same-day mean temperature (estimate = −0.15±0.07, 95% CI[−0.30, −0.01]) have a negative correlation with species richness (Fig. 2). Mds2 based on 105 identified plant species (Table 3) was found to be associated with the dominant ground cover plant species (Fig. 3), but there was an absence of an effect of mds2 on the observed species richness of orthopterans (estimate = −0.14±0.08, 95% CI[−0.29, 0.01].

We did not find any variable that predicted the orthopteran community in Pulau Ubin. The orthopteran community composition did not differ significantly between the two categories of sites (i.e., within public-accessible versus OBS sites; pseudo-F = 1.72, p-value = 0.105), or with different LandHistory (i.e., after rubber plantation or after fruit plantation or after managed land; pseudo-F = 1.34, p-value = 0.172) and plant assemblages (i.e., mds1: pseudo-F = 0.49, p-value = 0.821; mds2: pseudo-F = 1.66, p-value = 0.130) (Fig. 4A). There were also no significant differences in community dispersion within plots from public-accessible and OBS sites (pseudo-F = 1.08, p-value = 0.309) (Fig. 4B).

Discussion

What is the diversity of Orthoptera on Pulau Ubin?

The orthopteran survey between 2018 and 2019 is the most comprehensive sampling on Pulau Ubin, in terms of rigour, frequency and geographical scale. Previous checklists focused on specific sites (Tan, 2010), specific habitat (Tan, 2013) and diet content of scats from a common palm civet (Fung et al., 2018). Here, we are able to present the most-up-to-date checklist of Orthoptera in Pulau Ubin by sampling in both public-accessible and western forest.

Sampling yielded several new locality records of orthopterans. Specifically, eight species of katydids were recorded for the first time in Pulau Ubin: *Casigneta bisinuata* Karny 1926 (Fig. 5A), *Stictophaula* sp., *Alloteratura lamella* Jin 1995, *Alloteratura subanalis* (Karny 1926) (Fig. 5B), *Asiophlugis thaumasia* (Hebard 1922), *Carliphisis leontopolites* (Karny 1931) (Fig. 5C), *Neophisis siamensis* Jin 1992 (Fig. 5D) and *Nahlaksia bidadari* Ingrisch & Tan 2012. The large number of katydids undocumented in previous checklists can be attributed to these katydids typically occurring in low abundance and being restricted to less disturbed and/or denser forests. Furthermore, *Sclerogryllus* spp. and *Cycloptiloides* sp. and *Micrornebius* sp. were also recorded for the first time. These crickets are typically cryptic in behaviour hiding among leaf litter and tree branches or sometimes in tree bark (Tan, 2014b), and hence they may have been overlooked in previous sampling.

The systematic sampling is not without limitations. Compared to existing checklists, many open grassland species were not recorded, since it was not the focused habitat during the systematic sampling. These include *Acrida willemsei* Dirsh 1954, *Epistaurus aberrans* Brunner von Wattenwyl 1893, *Aiolopus thalassinus tamulus* (Fabricius 1798), *Trilophidia annulata* (Thunberg 1815), *Oxya* spp., *Euscyrtus concinnus* (Haan 1844), *Metioche pallipes* (Stål 1861) and *Homoeoxipha lycoides* (Walker 1869), many of which were previously recorded in the grassland and open habitats along Sensory Trail (Tan, 2010). In fact, only about 50% (10 out of 21 species) of the caeliferans known from Pulau Ubin (Fung et al., 2018) were recorded in the 26 transects.

We were also able to sample the hard-to-access mangrove canopy using boat surveys, something that has not been conducted before in Singapore. Seven species recorded during the two boat surveys appear to compare poorly to the 13 species previously recorded along the boardwalk in Chek Jawa mangrove (Tan, 2013). While it is not comparable since the sampling methods and efforts were different, the boat surveys have their challenges. In Siargao, Philippines (Tan et al., 2019), the mangrove forest was sampled while collectors were on a non-motorised wooden sampan; and the forest was more inland where the water currents were very weak. Owing to the strong currents at Pulau Ubin, it was extremely difficult to manoeuvre even the motorboat close enough to the canopy for detailed examination of the foliage. The strong current can be attributed to the hydrology of the seas around Pulau Ubin, as well as the short spring tides during the two night surveys. The densest mangrove forest was also not accessible and it is likely that the more open and disturbed mangrove forests were sampled during the two boat trips. Future surveys during the peak of the longer spring tides will have the potential to collect more samples higher up in the canopy, which was inaccessible during our visits.

What predicts the diversity?

We found that fewer orthopteran species were observed in transects with higher canopy cover and/or higher mean daily temperature. We speculate that as canopy cover increases, more species may be found on the canopy foliage, especially for many katydids, which could not be reached by the surveyors. Consequently, the richness of understorey species sampled would seem lower in transects with higher canopy. Alternatively, having less light penetrating into the understorey can also reduce productivity of the understorey vegetation, hence supporting fewer orthopteran species. This may be related to the more individuals hypothesis which predicts a positive relationship between resource availability and species abundance and hence richness (Yanoviak, 2001; Hurlbert, 2004). More plant food resources can drive greater species richness through supporting larger populations that are less vulnerable to local extinction (Cardinale et al., 2007; Müller et al., 2018). However, caution is needed with such interpretation for our context (see e.g., Yee & Juliano, 2007), because a large proportion of orthopteran species are not strictly herbivorous. It can be argued that higher plant productivity can correlate with higher herbivore richness and in turn correlate with higher secondary consumer richness. However, we believe that the ecosystem is probably much more complex where many species feed opportunistically.

On the surface, a negative relationship between mean daily temperature and observed species richness may contradict the "species–energy" metabolic hypothesis that predicts that increased productivity and metabolism at higher temperature support more species populations and species (Allen et al., 2002). But as Houston (2003) has pointed out, several variables can affect richness in tandem with temperature. That mean daily temperature is correlated to lower daily total rainfall suggests that perhaps more orthopteran species can be observed during wetter conditions. This is similar to the findings on the pygmy grasshoppers in Nee Soon freshwater swamp forest in which wetter microhabitats supported more grasshoppers (Tan et al., 2017). Ex-situ observations have also demonstrated that many forest katydids thrive better in cool but wet environment in captivity (Tan, pers. obs.). Hence, we can infer that more orthopteran species are more active in the forest during cooler and wetter nights.

Contrary to our expectation, our results suggest that the understorey orthopteran community (beta-diversity) in the secondary forest of Pulau Ubin is homogeneous and independent of the park management scheme (i.e., degree of public access to sites), land history and plant assemblages. Five species are consistently observed across the 26 transects i.e., *Lebinthus luae* Robillard & Tan 2013 (observed in all 26 transects, Fig. 5E) and *Velarifictorus aspersus* (Walker 1869) (18 transects) in the leaf litter, *Ornebius rufonigrus* Ingrisch 1987 (21 transects), *Traulia azureipennis* (Serville 1838) (13 transects) and *Endodrelanva jimini* Tan & Kamaruddin 2016 (12 transects, Fig. 5F) on the branches and foliage. The community was also dominated by *L. luae* and to a lesser extent *V. aspersus* across most transects. This lack of beta-diversity heterogeneity is contrary to numerous studies on orthopteran assemblages in other parts of the world (e.g., Fabriciusová et al., 2011; Fartmann et al., 2012; Hardwick, 2018; Fumy et al., 2020). It should however, be noted that the majority of these studies (except Hardwick, 2018) were conducted in non-tropical regions. In our case, we speculate that the scale of the landscape variables examined might also be too coarse. Similar to the findings on pygmy grasshoppers in Nee Soon forest (Tan et al., 2017a), fine-scaled microhabitat variables might be more important in shaping the orthopteran community. Furthermore, we are still missing the full picture of the orthopteran community as the species in the canopy layer were likely under-represented owing to the limitations of our sampling in the understorey. Future studies could consider examining the differences in beta-diversity of the orthopteran community across more narrowly defined microhabitats (e.g., wetness of leaf litter, leaf litter depth) and/or incorporating different forest strata as predictors.

Conclusions

Invertebrates in Singapore are mostly under-studied and many species are unidentifiable or undescribed. But the literature for a few taxonomic groups, which include the orthopterans, is mature enough to progress beyond producing checklists for sites. These relatively better studied groups can now be used for systematic ecological sampling to help answer the roles of invertebrates in the ecosystem in the context of Singapore and/or beyond. Even in the current study, 20 out of 50 taxa could not be given a precise species name (Table 1). Here, we demonstrate that with relatively sound species identification of orthopterans, we can better understand how their diversity is influenced and shaped in Pulau Ubin. We hope that this can provide a baseline for using orthopterans as a model for future ecological studies of invertebrates in Singapore.

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Table 1. Checklist of Orthoptera from Pulau Ubin based on the systematic sampling in 26 transects and mangrove sampling from a boat (the latter marked with an asterisk)

Suborder	Family	Species	Functional group
Caelifera	Acrididae	*Phlaeoba antennata*	open-field grasshopper
Caelifera	Acrididae	*Phlaeoba infumata*	open-field grasshopper
Caelifera	Acrididae	*Pseudoxya diminuta*	open-field grasshopper
Caelifera	Acrididae	*Spathosternum prasiniferum*	open-field grasshopper
Caelifera	Acrididae	*Traulia azureipennis*	forest grasshopper
Caelifera	Acrididae	*Valanga nigricornis* *	open-field grasshopper
Caelifera	Acrididae	*Xenocatantops humilis* *	open-field grasshopper
Caelifera	Pyrgomorphidae	*Tagasta marginella*	open-field grasshopper
Caelifera	Tetrigidae	Tetrigidae	pygmy grasshopper
Caelifera	Tetrigidae	*Thoradonta nodulosa*	pygmy grasshopper
Ensifera	Gryllacrididae	Gryllacridinae	raspy cricket
Ensifera	Gryllacrididae	*Gryllacris* sp.	raspy cricket
Ensifera	Gryllacrididae	*Gryllacris signifera* *	raspy cricket
Ensifera	Gryllidae	*Endodrelanva jimini*	bark cricket
Ensifera	Gryllidae	*Lebinthus luae*	bush cricket
Ensifera	Gryllidae	Gryllinae	ground cricket
Ensifera	Gryllidae	*Gymnogryllus* sp.	ground cricket
Ensifera	Gryllidae	*Loxoblemmus* sp.	ground cricket
Ensifera	Gryllidae	*Sclerogryllus* sp. 1	ground cricket
Ensifera	Gryllidae	*Sclerogryllus* sp. 2	ground cricket
Ensifera	Gryllidae	*Teleogryllus* sp.	ground cricket
Ensifera	Gryllidae	*Velarifictorus aspersus*	ground cricket
Ensifera	Gryllidae	*Aphonoides* sp.	tree-dwelling mute cricket
Ensifera	Mogoplistidae	*Cycloptiloides* sp.	ground scaly cricket
Ensifera	Mogoplistidae	*Microrнebius* sp.	tree-dwelling scaly cricket
Ensifera	Mogoplistidae	*Ornebius* sp. *	tree-dwelling scaly cricket
Ensifera	Mogoplistidae	*Ornebius pullus*	tree-dwelling scaly cricket
Ensifera	Mogoplistidae	*Ornebius rufonigrus*	tree-dwelling scaly cricket
Ensifera	Mogoplistidae	*Ornebius tampines*	tree-dwelling scaly cricket
Ensifera	Tettigoniidae	*Casigneta bisinuata*	bush katydid
Ensifera	Tettigoniidae	*Elimaea* or *Ducetia* sp.	bush katydid
Ensifera	Tettigoniidae	*Holochlora bilobata* *	bush katydid
Ensifera	Tettigoniidae	*Mecopoda elongata*	bush katydid
Ensifera	Tettigoniidae	*Phaneroptera brevis*	bush katydid

Table 1. Continuation

Suborder	Family	Species	Functional group
Ensifera	Tettigoniidae	*Stictophaula* sp.	bush katydid
Ensifera	Tettigoniidae	*Alloteratura lamella*	crystal predatory katydid
Ensifera	Tettigoniidae	*Alloteratura subanalis*	crystal predatory katydid
Ensifera	Tettigoniidae	*Asiophlugis thaumasia*	crystal predatory katydid
Ensifera	Tettigoniidae	*Carliphisis leontopolites*	crystal predatory katydid
Ensifera	Tettigoniidae	Meconematini	crystal predatory katydid
Ensifera	Tettigoniidae	*Neophisis siamensis*	crystal predatory katydid
Ensifera	Tettigoniidae	*Conocephalus maculatus*	meadow katydid
Ensifera	Tettigoniidae	*Conocephalus melaenus*	meadow katydid
Ensifera	Tettigoniidae	*Hexacentrus unicolor*	predatory katydid
Ensifera	Tettigoniidae	*Nahlaksia bidadari*	spine-headed katydid
Ensifera	Tettigoniidae	*Oxylakis singaporensis*	spine-headed katydid
Ensifera	Trigonidiidae	*Amusurgus* sp. 1	sword-tailed cricket
Ensifera	Trigonidiidae	*Amusurgus* sp. 2	sword-tailed cricket
Ensifera	Trigonidiidae	*Natula longipennis*	sword-tailed cricket
Ensifera	Trigonidiidae	*Svistella chekjawa* *	sword-tailed cricket
Ensifera	Trigonidiidae	*Svistella* sp.	sword-tailed cricket
Ensifera	Trigonidiidae	Trigonidiinae *	sword-tailed cricket

Table 2. Summary of the model selection of 57 proposed models used to predict observed orthopteran richness in Pulau Ubin. Only the first eleven models were presented.

Models and response variable(s)	Intercept	d.f.	logLink	AICc	delta	Weight
~ mds2 + MeanTemp	1.98	3	−53.1	113.4	0.0	0.10
~ CanopyCover + MeanTemp	1.98	3	−53.2	113.4	0.1	0.10
~ CanopyCover	1.99	2	−54.6	113.8	0.4	0.08
~ MeanTemp	1.99	2	−54.8	114.2	0.8	0.07
~ CanopyCover + mds2	1.99	3	−53.8	114.7	1.3	0.05
~ TotalRain + MeanTemp	1.99	3	−54.1	115.4	2.0	0.04
~ mds2	1.99	2	−55.6	115.8	2.4	0.03
~ CanopyCover + TotalRain	1.99	3	−54.3	115.8	2.5	0.03
~ CanopyCover × MeanTemp	1.99	4	−53.0	116.0	2.6	0.03
~ PlantRichness + MeanTemp	1.99	3	−54.4	116.0	2.6	0.03
~ 1	2.00	1	−56.9	116.1	2.7	0.03

Table 3. List of plant species, arranged in alphabetical order, identified from the 26 transects.

Species	Plant Type	Status
Acacia auriculiformis	Tree	Exotic
Adenanthera pavonina	Tree	Exotic
Adiantum sp.	Fern	Native
Adiantum latifolium	Fern	Exotic
Agelaea macrophylla	Climber	Native
Aidia densiflora	Tree	Native
Allamanda cathartica	Climber	Exotic
Alstonia angustifolia	Tree	Native
Alyxia reinwardtii	Climber	Native
Angelesia splendens	Tree	Native
Antidesma velutinosum	Shrub	Native
Ardisia elliptica	Shrub	Native
Artabotrys suaveolens	Climber	Native
Arthrophyllum jackianum	Tree	Native
Artocarpus heterophyllus	Tree	Exotic
Asplenium longissimum	Fern	Native
Axonopus compressus	Grass & Grass-like Plant	Exotic
Barringtonia asiatica	Tree	Native
Buchanania arborescens	Tree	Native
Calamus erinaceus	Palm	Native
Calophyllum inophyllum	Tree	Native
Cansjera rheedii	Climber	Native
Caryota mitis	Palm	Native
Champereia manillana	Tree	Native
Cinnamomum iners	Tree	Native
Citrus aurantifolia	Shrub	Exotic
Claoxylon indicum	Tree	Native
Clausena excavata	Tree	Native
Clerodendrum disparifolium	Shrub	Native
Clidemia hirta	Shrub	Exotic
Cocos nucifera	Palm	Exotic
Cyclosorus interruptus	Fern	Native
Cyperus trialatus	Grass & Grass-like Plant	Native
Cyrtococcum patens	Grass & Grass-like Plant	Native
Cyrtophyllum fragrans	Tree	Native

Table 3. Continuation

Species	Plant Type	Status
Daemonorops sp.	Climber	Native
Davallia denticulata	Fern	Native
Derris amoena	Climber	Native
Derris trifoliata	Climber	Native
Dianella ensifolia	Shrub	Native
Dicranopteris linearis	Fern	Native
Dillenia suffruticosa	Shrub	Native
Dracaena fragrans	Shrub	Exotic
Durio zibethinus	Tree	Exotic
Elephantopus scaber	Grass & Grass-like Plant	Exotic
Erycibe leucoxyloides	Climber	Native
Erycibe tomentosa	Climber	Native
Ficus aurata	Shrub	Native
Ficus fistulosa	Tree	Native
Ficus heteropleura	Tree	Native
Ficus punctata	Climber	Native
Flacourtia jangomas	Tree	Exotic
Flagellaria indica	Climber	Native
Flemingia strobilifera	Shrub	Native
Gnetum cf. *macrostachyum*	Tree	Native
Gnetum cf. *microcarpum*	Climber	Native
Gnetum gnemon	Tree	Native
Hevea brasiliensis	Tree	Exotic
Hibiscus tiliaceus	Shrub	Native
Indorouchera griffithiana	Climber	Native
Ixora congesta	Shrub	Native
Knema corticosa	Tree	Native
Leea indica	Shrub	Native
Licuala spinosa	Palm	Native
Litsea elliptica	Shrub	Native
Litsea umbellata	Tree	Native
Macaranga gigantea	Tree	Native
Macaranga triloba	Tree	Native
Malaisia scandens	Climber	Native
Mangifera indica	Tree	Exotic

