Formulation of design concept of urban park using butterflies as a good urban environment bio-indicator

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Abstract: Creating an urban eco-park an efforts to restore habitat in urban areas. The Urban Eco-Park is useful to be a wildlife refuge, as well as functioning the urban park to become an indicator of environmental quality by introducing butterflies. The butterfly is one of the animals that can be observed more easily and closely than other species of insects. Butterflies have a significant ecological role, which can be found in several habitats of urban areas. The benefit of butterfly is acting as a good urban environment bio-indicator. Some butterflies’ species mentioned in a case study as a bio indicator but the abundance and diversity of butterflies have more important role to indicate a good urban environment. The objective of this study is creating model to formulate a concept of urban park where the park is become an indicator of a good environment showing by butterflies appearance. The Site Plan was made with concept to invite butterflies by using their proper plants preferences (food plants and host plants). The method in this study using descriptive method comprised literature review from case studies and field observations. The result showed that a well landscape management was able to provide suitable food plants and host plants which were important to maintain the existence of butterflies in an urban park.

Keywords: urban park, butterfly, food plant, host plant, bio-indicator.

1. Introduction
The appearance of butterfly is an aesthetic and ecological value. The existence of butterfly in the environment are mentioned to be pollinators of plants, food sources for other animals and also has an important role in scientific discoveries. Butterfly can live in many different habitats and their populations undergo normal fluctuations form year to year. There can be large differences in butterfly’s abundance and diversity of their habitat in any given landscape. Unfortunately, environmental disturbance overcome decrease of the butterfly population. Environmental disturbance is a change in environmental components forming the habitat thereby affecting the ecosystem imbalance and biotic communities inside [4].

In order to reduce the impacts of disturbance, the thematic garden is needed, such as the ecological park (eco-park), wildflower gardening, and the butterfly park, which were useful in attracting butterflies...
and other pollinating insects. Currently, the appreciation of butterfly has evolved from consumptive use as collectibles and souvenirs to conservation measures. Increased knowledge and understanding of the importance of butterflies and ecological balance are getting [1].

Butterfly is one of the animal species that responds to environmental disturbances and is easy observed. Almost all butterfly species are herbivores, as well as its larvae or caterpillars are plants, flowers, or fruits’ leaf-eaters, which are often species-specific. The caterpillar of *Papilio polytes* and *Papilio demoleus* eats citrus leaf (*Citrus aurantifolia, Citrus grandis*). *Graphium Agamemnon* lays their eggs on *Annona muricata* (soursop) and *Polyalthia longifolia* (asoka tree). This shows that the diversity of butterfly species is associated with the diversity of plant species. The existence butterflies in a park will enhance the aesthetic value along with blooming flowers. In order to maintain these butterflies in the park, it necessary to ensure the feeding is sufficient for caterpillar and adult butterflies. Providing proper trees as host plants and flowers for food plants in the right place of the park. The abundance and diversity of butterflies indicate a good quality of urban environment.

The study aims to formulate the concept of an urban park as an indicator of good environment, with the approach of using butterflies. This study also made a concept of garden model that possible to attract butterflies. The concept consist of arranging suitable plant of butterflies’ preferred (food-plants and host plants), in order to live and survive in urban park.

2. Methods

The study located in Cibinong, Bogor, West Java, Indonesia. The urban park area in this district has a potential habitat of butterfly which is near water bodies and have a patch area that consist trees and herbaceous plants that would provide food plants for butterflies. The elevation is about 141-151 meter above the sea level.

The analysis method was descriptive qualitative by analyzing case studies and adapting information proposed to the butterfly and preferred plants [1,5]. In addition, field observations around the site was conducted to study butterflies behavior along the influence factors.

The scope of the study is determine butterflies behavior in some habitats in urban areas, identifying the type of preferred plants (food-plants for adult butterflies and host plants for caterpillars) and adding the preferred plants in urban park concept.

3. Discussion

3.1. Butterfly Diversity on Various Habitat and The Affecting Factors

Habitat is the environment in which an animal or plant normally lives or grows. Habitat degradation refers to a reduction of habitat quality. Habitat quality is reduced when the breeding success of a particular species is compromised, or when the number of individuals of a species that the habitat can support and the diversity of organisms supported by the habitat is reduced. Habitat may be degraded via the alteration of community components (species composition and diversity), structural components (physical habitat structure), or environmental components (climatic, chemical, and other abiotic variables) [18].

