

# Morphological Similarity Analysis of *Inga* sp. Mill in Bedugul Area, Bali with Reference *Inga* Species

Arendra Ariantoni<sup>a,1,\*</sup>

<sup>a</sup> Agricultural Biotechnology Study Program, Faculty of Agriculture, Udayana University, P.B. Sudirman Street, Denpasar, Bali, 80235, Indonesia

<sup>1</sup> [ariantoni.24001@student.unud.ac.id](mailto:ariantoni.24001@student.unud.ac.id)

\* corresponding author: [ariantoni.24001@student.unud.ac.id](mailto:ariantoni.24001@student.unud.ac.id)

## ABSTRACT

### Article history

Received  
Revised  
Accepted

### Keywords

*Inga*, comparative morphology, Bedugul, species identification, Fabaceae

The genus *Inga* (Fabaceae) represents a taxonomically complex group with over 300 Neotropical species exhibiting high morphological similarity. A population of *Inga* from Bedugul, Bali, Indonesia was systematically analyzed to determine its morphological affinity with five reference species: *I. edulis*, *I. feuillei*, *I. spectabilis*, *I. oerstediana*, and *I. vera*. Five diagnostic morphological parameters were examined: leaflet morphology, extrafloral nectary structure, rachis wing development, inflorescence characteristics, and fruit morphology. Field observations and measurements were conducted using standard botanical methods, with quantitative data obtained through digital calipers and qualitative characters described following established taxonomic conventions. Comparative analysis revealed that the Bedugul specimen shows strongest overall morphological correspondence with *I. feuillei*, particularly in rachis morphology, fruit form, and inflorescence structure, with secondary similarities to *I. vera*. However, extensive character overlap among closely related species indicates that morphology-based identification alone cannot provide definitive species determination. Given the documented limitations of vegetative characters in delimiting species within *Inga*, molecular phylogenetic analysis using chloroplast and nuclear markers is strongly recommended to confirm taxonomic identity and clarify evolutionary relationships.

This is an open access article under the [CC-BY-SA](https://creativecommons.org/licenses/by-sa/4.0/) license.



## 1. Introduction

The genus *Inga* Mill. (Fabaceae) represents one of the most diverse tree genera in tropical America, comprising over 300 species distributed across the Neotropics [1], [3]. Members of this genus are readily identified by their paripinnate leaves, extrafloral nectaries positioned along the rachis, inflorescences with numerous elongated stamens, and elongated leguminous fruits [1]. Within the evolutionary framework of Leguminosae, *Inga* belongs to the tribe Ingeae, whose phylogenetic relationships have been extensively examined through both morphological and molecular approaches [2], [5].

Despite taxonomic coverage in classical monographs, species identification within *Inga* remains challenging. Many taxa exhibit similar vegetative structures, particularly in leaflet morphology, rachis configuration, and overall leaf architecture. Reliable identification requires careful examination of both vegetative and reproductive structures, including nectary position, rachis development, inflorescence form, and fruit characteristics [1]. These diagnostic features often show subtle variation that determines species boundaries.

Species such as *Inga edulis*, *Inga feuillei*, *Inga spectabilis*, *Inga oerstediana*, and *Inga vera* are frequently encountered in floristic and systematic literature due to their morphological similarity and wide recognition [1], [3]. Phylogenetic studies of Ingeae have revealed complex relationships among species, emphasizing the need for detailed morphological documentation alongside molecular evidence [2], [5], [10].

In the Bedugul highlands of Bali, Indonesia, a population of *Inga* has been observed growing under montane tropical conditions. However, its morphological features have not been systematically compared with established reference species. Given the documented morphological variation within the genus [1], a structured comparative assessment is necessary to determine its taxonomic position. This study therefore aims to describe the vegetative and reproductive morphology of this Bedugul specimen and compare its diagnostic characters with five reference species through table-based morphological analysis.

## 2. Method

### 2.1. Study Site and Plant Material

Field observations were conducted in Bedugul, Bali, Indonesia, an upland tropical region characterized by moderate temperatures and relatively high humidity. Mature *Inga* individuals displaying complete vegetative and reproductive structures were selected to ensure comprehensive examination of diagnostic features.

### 2.2. Morphological Assessment

A descriptive comparative approach was employed. Morphological data from the Bedugul specimen were obtained through direct field observation, measurement, and photographic documentation. Qualitative characters such as leaflet apex and base form, rachis wing development, nectary position, and inflorescence structure were described following standard botanical terminology [9].

### 2.3. Selection of Diagnostic Parameters

Five morphological parameters were selected based on their established taxonomic value within *Inga* [1], [3]: (1) leaf morphology, (2) extrafloral nectary characteristics, (3) rachis structure, (4) inflorescence type, and (5) fruit morphology. These characters are consistently used in species delimitation within Ingeae and provide the foundation for comparative taxonomy in this genus.

