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Biotic and abiotic synergies in a log ecosystem

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ABSTRACT

Log ecosystems are unique ecosystems that arise from fallen trees, forming microhabitats that exhibit distinct ecological dynamics. This paper aims to describe what a log ecosystem is and what are its components and their connection. Additionally, it identifies the biotic and abiotic components present in the decaying bark of a tree and explains how these factors interact together in the log ecosystem. The study was performed at the Davao Oriental State University Marfori Demonstration Farm at Barangay Don Enrique Lopez, Mati City, Davao Oriental. In this study, a decaying *Swietenia macrophylla* log was pried open, and biotic and abiotic factors were observed and identified. A total of eleven (11) animal species were found and identified. These were, white rot fungi, scarlet millipede, fungus beetle, woodworm, isopod, dry wood termites, spider, tyrant ants, sun skink, dwarf wood scorpion, and flat bugs, collectively scoring a moderate diversity of 1.37 (Shannon-Wiener Index), and 0.65 in the Simpson's diversity index. Additionally, the observation of the abiotic factors revealed that the temperature in the area and the amount of sunlight were the most crucial factors shaping the ecosystem, followed by the moisture within the log and humidity, and precipitation in the environment was very low. The biotic and abiotic components coexist and interact with each other in this log ecosystem

Keywords: Decay, decomposition, fungi, log ecosystem, Marfori campus

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INTRODUCTION

An ecosystem is a complex community of living organisms together with their physical environment. According to Ostroumov (2002), an ecosystem, at its core, refers to a collection of interdependent living organisms that live together along with their immediate environment and their interactions with it. Additionally, Turner (2005) highlights that ecosystem dynamics rise from the interplay between biotic components and their diverse abiotic environment. It is where biotic or living components of an ecosystem such as plants, animals, and microorganisms interact and coexist with their physical environment which is composed of abiotic factors. The heart of every ecosystem lies in the complex relationship between organisms and their environment (Begon et al., 2006). These interactions give rise to complex ecological relationships, shaping the structure and function of the ecosystem over time. A change in the temperature of an ecosystem will often affect what plants will grow there, for instance, consequently affecting community structures by altering species abundances, causing extinctions, and changing species' interactions (Henle et al., 2004).

Ecosystems are prototypical examples of complex adaptive systems, in which patterns at higher levels emerge from localized interactions and selection processes acting at lower levels (Levin, 1998). Organisms of different levels, from producers like plants to top predators, form trophic interactions and become highly interconnected, particularly in terms of energy transfer. The sunlight fuels the process, captured by plants which are then consumed by herbivores which in turn become food for carnivores. These trophic interactions ensure a steady flow of energy, allowing each level to play its part in the ecosystem, whether it may be on land, in water, or within a log. Ecosystems can range in scale from a small pond to a rainforest, and play a crucial role in maintaining life on earth by providing essential services and supporting biodiversity. The terrestrial ecosystem refers to the ecosystems of different landforms, while the aquatic ecosystems are those in different bodies of water and are classified into marine and freshwater ecosystems.

Log ecosystems, which often overlooked in mainstream ecological research, play apivotal role in shaping terrestrial landscapes and supporting biodiversity. These unique ecosystems arise from fallen trees, forming microhabitats that exhibit distinct ecological dynamics. Logs act as intricate and interconnected microcosms where various biotic and abiotic interactions unfold over time. Deadwood represents an important habitat or substrate for numerous vertebrates, invertebrates, vascular plants, fungi, bryophytes, and lichens (Harmon et al., 1986; Samuelsson et al., 1994). Despite their modest scale, log ecosystems harbor a rich tapestry of life. Decaying logs are important for many organisms and play crucial roles in the global carbon cycle, soil formation, and water and soil conservation (Lassauce et al., 2011). Understanding the formation, dynamics, functions, and conservation, as well as the identification of biotic and abiotic components of log ecosystems is essential for holistic ecosystem management and biodiversity preservation. Thus, this paper aimed to describe what a log ecosystem is and what ae its components and their connection.

METHODOLOGY

In this study, a decaying log was found within the premises of the Marfori campus, Davao Oriental State University (DOrSU) (Figure 1A), and was assessed. The area where the log was found had the presence of dense covering of various short and mid-length weeds and grasses and interspersed trees. The area was closed to the University Research Complex (URESCOM) and field area, making it susceptible to anthropogenic activities and disturbances from large grazing animals and livestock. The log was first measured for its dimensions utilizing a measuring tape (Figure 1B).

Figure 1. Log ecosystem; Mahogany (*Swietenia mahagoni*) rotting log under study (A) and onsite measurement of the dead log (B).

