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Introduction

Phylogeny of Verbenaceae



Verbenaceae are a family of flowering plants in the large asterid order Lamiales. The family is New World in origin and primarily Neotropical in distribution with a center of diversity in arid regions of southern South America (Marx et al., 2010; Múlgura et al., 2012).

Neospartoneae was first proposed by Marx et al. (2010) and are one of eight named tribes in Verbenaceae. They are sister to a major clade formed by tribes Lantaneae, Verbenaeae, and the genus *Dipyrena*.

Geographic Distribution of Neospartoneae



Neospartoneae comprises seven species in three genera: *Diostea*, *Lampayo* and *Neosparton*, which are endemic to the arid regions of southern and central Andes.

Photo credits: <http://www.gbif.org/species/6689>

Objectives

1. Test if all these three genera are monophyletic groups.
2. Evolutionary relationship within this tribe.
3. Use the phylogenetic tree to explain the evolutionary patterns (character evolution).

Materials and Methods



13 samples of Neospartoneae were included in this study, including six out of seven species in the clade. DNA was extracted from dried plant tissue. Four chloroplast DNA (*ndhF*, *trnL-F*, *matK* and *rbcl*) and five nuclear loci (ITS, ETS, PPR11, PPR70, and PPR123) were targeted in this study.

Maximum likelihood and Bayesian analyses were conducted using single-locus and concatenated datasets to generate gene trees. Five datasets representing independent loci were constructed for individual gene tree analysis, including concatenated chloroplast DNA data, combined ITS and ETS sequences, and three loci from PPR gene family (PPR11, PPR70, and PPR123).

Species tree was reconstructed by Bayesian multispecies coalescent analyses.

Acknowledgements

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References

Marx, H., O'Leary, N., Yuan, Y., Lu-Irving, P., Tank, D., Múlgura, M., & Olmstead, R. 2010. A molecular phylogeny and classification of Verbenaceae. *American Journal of Botany*, 97(10), 1647-1663.

Múlgura, M. E., N. O'Leary, & A. D. Rotman. 2012. Verbenaceae, in F. Zuloaga & A. Anton (eds.), *Flora Argentina* 14, pp. i-v, 1-220. Buenos Aires: Estudio Sigma.

