Genetic diversity of black mangrove (*Rhizophora mucronata Lamk.*) based on morphological markers in Maros, Pangkep, and Barru Provenances

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Abstract. Mangrove forests are tropical and subtropical forests that grow typically along the coast or river estuaries. Black mangroves are a type of mangrove found in South Sulawesi, precisely in Maros, Pangkep, and Barru Districts. The decline in black mangrove populations overcomes the threat limit to germplasm which can lead to reduced genetic diversity in black mangrove plants. To reduce the incidence of extinction in black mangroves, information on genetic diversity using one of the markers is required, namely morphological markers in taking samples of tree parts taken, namely the leaves, stems, and roots which are then for monitoring carried out in the Biotechnology Laboratory and tree breeding. The method used in this study is based on the literature on the development of the Tropical Fruit Descriptor information system. The results of the three studies proved that there is a difference between the evidence and the interprovenencies. The very close morphological kinship between them proved to be found in Pangkep. Pangkep's provenance has a high coefficient compared to the proof of Maros and Barru, which is at the time level of 70%, while the proof of Maros has the lowest coefficient compared to the proof of Barru and Pangkep, which is at the gathering level of 64%.

1. Introduction
Mangrove forest is a typical tropical and subtropical forest type, growing along the coast or river estuaries that are influenced by tides. Many mangroves are found in coastal areas that are protected from the onslaught of waves and sloping areas [1]. Mangroves grow optimally in coastal areas that have large river mouths and deltas where the water flow containing a lot of mud [2].

Meanwhile, in coastal areas that do not flow into rivers, the growth of mangrove vegetation is not optimal. Mangroves are difficult to grow in coastal areas that are steep and have large waves with strong tidal currents because these conditions do not allow the deposition of mud needed as a substrate for their growth [3].
The coastal area is a meeting area between land and sea ecosystems, towards the land includes parts of the land both dry and submerged in seawater, and is still influenced by the physical properties of the sea such as tides, waves, and waves, and seawater seepage, while towards the sea includes parts of marine waters that are affected by natural processes occurring on lands such as sedimentation and freshwater flow from rivers as well as those caused by human activities on land such as deforestation, waste disposal, settlement expansion and agricultural intensification [4].

Plant species in mangrove forests respond differently to variations in the physical environment, giving rise to certain vegetation zones. As a depositional area, the substrate on the coast can be very different, the most common being mangroves growing on clay silt mixed with organic matter. However, in some places, this organic matter is in such a large proportion, there is even a mangrove forest that grows on peat soil. Another substrate is mud with a high sand content or even dominant coral debris on beaches adjacent to coral reefs [5].

Black mangrove is a type of mangrove that is used for the rehabilitation of mangrove areas on the west and east coasts of South Sulawesi. One of the reasons why this species is chosen for the rehabilitation of mangrove forests is because the fruit is easy to obtain, easy to sow, and can grow in areas of high tide and low tide. The decline in the black mangrove population due to over-exploitation and conversion of mangrove forests to other uses is a serious threat to this type of germplasm. The drastic population decline will result in a decrease in genetic diversity, which is an early symptom of the extinction of a species. Maros, Pangkep, and Barru regencies are one of the areas in South Sulawesi that still have mangrove forest areas. Efforts to reduce the extinction of mangrove forests have been carried out, both in-situ conservation and ex-situ conservation. However, for these conservation efforts, baseline data should be prepared beforehand. One of them is information on the genetic diversity of mangroves. Therefore we need research on genetic diversity using several markers, one of which is the morphology used in this study.

2. Materials and methods
This research was conducted in Maros, Pangkep, and Barru, South Sulawesi Province. Data analysis was conducted at the Laboratory of Silviculture and Tree Physiology, Faculty of Forestry, Hasanuddin University.

2.1. Data analysis
Data analysis was carried out using the NTSYSpc (Numerical Taxonomy and multivariate analysis system) version 2.0 program by scoring first. Scoring is done by dividing the morphological traits into possible sub-traits. Sub-traits that appear are marked with a value of 1, while those that do not appear are marked with a value of 0 [6].

3. Results and discussion
Na‘iem (2000) [7] suggests that if the level of similarity approaches the value of 1, then these individuals have a very close kinship with others. On the contrary, if it is close to the value of 0, then it has a large diversity.
3.1. Maros provenance
Analysis of the kinship of ten black mangrove trees that were used as research objects in the Maros provenance using the NTSYSpc version 2.0 program obtained a dendogram, as shown in Figure 1.

![Dendrogram of morphological relationships between individuals in Maros Provenance](image)

**Figure 1.** Dendrogram of morphological relationships between individuals in Maros Provenance

The results of the morphological kinship analysis of individuals in the Maros provenance show that in the dendogram, it can be seen that of the ten Maros provenance individuals in the sample, they are divided into four clusters with a coefficient of 0.75. The first cluster consists of individuals MR1 and MR2. The second cluster consisted of individuals MR3, MR4, MR6, MR7, and MR8. The third cluster consists of MR10. The fourth cluster consists of MR5 and MR9. MR10 individuals formed separate clusters, which showed differences in the appearance of their morphological characteristics with other individuals. Compared to other individuals in the Maros provenance, the MR10 individual has a distinctive characteristic of felling of bark texture. For breeding purposes, the MR10 individual has considerable differences from other individuals and has the potential to be used as a source of genetic diversity.

