Juliana Gastaldello Rando

Estudos filogenéticos, taxonômicos e biogeográficos em *Chamaecrista,* Leguminosae

Phylogenetic, taxonomic and biogeografic studies in *Chamaecrista*, Leguminosae

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Orientador: *Prof. Dr. José Rubens Pirani*

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Prof.(a) Dr. (a)

Prof.(a) Dr. (a)

Prof.(a) Dr. (a)

Prof.(a) Dr. (a)

Prof. Dr. José Rubens Pirani

Orientador

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"Viva ao povo brasileiro, viva nós!" – João Ubaldo Ribeiro

Para ser grande

Para ser grande, sê inteiro:
nada teu exagera ou exclui.
Sê todo em cada coisa. Põe quanto és
no mínimo que fazes.
Assim em cada lago a lua toda
brilha, porque alta vive.

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RESUMO

Neste trabalho apresentamos estudos filogenéticos, taxonômicos e biogeográficos em *Chamaecrista*, um gênero de Leguminosae com centro de diversidade na região Neotropical. Os estudos de sistemática, filogenia e taxonomia, focaram uma série com 22 espécies (*C.* ser. *Coriaceae*), sendo a maioria destas ocorrentes em Campos Rupestres. Já o estudo de biogeografia abrange todo o gênero, visando compreender sua história e diversificação. As etapas de laboratório molecular do trabalho foram realizadas na Universidade Estadual de Feira de Santana, Bahia, em colaboração com o Prof. Dr. Luciano Paganucci de Queiroz.

No capítulo 1, reconstruimos a filogenia de *C.* ser. *Coriaceae* utilizando quatro marcadores moleculares e também dados morfológicos. Nossos principais objetivos foram testar a monofilia da série e verificar possíveis padrões de evolução morfológica no grupo. Em nenhuma análise realizada o grupo foi reconstruído como monofilético, porque três espécies apareceram fora do clado que contém os demais representantes da série. Isso levou a uma definição de *C.* ser. *Coriaceae strictu sensu,* fortemente sustentada como monofilética nas análises combinadas, sendo que além de sinapomorfias moleculares, duas sinapomorfias morfológicas foram evidenciadas.

No capítulo 2, propomos uma nova circunscrição de *C.* ser. *Coriaceae s.s.*, baseada nos resultados do capítulo 1, destacando-se a exclusão das três espécies que emergiram distantes deste clado. Apresentamos um estudo morfológico mais detalhado das inflorescências, da morfologia floral e dos nectários extraflorais nessa série, comparativamente aos padrões observados nos demais clados do gênero, e visando a uma reavaliação da circunscrição taxonômica vigente. Compilamos uma sinopse taxonômica da série, incluindo as novidades nomenclaturais, chave de identificação e ilustrações diagnósticas. *Chamaecrista* ser. *Coriaceae s.s.* inclui 19 espécies, 2 variedades; três neotipificações são propostas, além de uma nova combinação, dois novos sinônimos. A série é restrita ao Brasil, tendo a maioria

dos táxons uma distribuição restrita ou endêmica, sobretudo nos Campos Rupestres das serras do Planalto Central. Este capítulo inclui também um artigo publicado durante o doutorado sobre novidades taxonômicas da série, no qual sinonimizamos uma variedade e elevamos três variedades à categoria de espécie.

No capítulo 3, realizamos a datação dos eventos cladogenéticos de *Chamaecrista*, seguida de análise biogeográfica e evolutiva. Esse estudo abrange mais de um terço das espécies de *Chamaecrista*. Visamos compreender como e quando se deu a origem e distribuição das espécies do gênero e verificar se esses processos teriam relação com transições morfológicas no grupo. As análises indicam uma origem do grupo relativamente antiga, no Terciário inferior na América do Sul, porém a maioria das espécies parece ter se diversificado mais recentemente e por meio de diferentes processos, sendo a dispersão o mais comum. Como observado em outros grupos de plantas lenhosas neotropicais, *Chamaecrista* também parece ter origem florestal com uma posterior invasão de áreas abertas, formações onde atualmente está concentrada sua maior diversidade. Alguns caracteres morfológicos derivados no grupo parecem estar relacionados com a ocupação dos habitats savânicos e rupestres, principalmente o surgimento de tricomas glandulares e a transição de hábito.

Abstract

This thesis focused on the phylogenetic, taxonomic and biogeographic studies in *Chamaecrista*, a genus of Leguminosae with the center of diversity in the Neotropics. The studies of systematic, phylogeny and taxonomy, were carried out on 22 species (*Chamaecrista* series *Coriaceae*), with most species occurring in Campos Rupestres (Chapter 1 and 2). The study of biogeography covers the entire genus, contributing to the understanding of its history and diversification (Chapter 3). Molecular work were conducted at the Universidade Estadual de Feira de Santana, Bahia, in collaboration with the Prof. Dr. Luciano Paganucci de Queiroz.

In Chapter 1, we reconstructed the phylogeny of *C.* ser. *Coriaceae* using four molecular markers as well as morphological data. Our objectives were to test the monophyly of the series and to identify possible patterns of morphological evolution in this group. In all analysis the group was not reconstructed as monophyletic because three species appeared outside the clade containing the remaining representatives of the series. This led to a definition of *C.* ser. *Coriaceae sensu strictu*, strongly supported as monophyletic by several molecular and two morphological synapomorphies in the combined analyzis.

In Chapter 2, we proposed a new circumscription of *C.* ser. *Coriaceae s.s.*, based on the results of Chapter 1, highlighting the exclusion of the three species emerged out this clade. We present a detailed morphological study of inflorescences, floral structure and extrafloral nectaries in the series, compared to patterns observed in other clades of *Chamaecrista*, seeking a reevaluation of the current taxonomic circumscription. We produce a complete taxonomic synopsis of the series, including nomenclatural novelties, key identification and diagnostic illustrations. *Chamaecrista* ser. *Coriaceae s.s.* includes 19 species and 2 varieties; three neotypification are proposed, a new combination, and two new synonyms. The series is restricted to Brazil, most taxa have a restricted or endemic distribution, especially in the Campos

Rupestres of the Brazilian central plateau. This chapter also includes an article published during the PhD about the taxonomic novelties of the series, in which we synonymized a variety and modified the taxonomic category of three varieties to species.

In chapter 3, we carried out the dating of the cladogenetic events in *Chamaecrista*, and the subsequent biogeographic and evolutionary analysis. The taxa sampling covered more than a third of species. We aim to understand when the genus emerged and how the group has distributed in the Neotropics, especially in the Cerrado and Campos Rupestres. Finally, we also explored whether these processes were related with morphological transitions. Our analyses indicated a relatively ancient origin of the group, at the lower Tertiary in South America, though most species seems to have diversified more recently and through different processes, being the most common species dispersion. As observed in other groups of woody plants from Neotropics, *Chamaecrista* also seems to have forest origin with a subsequent occupation of open areas, in which the genus actually had its greatest diversity. Some derived morphological characters seem to be correlated with the occupation of drier habitats (Cerrado and Campos Rupestres), especially the appearance of glandular trichomes and the transition of habit.

INTRODUÇÃO GERAL

A Sistemática Filogenética, fundamentada na premissa de que as classificações biológicas devem refletir o conhecimento atual sobre as relações de parentesco entre os táxons, é paradigmática na Biologia Comparada moderna (Hennig 1966, Amorim 2002, APG-III, 2009). Discussões recentes nessa escola envolvem questões de refinamento dos métodos analíticos e nos passos das análises, e no aprimoramento de critérios explícitos para a geração de classificações a partir das filogenias disponíveis. Grandes avanços têm sido alcançados nas duas últimas décadas com o advento de novas técnicas moleculares e de tecnologias computacionais, mas, sobretudo, graças à aplicação de métodos de reconstrução filogenética a partir de todos os tipos de dados (Wiens 2009). Por este motivo, a realização de trabalhos taxonômicos robustos depende cada vez mais da obtenção de filogenias consistentes que, em combinação com os métodos taxonômicos clássicos, permitem a elaboração de classificações aprimoradas. Além das classificações, as filogenias também têm tido ampla e crescente aplicação em estudos biogeográficos (*e.g.* Winkworth & Donoghue 2005, Wiens 2009), evolutivos (*e.g.* Donoghue *et al.* 2003, Friedman *et al.* 2004) e de diversificação (Ricklefs 2007).

Neste trabalho, visamos a contribuir para o avanço na compreensão da diversidade da biota neotropical, utilizando como estudo de caso em grupo de Leguminosae com centro de diversidade no Domínio do Cerrado brasileiro, analisado com métodos fundamentados no paradigma da Sistemática Filogenética e suas aplicações modernas.

O Cerrado forma um dos domínios fitogeográficos que mais contribuem na formação das paisagens naturais do Brasil (Ratter *et al.* 2006, Fiaschi & Pirani 2009). Apesar de grande parte desse domínio ter sofrido forte antropização, exibe ainda uma riqueza elevada de espécies e de endemismos (Ratter *et al.* 2006). A família de maior riqueza específica no

Cerrado é Leguminosae, compreendendo 123 gêneros e cerca de 1.174 espécies no domínio (Lima *et al.* 2014). Os gêneros mais representativos da família no Cerrada são *Mimosa* L., com *ca.* 217 espécies, e *Chamaecrista* Moench com ca. 207 espécies: ambos somam um terço da família nesse domínio (Dutra & Morim 2014, Souza & Bortolluzi 2014). Questões de diversificação, evolução e padrões biogeográficos de Leguminosae no Cerrado têm sido ainda pouco exploradas sob métodos explícitos, com escassos estudos baseados em dados moleculares adicionando temporalidade (Simon *et al.* 2009, Simon & Pennington 2012). Grande parte dos táxons endêmicos no domínio Cerrado são restritos às serras ao longo da Cadeia do Espinhaço (nos estados de Bahia e Minas Gerais) e na Chapada dos Veadeiros (em Goiás), sobretudo nas formações conhecidas como "Campos Rupestres" (Prance 1994, Giulietti *et al.* 1997, Simon & Proença 2000, Fiaschi & Pirani 2009, Rando & Pirani 2011). Pouco ainda se sabe sobre a diversificação dessa flora rica em endemismos, isso porque ainda são escassos estudos os filogenéticos e biogeográficos com grupos de plantas dessa região. O presente estudo de *Chamaecrista,* gênero rico em espécies no Brasil e sobretudo em habitats abertos como os do Domínio do Cerrado, tem por objetivo principal contribuir para completar essa lacuna.

Chamaecrista, grupo considerado monofilético (Conceição *et al.* 2009), inclui cerca de 330 espécies, distribuídas, principalmente, na América tropical, com menor diversidade na África, Ásia e Austrália e poucas espécies atingindo áreas temperadas (Irwin & Barneby 1982, Lewis 2005). No Brasil, ocorrem cerca de 230 espécies, sendo que 207 estão concentradas na região do Planalto Central brasileiro, nos estados de Bahia, Goiás e Minas Gerais (Irwin & Barneby 1978, 1982, Lewis 1987, Souza & Bortoluzzi 2014). Segundo diversos autores (Irwin & Barneby 1982, Lewis 1987, Conceição *et al.* 2001, Souza & Bortoluzzi 2014, Rando & Pirani 2011), os estados da Bahia e de Minas Gerais, com 105 espécies restritas a eles, são os principais centros de diversidade do grupo, sendo o Cerrado e os Campos Rupestres os locais de destaque por apresentarem diversas espécies endêmicas. Como exemplo desse endemismo temos *Chamaecrista* sect. *Chamaecrista* ser. *Coriaceae*

(Benth.) H.S. Irwin & Barneby. Esta série foi descrita por Bentham (1871) e recircunscrita por Irwin & Barneby (1982), os últimos autores reconheceram 28 táxons (20 espécies e 8 variedades). A série pode ser caracterizada pelo hábito subarbustivo a arbustivo com xilopódio que permite a rebrota de novos ramos depois do fogo, além da presença de nectário extrafloral (Irwin & Barneby, 1982). Segundo esses autores a série tem a maioria das espécies concentrada no domínio do Cerrado, com uma única espécie restrita à região do Caribe: *C. caribaea* (Northr.) Britton. No domínio do Cerrado, as espécies de *Chamaecrista* ser. *Coriaceae* encontram-se predominantemente nos Campos Rupestres, sendo diversas delas consideradas raras (Giulietti *et al.* 2009). Apesar da revisão relativamente recente de *Chamaecrista* (Irwin & Barneby 1982), persistem questões nomenclaturais a serem resolvidas, além de problemas de circunscrição de algumas variedades que podem ser melhor avaliados com um maior número de informações (*e.g.* observação das populações em ambiente natural e amplo estudo de coleções atualmente disponíveis).

Diversos trabalhos citam alguns grupos de angiospermas como bons candidatos em estudos que poderão trazer informações sobre a diversificação e história biogeográfica do cerrado e dos Campos Rupestres, e entre eles está *Chamaecrista* (Fiaschi & Pirani 2009, Queiroz *et al.* 2009). Dentro deste contexto apresentamos nesta tese estudos filogenéticos, taxonômicos e biogeográficos neste gênero. Os estudos de filogenia e taxonomia estão focados nas espécies de *Chamaecrista* ser. *Coriaceae,* que ocorrem predominantemente nos Campos Rupestres, e os estudos biogeográficos abrangem todo o gênero.

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Capítulo 1

Phylogeny of *Chamaecrista* sect. *Chamaecrista* ser. *Coriaceae* (Leguminosae): a diversified group in the Brazilian highlands

Phylogeny of *Chamaecrista* sect. *Chamaecrista* ser. *Coriaceae* (Leguminosae): a diversified group in the Brazilian highlands

JULIANA GASTALDELLO RANDO[1]; ALEXANDRE R. ZUNTINI[1]; ADILVA SOUZA CONCEIÇÃO[3]; CÁSSIO VAN DEN BERG[2]; JOSÉ RUBENS PIRANI[1] & LUCIANO PAGANUCCI DE QUEIROZ[2]

[1.] *Instituto de Biociências, Departamento de Botânica, Universidade de São Paulo, Rua do Matão 277, 05508-900, São Paulo, Brazil.*

[2.] *Universidade Estadual de Feira de Santana, Departamento de Ciências Biológicas, Laboratório de Sistemática Molecular de Plantas, Km 03 BR 116, Campus, 44031-460, Feira de Santana, Bahia, Brazil.*

[3.] *Universidade do Estado da Bahia, Campus VIII, Colegiado de Ciências, Rua do Gangorra, 503, CHESF, Paulo Afonso, Bahia, 48.608-290, Brazil*

Corresponding author: ju_rando@hotmail.com (author for correspondence)

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Abstract

Chamaecrista sect. *Chamaecrista* ser. *Coriaceae* is a group comprising 22 species, mostly distributed in highlands areas of Brazil. This study aims to clarify the phylogenetic relationship of the series using molecular and morphology data. The phylogeny of *Chamaecrista* ser. *Coriaceae* was inferred using sequence data from two nuclear regions, ETS and ITS, two plastid regions, *trnD-T* and *trnL-F*, and morphological evidence. The datasets were analyzed separated and combined. In all analyses, for all datasets, the series appeared as polyphyletic but most of the species ascribed to the series form a well supported clade endemic to highland areas in the Brazilian Cerrado (Savanna) Domain (thereafter the *Coriaceae* clade). The plastid regions provided high support for the monophyly of the *Coriaceae* clade and the nuclear regions provided better resolution within the clade. Two molecular and two morphological putative synapomorphies were found for the *Coriaceae* clade. The low resolution among species of this clade could be consequence of a recent radiation, a common pattern observed in some other groups restricted to highland areas in South America.

Key words: taxonomy, recent diversification, Brazil, *campo rupestre*, endemism.

Introduction

Chamaecrista Moench belongs to tribe Cassieae and to subtribe *Cassiinae* together with the genera *Cassia* L. and *Senna* Mill. (Lewis 2005). The genus comprises more than 330 species distributed mainly in the tropical America, with few species in Africa, Asia and Australia, tinily extending to temperate areas (Irwin & Barneby 1982, Lewis 2005). There are 253 species of *Chamaecrista* in Brazil, 204 of them restricted to the country, many being narrow endemics (Rando & Pirani 2011, Souza & Bortoluzzi 2014). *Chamaecrista* is one of the most diversified genera of Leguminosae in the Brazilian savannas and its greatest diversity centre is found in the Cerrado Domain in Brazilian Central plateau (Irwin & Barneby 1982, Lewis 1987, Rando & Pirani 2011). Recent phylogenetic studies support the monophyly of the genus (Conceição et al. 2009). Irwin & Barneby (1978, 1982) recognized six sections in the genus: *Chamaecrista* sect. *Absus*, *C.* sect. *Apoucouita*, *C.* sect. *Caliciopsis*, *C.* sect. *Chamaecrista*, *C.* sect. *Grimaldia* e *C.* sect. *Xerocalyx*. These sections could be recognized by a combination of characters such as the inflorescence type, presence or absence of glandular trichomes, sepals and leaflets venation pattern (Irwin & Barneby 1982).

Sect. *Chamaecrista* is the second most species-rich section, including ca. 76 species in the world and ca. 52 species in the Americas (Irwin & Barneby 1982). Species in this clade can be widespread, such as *C. flexuosa* (L.) Greene (*C.* ser. *Flexuosae), C. nictitans* (L.) Moench (*C.* ser. *Chamaecrista*) and *C. rotundifolia* (Pers.) Greene (*C.* ser. *Bauhinianae*), or endemic or rare as *C. anceps* (Benth.) H.S. Irwin & Barneby, and *C. lagotois* H.S. Irwin & Barneby (*C.* ser. *Coriaceae*) (Irwin & Barneby 1982). The section *Chamaecrista* includes shrubs and subshrubs with axillary and reduced inflorescences. However, the phylogenetic account presentd by Conceição et al. (2009) indicated that the section could be a paraphyletic grade including the sects. *Xerocalyx* and *Calyciopsis*. Six series were recognized in this section by Irwin & Barneby (1982) based on the position of inflorescence, number of stamens, patterns of leaflets venation, and presence of a xylopodium. Among the series of the sect. *Chamaecrista*, the ser. *Coriaceae* is characterized by the shrubby habit with the twigs sprouting from an woody underground xylopodium (Fig. 1-D), extrafloral nectaries on the petiole, thick-textured leaflets and axillary peduncles.

The series was highly supported as monophyletic in a recent phylogenetic account of the genus (Conceição et al. 2009), but only four species were sampled so that monophyly remains to be tested using a more thorough sampling (Conceição et al. 2009). The series currently comprises 22 species and six varieties distributed widely in drier areas of Brazil (Irwin & Barneby 1982, Rando et al. 2013): 21 species occur in upland areas, 18 of them restricted to the mountains of the Espinhaço Range in the states of Minas Gerais and Bahia, eastern Brazil (Fig. 1-A). One species is restricted to Goiás state (central Brazil), and one is disjunctly distributed in elevated areas in Roraima (northern Brazil) and Bahia (eastern Brazil) (Irwin & Barneby 1982, Rando & Pirani 2011), while *Chamaecrista caribaea* (Northr.) Britton occurs outside of South America at sea shores in the Bahamas (Irwin & Barneby 1982). Two main geographical patterns are observed in *C.* ser. *Coriaceae*: (1) six species have a continuous to disjunct occurrence throughout the Espinhaço Range or in adjacent areas; and (2) 14 species have an endemic distribution in the southern region of that same mountain range (Minas Gerais state) (Rando & Pirani 2011).

Most species in the series inhabit the *campo rupestre*, the dominant vegetation type at the Espinhaço Range, housing a high diversity of several plant groups, with many endemic species (Giulietti et al. 1997, Rapini et al. 2008, Ribeiro et al. 2012, Bitencourt & Rapini, 2013). The *campo rupestre* areas are generally disconnected from each other, and thus they have been treated as isolated islands (rocky fields above 900 m of elevation marked by a low herbaceous covering with scattered shrubs – Fig. 1-B,C) surrounded by either Caatinga or

Cerrado vegetation (Prance 1994, Pennington et al. 2000, 2004, 2006, Ramos et al. 2007, Fiaschi & Pirani 2009). Phylogenetic studies on plant groups of this rich and endemic flora are still scarce, but the few phylogenetic patterns available suggest a recent radiation of plant species throughout the cerrado and campos rupestres (Simon et al. 2009), a hypothesis shared by different authors (Pennington et al. 2006, Queiroz et al. 2009, Fiaschi & Pirani 2009).

Potential adaptations to fire have been also observed in the flora of *cerrado* and *campos rupestres* (Simon et al. 2009; Simon & Pennington 2012), suggesting that these traits could be especially important to the plant survival in drier habitats with fire regime (Gottsberger & Silberbauer-Gottsberger 2006). At least some of these traits could be identified in *Chamaecrista* ser. *Coriaceae*, as leaflets incrassate and indurate in texture, and presence of a xylopodium (Fig. 1D,E), making *Chamaecrista* sect. *Coriaceae* a special group in phylogenetic studies exploring the cerrado and campos rupestres flora. In this context, the main objective of our study was to understand the phylogenetic history of this species-rich plant group with most species from campos rupestres. More specifically, we carried out a phylogenetic study of *Chamaecrista* with a comprehensive sampling in the ser. *Coriaceae* aiming to (1) test its monophyly, (2) better understand the relationships within the genus, and finally (3) characterize the morphological evolution within the series.

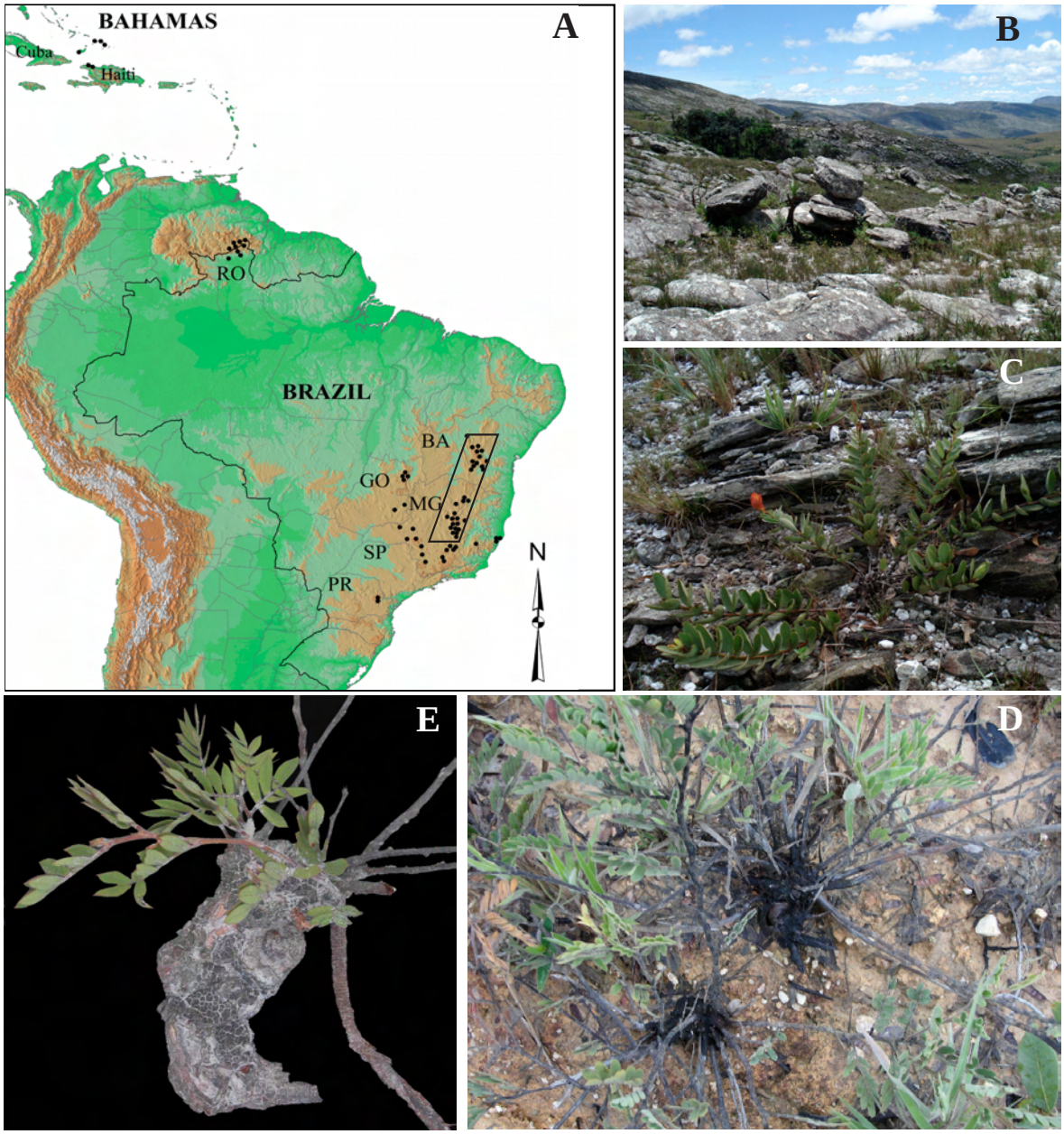

Figure 1. A. The map of South America and Antilles depicting the distribution of *Chamaecrista* sect. *Chamaecrista* ser. *Coriaceae* according to Irwin & Barneby (1982): the *Espinhaço* Range is delimited by a rhombic area - BA, Bahia state; GO, Goiás state; MG, Minas Gerais state; PR, Paraná state and RO, Roraima state, SP, São Paulo state. **B.** Landscape of the rocky fields that comprise the *campos rupestres* **C.** Habit of *Chamaecrista rossicorum*. **D.** *Chamaecrista papillata* after fire, with burned, dead branches, and new green sproutings. **E.** Detail of *C. papillata* underground structure, a xylopodium.

MATERIAL AND METHODS

Taxon sampling: molecular and morphological data - We sampled 44 accessions comprising 21 of the 22 known species (23 of the 26 taxa, considering varieties) of *Chamaecrista* sect. *Chamaecrista* ser. *Coriaceae*. To this, we added accessions from previous molecular sequences available in the GenBank, including species of all sections and series recognized in *Chamaecrista* based on the previous phylogenetic study of the genus (Conceição et al. 2009) (Appendix 1). Two distinct datasets were considered: (1) the broad sampling including 91 accessions from the plastid (*trnL-F*) and 82 from nuclear (ITS) sequences to test monophyly and the phylogenetic position of the series within the genus *Chamaecrista* and taking representatives of the genera *Cassia* and *Senna* as outgroups (Bruneau *et al.* 2008); and (2) the narrowm sampling used to clarify the phylogenetic relationship among species within the ser. *Coriaceae*. For this second dataset we included 44 accessions were sampled for the plastid *trnL-F* region, 39 for the plastid *trnD-T*, 35 for the ITS, and 39 for the nuclear ETS, including seven species of all sections as outgroups (Appendix 1). The sampling for the ser. *Coriaceae* represented 95.4% of the known species; only *C. multinervia* (Mart. ex Benth.) H.S. Irwin & Barneby was not found during field explorations. Attempts to obtain sequences from herbarium specimens were not successful. Genbank accession numbers for DNA sequences generated in this study are associated with voucher specimens (Appendix 1).

Morphological characters were surveyed for all taxa sampled for the lower-level study (21 species of *C.* ser. *Coriaceae* and seven outgroups). The morphological characters were coded from exsiccatae, liquid-preserved samples, and specimens observed in the field. All nomenclatural types were analysed. Only fully developed structures of mature plants (reproductive individuals) were considered.. Vouchers of the specimens sampled are located in the following herbaria: ALCB, B, BHCB, DIAM, EAC, ESA, F, G, GH, HRCB, HUEFS, HUFU, INPA, K, LE, M, MBM, MG, MIRR, NY, OUPR, P, R, RB, SP, SPF, UB, UEC, UFG, and US (acronym according to Thiers 2014, continuously update). Based on our detailed morphological investigations, we identified 27 variable characters, which were coded as binary or unordered multistate. The morphological terminology used, as well as the characters and character states are detailed in Appendix 2. The morphological data matrix is available in the Appendix 3.

DNA extraction, amplification, and sequencing - Total DNA was extracted mostly from fresh or silica-gel dried leaflets using an adapted 2 X CTAB procedure of Doyle & Doyle (1987) or by Invitek mini plant kit (Invitek, Berlin, Germany). Variable molecular regions were chosen based on a pilot study that sampled species from *Chamaecrista* ser. *Coriaceae,* as well as from other sections and series of the genus (unpublished data). The regions of cpDNA *rpl*32 spacer and *rps*16 intron were tested and discarded. The regions *trnD*-T, *trnL*-F, ETS and ITS 5.8S showed some molecular variation and were selected for this study.

Nuclear region: the primers 17SE and 26SE were used for amplification of ITS, and the primers 17SE and 26SE for sequencing (Desfeaux *et al.* 1996); for amplification and sequencing of ETS, we used the primers ETS IGS-760 (Baldwin & Markos, 1998) and ETS dioc3 (Pastore et al. unpubl, data). We performed the amplification for both nuclear regions using the same 30 µl PCR mix containing: 3.0 µl of supplied buffer, 1.5 µl of $MgCl_2$ (50 mM), 0.6 µl of dNTPs (10mM, GE Healthcare Life Sciences), 0.3 µl of each primer (15µM), 0.6 of µl BSA, Invitrogen), 6.0 µl of betaine, 1.0 µl DMSO (1%, Merck) and 0.15 µl Taq DNA polymerase (5U/µl, Phoneutria), 15.85 µl H_20 (q.s.p.) and 1.0 µl of DNA at 20-40 ng of concentration.

Plastid regions: For amplification and sequencing of *trnL*-F, we used two universal primers (C, F) of Taberlet *et al.* (1991). For amplification and sequencing of *trnD*-T, we used the primers and *trnD* (F) and *trnT* (R) (Shaw et al. 2005). For all plastids regions, we used the Toptaq Master Mix (Qiagen, Dusseldorf, Germany) scaled to 15 µl, containing: 7.5 µl pre-made mix, 0.2 µl of each primer (15µM), 6.6 µl of H_2O (Qiagen) and 0.5 µl of DNA at 20-40 ng of concentration. The same primers were utilized through amplification and sequencing reaction, except for the ITS. The sequences of the primers used, as well as the PCR cycles used for each reaction are in Table 1. PCR products were purified using enzymatic reaction with Exonuclease I and Shrimp Alkaline Phosphatase enzymes (Affymetrix, USB products, Ohio, U.S.A.) or with PEG 20% (Polyethylene Glycol). The samples were sequenced in both directions using the Spectrumedix SCI SCE9624 automated sequencer at Universidade Estadual de Feira de Santana (UEFS). In some cases the PCR products were sequenced at Macrogen Inc. (Korea). There are some differences in numbers of sequences obtained for samples of *C.* ser. *Coriaceae* among the different regions amplified, mainly for ITS (Table 2). However these differences are related to several accessions from each species, and we tried to obtain at least one sequence of each species sampled for all markers. In the combined analysis we chose the samples with maximum of sequences available.

Alignment and Phylogenetic analysis - Forward and reverse sequencing reads were assembled into contigs and edited in Geneious v6.1.7 (Biomatters 2013). Sequences of all loci were aligned using the algorithm Muscle (Edgar 2004a, 2004b), with manual edition to correct obvious alignment errors and to remove parts with dubious alignment. The gaps in the matrices were coded using the simple coding option (Simmons & Ochoterena 2000) in SeqState version 1.4.1. (Müller 2005). Individual and combined analyses were performed for each molecular marker and for morphological dataset. Ten different data matrices were prepared in the following combinations: *Broad sampling*: (1) ITS, (2) *trnL*-F, and (3) ITS + *trnL*-F; *Narrow sampling*: (4) ETS, (5) ITS, (6) *trnD*-T, (7) *trnL*-F, (8) morphology, (9) all molecular markers and (10) all molecular markers plus morphology. Congruence between the cpDNA and nuclear datasets was assessed using the partition homogeneity (ILD) test (Farris et al. 1995). The ILD test was implemented in PAUP* using 1000 replicates, MaxTrees set at 1000 and TBR branch swapping.

Parsimony analyses (PA) were performed using PAUP* version 4.0b10 (Sworfford, 2002) with Fitch parsimony (Fitch, 1971) as the optimality criterion. A heuristic search was conducted using 1,000 random taxon-addition replicates, with the tree-bisection-reconnection (TBR) algorithm, saving to 15 trees per replicate to prevent extensive swapping on islands with many trees. The resulting trees were then used as starting trees for a second round search using TBR branch swapping with an upper limit of 10,000 trees. Nonparametric bootstrap support was estimated using 10,000 pseudo-replicates and the same parameters used in our PA analyses (Felsenstein, 1985). Decay indices were calculated only for the morphological dataset.

Bayesian inferences (BA) were performed using MrBayes 3.1 (Ronquist & Huelsenbeck 2003). First, the nucleotide substitution model was selected based on the AIC values using JModeltest 2.1 (Guindon & Gascuel 2003, Darriba et al. 2012). The substitution model selected for each molecular marker is listed in the Table 2. Due to the rate heterogeneity of the ITS marker, it was partitioned three parts and to perform the model selection separately (ITS1, ITS5.8S, ITS2). Indels and morphological characters were coded as standard characters, respectively as “variable” and “all”. The datasets were analyzed in two independent runs, each with four chains. The individual analyses were conducted with 5,000,000 generations and the combined analyses with 10,000,000 generations. The burn-in stage needed to reach stationary was determined by plotting the likelihood scores against the number of generations. The trees sampled placed in the burn-in stage were excluded (1,000 for each marker and 10,000

combined analyses), and the remaining trees were assumed to be representative of the posterior probability distribution.