Table 3. Continuation

Species	Plant Type	Status
Manihot esculenta	Shrub	Exotic
Melastoma malabathricum	Shrub	Native
Memecylon cf. *lilacinum*	Shrub	Native
Memecylon edule	Shrub	Native
Morinda citrifolia	Tree	Native
Nephelium lappaceum	Tree	Exotic
Nephrolepis biserrata	Fern	Native
Olea brachiata	Tree	Native
Oncosperma tigillarium	Palm	Native
Oxyceros longiflorus	Climber	Native
Passiflora laurifolia	Climber	Exotic
Piper sarmentosum	Shrub	Native
Planchonella obovata	Tree	Native
Pteris semipinnata	Fern	Exotic
Rhodamnia cinerea	Tree	Native
Rourea fulgens	Climber	Native
Smilax megacarpa	Climber	Native
Spermacoce cf. *ocymifolia*	Grass & Grass-like Plant	Exotic
Stachytarpheta indica	Shrub	Exotic
Stenochlaena palustris	Fern	Native
Syzygium acuminatissimum	Tree	Native
Syzygium glaucum	Tree	Native
Syzygium grande	Tree	Native
Syzygium jambos	Tree	Exotic
Syzygium cerasiforme	Tree	Native
Syzygium myrtifolium	Tree	Native
Syzygium polyanthum	Tree	Native
Syzygium syzygioides	Tree	Native
Taenitis blechnoides	Fern	Native
Terminalia catappa	Tree	Native
Tetracera indica	Climber	Native
Timonius flavescens	Tree	Native
Utania racemosa	Tree	Exotic
Vanilla griffithii	Climber	Native
Vitex pinnata	Tree	Native

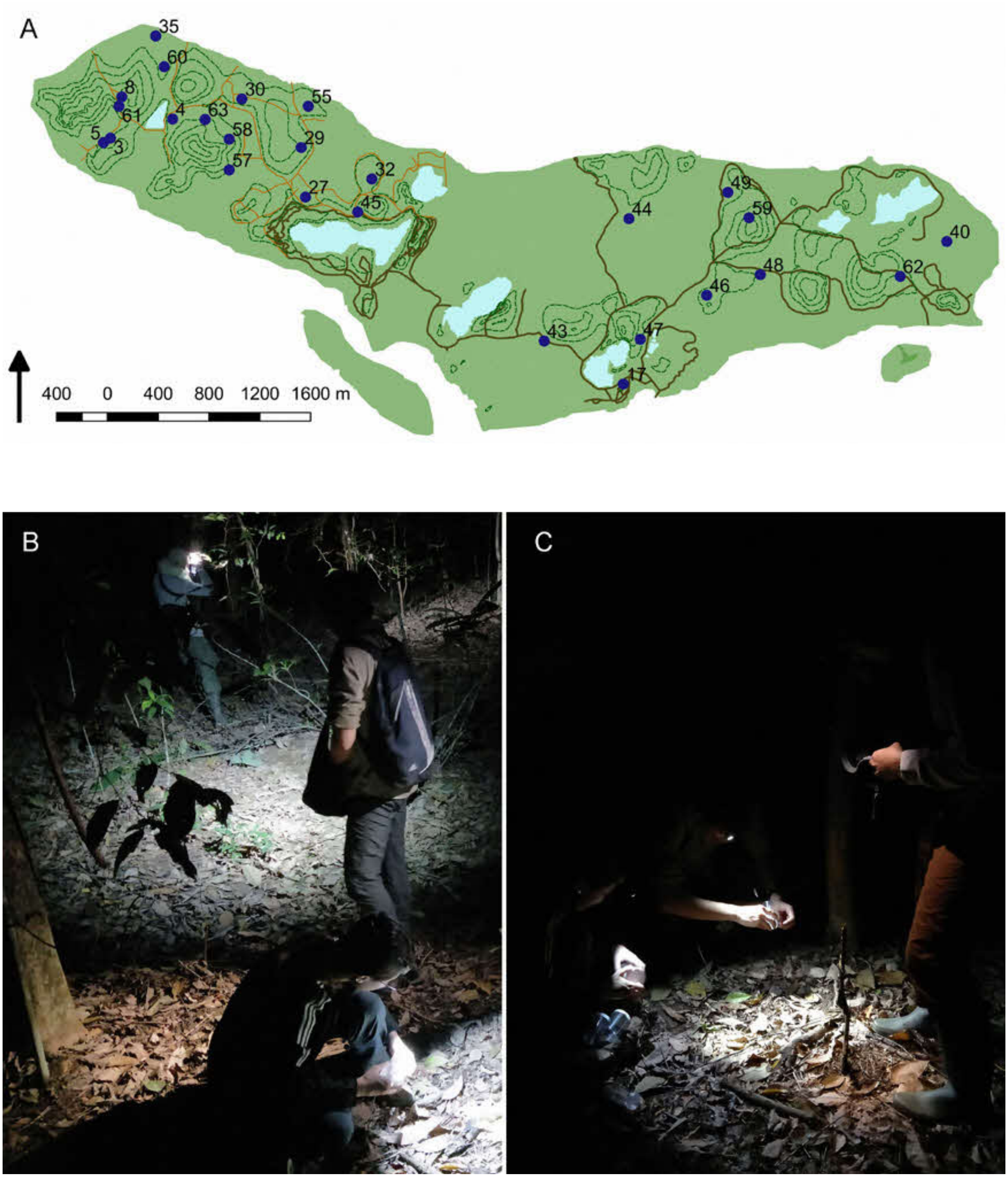

Fig. 1 (**A.**) Map of Pulau Ubin with the locations of the 26 transects. (**B.**) Opportunistic searching for orthopterans by three surveyors. (**C.**) Collection of orthopteran using containers.

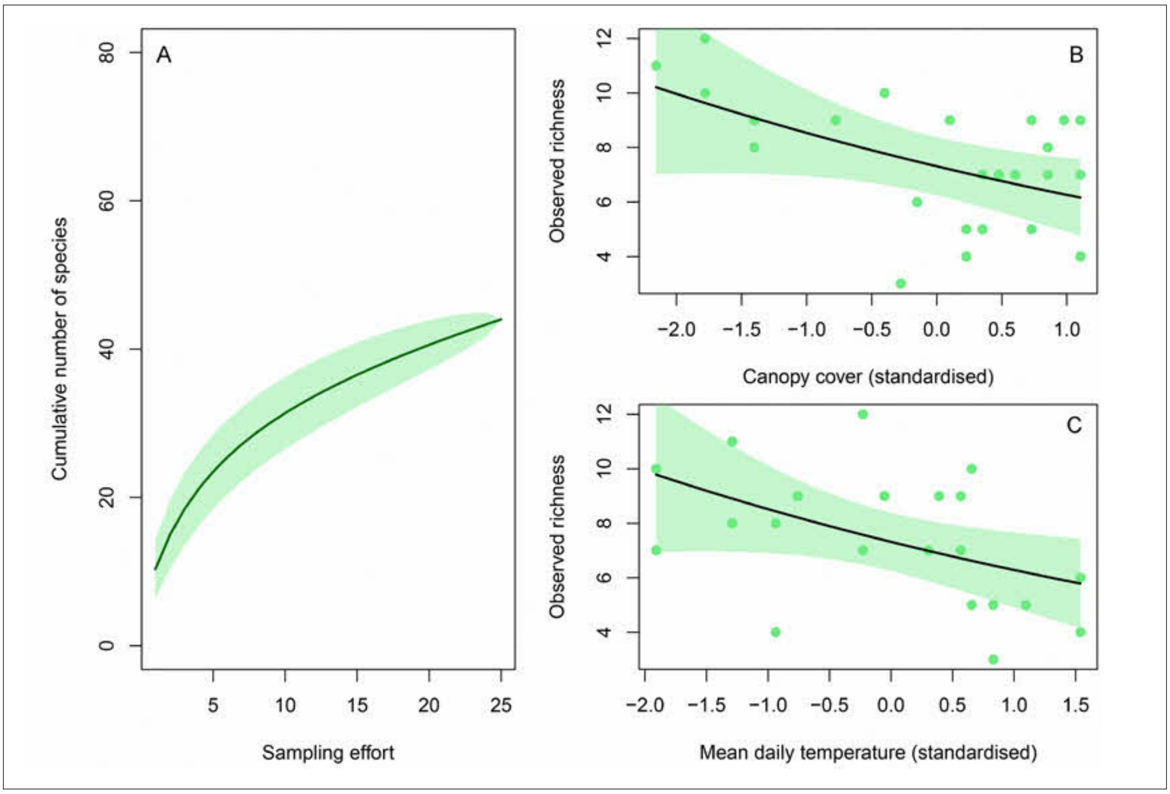

Fig. 2 (**A.**) Species accumulation curve based on rarefaction. (**B.**) Best fit line showing a negative correlation between observed richness and canopy cover (estimate = −0.15±0.07). (**C.**) Best fit line showing a negative correlation between observed richness and mean daily temperature (estimate = −0.15±0.07). Polygons around lines indicate 95% confidence intervals.

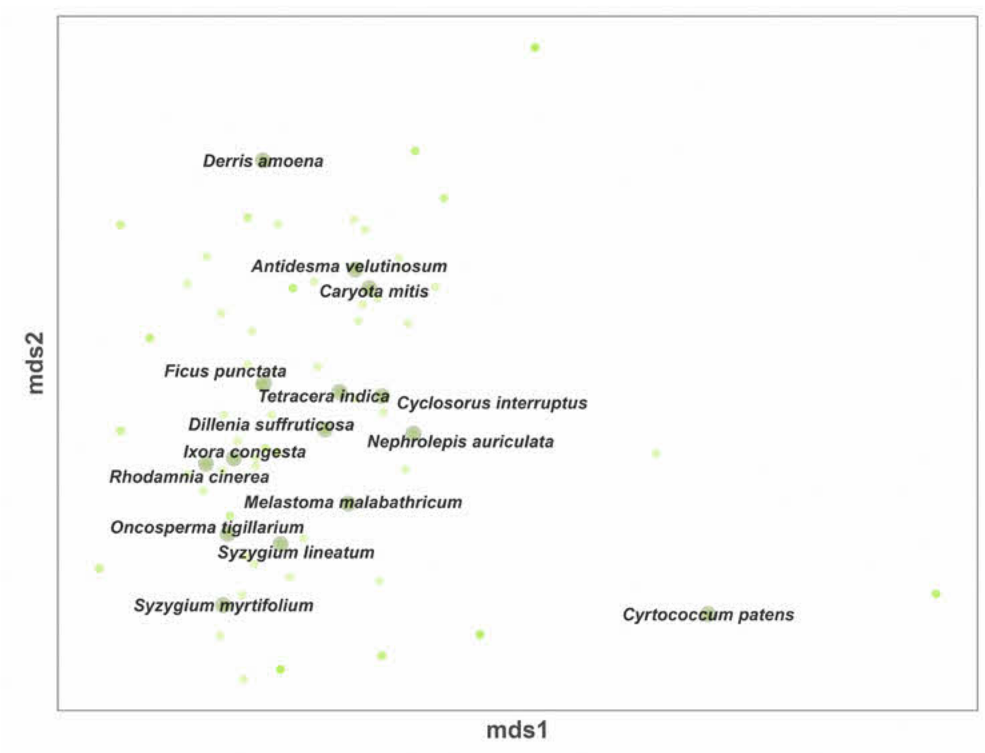

Fig. 3 NMDS ordination of understorey plant community in Pulau Ubin. The names of the dominant understorey plant species are provided.

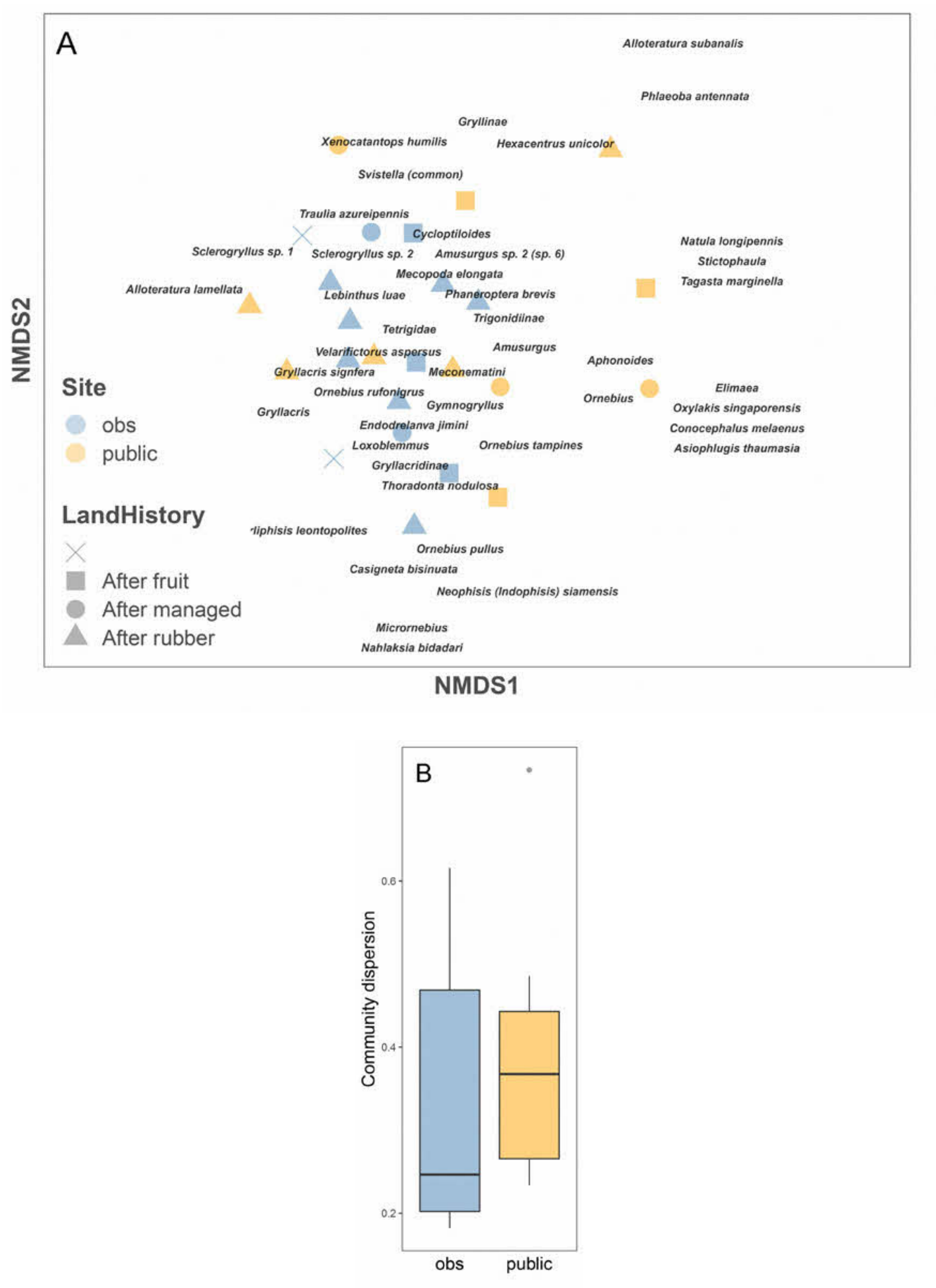

Fig. 4 (**A.**) NMDS ordination of orthopteran community in Pulau Ubin with no significant differences between different Site (blue points for plots within OBS site; orange points for plots within sites with public access) and LandHistory (square symbol for plots that were after fruit plantation, round symbol for plots that were after managed land, triangle symbol for plots that were after rubber plantation, and cross symbol for plots that do not have a distinct land history type). Stress value = 0.214, k = 2. (**B.**) Boxplot of community dispersion measured with Bray-Curtis dissimilarity measure comparing between OBS sites and sites with public access.

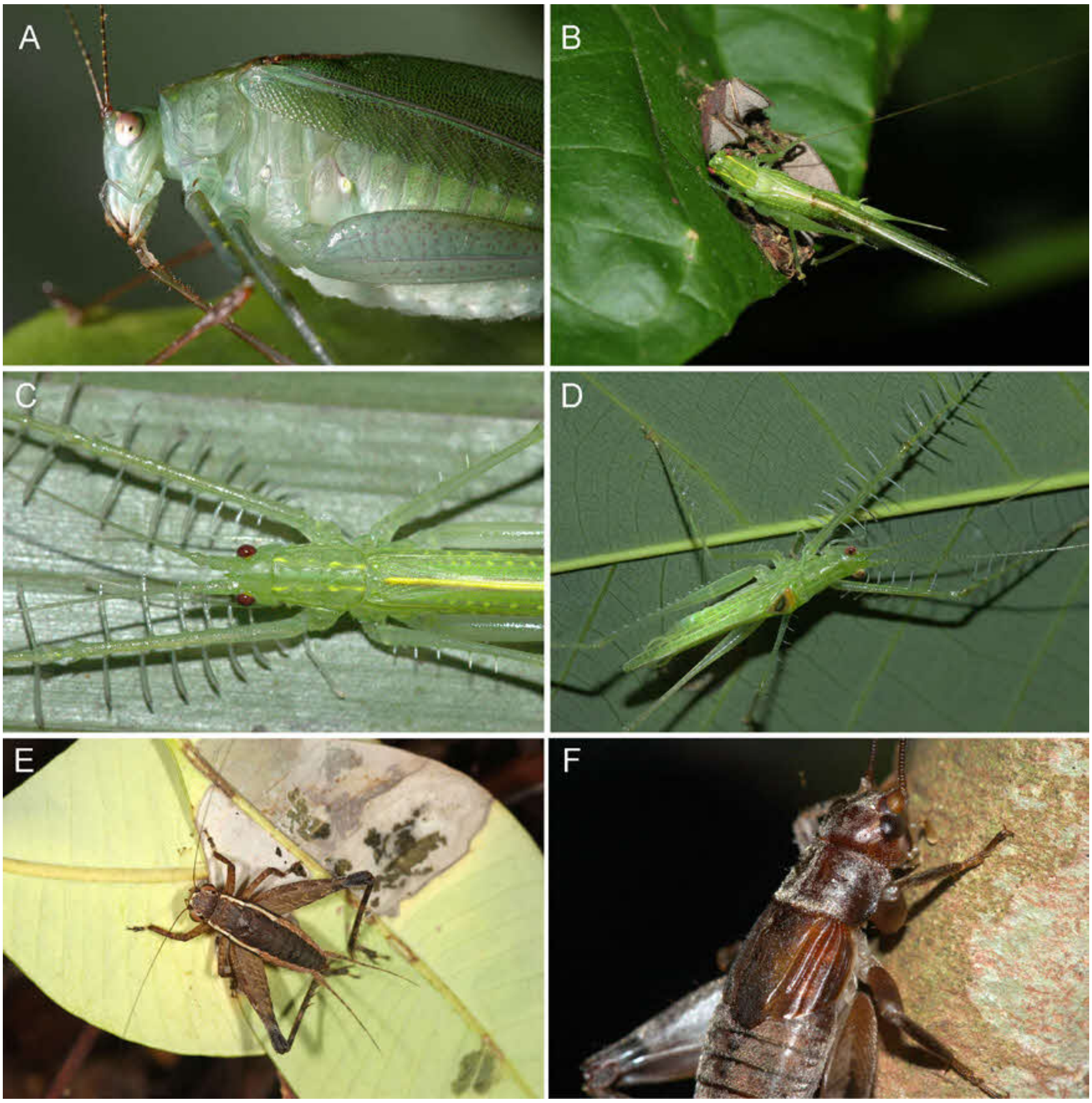

Fig. 5 Some orthopterans recorded in Pulau Ubin: (**A.**) *Casigneta bisinuata*, (**B.**) *Alloteratura subanalis*, (**C.**) *Carliphisis leontopolites*, (**D.**) *Neophisis siamensis*, (**E.**) *Lebinthus luae*, (**F.**) *Endodrelanva jimini*.

