

## PHYLOGENETIC RELATIONSHIPS OF THE GENUS *CALOPHYLLUM* L. (CLUSIACEAE) IN SRI LANKA

J.M.D.R. Menike and D.M.D. Yakandawala

*Department of Botany, Faculty of Science, University of Peradeniya*

### Introduction

The Family Clusiaceae harbors about 1610 species and 37 genera of trees and shrubs occurring throughout the world, mostly in tropical regions (Judd *et al.*, 2002). It has many species of economic importance, ranging from large trees grown for their timber, those grown for drugs, dyes, resins, and essential oils used in cosmetics, to edible fruits. The family is currently recognized in the order Malpighiales under the APG II classification (Judd *et al.*, 2002). The Genus *Calophyllum* is represented by 11 species in Sri Lanka (Kostermans, 1980); *Calophyllum inophyllum* L., *C. calaba* P.F. Stevens, *C. bracteatum* Thw., *C. cordato-oblongum* Thw., *C. cuneifolium* Thw. *C. moonii* Wight., *C. thwaitesii* Planch & Triana, *C. tomentosum* Wight., *C. trapezifolium* Thw. *C. walkeri* Wight., and *C. zeylanicum* Kostermans. These species are distributed through wet, dry, lowland and mountain forests. Except *C. inophyllum* L. and *C. calaba* P.F. Stevens, the other species are endemic to Sri Lanka. The endemic species are *C. bracteatum* Thw., *C. cordato-oblongum* Thw., *C. cuneifolium* Thw. *C. moonii* Wight., *C. thwaitesii* Planch & Triana, *C. tomentosum* Wight., *C. trapezifolium* Thw. *C. walkeri* Wight., and *C. zeylanicum* Kostermans.

The objective of the present study was to carry out a phylogenetic analysis of

the genus *Calophyllum* occurring in Sri Lanka, using morphological and anatomical data to determine their phylogenetic relationships and to compare with a phylogeny proposed using a phenetic analysis (Somaratne and Herat, 2001).

### Materials and Method

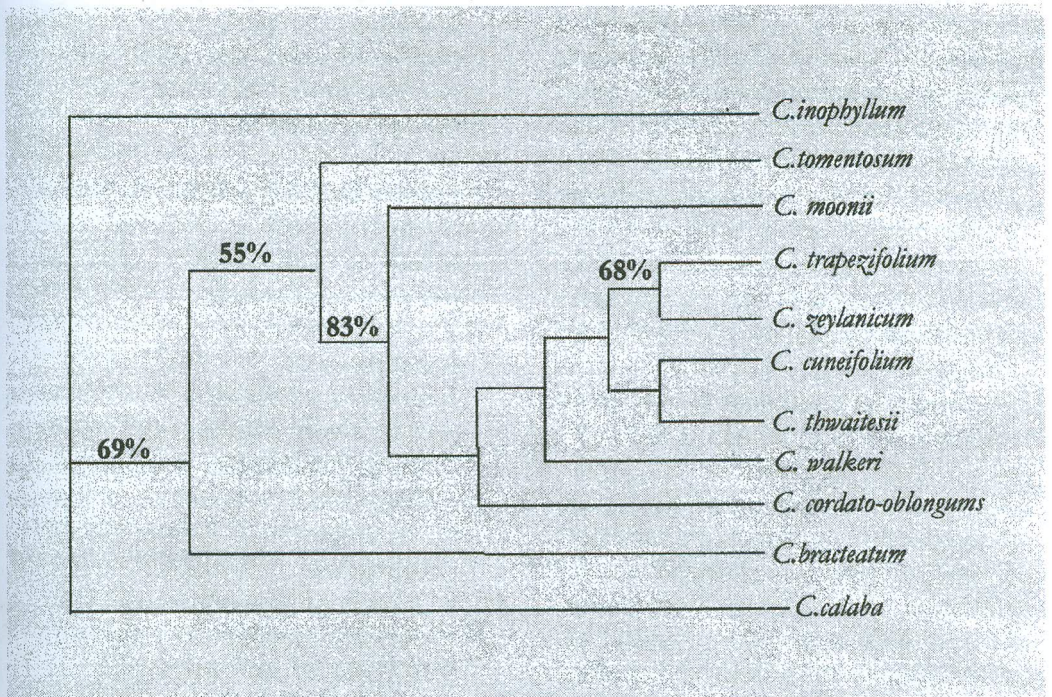
The data collection was done from different sources. All the *Calophyllum* specimens which were deposited at the National Herbarium of Royal Botanical Garden, Peradeniya were examined. Data were extracted from the Revised Handbook of Flora of Ceylon and a comparative vegetative anatomical study of the genus *Calophyllum* L. in Sri Lanka (Somaratne and Herat, 2001). Characteristics of the specimens were studied under morphological and anatomical data. The characters were coded into a data matrix based on different character states. A total of 36 characters were coded into discrete states, and a data matrix was constructed using the computer program MAC Clade. Phylogenetic analysis was carried out using the computer program PAUP 4.0. The analyses was initially carried out under unordered and equal weighting criteria of Fitch parsimony (Fitch, 1971) and steepest descent on, more than one tree was obtained from the initial analysis, a strict consensus and majority rule consensus was obtained. Successive weighting was carried out



