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Morphological identification of local raru producing trees from Sibuluan Nauli, Central Tapanuli, North Sumatera

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Abstract. Raru is a local name referring to those of wild tropical trees belonging to the member of *Dipterocarpaceae* family which are targeted by illegal logger for its wood and bark. Raru wood is widely used for buildings and furniture, while its bark is used for medicinal purposes. Raru tree has disjunctive distribution in Sumatera and Kalimantan with different species variations. The high demand on raru wood has led to population decrease in their natural distribution, meaning that conservation is needed for this species. Species identification is the initial step to determine diversity and relatedness among raru species. The objective of this study was to identify the morphological character of local raru trees in Sibuluan Nauli and to determine their phylogenetic relatedness. Morphological identification was conducted by observing and measuring the stem, leaf, canopy, and resin characters. The results of morphological analysis showed that there were variations in morphological characters of local raru tree species. The phylogenetic identification of songal raru, dahanon raru, pulut raru, and jonggi raru showed that songal raru and pulut raru were not closely related, with genetic distance of 0.8473 while the n dahanon raru and jonggi were closely related, with genetic distance of 0.3878.

1. Introduction

Dipterocarpaceae are a family with the largest number of species in the world and are known as producers of quality trading timber, and several species are also known as producers of non-timber products [1]. One non-timber forest product produced by a group of *Dipterocarpaceae* species is raru tree. Raru is the name of bark produced by several species of *Dipterocarpaceae* and used for various purposes in local community [2]. For Bataknese ethnic, the existence of raru trees is closely related to traditional drinks called 'tuak'. According to [3], raru wood has long been used by the Tapanuli community as building material and the decoction of raru leaves is believed to be able to clean and treat open wounds. While the bark is believed to be an antidiabetic drug [4].

The initial survey results in Sibuluan Nauli Village found 4 local raru species that are used by the surrounding community. According to [5], the raru tree identified in North Sumatra Province belongs



to *Vatica* sp and *Cotylelobium* spp. However, according to the information from the farmers in the field, there were 3-4 local raru tree species that are used daily by the community. Raru tree is commonly illegally harvested by the community for its wood and bark which causes its population tend to decline in their natural habitat. The absence of cultivation efforts also contributed to the scarcity of raru in the North Sumatra forests. The IUCN red list has classified raru from *C. melanoxylon* in the least concern status [6], while raru from *C. lanceolatum* is vulnerable [7]. Under this conditions there is a need for species conservation efforts. One of an initial step that can be done is identifying these local species.

Morphological identification is the first step for taxonomists in classifying species. Morphological character identification is an easy and fast method, it can be directly used in plant populations [8]. It can be done by observing organs that appear from trees such as leaves, stem, flower, fruits, canopies, resin and bark [9]. The morphological identification results also reflect the relatedness between species. This study aimed to identify 7 local raru trees in North Sumatra Province based on morphological character observations. The results of this study are expected to fill the gap in information about the confusion of the existence of raru trees, as well as the development of raru in the future.

2. Material and methods

This research was carried out in Sibuluan Village, Pandan District, Central Tapanuli Regency, North Sumatra Province. Sibuluan Nauli village has an area of 2.89 km² or 7.89% of the total area of Pandan Subdistrict [10].

The morphological identification was done descriptively, by observing and measuring the morphological characteristics of the raru trees. The characters included leaf shape, canopy shape, stem shape, stem bark and resin character. Observations of the morphological characters referred to [11]. To identify the colour of leaves and other organs, Munsell Colour for Plant Tissue was used.

Quantitative and qualitative data on observed morphological characters were converted into binary score data and formed into a data matrix using Microsoft Excel program. Data matrix was used to analyse sample grouping based on SAHN (Sequential Agglomerative Hierarchical and Nested Clustering) using UPGMA (Unweighted Pair Group Method Using Average) method with NTSYS PC program to obtain phylogenetic dendrogram. The results were compared descriptively.

