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Original Article

Morphological Characteristics of Plants in Compound Leaves

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Abstract

Plant morphology is a branch of biology that examines the physical forms, structures, and characteristics of plants. Compound leaves, defined as leaves bearing more than one leaflet on a single petiole, exhibit considerable morphological diversity across species. This study aimed to identify and compare the morphological characteristics of compound leaves from four plant species, namely cassava *(Manihot esculenta)*, moringa *(Moringa oleifera)*, starfruit *(Averrhoa bilimbi L.)*, and sensitive plant *(Mimosa pudica)*, with a focus on distinguishing the main petiole, leaflet stalk, and leaflet arrangement of each species. Morphological observation was conducted through direct visual examination of fresh leaf specimens, recording characteristics including leaf type, leaflet shape, venation pattern, surface texture, and leaflet arrangement along the rachis. The findings revealed distinct morphological profiles among the four species. Cassava leaves were identified as palmate compound leaves with 3-8 finger-like leaflets radiating from the tip of the main stalk. Moringa leaves were classified as triply odd-pinnate compound leaves with small, oval leaflets arranged alternately along the rachis. Starfruit leaves were identified as odd-pinnate compound leaves consisting of 21-24 pairs of oval leaflets with pinnate venation and a finely hairy surface. Sensitive plant leaves were identified as bipinnate compound leaves whose leaflets fold upon physical contact. It can be concluded that each species exhibits a unique combination of compound leaf morphological traits that serves as a reliable basis for visual identification and reflects functional adaptation to the respective plant's ecological environment.

Keywords: Characteristics, Compound Leaves, Plant Morphology.

1. Introduction

Indonesia, with its abundant natural resources, including its flora, as a "Mega Biodiversity" country, undoubtedly boasts a wide and abundant variety of flora. This is especially true for plants, which exhibit a wide variety of species, including stems, roots, and leaves. Plant morphology is a branch of biology that studies the physical form, structure, and external appearance of plants (Tjitrosoepomo, 1999). Morphology is derived from the Greek *"morphus"* (form) and *"logos"* (study) (Kodner, 2023). This science was introduced in 1790 by German scientist Johann Wolfgang von Goethe with his concept of "Urpflanze The Metarmorphosis of Plants," which describes the ancestral concept of plants and describes the origins of the diversity of plant forms.

Plant morphology is also a science that examines the main parts of plants, such as the shape of leaves, stems, and roots, flowers, fruits, and seeds, for the purpose of identifying and classifying these plants. One of the vegetative organs in plants is the leaf (folium), which is the main place for the photosynthesis process with various shapes, sizes and textures that are unique to each type of plant (Eka & Evi, 2016).

Compound leaves are a morphological variation of leaves commonly found in various plant species. This structure also has distinctive features that significantly differentiate it from simple leaves. Compound leaves also have a key characteristic: the presence of multiple leaflets on a single stalk. Unlike simple leaves, which have only one leaflet per stalk, such as jackfruit leaves, compound leaves appear as a collection of multiple leaflets attached to a common axis (Rohaeni & Yuliani, 2019). Leaves are plant organs that grow from stems. They are generally green (contain chlorophyll) and primarily function to capture energy from sunlight through photosynthesis (Susilo, 2015). Leaves are crucial for plant survival because plants are obligate autotrophs; they must supply their own energy needs by converting light energy into chemical energy (Latifa, 2016).

Compound leaves are also leaves with one main stem that branches where each branch has more than one leaflet that is different from a single leaf. With the main characteristic is that all the leaflets will fall off simultaneously, for example in moringa leaves and mimosa leaves (Koch et al., 2018). Some other examples of plants that have compound leaves include *Mimosa pudica* leaves, moringa leaves *(Moringa oleifera)*, starfruit leaves *(Averrhoa bilimbi)*.

Leaves are the primary photosynthetic organs of plants, although green stems also perform photosynthesis. Leaf shape varies greatly, but generally consists of a leaf blade and a petiole, which connects the leaf to the stem. Leaf patterns can be divided into simple leaf patterns (single leaf). A single leaf has a single, undivided leaf blade (Tsukaya, 2018). Axillary buds (buds) are located where the leaf stalk joins the stem. Nodes are the part of the stem where leaves attach (Bowo et al., 2011). Leaves are also one of the plant organs where photosynthesis occurs. They contain stomata, which function to exchange oxygen and carbon dioxide and evaporation of water. The primary functions of leaves are photosynthesis, gas exchange, transpiration, and storage of food or water reserves in certain plants (Oguchi et al., 2018).

