Avicennia marina leaf litter decomposition rate and its impact on milkfish growth in Sicanang Belawan Medan

Yunasfi[1,2*], *Muhammad Akbar Ilahi* Saragih[1], *Afifuddin* Dalimunthe[1], *Budi* Utomo[1], and *Patar* Simangunsong[1]

[1]Forestry Study Program, Faculty of Forestry, University of North Sumatra Campus II Kuala Bekala Deli Serdang, 20353, North Sumatra, Indonesia.
[2]Mangrove Center of Excellence, University of North Sumatra, Medan 20155, North Sumatra, Indonesia

Abstract. Leaf litter is the main component containing carbohydrates, proteins and nutrients. Litter must be decomposed first, so that it can be utilized by organisms and microorganisms in coastal environments. Fungi play an important role in the litter decomposition process. This study was conducted from August to November 2024 to determine the role of fungi, in decomposing leaf litter and increasing the growth of milkfish (*Chanos chanos*) seeds. 50 g of A. marina leaf litter was put into 20 litter bags measuring 40 x 30 cm, made of nylon with a mesh of 1 x 1 mm. *Aspergillus* sp. 1 fungi were cultured on PDA media. Pieces of 5 x 5 x 2 mm agar that had been grown with fungi were then made into a suspension in a test tube filled with 2.5 ml of sterile water. Milkfish seeds placed in cages, namely 80 seeds. Sampling was conducted every 15 days, taking eight milkfish and one bag containing litter. The decomposition rate and weight of the milkfish were then measured six times. The decomposition rate of *A. marina* leaf litter was 18.72/year, and the weight of the milkfish fed with *Aspergillus* sp. 1 liter was 39.48 grams, which was greater than the control, which was 19.9 grams

1. Introduction

Mangroves serve as a storehouse of biodiversity and are distinctive coastal ecosystems [1]. Through the fall of litter that decomposes and builds up in the sediment, mangroves provide vital nutrients to the soil [2]. Mangrove species, season, salinity, and stand location are some of the factors that affect the breakdown of trash in mangrove forests. The primary food chain components are mangrove litter, which includes leaves, twigs, blooms, and fruits [3] [4].

With an annual growth rate of 5.3% during the previous 20 years, aquaculture is the food industry with the quickest rate of expansion in the world [5]. Shrimp and fish species, which are often grown along the coasts of tropical and subtropical nations, dominate the Crustacean industry [6]. As the primary habitat for milkfish, which have significant

* Corresponding author: yunasfi@usu.ac.id

commercial value, the Sicanang Belawan mangrove environment plays a crucial role in promoting the sustainability of marine biodiversity. The primary organic material in the trophic chain, litter from *Avicennia marina*, is broken down by the fungus *Aspergillus* sp. 1. The purpose of this study is to ascertain how fungi contribute to the breakdown of leaf litter and whether treated leaf litter can promote the growth of milkfish seeds.

2. Materials and methods

2.1 Time and place

The study was carried out in 2024 between August and November. The Forest Cultivation Laboratory, Faculty of Forestry, University of North Sumatra, and Sicanang Belawan were the sites for conducting the study.

2.2 Tools and materials

Digital scales, plastic rope, stationery, an oven, sewing needles, sewing thread, razor blades, test tubes, cameras, a hand refractometer, Petri dishes, measuring cups, 40 x 30 cm nylon litter bags, sterile water, and the fungal species *Aspergillus* sp. 1, and milkfish seeds are among the equipment and supplies used.

2.3 Research procedures

2.3.1. Collection of A. marina leaf litter and application of fungi to the litter

Twenty 40 x 30 cm nylon litter bags with a 1 x 1 mm mesh are filled with up to 50 g of leaf litter *A. marina*. After growing on PDA media, the fungus species *Aspergillus* sp. 1 was extracted by chopping the agar into 5 x 5 x 2 mm pieces. To create a suspension, the fungus-grown agar pieces are subsequently placed in a test tube with 2.5 milliliters of sterile water [7].

