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Morphological Diversity and Phenetic Relationships Among *Araceae* Species in Lauru I Afulu Village, Indonesia

Nofamataro Zebua[a*] | Ite Morina Yostianti Tnunay[b]

[a]Department of Biology Education, Faculty of Teacher and Training Education, Universitas Nias, Gunungsitoli, Indonesia
[b]Department of Biology, Faculty of Agriculture, Science, and Health, Universitas Timor, Timor Tengah Utara, Indonesia

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Corresponding Author:
Author Name: Nofamataro Zebua
Email: zebuanofa99@gmail.com

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Abstract: Many rural communities have utilized *Araceae* plants for food, medicine, and ornamental purposes, yet scientific documentation of their diversity and relationships remains limited. This study aimed to analyze the morphological diversity and phenetic relationships among Araceae species in Lauru I Afulu Village, Indonesia. The research was conducted using a descriptive qualitative approach through field observations, interviews, and documentation, with species identified based on morphological characteristics. Data were analyzed using data reduction, classification, and comparative interpretation of morphological traits. The results showed that several genera of *Araceae* were identified, including *Alocasia, Colocasia, Homalomena, Caladium, Aglaonema,* and *Schismatoglottis*, exhibiting distinct variations in leaf shape, stem structure, and tuber characteristics. Species within the same genus demonstrated higher morphological similarity, indicating closer phenetic relationships, while intergeneric differences were more pronounced. A significant finding revealed a strong association between morphological traits and local utilization patterns. These findings highlight the importance of morphological analysis in understanding plant diversity and emphasize the value of integrating local knowledge with scientific approaches for biodiversity documentation and sustainable utilization.

Keywords: *Araceae*, morphological diversity, phenetic relationships, plant taxonomy

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Introduction

Indonesia is recognized as one of the countries with the highest levels of biodiversity in the world, particularly within tropical ecosystems that support the growth of diverse plant species (Harnowo et al., 2021; Rahman et al., 2024). Its geographical conditions and tropical climate enable the development of a wide range of flora with significant morphological variation. This diversity reflects variations at genetic, species, and ecosystem levels that interact within a given environment (Stange et al., 2021). In this context, the Araceae family represents a group of plants with wide distribution and distinctive morphological characteristics in tropical regions.

The Araceae family is known as a group of herbaceous plants characterized by the presence of spadix and spathe inflorescences and a high adaptability to moist environments (Croat & Ortiz, 2020). These plants hold ecological and economic value as they are utilized as food sources, traditional medicine, and ornamental plants by local communities. In addition, several Araceae species such as Colocasia esculenta have long been recognized as alternative carbohydrate sources in various regions of Southeast Asia (Ahmed et al., 2020). However, such utilization has not always been accompanied by scientific understanding of their diversity and phylogenetic relationships.

Scientifically, the study of plant diversity does not only focus on species identification but also on the analysis of relationships among species based on specific characteristics. One commonly used approach is phenetic analysis, which groups organisms based on morphological similarities (Maharachchikumbura et al., 2021). This approach is essential for understanding patterns of similarity and variation among species within a plant community. Therefore, morphological analysis serves as a fundamental basis in plant taxonomy and systematics.

Nevertheless, in practice, there remains a gap between ideal conditions and field realities, particularly in rural areas. Previous findings indicate that communities in certain regions have not fully recognized the diversity of Araceae species or their scientific classification. This condition is also observed in Lauru I Afulu Village, where plant utilization remains largely traditional and lacks adequate scientific documentation. As a result, the potential diversity and phylogenetic information of these species have not been systematically identified.

Previous studies have examined the diversity of Araceae in several regions, such as Hartati (2020), who identified multiple Araceae species in Palangka Raya using purposive sampling methods. Another study by Li et al. (2025) explored phenetic relationships among several Araceae species, although it was limited by a relatively small number of species. Additionally, Sinha & Borkataky (2025) focused more on the economic potential of Araceae as ornamental plants without in-depth analysis of their morphological relationships. These limitations indicate that previous studies have not yet integrated aspects of diversity, phylogenetic relationships, and utilization into a comprehensive analytical framework.

From a methodological perspective, most previous studies have relied on descriptive approaches without employing more in-depth quantitative analyses of morphological traits (Fleischmann et al., 2021; Rodriguez & Storer, 2020). This has led to interpretations of phylogenetic relationships that tend to be subjective and less measurable. Furthermore, the limited geographic scope of prior research has resulted in insufficient representation of Araceae diversity across different regions of Indonesia. Therefore, there is a need for research that combines field observations with systematic morphological analysis to produce more accurate and reliable data.

