

# The Taxonomy of Selected Economic Timber Species in Benue State, Nigeria: A Phylogenetic Approach to Sustainable Forest Utilization for the Prediction of Species Traits and Responses

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DOI: <https://doi.org/10.30880/jsunr.2026.07.01.001>

## Article Info

Received: 1 October 2025

Accepted: 9 June 2026

Available online: 30 June 2026

## Keywords

Genetic, taxonomy, RAPD,  
conservation, economic, variation,  
morphological

## Abstract

Illegal falling of economic trees in Benue State has led to destruction of ecosystems and habitats of rare species and possible extinction of many trees. The aim of this study was to investigate the taxonomy of economic trees in Benue State and trace phylogenetic relationships for conservation purposes. Random selection of four tree species located at Joseph Sarwuan Tarka University, Makurdi (JOSTUM) were investigated: *Bombax ceiba*, *Adansonia digitata*, *Ceiba pentandra*, and *Syzygium cumini*. Morphological variation and genetic diversity of each sample were evaluated using Random Amplified Polymorphic DNA (RAPD) markers. Phylogenetic trees to elucidate evolutionary relationships among these species were constructed. Morphological assessments focused on key traits such as leaf shape, flower structure, and fruit characteristics, revealing distinct variations that correlate with species identification. Molecular analysis using RAPD markers yielded informative genetic profiles, demonstrating significant polymorphism across the studied taxa. The constructed phylogenetic tree illustrates the genetic relationships, highlighting evolutionary patterns and divergence among the studied species. Overall, this study provides valuable insights into the morphological and genetic diversity of these economically and ecologically important plants, contributing to their conservation and utilization strategies.

## 1. Introduction

The clarity of taxonomic information is crucial for effective conservation and sustainable utilization of plant resources. Every day more than one in three of the world's trees are in danger of extinction according to a new report by the International Union for Conservation of Nature (IUCN), [1]. Economic trees are mostly impacted by anthropogenic activities and face an increasing risk of extinction. Myrtaceae and Malvaceae species includes trees with outstanding economic and ecological importance in Nigeria. They comprise of some abundant and dominant tree species in many tropical forests in Africa. Myrtaceae or the myrtle family is made up of at least 140 genera and about 3800 to 5650 species [2]. Notable trees genera in Myrtaceae include; *Psidium*, *Eugenia*, *Syzygium* and *Feijoa*. Malvaceae or the mallow family consist of 243 genera, notable genera include; Baobabs (*Adansonia*) and Kapok (*Ceiba*) and *Bombax* [3]. Despite recent efforts to clarify the phylogeny of Malvaceae, uncertainty remains,

especially in regard to inter-generic relationships in some species [4]. The lack of a well resolved phylogenetic framework hampers development of a coherent tribal classification and investigation of the tempo and mode of evolution in Malvaceae, which is crucial for understanding the diversification of the group. The family Malvaceae play vital roles in every respective ecosystem and holding cultural significance for many indigenous communities. For example, "kon u genger" is a kind of soup primarily made from dried petals of *Bombax costatum* tree, "Agbada" is a kind of soup made from matured unripe fruits from Kapok tree (*Ceiba pentandra*). *Syzygium cumini* is recognized as a medicinal edible fruit, utilized for timber and fuelwood in most parts of the state.

Generally, the taxonomy of Malvaceae has been resolved which comprises of four traditional families namely; Malvaceae, Bombacaceae, Sterculiaceae and Tiliaceae forming a natural grouping, [5]. The family Myrtaceae remains unresolved due to insufficient and inconsistent morphological data, limited molecular phylogenetic studies, and unclear species boundaries [6]. This taxonomic ambiguity poses challenges for the identification, conservation, and utilization of these plants. Therefore, a comprehensive taxonomic study is essential to clarify the classification, phylogenetic relationships, and species delineation within the Myrtaceae family. Such research will enhance better understanding of biodiversity of species in our ecological region (Guinea Savanna), support conservation efforts, and promote their sustainable use. This study provides essential taxonomic data to support conservation efforts needed in making informed sustainable management practices.