Some of the parts of a compound leaf include 1. The petiole *(Petiolis communis)* which is the most important part that is the seat of the leaf blades or leaflets, 2. The petioles (petioles) which are branches from the petiole that directly support each leaflet. 3. The leaflets (Foliolum) are small leaflets that are separate but are in one leaflet stalk. 4. The rib (costa) is a continuation of the different leaf stalks in the middle of the leaflet to provide strength and distribution channels for nutrients.

In general, these parts work together to carry out the plant's vital functions. The leaflets also serve as the primary sites for assimilation (food processing during photosynthesis), resorption, carbon dioxide, respiration, and transpiration. Meanwhile, the petiole and leaf veins also play a role in providing strength or acting as a framework and as a vascular bundle for transporting water, mineral salts, and assimilation products throughout the plant. Leaves also have their own distinct types, one of which is the compound leaf. Compound leaves have one main petiole with more than one leaflet growing on its branches. Compound leaves also have specific types, including pinnate, palmate, and compound leaves. Some examples of compound leaves in plants include starfruit and moringa leaves, while palmate leaves are found in cassava and sunflower leaves. Compound leaves are also found in *sikejut* leaves. Compound leaves are leaves with a single petiole and more than one leaf blade on the branches of the main petiole or main stem.

The content of this plant morphology course focuses on understanding the scientific terms for plant organs, both generative and vegetative. Furthermore, the course covers a general overview of plant organs, morphological structures, and other plant parts, such as stems, roots, fruits, and seeds, in terms of their morphology and function. This plant

morphology course also aims to enable students to understand, apply, and share their knowledge with others in the future study of plant morphology.

Several studies on plant classification related to computer vision discussed above emphasize the use of shape and texture features in plant recognition based on leaf morphology (Syaban & Harjoko, 2016). Leaves are divided into two types: simple leaves and compound leaves. Compound leaves are those with multiple leaflets on a single petiole. The parts of the petiole include the petiole, leaflet stalk, leaflet, and leaf sheath.

One example of a compound leaf is the starfruit *(Averrhoa bilimbi L.)*, a plant native to tropical America and cultivated in several countries such as Malaysia, Argentina, Australia, Brazil, India, the Philippines, Singapore, Thailand, and Venezuela. In Indonesia, starfruit has begun to be utilized for many purposes, including its leaves (Eka & Evi, 2016). From this research, only 4 plants were sampled which were included in compound leaves, namely starfruit, cassava and moringa leaves, these three plants were included in compound leaves.

2. Methods

The research was conducted in the Biology Education Laboratory, Faculty of Teacher Training and Education, University of Tangerang Raya. The subjects who conducted the observations were Biology Education students from the Class of 2023. The samples used in this observation were cassava leaves *(Manihot esculenta)*, moringa leaves *(Moringa oleifera)*, starfruit leaves *(Averrhoa bilimbi)*, and *sikejut* leaves *(Mimosa pudica)*.

The steps in this practicum included writing the name of the specimen and its family, describing and differentiating the petiole and leaflet, and studying the arrangement of compound leaflets within the leaf.

The method used in this research was a sampling technique. A field survey was conducted in 10 quadrants, each measuring 2 meters x 2 meters, at different locations. This research was conducted to determine which plants have perfectly compound leaves, so that students can differentiate between compound, simple, and imperfect leaves. This research, using a sampling technique, aimed to enable students to identify the types of trees/plants that are classified as having compound leaves.

The data obtained were qualitative, including the differences between the petiole, petiole, and leaflet, as well as the arrangement of compound leaflets within the leaf. The data collection technique used was observation, followed by descriptive analysis. The data analysis technique used was direct observation, along with reading various reference sources (books and journals), and explanations from the laboratory assistant.