Table 1. Primers used for PCR and/or sequencing and the PCR cycle.

Region (reference)	Name (usage)	Sequence	PCR Cycle
ETS (Baldwin & Markos, 1998)	ETS-DIOC3 ETS-18S	Pastore *et al.* unpubl. data ACT TAC ACA TGC ATG GCT TAA TCT	35 X (60”/94°C – 60”/52°C – 120”/72°C)
ITS (Desfeaux *et al.* 1996)	ITS17SE (PCR) ITS26SE (PCR) ITS92 (sequencing) ITS4 (sequencing)	ACG AAT TCA TGG TCC GGT GAA GTG TTC G TAG AAT TCC CCG GTT CGC TCG CCG TTA C AAG GTT TCC GTA GGT GAA C TCC TCC GCT TAT TGA TAT GC	28 X (45”/94°C – 60”/52°C – 180”/72°C)
trnD-T (Shaw et al. 2005)	trnD (F) trnT (R)	ACC AAT TGA ACT ACA ATC CC CTA CCA CTG AGT TAA AAG GG	36 X (50”/94°C – 50”/54°C – 90”/72°C)
trnL-F (Taberlet et al. 1991)	trnL-F (C) trnL-F (F)	CGA AAT CGG TAG ACG CTA CG ATT TGA ACT GGT GAC ACG AG	35 X (30”/94°C – 40”/53°C – 40”/72°C)

Morhological evolution

Morphological evolution reconstructions were conducted upon a simplified version of the majority consensus tree derived from Bayesian analysis from all combined datasets. Selected individuals of this tree were trimmed so that a single terminal represented each monophyletic species. The 27 characters used in the phylogenetic reconstruction were also selected for ancestral-state reconstructions with the same codification (Appendix 3 and 4). Ancestral-state reconstructions were performed in order to verify which morphological similarities were based on common ancestry, evidencing putative synapomorphies for the *Coriaceae s.s.* clade. Reconstructions were done in Mesquite 2.74 (Maddison and Maddison, 2010) using parsimony and Maximum likelihood criteria. The former used unordered character states and the later a single rate model of transition (Mk1).

Results

For all datasets, Maximum Parsimony (PA) and Bayesian Analyses (BA) supported *Chamaecrista* sect. *Chamaecrista* ser. *Coriaceae* as polyphyletic. Despite this, 19 out of 22 species of the series *Coriaceae* are grouped in a clade called here "*Coriaceae strict sensu* clade". It includes the type-species of the series, *Chamaecrista choriophylla* (Vogel) H.S.Irwin & Barneby. In all analyses, *C. caribaea*, *C. roraimae* and *C. venulosa* emerge out of the *Coriaceae s. s.* clade. The plastid data sets presented better support for the monophyly of the *Coriaceae s. s.* clade while the nuclear regions provided better resolution inside the clade. The tree obtained from morphological data alone was poorly resolved, but the total evidence (molecular + morphology) dataset increased the support and the resolution within of the *Coriaceae s. s.* clade. Details on DNA regions and the morphological datasets, as well as the phylogenetic analyses and supports are provided in Table 2.

Broad sampling

Combined analysis of nuclear ITS + plasdial *trnL*-F (Figure 2) **–** As the ILD test revealed that the two data partitions were significantly congruent (*P*=0.921) they were merged. Maximum parsimony and Bayesian analysis for this combined dataset exhibit congruent topology. The results show *Chamaecrista* sect. *Chamaecrista* ser. *Coriaceae* as a polyphyletic group because three species appear outside (*Chamaecrista caribaea*, *C. roraimae*, and *C. venulosa*). However there is good support for the *Coriaceae s. s.* clade (Clade D; BS=79 / PP=0.92), which includes the type-species of the series (*Chamaecrista choriophylla*). The *Coriaceae s. s.* clade emerged as closely related to other species traditionally recognized in the *C.* sect. *Chamaecrista* and in *C.* sect. *Xerocalyx*. In both analyses, the *Coriaceae s. s.* clade has as sister-group a species of *C.* ser. *Flexuosae* (*C. swainsonii*). Within Clade D (*Coriaceae strict sensu*), we can recognized the Clade E comprising some species possessing 1 pair of leaflets (*C. simplifacta*, *C. rossicorum*, and *C. latifolia*). The three species traditionally recognized in *C.* ser. *Coriaceae* that are not included in Clade D are placed elsewhere in the large Clade A, which is composed also by species partially from *C.* sect. *Chamaecrista* and partially from *C.* sect. *Xerocalyx*. *Chamaecrista caribaea* is placed in the Clade B, closely related to *C. nictitans*, *C. lineata* and *C. repens* (*Chamaecrista* sect. *C.* ser. *Chamaecrista*). *C. roraimae* is most related to *C. calycioides* (*C.* sect. *Caliciopsis*), and *C. venulosa* to *C. supplex* (*Chamaecrista* ser. *Prostratae*).

Table 2. Summary of data for *Chamaecrista:* morphological data, sequence characteristics of the *trnD-T*, *trnL-F*, ETS and ITS markers, and models applied in the Bayesian analyses for each molecular partition.

	trnL-F	**ITS1/ ITS5.8S/ITS2**	**Combined (*trnL-F* + ITS)**	***trnD-T***	**ETS**	**Morphology**	**Combined (cpDNA+ nDNA)**	**Combined (molecular + morphology)**
	BS / NS	BS / NS	BS	NS	NS	NS	NS	NS
No. of samples of *C.* ser. *Coriaceae*	44 / 44	33 / 35	33	39	44	36	36	36
No. of samples of outgroups	47 / 10	49 / 9	45	10	11	10	10	10
Total of samples	91 / 54	82 / 44	78	49	55	46	46	46
No. of bp in alignment or characters	1056	914	1971	1121	519	27	3470	3470
No. of indels coded (simple coding)	92 / 68	256 / 131	346	31	85	_	315	315
No. total of characters (bp + indels coded)	1148 / 1124	1170 / 1045	2316	1152	604	27	3785	3785+27
No. of variable characters	179 / 130	295 / 238	474	77	156	1	637	637
No. of PI characters	125 / 51	582 / 307	692	51	242	26	585	612
CI, RI, **tree length**	0.8213, 0.9113, **403** / 0.9135, 0.8696, **208**	0.4805, 0.8139, **2524** / 0.7327, 0.7014, **1040**	0.5875, 0.8185, **2902**	0.8947, 0.9144, **152**	0.7017, 0.7862, **771**	0.4732, 0.7108, **112**	0.7441, 0.7008, **2145**	0.7205, 0.6984, **2290**
ILD teste *P* value	NA	NA	*P*= 0.921	NA	NA	NA	*P*= 0.644	NA
Nucleotide substitution model	TVM+G	TIM3+G/ JC+G / TIM2+G	MIXED	TIM1+I	TIM2+G	NA	MIXED	MIXED
Support for *Coriaceae s.s.* clade	BS / NS	BS / NS	BS	NS	NS	NS	NS	NS
Boostrap – Parsimony	92 / 90	<50 / 51	79	94	<50%	100*	99	99
Posterior Probability – Bayesian	0.84 / 0.81	0.0 / 0.0	0.92	0.99	0.0	NA	1	1
Decay Index – Parsimony	NA	NA	NA	NA	NA	5*	NA	NA

CI consistency index; PI, parsimony-informative; RI, retention index; BS, Broad sampling; NS, Narrow sampling; NA= non-applicable.

* Support resulted from analysis using only one species as outgroup (*C. flexuosa*)

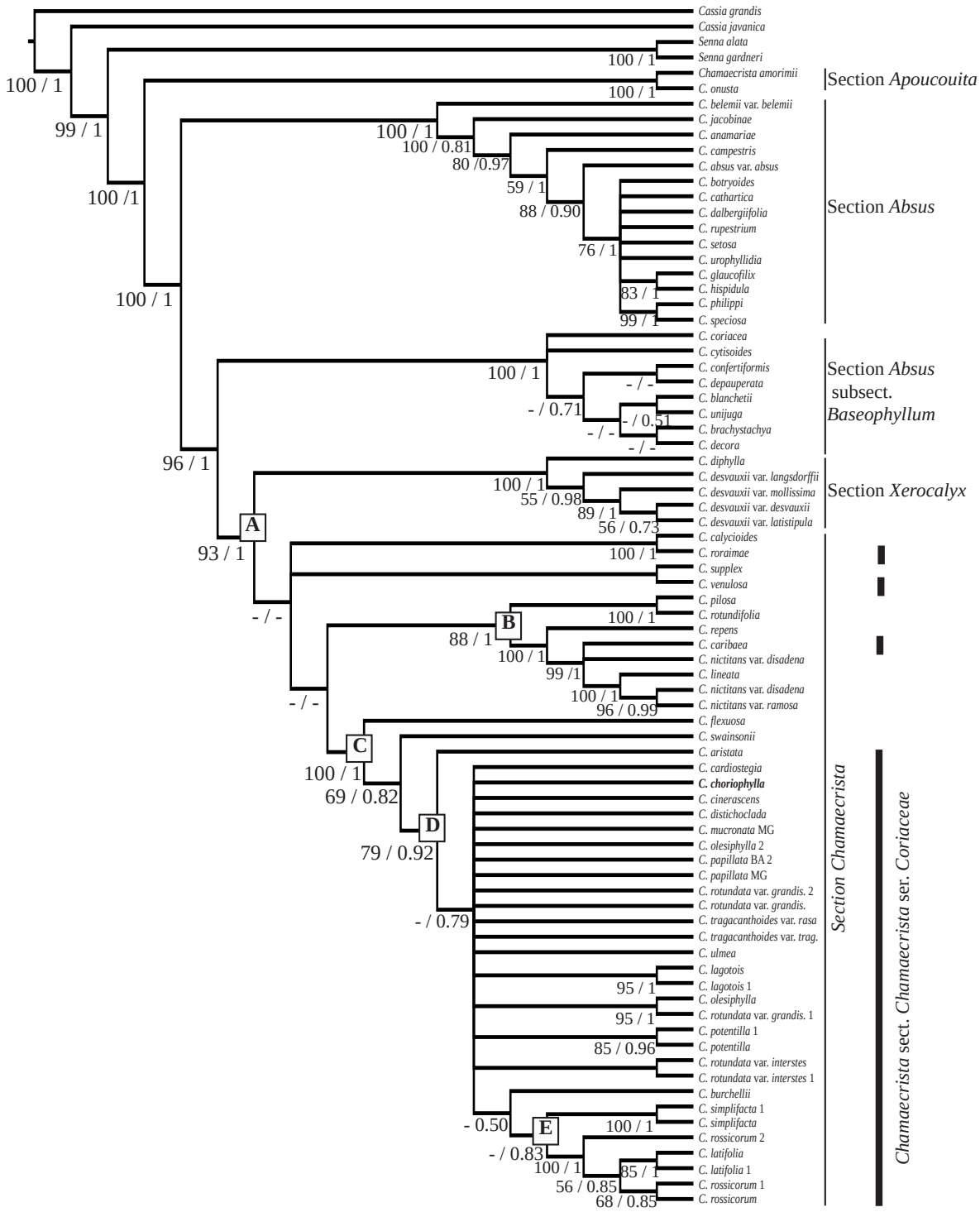

Figure 2. Broad sampling of *Chamaecrista*: strict consensus tree resulting from the combined datasets (ITS/5.8S and *trnL*-F). Numbers above branches are bootstrap support (BS) values and posterior probability (PP) for the clades that also emerged in the Bayesian analyses. Clades with capital letters are discussed in the text. *C. choriophylla*, the type-species of *C.* ser. *Coriaceae*, is in bold. At the right side the taxonomic groups recognized by Irwin & Barneby (1982), including *C.* ser. *Coriaceae*. Support: Bootstrap / Posterior probability.

Narrow sampling

Analyses of plastids region: *trnD*-T and *trnL*-F (Figure 3) **–** The topologies obtained from both plastid regions recovered a *Coriaceae s.s.* clade (Clade D) with high support, and the only three species traditionally recognized within *C.* sect. *Chamaecrista* ser. *Coriaceae* (*C. caribaea*, *C. roraimae* and *C. venulosa*) that do not emerged in that clade D are placed in Clade C. Parsimony and Bayesian analyses for *trnD*-T and *trnL-F* exhibit similar topology. *trnD-T* exhibits the highest support values of bootstrap and posterior probability (BS=94 / PP=1) for the *Coriaceae s. s.* clade, and also exhibits better resolution inside the *Coriaceae s. s*. clade compared with *trnL*-F. In the strict consensus tree (PA) of *trnD-T* region, the series *Coriaceae s. s.* clade emerged as sister group of a clade formed by species from *C.* ser. *Flexuosae* (*C. flexuosa* + *C. swainsonii*), however with low support of bootstrap and posterior probability (BS=<50 / PP=0.87). Parsimony and Bayesian analyses for *trnL*-F also exhibit a similar topology, without resolution for the relationships of the *Coriaceae s. s.* clade, and any internal resolution within species. Node D is the only bootstrap well supported node in *trnL*-F, with values of BS=89 / PP=0.81. For both spacer markers, there are deletions of base pairs exclusive to species of *Coriaceae s. s.* clade. For example, in the *trnD*-T region it is inferred a deletion of eight base pairs (GAGGGATA, position 883-891) and for *trnL*-F a large indel of ca. 260 bp (position 611-1017) that we were able to recognize even in eletrophoresis gel of the PCR products (figure 4).

Analyses of nuclear region: ETS and ITS (Figure 5) – Analysis of both regions provide additional evidence that the three species traditionally recognized in *C.* ser. *Coriaceae* (*C. caribaea*, *C. roraimae* and *C. venulosa*) do not belong in the clade with the bulk of the series. The relationships recovered for the three species, as well as for species of other series, are the same obtained from the studied plastid regions. The results of Maximum parsimony and Bayesian analyses for ETS exhibit some differences on the topologies: in the strict consensus tree (PA) the *Coriaceae s. s.* clade appears as a monophyletic group (Clade D), but with low support of bootstrap (BS=<50), and in the majority consensus tree (BA) it is a paraphyletic group with *C. aristata*, *C. flexuosa*, *C. swainsonii* and a clade with the remaining species of the series forming a polytomy. However, the ETS region shows a better resolution inside the clade, grouping several species in two main groups, Clades E and F. The results from ITS region are similar, with low bootstrap support (BS=51) for the clade comprising *Coriaceae s. s.* in the strict consensus tree (PA), and *Coriaceae s. s* included in a polytomy with species of other series in the majority consensus tree (BA). The ITS region shows some resolution inside the clade, grouping species in the Clade E.

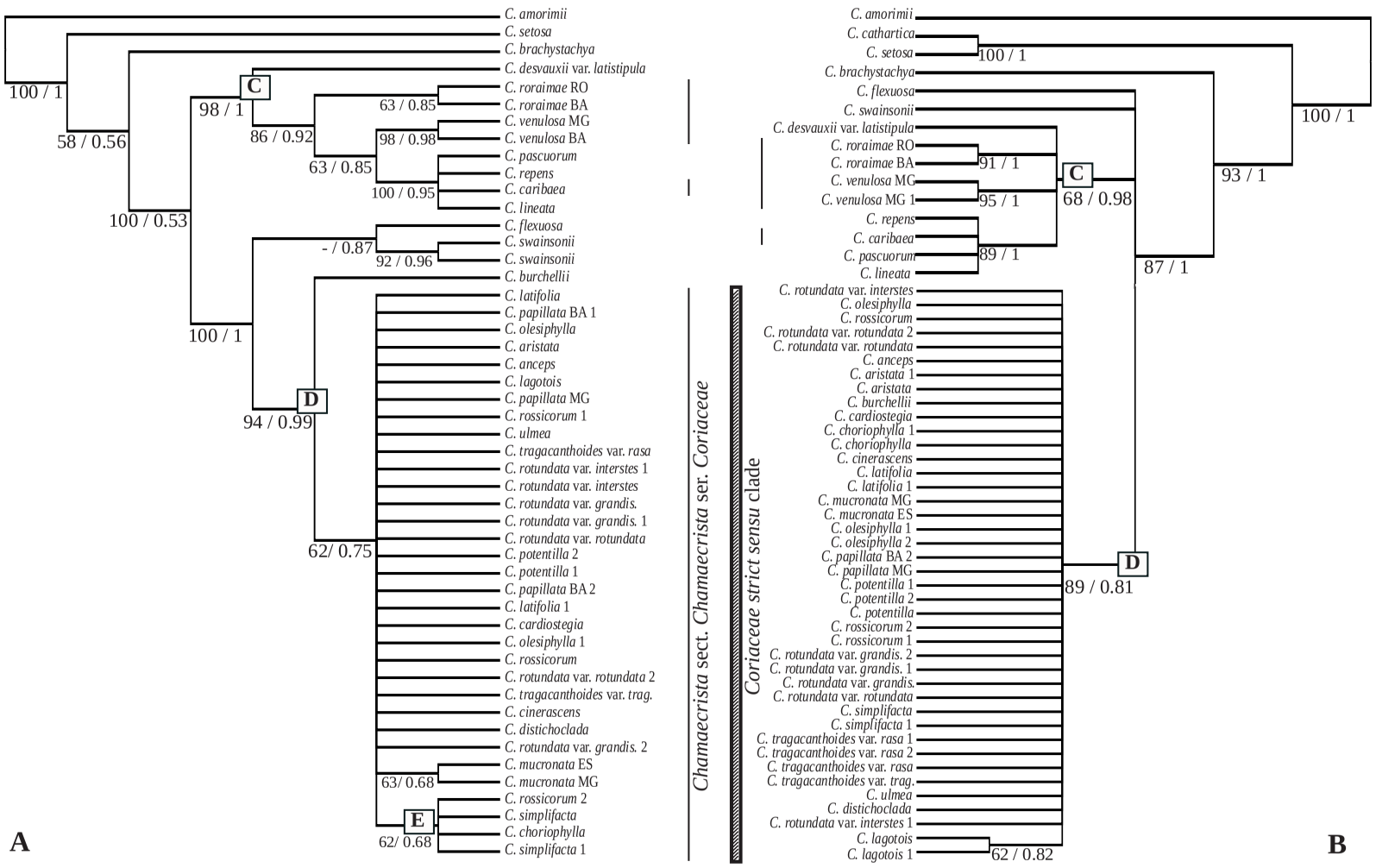

Figura 3. Narrow sampling of *Chamaecrista*: strict consensus trees resulting from the cpDNA datasets, **A.** *trnD-T* and **B.** *trnL-F*. Numbers above branches are bootstrap support (BS) values and posterior probability (PP) for the clades that also emerged in the Bayesian analyses. Clades with capital letters are discussed in the text. In the centre the traditionally circumscription of *C.* ser. *Coriaceae* (Irwin & Barneby 1982), and the *Coriaceae strict sensu* clade. Support: Posterior probability / Bootstrap

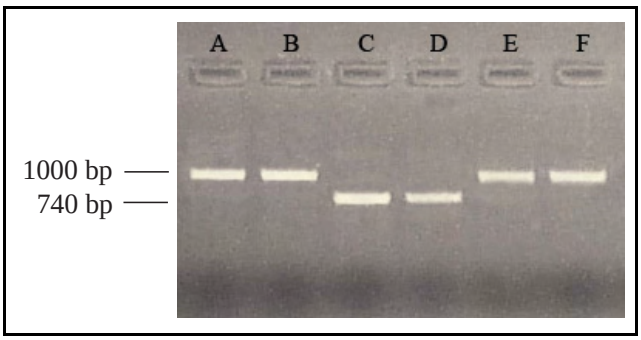

Figure 4. Eletrophoresis of PCR products in 1.0% agarose gel showing the species of *Chamaecrista* ser. *Coriaceae* with shorter sequences than other species of *Chamaecrista* in the *trnL*-F (deletion of ca. 260 bp). **A.** *C. supplex* (Mart. ex Benth.) Britton & Rose ex Britton & Killip (*Chamaecrista* sect. *Chamaecrista* ser. *Prostate*); **B.** *C. brachyrachis* (Harms) H.S.Irwin & Barneby (*C.* sect. *Absus*); **C.** *C. anceps* and **D.** *C. tragacanthoides* (*C.* sect. *Chamaecrista* ser. *Coriaceae*); **E.** *C. paniculata* (Benth.) H.S.Irwin & Barneby and **F.** *C. decumbens* (Benth.) H.S.Irwin & Barneby (*C.* sect. *Absus*).

Combined analysis for molecular and morphological data sets: *trnD*-T, *trnL*-F, ETS, ITS and morphology (Figure 6) **–** As the ILD test revealed no detectable incongruence among the molecular data partitions (*P*=0.644), all datasets were merged, including the morphological data. In all analyses the *Coriaceae s. s.* clade (Clade D) receives strong support as a monophyletic group (BS=99 / PP=1). The majority-rule consensus tree derived from Bayesian analysis shows to be better-resolved than the strict consensus tree (PA). In the strict consensus tree (PA) the collapsed branches correspond to the relationships with low support in BA analysis. *Chamaecrista caribaea*, *C. roraimae* and *C. venulosa*, as in all analyses done in combined datasets also seem to be more closely related to other species included in *C.* sect. *Chamaecrista* (Clade C) than to the *Coriaceae* s. s. clade. The sister-group is formed by species of *C.* ser. *Flexuosae*. In the BA and MP analyses, *Coriaceae s. s.* clade + *C.* ser. *Flexuosae* appear as sister-groups with high support (BS=100 / PP=1). The majority-rule consensus tree (BA) exhibits two main clades inside the *Coriaceae s. s.* clade, grouping plants with bifoliolate leaves (Clade E) as opposed to plants with multifoliolate leaves (Clades F), but the relationship between Clades E and F has low support (BS=68, PP=0.78). Within the Clade F, two other clades arise, G and H, both with low support.

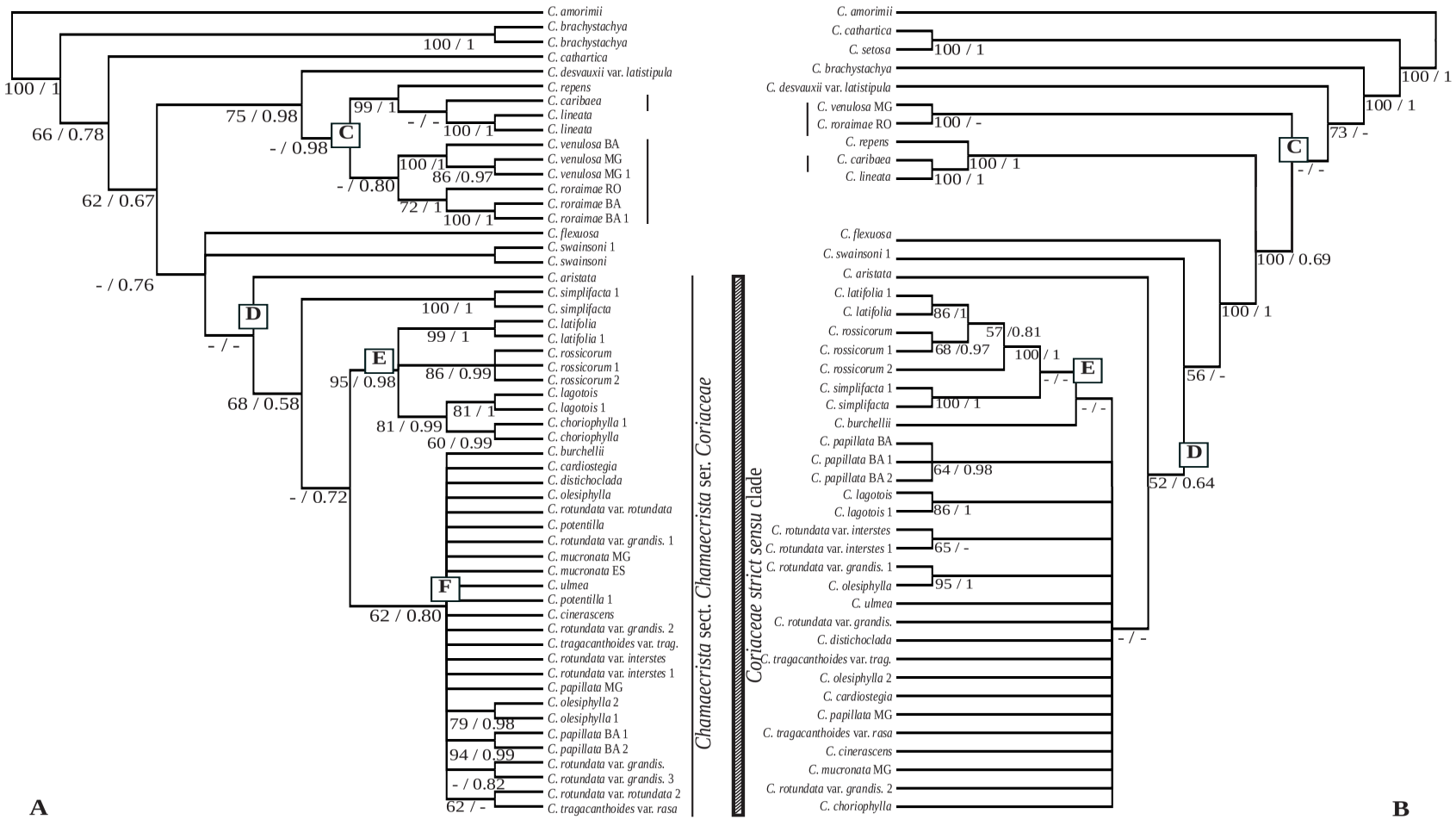

Figura 5. Narrow sampling of *Chamaecrista*: strict consensus trees resulting from nDNA datasets: **A.** ETS and **B**. ITS/5.8S. Numbers above branches are bootstrap support (BS) values and posterior probability (PP) for the clades that also emerged in the Bayesian analyses. Clades with capital letters are discussed in the text. Support: Bootstrap / Posterior probability.

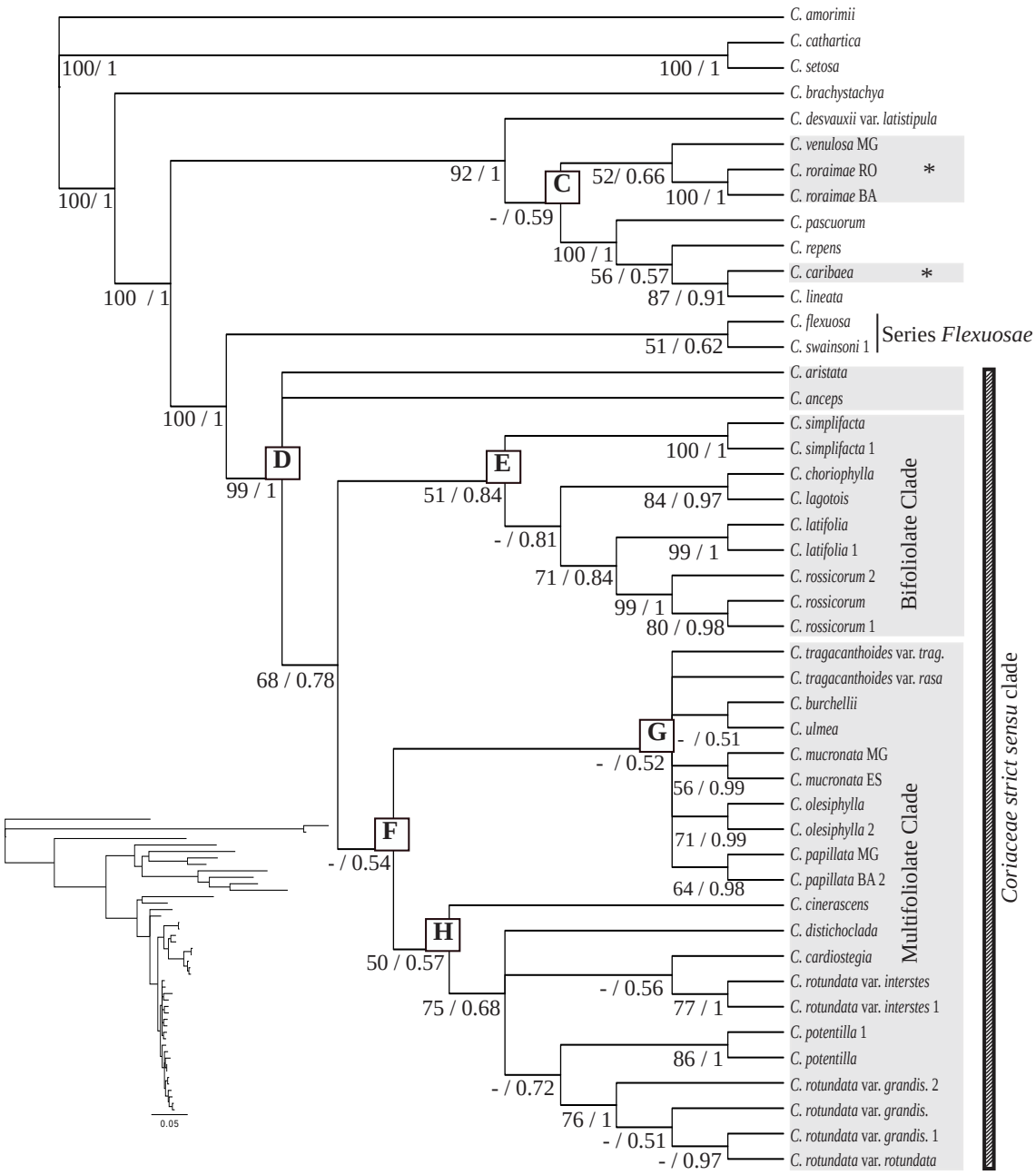

Figura 6. Narrow sampling of *Chamaecrista*: Majority-rule consensus tree with transformed branches derived from Bayesian analysis of the combined dataset (ETS, ITS, *trnd-T*, *trnl-F* and morphology), tree with real length of branches in the left side. Numbers above branches are bootstrap support (BS) values for the clades that also emerged in the Maximum Parsimony analysis, and after the posterior probability (PP). * Species traditionally recognized in *C.* ser. *Coriaceae*. Clades with capital letters are discussed in the text. Support: Bootstrap / Posterior probability.

Morphological evolution

Reconstructions performed with parsimony and maximum likelihood criteria did not exhibit significant differences, thus we opted to assume the parsimony reconstruction to present our results. Of the 27 characters used in the reconstruction, the transition of two (characters 2 and 26) appeared as evidence of putative synapomorphies for the *Coriaceae s. s.* clade: the presence of a woody rootstock (xylopodium), and the particular position of the stamens (Figure 7). Within the *Coriaceae s. s.* clade the transition of six characters appeared as informative (Figure 8): 1, 6, 12, 17, 18 and 22. The character 6 (Forked branches in the median region or close to apex) is a potential synapomorphy of the clade H without *C. cinerascens* and with a reversion in *C. cardiostegia*. The character 12 (Stipule position) also included the same species of character 6, now including *C. cardiostegia*, however this character is homoplastic appearing in others lineages. The multistate character 18 (Venation pattern of leaflets) show the state 18' as another probable synapomorphy of clade H appearing in all its species, and being homoplastic with *C. desvauxii* var. *latistipula* (*Chamaecrista* sect. *Xerocalyx*). The transition of characters 1, 17 and 22 are putative synapomorphies of the Clade E, however only the transition of the character 17 is exclusive (bifoliolate leaves). The character 1 (decumbent habit) and 22 (inflorescence frondose-bracteate) are homoplastic within the *Coriaceae s. s.* clade. The presence of a decumbent habit shows a reversion in *C. lagotois* and a parallel evolution in *C. anceps*, and the presence of inflorescence frondose-bracteate is likely to have independently evolved in *C. aristata* and *C. cardiostegia*.

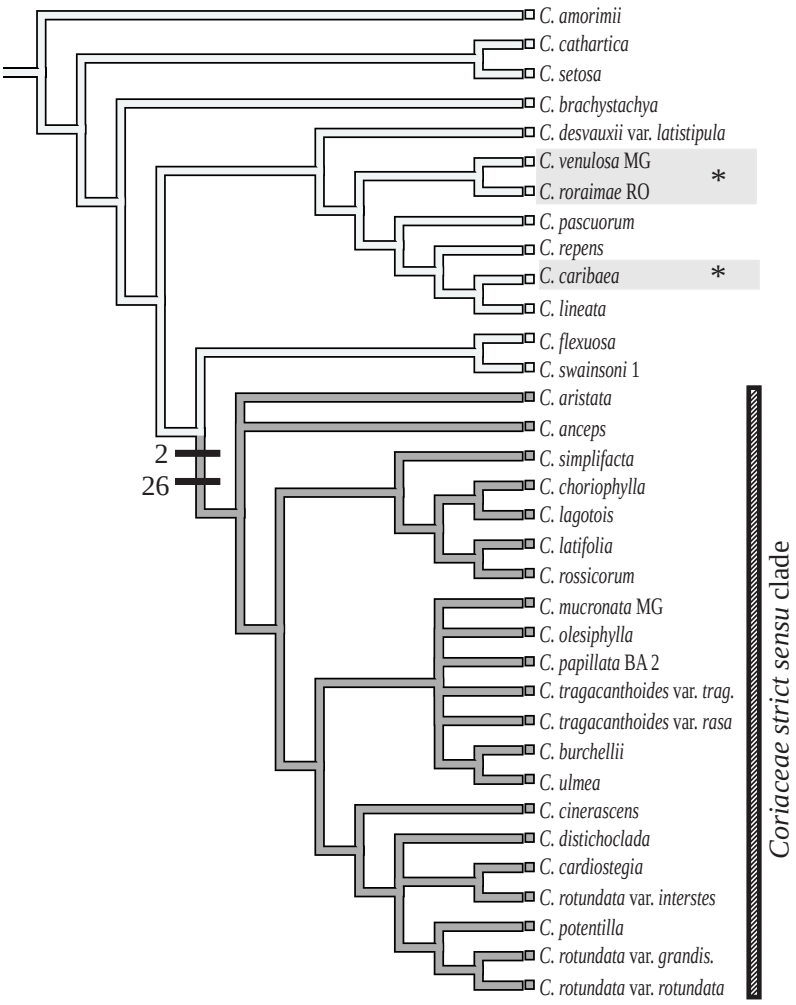

Figure 7. Ancestral-state reconstruction of two selected morphological characters in *Chamaecrista*. Branches are coloured according to the parsimony reconstruction. Transition 2 - Woody rootstock (xylopodium), white=absent, gray=present; Transition 26 - Stames position, white=all together, gray=one stamen displaced at the same side of gynecium. More details for the characters and states of characters selected see Appendix 3 and 4.