The use of the PCR based molecular technique Random Amplified Polymorphic DNA (RAPD) for identification of genetic variation in plants is cost effective and produces simple and reliable data which depends solely on short, arbitrary 10mer primers to amplify random segments of the DNA. Compared to other techniques like ISSR, AFLP and SSR, RAPD method is quick with simple protocols but has poor reproducibility and yield dormant markers [7]. Unlike the inter-simple sequence repeat (ISSR) which uses a longer primer (16-25 bp) based on microsatellites, RAPD is best for sampling unidentified samples, the difference is that ISSR is slightly higher in terms of reproducibility. The Amplified Fragment Length Polymorphism (AFLP) method is quite sophisticated compared to RAPD and produces a higher band and reproducibility in this case combining restriction enzyme digestion with PCR. Suitable for identification of closely related species with fine-scale variation [8]. The Simple Sequence Repeats (SSR) are mostly used for mapping and breeding because of the ability to distinguish homozygotes and heterozygotes which RAPD cannot, they are also highly reproducible. RAPD is likely an option especially when funds are limited and the research involves the use of small number of samples, it also provides a convenient source of inexpensive primers and obtaining a simple, fast protocols that can be used for any organism [9].

The aim of this study was to investigate the taxonomy of economic trees in Benue State and trace phylogenetic relationship for conservation purpose. Specific objectives were to determine the macro-morphological variations in selected economic trees. This study also aims to evaluate the molecular variation of economic trees (*Bombax ceiba*, *Adansonia digitata*, *Ceiba pentandra*) using RAPD markers and demonstrate evolutionary relationship by constructing a phylogenetic tree (dendrogram) using both morphological and molecular characteristics as delimiting characters for the sole purpose of predicting species trait and response.

## 2. Materials and Methods

### 2.1 Study Area

Makurdi (7°43'50"N 8°32'10"E) is the capital of the Benue State of Nigeria (Figure 1), located 104 meters above sea level with around 500,797 inhabitants [10]. The city is located in central Nigeria along the Benue River. The state is predominantly an agricultural catchment area specializing in cash crops, subsistence crops and a variety of potentials in human, capital and material resources and a veritable source of raw materials for processing plants and manufacturing industries.

The study was conducted in Joseph Sarwuan Tarka University, Makurdi comprising the South Core and North Core campuses. Species in both Malvaceae and Myrtaceae family were identified and collected using methods by Baum [11] and Hutchinson [12].