Results

Gene trees

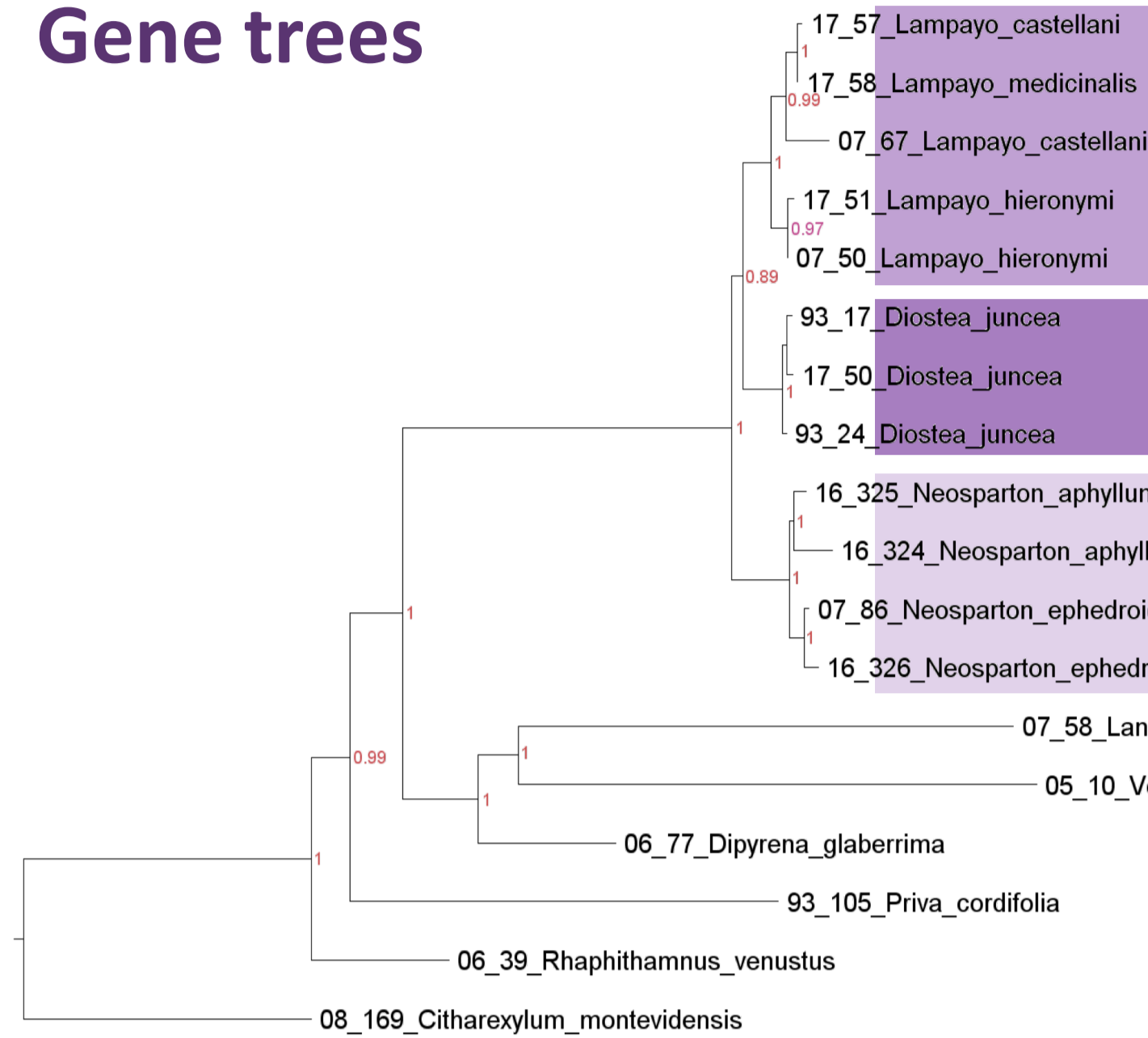


Figure 1. Concatenated maximum likelihood tree for nine-gene, 12-taxon dataset.