3. Results and discussions

According to the results of interview with the community in Sibuluan Nauli Village, there were 4 raru tree species used by the community, those were songal raru, dahanon raru, pulut raru and jonggi raru. The four raru trees were used as flavour enhancers in traditional alcoholic drinks called 'tuak'. The classification of raru trees made by the community was not based on its morphological appearance, but on the *tuak* flavour. Songal raru trees produce white tuak, gives a delicious taste and aroma and has its own uniqueness when it is still fresh, but when added to tuak, it's aroma turns into a fishy odour or in the language of the surrounding community, it is called 'songal'. Dahanon raru trees are the most popular raru trees added to the taste of *tuak* because it does not produce a fishy odour and can produce a white beverage rice like colour or in locally the surrounding community called 'dahanon'. Pulut raru is called "si Arang" due to its reddish colour product like *pulut* (sticky rice). Jonggi raru produces a yellowish colour with a deep sweet taste so that it is called "Jonggi". Beside the differences on flavour, our morphological identification also found variations in its leaves, stems, bark and resin character among local raru tree species.

3.1. Leaf

Raru leaves are often used by local people to differentiate raru tree species. They have different characteristics and become major identifier to differentiate raru species. In general, raru tree has a single leaf composition, alternate leaf layout, and bare leaf buds. The leaf characteristics and differences of local raru species presented in Table 1.

Table 1. Leaf characters of songal raru, dahanon raru, pulut raru, and jonggi raru

No	Leaf Character	Dahanon			
		Songal Raru	Raru	Pulut Raru	Jonggi Raru
1	Leaf Composition	Single	Single	Single	Single
2	Leaf Layout	Alternate	Alternate	Alternate	Alternate
3	Leaf Shape	Oblong	Oblong	Lanceolate	Oblong
4	Leaf Margin	Entire	Entire	Entire	Entire
5	Leaf Apex	Mucronate	Mucronate	Acuminate	Mucronate
6	Leaf Base	Acute	Acute	Acute	Acute
7	Leaf Area	104 cm ²	58 cm ²	31 cm ²	36 cm ²
8	Leaf Bone	Pinnate	Pinnate	Pinnate	Pinnate
9	Bone Leaves Length	21 cm	17 cm	13 cm	11 cm
10	Leaf Surface	Rugose	Grablous	grablous	Grablous
11	Number of Leaf Bones	32	45	58	49
12	Top Surface Colour	4/4 7.5GY	3/6 7.5GY	2/4 10GY	7/6 2.5GY
13	Colour of The Lower Surface	5GY 4/4	5GY 4/3	5GY 4/3	6/6 7.5 GY
14	Leaf Buds	Naked	Naked	Naked	Naked

Among four raru tree species, songal raru has wider leaf size (Figure 1a). The vein pattern found on the abaxial surface of songal raru leaf is more visible and easier to distinguish because it protruding (Figure 3a). When the adaxial surface of the leaf is touched, songal raru leaf has a slightly rough texture, with slightly visible vein pattern and smooth texture (Figures 1b, 1c, 1d).

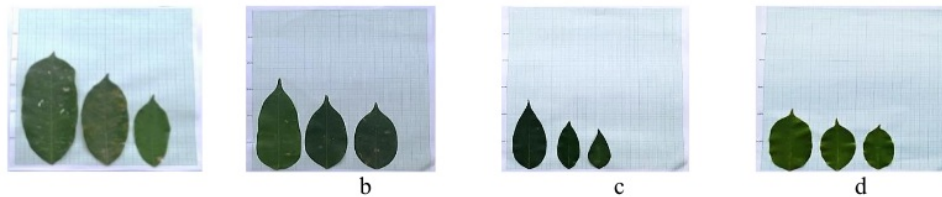


Figure 1. The shape of the adaxial surface of songal raru leaves (a), dahanon raru leaves (b), pulut raru leaves (c), jonggi raru leaves (d)

Similar to the adaxial surface of their leaves, the abaxial surface of dahanon leaves, pulut leaves and jonggi leaves have vein patterns that are less protruding than that of songal raru leaf (Figure 2b, 2c, 2d). When crushed, songal raru leaves will produce a fragrant aroma, while the other raru leaves do not. Dahanon raru leaf has the darkest leaf colour character, while jonggi leaf has the lightest leaf colour character.

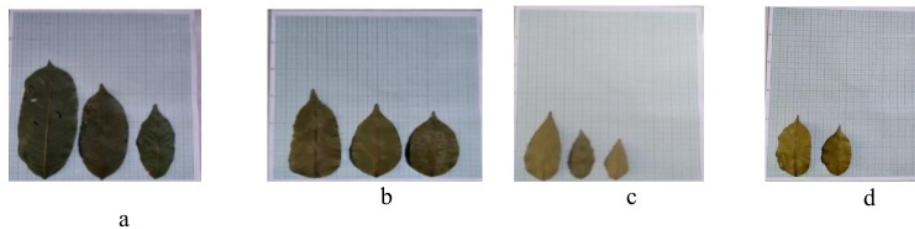


Figure 2. The shape of the abaxial leaf surface of songal raru leaves (a), dahanon raru leaves (b), pulut raru leaves (c), and jonggi raru leaves (c)

3.2. Stem

Local raru tree species has cylindrical stem, monopodial branch architecture and continuous stem characters. Songal raru tree has different bark characteristics compared to the other raru tree species i.e. its bark thickness. Songal raru bark is thicker and rougher than the other raru tree species (Table 2).