### 2.4. Comparative Framework

Morphological descriptions of five reference species (*I. edulis*, *I. feuillei*, *I. spectabilis*, *I. oerstediana*, and *I. vera*) were compiled from authoritative taxonomic literature [1], [3] and verified against specimens documented in major herbaria databases. While numerical taxonomy and multivariate methods are widely employed in systematic research [6], [7], [8], this study focused on qualitative comparison through direct evaluation of morphological correspondence. All observations were organized into a comparative table presenting the five parameters across six taxa. Taxonomic interpretation was based on character congruence between the Bedugul specimen and each reference species, with particular emphasis on features recognized as diagnostic in classical treatments [1].

## 3. Results and Discussion

### 3.1. Morphological Documentation of Observed and Reference Species

Comparative assessment was conducted between the Bedugul *Inga* specimen and five reference species. Reference data were compiled from Plants of the World Online (Royal Botanic Gardens, Kew) and Tropicos (Missouri Botanical Garden) and presented below [1], [3].



**Fig. 1.** Morphological documentation of *Inga* sp. specimen collected from the Bedugul area, Bali.



**Fig. 2.** Reference morphology of *Inga edulis* obtained from Plants of the World Online (Royal Botanic Gardens, Kew) and Tropicos (Missouri Botanical Garden).



**Fig. 3.** Reference morphology of *Inga feuillei* obtained from Plants of the World Online (Royal Botanic Gardens, Kew) and Tropicos (Missouri Botanical Garden).



**Fig. 4.** Reference morphology of *Inga spectabilis* obtained from Plants of the World Online (Royal Botanic Gardens, Kew) and Tropicos (Missouri Botanical Garden).



**Fig. 5.** Reference morphology of *Inga oerstediana* obtained from Plants of the World Online (Royal Botanic Gardens, Kew) and Tropicos (Missouri Botanical Garden).



**Fig. 6.** Reference morphology of *Inga vera* obtained from Plants of the World Online (Royal Botanic Gardens, Kew) and Tropicos (Missouri Botanical Garden)

The comparison focused on five diagnostic parameters selected for their utility in species delimitation within *Inga*.

**Table 1.** Comparative Morphological Characters

| Parameter           | <i>Inga</i> sp.<br>Bedugul   | <i>Inga</i><br><i>edulis</i> | <i>Inga</i><br><i>feuillei</i> | <i>Inga</i><br><i>spectabilis</i> | <i>Inga</i><br><i>oerstediana</i> | <i>Inga</i><br><i>vera</i> |
|---------------------|------------------------------|------------------------------|--------------------------------|-----------------------------------|-----------------------------------|----------------------------|
| Leaflet shape       | Elliptic–oblong              | Broad elliptic               | Elliptic                       | Broad, large                      | Elliptic                          | Elliptic–oblong            |
| Leaflet size        | Moderate                     | Large                        | Moderate                       | Large                             | Moderate                          | Moderate                   |
| Extrafloral nectary | Moderate                     | Prominent                    | Moderate                       | Present                           | Present                           | Moderate                   |
| Rachis wing         | Slight–moderate              | Strongly winged              | Slight                         | Winged                            | Slight                            | Moderate                   |
| Inflorescence       | Brush-like, moderate         | Dense                        | Brush-like                     | Robust, large                     | Moderate                          | Brush-like                 |
| Fruit               | Elongated, moderately curved | Long, strongly curved        | Elongated, curved              | Thick, large                      | Medium                            | Elongated                  |

- Leaflet Morphology

The Bedugul specimen exhibits elliptic to oblong leaflets of moderate dimensions. This configuration overlaps substantially with *I. feuillei*, *I. vera*, and *I. oerstediana*. The specimen differs from *I. spectabilis*, which typically displays larger, more robust leaflets, and shows slight variation from *I. edulis*, whose leaflets are generally broader. The closest morphological correspondence occurs with *I. feuillei* and *I. vera*.

- Extrafloral Nectary Structure

Moderately developed extrafloral nectaries are present between leaflet pairs in the Bedugul specimen. This condition aligns with descriptions of *I. feuillei* and *I. vera*, though it is less pronounced than the prominent nectaries characteristic of *I. edulis*. Given the limited interspecific variation in this feature, it provides supporting rather than definitive evidence for identification.

- Rachis Morphology

The rachis shows slight to moderate wing development, contrasting with the strongly winged rachis of *I. edulis* and the more conspicuous wings in *I. spectabilis*. This morphology resembles the slight wing structure described for *I. feuillei* and *I. oerstediana*, effectively narrowing the range of potential affinities.

- Inflorescence Structure

The brush-like inflorescence with moderate floral density lacks the robust, large-scale clusters observed in *I. spectabilis*. Its configuration is consistent with *I. feuillei* and *I. vera*, both of which display similar proportions. The overall floral architecture shows strongest resemblance to *I. feuillei*.

- Fruit Morphology

Fruits are elongated and moderately curved, less massive than those of *I. spectabilis* and without the exaggerated curvature typical of *I. edulis*. The morphology falls within the descriptive range of *I. feuillei* while partially overlapping with *I. vera*. Among all parameters examined, fruit characteristics provide particularly informative comparative data.