The existence of a butterfly in a habitat affected by the characteristics of the habitat itself. Forest reserve is one of the least distracted urban forest, which will be the most effective and affluence conservation for butterfly species [4,10,16].

Based on the level of sensitivity, tolerance, and the ability to adapt, species of organisms are divided into specialist species and generalist species, which require specific habitat requirements and conditions to live and breed.

A study was conducted to understand the value of conservation in forest reserves, forest fragments, and urban parks in Singapore. Forest reserve is part of the Central Catchment Nature Reserve of Singapore, which consists of secondary forests, tropical lowland rain forest, and freshwater swamp forest [10].
The forest reserves location has the highest diversity of butterflies than the other habitats. An urban park located near forest fragments, which has a similar composition and diversity, may increase the diversity of butterfly species. This can occur due to the varied microclimatic conditions and ecological niches in both of the habitats.

The research results in Singapore indicate that the butterfly cosmopolitan species or generalist species is able to survive in an urban park rather than the border areas. This may be due to the wide and easy adaptable distribution of this species than the butterfly specialist species. Differences in ecological treatment (host plants specificity) and environmental factors (such as canopy cover) in butterfly species may affect the distribution between different habitats. The number of survived butterfly species in an urban park depends on the number of available potential host plants.

Unmanaged areas are an area of semi-natural, which often in the early stages of ecological succession with a high diversity, and have plants that fit the needs of a butterfly [14]. Microhabitat components are consisting of, namely (a) shrub; b) hedges; c) nectar plants, and d) unmanaged areas. The diversity of microhabitat components determines the diversity of butterflies in the urban parks.

Butterfly communities respond and predisposes to its habitat conditions according to its needs and preferences. Butterfly is one of the organisms that have a sensitivity and specificity to a particular environmental condition that is indicated to be negatively affected, but also reflect the condition of its habitats [3].

Abiotic factors that affect the characteristics of the fourth urban forests are sunlight intensity, temperature, and humidity. Leaf area index was calculated to determine the flatness of canopy crown and the characteristics of canopy closure. The humidity required for the butterfly ranges between 50 to 75%, and the temperature ranges in 20 to 40°C [17]. While tolerance limit of light intensity ranges from 500 to 7500 lux [12].

3.2. Correlation Between Various Plants Preference and Butterfly Abundance
A study of four-type urban forest in East Jakarta, Indonesia had identified 22 species of butterflies. Urban Forest Rawa Dongkal, which has the settlement type of urban forest, reached the highest species diversity with as many as 18 species; followed by Urban Forest Kopassus Cijantung located in an office area with as many as 15 species, Urban Forest PT. JIEP located in an industrial area with 11 species; and the lowest was in Urban Forest Cawang UKI, located in the highway area, with only as many as 7 species of butterflies. The differences in observation periods resulted in differences in the number of butterflies. The highest number of species is found in the dry season. While in the transition between the dry season to rainy season, 20 species were found. And in rainy season, only found a total of 17 species.

Four species of butterflies found in overall locations and observation periods, which are *Graphium Agamemnon*, *Deliashyparete*, *Euremahecabe*, and *Leptosianina*. These four types of butterflies found in a large number in overall locations and observation periods. These species can be categorized as generalist species type [9].

Some butterfly species are found only in one location (site specific), among others, *Ideopsis juventa* and *NeptisHylas* at Urban Forest Rawa Dongkal, *Papilio demoleus* at Urban Forest PT. JIEP, and *Floss aniella* at Urban Forest UKI Cawang. In addition, there are two species of butterflies found only at certain locations and periods, which are *Polyurahebe* at Urban Forest Rawa Dongkal and *Ypthima hor sfieldii* at Urban Forest Koppassus Cijantung, both only during the dry season. The low frequency of attendance indicates that these species have a strong attachment to particular habitat components that only exist in locations that provide these habitat components and are sensitive to certain environmental conditions [2].

The results of correlation analysis showed a significant positive correlation between plant species richness with the species richness and diversity of butterflies. This supported the theory that abundance food plants and host plants species can be used as predictors of the variety of butterfly and is the most dependent factors in influencing population size and butterfly’s diversity [15]. Further confirmed that
the size of the butterfly population in an urban environment is related to the availability of various types of food plants, not by their abundance[16].

