# *The Development of Typology Matrixes on Design Patterns Inspired by the Mangroves Species of Sungai Merbok*

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The Asian Conference on Arts & Humanities 2019
Official Conference Proceedings

**Abstract**
More than 30 species of mangroves have been identified in Sungai Merbok, Kedah, Malaysia and are considered to be the most extensive collection of mangroves species in the world. Because of the profound natural and historical elements, Sungai Merbok is now has been identified as a second natural biosphere in the world and is recognised by the UNESCO. The researchers have found that the mangroves species have potentials to be developed into 2D or 3D design patterns. The information on mangroves species and the images were obtained from the research websites and books. Typology matrixes are designed to categorise the mangroves species, and a variety of design patterns can be seen in the matrixes developed for this study. All of the patterns developed inspired by the mangroves physical features (roots, leaves, fruits, flowers, skin texture or other parts). Rough sketches on idea developments or thumbnails were developed and documented in the matrixes. It is estimated around 265 basic patterns have been developed for this study. Moreover, the design patterns can be developed further and be the basis for more design works development.

Keyword: mangroves species, design, pattern, idea development, inspiration

## Introduction

The Sungai Merbok in Sungai Petani, Kedah not only known for its beautiful scenery but a diverse ecosystem where it has been recognised as the that has more than 30 mangroves species. Because of the profound natural and the historical elements, this mangroves conservation area is now has been identified and is acknowledged by the UNESCO. Furthermore, there are vast natural elements available in this region, such as paddy field, birds, and other types of flora and fauna, which can be used as a source of inspiration in designing. For this study, the researchers have identified and produced design patterns which are inspired by the mangroves species of the Sungai Merbok. These artworks can be used to represents the 'Sungai Merbok'. This research used an observation method to identify and translate the common physical forms of the mangroves into a design. It is estimated that 265 design patterns are developed and categorised in matrixes. The differences in pattern development can be seen in the matrixes.

Moreover, this study can also creates awareness on sustainability and the importance to preserve the nature (Flannery, 2005; Heerwagen, 2003; Beatley, 2011; Kellert, 2012) where the mangrove species, especially in Merbok, are endangered. It is essential to highlight this issue as it can be a way to protect the environment. However, the end products are not produced in this study, and further developments are required to be done. This study will serve as a basis for further and more detailed research in product development. It is hoping to inspire the designers or researchers of this project to develop products for daily usages (furniture or product design), graphic illustrations and many more, which can bring a meaningful and intrinsic interpretation towards designs that are inspired by nature.

## Design, Pattern and Inspiration by Nature

Design involves a process of creating or developing ideas. As alluded by Gabriel-Petit (2010), design is,
*"…the creative process in which we use our intuition and analytical ability to understand the opportunities and constraints business goals, competitive markets, customer needs, and technologies present, then envision, communicate, and realize practical solutions that meet customer needs and create business value".*
A pattern is a common and intelligible form or sequence discernible in the way in which something happens or is done (Unknown, 2018a). Patterns can be designed with the various usage of shapes, colours, images etcetera which can be repetitively designed. By using the natural patterns which are inspired by the mangroves species, this research has listed and categorised at least 265 basic design patterns. Moreover, the mangroves species are the primary subject matter in the development of the basic pattern.

It is quite a common process for designers and artists to produce designs which are inspired by nature. This study documented and developed matrixes that classify the mangrove in detail according to species and the physical form of the plants (leaves, flowers, fruits, roots and other parts if available). The physical forms of mangroves are used to generate ideas which can be developed further as functional designs. Inspiration is the process of being mentally stimulated to do or feel something, especially to do

something creative (Unknown, 2018b). Gonçalves et al. (2014) and Chan et al. (2015) discussed inspiration is a process is an idea searching where the active or passive design process is done by engaging which elicited with any diverse surrounding form of an object. It is one of the necessary procedures that designers use to develop ideas. In this context of the study, the patterns developed are inspired by the mangrove species available in Sungai Merbok. Yeler (2015) stated that by applying nature into design disciplines using the approach of observation of events and processes, it would have the capacity to change the life of humanity for the better. By looking or adopting nature, lots can be learned and benefitted from (Benyus, 1997; Orr, 2002; Thorpe, 2007; Helms et al., 2009; Heerwagen, 2003; Gruber et al., 2011; Gray and Birrell, 2014).