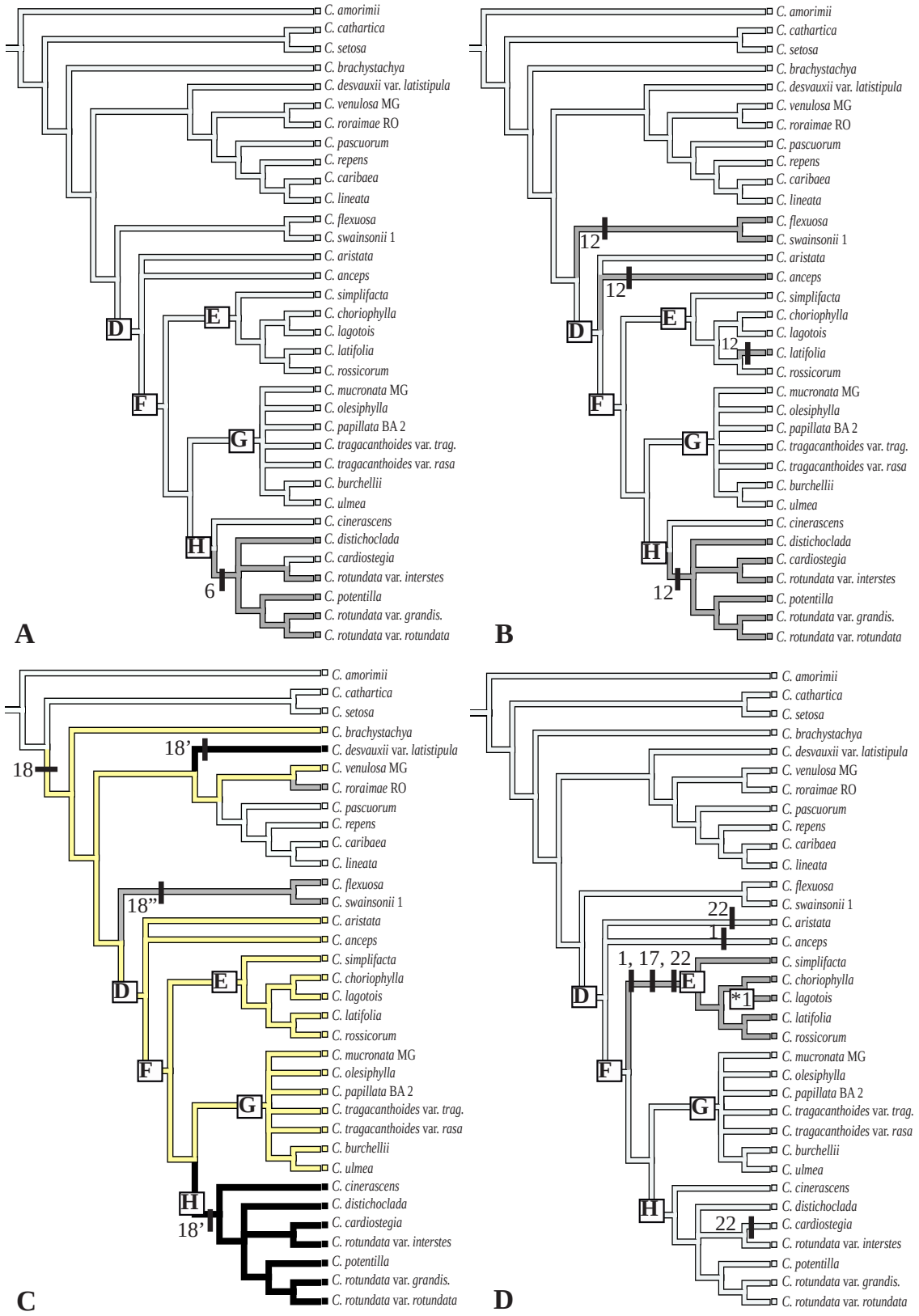

Figure 8. Ancestral-state reconstruction of six selected morphological characters in *Chamaecrista*. Branches are coloured according to the reconstruction under the parsimony criterium. **A.** Transition 6 – Forked branches, white=absent, gray=present; **B.** Transition 12 – stipule position, white=erect and adpressed to the branch, gray=perpendicular to the branch; **C.** Transition 18 – pattern of leaflet

venation, white=penninerved, gray=palmately veined, in this case 3 - 4 veins with apical anastomosis, yellow=palmately veined, in this case 3 - 4 veins without apical anastomosis, black=palmately veined, with more than 4 veins, without apical anastomosis; **D.** Transition 1 – Habit, gray= decumbent shrub, white=other types; Transition 17 – number of leaflets, white= 2 to 62 pairs, gray=only 1 pair; Transition 22 - Inflorescence type, white=other types, gray=terminal frondose-bracteate raceme. Parallel evolution in *C. anceps*, *C. aristata* and *C. cardiostegia*, and a reversion in *C. lagotois*. More details for the characters and states of characters selected see Appendix 3 and 4.

Discussion

All four molecular markers (*trnD-T*, *trnL-F*, ETS, ITS) and the morphological data analysed provide strong evidence that *Chamaecrista* sect. *Chamaecrista* ser. *Coriaceae* is a monophyletic group only under the exclusion of three species traditionally recognized within the series: *Chamaecrista caribaea*, *C. roraimae* and *C. venulosa*. Previous evidence for monophyly of the group (Conceição et al. 2009) was based on analysis including just four species of the series, and none of those three species now shown as not closely related to *C.* ser. *Coriaceae*. The broad analysis shows the *Coriaceae s. s.* clade in a phylogenetic position similar to the one presented by Conceição et al. (2009): closely related to other species traditionally recognized either in *C.* sect. *Chamaecrista* and in *C.* sect. *Xerocalyx*, and having as sister-group *C. swainsonii* (*C.* sect. *Chamaecrista* ser. *Flexuosae*). These results suggest that the circumscriptions of several other traditional sections and series in *Chamaecrista* shall be reevaluated.

Topologies obtained from all spacer markers analyzed, excepted the *trnL*-F region, show a clade that emerges within the *Coriaceae s. s.* clade, formed by species bearing only one pair of leaflets (*C. choriophylla*, *C. lagotois*, *C. latifolia*, *C. rossicorum* and *C. simplifacta*). The narrow and combined analyses show a better resolution inside the *Coriaceae s.s.* clade, however the characters added were not enough to resolve completely the relationship among these species. Remarkably, the narrow and combined dataset exhibit some patterns consistent with the morphology observed in the group. The ancestral-state reconstruction for 27 morphological characters here performed using the combined tree, revealed that it is possible to recognized two possible morphological synapomorphies for the *Coriaceae s. s.* clade, beyond two molecular synapomorphies detected. Despite presenting internal low supported clades, some tendency of character evolution could be explored within the *Coriaceae s. s.* clade. Below, we summarize all major results of the present study, as well as discuss implications for the taxonomy of *Chamaecrista* sect. *Chamaecrista* ser. *Coriaceae.*

Major considerations of plastid regions

The series *Coriaceae s. s.* (Clade D) clade emerged in all datasets, though with a higher support with the plastid data than with the nuclear ones. The earliest diverging lineage within the *Coriaceae s. s.* clade in the *trnD-T* tree is *Chamaecrista burchellii* (Figure 3). This hypothesis could be relevant, because *C. burchellii* is the only one species that occurs outside of the Espinhaço Range of mountains, being restricted to a small area in Goiás state (Niquelândia locality). However this divergence of *C. burchelli* as related to the remaining species of the *Coriaceae s. s.* clade has low support of bootstrap and posterior probability (BS=62 / PP=0.75), probably being supported by fell or a single base pair in the sequence of *trnD-T*. In the *trnD*-T tree there is also a polytomy (Clade E) inside the *Coriaceae s. s.* clade including three species (*C. choriophylla*, *C. rossicorum* and *C. simplifacta*). The Clade E includes three of the five species with only one pair of leaflets (bifoliolate species) known in *C.* ser. *Coriaceae*. Three different specimens of *C. rossicorum* were sampled in this analysis, but only one of the accessions appeared in this little group. The support in this clade is also low, since it is hold by a single base pair. The exclusion of the three species previously discussed (*C. caribaea*, *C. roraimae* and *C. venulosa)* from *C.* ser. *Coriaceae* is here strongly supported. In this analysis *C. caribaea* emerges closely related to *C. repens*, *C. pascuorum* and *C. lineata* (Clade C, BS=100 / PP= 1), species belonging in *C. ser. Chamaecrista*. These four species share some similarities in the morphology of flowers and a particular venation of leaflets (palmate veins). The *trnL*-F tree resulting from MP analysis presents a high bootstrap support (BS=89) for *Coriaceae s. s.* clade, but do not exhibit a good value for posterior probability (PP=0.81). Due to a large indel present in spacer marker *trnL*-F (with about 260 pb missing) exclusive to species of *Coriaceae s. s.* clade, the coding gaps performed in the matrix were very important to improve the support in the PA analysis, on the other hand for BA analysis it seems to make no difference. In BA analysis *C. flexuosa* appears inside the *Coriaceae s. s.* clade. The deletions present in these two spacers, *trnD-T* and *trnL-F*, are considered here as molecular synapomorphies of the *Coriaceae s. s.* clade. In both analyses the *trnL*-F trees shows a totally unresolved internal topology for the *Coriaceae s. s.* clade. The topology related to outgroups as well the three species traditionally recognized in *C.* ser. *Coriaceae* is exactly the same of that found in the *trnD*-T trees, also with high support.

Major considerations of nuclear regions

The nuclear regions produced lower supports to the *Coriaceae s. s.* clade than plastid regions did; however they provided much better internal resolution. The earliest diverging lineage within the *Coriaceae s. s.* clade for both markers is *Chamaecrista aristata,* a species restricted to a small and isolated geographic region (Grão-Mogol and Serra do Cabral, Espinhaço Range, northern Minas Gerais state). In fact this species share some base pairs with the potentially sister-group (*C. flexuosa* and/or *C. swainsonii*) and also present several molecular autopomorphies. The main reason for the low support of the *Coriaceae s. s.* clade found in both nuclear regions is the relationships with *C. aristata, C. flexuosa,* and *C. swainsonii*. The two latter are traditionally considered as members of *C.* sect. *Chamaecrista* ser. *Flexuosae*. The support for species of *C.* ser. *Flexuosae* + *Coriaceae s. s.* clade is high for bootstrap and is not good for posterior probability for ITS (BS=100 / PP=0.76) and unlike for ETS (BS=68 / PP=0.76). These two species of *C.* ser. *Flexuosae* do not always appear together, forming a clade. In the most cases *C. flexuosa* and *C. swainsonii* emerged in an unclear relationship, or *C. swainsonii* more closely related to the *Coriaceae s. s.* clade than to *C. flexuosa*. Accepting the *Coriaceae* s. s. clade as a monophyletic group only based in nuclear regions would turn *C.* ser. *Flexuosae* a paraphyletic group. Although this latter series comprises five species, only two were sampled in our analysis. Both series are usually differentiated by the pattern of leaflets venation, presence or absence of xylopodium and of geniculate stems (Irwin & Barneby 1982). In our studies an additional character was found that help recognize these series apart: the particular stamens position in species of the *Coriaceae s. s.* clade.

The ETS strict consensus tree shows the *Coriaceae s. s.* clade (Clade D) with low support. Inside Clade D we may recognize two main clades: the Clade E, which comprises part of species with only one pair of leaflets, highly supported (BS=95 / PP= 0.97); and the Clade F, comprising the species with two or more pairs of leaflets, with low support (BS= 62 / PP=0.80) and no internal resolution. The Clade E comprises four of five bifoliolate species (excepting *C. simplifacta*), forming a tritomy among *C. latifolia, C. rossicorum* and a clade formed by *C. choriophylla* + *C. lagotois*. The ITS data also recovered a clade of bifoliolate species inside the *Coriaceae s. s.* clade, but here *C. latifolia* appear closely related to *C. rossicorum* (BS=100 / PP=1), and on another level related to *C. simplifacta,* with low support (BS=<50). However, in the ITS tree *C. choriophylla* does not appear in the clade of bifoliolate species; instead it emerges in the basal polytomy of the *Coriaceae s. s.* clade. Finally it is noteworthy that in the ITS tree the three accessions of *C. papillata* from Bahia state appear together while the accession from Minas Gerais emerges elsewhere.

Combined data – taxonomic implications, synapomorphies and evolution

The combined data set shows the highest support for the *Coriaceae s. s.* clade (BS = 99 / PP = 1). Our limited taxon sampling of species from *C.* ser. *Flexuosae* does not allow us to make conclusive remarks about its relationships to the *Coriaceae s. s.* clade. But, considering several molecular and morphological characters exclusive to species of the *Coriaceae s. s.* clade, it is likely that *C.* ser. *Flexuosae* is its sister-group, corroborating previous results (Conceição et al. 2009).

Chamaecrista sect. *Chamaecrista* ser. *Coriaceae* can only be recognized as a monophyletic group after exclusion of the three species (*C. caribaea*, *C. roraimae* and *C. venulosa*) that now emerged nested among the basal most lineages of *C.* sect. *Chamaecrista* (Figure 6). The former circumscription of that series (Irwin & Barneby 1982) includes species with shrubby habit, presence of a xylopodium, thick-textured leaflets, exactly axillary peduncles and extrafloral nectaries. During field work and herbarium studies, we observed that even though characters like the shrubby habit, the axillary peduncles and the extrafloral nectaries do occur in all species of the series, they are also present in other species of other sections in *Chamaecrista.* On the other hand, we noticed that leaflets texture is very variable among the species inside the series, and the presence of xylopodium cannot be definitely ascribed to certain species lacking field observations or incomplete herbarium material. Unfortunately, Irwin & Barneby (1982) generalized the presence of xylopodium to all taxa in the series as originally circumscribed. Here we provide good evidence that the xylopodium is restricted to the *Coriaceae s. s.* clade, lacking in the three species that emerged elsewhere in the phylogeny. Finally, even though Irwin & Barneby (1982) considered that the morphology of the flower and the venation of the leaflets were not taxonomically relevant in this group, our results demonstrate they constitute very important characters.

Chamaecrista caribaea is nested within a group traditionally recognized by the peduncles adnate to the stems (*C.* sect. *Chamaecrista* ser. *Chamaecrista*), a feature not observed in *C. caribaea* neither in *C. lineata*, another species from the Bahamas – Central America region. Both species share a particular flower morphology: a heteromorphic androecium and a labellum-like petal (Figure 9. A). These Caribbean species also present a particular venation of leaflets and no evident xylopodium (Figure 9. H). Their leaflet venation is very similar to that of *C. pascuorum*, *C. repens* and *C. nictitans*, which appeared closely related in all our analyses. *Chamaecrista roraimae*, from northern Brazil, also lacks a xylopodium and displays a particular flower structure, with a homomorphic androecium and no differentiated petal (Figure

9. B). *Chamaecrista venulosa* exhibits the same distribution pattern of species of the *Coriaceae s. s.* clade, i.e. restricted to the Espinhaço Range in *campo rupestre* vegetation. However, *C. venulosa* has evident nodulated roots (no xylopodium), and a floral structure different from the *Coriaceae s. s.* clade (Figure C). The species included as outgroup in the narrow sampling analyses did not contribute for a good placement of *C. roraimae* and *C. venulosa*. However, in the broad analysis the placement of these two species is elucidated: *C. roraimae* emerges as closely related to *C. caliciopsis*, which traditionally constituted a monospecific section (*C.* sect. *Caliciopsis*), while *C. venulosa* emerges closely related to species of *C.* sect. *Chamaecrista* ser. *Prostratae*.

Several deletions observed in cpDNA, exclusive to species of the *Coriaceae s. s.* clade, are likely to configure as molecular synapomophies of this clade. Moreover, the following morphological characters also support the monophyly of the *Coriaceae s. s.* clade: (1) the presence of a xylopodium, and (2) the peculiar flower structure. The presence of xylopodium is recurrent in *Chamaecrista*, mainly in species of *C.* sect. *Absus* occurring in *cerrado* and *campo rupestre* vegetation. A special underground system like this probably evolved independently in distinct lineages of the genus, during their specialization to life – in the *cerrado* and *campos rupestres* habitats. However within *C.* sect. *Chamaecrista* (composed by ca. 52 Brazilian spp.) species bearing evident nodulated roots but no developed underground system prevail, and the *Coriaceae s. s.* clade is the only group consistently producing xylopodia. Nevertheless, it is known that the xylopodium is a complex underground structure, whose morphological nature, anatomy and ontogeny are still poorly known for most families (Appezzato-da-Gloria 2003), and there is no detailed study available for *Chamaecrista*. Overall morphological similarities like “thick underground system” actually may not be a confident evidence of homology in *Chamaecrista*, where anatomical and developmental studies are thus necessary. The floral structure also shows another possible non-homoplastic synapomophy of the *Coriaceae s. s.* clade: one stamen is displaced at the same side as the gynoecium, and away from the other stamens (Figure 9). This floral pattern is not observed in the remaining Brazilian species of *Chamaecrista*, and only the endemic Mexican *C. chamaecristoides* (Collad.) Greene presents a similar configuration, but in a consistently heteromorphic androecium (Arceo-Gomes et al. 2012).

The BA analysis provided a better-resolved relationship within the *Coriaceae s. s.* clade. Despite some relationships have low support, we consider this a better hypothesis to discuss. Two major groups appear well defined within the *Coriaceae s.s.* clade: the “Bifoliolate clade” (E), composed by species with only one pair of leaflets (Figure 9. I); and the “Multifoliolate

Clade” (F), composed by plants with two or more pairs of leaflets (Figure 9. J). The Clade E appeared in almost all our analyses excepted for the *trnL-F* one. In each spacer marker some bifoliolate species are grouped, but not all of them, while in the combined analyses, including the morphological matrix, all bifoliolate species form a clade. The reduction of the number of leaflets is this case seems a putative synapomorphy. Other morphological characteristics observed in clade E are the decumbent habit, with a reversion in *C. lagotois* (erect habit) and also appearing in *C. anceps*, and a particular type of inflorescence. A terminal frondose-bracteate inflorescence, characterized by several axillary flowers placed at the distal part of branches bearing reduced leaves, occurs in all species of Clade E. The presence of a similar frondose-bracteate inflorescence in *C. aristata* and in *C. cardiostegia* shall probably represent a homoplasy. The Clade F (Multifoliolate Clade) was also recovered in the ETS tree (BS=62 / PP= 0.81), however in the combined analysis of BA it receives lower support (PP=0.55). In the combined analysis two other groups within the Clade F are found both morphologically recognized: the Clade G, grouping plants conserving symplesiomorphic characters as erect stipules with truncate base and the pattern of leaflet venation; and Clade H, grouping plants with synapomorphic characters as stipules perpendicular to the axis and leaflets with a particular palmate venation pattern (Figure 9. L). The relationships of *C. aristata* and *C. anceps* to the remaining speciesof the series is unclear. The former could probably be the first species diverging from the rest of the clade, but the position of *C. anceps* is uncertain. This latter species is rare, known only by four collections, similar to *C. cardiostegia* but with fewer leaflets.

The position of the stipules (erect and adnate to the branches x perpendicular to the branch) seems to be correlated with the size of the stipules. Large stipules are adnate to the branches only at the distal part of the branch providing an effective protection to young leaves, afterwards they gradually change their position to a completely perpendicular one or may turn deciduous (Figure 9. L). Large stipules protecting the apical branches is a common character observed in Cerrado plants of several families,probably related to protection against fire (Simon & Pennington 2012). Additionally, the change of stipule position along the branch might be related to the exposition of the extrafloral nectaries to the ants, in which large stipules adnate to the branches would initially prevent access by the insects. As stipules turn perpendicular to the axis, the extrafloral nectaries become available to the ants. Although, small stipules provide less protection against fire or predators, and do not change their position, so that in any moment they can represent an obstacle to the ants.

Finally both molecular and morphological data indicate that a new, narrow definition of *Chamaecrista* ser. *Coriaceae* is required in order to be recognized a monophyletic group, excluding three species as previously discussed. In this new circumscription would the *Coriaceae* group comprise 19 shrubby species bearing a xylopodium, androecium with a stamen displaced to the same side as the gynoecium, and away from the remaining stamens, all restricted to highland areas of central-eastern Brazil, mainly to *campo rupestre* vegetation. Even though the phylogeny produced here provides a great opportunity for a new circumscription of that group, further work is still necessary to improve the resolution and to achieve higher support for the groups within the *Coriaceae* s.s. clade, as well as a better understanding of the character evolution in the lineage. Analyses of time divergence and ancestral reconstruction in *Chamaecrista* show a recent divergence of the *Coriaceae s. s.* clade, in the late Quartenary (4 - 2 mya) and the most likely ancestral range being the campos rupetres (Chapter 3). The low resolution among species inside the clade could be a reflect of this recent radiation, a common pattern previously reported to others groups that are restrict to highland areas in South America (Hughes & Eastwood, 2006, Simon et al. 2009).

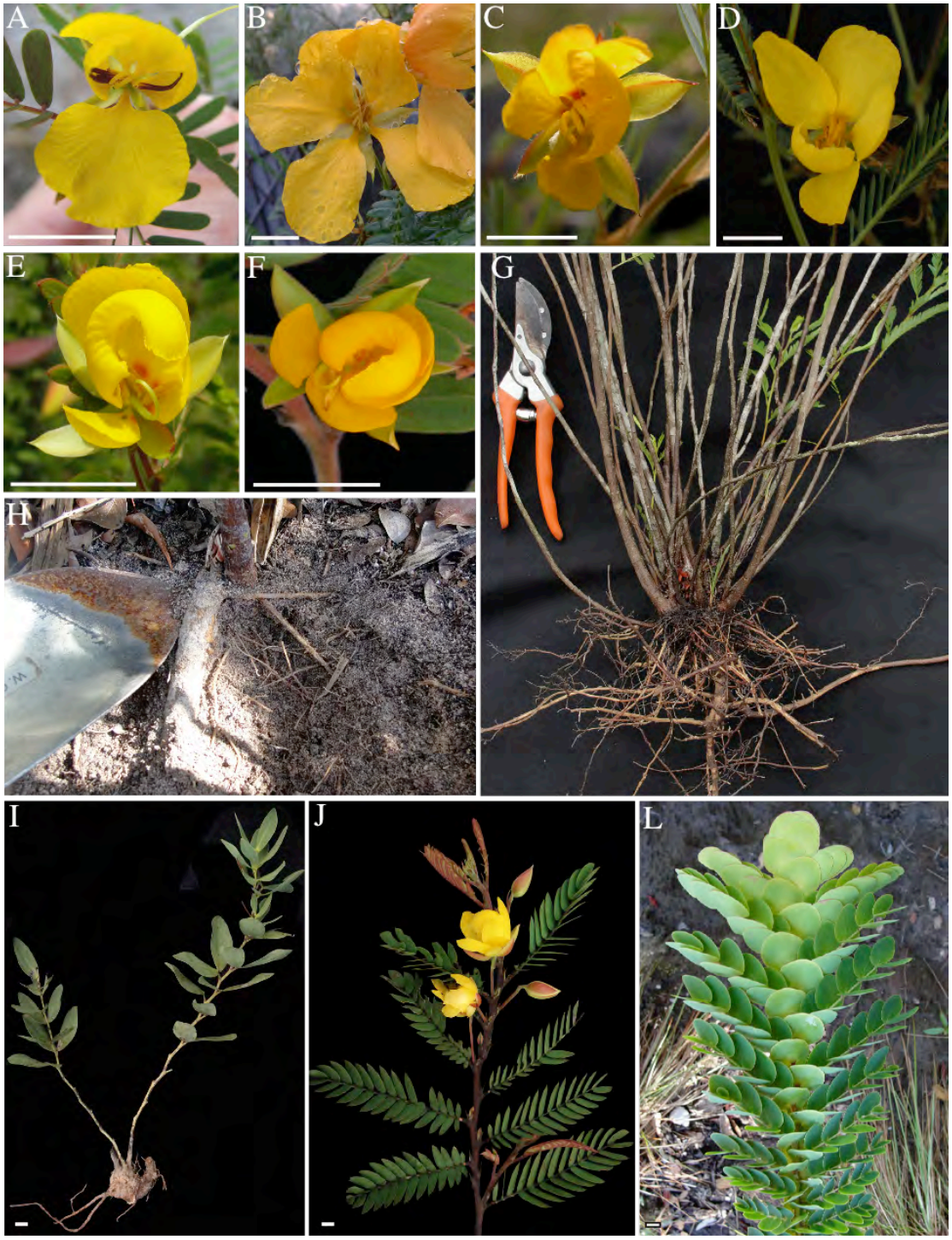

Figura 9. A, B, C, D, E and F - Differences in flower morphology in *Chamaecrista*. A. *C. lineata*, the same morphology of *C. caribaea*, biggest petal not curved and heteromorphic androecium; B. *C. roraimae*, no evident differentiated petal, homomorphic adroecium; C. *C. venulosa* and D. *C. flexuosa*, light curved petal, homomorphic androecium; E. *C. distichoclada* and F. *C. papillata*, strong curved petal, homomorphic androecium and one stamen displaced in opposite side of the rest. G and H - Underground structure. G. *C. caribaea* var. *lucayana*; H. *C. roraimae*; I. *C. choriophylla*. J. *C. olesiphylla*. L. *C. rotundata* var. *grandistipula*. Scale 1 cm.

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Appendix 1 (preliminary). Voucher information and GenBank accession numbers of the sequences included in this study. Sequences of GenBank are marked with asteristk (*).

Taxon; voucher, herbaria, origin, GenBank accession number for ITS/ETS/trnD-T/trnL-F.

INGROUP: ***Chamaecrista anceps*** (Benth.) H.S.Irwin & Barneby; *Cota 410;* Diamantina, MG; XXXXX/XXXXX/XXXXX/XXXXX. ***C. aristata*** (Benth.) H.S.Irwin & Barneby; *Rando 976;* Grão Mogol, MG; XXXXX/XXXXX/XXXXX/XXXXX. ***C. burchellii*** (Benth.) H.S.Irwin & Barneby; *Rando 1092;* Niquelândia, GO; XXXXX/XXXXX/XXXXX/XXXXX. ***C. cardiostegia*** H.S.Irwin & Barneby; *Rando 1125;* Delfinópolis, MG; XXXXX/XXXXX/XXXXX/XXXXX. ***C. caribaea* var. *lucayana*** (Britton) H.S.Irwin & Barneby; *Rando 963;* Great Exuma Island, Bahamas; XXXXX/XXXXX/XXXXX/XXXXX. ***C. choriophylla*** (Vogel) H.S.Irwin & Barneby; *Rando 907;* Santana de Pirapama, MG; XXXXX/XXXXX/XXXXX/XXXXX***C. choriophylla*** (Vogel) H.S.Irwin & Barneby; *Rando 1034;* Santana de Pirapama, MG; XXXXX/XXXXX/XXXXX/XXXXX. ***C. cinerascens*** (Vogel) H.S.Irwin & Barneby; *Rando 661;* Congonhas d Norte, MG; XXXXX/XXXXX/XXXXX/XXXXX. ***C. distichoclada*** (Benth.) H.S.Irwin & Barneby; *Rando 1230;* Diamantina, MG; XXXXX/XXXXX/XXXXX/XXXXX. ***C. lagotois*** H.S.Irwin & Barneby; *Rando 1029;* Santana do Riacho, MG; XXXXX/XXXXX/XXXXX/XXXXX. ***C. lagotois*** H.S.Irwin & Barneby; *Rando 1133;* Santana do Riacho, MG; XXXXX/XXXXX/XXXXX/XXXXX. ***C. latifolia*** (Benth.) Rando; *Rando 1024;* Santana do Riacho, MG; XXXXX/XXXXX/XXXXX/XXXXX. ***C. latifolia*** (Benth.) Rando; *Rando 1250;* Santo Antônio do Itambé, MG; XXXXX/XXXXX/XXXXX/XXXXX. ***C. latifolia*** (Benth.) Rando; *Rando 1127;* Santana do Riacho, MG; XXXXX/XXXXX/XXXXX/XXXXX. ***C. mucronata*** (Spreng.) H.S.Irwin & Barneby; *Rando 879;* Catas Altas, MG; XXXXX/XXXXX/XXXXX/XXXXX. ***C. mucronata*** (Spreng.) H.S.Irwin & Barneby; *Siqueira 825;* Linhares, ES; XXXXX/XXXXX/XXXXX/XXXXX. ***C. olesiphylla*** (Vogel) H.S.Irwin & Barneby; *Rando 632;* Congonhas do Norte, MG; XXXXX/XXXXX/XXXXX/XXXXX. ***C. olesiphylla*** (Vogel) H.S.Irwin & Barneby; *Rando 1147;* Diamantina, MG; XXXXX/XXXXX/XXXXX/XXXXX. ***C. olesiphylla*** (Vogel) H.S.Irwin & Barneby; *Van den Berg 1350;* Conceição do Mato Dentro, MG; XXXXX/XXXXX/XXXXX/XXXXX. ***C. papillata*** H.S.Irwin & Barneby; *Borba 1922;* Mucugê, BA; XXXXX/XXXXX/XXXXX/XXXXX. ***C. papillata*** H.S.Irwin & Barneby; *Rando 1109;* Palmeiras, BA; XXXXX/XXXXX/XXXXX/XXXXX. ***C. papillata*** H.S.Irwin & Barneby; *Rando 1011;* Jaboticatubas, MG; XXXXX/XXXXX/XXXXX/XXXXX. ***C. potentilla*** (Benth.) H.S.Irwin & Barneby; *Rando 814;* Diamantina, MG; XXXXX/XXXXX/XXXXX/XXXXX. ***C. potentilla*** (Benth.) H.S.Irwin & Barneby; *Rando 1139;* Serro, MG; XXXXX/XXXXX/XXXXX/XXXXX. ***C. potentilla*** (Benth.) H.S.Irwin & Barneby; *Rando 1245;* Diamantina, MG; XXXXX/XXXXX/XXXXX/XXXXX. ***C. potentilla*** (Benth.) H.S.Irwin & Barneby; *Queiroz 7606;* Diamantina, MG; FJ009859*/XXXXX/XXXXX/FJ009913*. ***C. roraimae*** (Benth.) Gleason; *Harley 55036;* Rio de Contas, BA; XXXXX/XXXXX/XXXXX/XXXXX. ***C. roraimae*** (Benth.) Gleason; *Rando 1154;* Amajari, RO; XXXXX/XXXXX/XXXXX/XXXXX. ***C. roraimae*** (Benth.) Gleason; *Rando 1154;* Amajari, RO; XXXXX/XXXXX/XXXXX/XXXXX. ***C. rossicorum*** (H.S.Irwin & Barneby) Rando; *Rando 1007;* Gouveia, MG; XXXXX/XXXXX/XXXXX/XXXXX. ***C. rossicorum*** (H.S.Irwin & Barneby) Rando; *Rando 1045;* Santana do Pirapama, MG; XXXXX/XXXXX/XXXXX/XXXXX. ***C. rossicorum*** (H.S.Irwin & Barneby) Rando; *Conceição 539;* Grão Mogol, MG; XXXXX/XXXXX/XXXXX/XXXXX. ***C. rotundata*** (Vogel) H.S.Irwin & Barneby; *Rando 1144;* Diamantina, MG;