With abundance food and host plants and the most diverse plant species make Urban Forest Rawa Dongkal the highest variety of butterflies. Caterpillars have specificity to certain food plants while on the other hand, adult butterflies have no specifications for their food plants. Based on the observations described in this study, in addition to nectar plants, adult butterflies are also often found to consume tree sap, decomposing fruit, animal feces, or animal carcasses.

Throughout the study, butterflies are often found perched on a variety of ground cover habitats. For example, *Mimosa pudica* was the most cover ground plants that was found in the four research sites and as food for the *Eureka hecabe* butterflies. The *Imperata cylindrica* (reed) is often visited by the *Nymphalidae* family, while Lantana camara (big-sage) due to its attractive colors and scents, is often visited by the genus *Graphium*.

These observations confirmed the theory that most butterflies are found in herbaceous feeding plants [11]. Various types of plants of the family Fabaceae found in the urban forests provide diverse host plants for the caterpillar. The legume is a plant family that is most widely used by the caterpillar as host plants. The presence of shrubs in overall locations, in addition to functioning as host plants, also serves as a shelter so that its presence supports the existence of butterflies. The areas with bush vegetation will affect the high diversity of butterflies in those areas[11].

![Figure 1. Nectar plants](image)

Those butterflies' preferences and requirements of the components of a certain habitat, where the resources availability of the habitat will affect the existence of butterflies[10].

Wildlife Habitat Management Institute and Wildlife Habitat Council of America (2000) mentioned various factors of butterflies’ requirements which to be considered in developing a suitable habitat for the survival of butterflies. These factors are:

- **Cover Plants**
  Tall trees that have wide canopy will protect butterflies from strong gusts of wind and rain [13]. Butterflies will choose the areas with less compact canopy, because less dense areas will allow sunlight to enter and create warmer micro-climate that can maximize the growth of caterpillar [7]. Butterflies also favor these areas because the sunlight maintains their temperature and metabolism.

- **Water**
  In the life cycle of butterflies, water requirements are fulfilled mostly in the caterpillar stage by its consumption of green vegetation. Whereas for the adult butterflies, the water requirements are fulfilled by the nectars. Nevertheless. Adult butterflies will gather in small mud puddles as well as wet sand areas to absorb minerals and salts contained in the puddles known as mud puddling. Puddling is more of nutrient source than water.
Food – butterflies (food plants)
Adult butterflies depend largely on the availability of nectar as food source. While other species take nutrition and minerals from rotting fruits, tree sap, animal feces and urine, and animal carcasses. Nectar plants are the main food for adult butterflies. The sufficient provision of light-colored nectar plants needs to be considered because butterflies can quickly recognize the plants. Planting in areas with an abundance of sun intensity is important for plants and butterflies. Nectar plants are flowering plants that require sun exposure. Butterflies also demand a high intensity of sunlight as butterflies use solar heat to increase metabolism and help them fly.

Food - Caterpillars (host plants)
Each species of butterflies laid their eggs on certain plants as host plants. Caterpillar’s host plants can be shaped as leaves on trees, shrubs, vegetables, legumes, wild flowers, grasses, and weeds in Figure 2. Female butterfly is quite selective in choosing host plant to lay their eggs to ensure the growth of caterpillars that fit the feed. The existence of host plants will also invite the female butterflies to lay their eggs. There are several important factors that affect the pattern of oviposition (egg-laying) on butterfly, namely microclimate, vegetation structure, the number of host plants available, and the availability of nectar-producing plants. When the number of plants that can be used by butterflies as oviposition sites increases, the abundance of caterpillar found will also increases [7].

Interspersion of habitat component
In ensuring the reproduction of butterflies goes well and their ability to survive, all the necessary habitat components must be available. The ideal butterfly habitat component consists of a complex of closely spaced vegetation, comprising with diverse sources of host plants and food plants (trees, shrubs, wildflowers, legume and grasses), open water, and puddling areas.

Minimum area for Habitat
Although butterflies can search for food in large areas, there is no minimum size for a butterfly habitat. Butterfly species has potential and can be found anywhere as long as the closure of plants required by caterpillars and adult butterflies are available. In general, minimum habitat size is not a limiting factor for each species, as the territory of each species varies.