Stick and leaf insects in Pulau Ubin, Singapore, in 2018–2020

F. Seow-Choen[1,5], A. Sani[2], E. J. Tan[3] & E. K. Chua[4]

[1]290 Orchard Road, Paragon #06-06, 238859 Singapore.
seowchoen@gmail.com
[2] Division of Science, Yale-NUS College, 16 College Avenue West, 138527 Singapore.
azlin@yale-nus.edu.sg
3Division of Science, Yale-NUS College, 16 College Avenue West, 138527 Singapore.
eunice.tan@yale-nus.edu.sg
[4]Prosthodontics Unit, National Dental Centre, 5 Second Hospital Avenue, 168938 Singapore.
simplygreen@gmail.com
[5]Honorary Research Associate, National Biodiversity Centre, National Parks Board, 1 Cluny Road, 259569 Singapore.

ABSTRACT. The Comprehensive Ubin Biodiversity Survey 2018–2020 showed that only five species of stick insects are present on Ubin. One pair of the species *Trachythorax* sp. (undescribed) had been photographed in June 2016 but has not been seen since. The other four species, *Lonchodes brevipes* Gray 1835, *Sipyloidea sipylus* (Westwood, 1859), *Orestes draegeri* Bresseel & Constant 2018 and *Cryptophyllium chrisangi* (Seow-Choen, 2017) appear in relatively large numbers on Pulau Ubin. The relative paucity of stick insect biodiversity on Pulau Ubin probably relates to the previous extensive utilisation of the island for agriculture. This no doubt entailed the widespread use of pesticides and herbicides, which would have exterminated most of these host-plant specific insects. The relative abundance of the few species that are found in or near the mangrove swamps hints at the ability of these insects to thrive on plants which grow in or near mangrove swamps. This may be due to the sparing of these non-agricultural areas from the use of toxic chemicals.

Keywords. Stick insect, Pulau Ubin, Leaf insect, Phasmids

Introduction

Stick insects and leaf insects (collectively known as phasmids) belong to the order Phasmida. The order is currently divided into three suborders. The suborders Agathemerodea and Timematodea are limited to the Neotropics. Only members of the suborder Verophasmatodea are found in Singapore. The suborder Verophasmatodea may be further divided into two infraorders, namely the Anareolatae and the Areolatae.

The stick insect biodiversity of Singapore had been reported several times over the last 25 years (Brock, 1999; Seow-Choen, 1997, 1997a, 2000, 2005, 2011, 2012, 2017; Seow-Choen et al., 2019). A survey conducted by the National Parks Board (NParks) in 1997 covered Bukit Timah Nature Reserve (BTNR) and reported both the stick insect biodiversity of BTNR and the Central Catchment Nature Reserve (CCNR) (Seow-Choen, 1997a). The reason for reporting broadly at that time was the relative paucity of stick insect species within BTNR. Forty-one species of phasmids found in Singapore, extant as well as extinct, were listed in that first report and aspects of their conservation were discussed.

A more recent publication (Seow-Choen, 2017) which was partly supported by NParks, listed 44 species from Singapore. This book pointed out nine erroneous synonyms, four new synonyms, three new name combinations, one species new to Singapore and three newly described species (Seow-Choen, 2017). Interested readers are referred to this recent book for the most comprehensive and current treatment of stick insects in Singapore.

A report on the Comprehensive Biodiversity Survey of BTNR, which was conducted from 1 April 2014 to 30 April 2018 found only 11 species, whereas historical records noted

16 species (Seow-Choen et al., 2019). The five species that were not recorded during that survey were noted to be rare with limited host-food-plant possibility.

This is the first report on the biodiversity of stick insects on Pulau Ubin. There is a significant change in the taxonomic systematics of stick insects in this report compared to the last survey report on BTNR in 2019 (Seow-Choen et al., 2019). A sister-group relationship between Necrosciinae and Lonchodinae was suggested already in 1893 (Brunner, 1893). This was strongly supported by a recently published molecular study (Robertson et al., 2018) and is the systematic arrangement followed in this paper. The subfamily Necrosciinae, listed previously under the family Diapheromeridae, has now been transferred to the family Lonchodidae. Therefore the family Lonchodidae has two subfamilies, the Lonchodinae and the Necrosciinae.

Materials and Methods

Four persons participated in the survey of stick insects of Pulau Ubin, as part of the Comprehensive Ubin Biodiversity Survey 2018–2020. Survey trips were undertaken usually on a Friday or Saturday night between 2000 and 2400 hours. The trips were conducted on an average frequency of once a month for the two years 2018 to 2019. Survey trips were less regular in 2020 both due to COVID-19 pandemic restrictions as well as the perceived adequacy of data collected over the previous two years.

The objectives of the survey were (a) to collect and document the number of species of stick insects as well as the abundance of individuals of these species in Pulau Ubin and to collect data regarding suitable habitats and foodplants; (b) to establish an accurate database of the same through the use of long-term surveys by monitoring these species; and (c) thereafter to apply the accurate data collected to formulate a data and science-based management plan to ensure the continued sustainability of Pulau Ubin as a wildlife habitat for these species.

Searching along the various tracks in Pulau Ubin was conducted by night by use of hand torches, with cameras for documentation. Voucher specimens were collected as needed. Foodplant identification was performed as and when needed.

Results

This Comprehensive Ubin Biodiversity Survey has shown that Pulau Ubin has a very high population of stick insects. The average number of specimens per species encountered was noticeably higher than was encountered during the Comprehensive Biodiversity Survey of BTNR undertaken from 2014 to 2018. Sadly, however, stick insect species biodiversity in Pulau Ubin is very low compared to BTNR or CCNR. What is interesting, however, is the presence of an undescribed species of stick insect on Pulau Ubin. This very elusive species, however, has so far evaded capture for closer scrutiny. A mating pair of this species was photographed at the Ubin Living Lab by a staff of Lee Kong Chian Natural History Museum, but not captured at that time.

There are therefore a total of five species, one of which is an undescribed species from five genera, three families and two infraorders present on Pulau Ubin. Notes on the four known species are as follows.

Infraorder: Anareolatae
Family: Lonchodidae
Subfamily: Lonchodinae
Species: *Lonchodes brevipes* Gray 1835
Foodplants: *Hibiscus tiliaceus, Psidium guajava*

Lonchodes brevipes is widespread on mainland Singapore, but numbers encountered are never high. On Pulau Ubin, however, dozens of adults and nymphs may be encountered on a short stretch of *Hibiscus tiliaceus*. These plants are commonly encountered along the coasts right alongside mangrove trees. Other mangrove coastlines on mainland Singapore with extensive growths of *Hibiscus tiliaceus*, e.g. Pasir Ris Park and Sungei Buloh Wetland Centre, do not seem to support such an extravagant population of this species. On Pulau Ubin the species reproduces sexually with specimens of both sexes present. This species flicks its eggs about randomly and therefore it is natural that groves of *Hibiscus tiliaceus* on more solid ground in the back mangroves where sea water intrudes less may be able to sustain a higher population of this species. This is because eggs expelled into the sea may not survive immersion or the high salinity of the water.

Subfamily: Necrosciinae
Species: *Sipyloidea sipylus* (Westwood, 1859)
Species: *Trachythorax* sp. (undescribed)
Foodplants: *Hibiscus tiliaceus, Psidium guajava, Grewia acuminata*

Sipyloidea sipylus (Westwood 1859) is not uncommon in Pulau Ubin where it is found feeding on *Hibiscus tiliaceus*. The species is also known to feed on *Psidium guajava* but the few trees of *Psidium guajava* on Pulau Ubin which were checked during the time of this survey did not reveal any specimens. A rare specimen of this species had also been found in Pasir Ris Park by the first author. This species is parthenogenetic in Singapore and populations here are female-only, without males. Parthenogenesis means that the female is able to reproduce fertile eggs without fertilisation from a male, and hatchlings from these unfertilized eggs will be exact clones of the mother stick insect. The eggs of this species are glued to leaves and bark. Therefore this species is highly adapted to living in mangrove swamps as the eggs do not run the risk of falling into the high-salt seawater.

The *Trachythorax* sp. (undescribed) mating pair that was photographed at the Ubin Living Lab mangrove patch had been actively searched for since the first photographs of the mating pair were seen (Foo, 2016). So far, there had been no repeat sightings of this elusive species.

Infraorder: Areolatae
Family: Heteropterygidae
Subfamily: Dataminae
Species: *Orestes draegeri* Bresseel & Constant 2018
Foodplants: Various aroids, *Leea indica*.

The dominant species of the subfamily Dataminae in Singapore is *Pylaemenes mitratus* (Redtenbacher 1906), which is ubiquitous in all the Nature Reserves in mainland Singapore. On the other hand, *Orestes draegeri* Bresseel & Constant 2018 on mainland Singapore is limited to the Singapore Botanic Gardens, and a small patch of forest at Track 7, Mandai, as well as in Dairy Farm Nature Park. On Pulau Ubin, *Pylaemenes mitratus* (Redtenbacher 1906) has not been found so far and is unlikely to be present. *Orestes draegeri* Bresseel & Constant 2018 however, is abundant and widespread on Pulau Ubin. This species was previously listed in all our publications as *Orestes mouhotii* (Bates 1865) but molecular studies by Bank et al. (2021: pp. 11, 14) showed the specimens from Tanjung Bunga, Penang to be identical to *Orestes draegeri* Bresseel & Constant 2018 from South Vietnam. Since specimens from elsewhere in Peninsular Malaysia and Singapore are identical morphologically to specimens in Penang, there is no reason to doubt that these are conspecific.

Males of this species had been found in Vietnam. In Peninsular Malaysia and Singapore, *O. draegeri* is parthenogenetic. No males have ever been found in Singapore and nymphs hatched from these eggs are all females.

Family: Phylliidae
Subfamily: Phylliinae
Species: *Cryptophyllium chrisangi* (Seow-Choen, 2017).
Foodplants: *Mangifera indica*, *Psidium guajava*, *Dimocarpus longan*, *Hibiscus tiliaceus.*

Cryptophyllium chrisangi (Seow-Choen, 2017) was until recently known as *Phyllium (Phyllium) chrisangi* Seow-Choen 2017. The species is now placed in a new genus recently erected by Cumming et al. (2020). It is widespread although not commonly seen along mangrove coasts in Singapore, including those of Pulau Ubin. This is a large, attractive and unusual species. The female resembles the leaves of trees in many respects. Females possess wings but are unable to fly as their bodies are heavy and their hind-wings are small. Their tegmina or fore-wings are hard wing-cases which are designed for camouflage and not for flight. The males are more slender than the females. They have very good flight and are arguably less leaf-like. Mango, longan and guava leaves are foodplants of this species. However, an intensive search amongst quite a few of the mango and guava plants present on Pulau Ubin did not reveal any specimens of this stick insect. Three specimens were found on a longan tree on one trip and one adult male was found on the same longan tree on another trip. Males are sometimes caught flying to light and one specimen was caught flying to a light source during this survey.

Discussion

The Comprehensive Ubin Biodiversity Survey 2018–2020 showed that there are only five species of stick insect present on Ubin. One pair of an undescribed species of *Trachythorax* had been photographed but not been seen since the first encounter. The other four species, *Lonchodes brevipes* Gray 1835, *Sipyloidea sipylus* (Westwood, 1859), *Orestes draegeri* Bresseel & Constant 2018 and *Cryptophyllium chrisangi* (Seow-Choen, 2017) appear in relatively larger numbers on Pulau Ubin compared to the forests in mainland Singapore.

Stick and leaf insects are generally specialised feeders. They are very reliant on their specific foodplants for survival. Foodplants of the stick and leaf-insects of Singapore had been discussed and listed in several publications previously (Seow-Choen et al., 1994; Tay & Seow-Choen, 1996; Seow-Choen, 2017). Of the five species present on Pulau Ubin, three species feed and thrive on *Hibiscus tiliaceus,* a plant of mangrove swamp, and the fact that these insects are abundant on these plants is remarkable. This intimate relationship between insects and their host-plants must be better studied and understood. Conservation of any animal must rely on good research and the creation of suitable environments for these insects to live and reproduce successfully.

The relative paucity of stick insect biodiversity on Pulau Ubin probably relates to the previous extensive utilisation of the island for agriculture. Extensive agriculture no doubt entailed the widespread use of pesticides and herbicides. Stick and leaf insects are very host-plant specific. The clearing of forested areas would firstly reduce the availability of the required host-plants of species. This would necessarily limit the number of species that may be sustained on the island. Secondly, the extensive use of insecticides and herbicides on agricultural land will definitely reduce the occurrence of insect species in such areas.

The relative abundance of the few species which are found in or near the mangrove swamps on the other hand, hints at the proliferation of insects which thrive on plants which grow in or near mangrove swamps. This may be due to the sparing of these non-agricultural areas from the use of toxic chemicals in the past. The abundance of the species of host food-plants for these insects in these mangrove areas is another contributory factor for the relative abundance of these species compared to mainland Singapore.

Conclusions

Pulau Ubin has a very limited diversity of stick and leaf-insects. However, the abundant supply of foodplants on Pulau Ubin supports an amazing number of these few species. This sort of host-plant/insect relationship must be taken into consideration when designing ecological models and land-use planning, in the quest to enable a sustainable insect population anywhere in the world and specifically on Pulau Ubin.

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The significance of Pulau Ubin for Singapore's avifauna, with a focus on species of conservation concern

K.M. Teo[1,4], K.C. Lim[2], L.J. Lin[1], K.K. Lim[2], D.L. Yong[2,3], S.M.J. Soh[1] & L.H. Ng[1]

[1]National Parks Board, Pulau Ubin Branch,
61 Pulau Ubin, Singapore 508310
[2]Nature Society (Singapore), Bird Group
510 Geylang Rd, Singapore 389466
[3]BirdLife International (Asia)
354 Tanglin Road, Tanglin International Centre,
Singapore, 247672
[4]Author for correspondence
E-mail: teo_kah_ming@nparks.gov.sg

ABSTRACT. Pulau Ubin's diverse ecosystems on the Singapore-Malaysia frontier form the core of an Important Bird and Biodiversity Area (IBA), Ubin-Khatib. The island supports one of the richest bird faunas in Singapore with more than 250 recorded species, including 26 nationally threatened species and important populations of two globally threatened species. Here, we report on the first ever comprehensive study of Pulau Ubin's avifauna using standardised sampling carried out over two years (2018–2019). We observed a total of 173 species during our surveys, of which 151 species were detected in (diurnal) point counts and shown by diversity estimators to have reached 77.4–92.2% of sampling saturation. An additional 22 species were recorded from the shorebird-focused and nocturnal surveys, as well as two species previously unknown to Pulau Ubin. Our analyses showed considerable overlap in bird species composition across six distinct vegetation types, with several generalist species traversing different habitats. Our density estimates of five species of concern confirmed the importance of Pulau Ubin for their conservation nationally and internationally, with the island supporting exceptionally high densities of the Straw-headed Bulbul. Overall, our study reinforces the importance of Pulau Ubin for bird conservation, and the need for continued monitoring, enforcement and conservation management.

Keywords. biodiversity, conservation, citizen science, island, landscape, habitat heterogeneity, monitoring, songbird, Straw-headed Bulbul, surveys.

Introduction

The low-lying island of Pulau Ubin abuts the international border between Singapore and Malaysia on the Straits of Johor, south-west of the mangrove-lined estuary of the Johor River. As Singapore's second largest satellite island, Pulau Ubin and its coastal waters form the heart of the Ubin-Khatib Important Bird and Biodiversity Area (IBA) and Key Biodiversity Area (KBA) (Yong et al., 2016; Key Biodiversity Area Partnership, 2020; BirdLife International, 2021), an important forest-to-coast landscape in Singapore that supports rich terrestrial and marine biodiversity (Lim & Gardner, 1997; Chua, 2000; Lim, 2009; Chua et al., 2016). Pulau Ubin's importance for bird diversity has been recognised since colonial times (e.g. Kelham, 1883; Chasen, 1925; Bucknill & Chasen, 1927), while recent inventories have identified in excess of 250 species for Pulau Ubin and its inshore waters, including several nationally and/or globally threatened (Chua, 2000; Lim, 2009; Teo, 2014; Tan, 2018; Lim et al., 2020; Lim, 2021). Among the best known of Pulau Ubin's flagship species is the Critically Endangered Straw-headed Bulbul *Pycnonotus zeylanicus*, a highly threatened, charismatic species where Pulau Ubin is known to be a globally important stronghold (Wells, 2007; Yong et al., 2016; Chiok et al., 2020), and the Vulnerable Chinese Egret *Egretta eulophotes* which winters in small numbers annually (Lim et al., 2020).

Despite its small area, Pulau Ubin supports a diverse and highly heterogeneous landscape mosaic of secondary forests of varying stature and extensive areas of mangrove forests, including some of the largest mangrove remnants left in Singapore along several tidal creeks (i.e. mangroves along Sungei Besar–Sungei Puaka, see also Chua, 2000; Koh et al., 2002; Yee et al., 2010; Yang et al., 2011). There are also substantial areas of fruit orchards (Durian *Durio zibethinus*, Jackfruit *Artocarpus heterophyllus*), abandoned rubber plantations and open woodland dominated by stands of *Acacia auriculiformis* and *Falcataria falcata* (Chua, 2000; Lim, 2009). On the island's eastern extremity are patches of disturbed coastal hill forest (Lee et al., 2003; Tan, 2018), a remnant of Pulau Ubin's original forest cover that once supported extirpated species such as the Scarlet-rumped Trogon *Harpactes duvauceli* and Blue-eared Barbet *Psilopogon australis* (Chasen, 1925; Gibson-Hill, 1950; Lim, 2009). Additionally, there are extensive areas of intertidal flats and estuarine waters, known to support congregations of more than 10 migratory shorebird species (Kelham, 1883; Tan & Yeo, 2003; Yong et al., 2017) and thus of conservation significance.