The rotting log was mainly examined for species composition and abundance. The log subject was first observed from the surface for organisms lying on its barks. Then, it was pried open and excavated using a garden trowel. Observations were recorded for organisms and thenindividually counted and photographed using a Samsung A52 smartphone. Several biotic factors were identified onsite using a previous research (Salang, 2020) as a field guide, while unidentified organisms were determined through Google Lens and observations from iNaturalist Mobile App. Initially identified organisms were also validated using the same methods. The data collected were then organized according to each species' English name, scientific name, and individual count before quantifying their relative abundance and diversity.

Diversity

In determining the diversity of organisms in the decaying log, Shannon-Wiener Diversity Index and Simpson's Diversity Index were used.

Shannon-Wiener diversity index

$$H' = \sum (P)\ (\ln P)$$

Where:

H' = Shannon-Wiener diversity index
P = proportion of the individuals of species
lnP = natural log of P
Σ =summation of all species

Simpson's diversity index

$$D = \Sigma n\ (n - 1) / N(N-1)$$

Simpson's diversity index = 1-D

Where:

D = proportion of the individuals of species I squared.
n = number of organisms that belong to species
N = total number of organisms

Furthermore, the abiotic factors of the log ecosystem under study were determined and identified using primary sensory observations. The environmental conditions in which the log was found, as well as the log itself and its internal characteristics were carefully examined. All observations were recorded and photographed. To avoid bias during the data collection brought by using sensory observations, multiple individuals independently observed the rotting log and its environment. A five-point Likert scale was utilized and a consensus-based approach (Arakawa and Bader, 2022) was then applied, wherein observations were compared and discussed among the observers (group members) to identify and eliminate possible personal biases.

RESULTS

The decaying log under the study was identified as a *Swietenia macrophylla*, or more commonly known as "Mahogany". The log measured 0.762 m (30 in) in length and around 0.254 m (10 in) wide. It was observed to have completely softened out, with most of its parts already broken down and reduced to powder. Other parts of the decaying log have also become indistinguishable from the soil underneath. Additionally, piles of sawdust were observed within the log. Cavities, traces and patterns created by organisms were also evident.

By the end of the observation period, several biotic components that contribute to the ecological balance of the area were observed. A total of eleven (11) different animal species were found and identified on the decaying log being studied (Figure 2). These were: white rot fungi, scarlet millipede, fungus beetle, woodworm, isopod, drywood termites, spider, tyrant ants, sun skink, dwarf wood scorpion and flat bugs.

