Termite assemblage structure in Batam Island, Indonesia

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Abstract. Termite’s biodiversity is known to be strongly affected by disturbance, particularly in an urban area. The present study evaluated termite biodiversity and distribution in Batam Botanical Garden, an urban conservation area in Batam Island. In the surveyed area, termites could play a major beneficial role through the promotion of essential ecological processes in ecosystems, such as soil modification and rehabilitation; as well as their well-established role as pests for vegetation. Therefore, biodiversity evaluation of termite is very important to identify economically and ecologically important species. Termite survey had been conducted by a 100 x 2 m belt-transect. Transect area was divided into 20 sections (5 x 2 m), in which each section was surveyed for 30 minutes by two trained people. In total, 106 specimens (15 termite genera) were collected from three sampling sites: Plantation, Mangrove forest, and Forest.

1. Introduction

Termites are considered as one of the most important bioecological indicator [1], given continued degradation of the environment, deforestation, and dramatic changes of land-use function in urban areas. The ecological disturbance is associated with the extinction of species. Termites can be important indicator taxa [2], as they form the bulk of species and have significant influence toward ecosystem processes. Environmental degradation can influence termites’ diversity, considering their dietary preferences, foraging, and nesting habits. Termites play an important role in mediating nutrient cycle and carbon fluxes at the decomposer levels in humid to semiarid regions of the earth. The magnitude of their ecological role is related to their population density and biomass [3].

The present study evaluated the termite community structure in Batam Island, Indonesia. The island is the core urban and industrial zone in the province of Riau Islands, located 20 km off Singapore’s south coast. According to Batam’s Environmental Impact Control Agency, the forest area has been shrinking in size to just 4.2 percent (around 743 hectares) in 2015, out of the island’s original 41,500 hectares in the 1970s. Because of fast depletion of forest area, the Riau Islands provincial administration and Batam municipality have been developing Batam Botanical Garden in an 86 hectare area since 2014, and the garden is expected to function as a conservation center (Figure 1).
Termites could play a major beneficial role through the promotion of essential ecological processes in ecosystems, such as soil modification and rehabilitation [4, 5]. At the other hand, some termite species have well-established status as pests for vegetation. The survey is very important for termite biologists to know species richness from a designated area [6], or to compare the number of species from different areas. Furthermore, the assessment of termite community structure in the designated area of the botanical garden is very important to map and identify economically and ecologically important termite species.

2. Materials and Methods

2.1. Sampling sites

The survey was run in May 2017 in Batam Botanical Garden (1°17’ N, 104°08’ E; altitude 0 – 30 m above sea level). The area consists of primary lowland mixed with mangrove and primary forest, with an average annual rainfall of about 2600 mm. Batam Island has a tropical climate with average temperatures between 26 and 32 °C. Humidity on the island ranges from 73% to 96%. The wet season spans from November to April, while the dry season is from May to October. Three transects were conducted on three different landscapes: Plantation, Mangrove forest, and Forest (Figure 2).
2.2. The Transect Protocol

The standardized belt-transect protocol was 100m long and 2m wide, and divided into 20 contiguous sections (each 5 x 2m) and numbered sequentially (Figure 3), as described by Eggleton et al. [7] and Davies [8]. Each section was sampled by two trained people for 30 min (a total of 1 h of collecting per section).

Termite collectors were working continuously during 30 min collecting period. During allocated time, termite microhabitats in each section were thoroughly evaluated, including 12 samples of surface soil (each about 12 x 12 cm, to 10 cm depth); the soil within and beneath rotten woods; the inside of dead woods, tree stumps, and branches; accumulations of litter and humus at the base of trees and between roots; all subterranean nests, mounds, and arboreal nests up to a height of 2 m above ground level [2]. The priority was given to collect soldiers, as they are the easiest caste to identify. Workers and alates were also collected, if present because these could be used in future taxonomic studies. Collected termites were put into vials filled with 90% ethanol and labeled according to their respective section number.
2.3. Specimens identification

The collected termites were sorted and clustered to their functional groups (Table 1), the grouping that reflects feeding preferences along the humification gradient of the dietary substrates [9, 10]. The collected specimens were then classified into the wood feeder, fungus feeder, and humus/soil feeder. All collected termites were identified until genus level, based on their morphological characteristics provided by Ahmad [11-13], Sornnuwat et al. [14], Takematsu & Charunee [14], and Tho [15]. Paleontological Statistics (PAST) Software ver. 3.2 was employed for data analysis.

3. Results and discussion

3.1. Termite specimen richness

From all collected termites, data inventories for each section were generated, and genus accumulation curves were constructed (Figure 4). The cumulative number of collected specimens was calculated by Sample-based Rarefaction [16, 17] to describe and to compare the richness index of termites found in the sampling areas. Each section of transects was treated as an independent sample. The sequential accumulation of individuals in a single sample, or the successive pooling of samples from a single sample set, produces an accumulation curve [16].

![Figure 4](image.png)

**Figure 4.** Sample-based rarefaction (interpolated genus accumulation) of termites in Batam Botanical Garden from three sampling sites: Plantation, Mangrove Forest, and Forest.

