Identification of *Shorea* species based on leaf morphological character with multivariate analysis

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**Abstract.** *Shorea* is one of the largest genera of the Dipterocarpaceae family that dominates Indonesian forests. This genus has an essential role in meeting the supply of wood, both at home and abroad. There are 194 species of shorea in the tropics. However, there is a high degree of similarity between one species and another, making it difficult to identify it. This study aims to estimate the variation of leaf morphology among 6 species of shorea at PT. Reki using multivariate analysis. Multivariate analysis is a statistical technique for analyzing data with a large number of variables. PCA (Principal component analysis), Biplot, and Manova were the three species of multivariate analysis used in this study. The results of PCA analysis showed that the variables of leaf elongation (PR), lamina length (PL) and leaf width to the base of the leaf (LP) had a strong relationship so that they could be used as a differentiator for the 6 shorea species. Biplot analysis showed that *Shorea parvifolia*, *Shorea acuminata* and *Shorea leprosula* had high similarities. It is also indicated by the leaves of the three species, which are more round in shape. The results of the Manova analysis showed a significant value <0.005, which means that all the variables tested have differences from one another. *Shorea acuminata* and *Shorea leprosula* have high similarity, and it is also indicated by the leaves of the three species, which are more round in shape.

## 1. Introduction

*Shorea* is one of the genera of the main family (Dipterocarpaceae) that grows in tropical forests [1]. The existence of Shorea is both economically and ecologically very beneficial. In the world of timber trade, the genus Shorea is in great demand so that it is included in the first commercial class [2]. Until now, the supply still comes from natural forests [3]. Shorea has many species, more than 190 species, where the distribution is increasingly challenging to know, so it requires special handling for its preservation [4,5]. One of the efforts in preserving tree species from the Shorea genus is to know the type correctly. So species identification activities, including taxonomic aspects and biological characteristics, become very important in the conservation, restoration and development of production forests [6,7].
Morphological identification is a method of identifying plant species that is commonly done in the field. According [8], this identification is highly dependent on the availability of morphological characters, both vegetative organs (leaves, stems, and branches) and generative organs (flowers and fruit). Leaf organs are often used in morphological identification because they are generally owned by every plant, available at any time, and have specific characteristics for each species [9]. Species identification based on leaf morphology is the first step usually carried out directly in the field, but Shorea species often experience difficulties. Species in this genus have many similarities, so that they are morphologically difficult to distinguish from one another [10]. This research aims to get the information specific characteristic morphology to different 6 Shorea species (S. Accuminata, S. parvifolia, S.guiso, S.Leprosula, S. Ovalis, and S. pinanga).

2. Materials and Methods

2.1. Leaf Sampling
Leaf sampling was carried out at the location of PT. REKI (Ecosystem Restoration) or Harapan Rainforest, Bungku Village, Batang Hari Regency, Jambi Province with leaf morphology diversity refers to [11] with some modifications. Each leaf sample was taken from one branch consisting of at least 5 leaves from each tree. GPS coordinates are 03013'800 South Latitude, 75065'67 East Longitude.

2.2. Leaf Morphology Identification
Botanists carried out species identification at the Indonesian Institute of Sciences' Center for Biology (LIPI) by matching the leaves with the herbarium collection. After identifying the species at LIPI, the leaf morphology was determined. The method used refers to [11] with some modifications aimed at simplifying the procedure. Finally, the leaf variables were measured and observed:

1. The variables calculated were abbreviated secondary leaf bones (JT) and leaves (JD).
2. Dimensional characters measured included: length of the lamina (PL), length of the petiole (PT), the width of the broadest leaf (LD), and the width of the broadest leaf at the base of the leaf (LP). The calculated dimensional characters and variables can be seen in Figure 1, as well as

![Leaf characteristic measurement](image)

Figure 1. Leaf characteristic measurement

3. Observed variables: The shape of the leaf tip (AS) and the shape of the base of the leaf (BS) were observed with an assessment (1 – 8) based on Figure 2.
4. Calculated Variables
The variables calculated in this study are Leaf area (LS), circumference of the leaf (KL), aspect ratio (AR), form factor (FF), and perimeter ratio of diameter (PR). The following is the formula for each measured variable.