### 3.2. Discussion

- Morphological Affinities and Species Delimitation

The comparative analysis reveals substantial morphological similarity between the Bedugul specimen and several reference species, particularly *I. feuillei* and *I. vera*. No single parameter independently resolves species identity; rather, taxonomic interpretation emerges from cumulative character assessment. This pattern aligns with previous observations that species boundaries within *Inga* are often difficult to establish using vegetative morphology alone [1].

The genus is characterized by extensive overlap in leaflet shape, rachis structure, and nectary morphology, which complicates species-level identification. Phylogenetic investigations have further demonstrated that vegetative characters within *Inga* may exhibit convergence and parallel evolution, particularly in response to ecological adaptation [10], [11]. Consequently, morphological similarity does not necessarily indicate close evolutionary relationships.

- Vegetative Character Overlap and Phenotypic Variation

Many vegetative traits in the Bedugul specimen fall within the morphological range described for multiple species. Leaflet dimensions and form, in particular, show broad overlap among *I. feuillei*, *I. vera*, and *I. oerstediana*—a pattern repeatedly documented in Neotropical taxonomic treatments.

Environmental conditions may also influence morphological expression. The highland climate of Bedugul, with its distinctive temperature regime, humidity levels, and soil characteristics, could contribute to phenotypic variation in introduced or cultivated populations. Morphological plasticity in response to ecological conditions has been reported in several Fabaceae taxa, including members of *Inga* [11], [12].

- Limitations of Morphology-Based Identification

While qualitative morphology remains fundamental in plant taxonomy, it has inherent limitations in genera characterized by high species richness and structural similarity. With more than 300 species distributed across the Neotropics, many *Inga* species display only subtle morphological differentiation.

Molecular phylogenetic studies using chloroplast and nuclear markers have revealed that morphologically similar *Inga* species may belong to distinct evolutionary lineages, while morphologically variable populations sometimes represent a single species [10], [11]. These findings emphasize the importance of integrating molecular data into species delimitation frameworks, particularly in taxonomically complex groups.

- Taxonomic Interpretation

Based on the five morphological parameters examined, the Bedugul specimen shows strongest overall resemblance to *I. feuillei*, particularly in rachis morphology, fruit form, and inflorescence structure. However, overlap with *I. vera* and certain similarities with other taxa indicate that morphology alone does not provide unequivocal resolution.

Considering the documented complexity of species boundaries in *Inga*, molecular analysis is strongly recommended to clarify phylogenetic placement. Chloroplast regions such as *matK* and *rbcL*, along with nuclear ITS sequences, have proven effective in legume systematics [2], [10] and would provide complementary evidence to the morphological assessment presented here.”

### 4. Conclusion

Morphological analysis of the Bedugul *Inga* specimen with five reference species indicates closest overall similarity to *I. feuillei*. However, overlapping vegetative characters among closely related species limit definitive identification based solely on morphological data. Given the taxonomic complexity within this genus, molecular phylogenetic analysis is recommended to confirm species identity and elucidate evolutionary relationships.

### References

- [1] T. D. Pennington, *The Genus Inga: Botany, Flora Neotropica Monograph 63*. New York: The New York Botanical Garden, 1997.
- [2] M. F. Wojciechowski, M. Lavin, and M. J. Sanderson, "A phylogeny of legumes (Leguminosae) based on analysis of the plastid matK gene," *American Journal of Botany*, vol. 91, pp. 1846–1862, 2004.
- [3] T. D. Pennington and E. C. M. Fernandes, "The genus *Inga*," in *Legumes of the World*, G. Lewis, B. Schrire, B. Mackinder, and M. Lock, Eds. Kew: Royal Botanic Gardens, 2005, pp. 203–213.
- [4] R. T. Pennington and C. E. Hughes, "The remarkable congruence of New and Old World savanna origins," *New Phytologist*, vol. 204, pp. 4–6, 2014.
- [5] C. E. Hughes et al., "Phylogeny of Ingeae (Leguminosae): patterns of diversification," *Systematic Botany*, vol. 28, pp. 705–722, 2003.
- [6] R. R. Sokal and P. H. A. Sneath, *Principles of Numerical Taxonomy*. San Francisco: W.H. Freeman, 1963.
- [7] P. H. A. Sneath and R. R. Sokal, *Numerical Taxonomy: The Principles and Practice of Numerical Classification*. San Francisco: W.H. Freeman, 1973.
- [8] F. J. Rohlf, *NTSYSpc: Numerical Taxonomy and Multivariate Analysis System*. New York: Exeter Publishing, 2000.
- [9] W. T. Stearn, *Botanical Latin*, 4th ed. Portland: Timber Press, 1992.
- [10] J. E. Richardson et al., "Rapid diversification of a species-rich genus of Neotropical rain forest trees," *Science*, vol. 293, pp. 2242–2245, 2001.
- [11] T. A. Kursar et al., "The evolution of antiherbivore defenses and their contribution to species coexistence in the tropical tree genus *Inga*," *Proceedings of the National Academy of Sciences*, vol. 106, pp. 18073–18078, 2009.
- [12] B. A. Roy et al., "Increasing leaf vein density facilitates greater leaf hydraulic conductivity," *Functional Ecology*, vol. 22, pp. 885–890, 2008.