based on the retention index. A bootstrap analysis was done to find the support for the recovery of the monophyletic clades. The resulting trees were rooted using the mid point rooting option.

### Results and Discussion

Initial heuristic search under Fitch criterion yielded 21 most parsimonious trees each with a tree length of 117 steps, a CI (consistency index) of 0.556 and a RI (retention index) of 0.409. Successively weighting based on the RI yielded only one most parsimonious tree (Figure 1) with 39.233 steps, a CI value of 0.670 and RI value of 0.64.



**Figure1. The most parsimonious tree recovered during successive weighting of the analysis, using morphological and anatomical data of the genus *Calophyllum* occurring in Sri Lanka.**

The phylogenetic analysis recovered the genus *Calophyllum* as a monophyletic group. The resulting phylogeny has separated the native and endemic species, where the endemics form a monophyletic group with low support. *Calophyllum inophyllum* and *C. calaba* are basal and unresolved. All the other species of *Calophyllum* endemic to Sri

Lanka (*C. bracteatum* Thw., *C. cordato-oblongum* Thw., *C. cuneifolium* Thw., *C. moonii* Wight., *C. thwaitesii* Planch & Triana, *C. tomentosum* Wight., *C. trapezifolium* Thw., *C. walkeri* Wight., and *C. zeylanicum* Kostermans) forms a monophyletic group with low support (69% bootstrap). Within this clade, *C. trapezifolium*, *C. zeylanicum*, *C.*



*cuneifolium*, *C. thwaitesii*, *C. walkeri*, *C. cordato-oblongums* and *C. moonii* forms a well separated monophyletic group with strong support (83% of bootstrap value). *Calophyllum zeylanicum* and *C. trapezifolium* are evolutionary closely related to each other. All the mountain species (*C. trapezifolium*, *C. cuneifolium* and *C. walkeri*) are well separated into one monophyletic clade with one exception, *C. thwaitesii* which is distributed through the wet lowland. *Calophyllum inophyllum* being basal agrees with the results of the phenetic analysis (Somaratne and Herat, 2001). However the idea of *C. calaba* forms a intermediate group from which the other taxa represented in Sri Lanka evolved (Somaratne and Herat, 2001) is not supported by the phylogeny and also not totally rejected as it is resolved as a basal taxa for the other species.

When considering the ecological distribution of the species, *C. walkeri*, *C. zeylanicum*, *C. cuneifolium*, are restricted to the mountains. *Calophyllum calaba* and *C. inophyllum* were wet lowland species. *Calophyllum inophyllum* was mostly distributed through the mangrove vegetation and sea shore vegetation. *Calophyllum bracteatum*, *C. moonii*, *C. cordato-oblongums* and *C. thwaitesii* were found in lowlands. All the mountain species formed a monophyletic clade with one

exception, where *C. thwaitesii* a wet lowland species occurred as sister to *C. cuneifolium*.

### Conclusion

The phylogenetic analyses of the *Calophyllum* species that naturally occur in Sri Lanka, recovered the genus as the monophyletic group. The endemics were recovered as a monophyletic group with 69% bootstrap support. The resulting phylogeny does not agree with the relationships suggested by the numerical analysis.

Further the study unveils the necessity of carrying out a study on species limits of *Calophyllum* with more informative characters.

### References

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