Several bird species have an important or, if not, a major part of their national populations on the island, including nationally threatened or highly localised species such as Great-billed Heron *Ardea sumatrana*, Oriental Darter *Anhinga melanogaster*, Brown Wood Owl *Strix leptogrammica*, Mangrove Pitta *Pitta megarhyncha*, White-rumped Shama *Copsychus malabaricus*, Oriental Pied Hornbill *Anthracoceros albirostris* (Davison et al., 2008; Lim, 2009; Ng et al., 2011; Ng et al., 2017) and Straw-headed Bulbul, a species first recorded in Singapore on Pulau Ubin (Lim, 2009; Yong et al., 2016). In the earliest national assessment of threatened birds, Lim (1992) reported more than 20 species of conservation concern on Pulau Ubin, and this number has since increased. Biodiversity surveys conducted by the National Parks Board and other researchers have continually detected new species or new breeding records for Pulau Ubin (or even at the national level) into the present day (e.g. Chua et al., 2009; Lim et al., 2011; Low et al., 2016; Li, 2017; Lim & Tan, 2019), thereby demonstrating the high terrestrial diversity on the island.

Although Pulau Ubin's avifauna is familiar to local birdwatchers, there has been, to date, no systematic study of the island's bird diversity using standardised sampling approaches. Our study aimed to address these knowledge gaps by comprehensive sampling of all of Pulau Ubin's major habitat types using a combination of a point-count approach and targeted transects for night birds and shorebirds. We identified three research questions in our study, (1) how heterogeneous is the composition of bird communities in each of the six main vegetation types on Pulau Ubin, (2) how many species of birds regularly occur on Pulau Ubin and the areas of high diversity, (3) what are the densities and local distributions of five key species of conservation interest on Pulau Ubin (Straw-headed Bulbul, White-rumped Shama, Oriental Pied Hornbill, Abbott's Babbler *Malacocincla abbotti*, Red Junglefowl *Gallus gallus*). We present our results based on two years of large-scale systematic fieldwork and discuss the implications of our findings on the long-term conservation and management of Pulau Ubin's heterogeneous and biologically rich landscape and coastline.

Materials and Methods

Standard point counts

We established 10 major transects covering all major terrestrial habitat types on Pulau Ubin (Fig. 1), and along presently accessible roads and tracks. Point counts were conducted along these transects from January 2018 to December 2019 over 24 months, and only from 7.30 am–10.30 am. Each count was conducted at pre-identified points spaced at least 250 m apart to minimise spatial correlation and counted by at least one experienced observer for 10 minutes. At each count, the approximate distance of the bird from the observer was also estimated and recorded in distance bands of '<10 m', '10–50 m', '50–100 m' and '>100m'. All birds seen or heard were recorded in point counts. Species nomenclature follows Lim (2021).

Shorebird surveys (transects)
To determine the diversity and relative abundance of shorebirds in the eastern coastline of Pulau Ubin (at Chek Jawa) and surrounding islets, we conducted shorebird surveys along one established transect (along a coastal boardwalk). Shorebird surveys were conducted during periods of low tide based on published tide information. We conducted a total of 22 shorebird transect counts over the survey period from the months of October to April in the two study years. Besides shorebird species, we also recorded several herons and egrets, and seabirds typically associated with coastal wetlands.

Nocturnal bird surveys
To determine the diversity and relative abundance of nocturnal bird species (i.e. owls, nightjars), we conducted nocturnal bird surveys along 10 established transects on a quarterly basis (four counts per year, Fig. 1). All transects were walked from 7.30 pm–9.30 pm by at least two observers. All birds seen or heard were counted by walking the transects. A total of seven cycles of nocturnal surveys were conducted over the study period.

Statistical Analysis
We plotted a species accumulation curve to estimate species richness and the extent of our sampling completeness with respect to Pulau Ubin's 'true' diversity. We used the function 'specaccum' in the R package 'Vegan' which adds data in random order without replacement with 1,000 permutations. All recorded species were categorised in five levels of relative abundance defined by the number of sampling points at which the species was recorded (see Table 1). Non-metric multi-dimensional scaling (NMDS) was performed using the function 'metaMDS' to compare bird species composition in six distinct vegetation types adapted from Yee et al., (2019); this included *Adinandra* belukar forest, Albizia-dominated forest, grassland, mangroves, secondary forest after fruit orchards, and secondary forest after rubber plantation. Bray-Curtis dissimilarity was used as the metric of community composition in this analysis. Statistical analyses were conducted using 'Vegan' package version 2.5-6 in R ver. 3.5.2 on R Studio (R Core Team, 2020).

To identify sites of high abundance (i.e., hotspots) for five key species of conservation concern (see Lim, 1992; Davison et al., 2008), we generated hotspot maps of points with the size-graduated function in QGIS 3.4.15, based on the observed count at each sampling point. The five key species are Abbott's Babbler, Oriental Pied Hornbill, Red Junglefowl, Straw-headed Bulbul, and White-rumped Shama. A similar overall species richness hotspot map was generated with the same method but this was based on species richness at each point.

Following this, we performed distance analysis to estimate the population densities of five species of conservation concern, using the package 'Unmarked' version 0.13-2 in R ver. 3.5.2 (R Core Team, 2020). We pooled data collected between January to June 2018 for our analysis in order to retain adequate number of observations, while applying the assumptions of a closed population for these species. As the data involve repeated surveys at the same series of sampling points, pseudo-replication might be a concern. However, Buckland (2006) has reported negligible effects of overlapping count stations on the results through simulations, and repeated surveys at the same sampling points are essentially 100% overlapping stations. Using the distance sampling function ‘distsamp’ (Fiske and Chandler 2011), we fitted a series of candidate models to a series of detection functions – (1) uniform, (2) half-normal, (3) hazard-rate and (4) negative polynomial for each of these five species. We then selected the best-fitted model from the set of candidate models based on its Akaike’s Information Criteria (AIC), and computed the mean density estimate for each species and its 95% confidence interval.

Results

Species richness and composition

Our surveys using point counts recorded a total of 151 bird species. Our species accumulation curve based on pooled point-count data has not reached a plateau but showed that we have detected the majority of species on Pulau Ubin (Fig. 2). The four species richness estimators (Chao, Jackknife1, Jackknife2, and Bootstrap) predicted that Pulau Ubin’s diurnal terrestrial species richness ranged from 161 to 200 species and showed that 77.4 to 92.2% of species were detected in our surveys (Table 2).

Including species detected in the nocturnal surveys and shorebird surveys, we recorded a total of 173 species. Of the 151 species detected in the point counts, 14.6% of species (22 species) are considered as ‘very common’. 10.6% (16 species) are ‘common’. Uncommon species (species only recorded at 25 to 50% of sampled points) stood at 10.6% (16 species) while 25.8% are considered ‘rare’ (39 species). The remaining 38.4% (58 species) were represented with very few records, being observed at fewer than 5% of the points.

Of 173 recorded species, 56 are species represented by migratory populations in Singapore (see Lim, 2021). Among resident and non-migratory species are 26 species that are considered as nationally threatened (see Davison et al., 2008; Lim, 2009), while two are globally threatened (i.e. Straw-headed Bulbul and Long-tailed Parakeet). We found that the Straw-headed Bulbul and White-rumped Shama were the most widely distributed species in Pulau Ubin, occurring at more than 95% of all sampling points (see Table A1). The Oriental Pied Hornbill is common and a highly detectable species but appeared to be scarce or absent on the western sector of the island.

Several species are possibly either rare (non-breeding) visitors from Malaysia (i.e. Buff-rumped Woodpecker *Meiglyptes tristis*, Black Hornbill *Anthracoceros malayanus*, Ruby-cheeked Sunbird *Chalcoparia singalensis*) or relict populations of now very rare resident species (Black-winged Flycatcher-shrike *Hemipus hirundinaceus*) associated with coastal forest habitat (Lim et al., 2020). Two of these are recorded on Pulau Ubin for the first time (excluding Black Hornbill). Our surveys also confirmed that a small breeding population of the Blue-winged Pitta *Pitta moluccensis* persists on Pulau Ubin, and it appears to be fairly widely distributed, occurring at 45% of sampling points (see Table A1 in Appendix). This species was formerly unknown as a breeding species in the southern Malay Peninsula and appears to have recently colonised Pulau Ubin as a breeder (Low et al., 2016). It is unclear if this population on Pulau Ubin is migratory.

Our survey of intertidal wetlands on eastern Pulau Ubin (i.e. Chek Jawa) found 15 shorebird species, including significant counts of species rare elsewhere in Singapore, particularly Red-necked Stint *Calidris ruficollis*, Sanderling *C. alba*, Grey Plover *Pluvialis squatarola* and Lesser Sand-plover *Charadrius mongolus*. While no species occurred at congregations exceeding the 1% threshold at the flyway level, more than five species are Near Threatened at the global level.

The NMDS analysis (stress = 0.0991) produced a fair fit (Kruskal, 1964), and revealed discernible clustering in bird composition across the vegetation types, despite considerable overlap (Fig. 3). The secondary forest after fruit plantation forms the biggest vegetation type surveyed and has the most diverse species composition. Secondary forest after rubber plantation and mangrove shared overlap with secondary forest after fruit plantation, but clearly show distinct clusters of its own. *Adinandra* belukar forest, Albizia-dominated forest and grassland almost overlap completely with the other three vegetation types.

Species-rich areas on Pulau Ubin

Our point-count data showed that areas of high species richness were clustered in the southern and south-western parts of Pulau Ubin, particularly along the southern vegetated fringes of three major disused granite quarries (i.e. Ketam Quarry, Ubin Quarry and Pekan Quarry) (Fig. 5). Another hotspot of high species richness occurred in the eastern sector of Pulau Ubin, along the fringes of another major disused quarry (i.e. Balai Quarry).

Density estimates and distribution of species of conservation concern

Red Junglefowl (*Gallus gallus*)

Based on the best-fitting model, we estimated the density of the Red Junglefowl at 0.316 ± 0.071 individual/ha (Table 3; Fig. 4a). Our count data showed that the species is widely distributed across the island in secondary forests, with elevated abundances in the western, and eastern sectors of Pulau Ubin (Fig. 6a).

Oriental Pied Hornbill (*Anthracoceros albirostris*)

We estimated the density of the Oriental Pied Hornbill at 0.747 ± 0.279 individual/ha (Table 3; Fig. 4b). Using observed count data, we found the species to be concentrated largely to the southern sectors of the island, with few records in western Pulau Ubin (Fig. 6b).

Straw-headed Bulbul (*Pycnonotus zeylanicus*) CR

We estimated the density of the Straw-headed Bulbul at 2.980 ± 0.597 individual/ha (Table 3; Fig. 4c). Based on observed count data, Straw-headed Bulbuls appear to be distributed widely throughout the island, occurring across different habitat types (Fig. 6c).

Abbott's Babbler (*Malacocincla abbotti*)

We estimated the mean density of Abbott's Babbler at 0.063 ± 0.015 individuals/ha (Table 3; Fig. 4d). Using observed count data, we found the species to be widely distributed across Pulau Ubin in secondary forest and plantations, with the highest abundances in the western sectors of the island (Fig. 6d).

White-rumped Shama (*Copsychus malabaricus*)

We estimated the density of the White-rumped Shama at 6.242 ± 0.979 individual/ha (Table 3; Fig. 4e). Based on observed count data, the White-rumped Shama appear to be distributed widely across the island, but mostly confined to secondary forests and plantations, and less so in mangroves (Fig. 6e).

Discussion

Our two-year long study is the first-ever systematic survey of Pulau Ubin's bird communities, with sampling sites spanning the full complement of habitats present on the island and its coastline. Our surveys found a total of 173 species, of which 151 species were detected through point-count sampling, and the remainder from shorebird or nocturnal bird specific surveys. Two nationally rare species were documented for Pulau Ubin for the first time, namely Buff-rumped Woodpecker and Ruby-cheeked Sunbird. A few species recorded from our surveys are known in Singapore only from Pulau Ubin, namely Black Hornbill, Little Stint *Calidris minuta*, and Scarlet-breasted Flowerpecker *Prionochilus thoracicus* (Li, 2017; Lim et al., 2020). Pulau Ubin's proximity to remnant forests and extensive estuarine mangroves in southern Johor across the Tebrau Straits meant that it forms a natural sink for species dispersing from source areas in Malaysia. Our surveys also demonstrate, for the first time, the importance of the intertidal flats in eastern Pulau Ubin as a nationally significant congregation site for migratory shorebirds, many species that are increasingly rare elsewhere in Singapore (e.g., Grey Plover).

Our NMDS analysis showed that bird species assemblages in secondary forests that have regenerated from fruit orchards and rubber plantations respectively, and mangrove forests formed three discernible clusters. Bird assemblages in other vegetation types, however, were highly similar, as shown by the large overlaps (Fig. 3). This suggests that bird communities on Pulau Ubin are dominated by generalists which are able to use different vegetation types. Given the relatively low cover of *Adinandra* belukar, Albizia-dominated forest and grassland in Pulau Ubin, it is unlikely that the species found in these areas are associated with a single vegetation type. As such, generalist species are favoured, and these three vegetation types do not support bird assemblages that are distinct from secondary forests and mangroves. In addition, as Pulau Ubin is a highly diverse and heterogeneous landscape mosaic of different vegetation and habitat types, it may not be surprising to find species occurring across a few vegetation types, as different forests are in close proximity.

Our hotspot analysis showed that areas of high bird diversity on Pulau Ubin tend to be adjacent to disused quarry lakes (Fig. 5), as indicated by high species richness at the site level. While higher species richness could be attributed to the relative openness near these sampling points allowing more species to be detected, it is possible the presence of water bodies and landscape heterogeneity at the small-spatial scale (i.e. edges, water, different vegetation cover) enhance species diversity.

Species of conservation concern on Pulau Ubin

Our species-specific analyses showed that the occurrences of five species of conservation concern in Pulau Ubin were uneven, with some species widely distributed across the island (e.g., White-rumped Shama) while others occurred at higher abundances in parts of the island. For instance, Red Junglefowl is more commonly found in the eastern and western parts of

Pulau Ubin, while Abbott's Babbler appeared commoner in the central and western parts. Our findings demonstrate Pulau Ubin's high bird diversity, and its conservation importance to species at the national and global level.

Out of all the species of conservation concern, the White-rumped Shama has shown the highest density at 6.242 ± 0.979 individuals/ha, followed by Straw-headed Bulbul at 2.980 ± 0.597 individuals/ha. The density estimates for the Straw-headed Bulbul is far higher than that by Chiok et al., (2020) and Yong et al., (2016), but this may be a consequence of over-detection, due to the conspicuous habits of this species. Our data show that Straw-headed Bulbul remains widely distributed in Pulau Ubin, and is able to utilise secondary forests, forest edges and old plantations as habitat (see also Robson, 2008; Wells, 2007; Lim et al., 2020), although it is unlikely to favour areas that are predominantly mangroves. We hypothesise that the species depend on highly heterogeneous habitat, and habitat edges abutting (man-made) water bodies, an environment which is common on Pulau Ubin.

The Oriental Pied Hornbill is a species first documented in Singapore from Pulau Ubin, from where it has since spread widely (Lim, 2006; Wells, 1999), partly through human-assisted means (Chua et al., 2016). However, Pulau Ubin's secondary forest environment evidently remains a stronghold for the species and several studies of its breeding ecology have been carried out here (Ng et al., 2011; Huang, 2011; Chua et al., 2016). Our estimate of the species density is 0.747 ± 0.279 individuals per ha, which would translate to an estimate of its local population that is higher than the previous estimates of 60 individuals in Pulau Ubin (National Parks Board, 2013).

As the data in our survey were largely collected by citizen scientists, the ability of individual surveyors to determine distance from an observed animal accurately, or to assess calls coming from a unique individual may vary greatly, with implications on analyses and density estimates. The high detectability of some species due to their vocal behaviours may drive biases in higher observer detections. Another limitation of our study is sampling bias given that point counts were located along roads and open trails, which are more open. Observers may perceive the auditory cues as louder and possibly underestimate the distance between the source of calls and their location.

Conservation implications for Pulau Ubin's birds

Although Pulau Ubin has lost virtually all of its old-growth forest cover, the island continues to retain a high proportion of forest cover which today comprises a mosaic of secondary forests, regenerating woodland, plantations and some of the most extensive areas of mangroves present in Singapore (Yang et al., 2011), and remnants of disturbed coastal forests. Our analyses suggest this habitat heterogeneity most likely explains the high species richness, while providing preferred (edge interfaces) habitats used by species like the Straw-headed Bulbul and Oriental Pied Hornbill. The proximity of Pulau Ubin to source habitats in southern Malaysia means that the island likely receives a stream of dispersing species (e.g. Black Hornbill, Buff-rumped Woodpecker, Ruby-cheeked Sunbird), as well as vagile species that utilise coastal habitats along the Singapore-Malaysia frontier (e.g. Great-billed Heron, Crested Serpent Eagle *Spilornis cheela*). Our findings also show for the first time that Pulau Ubin supports some of the most important congregations of migratory shorebirds in Singapore's coastal wetlands.

Our results demonstrate the need for a sustained, evidence-based management of Pulau Ubin's mosaic landscapes and coastal wetlands to better conserve the island's ecosystems and particular threatened species. By identifying areas of high species richness or areas used by threatened species at finer spatial scales, our findings provide insights that can strengthen bird conservation in Pulau Ubin by means of prioritising important features of the island's landscapes for strengthened management actions, while guiding ecological restoration to improve habitat quality.

From our results, we offer five key recommendations for strengthening (bird-specific) conservation management actions for Pulau Ubin. First, we recommend sustained habitat restoration work to improve habitat connectivity and quality (e.g., plantings of native species in cleared areas, removal of invasive plants). Habitat restoration can benefit species by increasing food sources for species in certain ecological guilds, while enhancing habitat structure and microclimates favoured by particular species. Second, we recognise a need for continued enforcement and patrol efforts to protect species targeted by the songbird trade. Third, we recommend improved zonation of the island's landscape to limit access to sensitive areas of habitat to minimise anthropogenic disturbance. Fourth, we recommend further research to better understand the ecology of key species at higher spatial resolutions. This can in turn underpin evidence-based, conservation actions that can be adapted to benefit threatened and rare species such as the Mangrove Pitta, Great-billed Heron and Straw-headed Bulbul. Last, we recommend sustained biodiversity monitoring work for key indicator species and species groups using data compiled from our surveys as baselines. This is to provide a regular stream of information to guide adaptation in management actions for Pulau Ubin. If effectively implemented, these actions can ensure that biodiversity can be better protected, while human usage of Pulau Ubin's environment for recreation can be considered in a sustainable manner.