XXXXX/XXXXX/XXXXX/XXXXX. ***C. rotundata* var. *grandistipula*** (Vogel) H.S.Irwin & Barneby; *Rando 994;* Diamantina, MG; XXXXX/XXXXX/XXXXX/XXXXX. ***C. rotundata* var. *grandistipula*** (Vogel) H.S.Irwin & Barneby; *Rando 1240;* Diamantina, MG; XXXXX/XXXXX/XXXXX/XXXXX. ***C. rotundata* var. *grandistipula*** (Vogel) H.S.Irwin & Barneby; *Rando 925;* Santana do Riacho, MG; XXXXX/XXXXX/XXXXX/XXXXX. ***C. rotundata* var. *interstes*** H.S.Irwin & Barneby; *Rando 1145;* Diamantina, MG; XXXXX/XXXXX/XXXXX/XXXXX. ***C. rotundata* var. *interstes*** H.S.Irwin & Barneby; *Rando 1236;* Diamantina, MG; XXXXX/XXXXX/XXXXX/XXXXX. ***C. rotundata* var. *rotundata*** (Vogel) H.S.Irwin & Barneby; *Van den Berg 1341;* Falta Localidade; XXXXX/XXXXX/XXXXX/XXXXX. ***C. rotundata var. rotundata*** (Vogel) H.S.Irwin & Barneby; *Van den Berg 1333;* Falta Localidade; XXXXX/XXXXX/XXXXX/XXXXX. ***C. simplifacta*** H.S.Irwin & Barneby; *Rando 1148;* Diamantina, MG; XXXXX/XXXXX/XXXXX/XXXXX. ***C. simplifacta*** H.S.Irwin & Barneby; *Rando 802;* Diamantina, MG; XXXXX/XXXXX/XXXXX/XXXXX. ***C. tragacanthoides* var. *rasa*** H.S.Irwin & Barneby; *Rando 969;* Grão Mogol, MG; XXXXX/XXXXX/XXXXX/XXXXX. ***C. tragacanthoides* var. *tragacanthoides*** (Benth.) H.S.Irwin & Barneby; *Pirani 6334;* Diamantina, MG; XXXXX/XXXXX/XXXXX/XXXXX. ***C. ulmea*** H.S.Irwin & Barneby; *Santos 650;* Itacambira, MG; XXXXX/XXXXX/XXXXX/XXXXX. ***C. venulosa*** (Benth.) H.S.Irwin & Barneby; *Snak 671;* Santana do Riacho, MG; XXXXX/XXXXX/XXXXX/XXXXX. ***C. venulosa*** (Benth.) H.S.Irwin & Barneby; *Rando 1256;* Rio de Contas, BA; XXXXX/XXXXX/XXXXX/XXXXX. ***C. venulosa*** (Benth.) H.S.Irwin & Barneby; *Rando 1015;* Santana do Riacho, MG; XXXXX/XXXXX/XXXXX/XXXXX. **OUTGROUP:** ***Cassia grandis*** L.f.; FJ009820*/ – / – / FJ009875*. ***Cassia javanica*** L.; FJ009821*/ – / – / FJ009876*. ***Chamaecrista absus var. absus*** (L.) H.S.Irwin & Barneby; FJ009832*/ – / – / FJ009886*. ***C. amorimii*** Barneby FJ009823* – / – / FJ009878*; *Conceição 795;* Itacaré, BA; FJ009823*/ – / – / FJ009878*. ***C. anamariae*** Conc. et al.; FJ009826*/ – / – / FJ009881*. ***C. belemii var. belemii*** (H.S.Irwin & Barneby) H.S.Irwin & Barneby; DQ787389*/ – / – / FJ009880*. ***C. blanchetii*** (Benth.) Conc. et al.; FJ009846*/ – / – / FJ009900*. ***C. botryoides*** Conc. et al.; FJ009836*/ – / – / FJ009890*. ***C. brachystachya*** (Benth.) Conc. et al.; *Conceição 713;* Grão Mogol, MG; FJ009847*/XXXXX/XXXXX/FJ009901*. ***C. brachystachya*** (Benth.) Conc. et al.; *Conceição 713;* Grão Mogol, MG; /XXXXX/XXXXX/. ***C. brachystachya*** (Benth.) Conc. et al.; FJ009847*/ – / – / FJ009901*. ***C. calycioides*** (DC. ex Collad.) Greene; FJ009863*/ – / – / FJ009917*. ***C. campestris*** H.S.Irwin & Barneby; FJ009829*/ – / – / FJ009883*. ***C. cathartica*** (Mart.) H.S.Irwin & Barneby; *Rando 990;* Diamantina, MG; XXXXX/XXXXX. ***C. cathartica*** (Mart.) H.S.Irwin & Barneby; *Conceição 789;* Gouveia, MG; FJ009841* /XXXXX/XXXXX/FJ009895*. ***C. chapadae*** (H.S.Irwin & Barneby) H.S.Irwin & Barneby; FJ009828*/ – / – / – /. ***C. confertiformis*** (H.S.Irwin & Barneby) Conc. et al.; FJ009848*/ – / – / FJ009902*. ***C. coriacea*** (Bong. ex Benth.) H.S.Irwin & Barneby; FJ009843*/ – / – / FJ009897*. ***C. cytisoides*** (DC. ex Collad.) H.S.Irwin & Barneby; FJ009844*/ – / – / FJ009898*. ***C. dalbergiifolia*** (Benth.) H.S.Irwin & Barneby; FJ009837*/ – / – / FJ009891*. ***C. decora*** (H.S.Irwin & Barneby) Conc. et al.; FJ009849*/ – / – / FJ009903*. ***C. depauperata*** Conc. et al.; FJ009850*/ – / – / FJ009904*. ***C. desvauxii* var. *desvauxii*** (Collad.) Killip; FJ009864*/ – / – / FJ009918*. ***C. desvauxii* var. *langsdorfii*** (Kunth ex Vogel) Britton ex Pittier; FJ009866*/ – / – / FJ009920*. ***C. desvauxii* var. *latistipula*** (Benth.) G.P.Lewis; *Conceição 912;* Guaraparí, ES; FJ009867*/XXXXX/XXXXX/FJ009921*. ***C. desvauxii* var. *mollissima*** (Benth.) H.S.Irwin & Barneby; FJ009865*/ – / – / FJ009919*. ***C. diphylla*** (L.) Greene; FJ009868*/ – / – / FJ009922*. ***C. flexuosa*** (L.) Greene; *Barbosa* (checar número)*;* Feira de Santana, BA; – /XXXXX/XXXXX/ – . ***C. flexuosa* var. *flexuosa*** (L.) Greene; FJ009858*/ – / – / FJ009912*. ***C. glaucofilix*** (H.S.Irwin & Barneby) H.S.Irwin & Barneby;

FJ009834*/ – / – / FJ009888*. ***C. hispidula*** (Vahl) H.S.Irwin & Barneby; FJ009833*/ – / – / FJ009887*. ***C. jacobinea*** (Benth.) H.S.Irwin & Barneby; FJ009827*/ – / – / FJ009882*. ***C. lineata* var. *lineata*** (Swartz.) Greene; *Rando 858;* Great Exuma Island, Bahamas; – / XXXXX/XXXXX/ –. ***C. lineata* var. *lineata*** (Swartz.) Greene; *Rando 960;* Great Exuma Island, Bahamas; – / XXXXX/XXXXX/ –. ***C. nictitans* subsp. *brachypoda*** (Benth.) H.S.Irwin & Barneby; FJ009855*/ – / – / FJ009909*. ***C. nictitans* subsp. *disadena*** (Steud.) H.S.Irwin & Barneby; FJ009852*/ – / – / FJ009906*. ***C. nictitans* subsp. *patellaria* var. *ramosa*** (Vogel) H.S.Irwin & Barneby; FJ009853*/ – / – / FJ009907*. ***C. onusta*** H.S.Irwin & Barneby; FJ009824*/ – / – / FJ009879*. ***C. pascuorum*** (Benth.) H.S.Irwin & Barneby; FJ009851*/ – / – / FJ009905*. ***C. philippi*** (H.S.Irwin & Barneby) H.S.Irwin & Barneby; FJ009838*/ – / – / FJ009892*. ***C. pilosa*** (L.) Greene; FJ009856*/ – / – / FJ009910*. ***C. repens*** (Vogel) H.S.Irwin & Barneby; *Giulietti 2325;* ver localidade; – /XXXXX/XXXXX/ – /. ***C. rotundifolia* var. *grandiflora*** (Pers.) Greene; FJ009857* / – / – / – . ***C. rotundifolia* var. *rotundifolia*** (Benth.) H.S.Irwin & Barneby; – / – / – / FJ009911*. ***C. rupestrium*** H.S.Irwin & Barneby; FJ009835*/ – / – / FJ009889*. ***C. setosa* var. *dentosa*** (Benth.) H.S.Irwin & Barneby; *Queiroz 10460;* Chapada do Guimarães, MT; FJ009842*/XXXXX/XXXXX/FJ009896*. ***C. speciosa*** Conc. et al.; FJ009839*/ – / – / FJ009893*. ***C. supplex*** (Mart. ex Benth.) Britton & Rose ex Britton & Killip; FJ009869*/ – / – / FJ009923*. ***C. swainsonii*** (Benth.) H.S.Irwin & Barneby; *Queiroz 12314;* ver localidade; XXXXX/XXXXX. ***C. unijuga*** (Benth.) Conc. et al.; FJ009845*/ – / – / FJ009899*. ***C. urophyllidia*** (H.S.Irwin & Barneby) H.S.Irwin & Barneby; FJ009840*/ – / – / FJ009894*. ***Senna alata*** (L.) Roxb.; HQ33041*/ – / – / – /. ***Senna gardneri*** (Benth.) H.S.Irwin & Barneby; FJ009822*/ – / – / FJ009877*.

Appendix 2. Morphological characters with states coded and the morphological reference.

1. Habit: Arborescent (0) / Erect or virgate shrub (1) / Erect shrub with flexuous branches (2) / Ramose shrub (3) / Decumbent shrub (4) - Radford et al. 1976	**15. Number of EFN on the petiole + leaf:** 2 to 10 (0) / only 1 (1) / absent (2) (EFN= extrafloral nectaries).
2. Woody rootstock (xylopodium): absent (0) / present (1) - Radford et al. 1976	**16. Stipite of EFNs:** long stipitate - it is longer than the diameter of the extrafloral nectaries's head (0) / short stipitate – it has the same length or shorter than the width of the extrafloral nectaries's head (1) / sessile (2) - Irwin & Barneby 1982.
3. Stem-cross section: terete (0) / rectangular (1) / rectangular and alate (2) / terete at base and rectangular at apex (3) - Radford et al. 1976.	**17. Number of leaflets:** 10 to 62 pairs (0) / 2 to 9 pairs (1) / only 1 pair (2).
4. Surface branches in adults: glabrous (0) / pubescent or pilose (1) - Harris & Harris 2001	**18. Leaflet venation:** penninerved (0) / palmately veined, in this case 3 - 4 veins with apical anastomosis (1) / palmately veined, in this case 3 - 4 veins without apical anastomosis (2) / palmately veined, with more than 4 veins, without apical anastomosis (3) - Ellis et al. 2009.
5. Glutinous trichomes: absent (0) / present (1) - Harris & Harris 2001	**19. Medial symmetry of the distal leaflets:** symmetrical (0) / asymmetrical (1) - Ellis et al. 2009
6. Forked branches in the median region or close to apex: absent (0) / present (1).	**20. Leaflet apex:** mucronate (0) / aristate (1) / rounded (2) - Harris & Harris 2001.

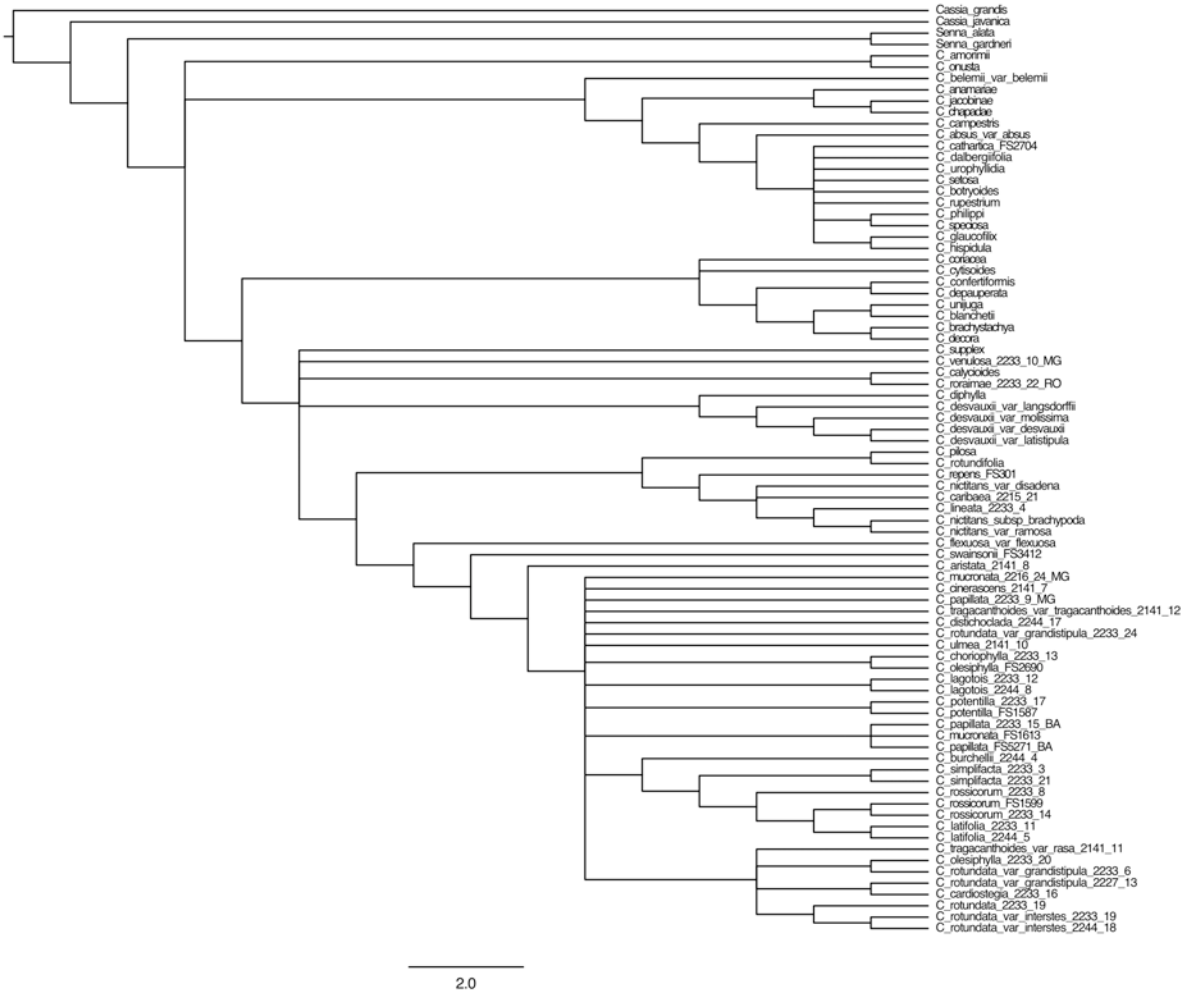
7. Stipule length: > 5.1 mm (0) / 2.3 to 5.0 mm (1) / until 2.2 mm (2)	**21. Surface texture:** glabrous or smooth (0) / pubescent (1) / papillate (2) - Harris & Harris 2001.
8. Stipule form: lanceolate (0) / triangular or ovate (1) / rounded (2) / oblong (3) - Radford et al. 1976.	**22. Inflorescence type:** axillary raceme (0) / terminal raceme (1) / reduced axillary raceme (2) / reduced supra-axillary raceme (3) / terminal frondose-bracteate raceme (4) – Irwin & Barneby 1982 and Weberling 1989.
9. Stipule base: cordate in one or both sides (0) / rounded (1) / truncate (2) - Harris & Harris 2001	**23. EFN (extrafloral nectarines) on the peduncles of inflorescence:** (0) present / (1) absent.
10. Stipule apex: acute, acuminate or mucronate (0) / long acuminate (1) / rounded (2) - Harris & Harris 2001	**24. Petals:** all petals equal (0) / a large petal curved but it is not involving the stames (1) / a large petal curved, hood-like involving the stamens (2) / a large petal different from the others but not curved, like a labelum (3). (Irwin & Barneby, 1982, Harris & Harris 2001)
11. Stipule presence: persistent (0) / deciduous (1).	**25. Androecium symmetry:** homomorphic (0) / few heteromorphic (1) / strong heteromophic (2). (Irwin & Barneby, 1982)
12. Stipule position: erect and adpressed to the branch (0) / perpendicular to the branch (1).	**26. Stamens position:** all together (0) / one displaced at the same side of gynoecium (1)
13. Raquis: present (0) / reduced, absent (1).	**27. Petal colour:** yellow (0) / orange (1)
14. Raquis-cross section: terete (0) / canaliculate (1) - Ellis et al. 2009.	

Appendix 4. Morphological matrix, 34 taxa and 27 characters.

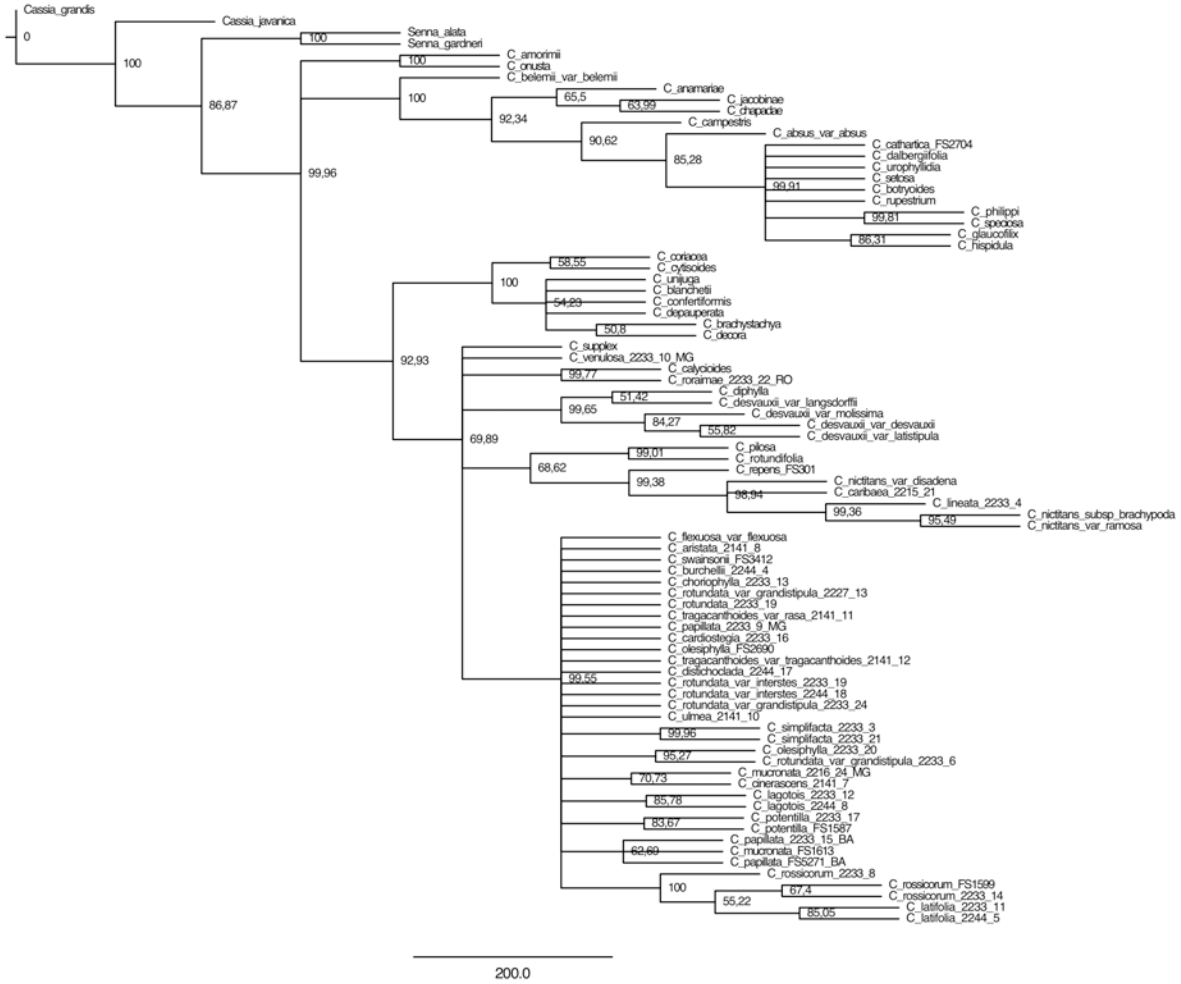
Species / Character	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
C. amorimii	0	0	0	0	0	0	2	1	2	2	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
C. anceps	4	1	1	0	0	0	0	1	0	1	0	1	0	1	0	1	1	2	1	0	0	2	1	1	1	1	0
C. aristata	1	1	3	1	0	0	1	0	2	1	1	0	0	1	0	1	1	2	1	1	0	4	1	1	1	1	0
C. brachystachya	1	0	0	0	0	0	2	1	2	2	1	0	0	1	0	2	1	2	0	0	0	0	0	1	1	0	0
C. burchellii	1	1	3	0	0	0	1	1	2	0	0	0	0	1	0	2	1	2	1	0	0	2	1	1	1	1	0
C. cardiostegia	1	1	0	1	0	0	0	1	0	1	0	1	0	0	1	1	1	3	1	0	0	4	1	1	1	1	0
C. caribaea	1	0	0	1	0	0	1	0	2	0	0	0	0	1	0	0	1	0	0	0	0	2	1	3	2	0	0
C. cathartica	3	0	0	1	1	0	1	0	2	2	0	0	0	1	2	3	0	0	0	0	2	2	1	2	1	0	0
C. choriophylla	4	1	0	0	0	0	2	1	2	0	0	0	1	-	1	2	2	2	1	0	0	4	1	1	1	1	0
C. cinerascens	1	1	0	1	0	0	0	1	1	0	1	0	0	0	1	1	1	3	1	0	0	2	1	1	1	1	0
C. desvauxii var. *latistipula*	1	0	0	0	0	0	0	3	0	2	0	0	0	1	1	2	1	3	0	2	0	2	1	1	1	0	0
C. distichoclada	1	1	0	1	0	1	0	1	0	1	0	1	0	0	1	1	1	3	1	0	0	2	1	1	1	1	0
C. flexuosa	1	0	1	1	0	0	0	1	0	1	0	1	0	1	0	1	0	1	1	0	0	2	1	1	3	0	0
C. lagotois	1	1	0	0	0	0	2	1	2	0	0	0	1	-	1	2	2	1	0	0	0	4	1	1	1	1	0
C. latifolia	4	1	2	0	0	0	0	1	0	1	0	1	1	-	1	1	2	2	1	0	0	4	1	1	1	1	0
C. lineata	3	0	0	1	0	0	1	0	2	2	0	0	0	1	1	0	1	0	0	0	0	2	1	3	2	0	0
C. mucronata	3	1	0	1	0	0	1	1	2	0	0	0	0	1	0	1	1	2	1	0	0	2	1	1	1	1	0
C. multinervia	3	1	1	0	0	0	1	1	2	0	0	0	0	1	0	1	1	2	1	0	0	2	1	1	1	1	0
C. olesiphylla	3	1	3	1	0	0	1	0	2	0	0	0	0	1	0	1	0	2	1	0	0	2	1	1	1	1	0
C. papillata	3	1	3	1	0	0	1	0	2	0	0	0	0	1	0	1	1	2	1	0	3	2	1	1	1	1	0
C. pascuorum	1	0	0	0	0	0	1	0	2	0	1	0	0	1	1	0	1	0	1	0	0	3	1	3	1	0	0
C. potentilla	1	1	0	1	0	1	0	1	0	1	0	1	0	0	1	1	0	3	1	0	0	2	1	1	1	1	0
C. repens	1	0	0	1	0	0	1	0	2	0	0	0	0	1	1	1	1	0	1	0	1	3	1	3	1	0	0
C. roraimae	1	0	0	1	0	0	0	1	2	0	1	0	0	1	0	1	0	1	1	0	0	2	1	1	1	0	0
C. rossicorum	4	1	1	0	0	0	1	1	2	0	0	0	1	-	1	1	2	2	1	0	0	4	1	1	1	1	0
C. rotundata var. *interstens*	1	1	0	1	0	1	0	1	0	0	0	1	0	0	1	1	1	3	1	0	0	2	1	1	1	1	0
C. rotundata var. *rotundata*	1	1	0	1	0	1	0	2	0	2	0	1	0	0	1	1	1	3	1	2	0	2	1	1	1	1	0
C. setosa	3	0	0	1	1	0	1	0	2	2	0	0	0	1	2	3	1	0	0	0	2	1	1	2	1	0	0
C. simplifacta	4	1	0	0	0	0	2	1	2	0	0	0	1	-	1	2	2	2	1	0	0	4	1	1	1	1	1
C. swainsonii	1	0	1	1	0	0	0	1	0	1	0	1	0	1	1	1	1	1	1	1	0	2	1	3	1	0	0
C. tragacanthoides var. *rasa*	3	1	0	1	0	0	1	0	2	0	0	0	0	0	1	1	1	2	1	0	0	2	1	1	1	1	0
C. tragacanthoides var. *tragacanthoides*	3	1	0	1	0	0	1	0	2	0	0	0	0	0	1	1	1	2	1	0	1	2	1	1	1	1	0
C. ulmea	2	1	3	0	0	0	1	0	2	0	0	0	0	1	1	1	1	2	1	0	0	2	1	1	1	1	0
C. venulosa	1	0	0	1	0	0	0	0	2	0	0	0	0	0	1	1	1	2	1	0	0	2	1	1	1	0	0

Supplementary materials. All trees not edited derived from all analyses done.

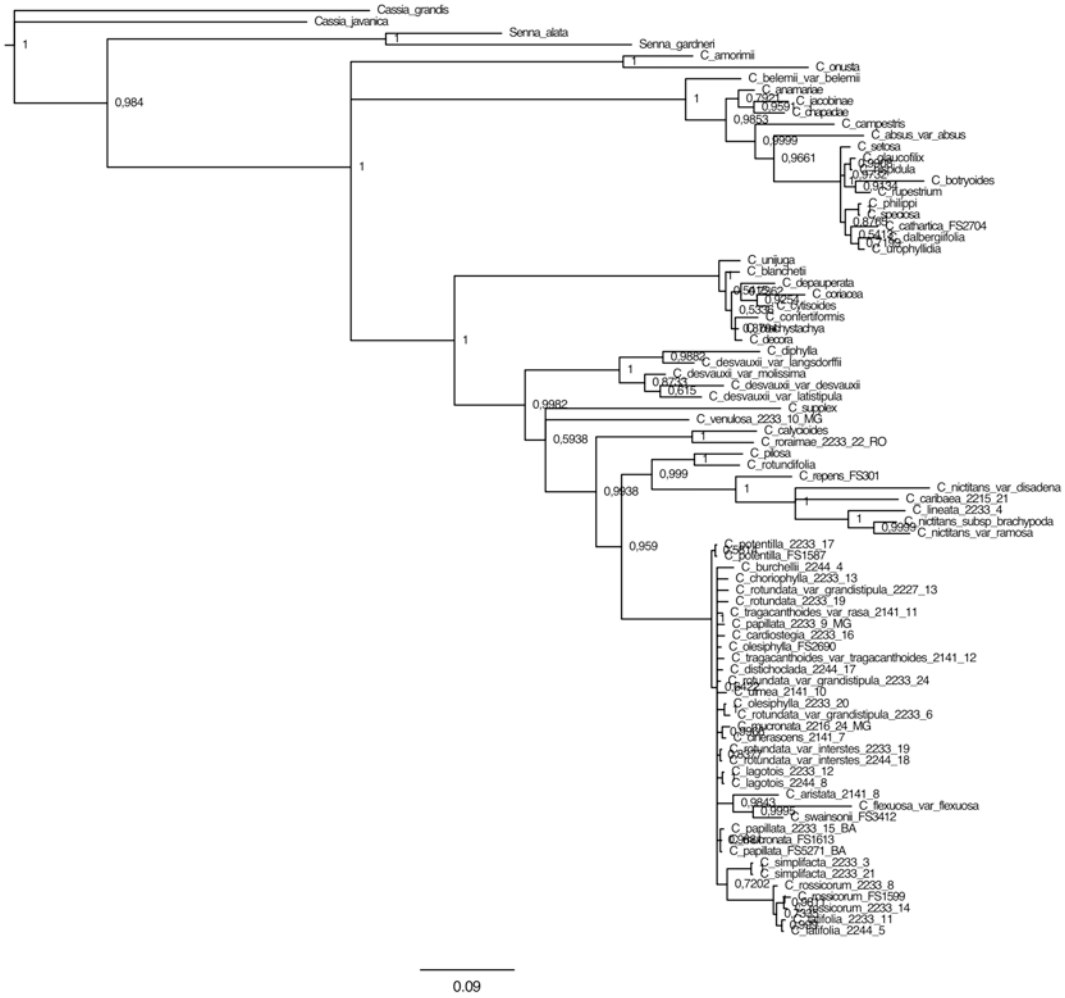
Broad Analysis - ITS. Strict Consensus tree from parcimony analysis



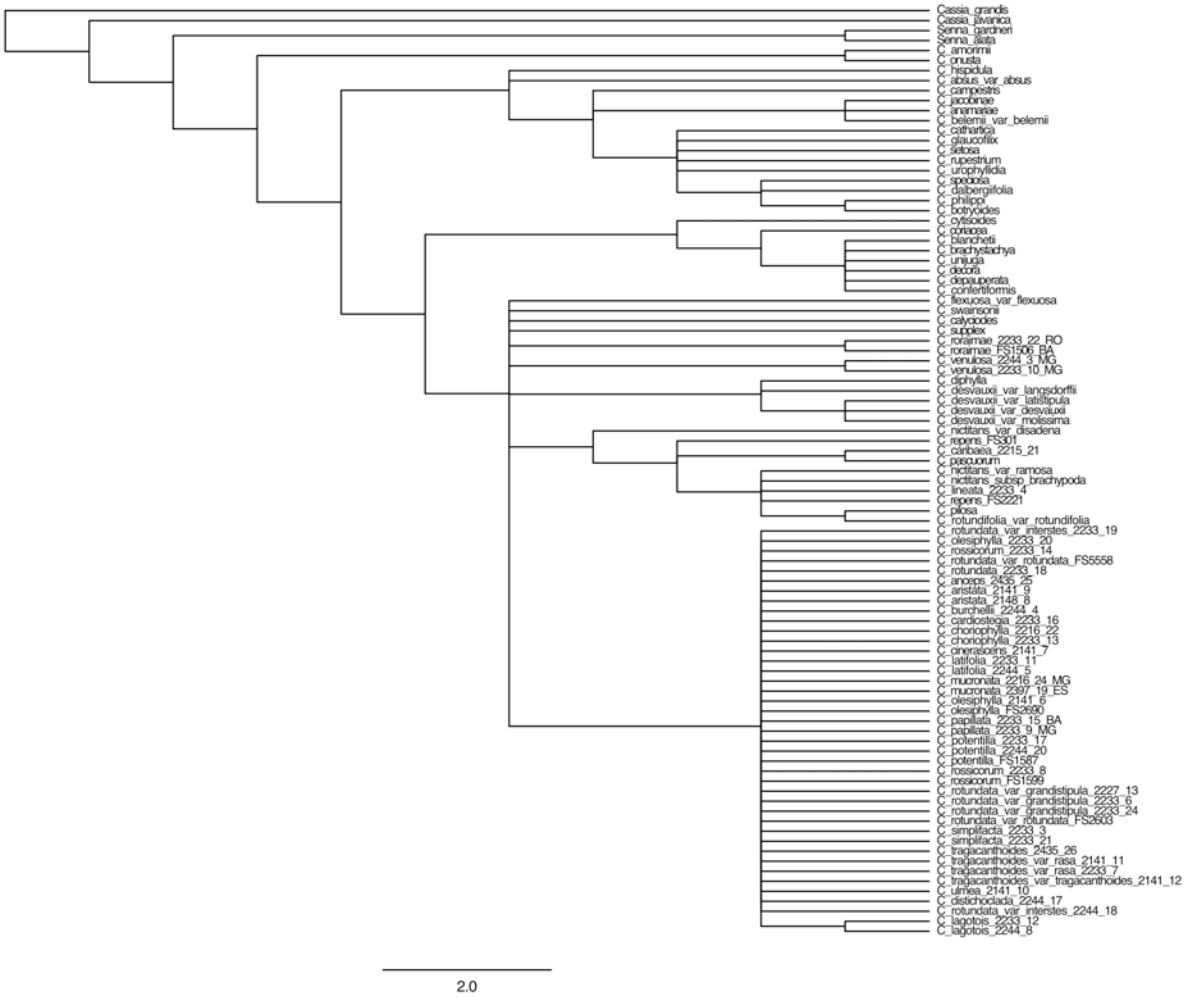
Broad Analysis - ITS. Bootstrap tree from parcimony analysis



Broad Analysis - ITS. Majority consensus tree from Bayesian analysis.