The results of the morphological kinship analysis of the Maros provenance individuals of all clusters formed the same morphological characteristics at a coefficient of 0.64, namely at the level of similarity of 64%. This shows that individuals in the Maros provenance have a distant kinship with others and have a large kinship. Based on the cluster formed on the 0.75 coefficient, it states that the second cluster formed from five individual trees (MR3, MR4, MR6, MR7, and MR8) shows many similarities in morphological characteristics, including elliptical leaf shape, apiculate leaf tip curve, leaf shape the curve of
the base of the leaves is cuneate, the shape of the entire leaf edge, the texture of the bark is sulcatus, the color of the bark is black, the shape of the stem is teres, the straightness of the stem, the diameter of the stem is less than 25 cm, the diameter of the canopy is between 1-7 m, the shape of the canopy is 1-7 m conical canopy, the first branch height is less than 5 m, and the proportion between the first branch height and the total height is less than 30%.

3.2. Pangkep provenance
Analysis of the relationship of ten black mangrove trees that were used as research objects in the Maros provenance using the NTSYSpc version 2.0 program obtained a dendogram as shown in Figure 2.

![Dendrogram](image)

Figure 2. Dendrogram of morphological relationships between individuals in Pangkep Provenance

The results of the morphological kinship analysis of individuals in the Pangkep provenance show that in the dendogram, it can be seen that from the ten individuals of the Pangkep provenance that became the sample, they were divided into three clusters with a coefficient of 0.75. The first cluster consists of individuals PK1 and PK8. The second cluster consists of individuals PK2, PK3, PK4, PK5, PK6, and PK7. The third cluster consists of individuals PK9 and PK10. In the Pangkep provenance, all clusters form the same morphological characteristics at a coefficient of 0.70, namely at the level of similarity of 70%. This shows that individuals in the Pangkep provenance have close kinship with others and have low diversity. Based on the cluster formed on the 0.75 coefficient, it states that the second cluster is formed from six individual trees (PK2, PK3, PK4, PK5, PK6, and PK7), which show many similarities in morphological characteristics, including elliptical leaf shape, apiculate leaf tip curve, the shape of the curve of the base of the leaves is cuneate, the shape of the entire leaf edge, the leaf width is less than 6 cm, the texture of the bark is sulcatus, the shape of the stem is teres, the straightness of the
The stem is straight, the diameter of the canopy ranges from 1-7 m, the shape of the canopy is conical, the first branch height is less than 5 m, the total height is more than 7 m, and the root length is more than 1.5 m.

3.3. Barru provenance
Analysis of the relationship of ten black mangrove trees that were used as research objects in the Maros provenance using the NTSYSpc version 2.0 program obtained a dendrogram describing the relationship between ten black mangrove trees in the Barru provenance as shown in Figure 3.

![Dendrogram](image)

**Figure 3.** Dendrogram of morphological relationships between individuals in the Barru provenance.

The results of the morphological kinship analysis of individuals in the Barru provenance show that in the dendogram, it can be seen that of the ten individuals of the Barru provenance in the sample, they are divided into four clusters at a coefficient level of 0.75. The first cluster consists of individuals BR1, BR2, BR5, and BR10. The second cluster consists of individuals BR3. The third cluster consists of BR4, BR8, and BR9. The fourth cluster consists of individuals BR6 and BR7. BR3 individuals formed separate clusters, which showed differences in the appearance of their morphological characteristics with other individuals. Compared to other individuals in the Barru provenance, individual BR3 has a distinctive characteristic of an opaque surface state.

In the Barru provenance, all clusters form the same morphological characteristics at a coefficient of 0.67, namely at the level of similarity of 67%. This indicates that individuals in the Barru provenance are distantly related to each other and have great diversity.

Based on the clusters formed on the 0.75 coefficient, it states that the first cluster formed from four individual trees (BR1, BR2, BR5, BR10) shows many similarities in morphological characteristics, including elliptical leaf shape, apiculate leaf tip curve, base curve shape. Cuneate leaves, entire leaf
margin, dark green upper surface color, nitidus upper surface condition, leaf width of more than 6 cm, sulcatus bark texture, terraced stem shape, straight stem straightness, canopy diameter was ranging from 1-7 m, conical canopy shape and a total height of more than 7 m. The morphological kinship relationship between individuals of combined provenance can be seen in Figure 4.

Figure 4. Morphological kinship dendrogram between individuals combined

The three provenances above, individuals in the Pangkep provenance have close relatives or come from parents that have relatively the same morphological characters. The close relationship between the various sample trees in the provenance as well as the morphological diversity between the sample trees indicates that the samples were taken from mixing different genetic material from one parent tree with the surrounding parent trees as a result of crossbreeding. In addition to cross-breeding, one of the factors that cause close kinship is the geographical location that is quite close. Mating can be through the medium of the wind or insects. A comparison of morphological and molecular markers was also conducted to determine the utility of molecular markers as a complement to and/or alternative to morphological criteria for varietal distinctness [8–10]. Cross-breeding occurs through the pollination process, especially open pollination and cross-pollination [11]. Based on observations of the morphological characteristics of black mangroves in each provenance, it can be seen that there is morphological diversity between individuals in the provenance. Differences in morphological conditions observed in each tree were generally found in the
leaves, which included color, surface condition, size, bark texture, bark color, trunk diameter, canopy diameter, first branch height, total height, the proportion between first branch height and height. Totals and roots.

4. Conclusion
The conclusion that can be drawn from the overall results of this study is that the morphological characteristics of black mangroves indicate differences between individuals in the provenance and between provenances. Individuals MR10 in the Maros provenance and BR3 in the Barru provenance have different morphological differences from other individuals.

The very close morphological relationship between individuals in the provenance is found in the Pangkep provenance. The Maros and Pangkep provenances have more morphological similarities, while the Barru provenances tend to form separate clusters. MR9 individuals between individuals of combined provenance form separate clusters and have morphological differences from other individuals.

The Pangkep provenance has a high coefficient compared to the Maros and Barru provenances at the level of similarity of 70%, while the Maros provenance has the lowest coefficient compared to the Barru and Pangkep provenances at the similarity level of 64%.

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