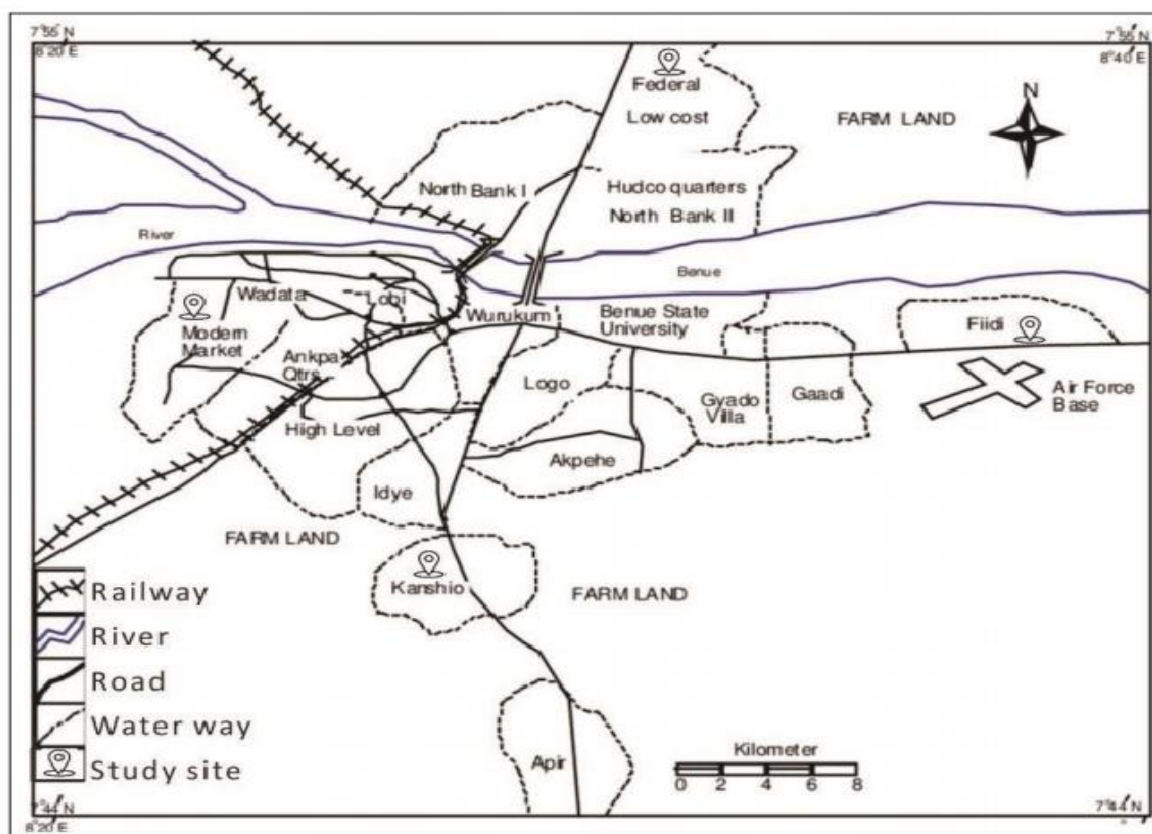
### 2.2 Sample Collection

Specimens from Malvaceae and Myrtaceae were collected from different locations within the study site. GPS coordinates and altitude data were recorded for each collection site. Standard herbarium practices were followed for the collection including pressing, drying, and preservation of the plant specimens [14].

### 2.3 Morphological Identification

Morphological characters were meticulously examined allowing for a detailed morphological characteristic. The process involved scrutinizing various aspects of morphological characteristics such as leaf shape, size, venation pattern, floral morphology, and fruit characteristics. For instance, when studying leaf shape, different types like

ovate, lanceolate, or elliptical were carefully distinguished to understand the diversity within the plant species. Moreover, the measurements of vegetative parts were meticulously recorded to create a comprehensive dataset. This included using digital caliper for precise measurements, ensuring accuracy in the data collected. The methodology followed during the analysis was in line with the standards set by Armitage et al. [15], guaranteeing reliability and consistency in the results obtained. By employing a systematic approach, the study aimed to provide a thorough understanding of the morphological variations of species in Malvaceae and Myrtaceae family.



**Fig. 1** Map of Makurdi metropolis, indicating the study site (Source: Ministry of Land and Survey, Makurdi [13])

## 2.4 DNA Extraction

Plant DNA was extracted from freshly harvested plant leaf using Edward's protocol [16]. 200  $\mu$ l of Edwards buffer was added to 50 – 100 mg of plant leaf tissue in a 1.5 ml microcentrifuge tube. The tissue was manually crushed for 5 minutes using a plastic pestle. An additional 300  $\mu$ l of Edwards buffer was added and the crushing continued for another 5 minutes. The volume was adjusted to 1000  $\mu$ l by adding 500  $\mu$ l of Edwards buffer. The sample was vortexed for 15 seconds and incubated at 100°C for 10 minutes. The sample was centrifuged at 2000 rpm for 10 minutes in a microcentrifuge. 500  $\mu$ l of the supernatant was transferred to a new 1.5 ml microcentrifuge tube and centrifuged again at 2000 rpm for 10 minutes, transferring 400  $\mu$ l of the supernatant to another new 1.5 ml microcentrifuge tube. 400  $\mu$ l of ice-cold isopropanol was added to the supernatant and the sample was gently inverted 5 times, incubating at room temperature for 10 minutes. The sample was centrifuged at 12,000 rpm for 10 minutes, the supernatant was discarded, and 500  $\mu$ l of 70% ethanol was added to the pellet without disturbing it. The sample was inverted 5 times and the ethanol was discarded, repeating the wash step. The pellet was air-dried for 10 minutes and re-suspend in 50  $\mu$ l of TE buffer.

## 2.5 PCR Setup

The components of the PCR setup consist of SOLIS BIODYNE FIREPol Master Mix ready-to-load reagent, which was used for the PCR reaction with 4  $\mu$ l volume at final concentration of 1 $\times$ . Forward and reverse primer (10 pmol/ $\mu$ l) was at 0.20  $\mu$ l volume with final concentration at 0.1  $\mu$ M. While DNA Template used was at 5.00  $\mu$ l with final concentration at 25 ng/ $\mu$ l. Distilled water was added up to 20  $\mu$ l with 10.60  $\mu$ l volume [17]. The initial

denaturation was at 95°C for 5 minutes at for one cycle, while the main denaturation duration was for 40 s repeated for 40 cycles at 95°C. Annealing temperature ranged from 38 - 45°C for 60 s. Initial extension period as for 2 minutes at 72°C, while the final extension duration was for 5 minutes at a constant temperature of 72°C [18]. Following the PCR amplification, sequencing was carried out using an automated DNA sequencer to determine the nucleotide sequence of the amplified DNA fragments. This sequencing step is crucial in molecular analysis as it provides detailed information about the genetic make-up of the sampled plant species. RAPD marker (OPA-04) was used, which produced AATCGGGCTG base sequence at 42.7 °C.

