Production of litter and detritus related to the density of mangrove

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Abstract. Research about the production of leaf litter and detritus related to the density of mangrove trees has been done. The aims of this research are to know and analyze the amount of litter and detritus produced to the density of mangrove trees. The production and collection of leaf litter were carried out in five stations. Production of detritus and decomposition rate were calculated by measuring its dry weight. The density and level of mangrove trees were determined using transect quadratic method. The relationship between the leaf litter and detritus production ratio related to mangrove density were then analyzed. Results showed that mangrove trees with the density of 766.67 ind ha\textsuperscript{-1} could produce the amount of litter and detritus to about 28597.33 g ha\textsuperscript{-1} day\textsuperscript{-1} and 1099.35 g ha\textsuperscript{-1} day\textsuperscript{-1} while mangrove trees with the density of 1300 ind ha\textsuperscript{-1} could produce the amount of litter and detritus to about 35093.33 g ha\textsuperscript{-1} day\textsuperscript{-1} and 1216.68 g ha\textsuperscript{-1} day\textsuperscript{-1} respectively. Data analysis showed that the increment of mangrove density is linearly related to the production increment of litter and detritus.

Keywords: Decomposition, organic material, nutrients, Karang Gading Wildlife Reserves

1. Introduction
Mangrove forest of Karang Gading Wildlife Reserve is located on the east coast of Sumatera Utara with the width of about 15765 Ha. Mangrove forest is very important to maintain the biological cycle balancing of mangrove trees shed. They store a great amount of organic matter in the form of leaf litter into tropical waters environments. Mangrove forest is a productive ecosystem with relatively high productivity. The high productivity is linerly related to the rapid leaf litter production and efficient recycling of nutrients. Mangrove leaves play an important role as the largest contributor to the total production in the mangrove ecosystem [1]. The production of leaf litter plays an important role to the transfer of organic material. Only less than 10% of leaf litter degradation produced by mangrove trees tend to be consumed by living organisms [2].

Mangrove leaves litter is partially decomposed by bacteria and fungi into dissolved nutrients. Nutrients produced are useful for the growth of mangroves as well as a source of detritus which will then be exploited by aquatic organisms. Mangrove ecosystem is a habitat with abundant availability of food in the form of detritus [3]. Detritus is the basis of food network. There is a significant correlation between the production of litter and detritus with the density of mangrove trees. Information on the relationship between the production of litter and detritus with the density...
of mangrove trees in Karang Gading Wildlife Reserves, Sumatera Utara has not been well-studied.

2. Methods
The study was conducted in July - October 2016. Mangrove density was measured at the level of the tree, using the transect quadratic methods in five stations (Figure 1). Three plots with the size of 10 m x 10 m were created, and the leaf litter production was measured by collecting leaf litter from each station using 45 litter traps installed randomly under the tree canopy (1.5 m above ground level). The leaf litter which was collected in the traps were taken every 15 days for 3 months period. Total dry weight of the leaf litter shows the value of litter production. The litter decomposition rate is measured every 15 days up to 75 days by collecting and putting 10 grams of the wind-dried leaf litter from the traps into a litter bag tied at the base of the mangrove stem not to be drawn tidal currents.

The leaf litter decomposition rate is known by comparing the dry weight of the litter. Production of detritus known from the rest of the decomposition after the time of observation. The litter production, litter decomposition rate, and detritus production are analyzed using a formula [4], while the density of mangrove trees is also analyzed [5].