The cumulative number was calculated for the first of the randomly selected sections, then the second section and so on up to the 20th. The mean of the ten sets of 20 sections was then calculated for each of the 20 steps of the genus accumulation, and the curves were generated for each transect (Figure 4). An accumulation curve is the graph of the number of the collected genus as a function of some measure of the sampling effort required to observe them. The results indicated that the Forest area generated a higher cumulative number of the genus, i.e., 13, than those of Plantation and
Table 1. List of termite genera and their distribution across three sampling location in Batam Botanical Garden

| Family/Sub-Family | Genus       | Functional Group* | Transects       |
|-------------------|-------------|-------------------|-----------------|
|                   |             |                   | Plantation      | Mangrove Forest | Forest          |
| Rhinotermitidae   | Coptotermes | I – Wood          | 6               | 3              | 3               |
|                   | Parrhinotermes | I – Wood         | -               | 3              | 1               |
|                   | Schedorhinotermes | I – Wood     | 6               | -              | -               |
| Amitermitinae     | Globitermes | II – Wood         | 3               | -              | 5               |
|                   | Microcerotermes | II – Wood       | 5               | 1              | 4               |
| Nasutitermitinae  | Bulbitermes | II – Wood         | 1               | -              | -               |
|                   | Nasutitermes | II – Wood         | 19              | 10             | 6               |
| Macrotetermitinae | Microtermes | II-F – Fungus     | 2               | -              | 6               |
|                   | Odontotermes | II-F – Fungus     | 3               | -              | 5               |
| Mirocapritermitinae | Dicuspiditermes | III – Humus     | -               | -              | 2               |
|                   | Pericapritermes | III – Humus     | -               | -              | 1               |
|                   | Procapritermes | III – Humus       | -               | -              | 3               |
|                   | Pseudocapritermes | III – Humus     | -               | -              | 3               |
| Termitinae        | Termes      | III – Humus       | -               | -              | 4               |

* The groupings reflect feeding preferences as follow:
  Group I : Dead wood and grass feeders. The only group with flagellate protists in their guts
  Group II : Feed on grass, dead wood, and leaf litter
  Group II-F : Feed on grass, dead wood, and leaf litter, with the help of fungal symbionts grown inside the nest ("Fungus-growing termites")
  Group III : Feed in the organically rich upper soil layers ("Humus feeders")
  Group IV : Feed on organically very poor soil ("True soil feeders")

3.2. Taxonomical composition

The taxonomic composition of transect specimens collected from three sampling sites is presented on Figure 5. Nasutitermitinae (wood feeder, and arboreal nester termites) were found dominance in plantation and mangrove forest, generating 45.65% and 58.82% of collected termites, respectively. In those two areas, termite assemblage communities are dominated by wood feeders from Amitermitinae, Nasutitermitinae, and Rhinotermitidae, enumerating 89.13% and 100% in Plantation and Mangrove Forest, respectively. Two fungus-growing termites, Odontotermes and Microtermes, from Macrotermitinae are two genera found from Plantation area, equal to 10.87% of collected specimens. Most of the area of Mangrove forest is flooded during high tide, and therefore, the condition is not suitable for soil feeder and fungus-growing termites to live.

In total, 106 specimens (15 termite genera, Table 1) were collected from three sampling sites: Plantation (46 vial specimens), Mangrove forest (17 vial specimens), and Forest (43 vial specimens). The taxonomic composition (Figure 5) indicated that Forest generated the highest number of termite genera. Mangrove Forest with flooded soil can be expected to have fewest termite genera, while...
Termite communities in Plantation may be recovered by the migration of some termite species from neighboring forest. The results may provide an insight into how termite diversity is affected by disturbance, as soil-feeding termites were absent from the Plantation area and were only collected from Forest.

Figure 5. The taxonomic composition of transect specimens collected from three sampling sites (Plantation, Mangrove Forest, and Forest) in Batam Botanical Garden.

Davies [8] argued that moisture stress of micro-environments and structure of ground cover vegetation play an important role in termite diversity in a tropical area. Macrotermiteinae, for instance, is at a considerable advantage in drier habitats where the action of free-living fungi has been curtailed by moisture stress. Higher average of rainfall in Batam Island may explain why fungus-growing termites are such low presence in Plantation area and flooded soil hinder their presence in Mangrove Forest.

4. Conclusion

The cumulative number of termite genera indicated that species richness from three sampling sites in Batam Botanical Garden is Forest > Plantation > Mangrove Forest. We found that arboreal nesters and wood-feeding termites from Nasutitermitinae dominate termite genera collected from Plantation and Mangrove Forest. Meanwhile, soil/humus feeder termites were only encountered in Forest and were absent from other two sampling sites.

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Authorship contribution

S Khoirul Himmi, B Wikantyoso, and T Kartika contributed equally to this work in research design & execution, data collection & analysis, termite identification, and paper writing; Y Takematsu contributed to give technical workshop & guidance for termite identification.
and discussion for data analysis; M Ismayati, NPRA Krishanti, D Zulfiana, A S Lestari contributed to termite collection; D Tarmadi, A Fajar, D Meisyara, S Yusuf, T Yoshimura contributed to data analysis and discussion for manuscript preparation.

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