**Mangroves**

Mangrove is a type of plant which can be found near the rivers or beaches which has distinctive root. Mangroves play a vital role in the marine ecosystem as it becomes a habitat for a vast range of animal species of birds, fishes, reptiles, amphibians and mammals (WWF, 2018). Mangroves as defined by Ong and Gong (2013, page 1);
*"…are a group of vascular plants that have special morphological, physiological and other non-visible adaptations to live in a saline intertidal environment dominated by low dissolved oxygen or sometimes anoxic fine sediments. These plants, together with their complement of microorganisms and animals, form the mangrove ecosystem. The term mangrove thus refers both to the plants themselves as well as to the ecosystem."*

Mangroves play vital roles in the ecosystem, which can adapt and survive the harsh conditions of the sea and land. It was a complex ecosystem that provides lots of benefits to the flora, fauna and humans. Spalding, Kainuma and Collins (2010) mentioned that mangroves in Malaysia are managed and controlled by the government of the state in the forest reserves, which are used for timber and charcoal production (Latiff and Faridah-Hanum, 2014; Kedah Forestry, 2015) although there were mass losses. It is contrary to the Philippines where mangroves were overused for industrial demand, population expansion etcetera and it resulted in massive losses for that country from the early 1950s. Mitigation policies for replanting and restoration helped to control and conserve the mangroves (Spalding, Kainuma and Collins, 2010).

**Mangrove Species in Merbok and Malaysia**

Mangroves are the most spectacular colonisers, which refer to a vast range of plants at the edge of the sea (Spalding, Kainuma and Collins, 2010). Spalding, Kainuma and Collins (2010) have identified 73 species of pure and hybrid mangrove all over the world which separated into Indo-West Pacific species and Atlantic East Pacific species. The Kedah state has at least 20, 533 ha and 17,185 ha of permanent forest reserves which consists of mangroves forest in Kisap Forest Reserves, Air Hangat Forest Reserves, Pulau Dayang Bunting Forest Reserves in Langkawi and Merbok Forest Reserves (Aldrie and Latiff, 2006). The Merbok Forest Reserves is situated in Kuala Muda with a 3,085.9ha, and it is the second largest mangrove forest in the West Malaysia after Larut Matang Forest Reserves in Perak.

Merbok Forest Reserves has at least 92 species of 63 genera and 39 families of high plants and ferns (including mangroves) Aldrie and Latiff (2006). It has been identified that over 30 mangrove species available in this area. Aldrie and Latiff (2006) have also listed the species of mangrove that can be found in Malaysia, as shown in Table 1 below.

Table 1: The list of mangroves species found in Malaysia by Aldrie and Latiff (2006)

| Family | Species | Family | Species |
|---|---|---|---|
| **Acanthaceae** | Acanthus ebracteatus | **Rhizophoraceae** | Bruguiera cylindrica |
| | Acanthus ilicifolius | | Bruguiera gymnorhiza |
| **Avicenniaceae** | Avicennia alba | | Bruguiera parviflora |
| | Avicennia marina | | Bruguiera sexangula |
| | Avicennia officinalis | | Ceriops tagal |
| **Bignoniaceae** | Dolichandrone spathacea | | Rhizophora apiculata |
| **Combretaceae** | Lumnitzera littorea | | Rhizophora mucronata |
| | Terminalia catappa | | Rhizophora Annamalayana |
| **Euphorbiaceae** | Bridelia tomentosa blume | **Rubiaceae** | Scyphiphora hydrophylacea |
| | Excoecaria agallocha | | Canthium horridum |
| | Sapium indicum willdenow | | Psychotria sp. |
| | Suregada multiflora | **Sonneratiaceae** | Sonneratia alba |
| **Meliaceae** | Aglaia cucullata | | Sonneratia caseolaris |
| | Xylocarpus granatum | | Sonneratia griffithii |
| | Xylocarpus moluccensis | | Sonneratia ovata |

The Kedah Forestry (2015) stated that there are more than 30 of true mangrove species in Merbok Forest Reserved. The types of mangrove available in Sungai Merbok can be seen in Table 2 below.

