

Taxonomic revision of *Bernardia* bifid style clade (Euphorbiaceae), a mostly South American group with a large morphological heterogeneity

INTRODUCTION

Bernardia Houst. ex Mill. (Euphorbiaceae, Acalyphoideae) is an American genus, mostly neotropical, with approximately 70–80 species (Carrión & al., in prep.) distributed from the southern United States to Uruguay and central Argentina region, including the Antilles, with centers of diversity in Mexico and Brazil, becoming the largest genus of Acalyphoideae endemic to the New World.

According to the most recent taxonomic treatment of *Bernardia* (Pax & Hoffman 1914), seven sections were recognized for the genus: *B.* sect. *Alevia* (Baill.) Müll. Arg., *B.* sect. *Crassifoliae* Pax & K. Hoffm., *B.* sect. *Phyllopassaea* Müll. Arg., *B.* sect. *Polyboea* (Klotzsch) Müll. Arg., *B.* sect. *Passaea* (Baill.) Müll. Arg., *B.* sect. *Traganthus* (Klotzsch) Müll. Arg., and *B.* sect. *Tyria* (Klotzsch) Müll. Arg. [= *B.* sect. *Bernardia*]. These are based on habit, indumentum, venation patterns, presence or absence of a pistillate disk, and style morphology. Cervantes (2006) mentioned the artificial nature of this classification. In addition, *B.* sect. *Traganthus* and *B.* sect. *Passaea* were suggested as candidates for exclusion from *Bernardia* (Webster 1994; Radcliffe-Smith 2001).

Molecular phylogenetic analyses performed during my PhD research, including a broad geographic and taxonomic sampling (comprising all sections) of *Bernardia* confirmed the monophyly of the genus, but do not support its infrageneric classification (Carrión & al., in prep.) (Fig.1). *Bernardia* was resolved into two major groups, which I refer to as the lacerate-laciniate and bifid styles clades (Fig.1). Beyond the type of styles, these two lineages also can be differentiated by the type of trichomes and by the number of stamens (Carrión & al., in prep.).

The lacerate-laciniate style clade comprises approximately 30 species distributed primarily in North America, the Antilles and Central America and is composed by species of *B.* sect. *Alevia* and *B.* sect. *Tyria* [= *B.* sect. *Bernardia*], which includes *B. dichotoma* (Willd.) Müll. Arg., the type of the genus (Fig.1). Species belonging to this clade have been included in the taxonomic treatments of *Bernardia* for Mexico (Cervantes 2002) and *B.* sect. *Bernardia* (Cervantes 2006), these two works are the largest monographs of *Bernardia* after the taxonomic treatment of Pax & Hoffman (1914).

The bifid style clade is composed by 40–50 species (Carrión & al., in prep.) mostly from South America and include represents of six to the seven current sections (except *B.* sect. *Bernardia*) of which only *B.* sect. *Traganthus* (*B. sidoides* (Klotzsch) Müll. Arg.) is recovered as monophyletic. This lineage encompasses a wide variety of habits (perennial and annual herbs, subshrubs, shrubs, trees) and a large heterogeneity expressed in the vegetative and reproductive morphology.

The taxonomy of the South American species of *Bernardia* has been neglected, being limited to taxonomic comments and regional floras monographs. This discrepancy between the number of species in this clade (40–50) is in part by cause of the absence of a recent taxonomic treatment including all South American species of *Bernardia*. In addition, in recent years there has been a greatly increased of *Bernardia* collections from areas with high floristic richness (e.g. the Amazonia, Atlantic Forest, Caatinga and Cerrado domains) that do not fit with the morphology of known species of the genus, which in turn is due to the lack of knowledge of taxonomic limits of some *Bernardia* key species. Moreover, through our molecular phylogenetic analysis, we realized that several species (and/or morphotypes with similar morphology) with wide distribution in Atlantic Rainforest are recovered in more than one lineage (e.g. *B. axillaris*, (Spreng.) Müll. Arg., *B. scabra* Müll. Arg., and *B. tamanduana* (Baill.) Müll. Arg.) (Fig.1).

I started my PhD studies in 2016 with expected to end in the second half of 2020. Currently, I have finished molecular phylogenetic analyzes and I am discussing the results obtained, but for that I need a more accurate knowledge of the morphological delimitation of the species involved, so the study of type specimens of *Bernardia* is fundamental to fulfill this purpose.