Based on the above considerations, an important question arises regarding the level of morphological diversity and phenetic relationships among Araceae species in Lauru I Afulu Village, Indonesia. Can the observed morphological characteristics reveal clear patterns of relationships among species within a local habitat? How can the community's utilization of these plants be linked to their diversity and species composition? This study is expected to contribute scientifically to a more comprehensive understanding of Araceae diversity and relationships, as well as to serve as a foundation for further research in taxonomy and biodiversity.

Methods

Research design and study area

This study was designed to examine the morphological diversity and phenetic relationships of Araceae species in Lauru I Afulu Village, North Nias Regency, Indonesia. A descriptive approach with a qualitative research design was employed to explore plant morphological characteristics. The study site was selected purposively based on the abundance of Araceae populations in the area. Data collection was conducted during the period from October to December 2025.

Study objects and sampling technique

The research objects consisted of all Araceae species found within the study area. Samples were determined using purposive sampling by selecting plant individuals that represented existing morphological variations. Each species encountered was identified based on observable morphological traits, including leaf shape, stem structure, root type, and characteristics of flowers and tubers. Species identification was carried out using plant identification keys and relevant taxonomic references.

Data collection methods

Data were collected through field observation, interviews, and documentation. Direct observation was conducted to examine the morphological characteristics of Araceae species in their natural habitats. Interviews were conducted with local community members to obtain information regarding plant utilization as food, traditional medicine, and ornamental plants. Documentation was performed using a digital camera to record the morphological features of each identified species as supporting data.

Research instruments

The instruments used in this study included observation sheets, interview guidelines, writing tools, and a digital camera. Observation sheets were used to systematically record morphological characteristics of each species. Interview guidelines ensured consistency in data collection from respondents. All collected data were compiled and organized for further analysis.

Data analysis techniques

Data were analyzed using qualitative analysis techniques, which included data reduction, data presentation, and conclusion drawing. Data reduction was performed by simplifying and categorizing morphological data based on shared characteristics. Data presentation was carried out in the form of tables and narrative descriptions to facilitate interpretation. Conclusions were drawn by identifying patterns of similarity and differences among species.

Phenetic relationship analysis

Phenetic relationships among species were analyzed based on the degree of similarity in observed morphological traits. The collected morphological data were compared across species to determine levels of similarity. A higher number of shared characteristics indicated a closer phenetic relationship. This analysis was conducted descriptively, referring to the principles of numerical taxonomy, although no advanced quantitative statistical calculations were applied.

Determination Key of Diversity and Phylogenetic Relationships Among Species of the Family Araceae Based on Morphology in Desa Lauru I Afulu is as follows:

1. a. Compound leaves...1a
   b. Simple leaves ....
2. a. Having compound inflorescence........................2a
   b. Having diverse types of flowers ....
3. a. Stem has nodes..3b
   b. Stem has no nodes ....
4. a. Having petiole...4a
   b. Without petiole ....
5. a. Solid stem (not hollow).....................................5a
   b. Hollow stem ....
6. a. Plant without a true stem...................................6a
   b. Plant with a true stem ....
7. a. Flowering plant...7a
   b. Non-flowering plant ....
8. a. Leaf apex pointed...8a
   b. Leaf apex not pointed ....
9. a. Stem without spines 9a
   b. Stem with spines ....
10. a. Herbaceous stem 10a
    b. Non-herbaceous stem ....
11. a. Fibrous root system...11a
    b. Taproot system ....
12. a. Herbaceous habitus 12a
    b. Tree habitus ....

The sequence of the determination key for diversity and phylogenetic relationships among species of the family Araceae based on morphology in Desa Lauru I Afulu is: 1a, 2a, 3b, 4a, 5a, 6a, 7a, 8a, 9a, 10a, 11a, 12a.

Data validity and presentation

To ensure data validity, triangulation of sources and methods was conducted. Observational data were compared with interview results and documentation to ensure consistency. Verification was also performed by comparing species identification results with relevant scientific literature. The analyzed data were then presented systematically in descriptive form to provide a comprehensive understanding of the morphological diversity and phenetic relationships of Araceae species in the study area.

Result

The study documented the presence of multiple Araceae species in Lauru I Afulu Village, which were distributed across different microhabitats such as moist soils, riverbanks, home gardens, and shaded forest edges. Based on field observations and identification procedures, the recorded taxa represented several genera, including Alocasia, Colocasia, Homalomena, Caladium, Aglaonema, and Schismatoglottis. The observed species exhibited clear morphological variation, particularly in leaf shape, venation patterns, stem structure, and tuber characteristics. These variations formed the primary basis for grouping species and assessing their phenetic relationships.