Table 2: The mangroves species and plants in Merbok, Kedah, taken from Galeri Merbok (2008)

| Family | Species | Family | Species |
|---|---|---|---|
| **Acanthaceae** | Acanthus ebracteatus Vahl | **Rhizophoraceae** | Bruguiera sexangula |
| | Acanthus Volubilis Wall | | Ceriops tagal |
| | Acanthus ilicifolius | | Rhizophora apiculata Blume |
| **Arecaceae** | Nypa Fruticans Wurmb | | Rhizophora mucronata Lam |
| **Avicenniaceae** | Avicennia alba | | Rhizophora Annamalayana ( |

| | | | |
|---|---|---|---|
| | Avicennia marina | | Bruguiera Cylindrica |
| | Avicennia officinalis | | Bruguiera gymnorhiza |
| **Combretaceae** | Lumnitzera littorea | | Bruguiera Hainesii (Critically endangered ) |
| **Euphorbiaceae** | Excoecaria agallocha | | Bruguiera parviflora |
| **Meliaceae** | Xylocarpus granatum | **Rubiaceae** | Scyphiphora hydrophylacea |
| | Xylocarpus moluccensis | **Sonneratiaceae** | Sonneratia alba |
| **Myrsinaceae** | Aegiceras Corniculatum | | Sonneratia griffithii (Critically endangered ) |
| **Pteridaceae** | Acrostichum Aureum | | Sonneratia ovata Backer |
| | Acrostichum Speciosum | **Sterculiaceae** | Heritiera Fomes (Endangered) |
| | | | Heritiera Littoralis |
| | | | |
| | | | Phoenix Paludosa Roxb |

**Research Methodology**

In order to achieve the research objectives, this research was done by; (1) *observations* on the images of mangrove species, (2) *literature review* - by gathering information from books, journal and research websites, (3) *developing matrix of categorisation,* by classifying the mangroves according to species, variation of roots, fruits, flowers, leaves and other physical parts of mangrove plants, (4) *Pattern design development* – developing design patterns based on the mangrove species and variations. This research used an approach of qualitative analysis to achieve the research outcomes, aiming to answer the research questions that were formulated based on the previous literature reviews and observation.

There are 5 phases which are Phase 1: Literature Review, Phase 2: Observation and Studies on Mangroves Species, Phase 3: Typology/ Matrix Design, Phase 4: Patterns development and finally Phase 5: Conclusions and Further Research which are designed according to the needs of this study. These phases are explained further below.

*Phase 1: Literature Review*
Related information is collected from journals, articles, research websites and books to help the researchers to understand more about the definitions of terms and the species of mangroves available in the Sungai Merbok.

*Phase 2: Observation and Studies on Mangroves Species*
Information on the types of mangroves was obtained through site visits to the display panels in the Galeri Merbok and the Kedah Forestry in Sungai Petani. To support this investigation, information on mangroves were also gathered from journals and articles.

*Phase 3: Typology/ Matrix Design*
The researchers have categorised, compared and listed the species of mangrove which are available in Sungai Merbok according to widespread species name/ family name, scientific species name, distribution (country), types of the roots, leaf, flowers, fruits/ seeds and other parts of mangroves.

*Phase 4: Pattern development*
The design patterns are, and there are at least two proposals for each species, and it estimated 265 patterns had been developed. However, the developments are not final and will go through several more design development phases for more future research. Only the basic patterns development will be featured in this study.

*Phase 5: Conclusions and Further Research*
Conclusions on this research are discussed, and recommendations for further research can be found at the end of the chapters. This part will explain the various developments of the design patterns, which inspired from mangrove species of Sungai Merbok. As mentioned earlier, this process will be continued until the final products are formed. This research will encourage more developments in designs which are inspired by nature.

**Typology of Matrixes**

The matrix typology has shown diverse types of mangrove and plant species in Sungai Merbok. The variation of roots, fruits, leaves, flowers and other parts of mangroves have inspired the researchers to design basic patterns. The examples of classification can be seen in Figure 1a below. The matrix was divided into the general species name or family name, scientific species name, distribution (country), root, leaf, flower, fruits/seeds and other parts of mangroves.