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Jamie Chan
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Jane Heppell
Jayasri Lakshminarayanan
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Liu Xinlu
Long Hongquan
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Nicky Ng
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Orlando L Osano Jr
Pereira Kerry Mervyn
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Richard Stanly
Robin Arnold
Roger Boey Kwang Wye
Ryuta Teo

See Toh Yew Wai
Shivaram Rasu
Sin Yong Chee Keita
Steven Lee
Steven Shields
Tan Hui Xian Rebecca
Tan Hui Zhen
Tan Jian Xiong David
Tan Ju Lin
Tanvi Dutta Gupta
Tay Yi Ling
Teo Hui Min
Terry Heppell
Thio Hui Bing
Tok Sock Ling Sox
Twang Fangqi
Veronica Foo Tse Fen
Wee Kai Bin
Wong Chee Weng
Wong Chung Cheong
Wong Yeang Cheng (YC)
Yap Wee Jin
Yap Yoon Seng Francis
Yeo Seng Beng

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List of figures and figure annotations

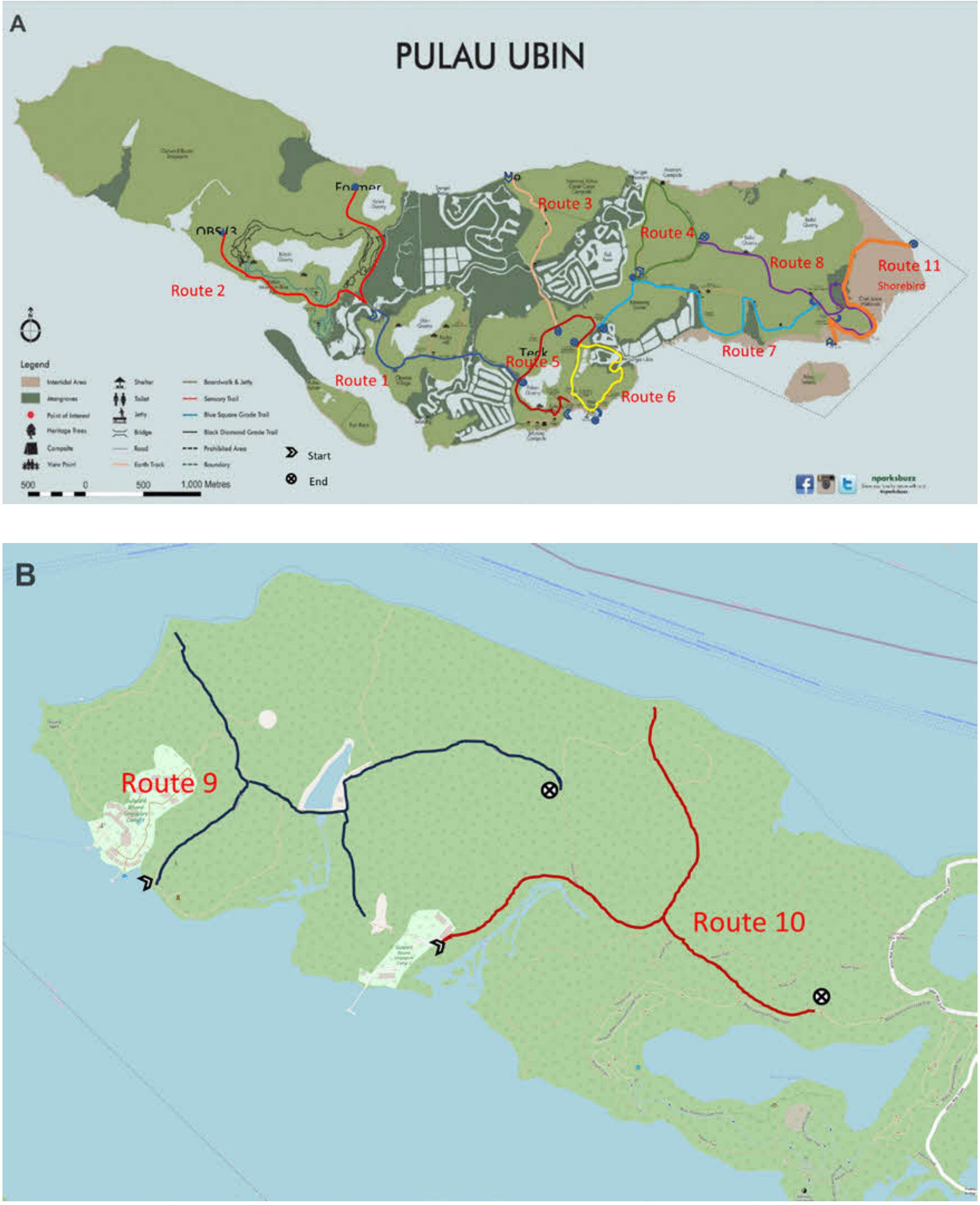


Fig. 1 (**A**) Map of Pulau Ubin and transects (Non-OBS areas), (**B**) Map of western Pulau Ubin and transects (OBS area)

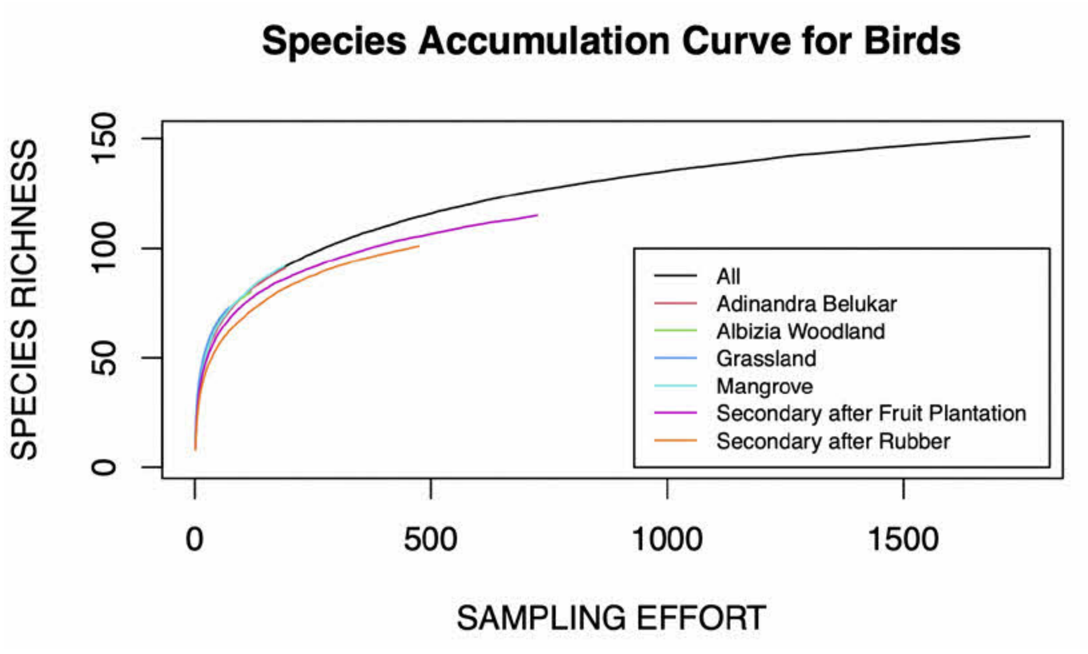


Fig. 2 Species accumulation curves for overall study, and habitat-specific accumulation curves for all major habitats sampled.

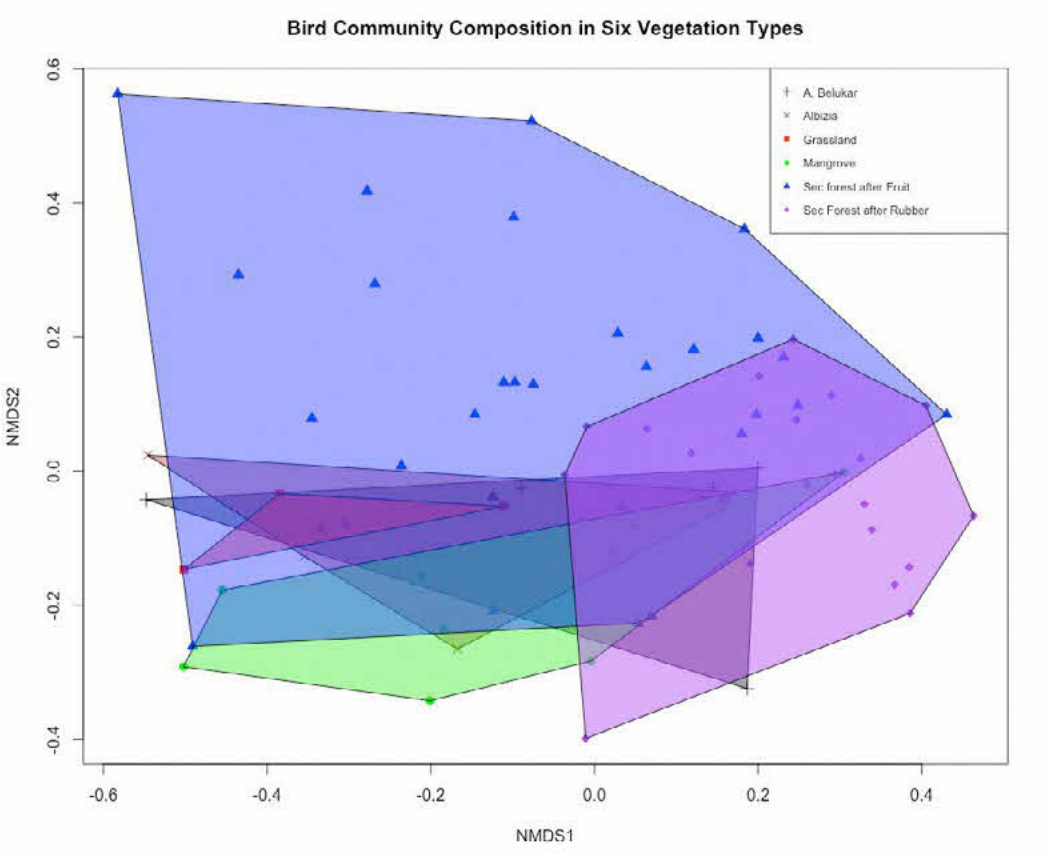


Fig. 3 Non-metric multi-dimensional scaling plot for all bird species found in the sampling points for CUBS survey.

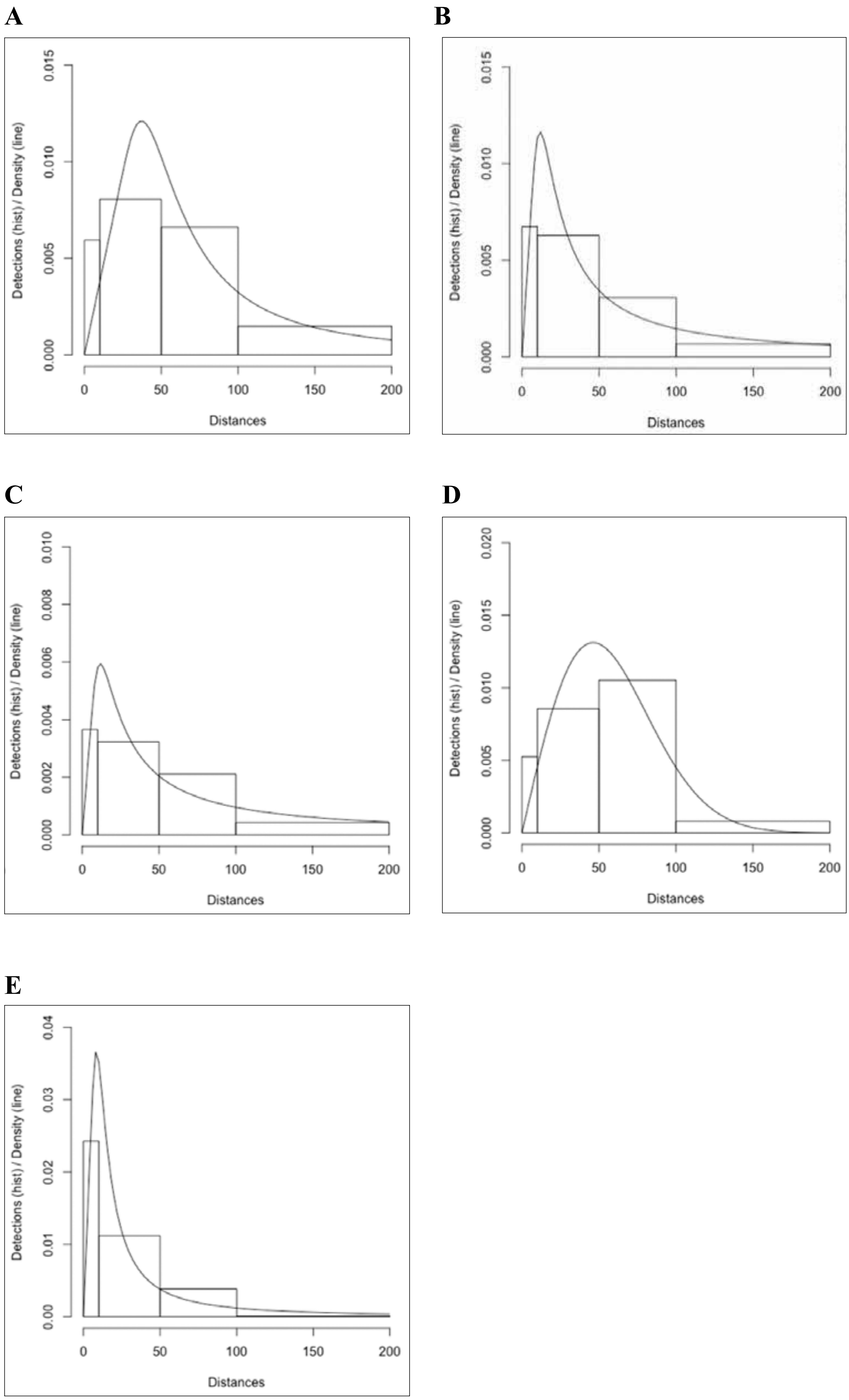


Fig. 4 Histograms of distances and density for five species of conservation concern in Pulau Ubin: (**A**) Red Junglefowl, (**B**) Oriental Pied Hornbill, (**C**) Straw-headed Bulbul, (**D**) Abbott's Babbler and, (**E**) White-rumped Shama.

Fig. 5 Overall species richness hotspot for all the species found in Pulau Ubin using point count data.

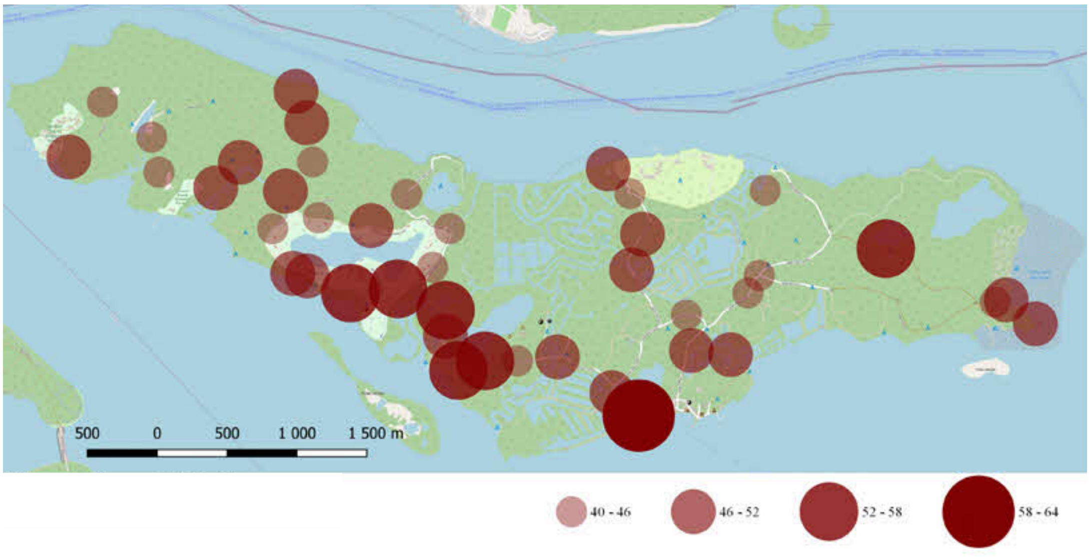
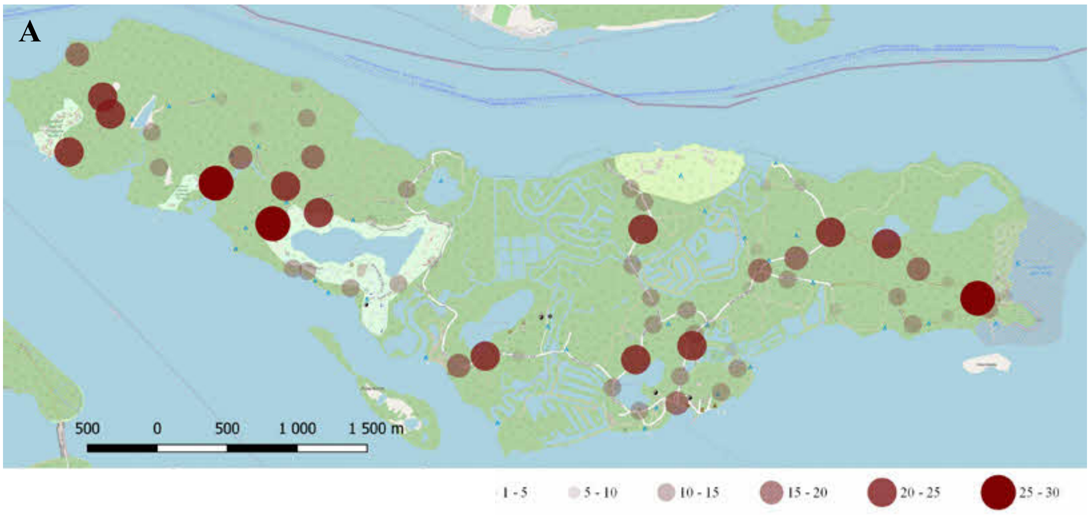


Fig. 6 Hotspot maps for five species of conservation concern in Pulau Ubin: (**A**) Red Junglefowl, (**B**) Oriental Pied Hornbill, (**C**) Straw-headed Bulbul, (**D**) Abbott's Babbler and, (**E**) White-rumped Shama.



