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EDIBLE INSECTARIUM: DESIGN CONSIDERATION FOR THE TROPICS

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Our ability to feed our growing population is becoming increasingly concerned. Population trends suggest that by 2050 there will be 9.6 billion people on the planet, and food demand will increase by 60%. Using edible insects as an alternative source of protein for human food and animal feed is the best idea for a solution. However, the challenge is to integrate insects as human's source of food and changing the human perceptions towards insect while educating human the importance of insect to the environment. The purpose of this study is to explore the design consideration of an insectarium in general. Four case studies of project in Malaysia and Southeast Asia are selected for this research: Entopia by Penang Butterfly Farm, Kuala Lumpur Butterfly Farm, Singapore Changi Airport's Butterfly Garden and Bangkok Butterfly Garden and Insectarium. Comparative study was done based on the availability of information internet findings, some own experience and suggestions from expert and others. As a result, a recommendation for design consideration in designing an insectarium in tropical climate will be compared and discussed on their pros and cons. This outcome will be a reference and attention to the designers in applying the best condition of design requirement as well as design principles to a build insectarium.

Keywords: Edible insectarium, Edible insect, Tropical insectarium, Insect species, Design consideration

1. INTRODUCTION

Insectarium is a space which insect are kept, exhibited, and studied, as in a zoo. According to Insectarium de Montréal (2019), the main purpose of an insectarium is to accompany people by helping them understand nature, especially to reconsider their relationship with insects. Insectarium can also highlight their essential roles in order to help our global issue and our planet's ecological balance. To make an impact on the way humans see insects, Insectarium does rely on intimate, experiential and emotional approaches. This is because as visitors wander through insectarium, they can engage all their senses in a transformation process at the end of which they better understand this unknown universe and marvel at its diversity.

Besides that, awareness and exposure to different environments has also helped in promoting entomophagy, where most people usually started trying eating insects when visiting countries that are more open to entomophagy, such as countries in Southeast Asia. Insects are also very abundant and diverse, with a lot of edible insect species, making it a lot easier to try out entomophagy. Other factors may include their sustainable ways of farming, and their high-quality protein content (Interesting Engineering, 2019).

2. UNDERSTANDING THE VIVARIUM-INSECTARIUM

Vivarium is a space designed by combining science and art, where it is resembling a terrarium, but the microenvironment inside the space must be created in the best interest of the animal inhabitants according to Missouri Botanical Garden (2018) and Space for Life (2019). While according to Mike Soper, 2017 a vivarium is an enclosed area intended for observation, education, and scientific research to provide a stable environment for animals and plants. Sometimes for a species with managed environmental conditions on a smaller scale, they include a portion of an ecosystem. A vivarium can therefore be small enough to sit on a desk or table, such as a terrarium or an aquarium, or it can be a very large structure, probably outside for example is insectarium, an enclose space containing insects, arachnids, and other similar arthropods.

3. METHODOLOGY

The approaches used to complete this study was using comparative research while focusing on qualitative research. In this study, qualitative research is used to create insight into certain parameters of the selected project. It helps to develop ideas or hypotheses at the start of quantitative research. Date and information basically came from;

Primary Data

Primary sources that are all the information collected for the case studies chosen. The finding is depending on primary data which is made up from the case studies. These methods were chosen as it is only seen as appropriate to understand the space of insectarium and achieve the research objectives. This is also because there is less research had done to discuss about insectarium.

Secondary data

Secondary sources that involve the theoretical frameworks through literature review. The findings of this study much probably will be depending on primary data such as case studies, but the secondary data is also an important aspect by providing the foundation to start this study. This includes all literature review from that been done through academic journals, websites, news articles and books. These all items have been summaries and discussed in detail in chapter 2 by establishing a rounded view of the subject matter. The review includes the study about insect and insectarium.

4. PRECEDENT STUDIES

The research has been done by selecting the 4 precedent studies on buildings that contain insectarium or any building that are suitable enough to consider as a vivarium. This potential project was found through internet findings, some own experience and suggestions from expert and others. This selected insectarium has something special that, when a further researched, could be of value when wanting to design a vivarium. The project was analysed to find out what it is that brings quality to them. And all the selected project is in Malaysia as well as around South East Asia. The in-depth precedent study project is;

a. Entopia by Penang Butterfly Farm – Malaysia

Figure 1: The map shown the location of Entopia by Penang Butterfly Farm

The Natureland, a living garden vivarium in Entopia, is a shared ecological environment for a variety of animals including invertebrates and reptiles living in their natural habitat that has been recreated. More than 200 plant species with waterfalls, ponds, caves and other imaginative landscape features are included in the living greenhouse.

