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The Morphological Characteristics of Water Bamboo (*Equisetum hyemale* Lour.)

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Abstract: This study aims to identify and analyze the characteristics of water bamboo plant (Equisetum hyemale) which grew in the Wisdom area of Park Gadjah Mada University (UGM). Aquatic bamboo, which is part of the Equisetaceae family, is known to have a distinctive body shape and plays an important role in the ecosystem as a pioneering plant. This study was conducted with direct observation of the water bamboo plant morphology found in the area. The data collected includes observations against the height of the plants, the shape of the stem, the leaf structure, as well as the rooting silver system. The results showed that the water bamboo in the Wisdom Park area had books with a cylindrical shape and dark green, and the leaves that were shrinking to turn into lite. This plant also has a well-developed silver system, supporting its resistance in a humid environment. This study provides a clearer picture of water bamboo morphological adaptation in the UGM region as well as its contribution to local biodiversity.

Keywords: Morphology, Water Bamboo Plant, Equisetum hyemale Lour.

Introduction

The name *Equisetum* derives from the Latin words *equus* (horse) and *saeta* (thick hair), hence plants in this genus are commonly called horsetails. Species of this genus generally grow in wet environments such as shallow ponds, riverbanks, or swampy areas. *Equisetum* ferns or horsetails belong to the division Sphenophyta. *Equisetum* is most commonly found in the Northern Hemisphere (Campbell, 2003). *Equisetum* typically grows to a height of less than 1.3 meters (4 feet), but some species in tropical regions and coastal tropical forests in California can exceed 4.6 meters or approximately 15 feet (Stern, 2003). The genus *Equisetum* comprises about 25 species, some of which are terrestrial and others aquatic or semi-aquatic (Holttum, 1959).

Equisetum hyemale Lour. (Water Bamboo) is a plant capable of living in aquatic environments. Large et al. (2006) explain that water bamboo has unique characteristics such as a round shape and bright green color. Its stems are green and hollow, topped with cone-like structures that serve both reproductive and vegetative functions. The cylindrical and segmented stems contain high silica content, making the plant strong and durable. This plant exhibits considerable resilience in both submerged and dry conditions and does not easily perish due to its densely tangled fibrous roots, which enhance the absorption of pollutants as nutrients. Water bamboo is a type of phytoextraction plant, absorbing contaminants through its roots and transferring them to the stems and leaves, where they are processed into H_2O or utilized for photosynthesis, the process by which plants synthesize food.

Equisetum hyemale Lour. is a marginal aquatic plant known for its ease of growth, low maintenance, and resistance to external influences. *E. hyemale* L. has been reported to remediate lead (Pb) levels in leachate wastewater by 82.2% in a batch system with 60 plants. Additionally, *E. hyemale* L. can reduce chromium levels after treatment with 60 plants in a continuous system. In

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constructed wetlands, *E. hyemale* L. achieved a 99.90% reduction in manganese (Mn) levels (Prihartini et al., 2020). *Equisetum hyemale* Lour. performs well in wastewater treatment using subsurface flow constructed wetlands (SSF-Wetlands) (Riswahyudi, 2010). According to Muslimin (2012), water bamboo absorbs waste components through its roots, which then bind lead content in the stems using silicate fluids produced by sclerenchyma fibers to immobilize lead in artificial solutions. Furthermore, *E. hyemale* L. is recognized for its potential in traditional medicine applications, particularly in treating urinary tract and skin disorders.

Understanding the morphology of *E. hyemale* L. is crucial for various scientific and practical applications, especially in botany, materials science, and ecology. The unique structural characteristics of this plant not only contribute to its ecological roles but also enhance its potential for industrial applications, particularly in silica extraction and biomaterials. Plant morphological characteristics can be used to easily and quickly assess plant diversity. Morphological identification provides information about the specific traits of a plant species (Santana et al., 2021). Studying the morphological characterization of plants is essential for visual identification, enabling the recognition and classification of plant diversity and the assignment of appropriate names.

Plants exhibit varied forms and distinct characteristics for each species, influenced by environmental and genetic factors. Bramasto et al. (2015) explain that plant morphological diversity results from the interaction between environmental and genetic factors. Environmental factors influencing morphological variation include altitude, temperature, slope, and general vegetation (Barbour & Pitts, 1987). In addition to environmental factors, plant morphology is also influenced by genetic factors. According to Sufardi (2020) and Wang et al. (2019), genetic factors can affect plant growth through physiological processes, ultimately influencing plant morphology. Genetic factors function optimally when environmental conditions are favorable, and under optimal environmental conditions, plant growth and yield are largely determined by genetic factors (Sufardi, 2020).

Based on the above background, research on the morphology of *E. hyemale* L. is necessary to understand the characteristics of water bamboo plant parts in greater detail. This study aims to provide explanations regarding the morphology of the roots, stems, leaves, and spores of water bamboo. The benefit of this research is expected to provide information on the morphology of *E. hyemale* L., enabling readers to better understand the distinctive features of water bamboo that set it apart from other plants, particularly among ferns.