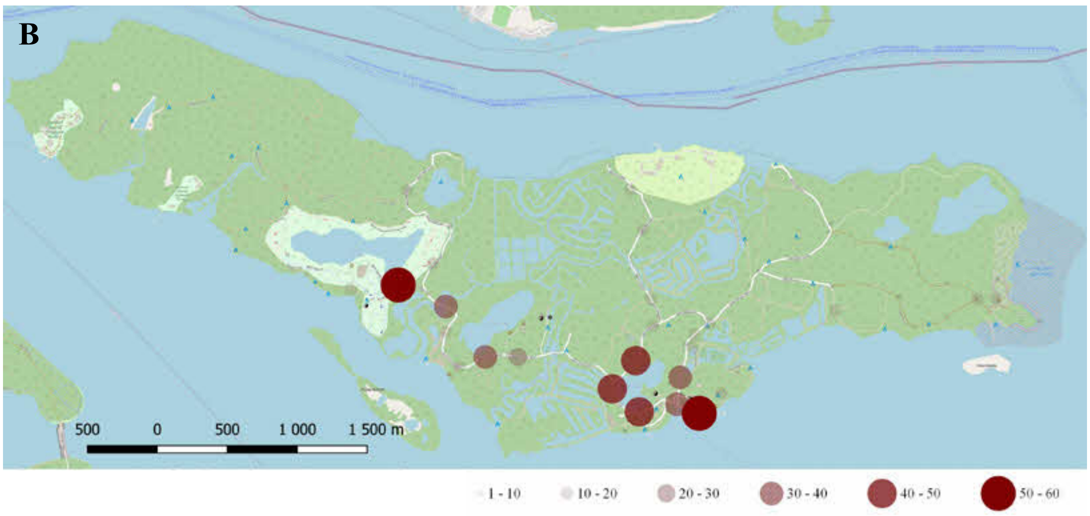


Fig. 6 Continuation

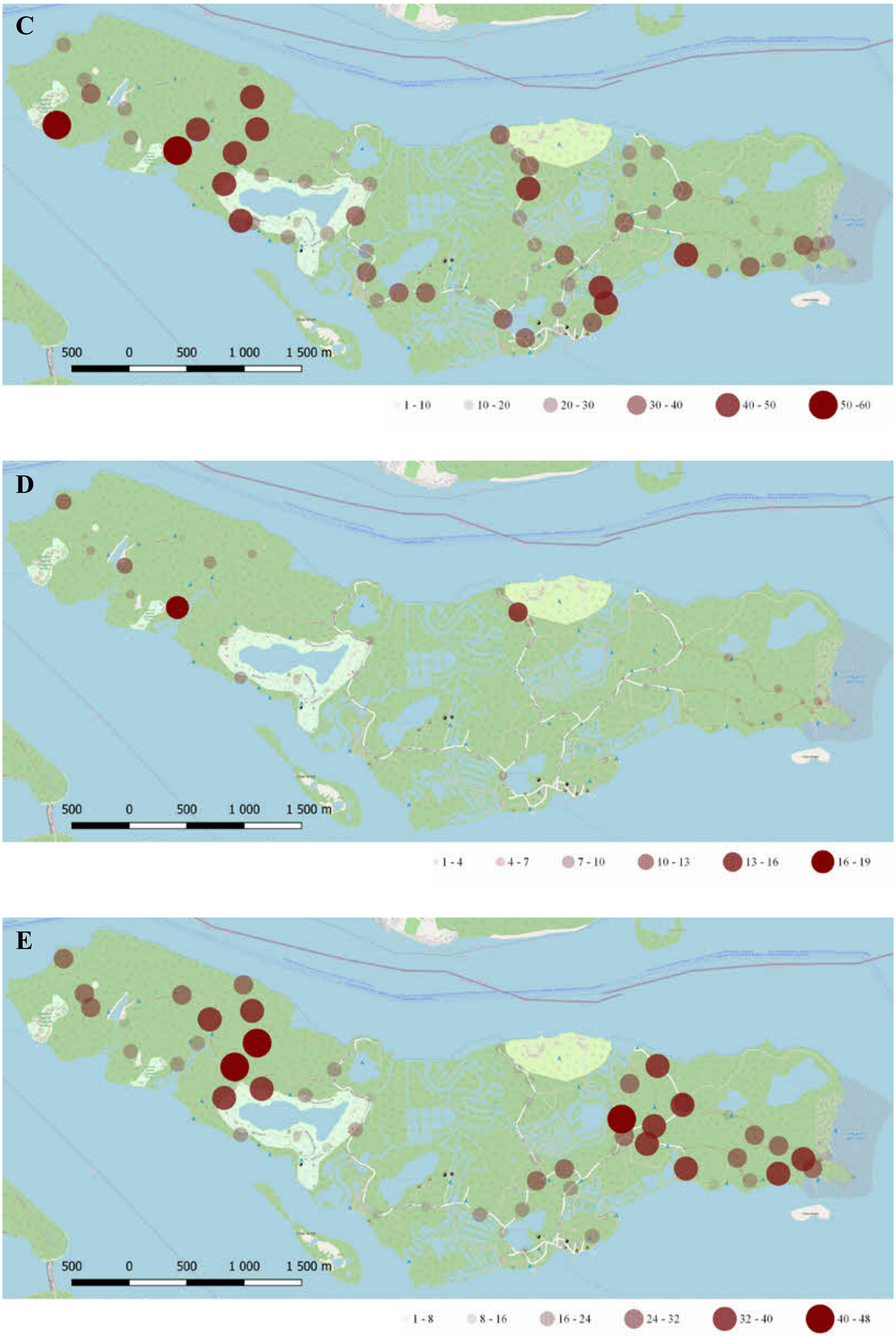


Table 1. Definition of categories of abundance of birds in Pulau Ubin found during point counts

Abundance categories	Definition
Very Common	More than or equal to 75% of the total sampling points recorded
Common	50 to 75% of the total sampling points recorded
Uncommon	25 to 50% of the total sampling points recorded
Rare	5 to 25% of the total sampling points recorded
Very Rare	Less than 5% of the sampling points

Table 2. Total bird species recorded in point count surveys and estimated species richness using the Chao, Jackknife1, Jackknife2, and Bootstrap estimators (with standard errors shown)

Species richness				
Observed	Chao	Jack1	Jack2	Bootstrap
151	183.0 ± 16.5	179.0 ± 5.3	195.0	163.7 ± 3.0
Proportion detected (%)	82.5	84.4	77.4	92.2

Table 3. Density estimates and range of 95% confidence intervals based on best-fit models

Species	No of observations	Best-ranked Model	Density (individuals/ha)	SE	Lower 95% CI (individual/ha)	Upper 95% CI (individual/ha)
Red Junglefowl	203	Hazard-rate	0.316	0.071	0.203	0.491
Oriental Pied Hornbill	88	Hazard-rate	0.747	0.279	0.360	1.552
Straw-headed Bulbul	386	Hazard-rate	2.980	0.597	2.013	4.413
Abbott's Babbler	38	Half-normal	0.063	0.015	0.039	0.101
White-rumped Shama	298	Hazard-rate	6.242	0.979	4.590	8.490

Appendices

Table A1. List of birds recorded from all CUBS surveys (point-counts, nocturnal surveys and shorebird surveys), their national (Davison et al., 2008) and global conservation statuses, and abundance in Pulau Ubin as defined in Table 1

Family	Species	Scientific Name	National Status	Global Status	Abundance	No of pts observed	%	Abundance in Pulau Ubin
Cisticolidae	Dark-necked Tailorbird	*Orthotomus atrogularis*	-	-	C	75	100.0%	Very Common
Columbidae	Pink-necked Green Pigeon	*Treron vernans*	-	-	A	75	100.0%	Very Common
Nectariniidae	Brown-throated Sunbird	*Anthreptes malacensis*	-	-	C	75	100.0%	Very Common
Pycnonotidae	Olive-winged Bulbul	*Pycnonotus plumosus*	-	-	C	75	100.0%	Very Common
Pycnonotidae	Straw-headed Bulbul	*Pycnonotus zeylanicus*	t	T	U	75	100.0%	Very Common
Aegithinidae	Common Iora	*Aegithina tiphia*	-	-	C	74	98.7%	Very Common
Dicaeidae	Scarlet-backed Flowerpecker	*Dicaeum cruentatum*	-	-	C	74	98.7%	Very Common
Muscicapidae	Oriental Magpie-Robin	*Copsychus saularis*	t	-	U	74	98.7%	Very Common
Oriolidae	Black-naped Oriole	*Oriolus chinensis*	-	-	A	74	98.7%	Very Common
Phasianidae	Red Junglefowl	*Gallus gallus*	t	-	C	74	98.7%	Very Common
Sturnidae	Asian Glossy Starling	*Aplonis panayensis*	-	-	A	74	98.7%	Very Common
Nectariniidae	Crimson Sunbird	*Aethopyga siparaja*	-	-	C	73	97.3%	Very Common
Nectariniidae	Olive-backed Sunbird	*Cinnyris jugularis*	-	-	C	73	97.3%	Very Common
Muscicapidae	White-rumped Shama	*Copsychus malabaricus*	t	-	U	72	96.0%	Very Common
Sturnidae	Javan Myna	*Acridotheres javanicus*	-	T	A	72	96.0%	Very Common
Alcedinidae	Collared Kingfisher	*Todiramphus chloris*	-	-	A	71	94.7%	Very Common
Accipitridae	White-bellied Sea Eagle	*Haliaeetus leucogaster*	-	-	C	69	92.0%	Very Common
Cisticolidae	Common Tailorbird	*Orthotomus sutorius*	-	-	C	66	88.0%	Very Common
Bucerotidae	Oriental Pied Hornbill	*Anthracoceros albirostris*	t	-	C	64	85.3%	Very Common
Cisticolidae	Ashy Tailorbird	*Orthotomus ruficeps*	-	-	C	63	84.0%	Very Common
Picidae	Common Flameback	*Dinopium javanense*	-	-	C	60	80.0%	Very Common

Table A1. Continuation

Family	Species	Scientific Name	National Status	Global Status	Abundance	No of pts observed	%	Abundance in Pulau Ubin
Columbidae	Common Emerald Dove	*Chalcophaps indica*	-	-	U	58	77.3%	Very Common
Corvidae	House Crow	*Corvus splendens*	-	-	C	56	74.7%	Common
Nectariniidae	Van Hasselt's Sunbird	*Leptocoma brasiliana*	-	-	C	56	74.7%	Common
Picidae	Laced Woodpecker	*Picus vittatus*	-	-	C	55	73.3%	Common
Alcedinidae	Stork-billed Kingfisher	*Pelargopsis capensis*	-	-	U	54	72.0%	Common
Pycnonotidae	Yellow-vented Bulbul	*Pycnonotus goiavier*	-	-	A	53	70.7%	Common
Pellorneidae	Abbott's Babbler	*Malacocincla abbotti*	-	-	U	52	69.3%	Common
Alcedinidae	White-throated Kingfisher	*Halcyon smyrnensis*	-	-	C	51	68.0%	Common
Meropidae	Blue-throated Bee-eater	*Merops viridis*	-	-	C	51	68.0%	Common
Columbidae	Zebra Dove	*Geopelia striata*	-	-	C	50	66.7%	Common
Phylloscopidae	Arctic Warbler	*Phylloscopus borealis*	-	-	C	50	66.7%	Common
Columbidae	Spotted Dove	*Spilopelia chinensis*	-	-	A	49	65.3%	Common
Accipitridae	Brahminy Kite	*Haliastur indus*	-	-	C	46	61.3%	Common
Accipitridae	Changeable Hawk-Eagle	*Nisaetus cirrhatus*	t	-	C	45	60.0%	Common
Dicaeidae	Orange-bellied Flowerpecker	*Dicaeum trigonostigma*	-	-	C	40	53.3%	Common
Ardeidae	Grey Heron	*Ardea cinerea*	t	-	C	38	50.7%	Common
Dicruridae	Greater Racket-tailed Drongo	*Dicrurus paradiseus*	-	-	C	38	50.7%	Common
Meropidae	Blue-tailed Bee-eater	*Merops philippinus*	-	-	C	37	49.3%	Uncommon
Psittaculidae	Red-breasted Parakeet	*Psittacula alexandri*	-	NT	C	35	46.7%	Uncommon
Pittidae	Blue-winged Pitta	*Pitta moluccensis*	-	-	U	34	45.3%	Uncommon
Cuculidae	Banded Bay Cuckoo	*Cacomantis sonneratii*	-	-	U	33	44.0%	Uncommon
Muscicapidae	Asian Brown Flycatcher	*Muscicapa dauurica*	-	-	C	31	41.3%	Uncommon
Coraciidae	Oriental Dollarbird	*Eurystomus orientalis*	-	-	C	30	40.0%	Uncommon

Table A1. Continuation

Family	Species	Scientific Name	National Status	Global Status	Abundance	No of pts observed	%	Abundance in Pulau Ubin
Picidae	Rufous Woodpecker	*Micropternus brachyurus*	-	-	U	30	40.0%	Uncommon
Psittaculidae	Long-tailed Parakeet	*Psittacula longicauda*	-	NT	C	30	40.0%	Uncommon
Cuculidae	Asian Koel	*Eudynamys scolopaceus*	-	-	C	29	38.7%	Uncommon
Zosteropidae	Swinhoe's White-eye	*Zosterops simplex*	-	-	C	29	38.7%	Uncommon
Cuculidae	Greater Coucal	*Centropus sinensis*	-	-	U	24	32.0%	Uncommon
Hirundinidae	Pacific Swallow	*Hirundo tahitica*	-	-	C	24	32.0%	Uncommon
Rhipiduridae	Malaysian Pied Fantail	*Rhipidura javanica*	-	-	C	23	30.7%	Uncommon
Corvidae	Large-billed Crow	*Corvus macrorhynchos*	-	-	U	22	29.3%	Uncommon
Sturnidae	Common Hill Myna	*Gracula religiosa*	-	-	U	22	29.3%	Uncommon
Rallidae	White-breasted Waterhen	*Amaurornis phoenicurus*	-	-	C	19	25.3%	Uncommon
Muscicapidae	Yellow-rumped Flycatcher	*Ficedula zanthopygia*	-	-	U	18	24.0%	Rare
Dicruridae	Crow-billed Drongo	*Dicrurus annectens*	-	-	U	17	22.7%	Rare
Pittidae	Mangrove Pitta	*Pitta megarhyncha*	t	NT	U	17	22.7%	Rare
Campephagidae	Ashy Minivet	*Pericrocotus divaricatus*	-	-	C	16	21.3%	Rare
Picidae	Banded Woodpecker	*Chrysophlegma miniaceum*	-	-	C	16	21.3%	Rare
Cuculidae	Plaintive Cuckoo	*Cacomantis merulinus*	-	-	U	15	20.0%	Rare
Hirundinidae	Barn Swallow	*Hirundo rustica*	-	-	A	15	20.0%	Rare
Cuculidae	Rusty-breasted Cuckoo	*Cacomantis sepulcralis*	t	-	U	14	18.7%	Rare
Nectariniidae	Copper-throated Sunbird	*Leptocoma calcostetha*	-	-	U	14	18.7%	Rare
Cisticolidae	Rufous-tailed Tailorbird	*Orthotomus sericeus*	-	-	U	12	16.0%	Rare
Cisticolidae	Yellow-bellied Prinia	*Prinia flaviventris*	-	-	C	11	14.7%	Rare
Cuculidae	Little Bronze Cuckoo	*Chrysococcyx minutillus*	-	-	C	11	14.7%	Rare
Accipitridae	Crested Honey Buzzard	*Pernis ptilorhynchus*	-	-	C	10	13.3%	Rare

Table A1. Continuation

Family	Species	Scientific Name	National Status	Global Status	Abundance	No of pts observed	%	Abundance in Pulau Ubin
Accipitridae	Japanese Sparrowhawk	*Accipiter gularis*	-	-	C	9	12.0%	Rare
Alcedinidae	Blue-eared Kingfisher	*Alcedo meninting*	t	-	U	9	12.0%	Rare
Cuculidae	Lesser Coucal	*Centropus bengalensis*	-	-	C	9	12.0%	Rare
Muscicapidae	Siberian Blue Robin	*Larvivora cyane*	-	-	C	9	12.0%	Rare
Sturnidae	Common Myna	*Acridotheres tristis*	-	-	C	9	12.0%	Rare
Laniidae	Tiger Shrike	*Lanius tigrinus*	-	-	C	8	10.7%	Rare
Picidae	Sunda Pygmy Woodpecker	*Yungipicus moluccensis*	-	-	C	8	10.7%	Rare
Acanthizidae	Golden-bellied Gerygone	*Gerygone sulphurea*	-	-	C	7	9.3%	Rare
Alcedinidae	Common Kingfisher	*Alcedo atthis*	-	-	C	7	9.3%	Rare
Estrildidae	Scaly-breasted Munia	*Lonchura punctulata*	-	-	C	7	9.3%	Rare
Timaliidae	Pin-striped Tit-Babbler	*Mixornis gularis*	-	-	C	7	9.3%	Rare
Ardeidae	Purple Heron	*Ardea purpurea*	t	-	U	6	8.0%	Rare
Cuculidae	Indian Cuckoo	*Cuculus micropterus*	-	-	U	6	8.0%	Rare
Megalaimidae	Lineated Barbet	*Psilopogon lineatus*	-	-	C	6	8.0%	Rare
Scolopacidae	Common Sandpiper	*Actitis hypoleucos*	-	-	C	6	8.0%	Rare
Accipitridae	Chinese Sparrowhawk	*Accipiter soloensis*	-	-	U	5	6.7%	Rare
Accipitridae	Crested Serpent Eagle	*Spilornis cheela*	t	-	R	5	6.7%	Rare
Ardeidae	Great-billed Heron	*Ardea sumatrana*	t	-	U	5	6.7%	Rare
Ardeidae	Striated Heron	*Butorides striata*	-	-	C	5	6.7%	Rare
Accipitridae	Black Baza	*Aviceda leuphotes*	-	-	C	4	5.3%	Rare
Accipitridae	Grey-headed Fish Eagle	*Haliaeetus ichthyaetus*	t	NT	U	4	5.3%	Rare
Bucerotidae	Black Hornbill	*Anthracoceros malayanus*	-	NT	R	4	5.3%	Rare
Columbidae	Red-collared Dove	*Streptopelia tranquebarica*	-	-	U	4	5.3%	Rare