## 2.6 Gel Electrophoresis

A 50ml solution of 1x TBE was prepared and 0.75g of agarose gel was added. The mixture was heated in the microwave on high for 1 minute to melt the gel. Ethidium bromide was added to a final concentration of 1:20,000 (3 ul). The solution was allowed to cool before being poured into a casting tray. Once set, the gel was transferred to a gel tank and covered with 1x TBE buffer. Amplification products (15 ul aliquots) were loaded into the wells, and the gel was run at 100V for 30 minutes. The resulting bands were visualized under UV light using a gel documentation system [18]. PyElph was used to analysis the banding pattern of the various RAPD markers and the resulting dendrogram [18].

## 2.7 Data Analysis

Morphological data were analysed using statistical software (IBM SPSS Statistics 25). Descriptive statistics, including mean, and standard deviation were calculated. The significance of differences in sample was determined using Analysis of Variance (ANOVA).

## 3. Result

Four studied tree species (*Bombax custatum*, *Ceiba pentandra*, *Adansonia digitata*, and *Syzygiun cumini*) which were both cultural and economically important commonly found in Benue State, Nigeria are outlined in Table 1. The trees species were found growing on Joseph Sarwuan Tarka University Makurdi (JOSTUM) campuses. Coordinates were inventoried along with relevant cultural and spatial information. Families of studied plants were categorised into two namely; Malvaceae and Myrtaceae. Native and common names of plants were inventoried for easy identification. The native names were selected based on the most populous ethnicity in the state especially dominant in Tiv and Idoma languages.

**Table 1** General classification of studied species, common name, location and geographical location

| Species                   | Family    | Common name | Native Name<br>(Tiv/Idoma) | Coordinate          |
|---------------------------|-----------|-------------|----------------------------|---------------------|
| <i>Bombax custatum</i>    | Malvaceae | Bombax tree | Genger                     | 7°46'25"N 8°37'19"E |
| <i>Ceiba pentandra</i>    | Malvaceae | Kapok tree  | Akpu/Ogwu                  | 7°46'25"N 8°37'2"E  |
| <i>Adansonia digitata</i> | Malvaceae | Boab tree   | Vambe                      | 7°47'52"N 8°36'52"E |
| <i>Syzygiun cumini</i>    | Myrtaceae | Plum tree   | Huru/Udu                   | 7°46'25"N 8°37'20"E |

The quantitative macro-morphological measurements of leaflets in the studied tree species with values given as mean  $\pm$  standard deviation (Table 2). The results obtained revealed that *Bombax ceiba* had the largest leaflet dimensions (12.10 $\pm$ 1.98), followed by *Syzygiun cumini* (11.20 $\pm$ 1.92), *Adansonia digitata* (7.25 $\pm$ 1.9) and *Ceiba pentandra* (6.00 $\pm$ 1.00) which exhibited the smallest. Leaflet width followed a similar pattern as *Bombax ceiba* had the widest leaflet dimensions (5.86 $\pm$ 1.06), followed by *Syzygiun cumini* (4.10 $\pm$ 1.14). *Adansonia digitata* (2.28 $\pm$ 0.62) and *Ceiba pentandra* (1.50 $\pm$ 0.35) which had the smallest. Additionally, Leaflet area showed variation as *Bombax ceiba* (72.00 $\pm$ 22.07) was determined the highest, followed by *Syzygiun cumini* (47.50 $\pm$ 21.74), *Adansonia digitata* (17.37 $\pm$ 8.11) and the least in *Ceiba pentandra* (9.20 $\pm$ 3.37). Also, *Syzygiun cumini* (34.50 $\pm$ 0.00) had the highest lamina values compared to the others such as *Ceiba pentandra* (29.50 $\pm$ 0.00), *Adansonia digitata* (25.50 $\pm$ 0.00), and *Bombax ceiba* (23.50 $\pm$ 0.00) respectively.