**Detailed information of Mangrove Species in Sungai Merbok (This list of species were taken from Galeri Merbok(2008))**

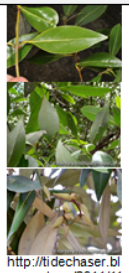
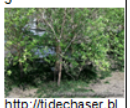
| General Species Name / Family Name | Scientific Species Name | Distribution (country) | Root | Leaf | Flower | Fruits/ seeds | Other part of mangroves |
|---|---|---|---|---|---|---|---|
| **White Grey Mangrove**<br><br>**Common Names:** ***Api Api, Api Api Putih*** | Avicennia alba | South East Asia, including Singapore, Australia and the Pacific islands. |  <br>http://tidechaser.blogspot.my/2011/11/api-api-putih-avicennia-alba.html |  <br>http://tidechaser.blogspot.my/2011/11/api-api-putih-avicennia-alba.html |  <br>https://florafaunaweb.nparks.gov.sg/Special-Pages/plant-detail.aspx?id=3263 |  <br>https://florafaunaweb.nparks.gov.sg/Special-Pages/plant-detail.aspx?id=3263 |  <br>https://florafaunaweb.nparks.gov.sg/Special-Pages/plant-detail.aspx?id=3263<br>  <br>http://tidechaser.blogspot.my/2011/11/api-api-putih-avicennia-alba.html |
| **Western Grey Mangrove**<br><br>**Family Name:** ***Acanthaceae (prev. Avicenniaceae)***<br><br>**Common name:** ***Grey Mangrove*** | Avicennia Marina | Coastal New South Wales along estuarine environments. |  |  <br>Leaf |  <br>http://www.roboastra.com/Riverscene22.htm |  <br>http://www.roboastra.com/Riverscene22.htm |  <br>Bark |

Figure 1a: The detailed information on mangroves species and plants in Sungai Merbok, taken from Galeri Merbok (2008). Source: Authors

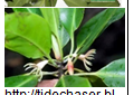
| General Species Name / Family Name | Scientific Species Name | Distribution (country) | Root | Leaf | Flower | Fruits / seeds | Other part of mangroves |
|---|---|---|---|---|---|---|---|
| **Large Leafed Orange Mangrove (Tumu Merah)** | *Bruguiera Gymnorhiza* | South and East Africa, Madagascar through to India, Myanmar, Thailand, Peninsular Malaysia, Singapore, throughout Indonesia, Brunei, the Philippines, Papua New Guinea, northern Australia to Ryuku Islands, Polynesia and Samoa |   http://www.alamy.com/stock-photo-roots-of-bruguiera-gymnorrhiza-beilun-estuary-national-nature-reserve-41937615.html |  http://www.madeinnys.com/mangrove/b_gymnorrhiza.htm |   http://www.mangrove.at/bruguiera-gymnorhiza_large_leafed-orange-mangrove.html https://id.wikipedia.org/wiki/Putut |   http://www.mangrove.at/bruguiera-gymnorhiza_large_leafed-orange-mangrove.html | |
| **Haines Orange Mangrove (Berus Mata Buaya)** | *Bruguiera Hainesii* | South East Asia in Indonesia, Malaysia, Thailand, Myanmar, Philippines, Papua New Guinea and Singapore. |  https://www.flickr.com/photos/adaduitokla/12134247913 |   http://tidechaser.blogspot.my/2011/11/berus-mata-buaya-bruguiera-hainesii.html |   https://www.flickr.com/photos/adaduitokla/12135639943 |  http://tidechaser.blogspot.my/2011/11/berus-mata-buaya-bruguiera-hainesii.html |  https://www.hmetro.com.my/mutakhir/2018/04/334627/perjanjian-alam-tanah-bencah |

Figure 1b: The detailed information on mangroves species and plants in Sungai Merbok, taken from Galeri Merbok (2008). Source: Authors

The variation of the species can be seen in Figure 1a and 1b. To avoid brevity, only a few examples will be shown. Evidently, these species have shown distinct criteria in the form of the roots, leaves, flowers, fruits/ seeds and tree barks because of its different family. Figure 2a and 2b show the matrixes of the variation of flowers and fruits/ seeds of Avicenniaceae family and Rhizophoraceae family. Only these few examples will be shown to avoid brevity. In the matrixes, the dissimilarity of the flower from the petals, stamens, pistils, pedicel or even colour disparity can be seen clearly. Same goes with the fruits/ seeds from the Rhizophoraceae family, although there are not so much of differences in the shape of the fruits/seeds, Bruguiera Parviflora tends to have longer and thin characters.

| Scientific Species Name | General Species Name / Family Name | Flower |
|---|---|---|
| Aegiceras Corniculatum | Southern River Mangrove/Black Mangrove/ Kuku Lang, Kacang-Kacang |  |
| Avicennia Alba | White Grey Mangrove/ Api Api, Api Api Putih |  |
| Avicennia Marina | Acanthaceae/ Western Grey Mangrove/ Grey Mangrove/ |  |
| Avicennia Officinalis | Indian Mangrove/ Api-Api Ludat |  |