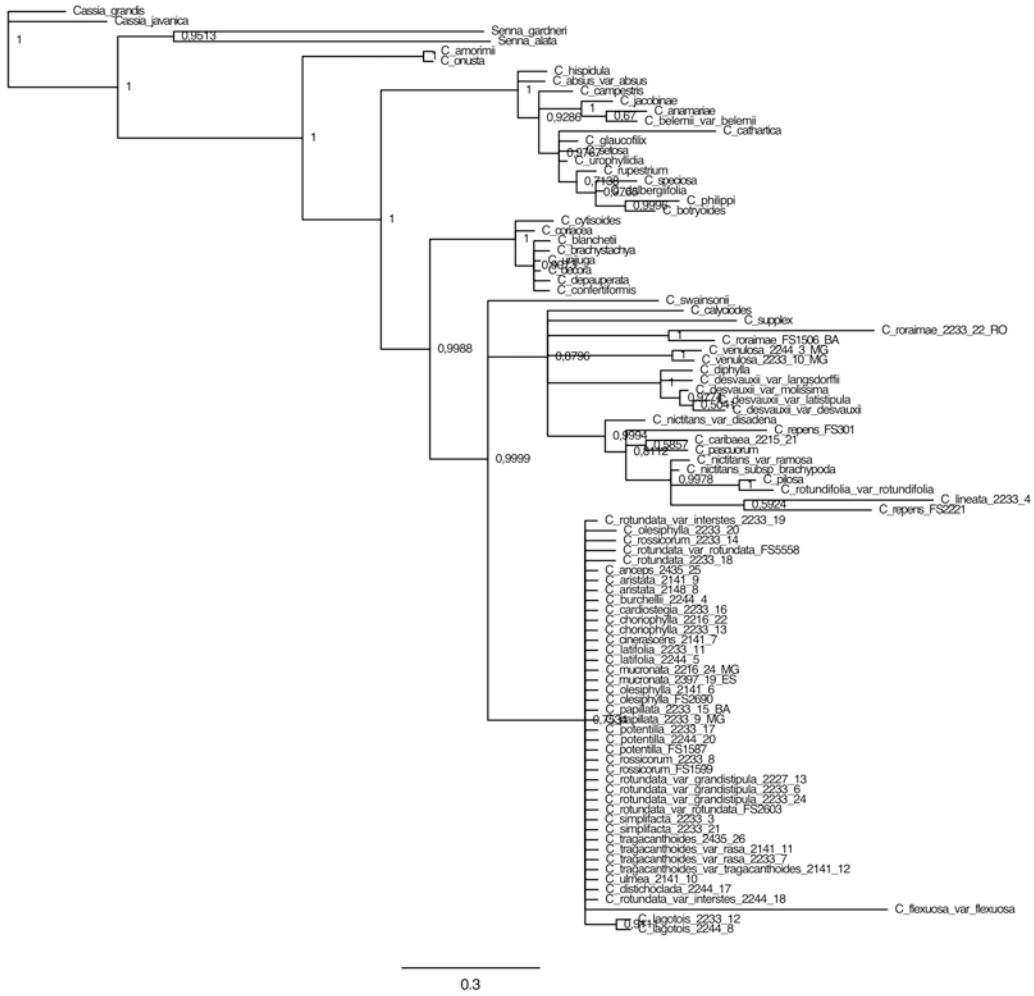


Broad Analysis - trnL-F. Strict Consensus tree from parcimony analysis

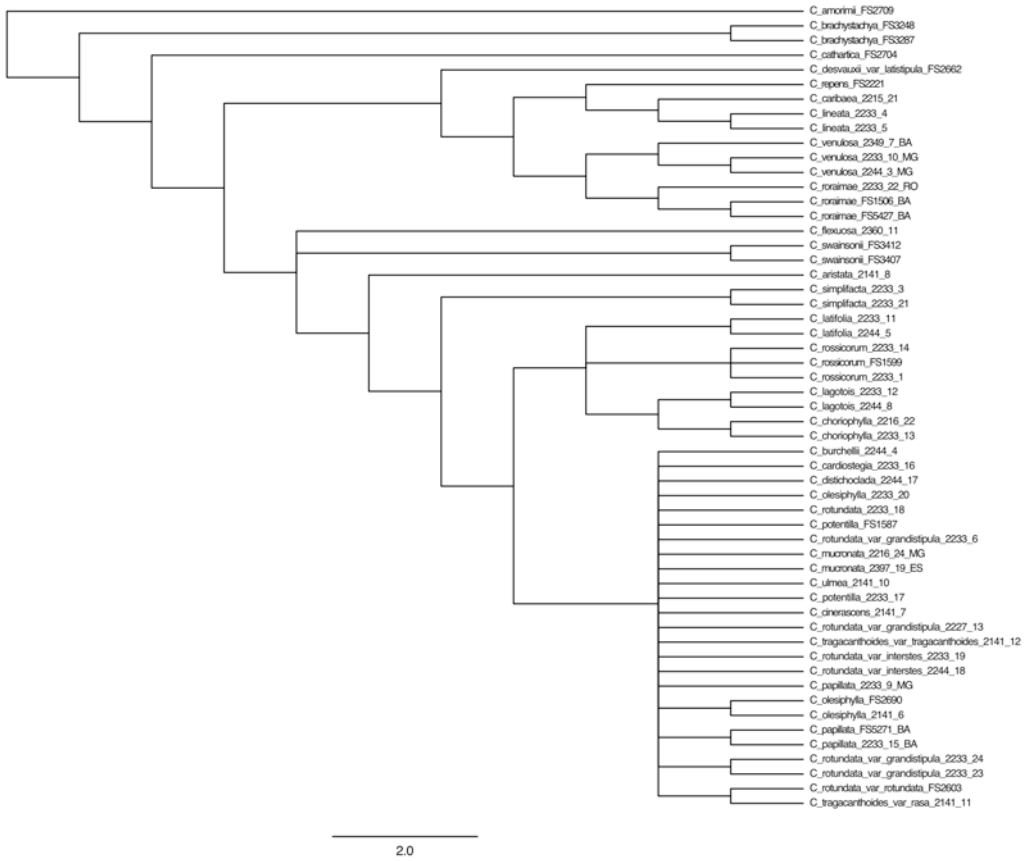


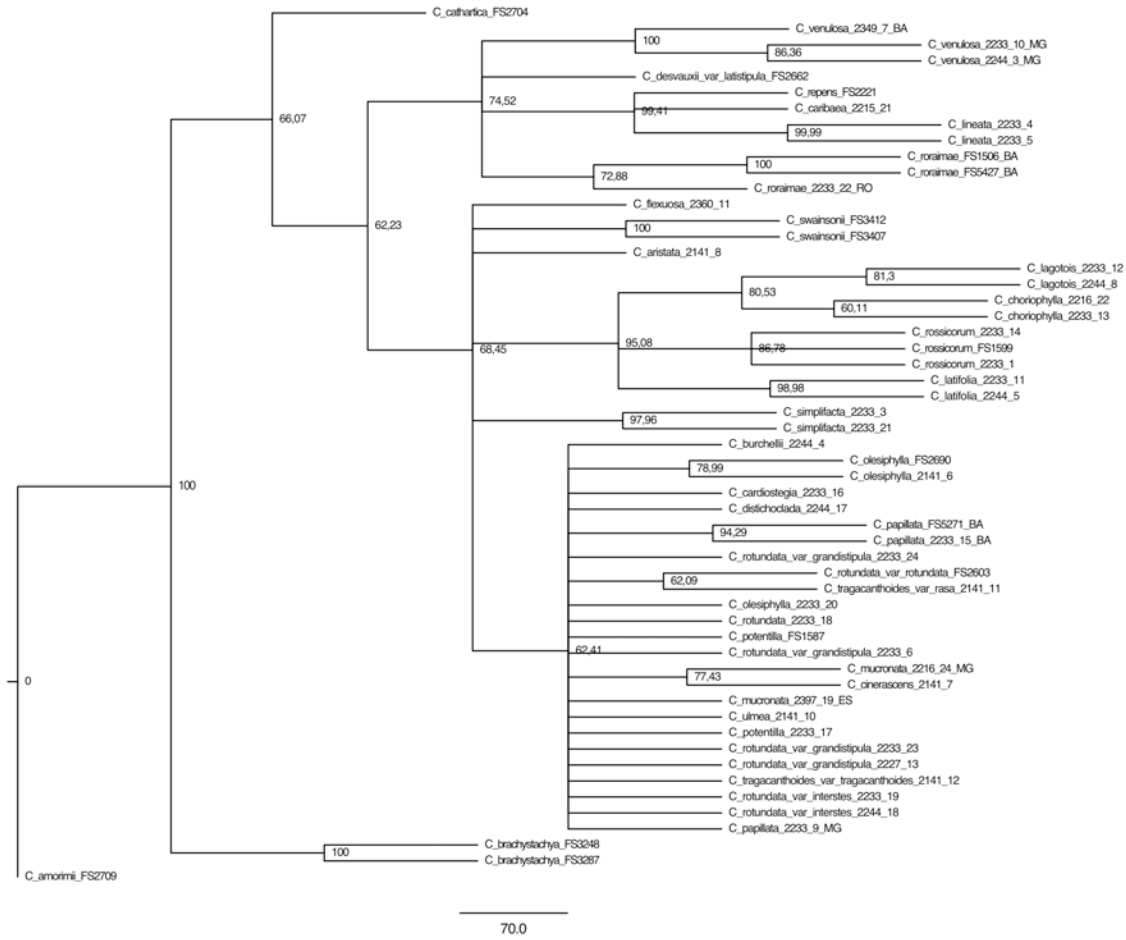
Broad Analysis - trnL-F. Bootstrap tree from parcimony analysis

Broad analysis, trnL-F. Majority consensus tree from Bayesian analysis.

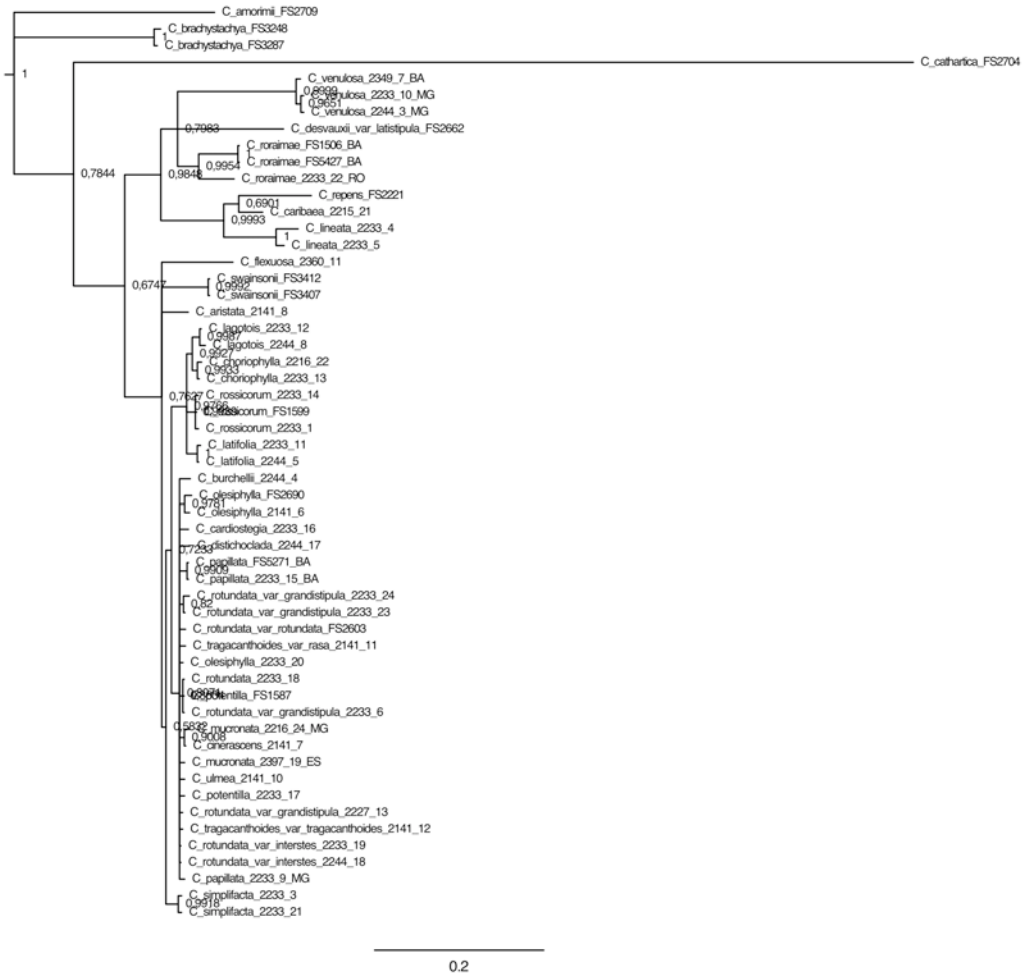


Narrow analysis, ETS. Strict Consensus and Bootstrap trees from parcimony analysis

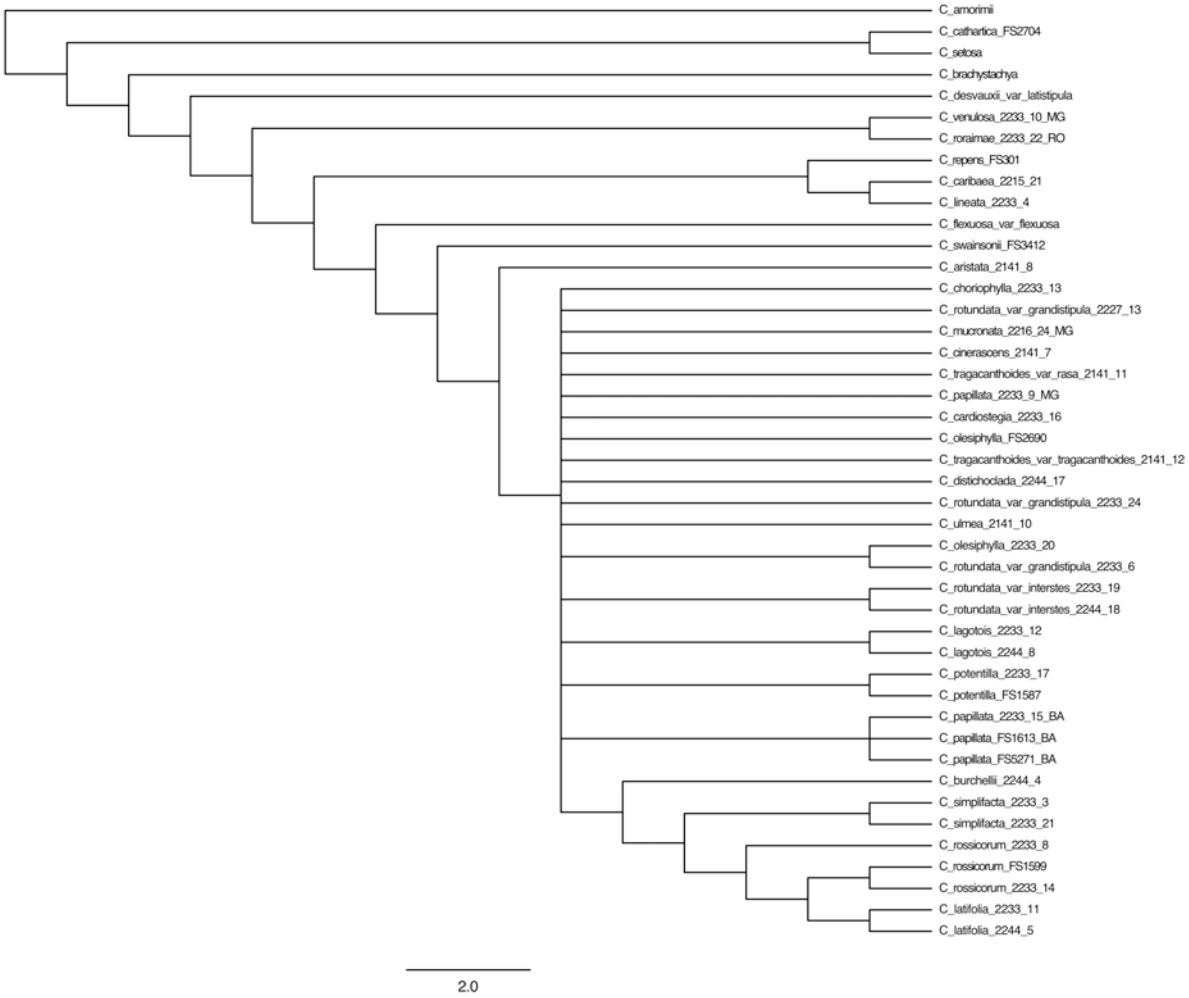


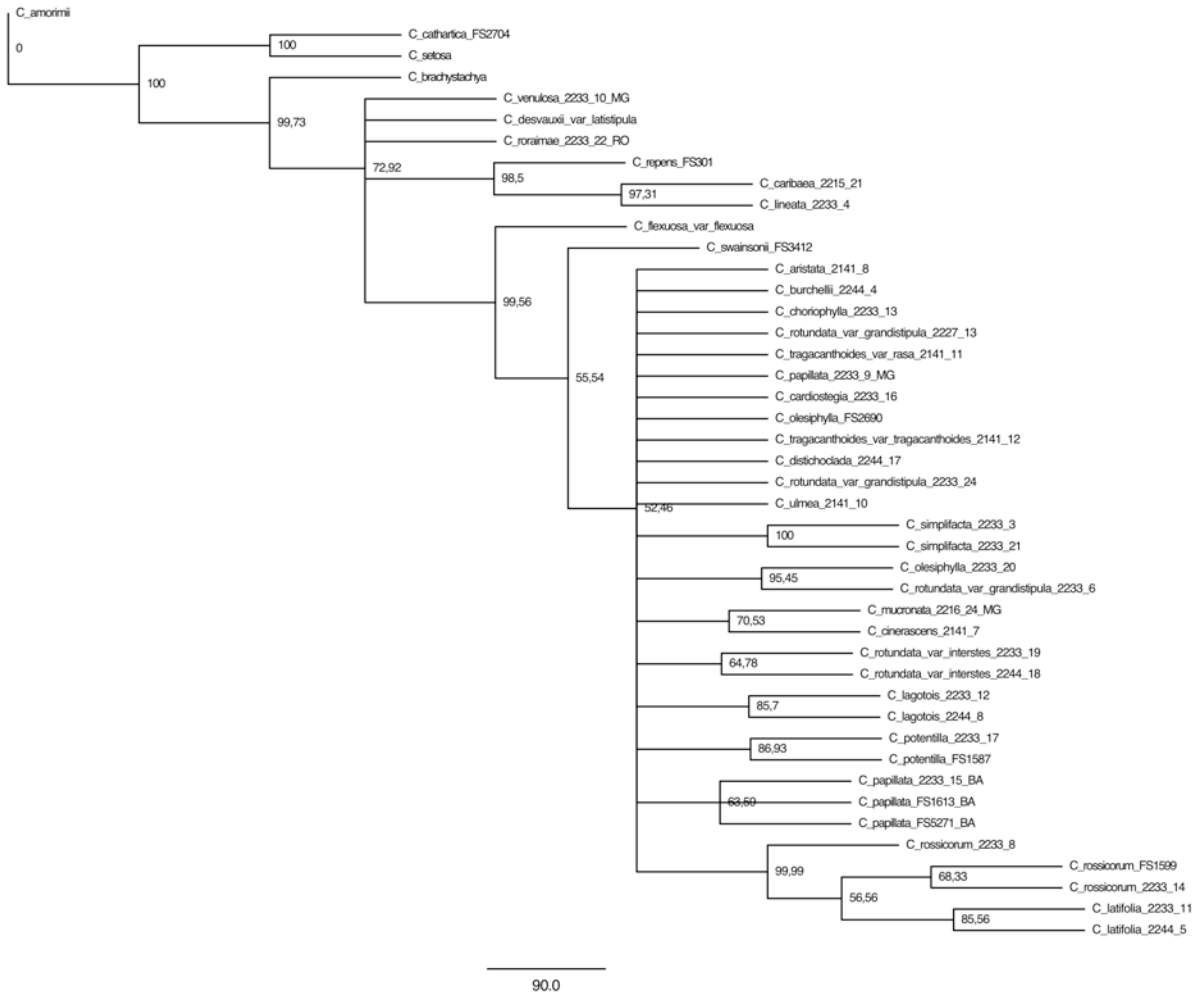


Narrow analysis, ETS. Majority consensus tree from Bayesian analysis.



Narrow analysis, ITS. Strict Consensus and Bootstrap trees from parcimony analysis.

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C_setosa
100
C_brachystachya
99,73
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C_desvauxii_var_latistipula
C_roraimae_2233_22_RO
72,92
C_repens_FS301
98,5
C_caribaea_2215_21
97,31
C_lineata_2233_4
C_flexuosa_var_flexuosa
99,56
C_swainsonii_FS3412
55,54
C_aristata_2141_8
C_burchellii_2244_4
C_choriophylla_2233_13
C_rotundata_var_grandistipula_2227_13
C_tragacanthoides_var_rasa_2141_11
C_papillata_2233_9_MG
C_cardiostegia_2233_16
C_olesiphylla_FS2690
C_tragacanthoides_var_tragacanthoides_2141_12
C_distichoclada_2244_17
C_rotundata_var_grandistipula_2233_24
52,46
C_ulmea_2141_10
100
C_simplifacta_2233_3
C_simplifacta_2233_21
95,45
C_olesiphylla_2233_20
C_rotundata_var_grandistipula_2233_6
70,53
C_mucronata_2216_24_MG
C_cinerascens_2141_7
64,78
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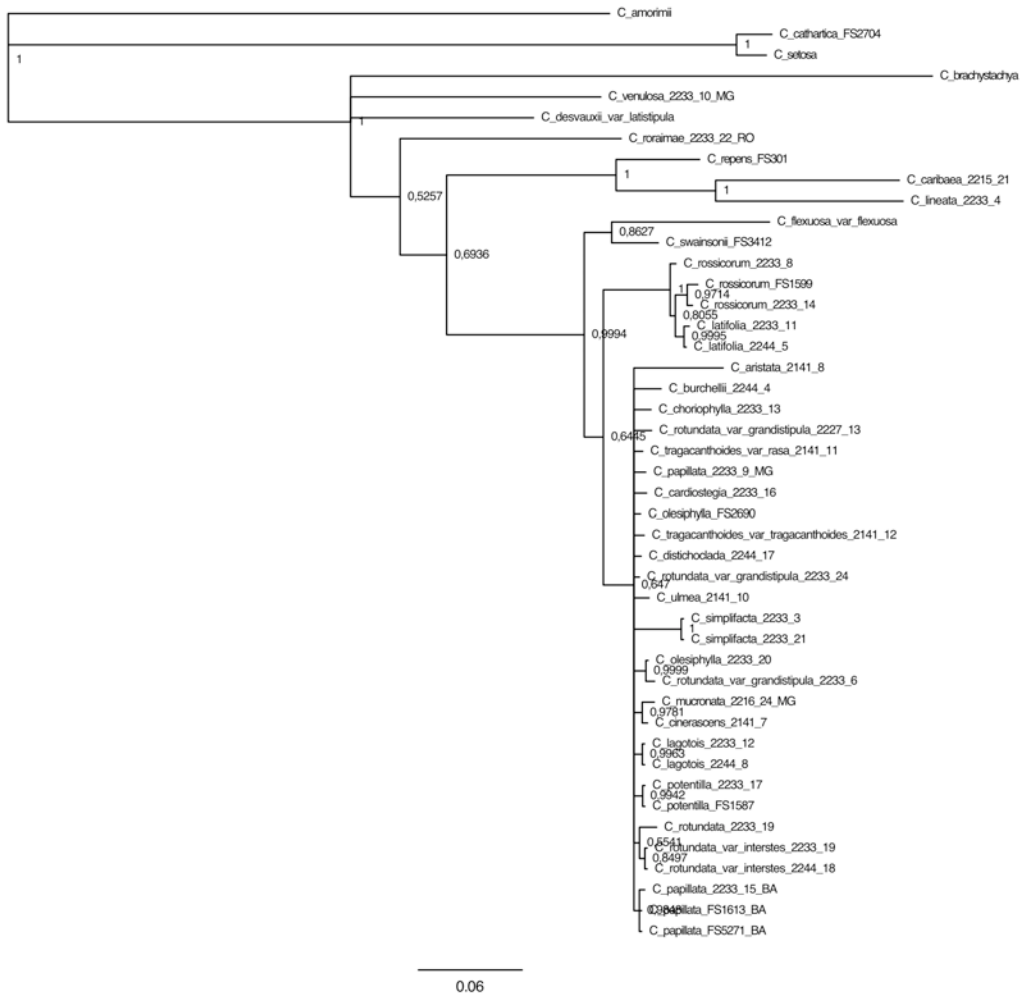
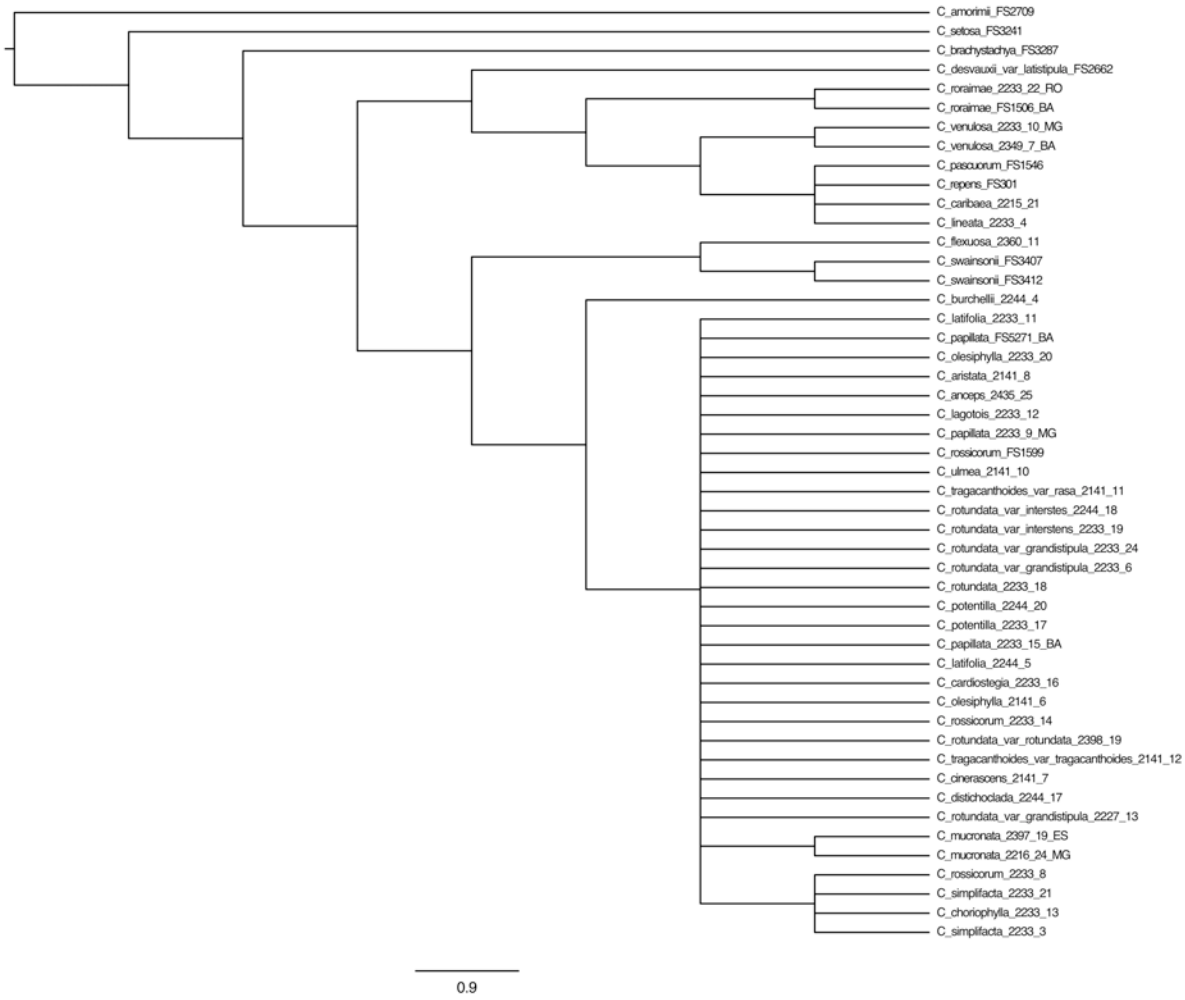
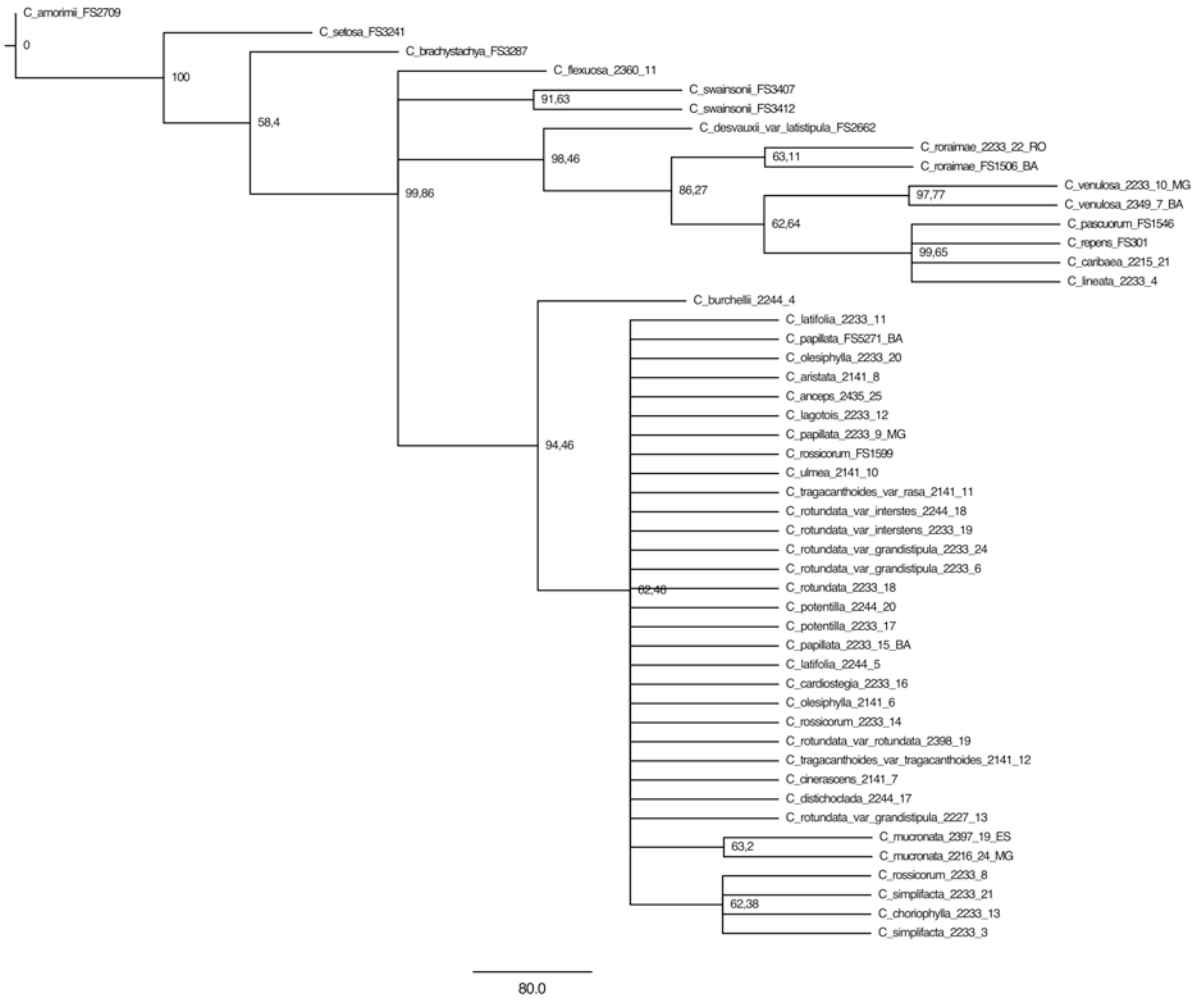
C_rotundata_var_interstes_2244_18
85,7
C_lagotois_2233_12
C_lagotois_2244_8
86,93
C_potentilla_2233_17
C_potentilla_FS1587
63,59
C_papillata_2233_15_BA
C_papillata_FS1613_BA
C_papillata_FS5271_BA
99,99
C_rossicorum_2233_8
68,33
C_rossicorum_FS1599
C_rossicorum_2233_14
56,56
85,56
C_latifolia_2233_11
C_latifolia_2244_5
90.0

Narrow analysis, ITS. Majority consensus tree from Bayesian analysis.



Narrow analysis, trnD-T. Strict Consensus and Bootstrap trees from parcimony analysis.

