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Identification of *Rhizophora mucronata* Root in Mangrove Areas with An Anatomical Approach as a Source of Biology Learning

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Abstract

A study of the anatomy of the roots of *Rhizophora mucronata* in various waters, such as freshwater, river estuaries, and beaches, has not been widely carried out. Therefore, this study aims to identify the roots of *Rhizophora mucronata* in the mangrove area with the approach of plant anatomy as a source of learning biology. The root anatomy research method uses the fresh preparation method by making thin transverse sections on the roots and observing them under a microscope. The results of the study showed similarities in the anatomical structure of the roots, namely the epidermis, cortex, endodermis, xylem, and phloem. The difference in the results of this study is in the cortex section, which has a difference in thickness. With this, it can be concluded that there are differences in the anatomy of the roots of *Rhizophora mucronata,* which live in various waters with differences in the thickness of their cortex cells, and the results of this study can be used as a source of learning in the form of practical instructions. So, it can be concluded that this study can be used as a source of learning for valuable instructions on plant anatomy by students in the course of plant anatomy.

Keywords: Mangrove, *Rhizophora* sp., Root Anatomy, Learning Resources

INTRODUCTION

Indonesia is known as an archipelagic country, where there are several mangrove forests ranging from several meters to several kilometers wide that dominate some coastal areas (Tumangger, 2019). Indonesia has the largest mangrove ecosystem and the highest biodiversity in the world (Kusumahadi *et al*., 2020; Leo *et al*., 2023; Usman *et al*., 2023). Marine and coastal resources are significant to support human life, one of which is the mangrove ecosystem. (Paulina *et al*., 2023). Mangrove ecosystems are located on the coast and are affected by the ebb and flow of seawater. They are dominated by typical tree or shrub species that are able to grow in brackish waters (Romadoni *et al*., 2023). The most crucial function of mangroves for coastal areas is to connect land and sea, as well as to dampen natural phenomena caused by waters, such as abrasion, waves, and storms, and also to buffer the lives of other marine biota (Darwati *et al*., 2022; Koda, 2021; Shinta *et al*., 2022; Zuswiryati *et al*., 2022). Mangrove ecosystems can be said to be ecosystems that include various types of typical (Sinabang *et al*., 2022). Mangroves are forest vegetation that grows between the tidal lines, so mangrove forests are also called tidal forests (Majid *et al*., 2016; Safe'i *et al*., 2021). Mangroves are also often referred to as coastal forests or brackish water forests/mangrove forests (Ersan *et al*., 2022; Mistriani *et al*., 2021).

Mangroves are a type of plant that makes up mangrove forests. (Rahmad *et al*., 2020). The habitat of mangrove trees is also estimated to be very abundant and diverse in Indonesia

(Paulina *et al*., 2023). One of the mangrove plants that can live in the area mangrove is *Rhizophoraceae*. The *Rhizophoraceae family* is one of the leading representatives of true mangroves, with the most significant number of members among other (Indriaty *et al*., 2023). The community also uses this family for medicine, food, dye, and aromatics (Ramya *et al*., 2023). The Rhizophoraceae family has many types, including *Rhizophora mucronata*. *Rhizophora mucronata* is one of the many types of mangrove plants that are very useful for mangrove forests. (Istriningsih *et al*., 2023). This type of plant can adapt and has a fast growth rate (Nilmini Wijeyaratne & Liyanage, 2020)Mangrove plants have supporting roots that function to help support trees and also stabilize soil sediments (Samosir *et al*., 2023). Mangrove roots play a role in selecting ions that are absorbed and transported to the xylem and can remove 80-90% of NaCl salt from the solution around the roots (Sinyo *et al*., 2022). Characteristics of mangrove roots and can live in various environments

Root growth and development result from the constant formation of cells (Eljebbawi *et al*., 2021). Root development results from the help of several plant hormones (Motte *et al*., 2019). Roots have a very important role in plant productivity, as they function as a plant strengthener to the soil and play a role in the absorption of water and nutrients (Huda *et al*., 2023). As one part of the plant, roots also play an important role in responding to water shortages (Nio & Torey, 2013). Roots are part of the plant that has an anatomical structure. Plant anatomy is one of the important basic data to reveal the potential of a plant (Warni & Junaedi, 2023). In addition, anatomy can be used to study plant organs using the slicing method (A'yuningsih, 2017). Each plant has different anatomical characteristics from the characteristics it has (Viranda & Anggraini, 2024). Likewise, mangrove areas have various types of plants and different root characteristics. Characters like this can be used as a source of learning biology through the use of the surrounding environment so that the obstacles of monotonous practicums and relying on preserved preparations can be minimized, namely by utilizing the environment. by utilizing materials as practicum materials.