Figure 2a: The variation of flower of Avicenniaceae family. Source: Authors

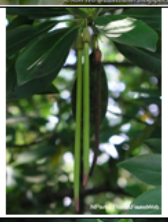
| Scientific Species Name | General Species Name / Family Name | Fruits/seeds |
|---|---|---|
| Bruguiera Gymnorhiza | Large Leafed Orange Mangrove/ Tumu Merah |  |
| Bruguiera Hainesii | Haines Orange Mangrove/ Berus Mata Buaya – Critically Endangered Species- |  |
| Bruguiera Parviflora | Rhizophoraceae/ Small Leafed Orange Mangrove/ Lenggadai |  |
| Bruguiera Sexangula | Rhizophoraceae/ Upriver Orange Mangrove/ Tumu Putih |  |

Figure 2b: The variation of fruits/ seeds of Rhizophoraceae family. Source: Authors

## The Ideas and Patterns Developments

The researchers have identified the mangroves species and sketched ideas to form design patterns for this study. The patterns are developed initially based on the physical beings of the mangrove leaves, fruits, flowers, roots and other parts of mangrove such as the

skins of the tree trunk. This process can also be called an analogy process where the ideas are depicted or illustrated from a subject matter. Analogical design involves the knowledge transfer of design situation to another new situation (Goel, 1997). An analogy used in the early idea generation and a fundamental process to develop ideas (Gonçalves et al., 2014). In this case, mangroves species are the main subject matter for this research. The researchers are exploring the ideas by doing sketching, roughly, by taking into consideration of the forms and shapes of the physical beings that the mangroves have. Only the basic patterns development will be featured in this study. The example of the development of the patterns is shown in Figure 3a to 3e below. However, the patterns on the other parts of mangroves (Figure 3e) are not developed as most of the images could not be gathered.