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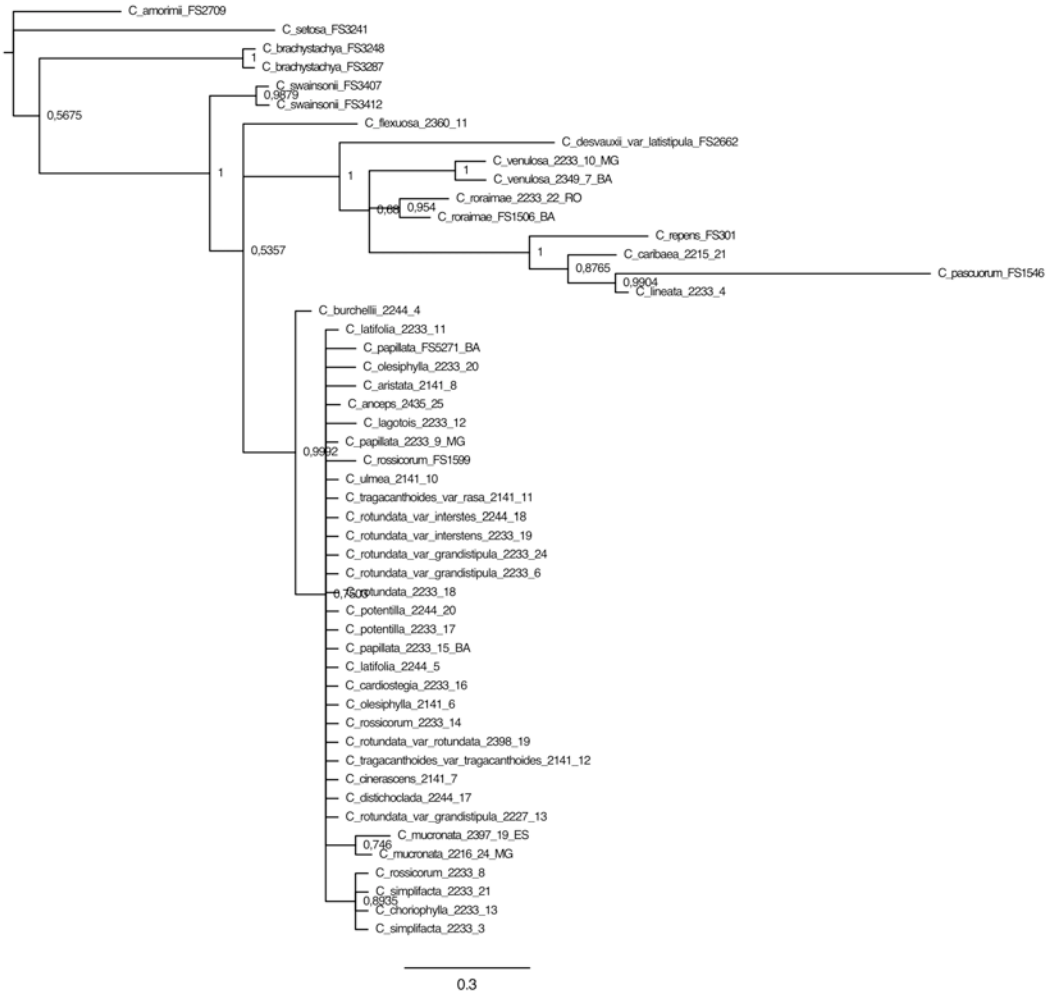
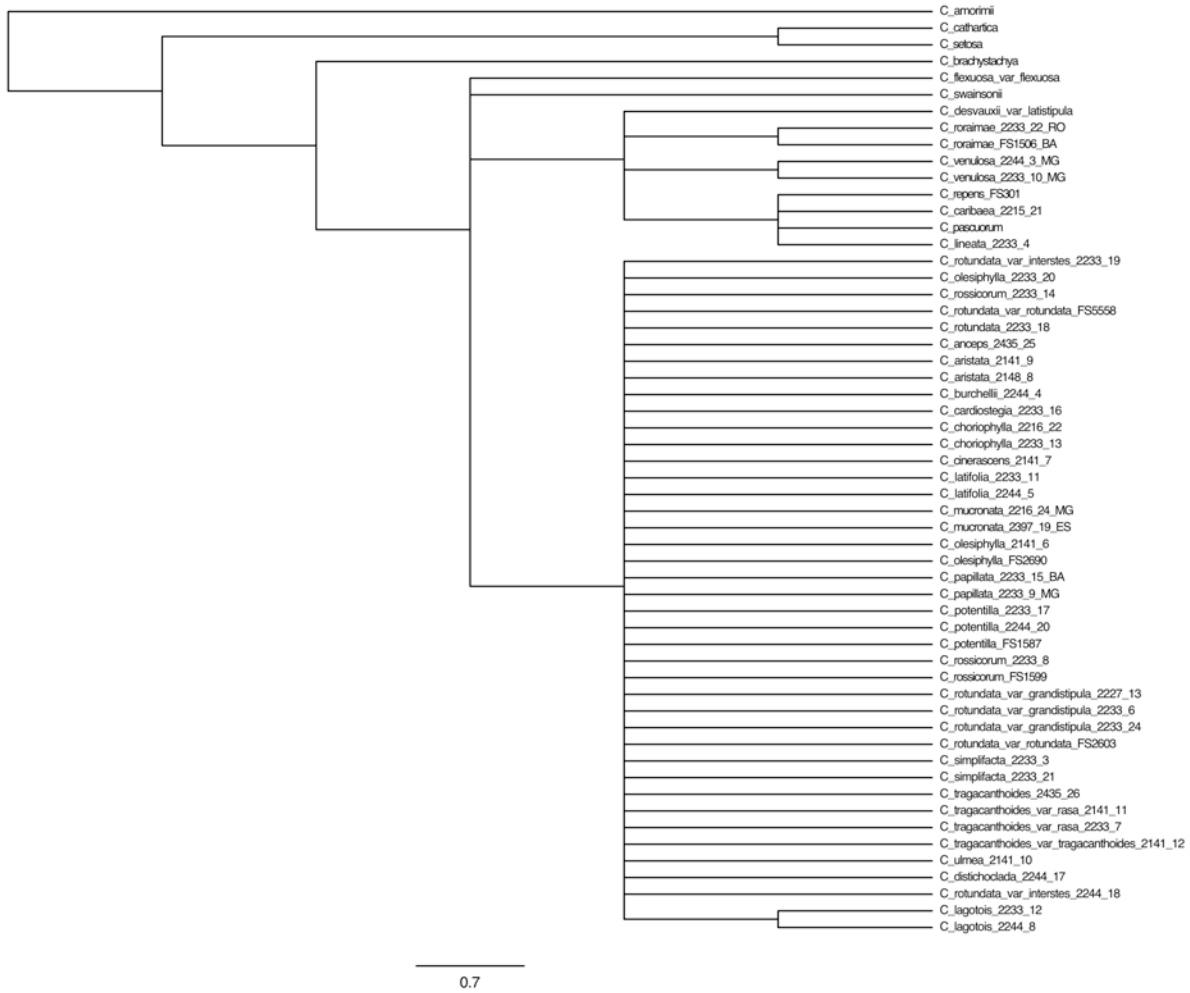
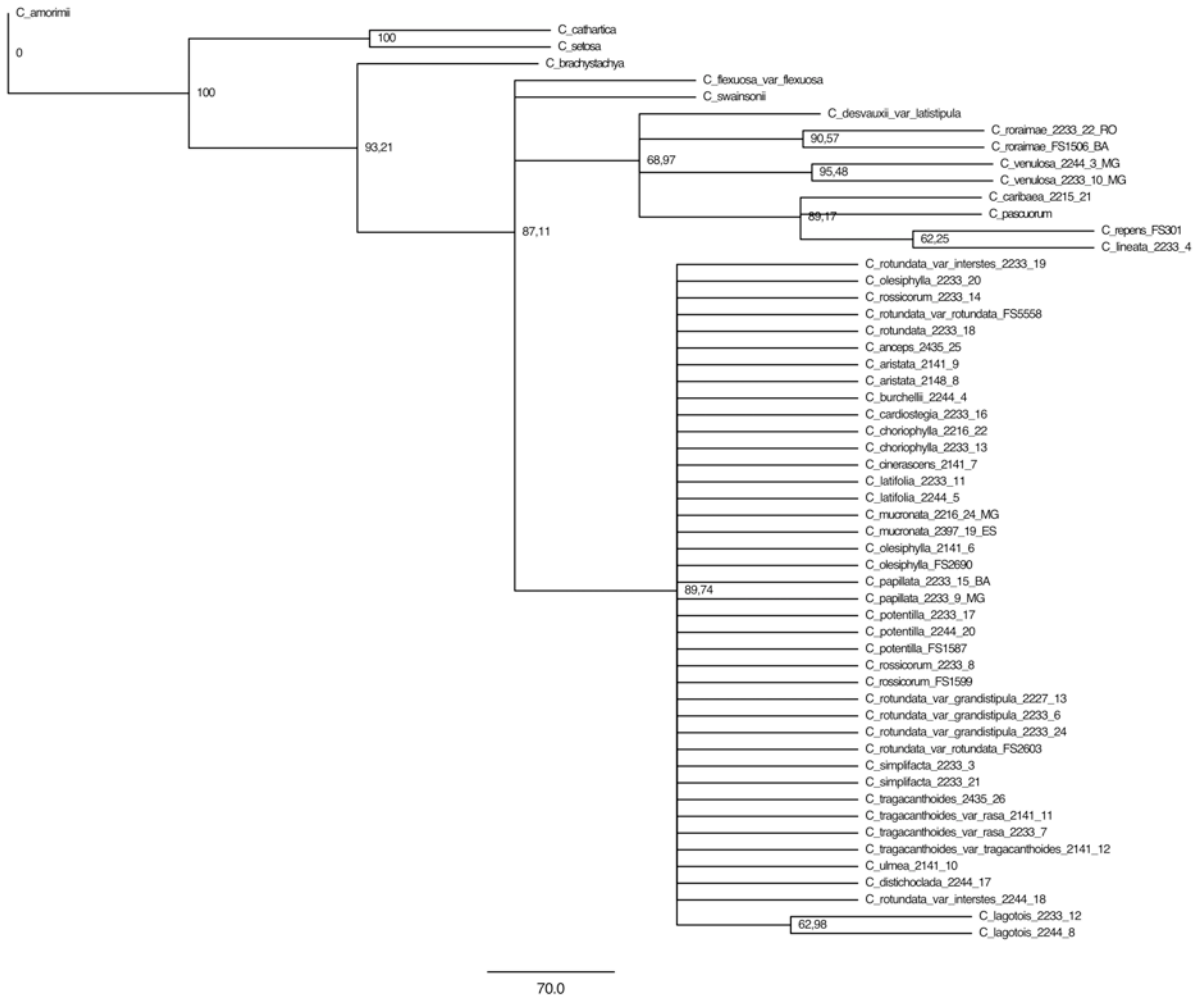
0
C_setosa_FS3241
100
C_brachystachya_FS3287
58,4
C_flexuosa_2360_11
91,63
C_swainsonii_FS3407
C_swainsonii_FS3412
C_desvauxii_var_latistipula_FS2662
98,46
63,11
C_roraimae_2233_22_RO
C_roraimae_FS1506_BA
99,86
86,27
97,77
C_venulosa_2233_10_MG
C_venulosa_2349_7_BA
62,64
C_pascuorum_FS1546
C_repens_FS301
99,65
C_caribaea_2215_21
C_lineata_2233_4
C_burchellii_2244_4
C_latifolia_2233_11
C_papillata_FS5271_BA
C_olesiphylla_2233_20
C_aristata_2141_8
C_anceps_2435_25
C_lagotois_2233_12
C_papillata_2233_9_MG
94,46
C_rossicorum_FS1599
C_ulmea_2141_10
C_tragacanthoides_var_rasa_2141_11
C_rotundata_var_interstes_2244_18
C_rotundata_var_interstens_2233_19
C_rotundata_var_grandistipula_2233_24
C_rotundata_var_grandistipula_2233_6
62,46
C_rotundata_2233_18
C_potentilla_2244_20
C_potentilla_2233_17
C_papillata_2233_15_BA
C_latifolia_2244_5
C_cardiostegia_2233_16
C_olesiphylla_2141_6
C_rossicorum_2233_14
C_rotundata_var_rotundata_2398_19
C_tragacanthoides_var_tragacanthoides_2141_12
C_cinerascens_2141_7
C_distichoclada_2244_17
C_rotundata_var_grandistipula_2227_13
63,2
C_mucronata_2397_19_ES
C_mucronata_2216_24_MG
C_rossicorum_2233_8
C_simplifacta_2233_21
62,38
C_choriophylla_2233_13
C_simplifacta_2233_3
80.0

Narrow analysis, trnD-T. Majority consensus tree from Bayesian analysis.



Narrow analysis, trnD-T. Strict Consensus and Bootstrap trees from parcimony analysis.




C_amorimii
0
100
100
C_cathartica
C_setosa
C_brachystachya
93,21
C_flexuosa_var_flexuosa
C_swainsonii
C_desvauxii_var_latistipula
68,97
90,57
C_roraimae_2233_22_RO
C_roraimae_FS1506_BA
95,48
C_venulosa_2244_3_MG
C_venulosa_2233_10_MG
C_caribaea_2215_21
89,17
C_pascuorum
87,11
62,25
C_repens_FS301
C_lineata_2233_4
C_rotundata_var_interstes_2233_19
C_olesiphylla_2233_20
C_rossicorum_2233_14
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C_rotundata_2233_18
C_anceps_2435_25
C_aristata_2141_9
C_aristata_2148_8
C_burchellii_2244_4
C_cardiostegia_2233_16
C_choriophylla_2216_22
C_choriophylla_2233_13
C_cinerascens_2141_7
C_latifolia_2233_11
C_latifolia_2244_5
C_mucronata_2216_24_MG
C_mucronata_2397_19_ES
C_olesiphylla_2141_6
C_olesiphylla_FS2690
C_papillata_2233_15_BA
89,74
C_papillata_2233_9_MG
C_potentilla_2233_17
C_potentilla_2244_20
C_potentilla_FS1587
C_rossicorum_2233_8
C_rossicorum_FS1599
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C_rotundata_var_grandistipula_2233_6
C_rotundata_var_grandistipula_2233_24
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C_simplifacta_2233_21
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C_tragacanthoides_var_rasa_2141_11
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C_tragacanthoides_var_tragacanthoides_2141_12
C_ulmea_2141_10
C_distichoclada_2244_17
C_rotundata_var_interstes_2244_18
62,98
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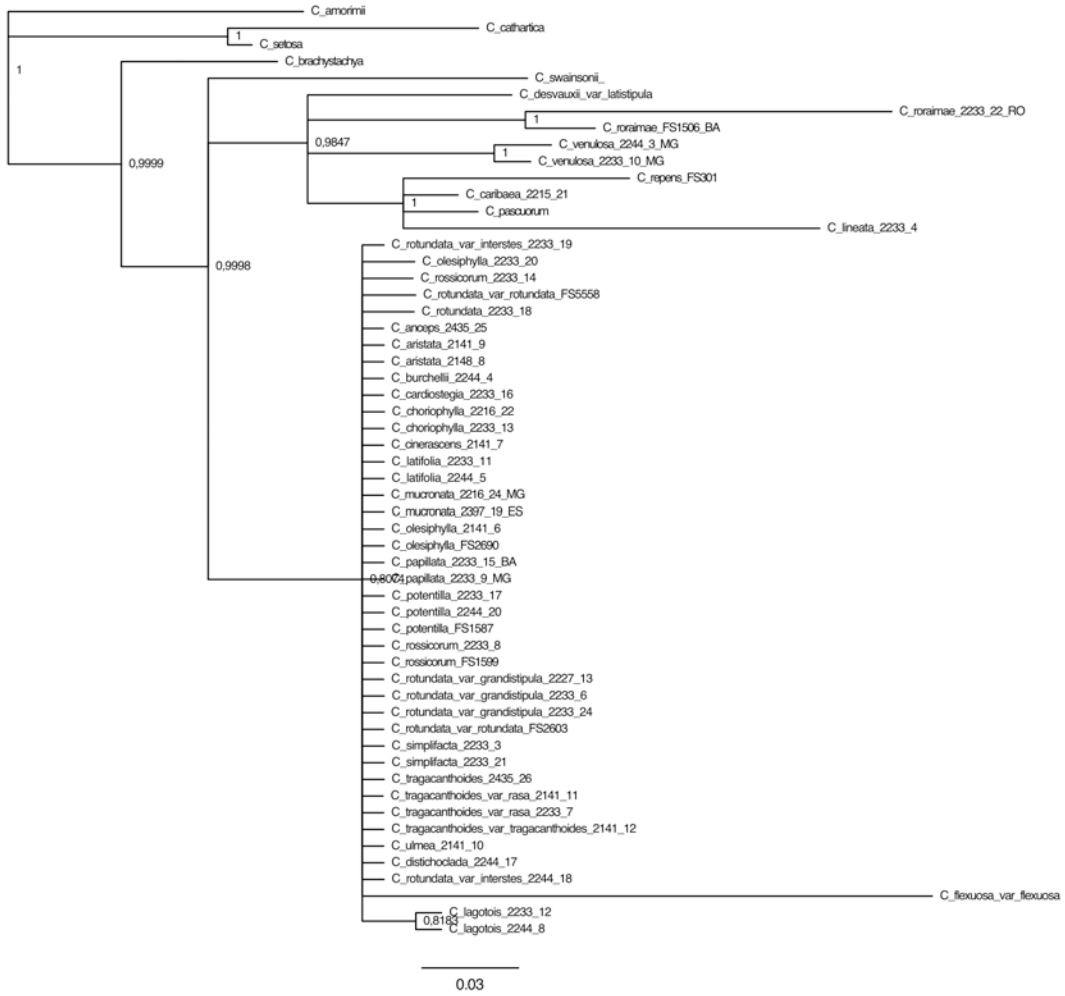
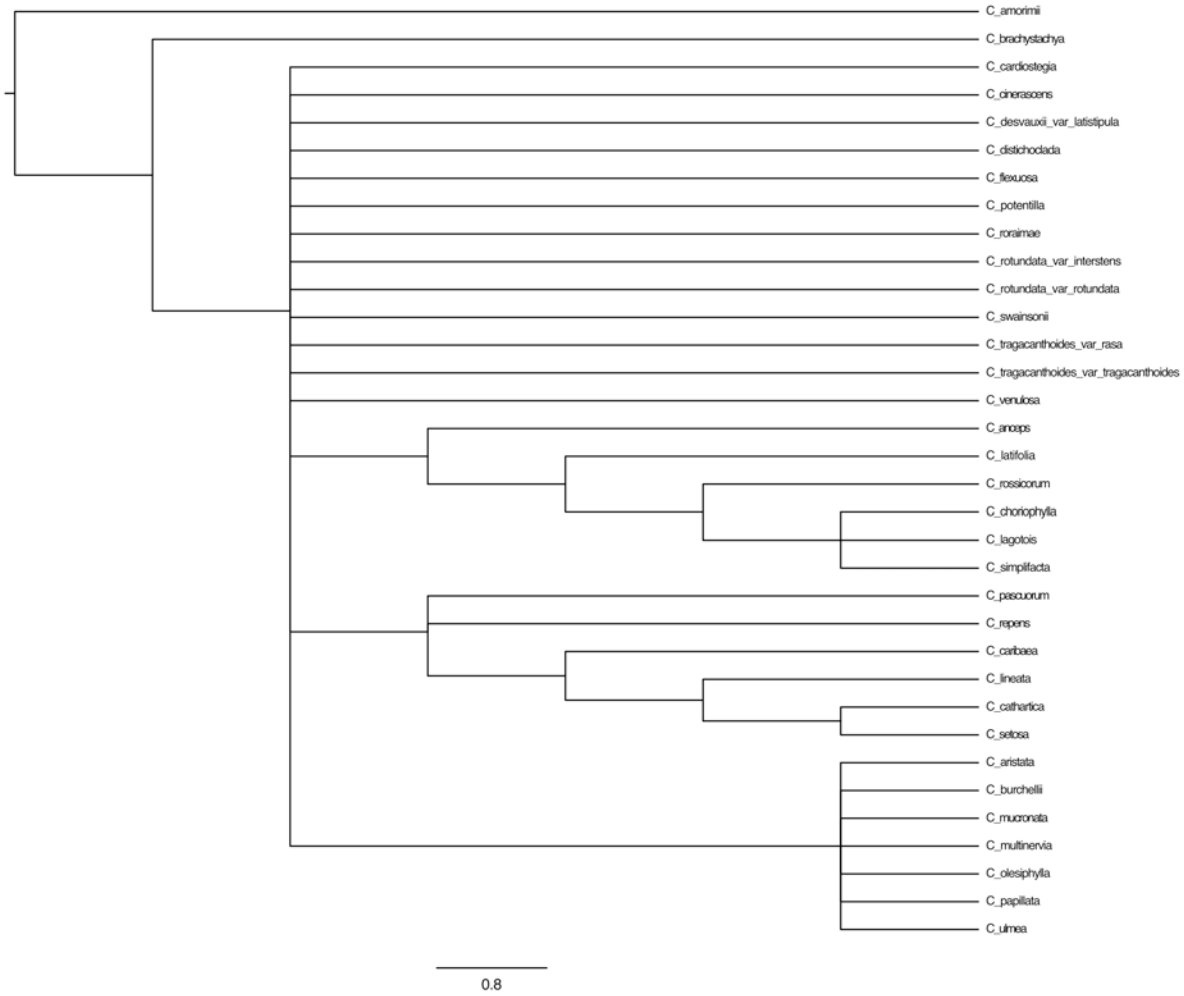
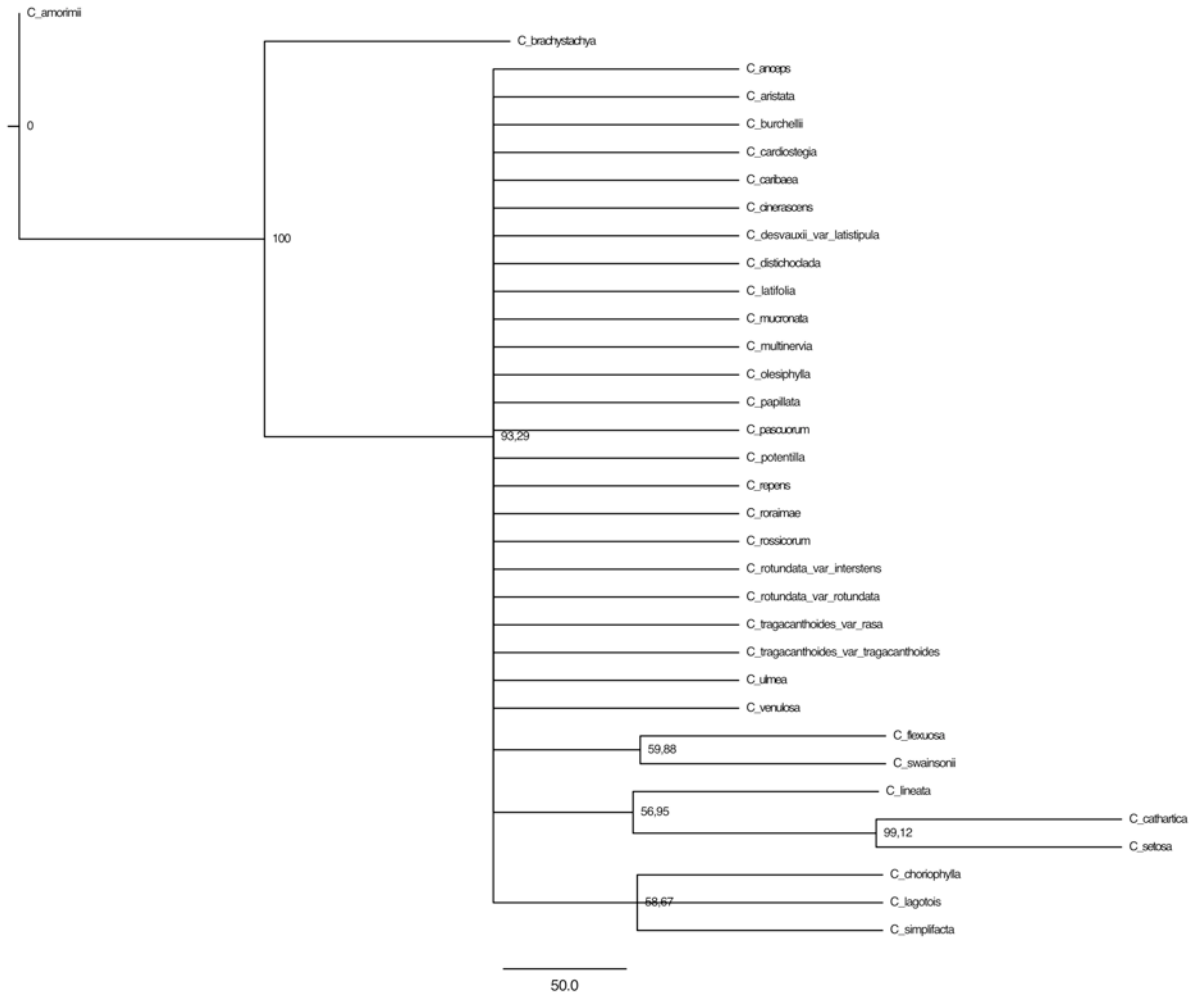
C_lagotois_2244_8
70.0

Narrow analysis, trnD-T. Majority consensus tree from Bayesian analysis.



Narrow analysis, Morphology. Strict Consensus and Bootstrap trees from parcimony analysis.

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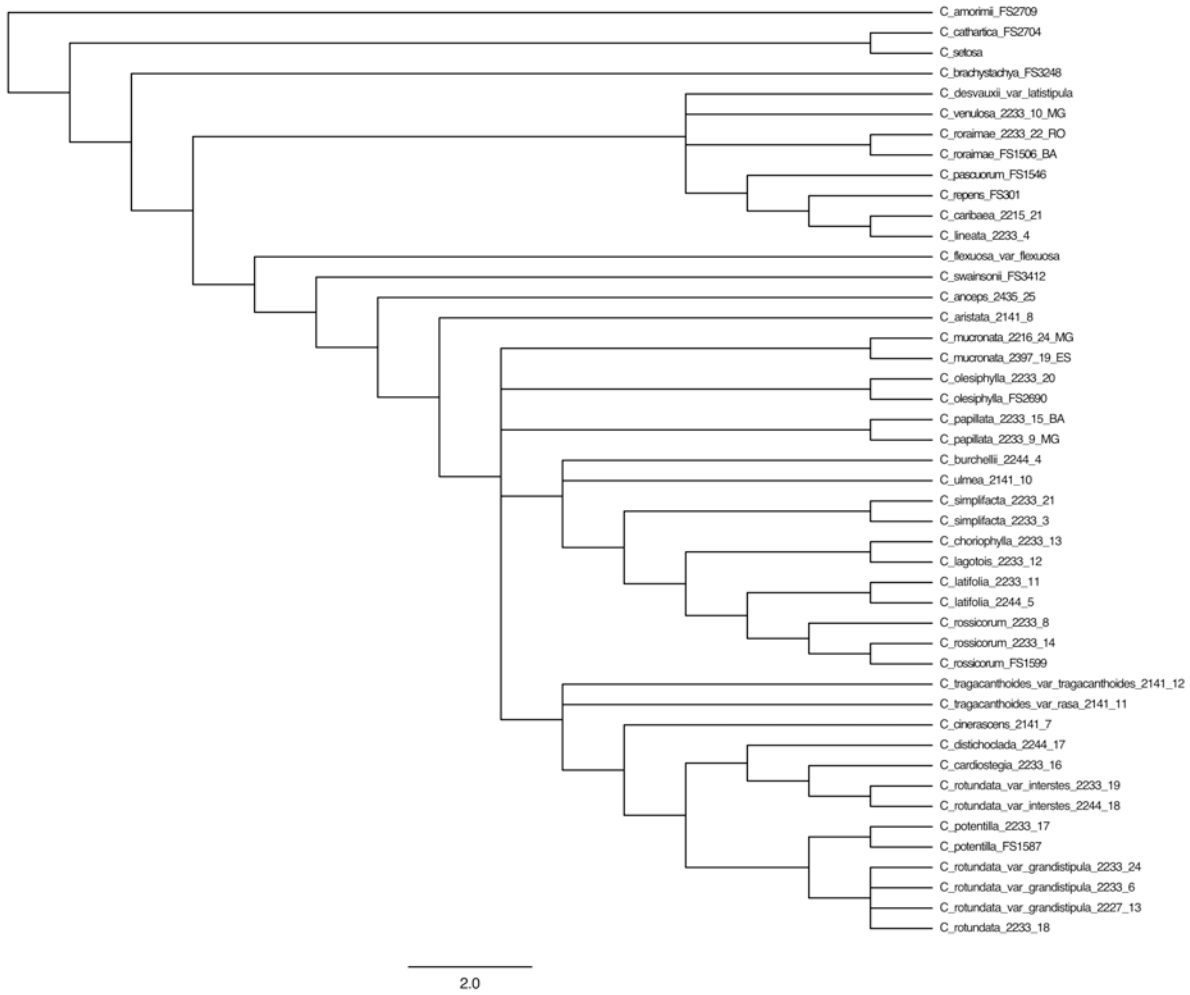
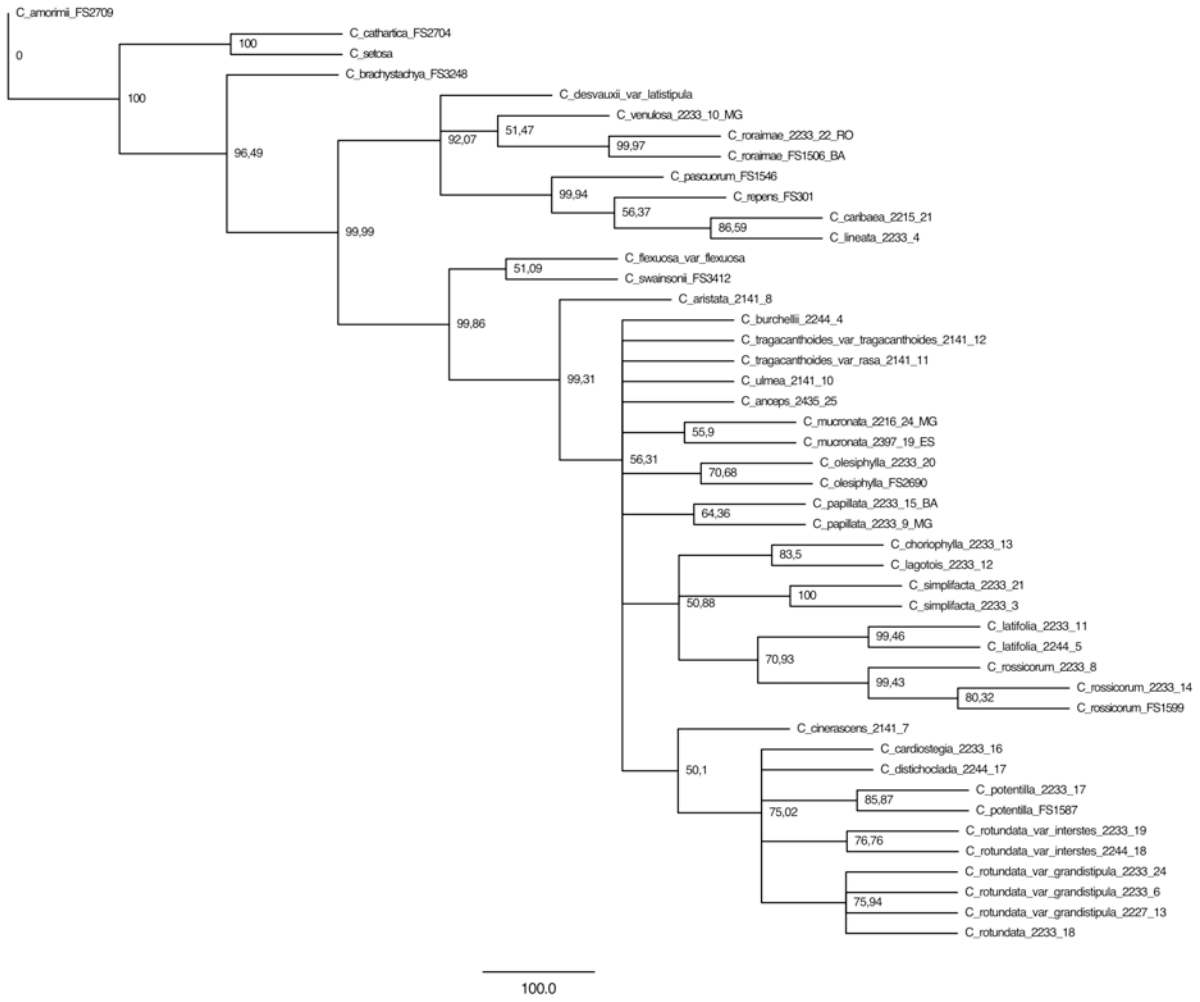
0
C_brachystachya
100
C_anceps
C_aristata
C_burchellii
C_cardiostegia
C_caribaea
C_cinerascens
C_desvauxii_var_latistipula
C_distichoclada
C_latifolia
C_mucronata
C_multinervia
C_olesiphylla
C_papillata
C_pascuorum
93,29
C_potentilla
C_repens
C_roraimae
C_rossicorum
C_rotundata_var_interstens
C_rotundata_var_rotundata
C_tragacanthoides_var_rasa
C_tragacanthoides_var_tragacanthoides
C_ulmea
C_venulosa
C_flexuosa
59,88
C_swainsonii
C_lineata
56,95
C_cathartica
99,12
C_setosa
C_choriophylla
58,67
C_lagotois
C_simplifacta
50.0

Narrow analysis, Combines. Strict Consensus and Bootstrap trees from parcimony analysis.