b. Kuala Lumpur Butterfly Farm – Malaysia

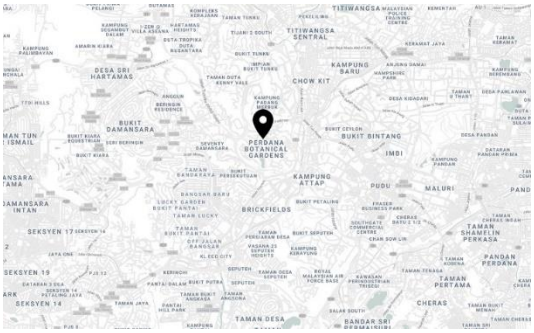

Figure 2: The map shown the location of Kuala Lumpur Butterfly Farm

Kuala Lumpur Butterfly Park in Kuala Lumpur, Malaysia, is a large public butterfly park. It's a popular country tourist attraction. It is adjacent to Lake Gardens and the Bird Park of Kuala Lumpur. It is one of the largest houses in the world, spreading over 80,000 square feet of landscaped garden with over 5,000 butterflies, exotic plants, butterfly host plants and ferns.

c. Singapore Changi Airport's Butterfly Garden – Singapore

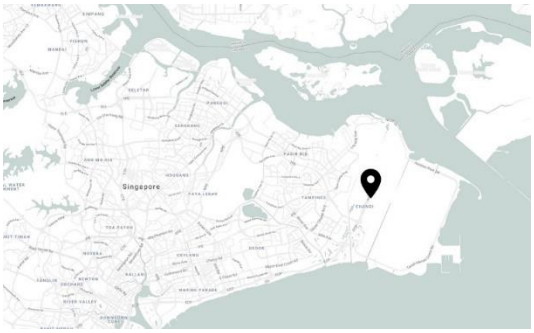

Figure 3: The map shown the location of SCA's Butterfly Garden

The world's first butterfly garden at an airport has been planned as a tropical butterfly ecosystem with an array of flowering plants, lush greenery, and a 6 m waterfall grotto. During the different seasons of the year, Singapore Changi Airport's Butterfly Garden showcase over 1,000 tropical butterflies from as many as 40 species are found.

d. Bangkok Butterfly Garden and Insectarium – Thailand

Figure 4: The map shown the location of Bangkok Butterfly Garden and Insectarium

Bangkok Butterfly Garden and Insectarium has a total of 2.4 acres, including exhibition rooms, educational resources and activities that allow you to learn about butterflies and insects like never before. Upon learning about the life cycles and survival of the butterfly in the main building, then visitor can walk into insect's home full of wildflowers and waterfalls among hundreds of incredible butterfly species.

The selection was made based on a few factors. The criteria selection of the case studies will be stated as the following:

i. The project is in tropical climate area
ii. The inside insectarium habitat must be mimicking tropical climate
iii. Having an enclosed space with vegetation inside (Vivarium)
iv. Having different type of material and construction

The project then being analyses according to a template. This template (Table 1) shows the criteria such as layout, water element, lighting system, roof structure and material, temperature and climate, air flow system, type of plant and captive animal in the volume. A total of four precedent studies will be compiled which include two projects in Malaysia and two insectariums from neighboring country which is from Thailand and Singapore. All the project was selected based on their climate location which is in tropical area. The precedent studies will be examined regarding

six criteria of a vivarium which is; Layout, water element, lighting, roof structure and material, temperature or climate, airflow system, plants and captive animal.

Table 1: Summary of selected precedent study.

Factor	Precedent Study			
	Entopia	KL butterfly farm	SCA butterfly garden	BKK butterfly garden
Layout & Space	Main Building - Entrance - Ticketing - Information - Gallery - Toilet - Souvenir Shop Insectarium - Landscape - Water Fountain - Pond - Man made Cave - Feeding Spot	Main Building - Entrance - Ticketing - Information - Gallery - Toilet - Souvenir Shop Insectarium - Landscape - Water Fountain - Pond - Gazebo - Feeding Spot	Located in the Airport Insectarium - Information - Landscape - Water Fountain - Pond - Feeding Spot	Main Building - Entrance - Ticketing - Information - Gallery - Toilet - Souvenir Shop Insectarium - Landscape - Water Fountain - Pond - Feeding Spot
Water Element	- Water feature - Manmade pond	- Water feature - Manmade pond	- Water feature - Manmade pond - Spray humidifier system	- Water feature - Manmade pond
Lighting	Natural lighting from the top	Natural lighting from the top and 4 side	Natural lighting from the top and a side	Natural lighting from the top and 4 side
Roof structure & Material	Roof -Steel structure shell Material -Stainless steel wire rope - Insect mesh	Roof - Steel column Material -Stainless steel wire rope - insect mesh	Roof -Steel structure shell Material -Stainless steel wire rope - insect mesh	Roof -Steel structure shell Material -Stainless steel wire rope - insect mesh
Climate	Tropical climate	Tropical climate	Tropical climate	Tropical climate
Airflow System	Natural Ventilation	Natural Ventilation	Natural Ventilation	Natural Ventilation
Plants	Understory and forest floor type of plant species	Understory and forest floor type of plant species	Understory and forest floor type of plant species	Understory and forest floor type of plant species
Captive Animal	- Silkworm - Rajah Brooke's Birdwing Butterfly - Diving Beetles - Atlas Moth - Giant Forest Scorpion - Indian Leaf Butterfly - Banded Swallowtail - Tarantula	- Variety species of butterfly - Variety species of dragonfly - Crickets - Rhinoceros beetles - Scorpions	- Variety species of butterfly - Variety species of moths	- Variety species of butterfly - Variety species of moths

5. DISCUSSION

The project then being analyses according to a template. This template (Table 1) shows the criteria such as layout, water element, lighting system, roof structure and material, temperature and climate, air flow system, type of plant and captive animal in the volume.