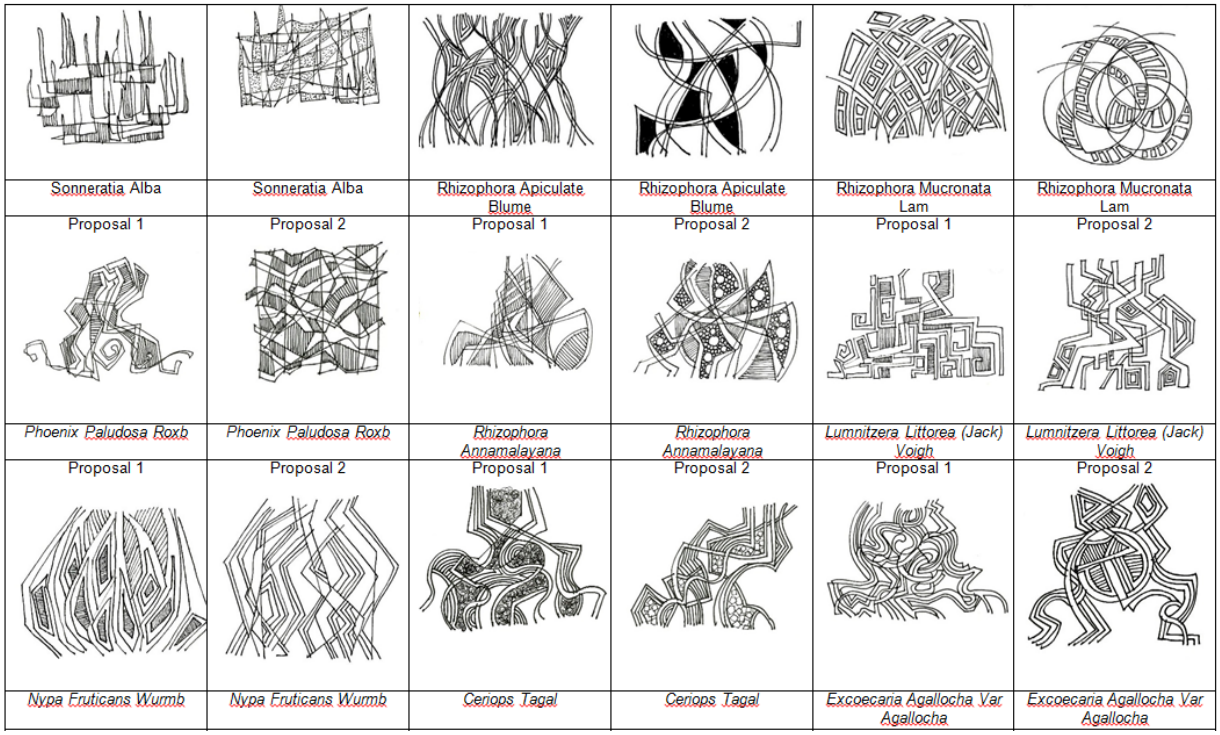



Figure 3a: The development of patterns according to mangrove roots. Source: Authors

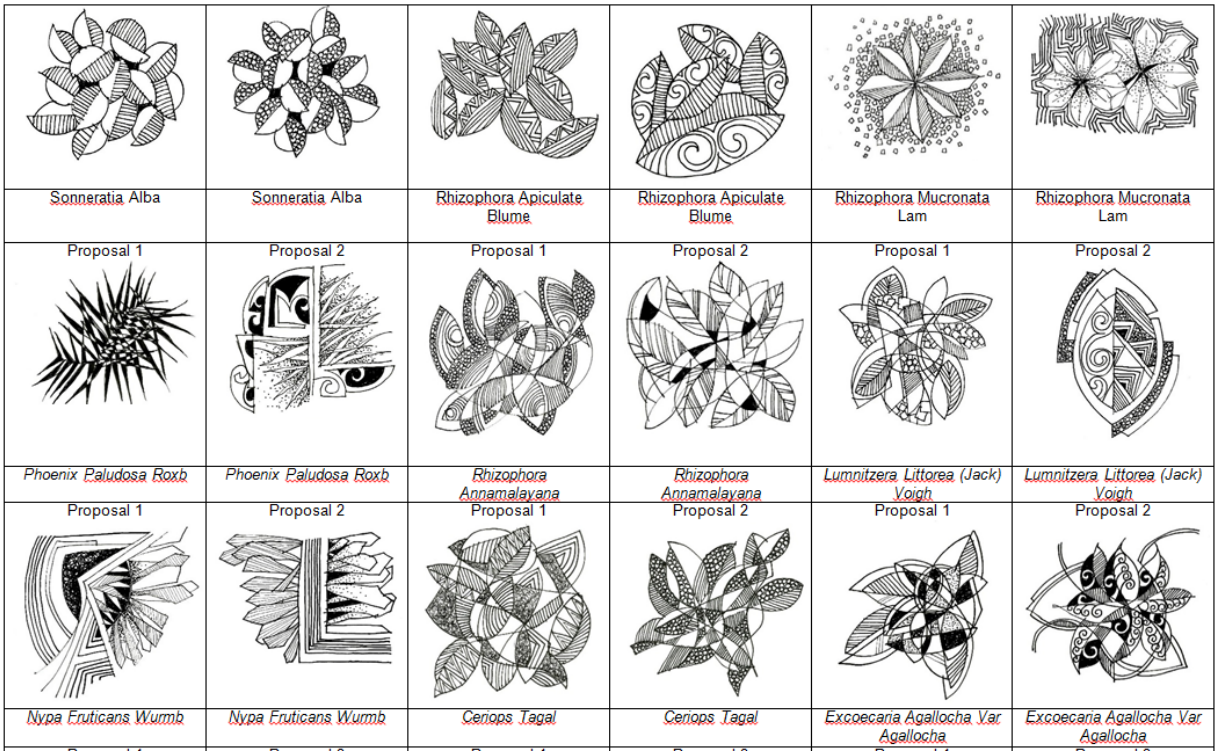



Figure 3b: The development of patterns according to mangroves leaves. Source: Authors