Table 2. Stem character of songal raru, dahanon raru, pulut raru and jonggi raru trees

Characteristic	Songal Raru	Dahanon Raru	Pulut Raru	Jonggi Raru
Stem Shape	cylindrical	Cylindrical	Cylindrical	Cylindrical
Outer Bark Colour	6/4 2,5Y	6/4 5YR	5/2 5Y	4/4 10YR
Bark Cork Colour	6/8 7.5 Y	7/6 10 YR	8/6 2.5 YR	8/6 7.5 YR
Bark Cork Cambium Colour	6/8 7.5 YR	8/6 2.5 Y	8/6 2.5 Y	8/6 7.5 YR
Bark Thickness	0.6 cm	0.3 cm	0.3 cm	0.3 cm
Wood Colour	7/8 5YR	9/3 10 YR	7/6 7.5YR	8/8 10YR
Branch Architecture	monopodial	Monopodial	Monopodial	Monopodial
Branch Structure	orthotropic	Orthotropic	Orthotropic	Orthotropic
Stem Character	continuous	Continuous	Continuous	Continuous
Bark Rough	rough	Smooth	Smooth	Smooth

According to [12], the bark of raru was added to *tuak* to increase the flavour of *tuak*. Beside increasing the tuak flavours, raru bark is also believed to have antidiabetic compounds [13], so local people consume raru bark for diabetes medicines. However, not all bark of raru are used for tuak mixture.

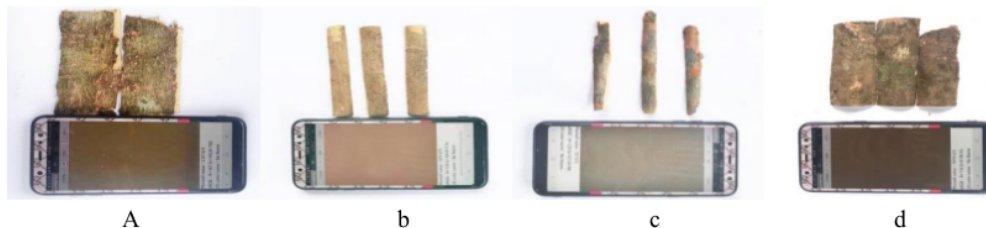


Figure 3. The outer bark colour of songal raru tree (a), dahanon raru tree (b), pulut raru tree (c), and jonggi raru tree (d)

The observations showed that raru trees had different cork tissue characteristics. Differences in the cork tissue characteristics were found in colour, thickness, and flavour which could affect the quality of tuak. Dahanon raru tree is the most preferable species in the market. It has bright cork tissue and produces a white *tuak*. Pulut raru tree has a reddish cork tissue, so it can produce a reddish *tuak*. Songal raru tree has a distinctive aroma with bright cork tissue colour, so it produces white drink. However, when mixed with wine, the flavour produced by the songal raru bark will turn to be unpleasant. Jonggi raru bark has a slightly brownish cork tissue and produces a yellowish beverage so that it is less desirable by the community.

The colour of raru wood is dominantly yellow to brownish. The yellow colour is found in wood of dahanon raru tree (Figure 6b) while the brownish yellow colour is found in pulut raru wood (Figure 6c) and jonggi raru wood (Figure 6d). Slightly different from the other raru trees, songal raru wood is reddish (Figure 6a). According to [14], raru has brownish yellow wood with no distinctive borders between sapwood and terrace. The texture of fine wood is straight and it has beautiful fibre direction. Harvesting the bark by means of debarking will cause the trees barkless (Figure 7). This harvesting technique has caused disrupted growth of the trees and generally leading to tree death.