**Table 2** Quantitative macro-morphological characteristics of studied species in the Malvaceae and Myrtaceae family. Data is showing mean  $\pm$  standard deviation.

| Species                   | Leaflet length   | Leaflet width   | Leaflet Area      | Lamina           |
|---------------------------|------------------|-----------------|-------------------|------------------|
| <i>Bombax ceiba</i>       | 12.10 $\pm$ 1.98 | 5.86 $\pm$ 1.06 | 72.00 $\pm$ 22.07 | 23.50 $\pm$ 0.00 |
| <i>Adansonia digitata</i> | 7.25 $\pm$ 1.91  | 2.28 $\pm$ 0.62 | 17.37 $\pm$ 8.11  | 25.50 $\pm$ 0.00 |
| <i>Ceiba pentandra</i>    | 6.00 $\pm$ 1.00  | 1.50 $\pm$ 0.35 | 9.20 $\pm$ 3.37   | 29.50 $\pm$ 0.00 |
| <i>Syzygiun cumini</i>    | 11.20 $\pm$ 1.92 | 4.10 $\pm$ 1.14 | 47.50 $\pm$ 21.74 | 34.50 $\pm$ 0.00 |

The qualitative macro-morphological description of studied species in the Malvaceae and Myrtaceae families, focusing on their leaflet shape, apex, base, and fruit type are presented in Table 3. Among the Malvaceae species *Bombax ceiba* has leaflet shape digitately compound, with long acuminate apex, acute to obtuse base and an ellipsoidal capsule fruit. *Adansonia digitata* have a palmately compound leaflet with an acute apex, cordate base and a woody capsuled fruit. *Ceiba pentandra* leaf is palmately compound with a long acuminate leaflet apex, cuneate base and a pulp-like interior seed. The representative species in the Myrtaceae, *Syzygiun cumini* has leaflet shape ellipsoidal with blunt tapering apex, ovate base and drupe fruit type.

**Table 3** Qualitative morphological description of studied species in the Malvaceae and Myrtaceae family

| Species                   | Leaflet Shape       | Leaflet Apex                 | Leaflet Base    | Fruit Type                   |
|---------------------------|---------------------|------------------------------|-----------------|------------------------------|
| <i>Bombax ceiba</i>       | Digitately compound | Long acuminate               | Acute to obtuse | Ellipsoidal capsule          |
| <i>Adansonia digitata</i> | Palmately compound  | Acute                        | Cordate         | Woody capsule                |
| <i>Ceiba pentandra</i>    | Palmately compound  | Long acuminate               | Cuneate         | Pulp-like interior with seed |
| <i>Syzygiun cumini</i>    | Elliptic oblong     | Blunt at tapering to a point | Ovate           | A drupe                      |

The continuation of qualitative macro-morphological characteristics of studied tree species, focusing on specific features of each plant's reproductive and vegetative parts are in Table 4. The results present variable qualitative characters for each species represented in each family. In the Malvaceae species (*Bombax ceiba*, *Adansonia digitata*, *Ceiba pentandra*) fruit colour ranges from dark brown in *B. ceiba*, greenish to brown in *A. digitata* and yellowish green in *C. pentandra*. Leaf arrangement palmately compound in *B. ceiba* and *A. digitata*, with variance in *C. pentandra*. Venation varied from unicostate reticulate in *B. ceiba*, Ciliate in *A. digitata* and reticulate in *C. pentandra*. Leaflet texture also varies from Leathery smooth in *B. ceiba*, Moderate protein content in *A. digitata*, Thick and wide spreading in *C. pentandra*. Floral characteristics such as petal shape and sepal shapes showed variation in the Malvaceae family as petal shape ranges from having long petioles in *B. ceiba*, obovate long in *A. digitata*, and rough in *C. pentandra*. Sepal shape ranges from Calyx cup shape in *B. ceiba*, and *A. digitata*, cylindrical in *C. pentandra*. In the Myrtaceae family (*Syzygiun cumini*) fruit colour ranges from deep purple to blueish, with opposite leaflet arrangement, pinnate venation and thick shiny and leathery texture, petal shape oval, sepal round shaped.