![Figure 1. Map of Research](image_url)

3. Results and Discussion
3.1. Mangrove Density
Twelve mangrove species from eight families were found during the study. The highest mangrove trees density at station 1 were from *Avicennia marina* (400 ind ha\(^{-1}\)), with lowest density from *Lumnitzera racemosa* (33.33 ind ha\(^{-1}\)). The highest density in station 2 was found from *Avicennia alba* (300 ind/ha), while the lowest mangrove trees density were found from *Bruguiera gymnorrhiza* (33.33 ind ha\(^{-1}\)). The overall mangrove density is presented in Table 1 below.
Table 1. Mangrove density (ind/ha) in each station

| No | Spesies               | Station 1 | Station 2 | Station 3 | Station 4 | Station 5 |
|----|-----------------------|-----------|-----------|-----------|-----------|-----------|
| 1  | Avicennia alba        | 233.33    | 200.00    | 66.67     | 33.33     | 33.33     |
| 2  | Avicennia marina      | 400.00    | 133.33    | 33.33     | 33.33     | 0.00      |
| 3  | Bruguiera gymnorrhiza | 66.67     | 33.33     | 100.00    | 66.67     | 33.33     |
| 4  | B. parviflora         | 66.67     | 66.67     | 166.67    | 100.00    | 66.67     |
| 5  | Excoecaria agallocha  | 66.67     | 66.67     | 66.67     | 100.00    | 66.67     |
| 6  | Hibiscus tiliaeus     | 0.00      | 0.00      | 66.67     | 66.67     | 66.67     |
| 7  | Lumnitzera racemosa   | 33.33     | 33.33     | 33.33     | 66.67     | 33.33     |
| 8  | Nypa fruticans        | 0.00      | 0.00      | 0.00      | 0.00      | 233.33    |
| 9  | Rhizophora mucronata  | 100.00    | 66.67     | 100.00    | 366.67    | 133.33    |
| 10 | R. apiculata          | 100.00    | 100.00    | 100.00    | 300.00    | 66.67     |
| 11 | Sonneratia alba       | 166.67    | 300.00    | 33.33     | 33.33     | 0.00      |
| 12 | Xylocarpus granatum   | 66.67     | 66.67     | 33.33     | 33.33     | 33.33     |
|    | Total                 | 1300      | 1066.67   | 800       | 1200      | 766.67    |

Hibiscus tiliaeus and Nypa fruticans were not found in station 1 and 2 due to the reason that both stations were located near the shore with higher salinity and pH, in which did not support the survival of both species. The highest mangrove tree density in station 3 was found from B. parviflora (166.67 ind/ha), while A. marina, L. racemosa, S. alba, and X. granatum were found to have the lowest density with 33.33 ind/ha.

The highest mangrove tree density in station 4 was found from R. mucronata (366.67 ind/ha) while the lowest was from A. alba, A. marina, S. alba, and X. granatum (33.33 ind/ha). The high density of R. mucronata was due to the sheltered location of station 4. Fresh water from mainland was also periodically supplied through the flow of the river together with the muddy substrate, in which they support growth. N. fruticans has the highest density at station 5 (233.33 ind/ha), while the lowest density was in A. alba, B. gymnorrhiza, L. racemosa, and X. Granatum with 33.33 ind/ha. Both A. marina and S. alba were not found in the station 5, due to the location of the station that was situated near mainland with a muddy substrate, in which they barely support the growth of these species of mangrove. The highest density of mangroves was found in Station 1 (1300 ind/ha), followed by station 4 (1200 ind/ha), station 2 (1066.67 ind/ha), the station 3 (800 ind/ha), and station 5 (766.67 ind/ha). The low density of mangroves at stations 3 and 5 were due to the location of the stations which were situated near farm settlements, in which the possibility of degradation was higher, compared to the other three stations.

3.2. Litter Production

Litter production is an important part of the organic matter transfer process from mangrove vegetation to the soil. Production of mangrove leaves litter was different on each station. The measurement during the 75 days of observation is presented in Figure 2. Leaf litter production was the highest in station 1, with 35093.33 gha⁻¹day⁻¹, and the lowest was at station 5, with 28597.33 gha⁻¹day⁻¹. The high production of leaf litter in station 1 was due to highest density of mangrove trees in this station. Mangrove density has a positive correlation with the production of litter. Mangrove trees in natural conditions are capable of producing 5% more litter than the degraded mangrove [1]. Station 1 is located nearer to the shore. The rapid incase of leaf litter has a positive correlation with temperature and water salinity. Temperature and high salinity can cause leaf litter of mangrove to be easily abscised. The rising of temperature can reduce the humidity, in which will cause the mangrove transpiration to increase. In order to reduce it, mangrove leaves should be
High temperature and salinity on the water surface (29.30%) accelerate litter fall by posing a physiological stress to mangrove species and to overcome this, mangrove leaves fall [6].