3. Results and Discussion

3.1. Research Results

Leaves are a plant organ that functions as a site for photosynthesis, located on the stems and branches of the plant. They also function as a means of gas exchange between O2 and CO2. Leaves come in various shapes and sizes. Compound leaves are leaves with a single main petiole consisting of more than one smaller leaflet, called leaflets, located on the branches of the main petiole, rather than a single leaflet like a typical simple leaf. Leaf morphology: Leaves are nutrient-carrying organs found only on the stem and never elsewhere. The parts of the stem where the leaves sit or are located are called nodes, while the angle between the stem and the leaf is called the axilla.

If we examine the leaves of various plants, we will see that some of these leaves, namely the petiole, contain only one leaflet; these leaves are called simple leaves (folium simplex). Meanwhile, leaves that have more than one blade on the main stem are called compound leaves (folium compositum).

Compound leaves also have separate notches, each on its own small leaf blade. Compound leaves also have distinguishable parts, including: 1) The petiole of Petiolis communis, where the leaf blades sit, each called a leaflet or foliolum. 2) The petiole, or patiololus, is the branch of the petiole that supports the leaflets. This part also manifests at the base of a single leaf vein. 3) The petiole, or petiole, is the branch of the leaflet, which has notches that separate them.

Many plant species have leaves with different shapes, sizes, and colors. A tree may have only a few leaves, such as a banana tree, but some trees can have thousands of leaves, such as the banyan tree *(Ficus benjamin L.)* (Anggraini, 2012).

Leaves, when viewed from the number of leaves, are divided into simple and compound leaves. If each leaf stalk is supported by a single leaf blade, the leaf is called a simple leaf. If a leaf stalk is supported by more than one leaf blade, the leaf is called a compound leaf. A simple leaf is a leaf whose axis (leaf stalk) supports only one leaf blade. Buds are generally located in the leaf stalk axil. The characteristic of single leaves is that they form asynchronously and fall in sequence from oldest to youngest (Nugroho et al., 2006).

Compound leaves are also leaves that have various types of leaves from various plants. These leaves are also often used by residents for various consumption needs, for example cassava leaves. Cassava leaves are also compound leaves. Cassava leaves are compound leaves with palmate leaves. Where on a single leaf stalk there are several small leaflets, or so-called leaflets that radiate like fingers from the tip of the main stalk. Cassava leaves have 3-8 leaflets with palmate veins, which is a characteristic of palmate leaves.

Cassava leaves or Manihot esculenta are compound leaves with palmate leaves that are also rich in various nutrients in them such as protein, vitamin C, and calcium. Some of the characteristics of this leaf are its palmate compound leaves, fan-shaped or palm-shaped, divided into 5-9 lobes. Its texture is relatively rough, and its color becomes deep green when ripe. Cassava leaves are also widely used as a food ingredient by local residents as a vegetable or as a salad, where the leaves are cooked first in boiling water. The cassava leaf is depicted in Figure 1 below:

Figure 1. Cassava Leaf *(Manihot esculenta)*
Source: Shutterstock.com

Besides cassava leaves, there are several other compound leaves, including moringa leaves. Moringa leaves are pinnate compound leaves arranged in double and odd-pinnate

(imparipinnate) and have small, oval or ovate leaflets arranged on the main leaf stalk or mother leaf. Moringa oleifera leaves are small, oval-shaped leaves arranged on a single leaf stalk. They are bright green or light green in color and have smooth edges. Moringa leaves also contain many nutrients, including essential nutrients, vitamins, minerals, antioxidants, and amino acids.

Some characteristics of moringa leaves include their small, ovate or oval shape with smooth edges, their small, parallel leaves, about 1-3 cm long, their arrangement of numerous leaflets on the main stalk, their bright green color, which darkens as the leaves age, and their texture becomes soft on young leaves and stiffer on older leaves.

Moringa oleifera, belonging to the family *Moringaceae*, has bipinnate compound leaves with small, oval leaflets arranged alternately. The plant develops a strong taproot system rather than rhizomes.

Moringa *(Moringa oleifera)* is a type of tree whose leaves can be used as a vegetable or medicine. Moringa plants have long been used in Asia and many African countries as a food and as a primary ingredient in medicines, both for prevention and treatment (Prihati, 2015). An illustration of the moringa leaf is shown in figure 2 below:

Figure 2. Moringa leaves *(Moringa oleifera)*
Source: Shutterstock.com

Next is the compound leaf of the starfruit *(Averrhoa bilimbi L.)*. It is an odd-pinnate compound leaf, consisting of 21-24 pairs of parallel, ovate-shaped leaflets. The leaves are bright green on top and light green on the bottom. They have pointed tips, rounded bases, flat edges, short stems, and measure approximately 2-10 cm x 1-3 cm. They also have pinnate veins and a finely hairy surface.