**Table 4** Qualitative morphological description of species in the Malvaceae and Myrtaceae family

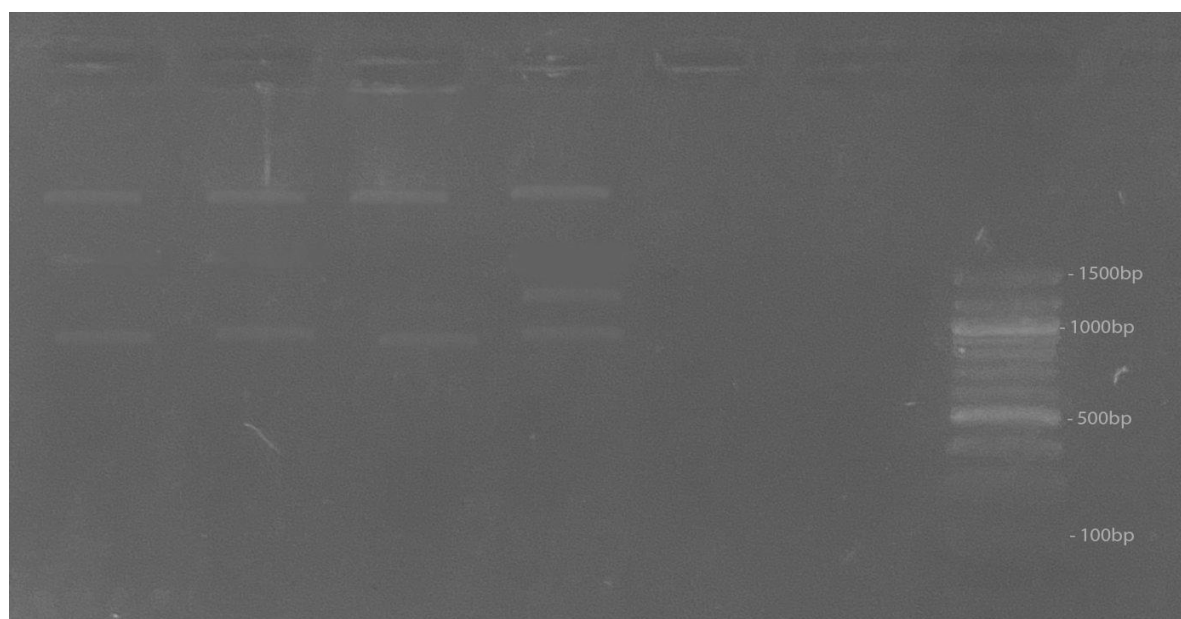
| Species                   | Fruit Colour                | Leaf Arrangement   | Venation              | Leaf Texture             | Petal Shape   | Sepal Shape     |
|---------------------------|-----------------------------|--------------------|-----------------------|--------------------------|---------------|-----------------|
| <i>Bombax ceiba</i>       | Dark brown                  | Palmate shape      | Unicostate reticulate | Leathery smooth          | Long petioles | Calyx cup shape |
| <i>Adansonia digitata</i> | Greenish to brown           | Palmately compound | Ciliate               | Moderate protein content | Obovate long  | Calyx cup shape |
| <i>Ceiba pentandra</i>    | Yellowish to green          | Alternate          | Reticulate venation   | Thick and wide spreading | Roughly       | Cylindrical     |
| <i>Syzygiun cumini</i>    | Deep purple or bluish black | Oppositely         | Pinnate venation      | Thick shiny and leathery | Oval          | Round           |

The comparative overview of floral morphology and reproductive characteristics of pollen and seed across the four studied tree species are in Table 5. The table is a continuation of the macro-morphological characteristics of species studied in the Malvaceae and Myrtaceae. In the Malvaceae species sepal colour ranges from red in *Bombax ceiba*, white in *Adansonia digitata* and brown in *Ceiba pentandra*. Petal colour ranges from red to orange in *Bombax ceiba*, white or roses in *Adansonia digitata* and white in *Ceiba pentandra*. Inflorescence type varies from multifoliate in *Bombax ceiba*, axillary fascicle in *Adansonia digitata* and single flower in the axis of the leaf in *Ceiba pentandra*. The number of seeds ranges from 21000 to 45000 *Bombax ceiba*, 10,000 to 45,000 in *Adansonia digitata* and 10 to 15 seeds in *Ceiba pentandra*. Also, pollen dispersal agents vary in species in the family Malvaceae, in *Bombax ceiba* mainly by Bees, Birds & Bats, in *Adansonia digitata* by Bats and in *Ceiba pentandra* by Wind, water, animal & insect. The morphology of the pollen produced varies as it is shown to impact on the kinds of agents of pollination that aids dispersal, thus, pollen shape varied from sub-oblato to spheroidal in *Bombax ceiba*, per oblato in shape in *Adansonia digitata* and bean shape with smooth texture in *Ceiba pentandra*.