2.3.2. Preparation of cages and placement of A. marina leaf litter that has been given a fungus application in the cages

A mosquito net is placed atop the cage to prevent fish seeds from escaping from the leaf litter bags *A. marina*. The cage is 3 × 3 m and has a depth of 1 to 1.5 m. The bags are evenly spaced apart, and the fungi that have been treated are suspended on plastic ropes that are extended over the cage.

2.3.3. Distribution of milkfish seeds, observation, and data collection

On the same day that the bags of litter were put inside the cages, the fish seeds were distributed. Eighty milkfish seeds were dispersed across the cages. Eight milkfish seeds were selected from among those 80 to serve as the study's sample. For three months, observations were made as part of this research project once every two weeks. Data was gathered six times, from the fifteenth to the ninetieth day. This time frame was used because, in Sicanang Belawan Medan, the leaf litter *A. Marina* degraded in 90 days, or three months.

2.3.4. Analysis of the rate of decomposition of A. marina leaf litter

Every fifteen days, the litter bags are picked up, cleaned of muck, and allowed to air dry. For three days, or until the weight remains consistent, the leftover air-dried litter is placed in an oven set to 75 degrees Celsius. Olson (1963) states that the following formula is used to estimate the average value of the litter decomposition rate [8]:

$$X_t = X_0.\ \text{and}^{-kt} \quad (1)$$

$$\text{Ln}\ (X_t/X_0) = -kt \quad (2)$$

Information:
X_t= dry weight of litter after time t (g)
X_0= initial litter weight (g) k= litter decomposition rate value
e= natural logarithm number (2.72) t= observation time (days)

2.3.5. Measurement of milkfish growth rate

Measurement of the development level of milkfish by weighing the weight of the milkfish, which was carried out at each observation, and harvesting the milkfish at the end of the study.

2.3.6. Determination of the number and type of macrobenthos

The number of macrobenthos is calculated based on the number of macrobenthos found attached to or in the litter bags of each type. The number of macrobenthos found in each litter bag collection was then used to identify the type of macrobenthos.

3. Results and Discussion

3.1 Leaf litter decomposition rate *A. marina*

During the 90-day observation period, which was conducted six times with a 15-day gap between each observation, leaf litter *A. Marina* gradually lost weight. With a litter mass of 0.25 per year, the decomposition rate over the 90-day observation period was 18.72 per year, according to the decomposition rate constant (k) of leaf litter *A. marina*, which was determined using the formula [8]. [9] Furthermore, the degradation process was accelerated by the presence of macrobenthos and fungi.

3.2 The role of fungi in the decomposition process

Applications of fungi by producing degrading enzymes, Aspergillus sp. 1 on leaf litter *A. marina* can quicken the decomposition process. [10] These enzymes aid in the breakdown of the lignocellulose layer found in litter cell walls, which is indigestible by other living things. As seen in Figure 1, the fungus Aspergillus sp. 1 possesses both macroscopic and microscopic forms.

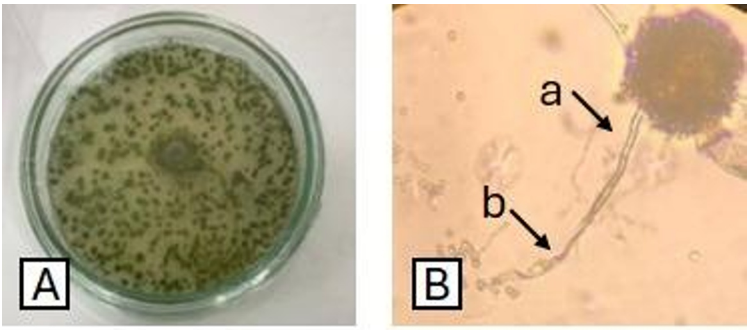

Fig. 1. A. *Aspergillus* sp. 1 (7 days old) on PDA media; B. Microscopic form (Microscope magnification 40x) with; (a). Conidia; (b) Conidiophores.

This process produces fine particles that can be used by milkfish as natural food in aquatic environments. [11] The enzymes produced by fungi have stronger abilities than the decomposer enzymes produced by bacteria.

3.3 Dry weight of litter

The data displayed in Figure 2 shows the variations in the dry weight of leaf litter.