Utilizing the environment as a learning resource is very useful in biology learning because it has a positive value, namely contextual-based learning. The right learning resources in biology learning are one solution to various learning problems faced by students (Yuliany *et al*., 2022). What is meant by learning resources are all sources of data, goods, or tools that can be used by students in learning (Sidiq & Syaripudin, 2022). Learning resources are anything that can be utilized either directly or indirectly (Ilhami *et al*., 2020). Several previous studies on learning resources have been conducted. Nurwidodo *et al*. (2022) conducted research utilizing the school garden environment as a learning resource to improve students' understanding of biology material (Muliana & Arsal, 2023). Utilizing the potential

of plants in the UNM FMIPA environment as a learning resource for plant morphology courses. Puspitasari & Salamah (2021) conducted research by analyzing the results of biological research as a learning resource for plant tissue material. Utilization of the results of learning resource research was also carried out by Hasana *et al*. (2022) by identifying the size of pak choy stomata (*Brassica rapa L.*) colchicine soaking results as a learning resource Hasana *et al*. (2022). Aroyandini *et al*. (2020) also utilized the results of research on the diversity of fungi in mushroom agrotourism as a source of learning biology based on local potential. Based on the presentation of previous research, this study is novel; it utilizes the mangrove area to identify the roots of *Rhizophora* plants. *mucronata* that live in various types of waters (living in river estuaries, brackish waters, and beaches). Therefore, the formulation of the problem in this study is as follows: How is the anatomical structure of *Rhizophora roots mucronata* in mangrove areas in various types of waters (living in river estuaries, brackish waters, and beaches)? With the approach of plant anatomy as a source of learning biology? This study aims to identify the roots of *Rhizophora mucronata* in the Mangrove Area in various types of water (living in river estuaries, fresh water, and beaches) with a plant anatomy approach as a source of learning biology.

METHOD

This study uses an exploratory, descriptive method. The exploratory descriptive method aims to describe a condition or phenomenon. It is not intended to test the hypothesis but only to describe the existence of a variable, symptom, or condition (Negari *et al*., 2017). In this case, this can explore the different anatomy of mangrove roots in various waters (living in river estuaries, brackish waters, and beaches). Figure 1 is location of research sampling.

Figure 1. Location of Research Sampling

The materials in this root anatomy study are mangrove roots that live in several waters and safranin solution, while the tools in observing these roots are microscopes, glass objects, and slides. In this study, the preparation of slides for observing the anatomical structure of roots, stems, and leaves was carried out using the fresh slide method (Saputri *et al*., 2022).

This fresh slide method is carried out by making a transverse incision on the root so that a thin section is obtained; after making the incision, the next process is to soak the root section in safranin solution for 5 minutes to show the color on the slide, and the slide is clearly visible in its anatomical structure. After soaking, place the root section on the glass object and cover it with a slide. Observation of the slide using a microscope with a magnification of 10x. After getting the results, the data will be processed by describing the results of the observations.

RESULTS AND DISCUSSION

After observing the root anatomy through exploration, the results were obtained in Table 1, which contains the anatomical parts of mangrove roots.

Table 1. Results of Observations of Root *Rhizophora mucronata*

No	Types of waters	Anatomical Characteristics	
		Anatomical Parts	Information
1	Bid	Epidermis, Cortex, Endodermis, Xylem, Phloem	The root anatomy network is clearly visible, with a small diameter
2	Estuary	Epidermis, Cortex, Endodermis, Xylem, Phloem	The root anatomy network is clearly visible, with a small diameter
3	Beach	Epidermis, Cortex, Endodermis, Xylem, Phloem	The root anatomy network is clearly visible, with a larger diameter

Rhizophora root anatomy *mucronata,* which grows in three waters, namely fresh water, river estuaries, and beaches, has anatomical differences; the differences in root anatomy can be seen in Figure 2.