Station 4, which also has high litter production, was dominated by R. apiculata and R. mucronata. Both of these mangrove species have high litter production, due to the form of the leaves that are easily invalidated by wind and rain. Mangrove forests of Indian Sundarbans had produced the total litter production ranges from 3.312 t ha\textsuperscript{-1} yr\textsuperscript{-1} to 5.874 t ha\textsuperscript{-1} yr\textsuperscript{-1} [6], showing a higher result compared to the litter production in mangrove forest of Karang Gading Wildlife North Sumatra.

### 3.3. Litter Decomposition

The first station has a higher litter decomposition rate than other stations (Table 2), typically because this station is an area that is inundated by a high or low tide, which caused it to have relatively higher salinity and temperature.

| Station | Days to | Average % |
|---------|---------|------------|
|         | 15      | 30         | 45         | 60         | 75         |
| 1       | 0.0326  | 0.0239     | 0.0214     | 0.0347     | 0.0325     | 0.0290     | 24.60      |
| 2       | 0.0255  | 0.0215     | 0.0172     | 0.0214     | 0.0250     | 0.0221     | 18.77      |
| 3       | 0.0252  | 0.0205     | 0.0162     | 0.0208     | 0.0244     | 0.0214     | 18.18      |
| 4       | 0.0295  | 0.0229     | 0.0192     | 0.0257     | 0.0261     | 0.0247     | 20.96      |
| 5       | 0.0239  | 0.0200     | 0.0155     | 0.0204     | 0.0232     | 0.0206     | 17.48      |

The average rate of litter decomposition in each station was ranging from 0.0206 g day\textsuperscript{-1} to 0.0290 g day\textsuperscript{-1} or 17.48% day\textsuperscript{-1} to 24.60% day\textsuperscript{-1}. Results showed that litter decomposition rate was higher in the first 15 days, and the value of percent residual litter was showing almost the same result.

Percentage of residual leaf litter during the decomposition process in each station (Figure 3), showed that the remaining litter ranges from 61.37% to 69.88% after 15 days of immersion, followed by a decrease after 30 days of immersion (48.89% to 54.81%), the remaining on day 45 was from 38.25% to 49.89%, while the remaining on day 60 and 75 were from 12.47% to 29.46%.
and 8.75% to 17.55% respectively. This condition is because that leaf litter experiences a loss of organic material that was dissolved by rainwater, leaching, and decomposer. The degradation of mangrove litter in an aquatic environment is totally dependent on the microbial biomass and environmental conditions [7]. Furthermore, the litter decomposition occurrence caused by leaching of organic compounds should go through three phases: the oxidation of cellulose and lignin by microbes, the physics and then followed by biology fragmentation [8]. The presence of bacteria and fungi in mangrove leaf litter decomposition process could cause a rapid leaching on organic matter [9].

![Figure 3. Percent residual litter in each station](image)

**3.4. Detritus Production**

The highest detritus production was found at station 1 (0.122 gm²⁻¹ day⁻¹ or 1216.68 gha⁻¹ day⁻¹), while the lowest was found at station 5 (0.110 gm²⁻¹ day⁻¹ or 1099.35 gha⁻¹ day⁻¹) (Table 3).

| Station | Days to | Average gm²⁻¹ day⁻¹ | Average gha⁻¹ day⁻¹ |
|---------|---------|---------------------|---------------------|
|         | 15      | 30                  | 45                  | 60                  | 75                  |                    |
| 1       | 3.86    | 5.11                | 6.17                | 8.75                | 9.13                | 0.122              | 1216.68            |
| 2       | 3.18    | 4.75                | 5.38                | 7.24                | 8.47                | 0.113              | 1129.09            |
| 3       | 3.15    | 4.60                | 5.17                | 7.12                | 8.40                | 0.112              | 1119.94            |
| 4       | 3.58    | 4.97                | 5.79                | 7.86                | 8.59                | 0.115              | 1145.10            |
| 5       | 3.01    | 4.52                | 5.01                | 7.05                | 8.25                | 0.110              | 1099.35            |

The high production of detritus at Station 1 was due to the high litter production and decomposition rate compared to other stations. Results showed detritus production positively correlated with the production of litter. The higher production of litter, the higher the production of detritus will be.