Starfruit is also a tropical plant that can bear fruit year-round. This plant is often found in home gardens. The starfruit fruit is oval, measuring 4-6 cm in length, has a shiny skin that changes color, from green when unripe to yellowish when ripe. Morphologically, starfruit can grow to a height of 5-10 meters. Its stem is relatively short, wavy, and has low branches.

Some characteristics of starfruit leaves include pinnate compound leaves with 21-24 pairs of leaflets. They are rounded and oval in shape, with pointed tips. The base fades and is rounded. The leaf margins are flat. Starfruit leaves range from 2-10 cm long and 1-3 cm wide. They are dark green on top and light green on the bottom. The veins on starfruit leaves are pinnate. They have a rough, hairy surface and are arranged opposite each other on the main leaf stalk. A picture of a starfruit leaf can be seen in Figure 3 below.

Figure 3. Starfruit leaf *(Averrhoa bilimbi L.)*
Source: Shutterstock.com

The starfruit *(Averrhoa bilimbi)* belongs to the *Oxalidaceae* family. It is a pinnately compound leaf, growing alternately on the left and right sides. Furthermore, the compound leaves of the *sikejut* plant, or sensitive plant, are a climbing plant that sometimes forms a shrub or semi-shrub with an average height of 0.3–1.5 cm.

The sensitive plant grows wild along roadsides, in yards, open spaces, and in community plantations. The sensitive plant has pinnate leaves with green edges and paler undersides. The leaves are small and compound, oval in shape with pointed tips. These leaves will close when touched, whether by humans or other animals.

An illustration of the Mimosa pudica leaf can be seen in Figure 4 below.

Figure 4. *Mimosa pudica* Leaf
Source: https://s.id/zH6dK

Mimosa pudica, or in Indonesian, the sensitive plant, is a type of wild plant and weed. The *Mimosa pudica* plant has been extensively studied both domestically and internationally and has long been used medicinally as an antidote for respiratory infections, herpes, skin infections, diarrhea, asthma, swelling due to wounds, and even insomnia (Parnanto et al., 2013).

3.2. Discussions

The findings of this study identified four plant species with compound leaves, namely cassava (*Manihot esculenta*), moringa (*Moringa oleifera*), starfruit (*Averrhoa bilimbi* L.), and sensitive plant (*Mimosa pudica*). These findings are consistent with previous studies that classify compound leaves as those bearing multiple leaflets on a single petiole, distinguishable from simple leaves in which each petiole supports only one leaf blade (Nugroho et al., 2006). The morphological diversity observed across these four species reflects the wide variation in compound leaf structure that has been documented in botanical literature.

3.2.1. Comparison with Previous Literature

The identification of starfruit, cassava, and moringa as compound leaf species aligns with the findings reported by Eka and Evi (2016), who similarly categorized these plants under compound leaves. Starfruit (*Averrhoa bilimbi* L.), which is native to tropical America and widely cultivated across Asia including Indonesia, has been consistently described as an odd-pinnate compound leaf species with 21-45 pairs of leaflets, a characteristic that was also confirmed in the present study. The present observation of 21–24 leaflet pairs per main stalk is coherent with the morphological descriptions found in existing taxonomic literature.

Moringa (*Moringa oleifera*) was confirmed as a triply odd-pinnate compound leaf, consistent with classifications in the Moringaceae family documented in prior studies. Its small, oval leaflets arranged alternately along the rachis represent a morphological pattern that has been widely reported across tropical and subtropical regions where the plant is cultivated both as food and medicine (Prihati, 2015). Similarly, cassava (*Manihot esculenta*) was identified as a palmate compound leaf, with 3-8 leaflets radiating from the tip of the main stalk, which corresponds to the descriptions documented in botanical studies of the Euphorbiaceae family.