Table A1. Continuation

Family	Species	Scientific Name	National Status	Global Status	Abundance	No of pts observed	%	Abundance in Pulau Ubin
Laniidae	Brown Shrike	*Lanius cristatus*	-	-	C	4	5.3%	Rare
Motacillidae	Forest Wagtail	*Dendronanthus indicus*	-	-	U	4	5.3%	Rare
Sturnidae	Daurian Starling	*Agropsar sturninus*	-	-	C	4	5.3%	Rare
Alcedinidae	Black-capped Kingfisher	*Halcyon pileata*	-	-	U	3	4.0%	Very Rare
Ardeidae	Great Egret	*Ardea alba*	-	-	C	3	4.0%	Very Rare
Campephagidae	Pied Triller	*Lalage nigra*	-	-	C	3	4.0%	Very Rare
Caprimulgidae	Large-tailed Nightjar	*Caprimulgus macrurus*	-	-	C	3	4.0%	Very Rare
Columbidae	Cinnamon-headed Green Pigeon	*Treron fulvicollis*	-	NT	R	3	4.0%	Very Rare
Cuculidae	Square-tailed Drongo-Cuckoo	*Surniculus lugubris*	t	-	U	3	4.0%	Very Rare
Megalaimidae	Coppersmith Barbet	*Psilopogon haemacephalus*	-	-	C	3	4.0%	Very Rare
Psittaculidae	Blue-crowned Hanging Parrot	*Loriculus galgulus*	t	-	C	3	4.0%	Very Rare
Pycnonotidae	Cinereous Bulbul	*Hemixos cinereus*	-	-	U	3	4.0%	Very Rare
Rallidae	Red-legged Crake	*Rallina fasciata*	t	-	U	3	4.0%	Very Rare
Apodidae	Pacific Swift	*Apus pacificus*	-	-	C	2	2.7%	Very Rare
Ardeidae	Little Egret	*Egretta garzetta*	-	-	C	2	2.7%	Very Rare
Charadriidae	Red-wattled Lapwing	*Vanellus indicus*	t	-	C	2	2.7%	Very Rare
Cuculidae	Chestnut-winged Cuckoo	*Clamator coromandus*	-	-	U	2	2.7%	Very Rare
Falconidae	Peregrine Falcon	*Falco peregrinus*	-	-	U	2	2.7%	Very Rare
Laridae	Black-naped Tern	*Sterna sumatrana*	t	-	U	2	2.7%	Very Rare
Monarchidae	Amur Paradise Flycatcher	*Terpsiphone incei*	-	-	U	2	2.7%	Very Rare
Nectariniidae	Little Spiderhunter	*Arachnothera longirostra*	-	-	U	2	2.7%	Very Rare
Pandionidae	Western Osprey	*Pandion haliaetus*	-	-	C	2	2.7%	Very Rare
Ploceidae	Baya Weaver	*Ploceus philippinus*	-	-	U	2	2.7%	Very Rare

Table A1. Continuation

Family	Species	Scientific Name	National Status	Global Status	Abundance	No of pts observed	%	Abundance in Pulau Ubin
Podicipedidae	Little Grebe	*Tachybaptus ruficollis*	t	-	R	2	2.7%	Very Rare
Psittaculidae	Blue-rumped Parrot	*Psittinus cyanurus*	t	NT	U	2	2.7%	Very Rare
Pycnonotidae	Red-whiskered Bulbul	*Pycnonotus jocosus*	-	-	U	2	2.7%	Very Rare
Scolopacidae	Eurasian Whimbrel	*Numenius phaeopus*	-	-	C	2	2.7%	Very Rare
Strigidae	Barred Eagle-Owl	*Bubo sumatranus*	-	-	R	2	2.7%	Very Rare
Strigidae	Buffy Fish Owl	*Ketupa ketupu*	t	-	U	2	2.7%	Very Rare
Strigidae	Spotted Wood Owl	*Strix seloputo*	t	-	U	2	2.7%	Very Rare
Alcedinidae	Ruddy Kingfisher	*Halcyon coromanda*	t	-	U	1	1.3%	Very Rare
Anhingidae	Oriental Darter	*Anhinga melanogaster*	-	NT	R	1	1.3%	Very Rare
Apodidae	Asian Palm Swift	*Cypsiurus balasiensis*	-	-	U	1	1.3%	Very Rare
Apodidae	House Swift	*Apus nipalensis*	-	-	U	1	1.3%	Very Rare
Ardeidae	Black-crowned Night Heron	*Nycticorax nycticorax*	t	-	U	1	1.3%	Very Rare
Ardeidae	Intermediate Egret	*Ardea intermedia*	-	-	U	1	1.3%	Very Rare
Ardeidae	Yellow Bittern	*Ixobrychus sinensis*	-	-	C	1	1.3%	Very Rare
Charadriidae	Grey Plover	*Pluvialis squatarola*	-	-	U	1	1.3%	Very Rare
Chloropseidae	Blue-winged Leafbird	*Chloropsis cochinchinensis*	-	-	U	1	1.3%	Very Rare
Columbidae	Green Imperial Pigeon	*Ducula aenea*	-	-	U	1	1.3%	Very Rare
Columbidae	Rock Dove	*Columba livia*	-	-	A	1	1.3%	Very Rare
Cuculidae	Hodgson's Hawk-Cuckoo	*Hierococcyx nisicolor*	-	-	U	1	1.3%	Very Rare
Cuculidae	Large Hawk-Cuckoo	*Hierococcyx sparverioides*	-	-	U	1	1.3%	Very Rare
Cuculidae	Violet Cuckoo	*Chrysococcyx xanthorhynchus*	t	-	U	1	1.3%	Very Rare
Estrildidae	Javan Munia	*Lonchura leucogastroides*	-	-	U	1	1.3%	Very Rare

Table A1. Continuation

Family	Species	Scientific Name	National Status	Global Status	Abundance	No of pts observed	%	Abundance in Pulau Ubin
Eurylaimidae	Black-and-red Broadbill	*Cymbirhynchus macrorhynchos*	-	-	R	1	1.3%	Very Rare
Glareolidae	Oriental Pratincole	*Glareola maldivarum*	-	-	U	1	1.3%	Very Rare
Hirundinidae	Sand Martin	*Riparia riparia*	-	-	U	1	1.3%	Very Rare
Laniidae	Long-tailed Shrike	*Lanius schach*	-	-	U	1	1.3%	Very Rare
Laridae	Greater Crested Tern	*Thalasseus bergii*	-	-	C	1	1.3%	Very Rare
Locustellidae	Pallas's Grasshopper Warbler	*Helopsaltes certhiola*	-	-	C	1	1.3%	Very Rare
Monarchidae	Blyth's Paradise Flycatcher	*Terpsiphone affinis*	-	-	U	1	1.3%	Very Rare
Muscicapidae	Ferruginous Flycatcher	*Muscicapa ferruginea*	-	-	U	1	1.3%	Very Rare
Muscicapidae	Mugimaki Flycatcher	*Ficedula mugimaki*	-	-	U	1	1.3%	Very Rare
Nectariniidae	Ruby-cheeked Sunbird	*Chalcoparia singalensis*	-	-	R	1	1.3%	Very Rare
Passeridae	Eurasian Tree Sparrow	*Passer montanus*	-	-	C	1	1.3%	Very Rare
Phylloscopidae	Eastern Crowned Warbler	*Phylloscopus coronatus*	-	-	C	1	1.3%	Very Rare
Picidae	Buff-rumped Woodpecker	*Meiglyptes tristis*	-	-	R	1	1.3%	Very Rare
Psittaculidae	Rose-ringed Parakeet	*Psittacula krameri*	-	-	C	1	1.3%	Very Rare
Rallidae	Ruddy-breasted Crake	*Zapornia fusca*	-	-	U	1	1.3%	Very Rare
Vangidae	Black-winged Flycatcher-Shrike	*Hemipus hirundinaceus*	-	-	R	1	1.3%	Very Rare

Table A2. Species detected from (coastal) shorebird surveys and nocturnal surveys

Family	**Species**	***Scientific Name***	**National Status**	**Global Status**	**Abundance**
Accipitridae	Black-winged Kite	*Elanus caeruleus*	-	-	U
Caprimulgidae	Savanna Nightjar	*Caprimulgus affinis*	-	-	C
Charadriidae	Greater Sand Plover	*Charadrius leschenaultii*	-	-	U
Charadriidae	Lesser Sand Plover	*Charadrius mongolus*	-	-	C
Charadriidae	Pacific Golden Plover	*Pluvialis fulva*	-	-	C
Laridae	Lesser Crested Tern	*Thalasseus bengalensis*	-	-	C
Laridae	Little Tern	*Sternula albifrons*	t	-	C
Scolopacidae	Bar-tailed Godwit	*Limosa lapponica*	-	NT	U
Scolopacidae	Black-tailed Godwit	*Limosa limosa*	-	NT	U
Scolopacidae	Broad-billed Sandpiper	*Calidris falcinellus*	-	-	U
Scolopacidae	Common Greenshank	*Tringa nebularia*	-	-	C
Scolopacidae	Common Redshank	*Tringa totanus*	-	-	C
Scolopacidae	Curlew Sandpiper	*Calidris ferruginea*	-	NT	U
Scolopacidae	Eurasian Curlew	*Numenius arquata*	-	NT	R
Scolopacidae	Great Knot	*Calidris tenuirostris*	-	T	R
Scolopacidae	Marsh Sandpiper	*Tringa stagnatilis*	-	-	U
Scolopacidae	Red-necked Stint	*Calidris ruficollis*	-	T	U
Scolopacidae	Ruddy Turnstone	*Arenaria interpres*	-	-	U
Scolopacidae	Terek Sandpiper	*Xenus cinereus*	-	-	U
Strigidae	Brown Hawk Owl	*Ninox scutulata*	-	-	C
Strigidae	Sunda Scops Owl	*Otus lempiji*	-	-	C
Tytonidae	Barn Owl	*Tyto javanica*	-	-	U

Updated inventory of amphibians, reptiles and mammals of Pulau Ubin, Singapore

N.J. Thomas[1], N.R. Baker[2], T.K. Fung[3], W.X. Chiok[3], R.C.H. Teo[4]

[1] c/o Pulau Ubin Branch, National Parks Board,
61 Pulau Ubin, 508310 Singapore
Noel_Thomas@nparks.gov.sg
[2]Vertebrate Study Group, Nature Society of Singapore,
510 Geylang Road, Singapore 389466
[3]Department of Biological Sciences, National University
of Singapore, Science Drive 4, Singapore 117558
[4]Pulau Ubin Branch, National Parks Board,
61 Pulau Ubin, 508310 Singapore

ABSTRACT. The Comprehensive Ubin Biodiversity Survey (CUBS) in 2018–2021 provided an opportunity to re-survey the mammals, reptiles and amphibians of Pulau Ubin, and to collate published and unpublished records since the previous large surveys in 1993 and in 1999–2001. The numbers of species were increased from seven to nine amphibians, from 20 to 50 reptiles, and from 15 to 35 mammals ever recorded. Pulau Ubin continues to yield new records and maintains its national importance for wildlife conservation in Singapore.

Keywords. Community structure, bat acoustics, species assemblage, tropical rain forest, vertebrate survey

Introduction

Past records of terrestrial vertebrates on Pulau Ubin, Singapore, have come from a long history of specimen collection, most now deposited in the Lee Kong Chian Natural History Museum, National University of Singapore, and sightings from many individuals. Records from the island were compiled by Subaraj (1996), based largely on a survey conducted by members of the Nature Society (Singapore) in 1993. At that time seven amphibians, 20 reptiles and 15 mammals were listed but the survey was not long or detailed enough to be exhaustive.

In 1999–2001, the first intensive survey was done for vertebrates on the island. The inventory was updated to a total of 63 species comprising eight amphibians, 33 reptiles and 22 mammals. Further work took place in 2008–2009 (Chua et al., 2009). In addition, there have been detailed studies of several vertebrate species on Pulau Ubin, or in Singapore including Pulau Ubin, for example on *Sus scrofa* (Yong et al., 2010), *Macaca fascicularis* (Riley et al., 2015), *Lutrogale perspicillata* (Theng & Sivasothi, 2016; Theng et al., 2016), *Paradoxurus musangus* (Fung, 2016; Fung et al., 2018), and *Prionailurus bengalensis* (Fung et al., 2017). Furthermore, a range of reptiles and mammals have been newly recorded on Pulau Ubin, some of which have been published individually (e.g., Chua et al., 2009; Fung & Chan, 2014; Lee & Teo, 2018; Tan, 2013; Thomas & Chua, 2014; Thomas & Law, 2017; Thomas & Lim, 2014; Thomas et al., 2016a, 2016b).

The National Parks Board (NParks), as custodian and regulatory body for matters related to biological diversity in Singapore, has carried out a series of comprehensive inventories, including the marine environment (Tan & Goh, 2015, 2016) and terrestrial sites (e.g., Chan & Davison, 2019; Teo & Thomas, 2019). The surveys have been organised by NParks providing maps, common areas for study of different taxonomic groups of plants and animals, permits and logistical support. The science-based field surveys have been executed by staff members of NParks, volunteers and experts from local societies and institutions. A Comprehensive Ubin Biodiversity Survey (CUBS) was proposed under the same model and was conducted between 2018 and 2021. The survey included amphibians, reptiles and mammals.

Materials and Methods

We conducted diurnal and nocturnal surveys using a range of methods described below, and collated published and unpublished records from a range of sources. Among these the most important were the periodic newsletters of the Vertebrate Study Group, Nature Society (Singapore) (*The Pangolin*) and two online publications from the National University of Singapore (*Nature in Singapore* and *Singapore Biodiversity Records*) (Lim, 1988, 1989a, 1989b, 1990, 1993, Lim & Lim, 1988, Lim & Subaraj, 1991, Lim et al., 1994, 1995; Yeo, 1989, 1991; Yeo et al., 1991, 1992), as well as observations by staff members of Pulau Ubin branch, NParks, while conducting their daily tasks. In assessing the native or non-native status of species we relied largely on Baker & Lim (2008) and for national level conservation status in Singapore we relied on Lim et al. (2024) and Thomas et al. (2024a, 2024b).

Transect surveys

Sixty-nine nocturnal surveys were conducted between 17:00 hrs and 08:00 hrs to record the bulk of amphibian, reptile and mammal species that are nocturnal, and diurnal species that can be spotted resting at night. Teams of three to nine surveyors were allocated 2–3 hours to walk transects of up to 3 km. The 69 survey transects were carried out over 12 overnight sessions.

Separate day transects were carried out 24 times along the same routes to complement the night transects.

Bat surveys

A total of 13 bat surveys were conducted. Four 2-bank harp traps were placed across known and likely microchiropteran bat flyways. Mist nets of 3 m to 12 m lengths and mesh thickness of 30 denier were used to survey bats. Where conditions were favourable, a three-tier 6 m mist net was used covering a height of about 10 m to sample higher flying individuals.

Bat detectors were also deployed to record the ultrasonic calls of microchiropteran bats at night and bats detected were identified by comparing sonograms with those available in online libraries and publications.

Camera trapping

A total of 87 Reconyx PC900 camera traps were deployed from August 2019 to February 2020 resulting in approximately 250 camera trap nights. The cameras were deployed in a 250 m grid across the whole of Pulau Ubin except over mangroves, water bodies and built-up areas. Each camera was checked on a 6 weekly basis when the SD cards and batteries were replaced. Independent captures (hereafter encounter rates) were designated to be 60 minutes. Camera trap data were subsequently sorted in a hierarchical structure, with reference to protocols outlined by Sanderson & Harris (2013).

Small mammal trapping

Sherman aluminium box traps were utilised for small mammals such as rats, mice and squirrels. In March 2020 and between March 2021 and April 2021, 50 sequentially numbered Sherman traps were deployed along six pre-planned sectors for the CUBS surveys. Traps were deployed at 20-metre intervals on a straight line (on alternate sides of the track if there was one). Traps were baited with papaya and banana.

Collation of other records

We compiled records from published literature, unpublished reports and information from staff members and volunteers working under the National Parks Board and screened these for reliability based on criteria such as the types of evidence available (e.g., photographs, written descriptions, anecdote), level of observers' experience, and likelihood of records (e.g., context, previous records, availability of suitable habitat).

Results

The updated mammal, reptile and amphibian checklist consists of 94 species comprising nine amphibians, 50 reptiles and 35 mammals. Of these, three amphibians and five reptiles are considered to be introduced to Singapore (and to Pulau Ubin), as indicated in Appendix 1.

Amphibians

Of the nine amphibian species recorded, six were native to Singapore. Two are considered to be very long-standing human introductions (*Duttaphrynus bengalensis*, *Kaloula pulchra*) and there was one addition to the species recorded in 2001: a single record of *Lithobates catesbeianus* from the Sensory Trail pond was likely to be a recently released specimen.

Reptiles

Of the 50 reptile species recorded, 45 were native to Singapore and five were non-native (Appendix 1). There were 17 additions to the 2000 checklist of reptiles. *Eretmochelys imbricata* was recorded offshore and there were two introduced chelonians, *Siebenrockiella crassicollis* and *Trachemys scripta*. Newly added lizards were *Hemiphyllodactylus typus*, *Lepidodatylus lugubris* and *Dasia olivacea*. Newly added native snakes were *Xenopeltis unicolor*, *Acrochordus granulatus*, *Sibynophis melanocephalus*, *Xenelaphis hexagonotus*, *Cantoria violacea*, *Gerarda prevostiana*, *Bungarus fasciatus*, *Calliophis intestinalis* and *Ophiophagus hannah*. Two additional snakes considered to be non-native were *Pareas margaritophorus* and *Xenochrophis vittatus*.

Mammals

Of the 35 mammals recorded, all were native to Singapore. Thirteen additions to the 2000 checklist of mammals were *Tupaia glis*, nine bats (*Eonycteris spelaea*, *Emballonura monticola*, *Taphozous longimanus*, *Taphozous melanopogon*, *Megaderma spasma*, *Hipposideros cineraceus*, *Myotis horsfieldii, Hypsugo macrotis* and *Pipistrellus javanicus*), *Lutrogale perspicillata*, *Tragulus napu* and *Hystrix brachyura*. Domestic dogs and cats occur on Pulau Ubin but were not included in the study.

The camera traps recorded eight species, with *Sus scrofa* (n=18,581) having the highest encounter rate, followed by *Tragulus napu* (n=2,032) and *Macaca fascicularis* (n=861). The greatest species diversity recorded by a single camera trap was six species. *Sus scrofa* was recorded at all camera locations, and was the only mammal recorded at three of the locations.

Discussion

Several species that are rare in Singapore were recorded on Pulau Ubin from only one or a few records. These include three marine reptiles, *Crocodylus porosus, Eretmochelys imbricata* and *Aipyurus eydouxii*, and two marine mammals, *Sousa chinensis* and *Dugong dugon*. On land, examples are *Dasia olivacea, Emballonura monticola, Taphozous longimanus, Hypsugo macrotis* and *Hystrix brachyura*. The snake *Argyrophis muelleri* is a new record.