**3.5. Production of Litter and Detritus Related to Mangrove Density**

Results showed that litter and detritus production positively correlated with the density of the mangrove. The higher density of the mangrove, the higher litter and detritus will be produced (Table 4).
Table 4. Production of litter and detritus relationship with Mangrove Density

| Station | Mangrove density ind ha⁻¹ | Litter production g ha⁻¹ day⁻¹ | Detritus production g ha⁻¹ day⁻¹ |
|---------|---------------------------|-------------------------------|-------------------------------|
| 1       | 1300                      | 35093.33                      | 1216.68                       |
| 2       | 1067                      | 32941.33                      | 1129.09                       |
| 3       | 800                       | 30574.67                      | 1119.94                       |
| 4       | 1200                      | 34749.33                      | 1145.10                       |
| 5       | 767                       | 28597.33                      | 1099.35                       |

Station 1 with the density of mangrove 1067 ind ha⁻¹ can produce as much litter 35093.33 g ha⁻¹ day⁻¹ and detritus 1216.68 g ha⁻¹ day⁻¹, dominated by Avicennia marina. Station 2 with a density of mangrove 1300 ind ha⁻¹ can produce as much litter 32941.33 g ha⁻¹ day⁻¹ and detritus 1129.09 g ha⁻¹ day⁻¹, dominated by Sonneratia alba. Station 3 with a density of mangrove 800 ind ha⁻¹ can produce as much litter 30574.67 g ha⁻¹ day⁻¹ and detritus 1119.94 g ha⁻¹ day⁻¹, dominated by Bruguiera parviflora. Station 4 with a density of mangrove 1200 ind ha⁻¹ can produce as much litter 34749.33 g ha⁻¹ day⁻¹ and detritus 1145.10 g ha⁻¹ day⁻¹, dominated by Rhizophora mucronata, and Station 5 with a density of mangrove 767 ind ha⁻¹ can produce as much litter 28597.33 g ha⁻¹ day⁻¹ and detritus 1099.35 g ha⁻¹ day⁻¹, dominated by Nypa fruticans.

4. Conclusion

1) Litter production in In Karang Gading Wildlife Reserves Sumatera Utara ranged from 28597.33 g ha⁻¹ day⁻¹ to 35093.33 g ha⁻¹ day⁻¹ while the detritus production ranged from 1099.35 g ha⁻¹ day⁻¹ to 1216.68 g ha⁻¹ day⁻¹. The density mangrove forest observed was from 766.67 ind ha⁻¹ to 1300 ind ha⁻¹.

2) Mangrove trees with the density of 1300 ind ha⁻¹ can produce as much litter of 35093.33 g ha⁻¹ day⁻¹, with detritus production 1216.68 g ha⁻¹ day⁻¹. Mangrove trees with the density of 1067 ind ha⁻¹ can produce as much litter of 32941.33 g ha⁻¹ day⁻¹, with detritus production 1129.09 g ha⁻¹ day⁻¹. Mangrove trees with the density of 800 ind ha⁻¹ can produce as much litter of 30574.67 g ha⁻¹ day⁻¹, with detritus production 1119.94 g ha⁻¹ day⁻¹. Mangrove trees with the density of 1200 ind ha⁻¹ can produce as much litter of 34749.33 g ha⁻¹ day⁻¹, with detritus production 1145.10 g ha⁻¹ day⁻¹, and Mangrove trees with the density of 767 ind ha⁻¹, can produce as much litter of 28597.33 g ha⁻¹ day⁻¹, with detritus production 1099.35 g ha⁻¹ day⁻¹.

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