Materials And Methods

This research was conducted at the Wisdom Park Area of Gadjah Mada University on December 24, 2024. The tools used in this research included stationery, research instrument guides, camera/smartphone, microscope, and lens. The materials used consisted of water bamboo plant samples. The research methods employed for observing the structure and morphology of water bamboo plants were descriptive exploratory and literature study. The descriptive exploratory method is research about a condition by creating systematic, factual, and accurate descriptions of facts, properties, and their relationships (Kariada & Irsadi Andin, 2014). This research is a field study conducted through direct observation by exploring and directly observing the morphological characteristics of water bamboo plants. Field research involves observation and recording of necessary information by researchers directly during the study of the subject under investigation (Abubakar, 2021).

Sampling was conducted through direct observation in the Wisdom Park Area of UGM. Sampling was carried out using purposive sampling method. Purposive sampling is a sampling technique used when researchers have specific considerations in sample selection or determining samples for particular purposes (Sartina, 2021). Data collection methods utilized documentation techniques. The data obtained from direct observation of the water fern plants included

morphology of plant parts, specifically roots, stems, leaves, and spores. The identification process was conducted through morphological observation of samples with the assistance of several literature sources in the form of identification books and journals. The research data obtained were then analyzed using descriptive analysis regarding the morphological characteristics of water bamboo.

Results And Discussion

The *Equisetum hyemale* Lour (Water Bamboo) sample used in this study was found in the Wisdom Park area of UGM, where it is utilized to enhance the aesthetics of the surrounding area or as an ornamental plant. *E. hyemale* L. grows in an aquatic environment, planted in pots containing stagnant water. The observed morphological characteristics of the *E. hyemale* L. plant include 4 morphological traits: root morphology, leaf morphology, stem morphology, flower morphology, and fruit morphology. Each morphological characteristic of *E. hyemale* L. is described in the following explanation:

Table 1. Observation Results of Morphological Characteristics of Horsetail (Equisetum hyemale Lour.).

no	Plant parts	Description
1	Root System	Fibrous and branched, brown in color
2	Root Length	Average 8 cm
3	Stem Surface	Hollow, grooved, and segmented
4	Stem Length	Average 50-120 cm
5	Leaf Color	Bright green
6	Leaf Arrangement	Arranged circularly around the stem
7	Leaf Blade Shape	Simple
8	Leaf Margin	Scaly
9	Leaf Base	Sheath-shaped surrounding the stem segment
10	Leaf Apex	Pointed
11	Leaf Surface	Not slippery, smooth (slightly rough)
12	Leaf Midrib	No leaf midrib
13	Leaf Veins	Small and round-shaped
14	Leaf Texture	Scaly
15	Leaf Length	Average 1 cm
16	Number of Leaves	Has 4-8 leaf circles
17	Sorus	Round-shaped and located at the stem base
18	Sori	Appear as black dots on the leaf surface

1. Strobilus

Spores are stored in a club-shaped structure called a strobilus (plural strobili) which forms at the apex of the stem (Silalahi, 2009). The strobilus in *E. hyemale* L. emerges at the tip of younger stems, typically on upright stems that are separate from the vegetative (sterile) stems. The strobilus is cylindrical, elongated, and narrow in shape, with a brownish or yellowish-green color when mature. The spores produced by *E. hyemale* L. are dispersed after the strobilus matures. These spores will germinate in a moist environment and form a gametophyte, which will then produce gametes for the fertilization process and the plant's life cycle (De Lange, P. J. & Murray, D., 1996). The morphological characteristics of the *E. hyemale* L. strobilus can be observed in Figure 1.

(Haggstrom, 2005)
Figure 1: Strobilus Morphology of Equisetum hyemale Lour.

2. Leaf

E. hyemale L., commonly known as rough horsetail or scouring rush, possesses a highly characteristic

leaf morphology. The leaves of *E. hyemale* L. are not well-developed; upon closer inspection, they appear as scale-like structures appressed to the stem (Silalahi, 2009). These are not true leaves (like those found in flowering plants) but are more akin to structures called sheaths. In *E. hyemale* L., the leaves lack the distinct lamina typical of other plants. Instead, this plant has sheaths that encircle its stems. These sheaths are composed of small, tightly arranged cells that closely envelop the stem (Sporne, K. R., 1975). The leaves of *E. hyemale* L. are very small and scale-like or sheath-like in form. These leaves do not detach from the stem and function primarily to support stem growth, not photosynthesis (Baker, H. G. & Baker, I., 2000). Consequently, the stems of the horsetail are the primary organs responsible for photosynthesis, substituting for the leaves. The morphological characteristics of the *E. hyemale* L. leaf can be observed in Figure 2.

Figure 2: Leaf Morphology of Equisetum hyemale Lour.