3.3. Landscape Design Concepts for Inviting Butterflies into The Urban Park
The beauty of butterflies has been admired so far because it appears attractive with various patterns and colors. Butterflies roam the sunny wildflower gardens; lawns and garden fields, searching for feed on the nectar of flowering plants. The correct selection of plants will help to influence the visit of interested butterflies, which then settle and reproduce there [8].

**Figure 2.** Host plants for caterpillar
Environmental consideration becoming an important part in creating a concept planning of a landscape [5]. Analyzing site’s micro and macrclimates, ecosystem, hydrology, vegetation and soil condition will conclude a valuable consideration. The organizing of a landscape concept has to be well designed for the sustainability of an urban park. Base on various factors purposed by Wildlife Habitat Management Institute and Wildlife Habitat Council of America [1], the criteria that establish the landscape space concept consist of:

- Butterfly habitat components
  Six components of butterfly life requirements that have described previously are priority factors in preparing the concept of an urban park as a butterfly park. Furthermore, the next consideration is the abiotic factors and environmental disturbances that exist around the site. Urban park area that has been qualified according to these criteria will determine the survival of the butterfly.

- Butterfly Maintenance Area
  This area was created with the aim of providing life support for the butterfly. The live support component may consist of a caterpillar conservation area, cocoon (chrysalis) space, and adaptation area for butterflies before being released into the wild.

- Vegetation arrangement by function
  In essence, there are four categories of vegetation areas based on their function, namely the shelter plants (canopy cover), the caterpillars’ host plants, the butterfly’s food plants, and the nursery plants. This vegetation placement is arranged in zones according to its function. Plants are arranged by the composition of plants’ strata (ground cover, shrubs, trees) to look aesthetic.

- Butterfly display and collection room
  This is an enclosed area, which designed according to the life requirements of a butterfly. The sunlight should sufficiently penetrate through parnet. Plants display in this area is only for food plants for butterfly due to the presence of caterpillars may cause inconvenience for visitors. Butterflies are supplied from the butterfly maintenance area.

- Butterfly Collections Introduction
  The determination of the butterfly species that will be displayed is related to food plants and abiotic factors that influence it. Butterflies that will be introduced are local butterfly species that already exist on the site. To maintain its existence, the plant feed should always be available and assisted with well treatment in the butterfly maintenance area.

- Management and service area
  The park management requires an area that serves as management space, office, and visitor services. The management and office area are private, while the visitor service area is semi-private.

- Visitor management program
  The urban park is a green open space that accessible and can be enjoy by visitors as part of recreation and tourism. The visitor management serves to provide visitors comfort, as in determining the visit time and also serving the group visits (school and community), route visits, and educational tourism program packages.

The green open spaces in urban park should be optimally functioned to maintain biodiversity, including the butterflies’ habitat. Furthermore, the selection of plants located in green open spaces should include the caterpillar host plants and nectar sources for the butterflies [7]. This statement is valid that food plants and host plants have the important role in attracting butterflies. Concept in
arranging butterflies habitat in urban park should be focusing on a proper placement for food plants and host plants in Figure 3.

![LEGEND](image)

**Figure 3.** Zoning and developed concept

Nursery plants area have to be well managed in order to maintain sustainability of butterflies of the urban park. Since the caterpillar needs plenty of particular leafs while adult butterflies will search plants with more flowers. These plants in the nursery area should have always been ready to support food plants and host plants. Not only concern in plants but also periodically, the caretaker should check butterflies’ eggs and caterpillar. And then bring them to the breeding house to keep away from predators such as aphids, spider and mantis. When the chrysalis is hatch and the young butterfly ready to fly, it means they are ready to be moved to the display area. A good management will support the life of butterflies in the urban park.

4. Conclusions

Some result study mentioned that several species of butterfly has sensitive responses to disturbance of environment called as bio indicator. However, the higher diversity of butterflies occupied particular areas shows that the environment is in good condition.

Urban parks ecological function could be enhance to be a habitat for butterflies in urban areas, hence it becomes a patch (stepping stones) or even as a small habitat for the butterflies. The diversity of butterfly species and population that exist in an urban park indicates that the environment is in a good quality and suitable as butterflies’ habitat. Food plants and host plants are the important factors to maintain the existence of butterflies in an urban park. Butterflies will seek another area if the food plants and host plants are insufficient.

Further research was necessary to explore more detail information in providing sufficient food plants and host plants in the urban parks, as it has become the important factor to create a sustainable environment for the butterflies in urban parks.

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