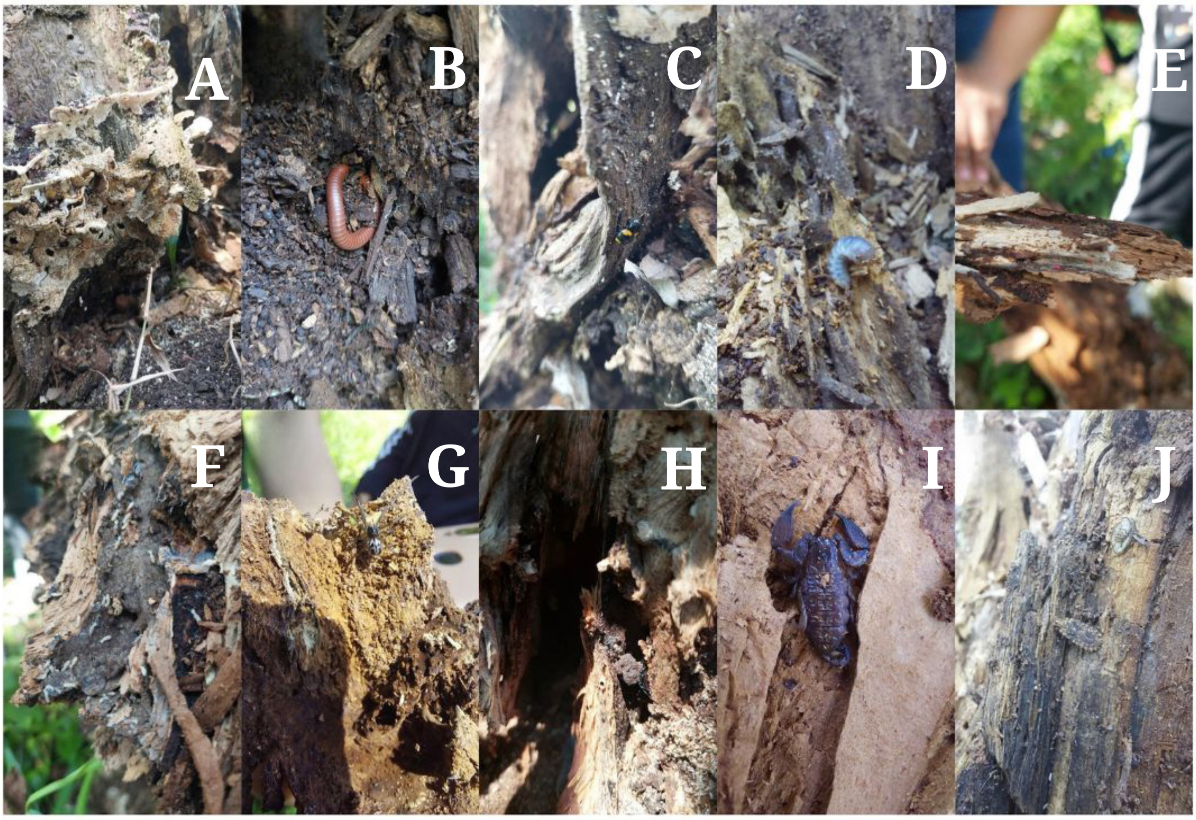

Figure 2. Organisms found in the study log: (A) fungi, (B) millipede, (C) beetle, (D) woodworm, (E) isopods, (F) termites, (G) spider, (H) ants, (I) wood scorpion, (J) flat bugs.

The table below shows the organisms found on the log ecosystem as well as the number of individuals for each species, relative abundance, and calculated Simpson's and Shannon-Wiener Diversity Index.

The most abundant biotic component found in the log being studied were drywood termites with a relative abundance of 45.88%, followed by tyrant ants with 36.47%. Multiple groups of white rot fungi were also observed both at the internal and external parts of the log. This is followed by fungus beetles and isopods with a calculated relative abundance of 2.35% each species. Flat bug comes next with 1.76%, followed by woodworm, spider and dwarf wood scorpion, each having a relative abundance value of 1.18%. The least abundant organisms were the scarlet millipede and sun skink, with only one (1) individual each, having a relative abundance of only 0.59%.

Furthermore, the calculated species biodiversity revealed that the log under study has moderate diversity, yielding a value of 1.37 on the Shannon-Wiener index and 0.65 on the Simpson's diversity Index. The Shannon-Wiener index underscores the species richness in an ecosystem while the Simpson's index stresses on its evenness and the presence of dominant individual

Table 1. Diversity of biotic components in the log ecosystem.

English name	Scientific name	Count	Relative abundance (%)
Fungi	*Ceriporiopsis subvermispora*	11	6.47
Millipede	*Trigoniulus corallinus*	1	0.59
Beetle	*Episcapha quadrimacula*	4	2.35
Woodworm	*Anobium punctatum*	2	1.18
Isopod	Isopoda	4	2.35
Termites	*Cryptotermes cavifrons*	78	45.88
Spider	*Neoscona inusta*	2	1.18
Ant	*Iridomyrmex anceps*	62	36.47
Common sun skink	*Eutropis multicarinata*	1	0.59
Wood scorpion	*Liocheles australasiae*	2	1.18
Flat bugs	Aradidae	3	1.76
	Simpson's diversity index (D**)**		0.65
	Shannon-Wiener diversity index (*H'*)		1.37

species. This suggests a moderate richness and evenness of species in the log ecosystem, with a moderate balance between the number of species and the number of individuals in each species, as well as their corresponding relative abundance. Some species are more abundant than others, but it does not overwhelmingly dominate the ecosystem.

Moreover, a range of non-living components that interact with the biotic factors to influence the dynamics and shape the ecology of the area was observed and documented. The rotting log studied was located in an area with diverse environmental characteristics, making it susceptible to various factors affecting the ecosystem within the log itself. Among the abiotic factors observed and considered are the temperature in the area, the amount of sunlight, as well as the texture and moisture within the log itself. Additionally, humidity, precipitation, and the amount of water in the environment are also deemed as important factors in molding this ecosystem.

The table below shows the parameters considered in the log ecosystem and their average perceived levels.

Table 2. Likert scale on the abiotic components of the log ecosystem.

Parameters	Rating			
	High (4)	**Average (3)**	**Low (2)**	**Very Low (1)**
Temperature	/			
Sunlight		/		
Moisture			/	
Humidity			/	
Precipitation				/
Presence of water				/

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Results from the observation on the abiotic factors show that the log ecosystem under study was susceptible to high temperature and an average amount of sunlight, suggesting that these factors may be perceived as the most critical factors affecting the ecosystem. Moreover, water availability and other water-related factors emerged as the least influential factors, with moisture and humidity scoring low, and precipitation and amount of water in the environment ranking last with very low levels.

DISCUSSION

Logs are more than pieces of wood. They serve as ecological incubators, nurturing a diverse array of organisms from microorganisms to vertebrates (Cornelissen et al., 2012). Particularly, a rotten log serves as habitat to many different species, which includes but are not limited to microscopic organisms, fungi, and many other insects and invertebrates. It becomes an ecosystem that supports all kinds of organisms that each play an important role in the ecosystem (Menke et al., 2011).