The inclusion of *Mimosa pudica* as a fourth specimen extends the scope of this study beyond the three species previously reported by Eka and Evi (2016). *Mimosa pudica* exhibits bipinnate compound leaves with small, oblong leaflets arranged in opposite pairs, a structural feature that distinguishes it from the other three species observed in this study.

3.2.2. Functional Significance of Morphological Traits

The morphological traits identified in this study carry important functional implications. The palmate leaf arrangement in cassava allows for maximum light interception across a broad surface area, which is advantageous in open agricultural environments. In contrast, the small and numerous leaflets of moringa and starfruit serve to reduce water loss through transpiration while maintaining sufficient photosynthetic capacity, a trait that is particularly adaptive in tropical climates with fluctuating rainfall.

The thigmonastic response of *Mimosa pudica*, the closing of leaflets upon physical contact, represents one of the most distinctive functional traits observed in this study. This rapid leaf movement is widely understood as a defense mechanism against herbivory and physical disturbance, and is made possible by the compound leaf structure that allows each leaflet to fold independently along the rachis (Parnanto et al., 2013).

3.2.3. Role of Morphological Traits in Plant Identification

Leaf morphology, including leaf type, leaflet shape, venation pattern, and surface texture, plays a central role in plant identification and taxonomic classification. As emphasized by Syaban & Harjoko (2016), shape and texture features derived from leaf morphology are among the most reliable indicators used in plant recognition systems, including those based on computer vision approaches. The present study demonstrates that each of the four species examined exhibits a distinct combination of morphological traits, such as the pinnate venation

of starfruit, the palmate arrangement of cassava, the triply compound structure of moringa, and the bipinnate form of *Mimosa pudica*, that collectively enable reliable visual differentiation among species.

3.2.4. Study Limitations

Despite the descriptive richness of the findings, this study is subject to several limitations. First, the sample was restricted to only four plant species, which limits the generalizability of the morphological comparisons to a broader range of compound leaf plants. A larger and more taxonomically diverse sample would provide a more comprehensive basis for comparative morphological analysis. Second, the study relied exclusively on visual and descriptive morphological observation without the support of quantitative measurements or imaging analysis tools, such as those used in computer vision-based leaf recognition systems (Syaban & Harjoko, 2016). The incorporation of such tools in future studies could enhance the objectivity and reproducibility of morphological descriptions. Third, environmental factors such as plant age, growing conditions, and seasonal variation, all of which are known to influence leaf morphology, were not systematically controlled or recorded, which may affect the consistency of the observations reported.

4. Conclusion

This study examined the morphological characteristics of compound leaves from four plant species, namely cassava (*Manihot esculenta*), moringa (*Moringa oleifera*), starfruit (*Averrhoa bilimbi* L.), and *sikejut* (sensitive) plant (*Mimosa pudica*). The observations confirmed that all four species bear compound leaves, each exhibiting a distinct structural arrangement. Cassava leaves were identified as palmate compound leaves with finger-like leaflets radiating from the tip of the main stalk. Moringa leaves were classified as imperfect odd-pinnate triply compound leaves with small, oval leaflets arranged alternately along the rachis. Starfruit leaves were identified as alternate odd-pinnate compound leaves consisting of 21–24 pairs of oval leaflets with pinnate venation and a finely hairy surface. Sensitive plant leaves were identified as bipinnate compound leaves, distinguished by their unique thigmonastic response in which leaflets fold upon physical contact. These findings demonstrate that leaf morphology, particularly the type of compoundness, leaflet arrangement, venation pattern, and surface texture, constitutes a reliable and accessible basis for plant identification in the field. The morphological diversity observed across the four species also reflects functional adaptations to their respective ecological environments, such as maximizing light interception, reducing water loss, and providing defense against herbivory. This underscores the significance of morphological study not only for taxonomic purposes but also for understanding plant ecology and physiology.

From an applied perspective, the morphological traits documented in this study can serve as foundational reference data for the development of plant identification tools, including computer vision-based leaf recognition systems. Future studies are encouraged to expand the sample to a greater number of compound leaf species to enable broader comparative analysis. Additionally, the integration of quantitative morphometric measurements, microscopic anatomical observation, and controlled environmental variables would strengthen the scientific rigor of morphological investigations. Longitudinal studies examining how leaf morphology changes across plant developmental stages and in response to environmental stress would also contribute valuable insights to the existing body of botanical knowledge.

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