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0
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C_cathartica_FS2704
C_setosa
100
C_brachystachya_FS3248
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C_desvauxii_var_latistipula
C_venulosa_2233_10_MG
92,07
51,47
C_roraimae_2233_22_RO
99,97
C_roraimae_FS1506_BA
C_pasuorum_FS1546
99,94
C_repens_FS301
56,37
C_carbaea_2215_21
86,59
C_lineata_2233_4
99,99
C_flexuosa_var_flexuosa
51,09
C_swainsonii_FS3412
C_aristata_2141_8
99,86
C_burchellii_2244_4
C_tragacanthoides_var_tragacanthoides_2141_12
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99,31
C_ulmea_2141_10
C_anceps_2435_25
C_mucronata_2216_24_MG
55,9
C_mucronata_2397_19_ES
56,31
C_olesiphylla_2233_20
70,68
C_olesiphylla_FS2690
C_papillata_2233_15_BA
64,36
C_papillata_2233_9_MG
C_choriophylla_2233_13
83,5
C_lagotois_2233_12
C_simplifacta_2233_21
100
50,88
C_simplifacta_2233_3
C_latifolia_2233_11
99,46
C_latifolia_2244_5
70,93
C_rossicorum_2233_8
99,43
C_rossicorum_2233_14
80,32
C_rossicorum_FS1599
C_cinerascens_2141_7
C_cardiostegia_2233_16
50,1
C_distichoclada_2244_17
C_potentilla_2233_17
85,87
75,02
C_potentilla_FS1587
C_rotundata_var_interstes_2233_19
76,76
C_rotundata_var_interstes_2244_18
C_rotundata_var_grandistipula_2233_24
C_rotundata_var_grandistipula_2233_6
75,94
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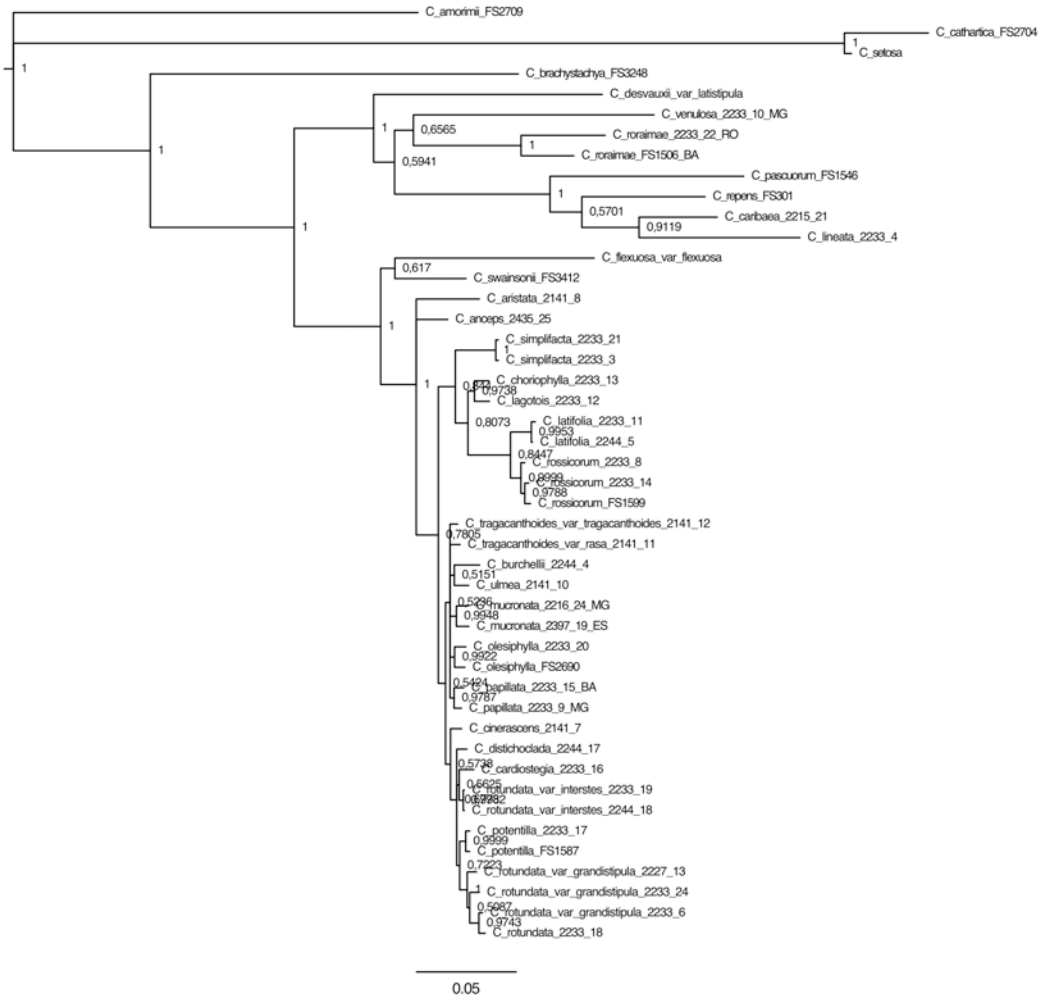
C_rotundata_2233_18
100.0

Narrow analysis, Combinada. Majority consensus tree from Bayesian analysis.



Capítulo 2

2.1. New circumscription, morphology and synopsis of *Chamaecrista* sect. *Chamaecrista* ser. *Coriaceae* (Benth.) H.S. Irwin & Barneby

2.2. Artigo publicado:

Taxonomic novelties in *Chamaecrista* Moench from Brazil

New circumscription, morphology and synopsis of *Chamaecrista* sect. *Chamaecrista* ser. *Coriaceae* (Benth.) H.S. Irwin & Barneby (Leguminosae)

Juliana Gastaldello Rando[1], José Rubens Pirani[1], Matheus Martins Cota[1] and Gwilym Lewis[2]

[1]Instituto de Biociências, Departamento de Botânica, Universidade de São Paulo, Rua do Matão 277, São Paulo, Brazil;

[2] Herbarium, Royal Botanic Gardens, Kew, Richmond, Surrey, TW9 3AB, U.K.

Corresponding author, email: ju_rando@hotmail.com

*** Manuscript to be submitted for publication in the journal "Systematic Botany".**

Abstract

A new circumscription of *Chamaecrista* sect. *Chamaecrista* ser. *Coriaceae* is presented based on the results of molecular and morphological analyses. The series is monophyletic upon exclusion of three species, which were included by Irwin and Barneby. Morphological variation within the series is discussed. Characters previously neglected as the detailed morphology of extrafloral nectaries and position of stamens are shown to be valuable for taxonomic purposes. The synopsis includes three neotypifications, a two new synonyms and a new combination. A key for identification of the species, all specimens analysed, notes of taxonomy, nomenclature, geographic distribution of all taxa, as well as illustrations of diagnostic characters are presented.

Key words – Taxonomy, *cerrado*, *campos rupestres*, Brazil.

Introduction

Chamaecrista Moench began to be recognized at generic level only in 1976 (Irwin & Barneby 1976); before then, it was considered a natural group within of the diverse genus *Cassia* L., which also envolved all species of the current genera *Cassia* s.s. and of *Senna* Mill. During the post-Linnaean treatments (*e.g.* Vogel 1837, Bentham 1870, 1871), several taxa were described in *Cassia*, and numerous categories and varieties were proposed. In the revision of the segregated genus *Chamaecrista*, Irwin & Barneby (1978, 1982) reconized 239 native species to the Americas, three subspecies and 120 varieties. Currently, *Chamaecrista* is represented by more than 330 species distributed mainly in tropical America, with only a few species in Africa, Asia and Australia, some of them reaching temperate areas (Lewis 2005). In Brazil 253 species occur, 204 of them being restricted to the country (Rando & Pirani 2012, Souza & Bortoluzzi 2014); many are narrow endemics. This high diversity of *Chamaecrista* is centered in the Cerrado Domain located in the Brazilian Central plateau, mainly in Bahia, Goiás and Minas Gerais states (Irwin & Barneby 1982, Lewis 1987, Rando & Pirani 2011). *Chamaecrista* includes trees, shrubs, and subshrubs, and is characterized by pedicels bearing two bracteoles near or above the middle, an actinomorphic androecium with anthers pubescent along the sutures, elastically dehiscent pods, and, when present, disc- or cup-shaped extrafloral nectaries (Irwin & Barneby 1982). Recent phylogenetic studies support it as a monophyletic group (Conceição et al. 2009).

Irwin & Barneby (1982) recognized six sections in *Chamaecrista,* based on a combination of characters, such as patterns of inflorescence, presence or absence of extrafloral nectaries and secretory hairs, and venation patterns of the leaflets and sepals. Species of *Chamaecrista* sect. *Chamaecrista* are shrubs and subshrubs, with axillary inflorescences reduced to fascicles and extrafloral nectaries always present (Irwin & Barneby, 1982). Six series in the section *Chamaecrista* are recognized (Irwin & Barneby, 1982), and among them *Chamaecrista* sect. *Chamaecrista* ser. *Coriaceae* is the target of this work. This series comprises 22 species and six varieties, distributed largely in drier areas of Brazil; 21 species occur in upland areas, and 18 are restricted to the "Espinhaço" Range of mountains in the states of Minas Gerais and Bahia (Brazil); one species is restricted to Goiás state (Brazil), and one is disjunct between elevated areas in Roraima and Bahia (Brazil) (Irwin & Barneby 1982, Rando & Pirani 2011, Rando et al. 2013). Only one species, *Chamaecrista caribaea* (Northr.) Britton, occurs outside South America, endemic to sea shores in the Bahamas (Irwin & Barneby 1982, Rando & Pirani 2011). Most species occur in *campos rupestres* vegetation in the "Espinhaço" Range (Rando & Pirani 2011). *Campos rupestres* are upland areas comprising many rocky outcrops surrounded by sandy or stony soils, largely covered by a low, herbaceous vegetation with scattered shrubs, housing several endemic taxa (Giulietti et al. 1997).

However, *Chamaecrista* ser. *Coriaceae* as defined by Irwin and Barneby emerged as a polyphyletic group in recent phylogenies, because three species – *C. caribaea* (with three varieties), *C. roraimae* (Benth.) Gleason and *C. venulosa* (Benth.) H.S. Irwin & Barneby, occur outwith the *Coriaceae* clade (Figure 1). Even though Irwin & Barneby's treatment for *C.* ser. *Coriaceae* is fairly recent (1982), our studies (*e.g.* Rando et al. 2013a, Rando et al. 2013b) have highlighted outstanding taxonomic and nomenclatural issues that still require resolution. The main objective of the present study is to resolve these issues and present a new classification of *C.* series *Coriaceae,* in order to circumscribe it as a monophyletic group. More specifically, we present (i) a detailed description of the previously understudied morphological characters; (ii) a new circumscription of *C.* ser. *Coriaceae* based on molecular and morphological analyses; and (iii) a synopsis of the series with standardization of nomenclatural terminology, updates and new considerations.

Methodology

Morphological studies

Morphological analyses are based on field observations and on collections from several herbaria housing specimens from Central Brazil (including type collections) both in the United States and Europe (acronym according to Thiers 2014, continuously update): ALCB, B, BHCB, DIAM, EAC, ESA, F, G, GH, HRCB, HUEFS, HUFU, INPA, K, LE, M, MBM, MG, MIRR, NY, OUPR, P, R, RB, SP, SPF, UB, UEC, UFG, and US. The terminology of morphological characters follows Radford et al. (1974) for habit, stems, underground structure and parts of the flower; Harris & Harris (2001) for leaflet surface indumentum; and Weberling (1989) for inflorescence structure. All cited specimens were examinated by the authors, with the exception of a small number of type specimens; types seen are indicated by an exclamation mark. Specimens used to document the new taxonomic circumscriptions are fully cited.

Anatomy of extrafloral nectaries

We selected fresh and herbarium specimens (two and four species, respectively) to characterize the extrafloral nectaries on the petiole/rachis in the series *Coriaceae*. Samples from herbarium material were boiled in distilled water for 15 min, kept overnight, and treated with 2 % potassium hydroxide for 2 hours. After they were rinsed in tap water three times, dehydrated in ethanol series (30–70 %) and stored in 70 % ethanol for at least 48 h (Coutinho *et al.* 2012, modified). Fresh samples from the field were fixed in FAA (formaldehyde, acetic acid and 50 % ethanol; 1:1:18, v/v) for 48 h, and after stored in 70 % ethanol. Voucher specimens were deposited at the herbarium of the Universidade de São Paulo (SPF) or Universidade Federal dos Vales do Jequitinhonha e Mucuri (DIAM). Anatomical cuts were made freehand in the region where the EFN are placed on the petiole. Subsequently, the samples were cleared using 20 % hypochlorite solution, successive washes in distilled water, stained with diluted safranine/Astra blue (safrablue) and prepared in glycerinated gelatin. Finally, we analysed the EFNs of each species using a stereomicroscope.

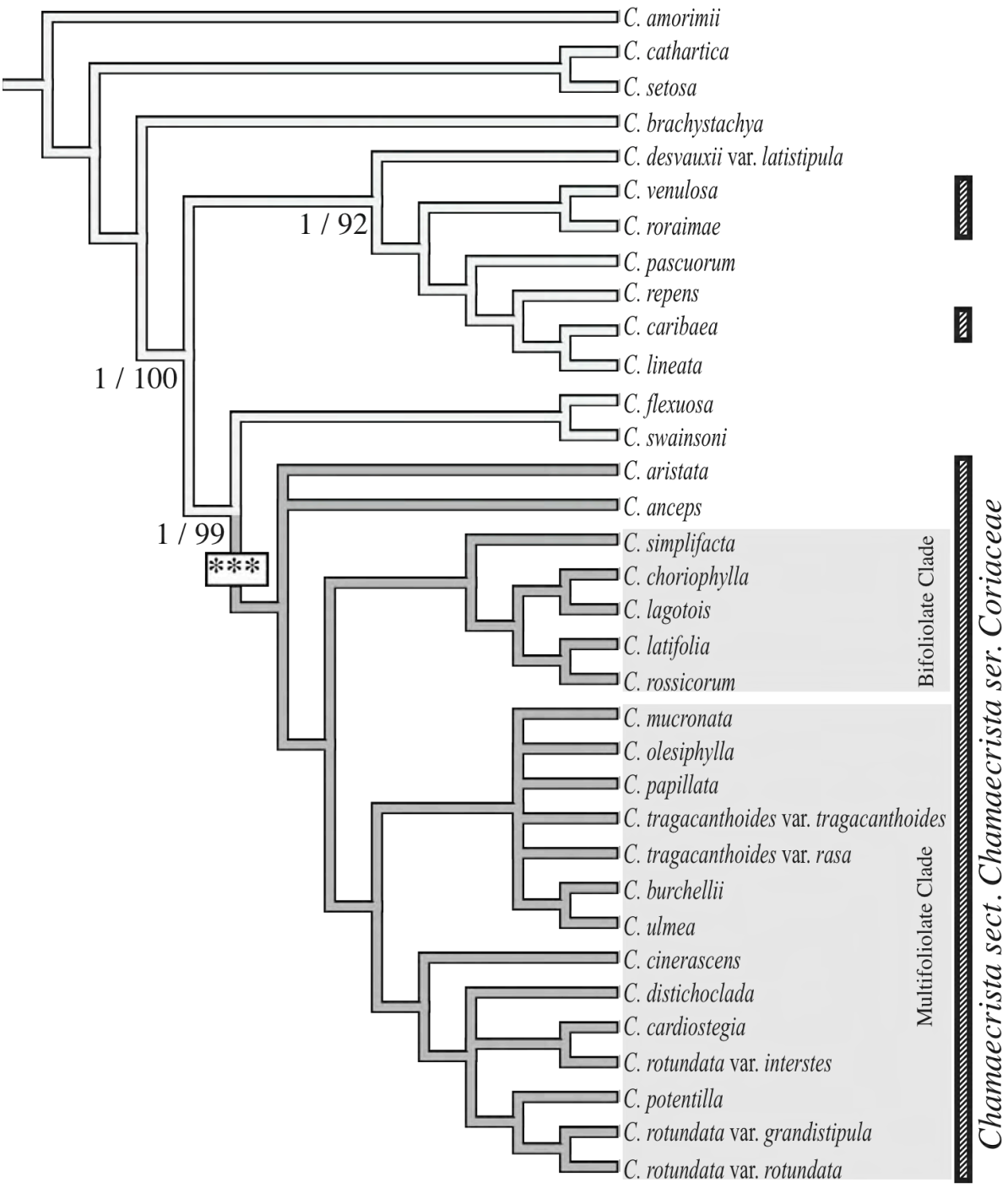


Figure 1. Adapted tree derived from Bayesian analysis of the combined dataset (ETS, ITS, *trnd-T*, *trnl-F* and morphology). Numbers above branches are posterior probability and after bootstrap support values obtained in the Maximum Parsimony analysis. *** Clade supported by 2 morphological synapomorphies and several deletions in the cpDNA (Rando et al. **Chapter 1**).

Taxonomic History

Chamaecrista sect. *Chamaecrista* ser. *Coriaceae* was first proposed by Bentham as *Cassia* subg. *Lasiorhegma* sect. *Chamaecrista* ser. *Coriaceae* in Flora Brasiliensis (Bentham 1870), and reinforced later in a revision of *Cassia* (Bentham 1871). The series then comprised 18 species and three varieties. In 1982 Irwin & Barneby published a revision of the subtribe Cassiinae in the New World, in which they presented a new circumscription of *C.* series *Coriaceae,* including species from another Bentham series: *Cassia* subg. *Lasiorhegma* sect. *Chamaecrista* ser. *Subcoriaceae*, and removing four species to a new series *Chamaecrista* sect. *Chamaecrista* ser. *Flexuosae* H.S. Irwin & Barneby (Table 1). Irwin & Barneby (1982) diagnosed *C.* ser. *Coriaceae* as: "*shrubs (some subarborescent) or subshrubs from a xylopodium; petiolar gland always present (except in West Indian* Chamaecrista caribaea*), sessile or almost so; leaflets (1-many pairs) mostly thick-textured, variably venulose, but the midrid and one adjacent primary nerve not apically anastomosing as in ser. Flexuosae; peduncles exactly axillary; sepals acute or acuminate; flowers relatively large, the long petal (11–) 12 – 28 mm*". In this revision, Irwin & Barneby (1982) described five new species and recognized 28 taxa in total: 20 species and 8 varieties. Rando et al. (2013) proposed to change the status of three varieties of *C. choriophylla* (Voegl) H.S.Irwin & Barneby to the species level – *C. choriophylla*, *C. latifolia* (Benth.) Rando, and *C. rossicorum* (H.S.Irwin & Barneby) Rando; and a synonymization of *C. potentilla* var. *specuum* H.S.Irwin & Barbeby under *C. potentilla* (Mart. ex Benth.) H.S.Irwin & Barneby var. *potentilla*. Currently the series comprises 22 species and six varieties.

Morphology

Habit, branching and roots (Figure 2)

Species of *C.* ser. *Coriaceae* are perennial shrubs with several branching patterns. Some species are decumbent (*e.g. Camaecrista choriophylla*, *C. latifolia*, *C. rossicorum* and sometimes *C. simplifacta*), others are erect and profusely branched (*Ch. distichoclada*, *Ch. potentilla* and *Ch. rotundata*), some are sparsely or loosely ramose (*Ch. arrojodoana*, *Ch. mucronata*, *Ch. olesiphylla* and *Ch. tragancanthoides*), and one species can appear as caespitose shrubs (*Ch. tragancanthoides*). Plants can attain 1 m in stature with erect and many branches arising from a xylopodium (*Ch. anceps*, *Ch. burchellii*, *Ch. cardiostegia* and sometimes *C. simplifacta*), or with longer, virgate branches (*Ch. aristata*, *Ch. lagotois* and some individuals of *Ch. rotundata*). *C. rotundata* branches can reach a length of 4 m in some

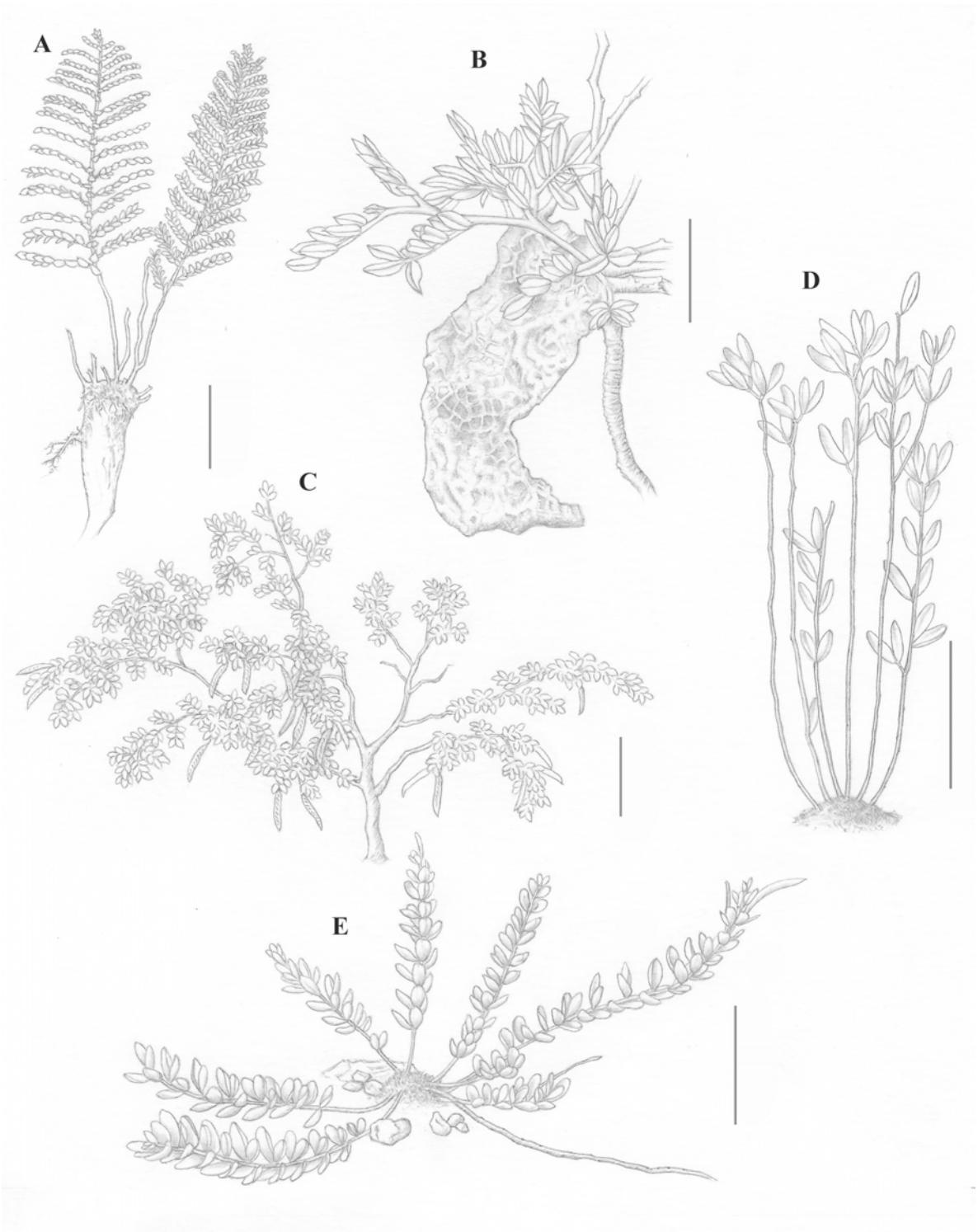


Fig. 2. Differents habit in *Chamaecrista* series *Coriaceae.* A. Erect shrub with many branches arising from a xylopodium, *C. cardiostegia* (Rando & Nogueira 1125, SPF); B. Woody rootstock, *C. arrojadoana* (Rando & Shimizu 508, SPF); C. Shrub sparsely or loosely ramose, *C. mucronata* (Rando et al. 879, SPF); D. Erect shrub with longer, virgate branches, *C. lagotois* (Rando et al. 617, SPF) ; E. Decumbent shrub, *C. rossicorum* (Rando et al. 667, SPF). Scales bars: A=10 cm, B=5 cm, C=20 cm, D=30 cm, E=30cm. Ilustrator:Hiroe Sasaki.

cases. Species with flexuous branches include *Ch. cinerascens* and *Ch. ulmea*. In the new circumscription of the series presented here, all species have a developed underground structure, sometimes referred as a xylopodium. Nevertheless, as detailed morphogical studies of these structures are still lacking, we prefer to use the general term woody rootstock. Species in the group seem to behave as hemicryptophytes or crytophytes, with new branches sprouting after fire. They are usually heliophytes living in open formations as *campo rupestre* and *cerrado*, but some may inhabit at the border of gallery forests.

Indumentum

In general the leaflet surface in species of *C.* ser. *Coriaceae* lacks hairs, probably related to their incrassate and indurate leaflets, with a thickened cuticle. Some species often have glaucous leaflets (*e.g. C. burchellii*, *C. choriophylla* and *C. lagotois*). When hairs are present, they concentrate mostly on young branches and leaves, and the indumentum can be pubescent, ciliate or rarely pilose. *C. cinerascens* is pilose on its branches and has ciliolate leaflets; *C. arrojodoana*, *C. aristata*, *C. mucronata*, *C. olesiphylla* and *C. potentilla* have pubescent branches. Seedlings of several species are pubescent or pilose, but loose the hairs with age to become completely glabrous at maturity (e.g. *C. burchelli*, *C. choriophylla*, *C. lagotois*, *C. latifolia*, *C. rossicorum*, *C. simplifacta*). *C. tragacanthoides* var. *tragacantoides* is characteristically completely covered by greyish hairs, compared with *C. tragacanthoides* var. *rasa*, which is sparsely pubescent to glabrous.

Extrafloral nectaries (Figure 3)

Patteliform extrafloral nectaries (EFNs) were observed on the petiole in six species of *Chamaecrista* series *Coriacea* varying between two morphologies: short stipitate and sessile. The difference between these two morphologies is the presence of a stalk formed by parenchymal tissue supporting the secretory region in the short stipitate extrafloral nectaries. The majority of species in the series *Coriaceae* has short stipitate EFNs and the sessile form is restricted to *C. choriophylla* and *C. lagotois*. The general pateliform shape was also observed in others species of the same section (section *Chamaecrista*) and in section *Xerocalyx* (Francino *et al.*, 2006; Francino, 2010). However, the morphological pattern of a pateliforme sessile extrafloral nectary was observed for the first time in *Chamaerista*.

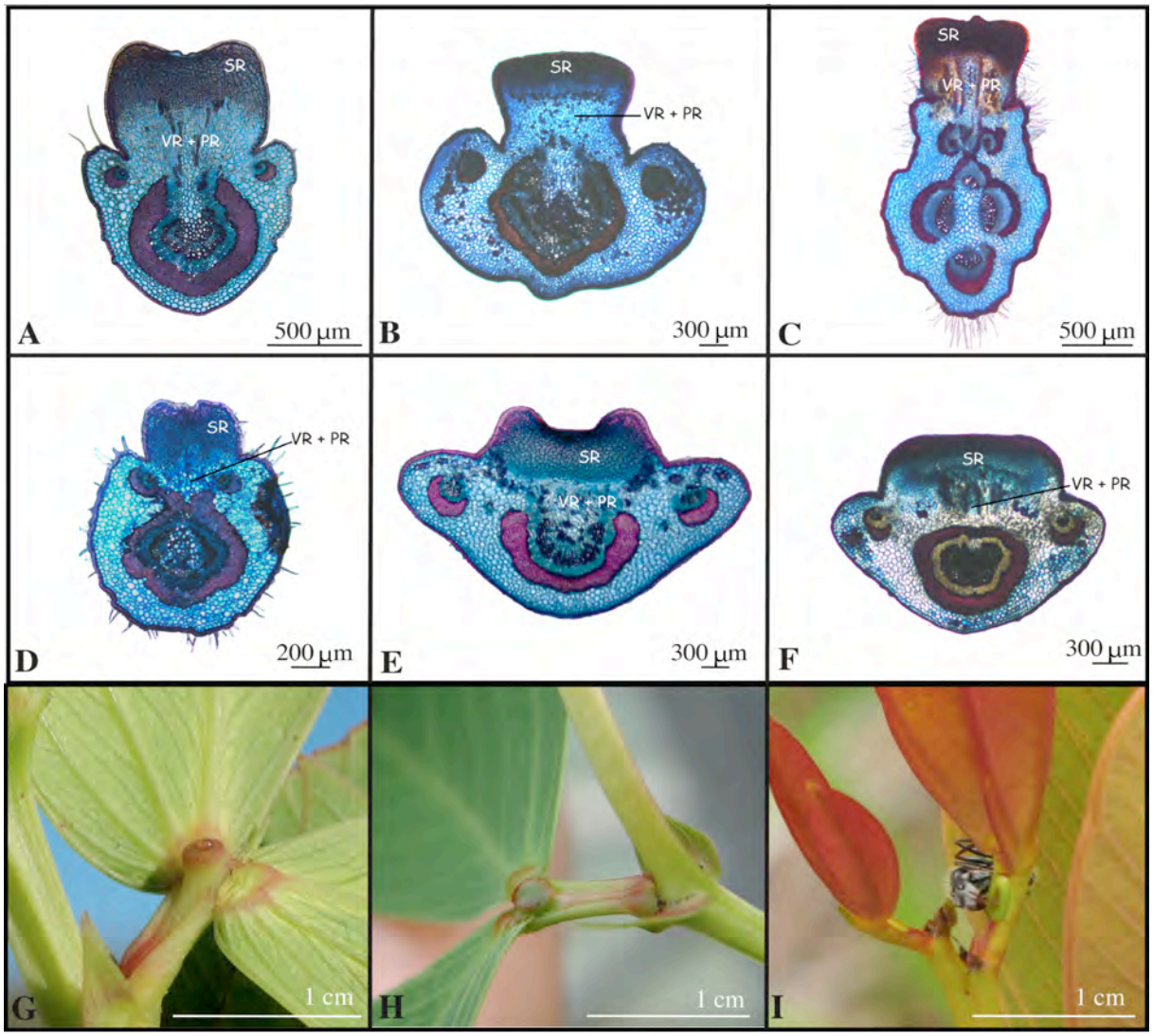


Fig. 3. A – F. Longitudinal sections of extrafloral nectaries of six species of *Chamaecrista* series *Coriaceae*. A-C: short stipitate patelliform nectaries. D-F: sessile patelliform nectaries. A. *C. anceps* (Cota 410, DIAM); B. *C. latifolia* (Rando et al. 1226, SPF); C. *C. rotundata* (Cota 85, DIAM); D. *C. olesiphylla* (Rando 1005, SPF); E. *C. choriophylla* (Rando et al. 906, SPF); F. *C. lagotois* (Rando et al. 1029, SPF). Abbreviations: PR: Parenchyma region, SR: Secretory region,VS: Vascular region. G – I. Field images of EFNs, with different morphologies. G and H, short stipitate and I, sessile with an ant species. G. *C. rossicorum*; H. *C. latifolia*; I. *C. lagotois.*

Inflorescence and flowers (Figure 4)

Chamaecrista inflorescences are commonly racemose. In contrast to the cauliflorous racemes of *C.* sect. *Apoucouita*, and to the terminal ones typical of *C.* sect. *Absus, C.* sect. *Chamaecrista* and *C.* sect. *Xerocalyx* produce reduced racemes or fascicles, sometimes solitary flowers. Reduced racemes can be axillary or supra-axillary. Even though the inflorescence in *C.* ser. *Coriaceae* has been treated by Irwin & Barneby (1982) as a reduced axillary raceme, and that our observations confirm that for most species, some others produce a terminal frondose-bracteate inflorescence, characterized by several axillary flowers placed at the distal part of the branches with reduced leaves. The flowers in *C.* ser. *Coriaceae* have five similar sepals, while the five petals show differences in length and shape, with an internal cucullate one, which hoods the major part of the androecium. The ten stamens are homomorphic or almost so, the small differences in length among the stamens are not enough to consider them as heteromorphic. The anthers are basifixed and apically poricidal. The style is terete and sometimes geniculate, the stigma is crested. A peculiar floral character of *C.* ser. *Coriaceae* that arised as a puntative synapomorphy in phylogenetic analyses is a stamen displaced to the same side as the style, a pattern which is uncommon in the remaining Brazilian species of the genus, while observed in an endemic Mexican species, *C. chamaecristoides* (Collad.) Greene, but in this case the androecium is consistently heteromorphic (Arceo-Gomes et al. 2012).