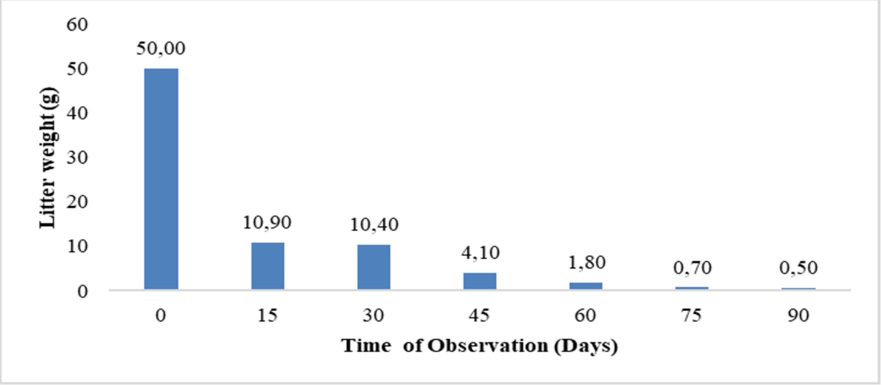

Fig. 2. Dry Weight of Litter *A. Marina* For 90 Days.

A. marina leaf litter weight data revealed a steady decline in dry weight over the course of the 90-day observation period. The starting weight of the litter was 50.00 grams. The litter weight dropped considerably to 10.90 grams after 15 days. Although it happened more slowly, weight reduction continued on the 30th day, reaching 10.40 grams. Continued weight reduction reached 4.10 grams on day 45, 1.80 grams on day 60, 0.70 grams on day 75, and 0.50 grams on day 90. Easy-to-decompose organic molecules broke down quickly, and the remaining, more resistant chemicals caused a sluggish phase to follow. Within 30 days, the majority of the litter broke down, contributing significantly to the aquatic ecosystem's nutrient supply.

3.4 Residual litter weight

The dry weight loss data of *A. marina* leaf litter in Figure 2 shows the percentage of litter remaining in the litter bag, which can be further observed in Figure 3.

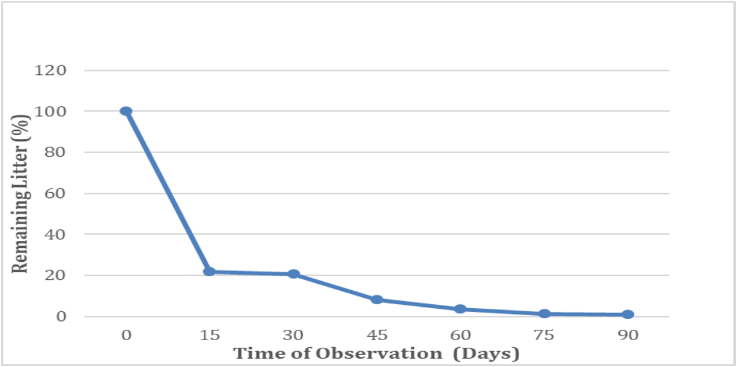

Fig. 3. Percentage of Remaining Litter *A. marina* for 90 Days.

Over the course of the 90-day observation period, the residue of *A. marina* leaf litter has shown a notable declining trend. The percentage of leftover litter was 100% on day 0, 21.8% on day 15, and 20.8% on day 30. Day 45 saw a more dramatic drop, with 8.2% of litter left, followed by a slow decline to 3.6% on day 60, 1.4% on day 75, and 1.0% on day 90. The observation's findings demonstrated that the majority of the organic material that decomposed readily had done so in a comparatively short amount of time. By day 30, just around 21% of the residual litter had changed, suggesting that the decomposition process was beginning to loose. This is consistent with the results of [11], which show that the loss of readily soluble inorganic and organic chemicals was correlated with high solubility in the early phases of decomposition.

3.5 Number and type of macrobenthos

Through its biological activities, such as physically destroying litter and enhancing the chance for decomposing microorganisms to come into direct contact with organic matter, macrobenthos plays a significant role in speeding up the decomposition process of litter and releasing nutrients into the aquatic environment. Table 1 displays the number of macrobenthos discovered in trash bags based on observations made over a 90-day period.