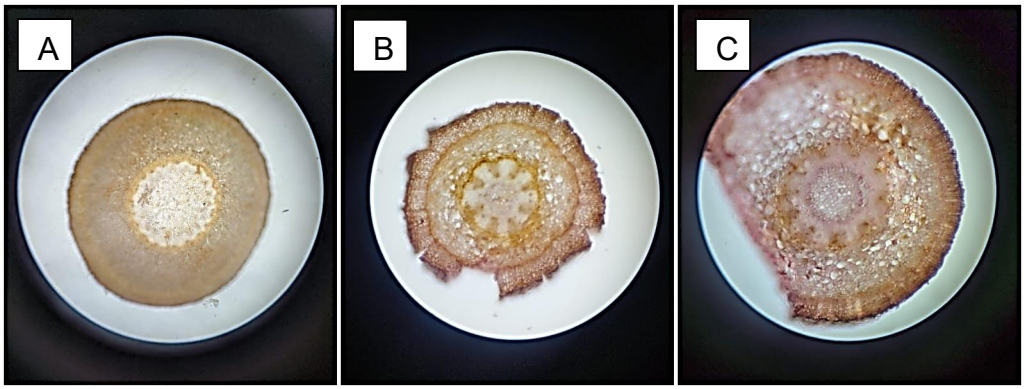
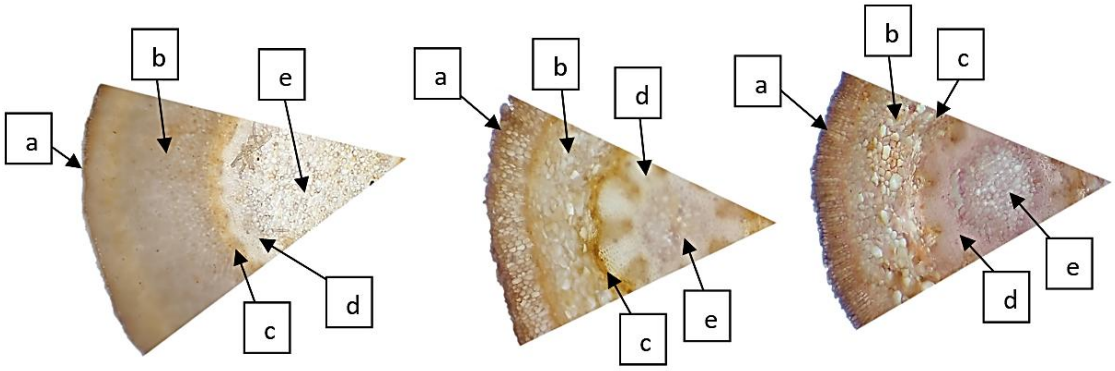


Figure 2. Observation of Mangrove Root Anatomy. 10x Microscope Magnification (A) Fresh Water, (B) River Estuary, (C) Coast

Based on the results of observations in Figure 2, it can be seen that the identification of root anatomy in various waters differs in terms of the shape and size of each part of the root anatomy. Mangrove roots in freshwater waters and river estuaries have a smaller diameter compared to mangroves that live in coastal waters, which have a larger diameter. The results of observations of Rhizophora mucronata root diameter are in Table 2.

Table 2. Results of Observations of Root Diameter *Rhizophora mucronata*

No	Types of Waters	Sample 1	Sample 2	Sample 3	Average Sample Diameter Size
1	Freshwater	0.9 cm	1.1 cm	1.0 cm	1.0 cm
2	Estuary	0.7 cm	0.8 cm	0.7 cm	0.7 cm
3	Beach	1.3 cm	1.5 cm	1.5 cm	1.4 cm



(A) (B) (C)

Figure 3. Anatomy of Mangrove Roots (A) Fresh Water, (B) Estuary Water, (C) Coastal Water. (a) Epidermis, (b) Cortex, (c) Endodermis, (d) Xylem, (e) Phloem

Observation results show that the anatomical structure of roots living in freshwater contains epidermis, cortex, endodermis, xylem, and phloem, as shown in Figure 3 (A). Mangrove roots in estuary waters have a smoother anatomical structure. The epidermis appears on the edge or is located on the outer tissue of the root. The cortex of mangrove roots in freshwater waters looks like tiny spots, and the cortex area is wider compared to the anatomy of estuary and coastal water roots. The thickening of the cortex size in drought-stress conditions is thought to be an adaptation of plants to increase water flow and efficiency of water use (Sari *et al*., 2023). The cortex in freshwater roots is dark in color. The cortex tissue appears darker in color, indicating the presence of ergastic substances that appear darker in color than parenchymal cells (Nurhayati & Linda, 2016). The endodermis is found in the middle, which is lighter in color than the cortex. Meanwhile, the xylem and phloem appear to spread out in the form of more prominent spots and appear to be the brightest in color compared to the epidermis, cortex, and endodermis. Xylem plays a role in transporting water and dissolved substances in the form of minerals. In contrast, the phloem transports assimilation from the results of photosynthesis from the ' source ' leaves to the ' sink ' or the part that utilizes photosynthesis. (Aikmelisa & Waluyo, 2019).