Results from the study show diverse species of organisms which all play a vital role in the ecosystem. Species of termites, millipedes and isopods were evident with in the different parts of the examined rotting log. A few woodworms and fungus beetles were spotted at the inner part of the pried log, and fungi were also present particularly at the external part (Potapov et al., 2022). These organisms are generally identified as decomposers. According to the study of Hanley and Pierre (2015), decomposers are organisms identified by their distinctive utilization of dead organic matter for energy, breaking down macromolecules into smaller components and excreting nutrients as waste products during the process of decomposition. These organisms play a vital role in an ecosystem, with Hardwood and Wilkin (2015) emphasizing that in the absence of decomposers, important nutrients would remain within the tissues of dead organisms, preventing its release in the environment, and therefore disrupting important processes within the ecosystem. Moreover, a population of tyrant ants as well as a few spiders, scorpions and sun skinks were also found during the observation. These organisms burrow into the log and soil beneath for food and shelter. They pry and feed on scavengers who are feeding on the rotting logs. These phenomena, interacting with the abiotic factors in the environment creates a unique balance, enabling the sustainability of life in the log ecosystem.

According to Odum (1971), an ecosystem has two elements, the biotic and abiotic components. It is a geographic area where living things (biotic components) interact and become interconnected with the non-living things in their environment (abiotic factors). At the heart of these connections lies the concept of interdependence. Biotic factors, ranging from the smallest microorganisms to the largest predators, are dependent on abiotic factors for survival. In the log ecosystem observed in this study, the abiotic components observed are temperature, sunlight, humidity, precipitation, amount of water in the environment and the log itself. The availability and intensity of these conditions shape the distribution and abundance of species within the ecosystem. For instance, Clarke and Gaston (2006) states that diversity tend to be greater where temperatures are higher since it is easier for organisms to make a living in warmer habitats than colder ones, anchoring their statement to the study of Currie et al., (2004) which highlights that ‘benign conditions permit more species’. Similarly, the presence of certain biotic factors can have a transformative impact on abiotic conditions. The presence of grassland areas around the rotting log under study can regulate temperature and humidity, reduce sunlight exposure, and even influence microclimate conditions.

One of the most salient features and striking demonstrations of interdependence within an ecosystem is the nutrient cycle carried out particularly by and between biotic components (Salang, 2020). This was evident in the log ecosystem under study, wherein decomposers break down the rotting log into simpler inorganic materials for other organisms to utilize. Biotic factors then interact with abiotic factors like soil and water to facilitate the cyclic movement of essential nutrients. For instance, plants extract nutrients from the soil, which are then consumed by herbivores. When organisms die, decomposers break down their organic matter, releasing nutrients back into the soil. This intricate dance of biotic and abiotic factors ensures the continuity of life and sustains the flow of energy through ecosystems (Yu and Kuzyakov, 2021).

Furthermore, energy flow within ecosystems is another embodiment of their interconnected nature. Biotic factors are intricately linked to abiotic factors through the transfer of energy. Producers, primarily plants, capture solar energy through photosynthesis, converting it into organic matter. This energy-rich matter is then transferred through the food chain as consumers feed on one another (Khatoon et al., 2017). Eventually, the energy is dissipated as heat during metabolic processes. This energy flow unites the biological components of an ecosystem with its physical environment, illustrating how life is intricately woven into the fabric of the natural world.In addition, the adaptation of organisms in their environment, an intricate balance of biotic and abiotic factors, underscores their connection. Organisms develop traits and behaviors that allow them to thrive in specific habitats. These adaptations often stem from a response to abiotic pressures (Sokolova, 2021).

CONCLUSION

In conclusion, the examination of log ecosystems has revealed their intricate complexity and the mutual dependence among their various components. Through careful observation and analysis, a diverse range of organisms residing in decaying logs, from decomposers aiding in nutrient recycling to predators influencing population dynamics were found. The biodiversity in these ecosystems highlights their crucial role in terrestrial environments, bolstering ecosystem resilience and functionality. Further, our research has highlighted how abiotic factors significantly shape the structure and behavior of log ecosystems. Variables such as temperature, moisture, sunlight, and soil composition are pivotal in determining species distribution and interactions. Understanding these intricate connections between living organisms and environmental conditions provides valuable insights into ecosystem resilience and the potential effects of environmental changes. This understanding is vital for developing conservation strategies aimed at preserving log ecosystems and the biodiversity they harbor for future generations. Furthermore, utilizing appropriate instruments to identify and measure these components is necessary if resampling would be done to provide a more objective and precise description of both the biotic and abiotic environment affecting the log ecosystem.

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