Table 1. Macrobenthos that are in the litter bag for 90 days.

Class	Observation Time (Day)						Total	Average
	15	30	45	60	75	90		
Polychaetes	25	10	5	1	2	1	44	7.3
Crustacea	15	8	5	2	1	2	33	5.5
Gastropods	13	9	4	2	3	1	32	5.3
Bivalvia	12	10	8	4	3	3	40	6.6

The presence of macrobenthos from four classes found in litter bags during the course of the 90-day observation period is shown in the table above. With a total of 44 individuals, the Polychaeta class demonstrated the greatest dominance, followed by Bivalvia (40), Crustacea (33), and Gastropoda (32). The number of macrobenthos, peaked on the fifteenth day and then steadily declined until the ninetieth, suggested that the decomposition of the litter was reducing the amount of organic matter available. In order to speed up the breakdown process, macrobenthos break down entire mangrove leaves into tiny pieces.

3.6 Milkfish growth rate

Measurement of milkfish growth rate was done by weighing body weight using a digital scale. The measurement process was carried out on 8 milkfish, then the average weight value was obtained as an indicator of growth. The milkfish weighing results data are presented in Figure 4.

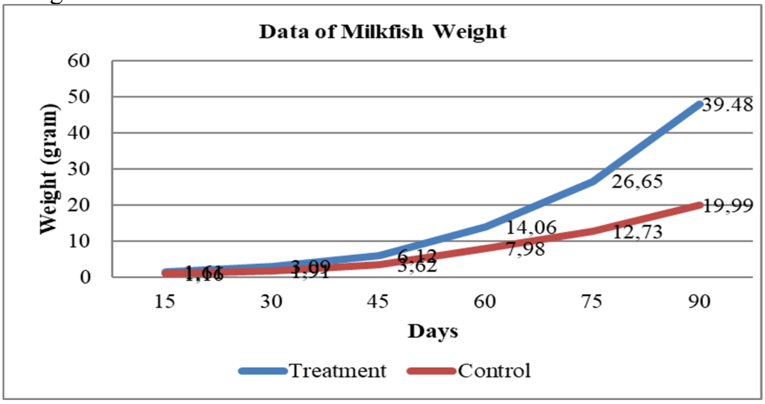

Fig. 4. Milkfish Weight Data for 90 Days

Data on milkfish weight growth revealed a notable rise throughout the course of the observation period. The fish weighed 1.16 grams on average on the 15th day, and by the 30th day, it had grown to 4.09 grams. Fish weights reached 6.22 grams on the 45th day, 11.46 grams on the 60th day, and 22.41 grams on the 75th day, indicating that this growth proceeded gradually. The milkfish weighed 39.48 grams at the end of the time, which was the 90th day. The presence of natural food sources, such as litter or detritus, supports milkfish growth. [14], milkfish, which were generalist plankton feeders, exploit debris as one of their main sources of food. The discovery of debris or litter in the milkfish's digestive tract [15] further supports this claim.

4. Conclusion

Mangroves play an important role in supplying nutrients to the soil through fallen litter. Leaf litter is the main component containing carbohydrates, proteins, and essential nutrients for coastal vegetation. Fungi have an important role in the ecosystem as decomposers and as plant symbionts. The decomposition rate during the 90-day observation period was 18.72 per year. Macrobenthos found in litter bags are the Polychaeta, Crustacea, Gastropoda, and Bivalvia classes, which also act as decomposers. Difference in weight of milkfish fed with *A. marina* leaf litter with *Aspergillus* sp. 1 higher, namely 39.48 grams compared to the control weighing 19.99 grams.

The authors would like to thank The Research Institute of Universitas Sumatera Utara for funding this study under the terms of Universitas Sumatera Utara's TALENTA Research Implementation Contract, Number 1625/UN5.1.R/SK/PPP/2024 dated on 29 Mei 2024.