**Table 5** Qualitative morphological description of species in the Malvaceae and Myrtaceae family

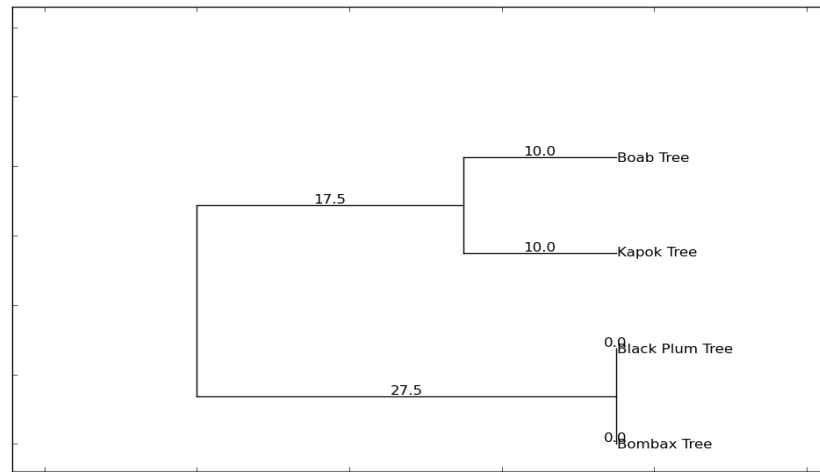
| Species                   | Sepal colour | Petal colour          | Inflorescence type                    | Number of seeds  | Pollen dispersal             | Pollen shape                     |
|---------------------------|--------------|-----------------------|---------------------------------------|------------------|------------------------------|----------------------------------|
| <i>Bombax ceiba</i>       | Red          | Red to orange         | Multifoliate                          | 21,000 to 45,000 | Bees, Birds & Bats           | Sub-oblato to spheroidal         |
| <i>Adansonia digitata</i> | White        | White or roses colour | Axillary fascicle                     | 10,000 to 45,000 | Bats                         | Per-oblato in shape              |
| <i>Ceiba pentandra</i>    | Brown        | White                 | Single flower in the axis of the leaf | 10 to 15 seeds   | Wind, water, animal & insect | Bean shape with smooth texture.  |
| <i>Syzygiun cumini</i>    | Greenish     | Purple                | Short                                 | 20 seeds         | Wind                         | Round, triangular disc in shape. |

The banding patterns of plant species studied using RAPD and OPA-04 marker can be observed in Figure 2. The image showed banding patterns with molecular weight marker on the left with bands labelled at 100 bp, 500 bp, 1000 bp and 1500 bp respectively.



**Fig. 2** Banding patterns with molecular weight marker on the left with bands labelled at 100 bp, 500 bp, 1000 bp and 1500bp respectively

A phylogenetic tree diagram was constructed to illustrate the evolutionary relationships among studied tree species represented as Boab (*Adansonia digitata*), Kapok (*Ceiba pentandra*), Black Plum (*Syzygium cumini*), and Bombax (*Bombax ceiba*) (Figure 3). The tree structure uses horizontal lines and branching points to indicate the relative genetic distances or evolutionary divergence between species. The photograph of studied species presents species in their natural habitat are showed in Figure 4 – 7.



**Fig. 3** Shows the dendrogram of four economic trees in Benue State: Baobab (*Adansonia digitata*), Kapok (*Ceiba pentandra*), Black plum (*Syzygium cumini*) and Bombax (*Bombax ceiba*), each branching points indicates the relative genetic distances or evolutionary divergence between studied species