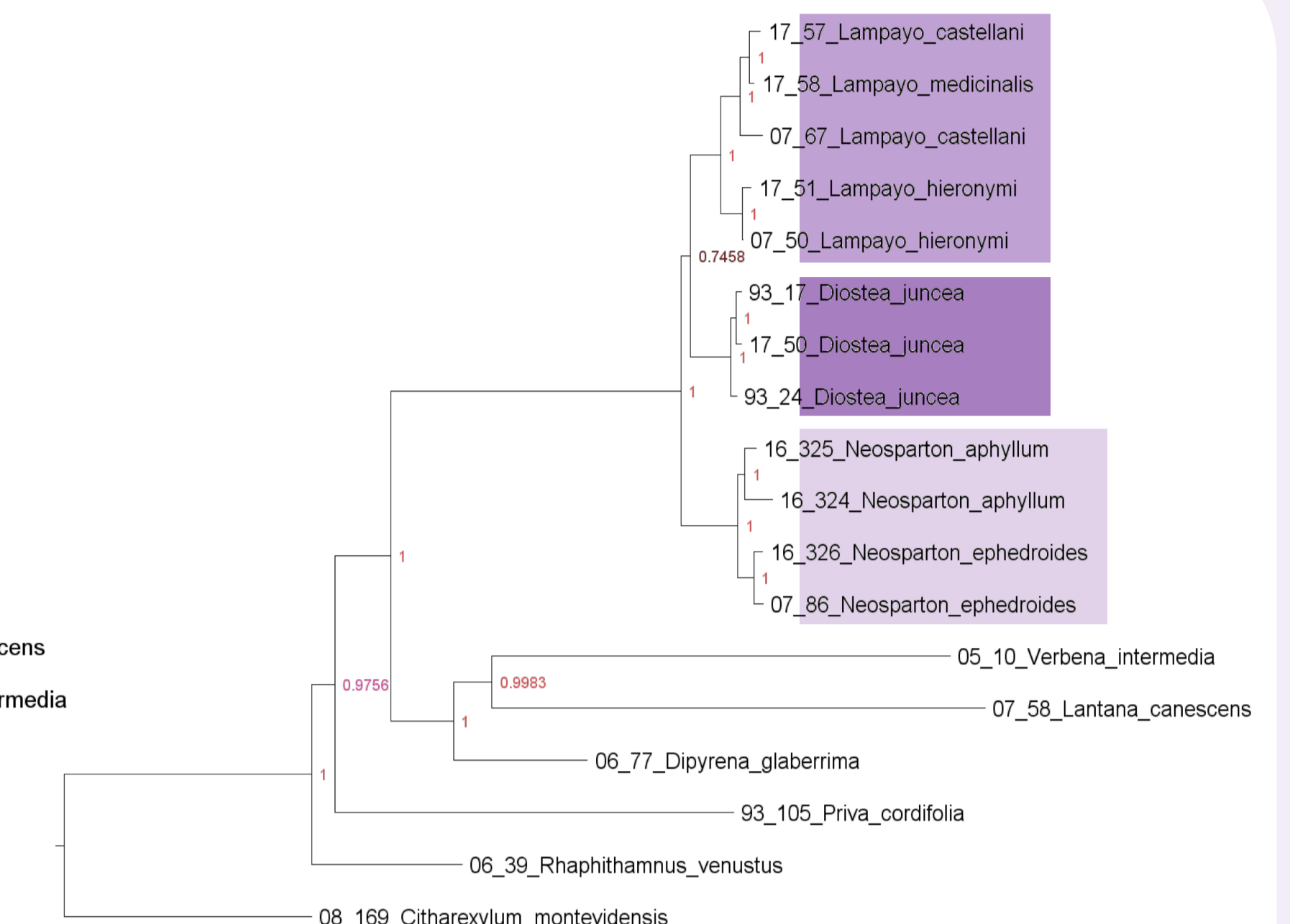


Figure 2. Concatenated Bayesian tree for nine-gene, 12-taxon dataset.

Based on the statistical evaluation from jModeltest 2.1.4, the model of evolution implemented for generating gene trees was set as GTR+G.

Gene Trees Representing Independent Loci

In the chloroplast trees from both analyses, *Lampayo* does not form a monophyletic group, with *L. hieronymi* appearing sister to *Diostea*. Topologies varied among individual nuclear gene trees. Some trees showed that *Lampayo* is sister to *Neosparton*, while others indicated that *Lampayo* is sister to *Diostea*.

Concatenated Gene Trees

Both analyses of the nine-locus concatenated dataset produced congruent trees with respect to relationships in Neospartoneae (Fig. 1, Fig. 2). Each genus is monophyletic with strong support and *Lampayo* is sister to *Diostea* with moderate support.