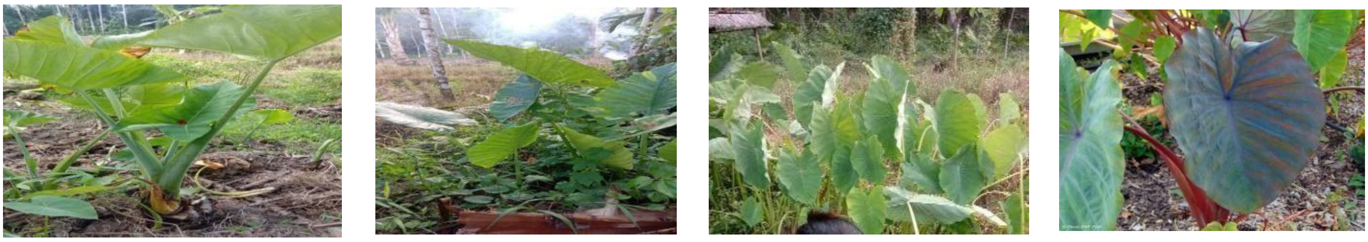
The morphological assessment showed that leaf characteristics were the most distinguishing features among species, including variations in shape (sagittate, cordate, peltate), color patterns, and surface texture. Stem and tuber traits also contributed to differentiation, particularly in identifying species used as food sources, such as Colocasia esculenta, which exhibited well-developed underground storage organs. In contrast, ornamental species such as Caladium bicolor and Aglaonema crispum showed more diverse leaf coloration and patterning. These findings indicated that morphological traits were consistent and sufficient for distinguishing species within the Araceae family in the study area.

Based on the similarity of morphological characters, species were grouped into phenetic clusters reflecting their degree of relatedness. Species within the same genus, such as Alocasia macrorrhizos and Alocasia cucullata, showed high similarity in leaf structure and growth habit, indicating a close phenetic relationship. Similarly, species within the genus Homalomena shared common features such as cordate leaves and aromatic tissues, supporting their grouping. In contrast, intergeneric comparisons revealed lower similarity, particularly between food crop species and ornamental taxa. To summarize the main findings, the identified species and their primary characteristics are presented in Table 1.

Table 1. Summary of Identified Araceae Species and Key Morphological Traits

Genus	Representative Species	Key Morphological Traits	Main Utilization
Alocasia	*A. macrorrhizos, A. cucullata*	Sagittate leaves, erect stems, fibrous roots	Food, ornamental
Colocasia	*C. esculenta, C. sangria*	Peltate leaves, tuberous roots, waxy surfaces	Food
Homalomena	*H. sp., H. occulata*	Cordate leaves, aromatic tissues	Medicinal
Caladium	*C. bicolor*	Variegated leaves, thin stems	Ornamental
Aglaonema	*A. crispum*	Broad leaves, patterned coloration	Ornamental
Schismatoglottis	*S. calyprata*	Lanceolate leaves, moist habitat adaptation	Ornamental, medicinal

The phenetic relationship pattern observed in this study can be conceptually illustrated as a clustering structure based on morphological similarity. Species within the same genus formed closely related clusters, while species from different genera were more distantly related. This pattern supports the reliability of morphological characters in identifying relationships at the genus level, although finer distinctions at the species level may require additional data.

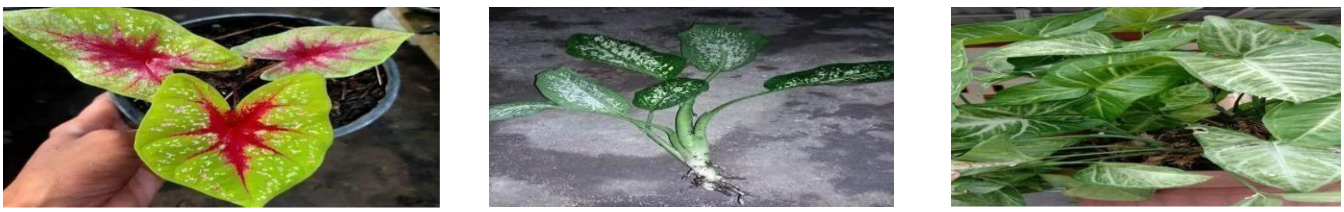


a **b** **c** **d**

Figure 1. Types of *Araceae* Plants That Can Be Used as Food; (a) *Alocasia marcorrizhos*; (b) *Alocasia culculata*; (c) *Colacasia esculenta*; (d) *Colacasia sangria*

a **b** **c**

Figure 2. Plants of the *Araceae* family as ingredients in traditional medicine; (a) *Homolomena meggie*; (b) *Homolomena occullta*; (c) *Homolomena sp.*



a **b** **c**

Figure 3. Species of the *Araceae* Family as Ornamental Plants; (a) *Coladium bicolar*; (b) *Aglaonema crispum*; (c) *Schismatoglottis calyprata*

In general, the findings indicated that the Araceae species in Lauru I Afulu Village exhibited moderate to high morphological diversity, with clear grouping patterns based on shared traits. The integration of observational data and local knowledge also revealed that species utilization (food, medicinal, ornamental) was closely related to their morphological characteristics. These results provided a concise yet comprehensive overview of species diversity and phenetic relationships, without requiring extensive quantitative analysis.