1. Leaf area (LS) is calculated using the formula for the size of the ellipse:
\[ \frac{1}{2} \times 3.14 \times (LD \times PL) \]

2. The circumference of the leaf (KL) is calculated using the formula for the circumference of the ellipse:
\[ \frac{1}{2} \times 3.14 \times (LD + PL) \]

3. Aspect ratio (AR) is the ratio of the length and width of the leaf used to estimate the shape of the leaf blade. If the value is less than 1, the leaf shape is wide. If the value is more than 1, the shape of the strand is elongated. The formula calculates aspect ratio:
\[ \frac{PL}{LD} \]

4. Form factor (FF) describes the leaf's shape and finds out how round the shape of the leaf blade is. The formula calculates the form factor:
\[ \frac{4\pi \times LS}{KL^2} \]

5. Perimeter ratio of diameter (PR) is a feature to measure how oval the leaf is. The formula calculates the perimeter ratio of diameter:
\[ \frac{KL}{LD} \]

2.3. Morphological Analysis
Morphological analysis used 3 different multivariate analyzes, namely Principal Component Analysis (PCA), Biplot, and Manova using SPSS software. Multivariate analysis is one type of statistical analysis used to analyze the data used in the form of many independent variables (independent variables) and many dependent variables (dependent variables). The three analyses distinguish each type's leaves from the measured and calculated characteristics [13]. According [14], multivariate analysis can facilitate complex and correlated data interpretation into more specific data.
3. Results and Discussion

3.1. Leaf Morphological Characteristics
The morphological characteristics of plants are fundamental in identifying species. These characters were observed in the vegetative organs of plants such as leaves, stems, and branches and the generative organs of plants such as flowers and fruits. Generally, what is used to identify a plant species is the leaf part. Leaves are organs in plants that have a central function, where the process of processing food substances for plants is carried out in the leaves called photosynthesis. Leaves have a variety of shapes and sizes so that they can distinguish between plant species. Initial characters that can distinguish leaf samples are by knowing the number of leaf bones, leaf base, leaf tip, leaf length, leaf width, widest leaf width, leaf area and leaf circumference [15].

3.2. PCA (Principal Component Analysis) Analysis
PCA analysis or principal component analysis is a technique used to reduce significant and correlated data dimensions into smaller and independent measurements. This analysis can determine the number of components or factors that must be maintained [16] [17]. PCA was used to analysis relationship between the variables in this study. In Figure 3, the smaller the angle formed between the variables, the stronger their relationship. It can be interpreted that variables that have a strong relationship become the choice to differentiate species. In comparison, the variables with a distant relationship become the primary variable that can distinguish the style.

Based on the study results, Figure 3 shows the diversity that can be explained by the first component of 63% and the second component of 27.5%. Thus, the two components can explain the overall diversity by 90.5%. The variables PR (leaf elongation), PL (lamina length), LP (length of leaf width and width of leaf base) had the most substantial relationship when compared to other variables. Meanwhile, KL (leaf circumference) and LS (leaf area) form the same line showing the same KL and LS data.

3.3. Biplot analysis
Biplot analysis in this study aims to see the most distinguishing characteristics of each type of Shorea studied. In Figure 4, it can be seen that the closer a point is to a variable, the character that most characterizes that point is the closest variable. Figure 1.2 shows the variance that can be explained by the first component of 63% and the second component of 27.5% so that the overall conflict that the two components can explain is 90.5%. The Shorea guiso species has a higher LD (widest leaf width)

![Figure 3](image-url)
Shorea pinanga has different attributes of BS (leaf base shape), Shorea ovalis has distinct characteristics of JT (number of leaf bones), PL (lamina length), PR (perimeter ratio).

**Figure 4.** The relationship between the thirteen variables and the six species of PT Reki meranti based on BIPLOT analysis

In the picture, it can also be seen the relationship between the species symbolized by a point. The closer the point is to other issues, the higher the similarity level. The analysis results showed that S. parvifolia, S. acuminata and S. leprosula had high and medium similarities with other species.

### 3.4. Manova Analisis

The Manova analysis in this study designed to see the characteristics that best characterize the type under investigation. Based on the Manova analysis, a significant value was obtained < 0.005, which means that all the characters tested were different, so it continued to the Duncan test. Therefore, in Table 1, each species has different characteristics from the calculated and measured characteristics.