3. Stem

The stem of *E. hyemale* L. is cylindrical with distinct nodes, similar to common bamboo. The outer part of the stem is typically bright green and feels smooth to the touch. As it ages, the stem surface can become slightly rough. The inside of the *E. hyemale* L. stem is hollow, an adaptation that helps it float in water and serves as a storage area for food reserves. The stem wall of this plant is quite strong and hard, containing fibers that make it sturdy and not easily broken. At each node, there is a protrusion called a nodule, which is a harder and thickened part. From these nodules, new roots and shoots will grow. The water bamboo plant has an average stem height of 15-120 cm and a stem diameter ranging from 0.1 to 0.5 cm. Large (2006) explains that the *E. hyemale* L. plant has an average height of less than 1.3 meters and can sometimes reach 3m. Its stem is green and hollow, but the tip is cone-shaped, which has a dual role as both generative and vegetative. Furthermore, Silalahi (2009) also explains that *E. hyemale* L. has a stem that functions as a photosynthetic organ replacing leaves and has a stem that can branch and contains much silica. The leaf parts are not well developed, but upon closer inspection, they only resemble scales arranged in whorls covering the nodes. The morphological characteristics of the *E. hyemale* L. stem can be observed in Figure 3.

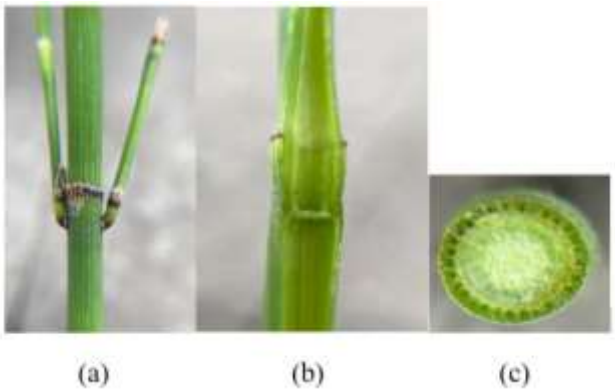

Figure 3. Stem Morphology of Equisetum hyemale Lour. (a) external view (b) internal longitudinal section view (c) internal cross-section view.

4. Roots

Equisetum hyemale L. has a fibrous and branched root system that is dark brown in color. The root surface has a rough texture, and the root length of this plant is approximately 8 cm. *E. hyemale* L. possesses long, fibrous roots, which increases the contact surface area between the roots and leachate. When a plant has long, fibrous roots, the area for microorganisms to colonize in the rhizosphere zone becomes larger and more extensive (Triastianti, 2023). The roots of *E. hyemale* L. are also capable of releasing oxygen, thereby enriching the oxygen content in the surrounding environment. The ability of water bamboo as a phytoremediator is due to the presence of rhizosphere microbes on the roots, which can break down contaminants by absorbing them from the water and accumulating the dissolved substances into their body structures. Consequently, the more water bamboo plants present, the greater the

reduction in BOD levels (Margowati & Abdullah, 2017). Furthermore, the roots of this plant host microorganisms that can form symbiotic relationships for the decomposition of organic pollutants. These microbes are rhizosphere microbes located in the rhizosphere zone and function to decompose organic substances present in wastewater. These rhizosphere microbes utilize exudates (fluids secreted by the roots containing amino acids and proteins) to proliferate in the rhizosphere area (Anggraini, 2022). The morphological characteristics of the *E. hyemale* L. roots can be observed in Figure 4.

Figure 4. Root Morphology of Equisetum hyemale Lour.

Conclusion

The conclusion of this research is that the morphological characteristics of the water bamboo plant (*Equisetum hyemale* Lour.) found in the Wisdom Park Area of UGM display distinctive features across various plant parts that are highly adaptive to aquatic environments. The morphological characteristics observed in this plant include the morphology of the strobilus, leaves, stem, and roots. The strobilus morphology of *E. hyemale* L. appears at the tips of younger stems and functions in the reproduction process through spore dispersal. The leaves of *E. hyemale* L., although not well-developed and more resembling scales or sheaths, function to support stem growth as a photosynthetic organ. The stem of this plant is cylindrical, hollow, and has distinct nodes, with the primary function of substituting for leaves in the photosynthesis process, as well as having generative and vegetative roles. The roots of *E. hyemale* L. are fibrous, branched, and capable of releasing oxygen, functioning to enrich oxygen content in the water and supporting this plant's ability in phytoremediation. The rhizosphere microorganisms present in the roots also play a role in decomposing organic pollutant materials in wastewater. With these various characteristics, *E. hyemale* L. has great potential for reducing water pollution, and although not primarily developed as an ornamental plant, this plant can also be utilized for aesthetic purposes around aquatic areas.

Conflict of Interest: The authors declare that there is no conflict of interest regarding the paper. No financial or personal relationships with other people or organizations have influenced the work reported in this study.

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