Discussion

The findings of this study confirmed that morphological characters played a central role in distinguishing species and identifying phenetic relationships within the Araceae family. The observed variation in leaf morphology, stem structure, and underground organs aligned with the fundamental principles of plant taxonomy, where morphological traits were widely used to classify and group plant species (Shepeleva et al., 2020). The clustering of species based on shared characteristics supported the concept of phenetic relationships, which emphasized overall similarity rather than evolutionary lineage (Burbrink et al., 2022). Thus, the results were consistent with the theoretical framework that morphological similarity could effectively reflect taxonomic proximity at the genus level.

The dominance of leaf morphology as a key distinguishing trait in this study was also in agreement with previous findings. Leaf shape, venation, and coloration have been widely reported as reliable taxonomic markers in Araceae due to their high variability and ecological adaptability (Croat & Ortiz, 2020; Pimenta et al., 2025). The clear grouping of Alocasia and Colocasia species based on shared vegetative traits further reinforced this perspective. However, it was also observed that some species exhibited overlapping morphological features, which could potentially lead to misidentification if not supported by additional data, as noted in previous studies (Cardini et al., 2021).

An interesting and somewhat unexpected finding was the strong alignment between morphological traits and local utilization patterns. Species with well-developed tubers, such as Colocasia esculenta, were consistently used as food sources, while species with visually attractive leaves, such as Caladium bicolor and Aglaonema crispum, were predominantly cultivated as ornamental plants. This pattern suggested that morphological characteristics not only influenced taxonomic classification but also shaped human perception and utilization of plant resources. Similar observations have been reported in ethnobotanical studies, where plant morphology influenced local knowledge systems and usage (Arjona-García et al., 2021).

Despite these consistencies, differences were noted when comparing this study with previous research. For instance, Arjona-García et al. (2021) reported a higher number of Araceae species in a different ecological setting, which may have been influenced by broader sampling coverage and habitat variation. In contrast, this study identified a more limited number of species, reflecting the specific ecological conditions of Lauru I Afulu Village. Additionally, Polihito (2022) applied a more focused approach to phenetic relationships but involved fewer species, whereas the present study integrated diversity and utilization aspects within a single framework. These differences highlighted the importance of spatial scale and research design in biodiversity studies.

From a methodological perspective, the reliance on descriptive morphological analysis provided a clear and accessible understanding of species diversity and relationships. However, this approach also presented limitations, particularly in resolving finer-scale relationships among closely related species. Previous studies have suggested that integrating molecular data with morphological analysis could significantly improve the accuracy of phylogenetic interpretation (Keating et al., 2023). Therefore, while the current findings were valid within the scope of phenetic analysis, they should be interpreted with caution when extended to evolutionary relationships.

The position of this study within the broader field of plant taxonomy and biodiversity research can be seen as a localized but meaningful contribution. The documentation of Araceae diversity in Lauru I Afulu Village added empirical data from a relatively underreported region, thereby enriching the overall understanding of tropical plant diversity in Indonesia. Although the findings were context-specific, the observed patterns of morphological variation and utilization could be generalized to similar tropical rural ecosystems, where environmental conditions and cultural practices share common characteristics.

Based on the limitations and contributions of this study, several recommendations can be proposed for future research. First, the inclusion of quantitative methods such as cluster analysis or similarity indices would strengthen the objectivity of phenetic relationship assessment. Second, the integration of molecular approaches, such as DNA barcoding, would provide deeper insights into phylogenetic relationships beyond morphological similarity. Third, expanding the study area and increasing sample size would improve the representativeness of biodiversity data. Overall, this study opened opportunities for further interdisciplinary research combining taxonomy, ecology, and ethnobotany to achieve a more comprehensive understanding of plant diversity.

Conclusion

This study highlights the importance of integrating morphological observation with local ecological knowledge to better understand plant diversity and species relationships in underexplored tropical areas. The findings emphasize that even simple, field-based approaches can provide meaningful insights when applied systematically and contextually. At the same time, the study underlines the need for methodological refinement, particularly through the inclusion of quantitative and molecular techniques, to strengthen future analyses. Overall, the research reinforces the value of localized biodiversity documentation as a foundation for broader scientific understanding, conservation efforts, and sustainable utilization of plant resources.

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