The nine amphibians were detected mainly around bodies of freshwater and mangroves. Freshwater is scarce on Pulau Ubin but *Fejervarya cancrivora* does well in Pulau Ubin as it can be found in the mangroves as well as brackish water. Most of the amphibians, whether native or introduced, are typical of disturbed habitats and none was forest dependent. Because Pulau Ubin is separated from other land by salt water, human agency can be the most significant cause of amphibian arrivals, perhaps in cargoes of supplies, among plants, soil or water brought to the island, or through deliberate release. The same might be true of commensal reptiles.

Dominant species

Extirpated from mainland Singapore from the 1960s (Teo & Rajathurai, 1997), *Sus scrofa* recolonised Pulau Tekong, Pulau Ubin and then mainland Singapore from the 1990s, unaided (Baker & Lim, 2008), despite the highly urbanised landscape (Yong et al., 2010), occurring within the Central Catchment Nature Reserve (Teo & Thomas, 2019) and subsequently nearly all mainland areas whether forested or not (Woon, 2021). The current survey on Pulau Ubin coincided with the period of abundance: case studies have shown that pig populations can grow exponentially if left unchecked, and at high densities can damage soil and prevent seedling regeneration (Luskin et al., 2017). Since the survey, African swine fever has been detected in the Singapore population of *S. scrofa* (Soh & Ang, 2023; CNA, 2023), which was part of a regional disease outbreak (FAO, 2024), leading to the decimation of the population.

A few museum specimens of *Tragulus napu* exist, collected from mainland Singapore and Pulau Ubin up to the year 1923, but the species was then considered locally extirpated (Yang et al., 1990). However, suspected sightings on Pulau Ubin from 2006 onwards were later confirmed as this species (Chua et al., 2009). The more than 2,000 photographs obtained during the survey, making this the second most commonly detected mammal, suggest a large population increase over about 15 years (Khoo et al., 2021). This is in spite of the presence of various potential predators such as *Malayopython reticulatus*, *Varanus* spp., dogs and cats.

Species at Risk

Several species are listed as threatened at national level (Table 1). They include 14 of the 45 native species of reptiles found on Pulau Ubin, and 17 of the 35 species of mammals found there. Pulau Ubin is an important conservation locality for some of them.

The ashy roundleaf bat, *Hipposideros cineraceus* was a new discovery for Pulau Ubin and Singapore when a sizeable roost of more than 50 individuals was found with a mix of adults, nursing females and juveniles (Fig. 1). Another small group was found sharing a roost site with *Megaderma spasma*. The easily identifiable constant frequency calls of this bat (Hughes et al., 2011) were not recorded on sonograms. Two individuals of *H. cineraceus* were trapped in Sector 3 of Pulau Ubin (Chek Jawa) during the bat trapping programme, both in mangrove habitat in the east of the island. Apart from a single record at Changi Point Ferry Terminal, the species has only been recorded in Singapore from Pulau Ubin.

Table 1. Number of vertebrates whose Singapore populations have been assessed at various national threat levels, after Lim et al. (2024) and Thomas et al. (2024a, 2024b). Those listed as Critically Endangered, Endangered or Vulnerable are considered threatened. Those listed as Near Threatened or of Least Concern are not considered threatened.

Threat category	**Amphibians**	**Reptiles**	**Mammals**
Critically Endangered		5	13
Endangered		4	1
Vulnerable		5	3
Near Threatened		6	
Least Concern	7	25	18

Two photographs of *Prionailurus bengalensis* were obtained from two of the camera traps. There are 12 other sightings and camera trap records from Pulau Ubin between 2014 and 2023, and a dead juvenile has been found. The evidence suggests a small but sustained population.

Fig. 1 (**A.**) Interior of roost. (**B.**) *Hipposideros cineraceus* hanging on roost.

Fig. 1 Continuation (**C.**) Female *Hipposideros cineraceus* with pup.

Aonyx cinereus is known to occur on the northern and western coast of Singapore in the Western Catchment Area, Sungei Buloh Nature Reserve and Kranji, as well as in the Central Catchment Nature Reserve and on Pulau Tekong (Baker & Lim, 2008; Thomas et al., 2016a). On Pulau Ubin the species has occasionally been seen in the mangrove rivers and sightings have become more frequent in recent years (Khoo & Lee, 2020), including large family groups (Fung & Xu, 2014). During monitoring for a species recovery project, a group of ten individuals was observed by camera trap for a few days crossing from the mangrove rivers to a freshwater body. Both *A. cinereus* and *L. perspicillata* are known to forage and travel in salt and brackish water and also seek out freshwater to "wash" themselves. *A. cinereus* breeds on Pulau Ubin, juveniles having been recorded at natural and artificial holts on the island.

Hybridisation has occurred between the two otter species in Singapore, demonstrated by mitochondrial DNA capture with nuclear introgression (Moretti et al., 2017), the direction of hybridisation being female *A. cinereus* x male *L. perspicillata*. The frequency of hybridisation is not clear but in Singapore and on Pulau Ubin the two species morphotypes behave independently and are readily distinguishable. Moretti et al. (2017) have suggested repeated back-crossing to *L. perspicillata* by hybrids, thus maintaining the *L. perspicillata* morphotype among resident otters, and the possibility that *A. cinereus* recorded in Pulau Ubin and nearby Pulau Tekong might be visitors from Peninsular Malaysia. The evidence of breeding by *A. cinereus* on Pulau Ubin (above) does not in itself refute the possibility that *A. cinereus* might be reinforced by immigrant individuals.

Other noteworthy species

Bungarus fasciatus was recorded four times during nocturnal transects. There have also been multiple photographic records of banded kraits by NParks staff (15 unpublished records) and members of the public (Tan, 2013), and interesting behavioural observations (Lim H.Y., 2019). These records contributed to *B. fasciatus* being downlisted from Endangered in the second edition of the Singapore Red Data Book (Davison et al., 2008) to Vulnerable in the third edition (Thomas et al., 2024b).

A single individual *Calliophis intestinalis* was found by a horticultural worker in the western part of Pulau Ubin marking the first record of this species for the island. In mainland Singapore, *C. intestinalis* is known to be found in disturbed habitats outside the nature reserves.

Other notable snakes include *Boiga cynodon and Dryophiops rubescens,* for both of which there are many records on Pulau Ubin compared with mainland Singapore.

Megaderma spasma is a microchiropteran bat known primarily from Pulau Ubin and Pulau Tekong. It is listed as Endangered in Singapore (Lim et al., 2024). Since 2014, at the start of a species recovery project for bats, NParks has been closely monitoring the *Megaderma spasma* population on Pulau Ubin. A 2016 island wide count of the species resulted in 115 individuals recorded. Since 2016, several smaller roosts have been found and the numbers in their existing roosts have increased. These included purpose-built bat houses as part of the species recovery project. In 2019 the island wide count for the species recorded 258 individuals. This affirms Pulau Ubin as a stronghold for *M. spasma* in Singapore, especially since the population Pulau Tekong is not easily monitored.

These noteworthy species, together with species at risk and species for which the Pulau Ubin populations represent important national components, indicate the continuing significance of Pulau Ubin for wildlife conservation. New discoveries and major surprises continue to occur, such as the occurrence of a single *Tapirus indicus* in 2023–2024 (Ang, 2024), presumably displaced from adjacent Peninsular Malaysia (Yong, 2012).

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Appendix 1. Checklist of Amphibians, Reptiles and Mammals of Pulau Ubin, Singapore. **Status**: N = Native, I = Introduced. **Conservation Status** in Singapore following Lim et al. (2024), and Thomas et al. (2024a, 2024b): LC = Least Concern, NT = Near Threatened, VU = Vulnerable, EN = Endangered, CR = Critically Endangered

Order	Family	Scientific Name	Vernacular Name	Status	2000	2021	Conservation Status
Anura	Bufonidae	*Duttaphrynus bengalensis*	Bengal Toad	I	✓	✓	LC
Anura	Ranidae	*Fejervarya cancrivora*	Crab-eating Frog	N	✓	✓	LC
Anura	Ranidae	*Fejervarya limnocharis*	Field Frog	N	✓	✓	LC
Anura	Ranidae	*Hylarana erythraea*	Common Greenback	N	✓	✓	LC
Anura	Ranidae	*Lithobates catesbeianus*	American Bullfrog	I		✓	–
Anura	Rhacophoridae	*Polypedates leucomystax*	Four-lined Tree Frog	N	✓	✓	LC
Anura	Microhylidae	*Kaloula pulchra*	Banded Bullfrog	I	✓	✓	–
Anura	Microhylidae	*Microhyla butleri*	Painted Chorus Frog	N	✓	✓	LC
Anura	Microhylidae	*Microhyla heymonsi*	Dark-sided Chorus Frog	N	✓	✓	LC
Testudines	Cheloniidae	*Eretmochelys imbricata*	Hawksbill Turtle	N		✓	CR
Testudines	Geoemydidae	*Cuora amboinensis*	Malayan Box Turtle	N	✓	✓	NT
Testudines	Geoemydidae	*Siebenrockiella crassicollis*	Black Marsh Turtle	I		✓	–
Testudines	Emydidae	*Trachemys scripta*	Red-eared Slider	I		✓	–
Squamata	Gekkonidae	*Gehyra mutilata*	Four-clawed Gecko	N	✓	✓	LC
Squamata	Gekkonidae	*Gekko monarchus*	Spotted House Gecko	N	✓	✓	LC
Squamata	Gekkonidae	*Hemidactylus frenatus*	Spiny-tailed House Gecko	N	✓	✓	LC
Squamata	Gekkonidae	*Hemidactylus platyurus*	Flat-tailed Gecko	N	✓	✓	LC
Squamata	Gekkonidae	*Hemiphyllodactylus typus*	Lowland Dwarf Gecko	N		✓	NT
Squamata	Gekkonidae	*Lepidodactylus lugubris*	Maritime Gecko	N		✓	LC
Squamata	Agamidae	*Bronchocela cristatella*	Green Crested Lizard	N	✓	✓	LC
Squamata	Agamidae	*Calotes versicolor*	Changeable Lizard	I	✓	✓	–
Squamata	Agamidae	*Draco sumatranus*	Sumatran Flying Dragon	N	✓	✓	LC
Squamata	Scincidae	*Dasia olivacea*	Olive Tree Skink	N		✓	CR

Appendix 1. Continuation

Order	Family	Scientific Name	Vernacular Name	Status	2000	2021	Conservation Status
Squamata	Scincidae	*Eutropis multifasciatus*	Many-lined Sun Skink	N	✓	✓	LC
Squamata	Scincidae	*Lygosoma bowringii*	Garden Supple Skink	N	✓	✓	LC
Squamata	Varanidae	*Varanus nebulosus*	Clouded Monitor	N	✓	✓	LC
Squamata	Varanidae	*Varanus salvator*	Malayan Water Monitor	N	✓	✓	LC
Squamata	Typhlopidae	*Indotyphlops braminus*	Brahminy Blind Snake	N	✓	✓	LC
Squamata	Typhlopidae	*Argyrophis muelleri*	White-bellied Blind Snake	N	✓	✓	CR
Squamata	Xenopeltidae	*Xenopeltis unicolor*	Sunbeam Snake	N		✓	LC
Squamata	Pythonidae	*Malayopython reticulatus*	Reticulated Python	N	✓	✓	LC
Squamata	Acrochordidaae	*Acrochordus granulatus*	Banded File Snake	N		✓	NT
Squamata	Colubridae	*Ahaetulla prasina*	Oriental Whip Snake	N	✓	✓	LC
Squamata	Colubridae	*Boiga cynodon*	Dog-toothed Cat Snake	N	✓	✓	VU
Squamata	Colubridae	*Boiga dendrophila*	Mangrove Snake	N	✓	✓	NT
Squamata	Colubridae	*Chrysopelea paradisi*	Paradise Tree Snake	N	✓	✓	LC
Squamata	Colubridae	*Chrysopelea pelias*	Twin-barred Tree Snake	N	✓	✓	NT
Squamata	Colubridae	*Coelognathus flavolineatus*	Malayan Racer	N	✓	✓	LC
Squamata	Colubridae	*Dendrelaphis caudolineatus*	Striped Bronzeback	N	✓	✓	LC
Squamata	Colubridae	*Dendrelaphis pictus*	Painted Bronzeback	N	✓	✓	LC
Squamata	Colubridae	*Dryophiops rubescens*	Keel-bellied Whip Snake	N	✓	✓	EN
Squamata	Colubridae	*Lycodon capucinus*	House Wolf Snake	N	✓	✓	LC
Squamata	Colubridae	*Oligodon octolineatus*	Striped Kukri Snake	N	✓	✓	LC
Squamata	Colubridae	*Ptyas korros*	Indochinese Rat Snake	N	✓	✓	LC
Squamata	Colubridae	*Pseudorabdion longiceps*	Dwarf Reed Snake	N	✓	✓	NT
Squamata	Colubridae	*Sibynophis melanocephalus*	Black-headed Collared Snake	N		✓	VU
Squamata	Colubridae	*Xenelaphis hexagonotus*	Malayan Brown Snake	N		✓	CR

Appendix 1. Continuation

Order	Family	Scientific Name	Vernacular Name	Status	2000	2021	Conservation Status
Squamata	Homalopsidae	*Cantoria violacea*	Cantor’s Water Snake	N		✓	EN
Squamata	Homalopsidae	*Cerberus rynchops*	Dog-faced Water Snake	N	✓	✓	LC
Squamata	Homalopsidae	*Gerarda prevostiana*	Gerard’s Water Snake	N		✓	EN
Squamata	Pareatidae	*Pareas margaritophorus*	White-spotted Slug Snake	I		✓	–
Squamata	Natricidae	*Xenochrophis vittatus*	Striped Keelback	I		✓	–
Squamata	Hydrophiidae	*Aipysurus eydouxii*	Marbled Sea-snake	N	✓	✓	EN
Squamata	Elapidae	*Bungarus fasciatus*	Banded Krait	N		✓	VU
Squamata	Elapidae	*Calliophis intestinalis*	Banded Malayan Coral Snake	N		✓	NT
Squamata	Elapidae	*Naja sumatrana*	Equatorial Spitting Cobra	N	✓	✓	LC
Squamata	Elapidae	*Ophiophagus hannah*	King Cobra	N		✓	VU
Squamata	Crotalidae	*Trimeresurus purpureomaculatus*	Shore Pit-viper	N	✓	✓	VU
Crocodilia	Crocodylidae	*Crocodylus porosus*	Estuarine Crocodile	N	✓	✓	CR
Chiroptera	Pteropodidae	*Pteropus vampyrus*	Large Flying Fox	N	✓	✓	CR
Chiroptera	Pteropodidae	*Cynopterus brachyotis*	Lesser Short-nosed Fruit Bat	N	✓	✓	LC
Chiroptera	Pteropodidae	*Eonycteris spelaea*	Cave Nectar Bat	N		✓	VU
Chiroptera	Pteropodidae	*Macroglossus minimus*	Lesser Long-tongued Nectar Bat	N	✓	✓	VU
Chiroptera	Emballonuridae	*Emballonura monticola*	Lesser Sheath-tailed Bat	N		✓	CR
Chiroptera	Emballonuridae	*Taphozous longimanus*	Long-winged Tomb Bat	N		✓	CR
Chiroptera	Emballonuridae	*Taphozous melanopogon*	Black-bearded Tomb Bat	N		✓	LC
Chiroptera	Emballonuridae	*Saccolaimus saccolaimus*	Pouched Tomb Bat	N	✓	✓	LC
Chiroptera	Megadermatidae	*Megaderma spasma*	Lesser False-Vampire	N		✓	CR
Chiroptera	Hipposideridae	*Hipposideros cineraceus*	Ashy Roundleaf Bat	N		✓	CR
Chiroptera	Vespertilionidae	*Myotis muricola*	Whiskered Myotis	N	✓	✓	LC
Chiroptera	Vespertilionidae	*Myotis horsfieldii*	Horsfield’s Large-footed Bat	N		✓	LC

Appendix 1. Continuation

Order	Family	Scientific Name	Vernacular Name	Status	2000	2021	Conservation Status
Chiroptera	Vespertilionidae	*Scotophilus kuhlii*	Lesser Asian House Bat	N	✓	✓	LC
Chiroptera	Vespertilionidae	*Tylonycteris malayana*	Greater Bamboo Bat	N	✓	✓	VU
Chiroptera	Vespertilionidae	*Hypsugo macrotis*	Big-eared Pipistrelle	N		✓	CR
Chiroptera	Vespertilionidae	*Pipistrellus javanicus*	Javan Pipistrelle	N		✓	LC
Pholidota	Manidae	*Manis javanica*	Sunda Pangolin	N	✓	✓	CR
Soricomorpha	Soricidae	*Suncus murinus*	House Shrew	N	✓	✓	LC
Scandentia	Tupaiidae	*Tupaia glis*	Common Treeshew	N		✓	LC
Primates	Cercopithecidae	*Macaca fascicularis*	Long-tailed Macaque	N	✓	✓	LC
Carnivora	Mustelidae	*Lutrogale perspicillata*	Smooth Otter	N		✓	EN
Carnivora	Mustelidae	*Aonyx cinereus*	Oriental Small-clawed Otter	N	✓	✓	CR
Carnivora	Viveriidae	*Paradoxurus musangus*	Sumatran Palm Civet	N	✓	✓	LC
Carnivora	Felidae	*Prionailurus bengalensis*	Leopard Cat	N	✓	✓	CR
Artiodactyla	Suidae	*Sus scrofa*	Eurasian Wild Pig	N	✓	✓	LC
Artiodactyla	Tragulidae	*Tragulus napu*	Greater Mousedeer	N		✓	CR
Rodentia	Sciuridae	*Callosciurus notatus*	Plantain Squirrel	N	✓	✓	LC
Rodentia	Muridae	*Mus musculus*	Asian House Mouse	N	✓	✓	LC
Rodentia	Muridae	*Rattus tanezumi*	Asian House Rat	N	✓	✓	LC
Rodentia	Muridae	*Rattus tiomanicus*	Malaysian Wood Rat	N	✓	✓	LC
Rodentia	Muridae	*Rattus exulans*	Pacific Rat	N	✓	✓	LC
Rodentia	Muridae	*Sundamys annandalei*	Annandale’s Rat	N	✓	✓	LC
Rodentia	Hystricidae	*Hystrix brachyura*	Malayan Porcupine	N		✓	CR
Cetacea	Delphinidae	*Sousa chinensis*	Indo-Pacific Humpback Dolphin	N	✓	✓	CR
Sirenia	Dugongidae	*Dugong dugon*	Dugong	N	✓	✓	CR







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