In relation to the taxonomic treatment of *Bernardia* bifid style clade, I have described two new species of *Bernardia* with remarkable morphology from this clade (Carrión & al., 2017, 2019) and I have studied several *Bernardia* collections, including important South America collections depositories e.g. A, F, CTES, GH, LIL, MO, NY, R, RB, SI, and US herbaria. However, I have not visited any European herbarium, and many types of key South American *Bernardia* species are deposited at these herbaria, especially at the National Museum of Natural History-

Paris, France (P). Where types specimens of *B. axillaris*, *B. caperoniifolia* (Baill.) Müll. Arg., *B. celastrinea* (Baill.) Müll. Arg., *B. hirsutissima* (Baill.) Müll. Arg., *B. micrantha* Pax & K. Hoffm., *B. multicaulis* Müll. Arg., *B. paraguariensis* Chodat & Hassl., *B. pulchella* (Baill.) Müll. Arg., *B. scabra*, *B. spartioides* (Baill.) Müll. Arg., and *B. tamanduana* are deposited.

The detailed study of *Bernardia* type specimens deposited at P Herbarium and others European herbaria in conjunction with the phylogenetic hypothesis generated, new botanical collections and field observations are the main pillars of my work and fundamental for the description of five or six possible new species of *Bernardia* from the Brazilian Atlantic Forest. Also, an analysis of the type species *in situ* are indispensable to establish the taxonomic boundaries of controversial taxa with similar morphology (e.g. *B. alarici* Allem & Irgang, *B. caperoniifolia*, *B. multicaulis*, and *B. lorentzii* Müll. Arg.) and consequently are crucial to resolve problems related to synonyms and types.