Layout & Space

A Based on precedent study we can conclude that in general the layout of insectarium is an open layout design with landscape design that play crucial part of the planning. The often-green atmosphere offers a welcome contrast to the rest of the building. Besides circulation the areas are also used for people to get together to interact with insect. Those insectariums that charge for entrance fees such as Entopia, KL butterfly farm, and Bangkok butterfly garden & insectarium will include ticketing and gallery for visitor to learn more about insect as well as a souvenir shop at the end of the tour. Public insectarium such as SCA butterfly garden does not have this kind of space because it is a free entrance attraction built at the airport.

Water Element

According to Fei Xue (2014), a water fountain can improve the thermal environment by increasing the humidity and lowered the temperature of the surrounding. Incorporation of water features in design benefits the thermal performance as well as providing aesthetic value to the design. Humidity plays an important role in insect development. In general, most insect species need a humid environment which is around 60% 80% RH while according to Hitomi Tsutsumi (2006) human body need 30% to 70% relative air humidity, RH to be comfortable. Thus, we can conclude that in order to maintain both comfortable humidity for human to visit and for the insect to thrive inside the insectarium should be around 60% to 70% RH.

Climate, Lighting & Plants

The study is about insectarium in tropic, the interior volume received a lot of sunlight and the amount the sunlight received is constantly throughout the years. All precedent study is using translucent material that allow sunlight to go through. In tropical environment, light is a significant determinant for endurance and development of tree, and it is normal that plants can modify their leaf as well as whole-plant qualities to changing light accessibility. According to Bongers & Popma 1988, shade-growing leaves are thinner, have lower mass per unit area and have higher mass-based chlorophyll content than do sun-growing leaves.

In this way, acclimation to a high light condition frequently brings about thicker leaves. Thus, the structure and design of vivarium plays an importance role in order to allow the sunlight intake for the tree inside the volume to grow while this tree is providing a habitat and food source to the insect species.

Roof structure, Material & Airflow System

To create a space and ecosystem that build for tropic, the inner volume must have a stable environment with outside. Thus, roof structure and material play a crucial part in determine on how the insectarium sustain the environment for insect survival. It is an advantage for insectarium located in the tropical setting as the design can be incorporated well with climate. Natural ventilation insectarium plays a major contribution in order to be a sustainable insectarium. Thus, material that covered insectarium need to be breathable but at the same time it does not allow insect to go out for example stainless steel wire rope and insect mesh.

Captive Animal

Insects are a decent source of nutrients and are equivalent to the ease of high protein content compare to other animal sources. In general, insects can supply protein (20-70%), amino acids (30-60%), fats (10%-50%), minerals and vitamins that are essential to human health. According to Lumsa (2001), the nutritional values vary according to the species and how they are prepared for consume on. Almost 200 edible insect species are consumed in Thailand and 50 edible insect species are consumed in Malaysia. In poor or rural area, people consuming insects is no longer viewed as a bad thing. According to Hanboonsong et al. (2001) nowadays, they are often eaten by urbanites, also by high income earners. People eat insects not only because of their nutritious content but also because of their

palatability. According to UN and Yupa, (2013), edible insect can be categories into two; farmed edible insect and wild harvested edible insect.

Table 2: Most popular edible insect.

Wild Harvested Edible insect	 Bamboo caterpillar
	 Weaver ant
	 Giant water bug
	 Grasshoppers
Farmed edible insect	 Cricket
	 Palm weevil

6. CONCLUSION

The research question posed at the beginning of this research was: What are the species of edible insect that are suitable for farming and wild harvesting inside insectarium? And what is the ideal design consideration for edible insectarium in tropical climate. In general, we all know that the function of an insectarium is a space which insect are kept, exhibited, and studied, as in a zoo which will help people to understand insects. But in order to create an edible insectarium a selection of edible insect species is needed to the be raise and breed inside. It is not really a hard measure since almost every species from tropical climate has the same requirement and condition for their habitat.

Only certain species such as crickets need to have their own breeding container for easier harvesting session. It is an advantage for insectarium located in the tropical setting as the design can be incorporated well with climate. Natural ventilation insectarium plays a major contribution in order to be a sustainable insectarium. Besides, landscape planning mainly used as a circulation area and the atmosphere and natural light of the landscape offers a welcome contrast to the rest of the building as well as important for people to interact with insect.

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