The results of the root anatomy research in the estuary waters clearly show the anatomical parts, namely, the epidermis, cortex, endodermis, xylem, and phloem, which are shown in Figure 3 (B). The root epidermis appears to be the darkest in color and is the outermost. The epidermis is the outermost layer of cells and covers the surface of leaves,

flowers, fruit, seeds, stems, and roots (Ishaq *et al*., 2022). The cortex appears thinner. The thin cortex layer is an anatomical adaptation to accelerate the flow of water from the epidermis to the xylem bundles (Anu *et al*., 2017; Akmalia, 2021). Mangrove roots in estuary waters also contains endodermis, which appears as a dark-colored barrier. Endodermis is a cell that limits the cortex and stele and functions as a selective barrier that regulates materials that will enter the stele (Malak, 2017). Xylem and phloem appear in bright colors. Xylem-phloem is the primary root tissue that helps in the movement of substances through the plant (Aikmelisa & Waluyo, 2019). Phloem is composed of various forms of living and dead cells. Phloem elements include sieve elements, companion cells, albumin cells (in gymnosperms), phloem fibers, and phloem parenchyma (Kusumaningrum, 2017). Stress on plant roots that causes reduced water supply will cause changes in the phloem tissue by shrinking and thinning the diameter of the phloem tube (Punjungsari & Ulfa, 2022).

The results of this coastal water root research clearly show the anatomical parts, namely, the epidermis, cortex, endodermis, xylem, and phloem, as shown in Figure 3 (C). There are epidermal cells that appear on the outermost part with a darker color. The cortex appears thicker and is shaped like small spots, which are vascular bundles that are spread in a circle. This research also shows the endodermis that limits the cortex with the xylem and phloem. The endodermis functions as a selective barrier that regulates the entry of materials from the soil solution into the vascular tissue in the stele (Malak, 2017). The inner side of the pericycle contains xylem and phloem tissue transport bundles (small and dense cells) (Hadi *et al*., 2016). The xylem tissue of coastal mangrove roots appears denser. The addition of xylem channels is one of the root mechanisms to maintain hydraulic conductance by reducing the long path effect. The density of the channels increases as a further mechanism of the reduced area of root absorption due to metal stress (Punjungsari & Ulfa, 2022). The xylem and phloem appear brighter or lighter in color compared to other parts of the root anatomy. One of the parts of the plant that is most affected by high aluminum metal stress is the transport tissue (xylem and phloem) (Punjungsari & Ulfa, 2022).

Mangrove roots are also caused by the adaptation to the environment where they grow. Differences in water are one of the factors that influence differences in mangrove root structure. Mangrove roots play a role in selecting ions that are absorbed and distributed to the xylem (Sinyo *et al*., 2022). Mangrove roots also have an ability called a biofilter; this ability is the role of roots in filtering, binding, and trapping pollution in the wild. Mangroves also have an ability called a biofilter, namely the ability to filter, bind, and trap pollution in the wild in the form of excess sediment, garbage, and other household waste. This function plays a role in improving water quality (Sanadi *et al*., 2018). The root architecture system refers to

the spatial configuration of the root system or the explicit distribution of the root axis (Huda *et al*., 2023). In scientific terms, the root is called a radix, and the root is the central part of the plant that already has vessels. The root tip has a meristem with active division and a protective sheath or root cap (Rahman, 2022).

Research on the anatomical differences in mangrove root structures in various waters needs to be done to find out the differences in root structures in different waters. The differences in structure are seen in the thickness of the anatomical parts. This research can be helpful in learning biology resources because the study of comparative root anatomy mangrove in various waters is still tiny, so this writing can be used as a reference in biology learning for students. Learning resources are very important in supporting learning. Learning resources or learning sources are important components and have a very important role in improving the quality of learning (Samsinar, 2019). Learning resources are not only tools and materials used in learning but also include people, budgets, and facilities (Manurung, 2021). This article is accompanied by photos of observation results that can be used as visual learning sources through observation photos in this research article.

CONCLUSION

Based on the research that has been done, it can be concluded that the anatomy of mangrove roots from these three waters has similarities and differences in terms of anatomical structure. All mangrove roots have anatomical similarities consisting of the epidermis, cortex, endodermis, xylem, and phloem. Meanwhile, the differences between the three mangrove roots are seen in the thickness of the root anatomy, one of which is in the cortex of mangrove roots in freshwater. The thickening of the cortex size under drought-stress conditions is thought to be a plant adaptation to increase water flow and water use efficiency. Learning resources are anything that can be used as a source in the form of material or data in learning activities. Studying biology can utilize the results of observations made in the laboratory, one of which is observing root anatomy. Contributions from the identification of Rhizophora mucronata roots in the mangrove area are used as a learning resource for understanding concepts in learning plant anatomy through direct practical activities in the laboratory using fresh preparations (preparation using the section method).

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