References

1. P. Murugesan, P.P. Sarathy, S. Muthuvelu, G. Mahadevan, Diversity and distribution of polychaetes in mangroves of east coast of India. (In tech Open, 2018). http://dx.doi.org/10.5772/intechopen.78332

2. T. Srisunont, C. Srisunont, T. Jaiyen, M. Tenrung, M. Likitchaikul, Nutrient accumulation by litter fall in mangrove forest at Klong Khone, Thailand. Thammasat Int. J. Sci. Tech. **22**, 9–18 (2017). https://doi.org/10.14456/tijsat.2017.2
3. Kristensen E, R.M. Connolly, X.L. Otero, C. Marchand, T.O. Ferreira, V.H. Rivera-Monroy, Biogeochemical cycles: global approaches and perspectives. In: V. Rivera-Monroy, S. Lee, E. Kristensen, R. Twilley (Eds.), Mangrove Ecosystems: A Global Biogeographic Perspective. (Cham: Springer, 2017). http://doi.org/10.1007/978-3-319-62206-4_6
4. I. Wahyuni, Analysis of production and nutrient potential of mangrove litter in Pulau Dua Serang Nature Reserve, Banten. Biodidactics: J. Biol. Learner. **11**, 66-76 (2016) http://dx.doi.org/10.30870/biodidaktika.v11i2.2346
5. FAO, The state of world fisheries and aquaculture 2020: Sustainability in action, Fisheries and Aquaculture Technical Paper (FAO, Rome, 2020)
6. T. Viet Nguyen, L.W. Ryan, J. Nocillado, M. Le Groumellec, A. Elizur, T. Ventura, Transcriptomic changes across vitellogenesis in the black tiger prawn (Penaeus monodon), neuropeptides and G protein-coupled receptors repertoire curation. Gen. Comp. Endocrinol. **298**, 113585 (2020). https://doi.org/10.1016/j.ygcen.2020.113585
7. Yunasfi, N. Rakesya, Desrita, Application of *Aspergillus fumigatus* from *Rhizophora mucronata* leaves that have decomposition in various salinity levels in Belawan. IOP Conf. Ser. Earth Environ. Sci. **713**, 012030 (2021). http://doi.org/:10.1088/1755-1315/713/1/012030
8. J.S. Olson, Energy storage and the balance of producer and decomposer in ecological system. Ecology **44**, 322–331 (1963). https://doi.org/10.2307/1932179
9. S. Siagian, A. Susatya, S. Saprinurdin, Leaf litter decomposition rate *Psychotria malayana* in the campus forest of Bengkulu University. J. Glob. For. Environ. Sci.**1**, 1–9 (2021)
10. D.S. Tennakoon, E. Gentekaki, R. Jeewon, C.H. Kuo, I. Promputtha, K.D. Hyde, Life in leaf litter: Fungal community succession during decomposition. Mycosphere **12**, 406–429 (2021). http://doi.org/10.5943/mycosphere/12/1/5
11. C.I. Fitriani, Isolation and identification of the diversity of fungal genera that decompose leaf litter *Sonneratia alba* and its use as a book chapter. Thesis, Faculty of Teacher Training and Education, University of Jember (2020)
12. O. Devianti, D. Tjahjaningrum, Study of litter decomposition rate in pine forest in Taman Safari Indonesia II tourist area, East Java. J. Science Arts ITS. **6**, 105–109 (2017). http://doi.org/10.12962/j23373520.v6i2.27535
13. R. Andriyansah, T.Z. Ulqodry, Rate of decomposition of leaf litter *Rhizophora apiculata* in the Banyuasin River Estuary area, South Sumatra. Maspari J. Mar. Sci. Res. **15**, 55–62 (2023). https://doi.org/10.56064/maspari.v15i1.22
14. F. Muhammad, M. Izzati, M.A. Mukid, Macrobenthos as an indicator of pond fertility levels on the North Coast of Central Java. Bioma: Berk. Ilm. Biol. **19**, 38–46 (2017). https://doi.org/10.14710/bioma.19.1.38-46
15. Djumanto, Milkfish food and growth *Chanos chanos* (Forskal, 1975) spread in Sermo Reservoir, Kulon Progo. J. Ichthyol. Indones.**17**, 83–100 (2017). https://doi.org/10.32491/jii.v17i1.306