**Fig. 4** Black plum (*Syzygium cumini*)



**Fig. 5** Baobab tree (*Adansonia digitata*)



**Fig. 6** Bombax tree (*Bombax ceiba*)



**Fig. 7** Kapok tree (*Ceiba pentandra*)

## 4. Discussion

This study focused on the determination of macro-morphological and molecular variations in the leaf of selected economic trees belonging to Malvaceae and Myrtaceae. Observed variation in morphological features such as leaflet length, width, area and lamina showcased ecological plasticity while data obtained from molecular analysis using RAPD marker (OPA-04) displayed unique genetic divergence during phylogenetic characterization [19]. Both vegetative and reproductive characters provided useful information on relationships and diversity of species. The evaluation of both morphological and molecular data from economic trees such as *Bombax ceiba*, *Adansonia digitata*, *Ceiba pentandra* using RAPD markers demonstrated the importance of using integrated statistical interpretation tools for evolutionary studies as affirmed by Jian-Hua [20]. The use of molecular markers (OPA-04) tends to be simple and quick providing insight into species identification and diversity as obtained from the results from this study. The dendrogram constructed in this study confirmed the relevance of combining morphological features and RAPD markers thereby producing two distinctive clusters. The first cluster contain Baobab and Kapok species, while the second cluster contain the Black plum and *Bombax* species respectively.

In terms of the variation in the morphology of leaflets, *Bombax ceiba* exhibited the largest leaflet area (72.00 cm<sup>2</sup>), indicating its potential for greater photosynthetic capacity and energy absorption. In contrast, *Ceiba pentandra* which possessed the smallest leaflet area (9.20 cm<sup>2</sup>), suggests adaptations suited for its specific environment [21]. This significant difference in leaflet size could reflect variations in habitat preferences and resource allocation among the species. The genetic analysis reveals that the Baobab and Kapok trees are more closely related, sharing a short branch length of 10.0, while the black Plum and Red Silk-Cotton trees diverge at a distance of 0.0, hinting at a direct lineage connection. The major split between these pairs occurs at a longer distance of 27.5, emphasizing greater genetic divergence and evolutionary paths among these groups [22].

Additionally, the qualitative morphological traits summarized in the tables highlight the distinctive characteristics of these species. The leaf and fruit features observed are critical for identifying the species and understanding their ecological interactions. For example, the diverse shapes of leaflets and fruit types suggest various adaptations to attract pollinators or facilitate seed dispersal. Such traits are essential for their survival and reproductive success in their respective habitats [23]. The combination of morphological and genetic data not only enhances our understanding of these species' biodiversity but also aids in their conservation and sustainable use. This study utilized a variety of taxonomic methodologies, including morphometric assessments and molecular procedures, to demarcate species boundaries and unravel evolutionary affinities. Moreover, the study carries implications for comprehending the ecological roles played by members of Malvaceae in their respective ecosystems [23]. For instance, the distinctive capacity of baobabs to store water is a significant adaptation to arid regions, while the dispersal mechanisms employed by other species contribute to forest rejuvenation and the preservation of biodiversity in tropical zones [24].

The studied species play critical roles in the ecosystems, such as providing resources for both humans and wildlife. *Bombax ceiba*, *Adansonia digitata*, *Ceiba pentandra*, and *Syzygium cumini* are not only nutritionally and culturally significant but also provide essential ecological services such as habitat for wildlife and soil stabilization [24]. However, these benefits are countered by threats like habitat loss, over-harvesting, and in some cases, invasive spread. If current pressures continue, there is a risk of losing valuable genetic species and ecological resources especially studied trees inherent to this area.

## 5. Conclusion

The protective management of *Bombax ceiba*, *Adansonia digitata*, *Ceiba pentandra*, and *Syzygium cumini* requires integrated efforts by researchers and local dwellers to balance ecological, economic, and social needs. Sustainable practices and conservation strategies can help maintain the populations of trees in a particular ecosystem and ensure their benefits for future generations. On the improvement of local biodiversity, effective management practices such as education and controlled utilization of products can ensure that the species provide benefits without harming native ecosystems, the knowledge of diversity and taxonomic relationship can help a better understanding of conservation priorities and strategies.

## Acknowledgement

The communication of this research was made possible through the support of the following contributors: Okpara, O.P and Ngbede, W. The research was self-funded by both authors.

## Conflict of Interest

Authors declare that there is no conflict of interest regarding the publication of the paper.

## Author Contribution

The authors confirm the contribution to the paper as follows: **study conception and design:** Okpara Onyinyechi Priscilla, **data collection:** Ngbede W., **analysis and interpretation of results:** Okpara O. P, draft **manuscript preparation:** Okpara O.P and Ngbede W. All authors reviewed the results and approved the final version of the manuscript.

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