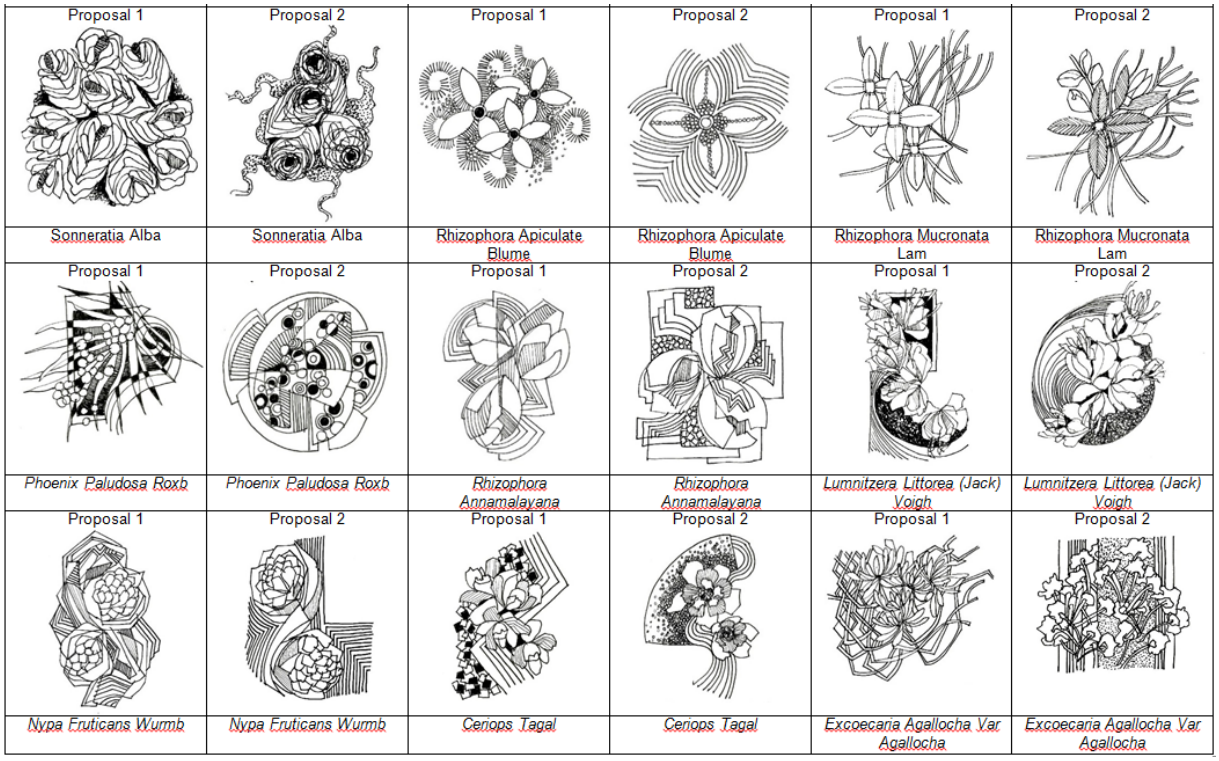



Figure 3c: The development of patterns according to mangroves flowers. Source: Authors

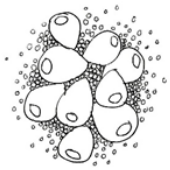
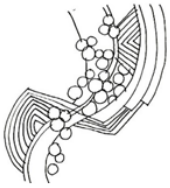
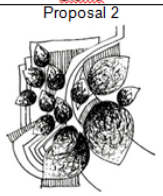
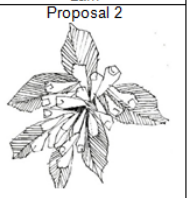
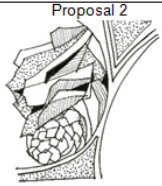
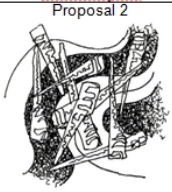
| Proposal 1 | Proposal 2 | Proposal 1 | Proposal 2 | Proposal 1 | Proposal 2 |
|---|---|---|---|---|---|
|  |  |  |  |  |  |
| Sonneratia Alba | Sonneratia Alba | Rhizophora Apiculate Blume | Rhizophora Apiculate Blume | Rhizophora Mucronata Lam | Rhizophora Mucronata Lam |
| Proposal 1 | Proposal 2 | Proposal 1 | Proposal 2 | Proposal 1 | Proposal 2 |
|  |  |  |  |  |  |
| *Phoenix Paludosa Roxb* | *Phoenix Paludosa Roxb* | *Rhizophora Annamalayana* | *Rhizophora Annamalayana* | *Lumnitzera Littorea (Jack) Voigh* | *Lumnitzera Littorea (Jack) Voigh* |
| Proposal 1 | Proposal 2 | Proposal 1 | Proposal 2 | Proposal 1 | Proposal 2 |
|  |  |  |  |  |  |
| *Nypa Fruticans Wurmb* | *Nypa Fruticans Wurmb* | *Ceriops Tagal* | *Ceriops Tagal* | *Excoecaria Agallocha Var Agallocha* | *Excoecaria Agallocha Var Agallocha* |