Based on the results of Duncan's test, the PL character (lamina length) was different for each type of shorea except for Shorea pinanga and Shorea leprosula. The PT character (stalk length) was the same in each species except for Shorea pinanga and Shorea guiso. The LD (leaf width) in Shorea parvifolia and Shorea acuminata had the same value, Shorea sp, Shorea guiso and Shorea ovalis also had the same value, only in different Shorea leprosula. The LP character (widest leaf width at the base of the leaf) in S. parvifolia and S. acuminata had the same value, Shorea pinanga and Shorea acuminata have the same value, while others were different. The BS character (leaf base shape) in all species has the same value except for Shorea pinanga.

The LS character (leaf area) in S. parvipolia and S. acuminata had the same value and Shorea pinanga. And S. guiso have the same value too, the other species are different. The KL character (leaf circumference) in S. parvifolia and S. acuminata had the same value, Shorea pinanga and Shorea acuminata have the same value, while others were different. AR (aspect ratio) character, Shorea pinanga. And S. ovalis have different values, while the others are the same. The characters of FF (form factor), Shorea pinanga and S. guiso have the same value, while the others are different. PR (perimeter ratio of
diameter) character, *Shorea pinanga*. And *S. leprosula* have the same value, while others are different. The same value means that there is a high similarity.

Table 1. Duncan test results on the morphological characters of PT Reki meranti leaves

| Leaf Morphological Character | Type          | Shorea parvifolia | Shorea acuminata | Shorea pinanga | Shorea leprosula | Shorea guiso | Shorea ovalis |
|------------------------------|---------------|-------------------|------------------|----------------|-----------------|--------------|--------------|
| PL                           |               | 9.563 d           | 11.089cd         | 12.043 c       | 12.268 c        | 14.088 b     | 18.088 a     |
| PT                           |               | 0.525 c           | 0.608 c          | 0.863 b        | 0.603 c         | 1.134 a      | 0.496 c      |
| LD                           |               | 3.423 c           | 3.652 c          | 5.323 a        | 4.333 b         | 5.040 a      | 5.245 a      |
| LP                           |               | 4.298 d           | 4.474 d          | 5.700 c        | 5.829 c         | 7.769 b      | 11.227a      |
| JT                           |               | 8.564 e           | 11.145 d         | 11.70 ed       | 15.722 b        | 12.261 c     | 21.241 a     |
| JD                           |               | 5.000 a           | 5.000 a          | 5.000 a        | 4.889 b         | 4.909ab      | 4.446 c      |
| BS                           |               | 3.000 b           | 3.000 b          | 4.000 a        | 3.014 b         | 3.000 b      | 3.000 b      |
| LS                           |               | 53.027d           | 65.904d          | 102.95b        | 86.293c         | 151.62a      | 151.62a      |
| KL                           |               | 53.027d           | 65.904d          | 102.95b        | 86.293c         | 151.62a      | 151.62a      |
| AR                           |               | 2.822 b           | 3.041 b          | 2.263 c        | 2.878 b         | 2.865 b      | 3.510 a      |
| FF                           |               | 0.278 a           | 0.233 b          | 0.133 d        | 0.171 c         | 0.134 d      | 0.0930 e     |
| PR                           |               | 15.014 d          | 17.409cd         | 18.908 c       | 19.261 c        | 22.117 b     | 28.398 a     |

Note: JT (number of bones); JD (number of leaves); PL (lamina length); PT (Stem length); LD (leaf width); LP (length of the widest leaf at the base of the leaf); AS (leaf tip shape); BS (form of leaf base); LS (leaf area); KL (circumference of the leaf); AR (aspect ratio); FF (form factor); PR (perimeter ratio of diameter).

4. Conclusion

Present study concluded that based on the morphological analysis carried out to distinguish the six species of shorea from PT REKI, it can be concluded that the kind of *Shorea guiso* has a higher LD (widest leaf width) characteristic than the other five species. Furthermore, *Shorea pinanga* has different attributes of BS (leaf base shape), *Shorea ovalis* has distinct features of JT (number of leaf bones), PL (lamina length), PR (perimeter ratio). On the other hand, *Shorea parvifolia*, *Shorea acuminata* and *Shorea leprosula* have the same characteristics, namely having a higher FF (form factor). Therefore, it indicates that the three species have rounder leaf shapes.

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