Figure 4. The inner bark colour of songal raru tree (a), dahanon raru tree (b), pulut raru tree (c), and jonggi raru tree (d)



Figure 5. Cork cambium colour of songal raru tree (a), dahanon raru tree (b), pulut raru tree (c) and jonggi raru tree (d)



Figure 6. The wood colour of songal raru (a), dahanon raru (b), pulut raru (c), and jonggi raru (d)

Raru wood were rarely used by local people because they thought that the bark was more profitable. Moreover, raru wood was quite heavy which made it difficult to be transported easily from forest to villages. Even though it is known to have high durability and strength [14], difficulties in its transportation process has made them less attractive. According to [15] *Cotylelobium lanceolatum* Pierre has a specific gravity of 1.01 and durability class I while *Cotylelobium melanoxyton* Pierre has a specific gravity of 0.99 with durability class II.



Figure 7. Raru wood being left after debarking

3.3. Resin

Each raru resin produced by different raru trees has distinctive odour. Songal raru resin has a stronger odour compared to the other raru tree species. Differences in the characteristics of songal resin also

exist in its colour and hardness (Table 3). Songal raru resin tends to be white and soft (Figure 8a) while the other raru resin tends to be yellow to clear orange with hard crystal.

Table 3. Characteristics of raru resin

Characteristics	Songal Raru	Dahanon Raru	Pulut Raru	Jonggi Raru
Resin colour	N9	8/8 2.5Y	6/12 5 YR	8/8 2.5Y
Aromatic Resin	Yes	Yes	Yes	Yes
Resin Type	Mushy	Hard Crystallized	Hard Crystallized	Hard Crystallized
Resin Flow	Clot	Clot	Clot	Clot



Figure 8. The resin of songal raru tree (a), dahanon raru tree (b), pulut raru tree (c), and jonggi raru tree (d)

3.4. Phylogeny based on morphological characters

Based on the morphological characteristics, raru trees were divided into 2 clades. The first clade consisted of solely songal raru, whereas the second clade consisted of dahanon raru, pulut raru and jonggi raru trees (Figure 9). Songal raru trees showed a clear difference from the others with a coefficient index of 0.6931. Jonggi raru and dahanon raru trees formed one small group with a genetic distance of 0.3878.

Table 4. Raru tree's genetic identity and distance

pop ID	Songal Raru	Dahanon Raru	Pulut Raru	Jonggi Raru
Songal Raru	****			
Dahanon Raru	0.6931	****		
Pulut Raru	0.8473	0.4418	****	
Jonggi Raru	0.6931	0.3878	0.5596	****

Broad genetic variability is one of the requirements for an effective breeding program. According to [16], the availability of genetic resources or germplasm with considerable genetic variability and accurate genetic information is one of the essential factors in plant breeding programs. In addition to genetic variability in plant phenotypes also plays an important role in tree breeding programs to obtain superior trees [17].

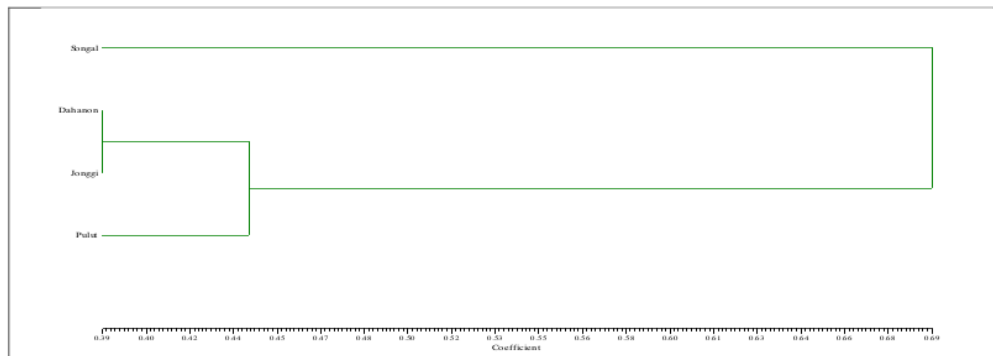


Figure 9. Phylogeny of Raru trees based on their morphological characteristics

4. Conclusion

There are 4 (four) local raru tree species in Sibuluan Nauli village, namely songal raru, dahanon raru, pulut raru and jonggi raru trees. All raru trees showed almost similar morphological characteristics except songal raru which was rather distinctive than the others. Songal raru showed different characteristics in their bark, leaves and resin. Phylogenetic analysis showed that dahanon raru trees and jonggi raru trees had the closest relatedness with genetic distance of 0.3878, while the furthest relatedness was found in songal raru trees and pulut raru with genetic distance value of 0.8473.

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