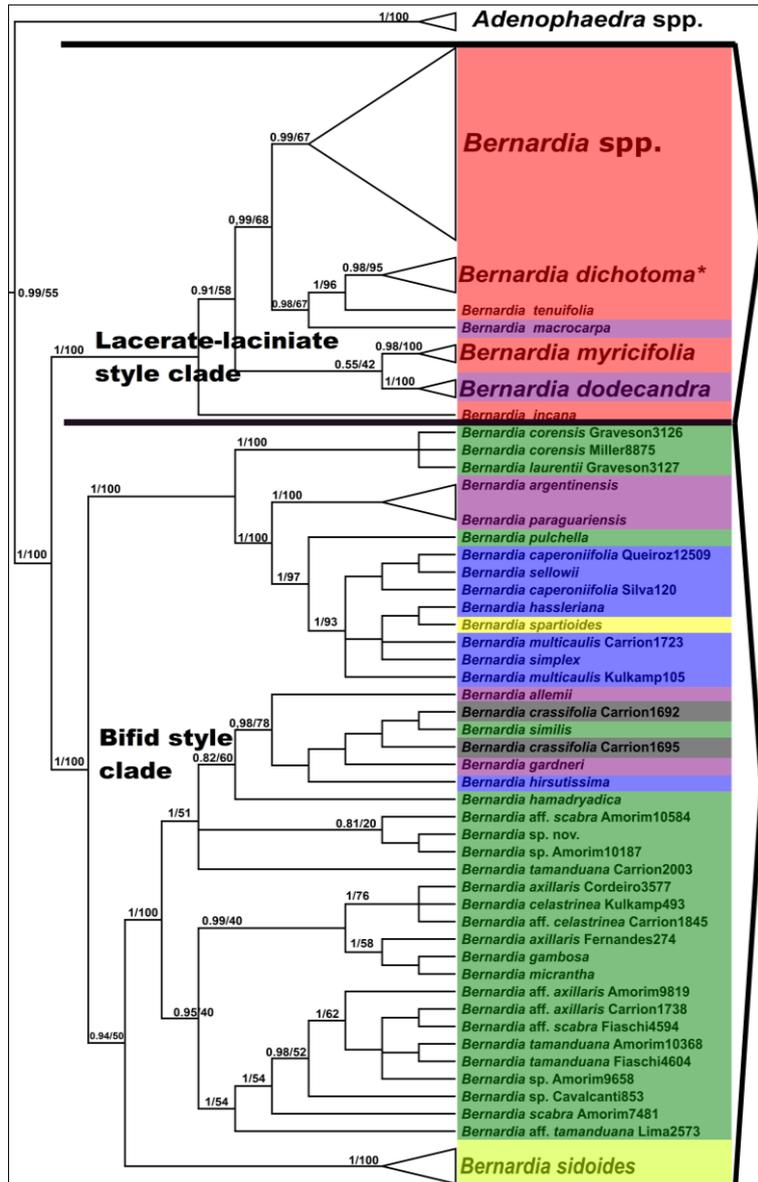


Figure 1. Molecular phylogeny of *Bernardia* (Euphorbiaceae) from the Bayesian analysis of the combined nuclear (ITS/5.8S) and plastid (*matK/trnK*, *pet-D*, *trnL-trnF*) datasets. Numbers above branches are posterior probabilities (left) and maximum likelihood (right) values. Colors indicate the current infrageneric classification of the genus, purple: *Alevia*, red: *Bernardia*, black: *Crassifoliae*, blue: *Phyllopassaea*, green: *Polyboea*, yellow: *Passaea*, and light green *Traganthus*. Asterisk indicates the type species of *Bernardia* (Carrión & al., in prep.).

PROJECT PROPOSAL – Juan Carrión

Indumentum type from vegetative and reproductive structures as well as flower elements (e.g. staminate disk type, stamens number, and pistillate disk type) are useful features for *Bernardia* species delimitation. However, these characters are microscopic and cannot be seen through high-resolution specimens pictures, therefore to observe these morphological details is necessary analyze physically specimens under a stereomicroscope, situation that also cannot be solved by specimen loan, due currently many international herbaria are not sending loan to herbaria from Brazil, -mainly types specimens- due to Brazilian recent prohibitive customs policies, then for to study these specimens it seems that it is only possible visiting the collections where the types are deposited.

OBJECTIVES

To visit the European herbaria where type specimens of key species are deposited in order to be able to produce a complete taxonomic revision of the *Bernardia* species belonging to the bifid style clade (most South American species of *Bernardia*).

Specific goals:

1. Analyze and redefine the taxonomic boundaries of *Bernardia* bifid style clade species and their infraspecific categories by analyzing under the stereomicroscope the type specimens deposited in European herbaria;
2. Revise, include and curate the collections I visit;
3. Resolve problems related to synonyms and types that are encountered;
4. Describe accepted *Bernardia* species belonging to bifid style clade;
5. Develop a key for the identification of *Bernardia* bifid style clade accepted taxa.

MATERIAL AND METHODS

I have already performed fieldwork to collect *Bernardia* specimens for morphological and molecular studies; and I have produced a molecular phylogeny to test the monophyly of the genus in order to evaluate the current infrageneric classification and the phylogenetic relationships among the species of the genus. Protologues of the names of *Bernardia* from South America were studied, as well high-resolution images available of its nomenclatural types. The main herbaria from North and South American with historical collections of *Bernardia* were also visited.

What is of seminal importance to conclude my PhD is to be able to analyze the type specimens of *Bernardia* deposited in European herbaria. In addition to the type specimens analysis, I will also gather information from more collections and contribute with these herbaria by curating their *Bernardia* collection.

LITERATURE CITED

- Carrión, J.F., Cordeiro, I. & Amorim, A.A.** 2017. A new species of *Bernardia* (Euphorbiaceae) from the Chapada Diamantina, Bahia State, Brazil. *Phytotaxa* 317 (1): 069–075.
- Carrión, J.F., Cordeiro, I. & Amorim, A.M.** 2019. A New *Bernardia* (Euphorbiaceae) with Stellate Trichomes from the Brazilian Cerrado. *Syst. Bot.* 44(4): 826–831.
- Cervantes, A.** 2002. *Revisión taxonómica de las especies mexicanas de Bernardia (Euphorbiaceae)*. Dissertation. Mexico City: UNAM.
- Cervantes, A.** 2006. *Sistemática de Bernardia sección Tyria (Euphorbiaceae)*. Thesis. Mexico City: UNAM.
- Pax, F.A. & Hoffmann, K.** 1914. Euphorbiaceae-Acalyphaeae-Mercurialinae. Pp. 1–473 in: Engler, A. (ed.), *Das Pflanzenreich*, vol. IV.147. VII (Heft 63). Leipzig: Engelmann.
- Radcliffe-Smith, A.** 2001. *Genera Euphorbiacearum*. Kew: Royal Botanic Gardens.
- Webster, G.L.** 1994. Synopsis of the genera and suprageneric taxa of Euphorbiaceae. *Ann. Missouri Bot. Gard.* 81(1): 33–144.