Figure 3d: The development of patterns according to mangroves fruits. Source: Authors

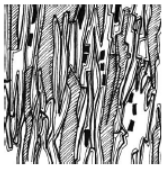
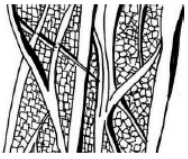
| Proposal 1 | Proposal 2 | Proposal 1 | Proposal 2 | None developed | None developed |
|---|---|---|---|---|---|
|  |  |  |  | | |
| Avicennia Alba | Avicennia Alba | Grey Mangrove | Grey Mangrove | Acrostichum speciosum | Acrostichum speciosum |
| None developed | None developed | None developed | None developed | None developed | None developed |
| Aegiceras corniculatum | Aegiceras corniculatum | Sonneratia caseolaris | Sonneratia caseolaris | Sonneratia Griffithii | Sonneratia Griffithii |
| None developed | None developed | Proposal 1  | Proposal 2  | None developed | None developed |
| Sonneratia ovata Backer | Sonneratia ovata Backer | Xylocarpus Granatum | Xylocarpus Granatum | Scyphiphora Hydrophylacea | Scyphiphora Hydrophylacea |
| None developed | None developed | None developed | None developed | None developed | None developed |
| Sonneratia Alba | Sonneratia Alba | Rhizophora Apiculate Blume | Rhizophora Apiculate Blume | Rhizophora Mucronata Lam | Rhizophora Mucronata Lam |
| None developed | None developed | None developed | None developed | None developed | None developed |
| Phoenix Paludosa Roxb | Phoenix Paludosa Roxb | Rhizophora Annamalayana | Rhizophora Annamalayana | Lumnitzera Littorea (Jack) Voigh | Lumnitzera Littorea (Jack) Voigh |
| None developed | None developed | None developed | None developed | None developed | None developed |

Figure 3e: The development of patterns according to other parts of mangroves.
Source: Authors

## Conclusion and Further Research

In this research project, typology matrixes on mangroves species of Sungai Merbok, basic design patterns developments and basic design patterns comparison were developed, and these were the main contributions of this project – which also the main objectives for this study. This process of developing ideas taken from the mangroves species had produced different variations in the design patterns. In general, the mangroves species gathered and analysed in this design development study had not been previously classified and analysed, although there are fascinating findings towards this type of natural inspirations. Because of the distinctively and diverse characters and the abundant of the mangroves species, this plant was chosen to be the main source of inspiration. However, the basic idea developments produced will go through several more design development phases before the final product can be produced, and this will be part of future research.

This study used a pragmatist qualitative approach where the researchers choose the methods that are deemed appropriate for this study, such as the used of observation method on the images of the available species of mangroves in Sungai Merbok by looking into secondary data (books on mangrove species and internet search). The findings then were categorised in the typology matrix before the idea development process (early ideation sketches) taking place. No primary data collection (no interview or survey) involving people or the expertise was done. This study employed the design process directly, which are deemed suitable and necessary. Moreover, this research will encourage more developments in designs which are inspired by nature. Although the conceptual idea is still in the early phase, each design has shown potential and variations. The design patterns are made roughly (known as a quick sketch) as the basic ideation that simplified the detail features of the mangroves physical beings.

Additionally, the new range developments can be used to produce product designs or any other form of design (2D or 3D) such as illustrations and graphics, fine art, souvenirs, jewellery and other fashionable items or household products. To achieve this stage, the study will require further research and a step-by-step exploration of forms and shapes specifically towards the intended end products. This process will be done continuously and up to the final stage by finalising the functions and considering the suitable materials use. However, the usages of the mangroves patterns (product proposals) are still undecided because of many prospects on the application of the patterns. Hence, this is the stage that the researchers aim to pursue in future research. It is hoping that this project will continue further where more findings (more design developments on 2D and 3D) can be done, and more research and design processes can be integrated. The variations on idea developments show the potential to bring forward this subject matter and fully developed it to be adapted in the educational design project as well.

## Acknowledgement

We would like to acknowledge the fund received for this research is from the Excellence Grant (Dana KCM), UiTM Kedah.

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