Species tree

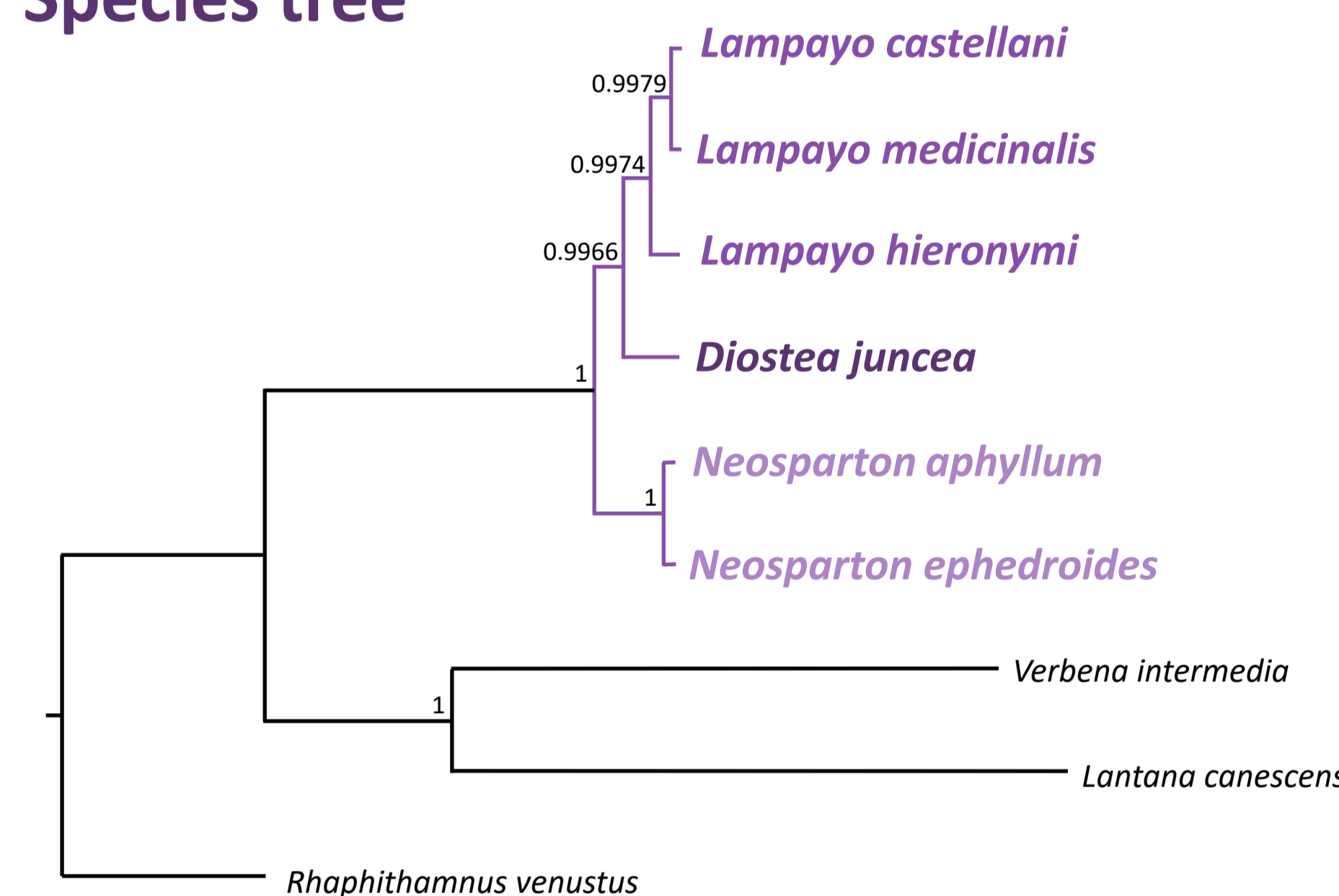


Figure 3. Species tree for nine-gene, 9-taxon dataset.

The species tree was generated under the multispecies coalescent model using *BEAST (Fig. 3). The substitution model for species trees used HKY+G and the nucleotide base frequencies was set as empirical (estimated empirically from the data and then fixed). The species tree confirmed that all three genera were monophyletic with strong support. The species tree was congruent with the topology from the concatenated DNA sequence tree from the nine-locus dataset, including that *Lampayo* was sister to *Diostea*, with strong support.

Conclusion

1. The generic relationships are well resolved and confirm the monophyly of this Neospartoneae and each genus under this tribe.
2. The topologies show that *Diostea* is sister to *Lampayo* and has a more distant phylogenetic relationship with *Neosparton*.

Discussions

This study presents the first molecular phylogeny of Neospartoneae with almost complete species-level sampling in this tribe.

Why do discordance and poor resolution exist in gene trees?

rapid radiations hybridization and introgression incomplete lineage sorting
history of incomplete coalescence the inability of small data

Character Evolution



Diostea juncea

Lampaya castellani

Neosparton aphyllum

Evolution in fruit morphology: the reduction in carpel number in the common ancestor of the three genera was followed by the evolution of fleshy fruits in *Neosparton*

Ephedroid habit: shared ephedroid habit of *Diostea* and *Neosparton*, although also found in some distantly related Verbenaceae (some species of *Junellia*, e.g., *J. spathulata*), suggests that this unusual morphology either evolved in the common ancestor of Neospartoneae, or independently in each genus. *Lampayo* represents a return to a leafy habit, but with fleshy leaves that are unusual in Verbenaceae.