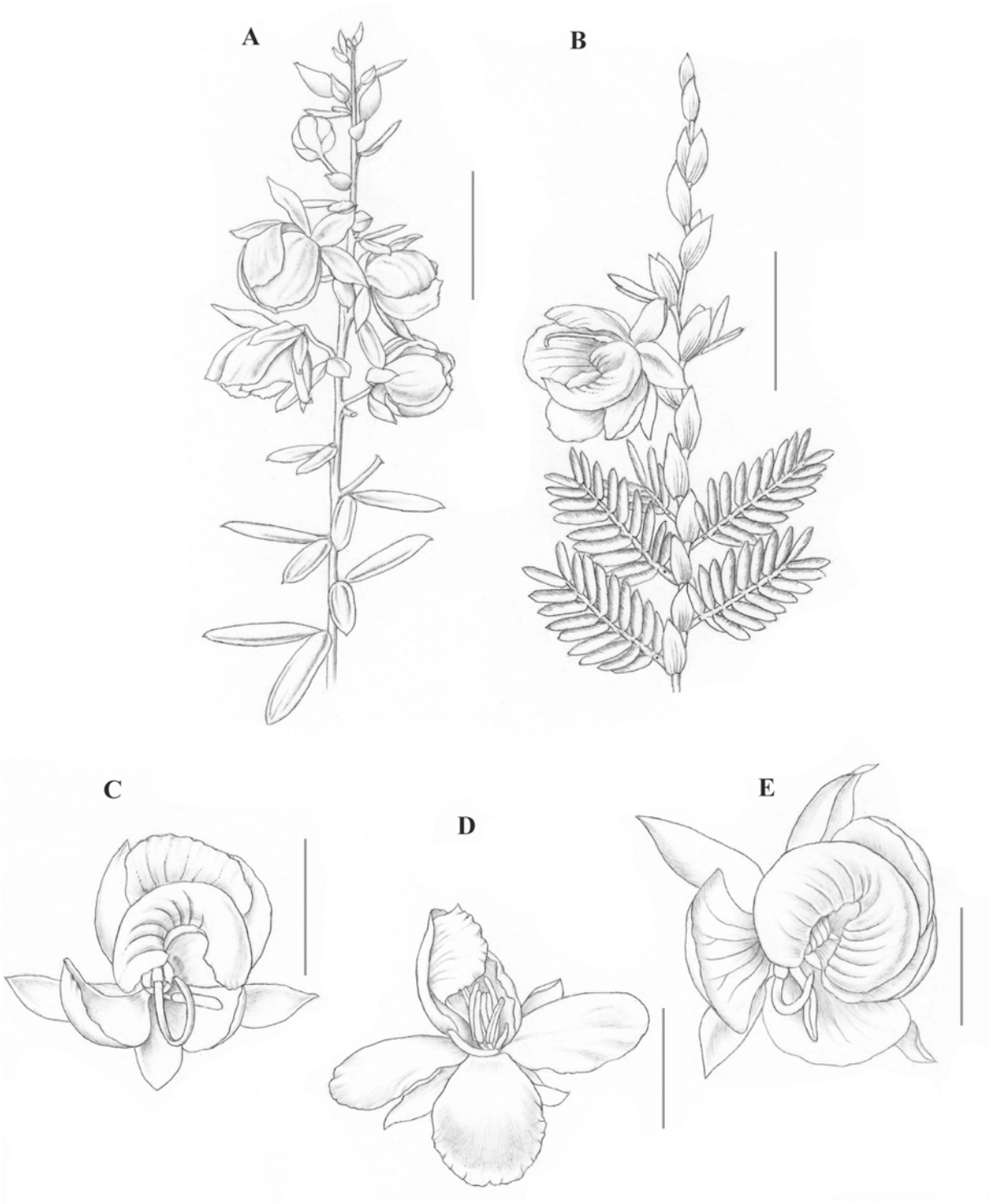


Fig. 4. Inflorescences and flowers of *Chamaecrista* series *Coriaceae*. A. Terminal frondose-bracteate inflorescence, *C. simplifacta* (Rando et al. 1242, SPF); B. Solitary flower from a reduced raceme, *C. cinerascens* (Rando et al. 875, SPF). C. *C. distichoclada* (Rando et al. 1230, SPF), D. *C. arrojadoana* (Rando & Shimizu 508, SPF), and E. *C. cinerascens* (Rando et al. 875, SPF), flowers showing displaced stamen to the same side as the style. Scale bars: A and B= 3 cm; C, D and E= 1cm. Ilustrator:Hiroe Sasaki.

New circumscription and synopsis of *Chamaecrista* sect. *Chamaecrista* ser. *Coriaceae* (Benth.) H.S. Irwin & Barneby

In order to turn ***Chamaecrista*** sect. ***Chamaecrista*** ser. ***Coriaceae*** a monophyletic group, three species traditionally recognized in the series by Irwin & Barneby (1982) must be excluded: *C. caribaea* (Northr.) Britton (with three varieties), *C. roraimae* (Benth.) Gleason, and *C. venulosa* (Benth.) H.S. Irwin & Barneby. This new circumscription is supported by molecular and morphological data (Rando et al. Chapter 1). These three species differ from the remaining mainly by the lack of an underground woody rootstock, the distinct leaflet venation pattern, and the shape of extrafloral nectaries.

Chamaecrista sect. ***Chamaecrista*** ser. ***Coriaceae*** (Benth.) H.S. Irwin & Barneby, Mem. New York Bot. Gard. 2: 667, 1982, emend Rando. *Cassia* sect. *Chamaecrista* ser. *Coriaceae* Bentham in Martius, Fl. Bras. 15(2):165. 1870.—TYPE: BRAZIL. *Chamaecrista choriophylla* (Vogel) H.S. Irwin & Barneby (lectotype designated by Irwin & Barneby [667:1982]).

Shrubs (perennial) from a well-developed woody rootstock (xylopodium for some authors); branches few to many; extrafloral nectaries always present on the petiole and sometimes also on the leaf rachis, these sessile or short-pedicellate, concave or convex; leaflets 1- many pairs per leaf, mostly incrassate and indurate in texture, glaucous in some species; peduncles axillary, flowers in racemes of 1– 7 flowers or several axillary flowers at the distal portion of the branches, which bear reduced leaves forming a terminal, frondose-bracteate inflorescence).

19 spp. (21 taxa) concentrated in the Brazilian Central Plateau, with one species (*C. cardiostegia*) disjunct in southern Brazil (Jaguaraíva, Paraná) and another (*C. mucronata*) disjunct between the “Espinhaço” Range and coastal restinga of Linhares, Espírito Santo; one species (*C. arrojodoana*) occurs exclusively throughout the “Espinhaço” Range along Bahia and Minas Gerais states; fifteen species are restricted to the highland areas of the “Espinhaço” Range in Minas Gerais state; and one species (*C. burchellii*) is restricted to the uplands of Goiás state (Figure 7).

Identification Key

1. Leaves with one pair of leaflets..... 2

1'. Leaves with 2 or more pairs of leaflets..... 6

2. Extrafloral nectaries sessile; branches terete..... 3

2'. Extrafloral nectaries shortly pedicellate; branches quadrangular to 4-alate 4

3. Decumbent shrub up to 0.6 m tall; leaflet rhombic to obovate or wide elliptic, 27.0 – 68.3 x (10.0-)14.2 – 34.8 mm; stipules 3 – 5-veined; pedicels 18.0 – 41.1 mm long; W of Serra do Cipó and Diamantina (Minas Gerais)..... 6. *C. choriophylla*

3'. Erect shrub 1.60 – 2.0 m tall; leaflet elliptic, 46.0 – 69.8 x 8.95 – 15.2 mm; stipules 1-veined; pedicels 14.4 – 19.9 mm long; endemic to the Serra do Cipó (Minas Gerais) .....

.....9. *C. lagotois*

4. Stipules 11.0 – 19.5 mm compr. long, triangular, apex long-acuminate, base cordate and amplexicaule; pedicels 26.0 – 39.9 mm long ..... 10. *C. latifolia*

4. Stipules 0.98 – 4.0 mm compr., triangular, apex acute or acuminate, base truncate; pedicels 6.0 – 15 mm..... 5

5. Petals yellow; leaflets 16 – 49.0 x 5.5 – 22.3 mm; stipules 2.0 – 4.0 mm compr.; head of extrafloral nectaries concave.....*C. rossicorum*

5'. Petals orange; leaflets 8.5 – 38.2 x 3.3 – 8.5 mm; stipules 0.98 – 1.39 mm compr.; head of extrafloral nectaries convex .....*C. simplifacta*

6. Leaves with 2 – 9 pairs of leaflets..... 7

6'. Leaves with 10 – 20 pairs of leaflets 18

7. Stipules triangular, base truncate 8

7'. Stipules ovate, base rounded, cordate or auriculate..... 14

8. Erect shrubs to 2 m tall with longer and virgate branches; apex of leaflets aristate and rigid

..... 2. *C. aristata*

8’. Shrub to 0.4 m tall with flexuous branches or sparsely or loosely ramose or caespitose; apex of leaflets mucronate or long-acuminate, not rigid..... 9

9. Pedicels 28.94 – 48.4 mm long; leaflets in (1–) 2 – 3 pairs, 26.9 – 46.5 x 5.4 – 23.7 mm; restrict to the center of Goiás state ..... 4. *C. burchellii*

9’. Pedicels 7.0 – 20.0 mm long; leaflets in 2 – 9 pairs, 4 – 28 x 1.1 – 21.75 mm; restrict to Bahia and Minas Gerais states 10

10. Erect shrub with flexuous branches; leaflets in 2 pairs; restrict to Grão-Mogol region in Minas Gerais state .....*C. ulmea*

10’. Ramose or caespitose Shrub with erect branches; leaflets in 2 – 9 pairs; distribution along to “Espinhaço” Range in Minas Gerais and Bahia states..... 11

11. Leaf rachis curved; leaflet apex long acuminate and curved .....*C.tragacanthoides*

11’. Leaf rachis straight; leaflet apex mucronate, not curved 12

12. Leaflets in 2(3) pairs; extension of leaf rachis 3 – 4 mm long..... 12. *C. multinervia*

12’. Leaflets in 3 – 8 pairs; extension of leaf rachis < 3 mm long..... 13

13. Leaf rachis 13.0 – 24.9 mm long, glabrous or sparsely pubescent; leaflets in 3 – 4 pairs, obovate ..... 11. *C. mucronata*

13’. Leaf rachis 18.6 – 44.1 mm long, pubescent; leaflets in 4 – 8 pairs, oblong or oblong-obovate ..... 3. *C. arrojadoana*

14. Stipules orbicular, apex rounded or acute ..... *C. rotundata*

14’. Stipules ovate, apex acuminate or acute 15

15. Stipule deciduous on older branches, apex acute, base rounded; 7 – 9 pairs of leaflets.....

.....7. *C. cinerascens*

15’. Stipules persistent, apex long-acuminate, acuminate or acute, base cordate or auriculate; 2 – 8 pairs of leaflets 16

16. Pulvinus plus petiole 1.5 – 2.7 mm long; leaflets 5.0 – 7.3 x 2.2 – 3.17 mm; stipules with a long acuminate apex ..... 8. *C. distichoclada*

16’. Pulvinus plus petiole 3.3 – 8.12 mm long; leaflets 9.85 – 28.0 x 3.29 – 10.1 mm; stipules with an acuminate apex 17

17. Leaves with 2-4 pairs of leaflets, extrafloral nectaries present between each pairs of leaflets .....1. *C. anceps*

17’. Leaves with 4-8 pairs of leaflets, extrafloral nectaries present just at the petiole .....

.....5. *C. cardiostegia*

18. Leaflet midvein strongly displaced, close to the margin of the blade; stipules narrow triangular, 3.3 – 8.0 mm long, apex acute, base truncate ..... 13. *C. olesiphylla*

18’. Leaflet midvein centralized; stipules ovate, 5.6 – 11.0 mm long, apex long-acuminate, base cordate or auriculate ..... 14. *C. potentilla*

1. *Chamaecrista anceps* (Benth.) H. S. Irwin & Barneby, Mem. New York Bot. Gard. 2: 679, 1982. *Cassia anceps* Benth. in Mart., Fl. bras. 15(2): 166, 1871.—TYPE: BRAZIL “in rupibus prope Diamantina prov. Minas Gerais”, 1833 (fl), *Vauthier 155* (lectotype designated by Irwin & Barneby [1982:679] from syntypes cited by Bentham [1870:167]: G!; isolectotype: P!, photo of isolectotype [NY neg. 9184]: NY!), *Riedel 483* (paratype: LE!), *Riedel 1239* (paratype: NY!, US!).

Figure 5A.

Specimens Examined—BRAZIL. **Minas Gerais**: Serra do Cipó, April 1908 (fl), *Damazio 2016* (RB); Santana do Riacho, Cardeal, Serra do Cipó, próximo à estatua do velho Juca, 7 June 1997 (fl, fr), *Farinaccio et al. 60* (HRCB, SPF); Diamantina, Campus Juscelino Kubistchek da Universidade Federal dos Vales do Jequitinhonha e Mucuri, campo rupestre, 6 December 2012 (st), *Cota et al. 410* (DIAM).

There are only two recent collections of *Chamaecrista anceps*, one from Serra do Cipó National Park and another from a natural area at the University campus in Diamantina. This rare species is morphologically related to *C. cardiostegia*, although in addition to the distinguishing characters used in the key the two species also have distinct allopatric geographical distributions. *C. anceps* occurs in *campo rupestre* vegetation.

2. *Chamaecrista aristata* (Benth.) H. S. Irwin & Barneby, Mem. New York Bot. Gard. 2: 683, 1982. *Cassia aristata* Benth. in Mart., Fl. bras. 15(2): 170, 1870.—TYPE: BRAZIL “Brasilia

Provinc.”, loco accuratius non indicato, s.d. (fl), *Martius s.n.*, (holotype: M! [M-0217324], photo of holotype [F neg. 6226]: F, NY!).

Figure 5B, 8A

Specimens Examined—BRAZIL. **Minas Gerais**: **Grão-Mogol**, Serra de Grão-Mogol, 16 August 1960 (fl), *Maguire et al. 49210* (K, NY, SP); Serra do Espinhaço, ca. 7 km west of Grão-Mogol, 16°33'53"S, 42°53'39"W, 16 February 1969 (fr), *Irwin et al. 23409* (K, NY, RB, UB); ibidem, 22 July 1978 (fl), *Hatschbach 41465* (MBM, NY); 4-6 km de Grão-Mogol, 21 July 1985 (fl), *Martinelli et al. 11236* (BHCB, NY, RB); Córrego Escurinha, 23 July 1986 (fl), *Zappi et al. CFCR 9858* (K, NY, SPF); Ribeirão dos Bois, 2 September 1986 (fr), *Mello-Silva & Cordeiro CFCR 10016* (NY, SPF); trilha dos Garimpeiros, 14 June 1990 (fl), *Hatschbach et al. 54294* (MBM); 12 June 1991 (fl), *Mello-Silva et al. 451* (NY, SPF); Estrada Grão-Mogol para Cristália, ponte sobre Rio Itacambiruçu, 18 July 1998 (fl), *Hatschbach et al. 67980* (ESA, MBM, RB); atrás da cidade, trilha do Barão, 16°33'76"S, 42°53'42"W, 2 August 1998 (fl), *Carvalho et al. 6548* (CEPEC, K, NY); estrada Grão-Mogol - Cristália, ca. 6 km de Grão-Mogol, 11 July 2001 (fl), *Souza et al. 25670* (ESA, K, RB, SPF); próximo do km 101, 20 August 2002 (fl), *Hatschbach 73674* (MBM); Serra de Grão-Mogol, 16°33'20'S, 42°53'43' S, 903 m, 8 March 2003 (fl), *Queiroz 7528* (HUEFS); Serra do Barão, 16°33'16"S, 42°53'25"W, 9 September 2003 (fr), *Conceição et al. 715* (HUEFS, K); Serra de Grão-Mogol, 16°35'25.3’S, 42°54'4.4”W, 12 Aprill 2011 (st), *Rando & Nogueira 976* (SPF); **Joaquim Felício**, Serra do Cabral, 31 August 1985 (fl, fr), *Kawasaki et al. CFCR 8071* (K, NY, SPF); ibidem, 950-1000 m, 15 May 2001 (fl), *Hatschbach et al. 72064* (MBM, ESA); entre o rio Embaiassaia e o Rio Preto, 7 June 2004 (fl), *Hatschbach et al. 77507* (MBM).

Chamaecrista aristata is restricted to the Serra de Grão-Mogol and Serra do Cabral, both comprised as part of the “Espinhaço” Range in northern Minas Gerais. *C. aristata* is a common species in that region, where it is easily recognized by the leaflets with a rigid and apiculate apex, which is almost pungent. *C. aristata* occurs in *campo rupestre* vegetation at elevations around 800 – 1000 m.

3. *Chamaecrista arrojadoana* (Harms) Rando, *comb. nov.* Basionym: *Cassia arrojadoana* Harms, Notizbl. Bot. Gart. Berlin 8(80): 715. 1924. —TYPE: BRAZIL. Bahia, Rio de Contas, casa de Pedra, campo, 1913, *Ph. von Luetzelburg 8* (holotype: B destroyed); Rio de Contas, casa de Pedra, campo, July 1913 (fl), *Luetzelburg s.n.*, (neotype designated by Irwin & Barneby [684,1982]: M! [M-0217422]).

Figure 2B, 4D, 6C, 8B

New synonym: *Chamaecrista papillata* H.S. Irwin & Barneby, Mem. New York Bot. Gard. 2: 688, 1982. —TYPE: BRAZIL. Minas Gerais, frequent on sandstone, 1200 m, summit of Serra

do Cipó, km 111-120, road from Hotel Chapéu do Sol, 6 August 1960 (fl), *Maguire, Mendes Magalhães & C. K. Maguire 49019* (holotype: NY!; isotype: RB!).

Specimens Examined—BRAZIL. **Bahia: Abaíra,** tanque do Boi, 13°16'S, 41°54'W, 1450 m, 6 July 1992 (fl), *Ganev et al. 612* (HUEFS, K, NY, SPF); Serra do Bicota, 13°50'S, 42°22'W, 1550 m, 5 July 1993 (fl), *Ganev 1802* (K, NY, SPF); caminho Boa Vista - Bicota, 13°19'S, 41°51'W, 1200 m, 23 July 1994 (fl, fr), *Ganev 3429* (HUEFS, K, NY); 9 km ao norte de Catolés, 13°2'S, 41°50'W, 1450 m, 10 July 1995 (fl), *Queiroz et al. 4388* (HUEFS, MBM, SPF); same loc., 13°2' S, 41°50' W, 1450 m, 10 July 1995 (fl), *Queiroz et. al. 4388* (MBM); estrada para Serrinha e Bicota, 20 April 1998 (fl), *Queiroz 5032* (BHCB, HUEFS, K); Catolés, 23 October 1999 (fl. fr), *Conceição et. al. 424* (ALCB, HUEFS); Campo do Courvão, 23 October 1999 (fr), *Conceição et al. 424* (HUEFS); Catolés, 19 September 1999 (fl), *Conceição et al. 397* (HUEFS, MBM, SPF); entre Catolés - Bicota, 19 September 1999 (fl, fr), *Conceição et al. 397* (HUEFS, MBM); Catolés, Serrinha, 13°19'10"S, 41°51'7"W, 1448 m, 31 May 2003 (fl), *Conceição et al. 590* (HUEFS, R); **Andaraí**, 22 km S. of Andaraí on road to Mucugê, 1000 m, 16 February 1977 (fl), *Harley 18742* (K); **Barra da Estiva**, Camulengo, estrada Barra da Estiva - Triunfo do Sincorá, km 17, 1100-1250 m, 23 May 1991 (fl), *Santos et Mayo 275* (K, RB); **Lençóis**, BR 242, entre km 224 e 228, 900 m, 2 November 1979 (fr), *Mori 12965* (CEPEC, K, NY, RB); estrada de Seabra a Itaberaba, Serra dos Lençóis, 27 May 1980 (fl, fr), *Harley 22676* (K, RB, UEC); along to BR242, ca. 15 km NW of Lençois at km 225, 900 m, 10 June 1981 (fl), *Mori & Boom 14290* (K); Mucugezinho, km 220 da rod. BR242, 947 m, 21 December 1981 (fr), *Lewis et al. 947* (K); Serra do Pai Inácio, 29 June 1983 (fl), *Luciano, Denise et Norma 645* (ALCB); BR - 242, entrocamento Lençóis-Seabra, km 8, 12°27'00"S, 41°25'00"W, 720 m, 5 September 1994 (fl), *Silva et al. 2628* (HUEFS, INPA); Chapadinha, 12°27'44"S, 21°45'12"W, 810 m, 27 September 1994 (fl, fr), *Stam et al. 937* (ALCB); Morro da Chapadinha, 12°27'24"S, 41°27'10"W, 1000 m, 22 November 1994 (fr), *Melo et al. 1242* (ALCB, K, SPF); próximo ao rio Mucugezinho, 12°27'44"W, 41°25'12" W, 27 September 1994 (fr), *Stam et al. 937* (ALCB); Serra da Chapadinha, 12°27'35"S, 41°26'25"W, 910 m, 29 July 1994 (fl), *Pereira et al. 256* (ALCB, K, RB, SPF, UFBA); Serra da Chapadinha, 12°27'35"S, 41°26'25" W, 910 m, 27 October 1994 (fr), *Carvalho et al. 1066* (ALCB, K, RB); Serra da Chapadinha, 12°28'01"S, 41°27'15"W, 31 August 1994 (fl), *Guedes et al. 694* (ALCB, K, RB, SPF); Caminho para a Serra da Chapadinha, 24 August 1996 (fl. fr), *Harley et al. 3784* (ALCB, K); próximo ao rio Mucugezinho, 12°27’52"S, 41°25'9"W, 16 October 2006 (fl), *Neves & Costa 122* (HUEFS); **Mucugê**, 3 km ao S de Mucugê, na estrada para Jussiape, 26 July 1979 (fl), *Mori et al. 12606* (RB); estrada Mucugê -Guiné, 7 September 1981 (fl, fr), *Furlan et al. CFCR 1947* (K, SPF, UEC); ibidem., 8 April 1992 (fl), *Hatschbach et al. 56871* (UEC, MBM); ibidem, 27 March 1994 (fl), *Fernandes et. al. s.n.* (EAC 20.504); Serra da Tesoura, 13°8'13"S, 41°20'21"W, 1427 m, 5 August 2004 (fl), *Borba et al. 1922* (BHCB, HUEFS); Parque Nacional da Chapada Diamantina, 12°46'S, 41°28'W, 1336 m, 19 June 2005 (fl), *Cardoso & Conceição 597* (HUEFS); **Palmeiras**, Pai Inácio, 12°27'20"S, 41°28'15"W, 1100 m, 29 August 1994 (fl. fr), *Orlandi et al. 417* (ALCB, K, RB, SPF); Pai Inácio, 12°27'20"S, 41°28'15"W, 1080 m, 26 October 1994 (fl. fr), *Carvalho et. al. 1030* (ALCB, K, RB, SPF); Pai Inácio, 12°27'00"S, 41°28'20"W, 1090 m, 30 August 1994 (fl. fr.), *Guedes et.al. 555* (ALCB, K, RB); ibidem., 10 August 1995 (fl), *Félix 7268* (HUEFS); Morro do Pai Inácio, 5 July 1998 (fl), *Silva et al. 85* (BHCB, HUEFS, SPF); Morro do Pai Inácio, 12°27'20"S, 41°28'23"W, 1070 m, 20 July 2006 (fl), *Souza et al. 6218* (ESA, RB, SPF); same loc., 27 Octuber 2011 (fl, fr), *Rando et al. 1109* (HUEFS, SPF). **Rio de Contas**, Guarda Mor, Capão de Quinca, 13°52'S,

42°20'W, 19 July 1993 (fl), *Ganev 1895* (HUEFS, K, NY, SPF); **No locality**, entre Palmeiras e Lençóis, 14 September 1956 (fl), *Pereira 2037* (NY, RB). **Minas Gerais: Belo Horizonte**, Serra da Mutuca, 16 November 1938 (fl), *Markgraf & Brade 3537* (BHCB, SP); Serra da Mutuca, 28 July 1940 (fl), *Magalhães 92* (US); Serra do Curral, 15 January 1957 (fl), *Roth 1845* (RB); **Betim**, Serra da Caveira, 18 September 1945 (fl), *Williams & Assis 7506* (US); **Brumadinho**, Serra da Moeda, 20°06'S, 43°59' W, 20 September 1998 (fl), *Madsen & Silveira 91* (BHCB, BHZB, NY); Serra da Moeda, 20°06'S, 43°59' W, 1400 m, 5 July 1998 (fl), *Madsen et al. 41* (BHCB, BHZB); PE Serra do Rola Moça, 20°4'36.7"S, 44°1'36.2"W, 1360 m, 25 January 2009 (fl), *Carmo 4060* (BHCB); **Caeté**, Alto do Serrote, 2 July 1933 (fl), *Barreto et al. 5976* (BHCB); Serra da Piedade, 28 July 1933 (fl), *Barreto 5969* (SPF); Serra da Piedade, 27 August 2001 (fl), *Souza et al. 26962* (ESA); **Conceição do Mato Dentro**, próximo ao km 170, 800 m, 16 July 1977 (fl), *Martinelli & Távora 2585* (RB); **Congonhas do Norte**, Serra Talhada, estrada vicinal saindo da estrada Congonhas do Norte – Gouveia, ca. 3.7 km NW de Congonhas do Norte, perto da ponte sobre o Rio Preto, 18°47'57"S, 43°42'35"W, 4 February 2009 (st.), *Rando et al. 674* (SPF); **Diamantina**, Serra do Espinhaço, 40 km sudoeste de Diamantina na BR259, 23 February 1975 (fr), *Anderson 11542* (MBM, NY); margem da estrada Diamantina- Conselheiro Mata, 30 August 1981 (fl), *Giulietti et al. CFCR 1767* (NY, SPF, UEC); **Francisco Sá**, Serra do Espinhaço, 1100 m, 10 February 1969 (fl), *Irwin et al. 22965* (SP); **Gouveia**, Serra do Espinhaço, 1300 m, 6 September 1971 (fl), *Hatschbach 27350* (MBM, NY); Barro Preto, Torre Telemig, 14 September 1985 (fl, fr), *Hatschbach & Kummrow 49699* (MBM, INPA); **Jaboticatubas**, Usina Pacifico Mascarenhas, 16 November 1939 (fl), *Barreto 10257* (BHCB); Serra do Cipó, km 131, Palácio, 18 August 1940 (fl), *Oliveira 129* (BHCB, SPF, UB); Serra do Cipó, km 114 ao longo da rodovia Lagoa Santa - Conceição do Mato Dentro - Diamantina, 1150 m, 5 June 1970 (fl), *Joly et al. 54* (SP); Serra do Cipó, km 116 ao longo da rodovia Lagoa Santa - Conceição do Mato Dentro, 6 June 1970 (fl), *Joly et al. CFSC 117* (SP, UEC); Serra do Cipó, 4 August 1972 (fl, fr), *Hatschbach 29841* (MBM, NY); Serra do Cipó, km 114 ao longo da rodovia Lagoa Santa - Conceição do Mato Dentro - Diamantina, 20 July 1972 (fl), *Semir & Sazima CFSC 2664* (SP); Serra do Cipó, km 114 ao longo da rodovia Lagoa Santa - Conceição do Mato Dentro - Diamantina, 20 August 1972 (fl), *Joly & Semir CFSC 2901* (SP, UEC); Serra do Cipó, km 118 ao longo da rodovia Lagoa Santa - Conceição do Mato Dentro - Diamantina, 4 March 1972 (fl), *Joly et al. CFSC 982* (SP); Serra do Cipó, km 120 ao longo da rodovia Lagoa Santa - Conceição do Mato Dentro, 21 July 1972 (fl), *Semir & Sazima CFSC 2686* (SP, UEC); Serra do Cipó, estrada da Usina, ca. de 10 km da entrada da estrada principal, 21 August 1972 (fl), *Joly & Semir CFSC 3069* (SP); Serra do Cipó, estrada da Usina, ca. de 10 km da entrada da estrada principal, 21 August 1972 (fl), *Joly & Semir CFSC 3076* (SP, UEC); Serra do Cipó, km 112 ao longo da rodovia Lagoa Santa - Conceição do Mato Dentro - Diamantina, 7 February 1972 (fl), *Semir & Sazima CFSC 703* (SP); Serra do Cipó, km 113 ao longo da Rodovia Lagoa Santa - Conceição do Mato Dentro, 7 February 1972 (fl), *Semir & Sazima CFSC 648* (SP, UEC); Serra do Cipó, km 114 ao longo da rodovia Lagoa Santa - Conceição do Mato Dentro - Diamantina, 7 February 1972 (fl), *Semir & Sazima CFSC 676* (SP, UEC); Serra do Cipó, km 114 ao longo da rodovia Lagoa Santa - Conceição do Mato Dentro - Diamantina, 20 July 1972 (fl), *Semir & Sazima CFSC 2667* (SP, UEC); Serra do Cipó, km 114 ao longo da rodovia Lagoa Santa - Conceição do Mato Dentro - Diamantina, 24 July 1972 (fl), *Semir & Sazima CFSC 2790* (SP, UEC); Serra do Cipó, km 114 ao longo da rodovia Lagoa Santa - Conceição do Mato Dentro - Diamantina, 29 August 1972 (fl), *Joly & Semir CFSC 2875* (SP); Serra do Cipó, km 114 ao longo da rodovia Lagoa Santa - Conceição do Mato Dentro - Diamantina, 20 August 1972 (fl), *Joly & Semir CFSC 2901* (SP, UEC); Serra do Cipó, km 116 ao longo da

Rodovia Lagoa Santa - Conceição do Mato Dentro, 7 February 1972 (fl), *Semir & Sazima CFSC 709* (SP); Serra do Cipó, km 120 ao longo da rodovia Lagoa Santa - Conceição do Mato Dentro - Diamantina, 22 August 1972 (fl), *Joly & Semir CFSC 3253* (SP, UEC); Serra do Cipó, km 127 ao longo da Rodovia Lagoa Santa - Conceição do Mato Dentro, 19 July 1972 (fl), *Semir & Sazima CFSC 2615* (SP); Entre Rio Doce e Colonia, 24 October 1974 (fl, fr), *Hatschbach & Koczicki 35266* (MBM, NY); Serra do Cipó, km 111 ao longo da rodovia Lagoa Santa - Conceição do Mato Dentro - Diamantina, 22 July 1980 (fl), *Menezes et al. CFSC 6363* (SP); Serra do Cipó, 9 September 1987 (fl, fr), *Vasconcellos et al. 19644* (UEC); Serra do Cipó, 26 July 1997 (fl.), *Tomé 1139* (MBM); após o Córrego Grande, localidade conhecida como Mata das Flores, 21 October 1997 (fl), *Hervencio et al. 115* (SPF); Serra do Cipó, trilha para a lagoa Azul, próximo ao alojamento do IBAMA, 13 October 2013, *Rando & Barbosa 1011* (HUEFS, SPF). **Morro do Pilar**, ao lado da população de *Vellozia gigantea*, 28 October 2008 (fl), *Rando 607* (SPF); ao lado da população de *Vellozia gigantea*, 19º14'48"S, 43º31'06" W, 28 October 2008 (fl), *Rando et al. 606* (SPF); entrada da Trilha para as *Vellozia gigantea*, 19º15'28"S, 43º31'57"W, 28 October 2008 (fl), *Rando et al. 602* (SPF). **Ouro Branco**, Serra da Moeda, 13 September 1964 (fl), *Pereira et al. 9188* (NY, RB); Serra de Ouro Branco, 20°29'0.2"S, 43°42'7.52"W, 20 April 2003 (fl), *Meireles et al. 1407* (UEC); **Ouro Preto**, Bráz Gomes, caminho para PE Uaimii e Serra do Capanema, 1100 m, 26 July 2006 (fl), *Fontana et al. 2290* (RB); **Sabará**, Tapera, 2 August 1942 (fl), *Magalhães 3220* (BHCB); **Mariana**, Samarco, 15 August 2000 (fl), *Brina et.al. s.n.* (BHCB60058); **Santa Luzia**, Serra do Cipó, 23 August 1933 (fl), *Barreto 5973* (BHCB, SP); **Santana do Riacho**, Serra do Cipó, Palacinho, 25 October 1961 (fl), *Duarte 6421* (RB); Serra do Cipó, km 120, 1200 m, 14 February 1968 (fl), *Irwin et al. 20022* (RB, UB, US); Serra do Cipó, Chapéu do Sol, 1350 m, 16 May 1978 (fl, fr), *Brantjes 705902* (SP, UEC); Serra do Cipó, km 109 antigo 114 da estrada Loagoa Santa - Conceição do Mato Dentro, 1100 m, 6 September 1980 (fl), *Forero et al. 7752* (SP, SPF); Serra do Cipó, km 117 ao longo da Rodovia Belo Horizonte - Conceição do Mato Dentro, 19 April 1981 (fl), *Furlan et al.* 7218 (SP, SPF, UEC); Serra do Cipó, 21 May 1982 (fl), *Almeida 220* (RB); Estrada da Usina, 26 July 1986 (fl, fr), *Chukr et al. CFSC 9849* (NY, SPF); Serra do Cipó, 1200 m, 9 September 1987 (fl), *Cordeiro et al. CFSC 10528* (SP, SPF); km 106-107 (antigo 112-113) da Rodovia Belo Horizonte – Conceição do Mato Dentro, próximo a entrada da Estrada da Usina, 1 September 1988 (fl), *Kameyama et al. CFSC 11235* (SPF); Serra do Cipó, 2 August 1990 (fl), *Salauregui 46* (MBM); Serra do Cipó, 20 October 1990 (fl), *Stehmann et al. s.n.* (BHCB 18.946); Serra do Cipó, 20 October 1990 (fl), *Stehmann* (BHCB 18.862); Serra do Cipó, 20 October 1990 (fl), *Stehmann et al. s.n.* (BHCB 18.839); Serra do Cipó, km 109, 2 August 1990 (fl), *Sakuragui & Souza 46* (ESA, MBM, SPF); Parque Nacional da Serra do Cipó, descida da Serra das Bandeirinhas, 28 July 1991 (fl), *Giulietti et al. CFSC 12634* (SPF); Parque Nacional da Serra do Cipó, 13 September 1992 (fl), *Lucca 89* (UEC); Serra do Cipó, 13 September 1992 (fl), *Lucca et al. 89* (BHCB); Serra do Cipó, ca. de 2 km do Córrego Chapéu de Sol, 3 July 1996 (fl), *Souza et al. 11545* (ESA); Lapinha, 1126 m, 23 November 2000 (fl), *Kinoshita & Mansanaress 00-279* (UEC); Serra do Cipó, estrada entre a sede do IBAMA e a Cachoeira da Farofa, 4 July 2001 (fl), *Souza et al. 25025* (ESA, RB, SPF, UEC); Cardeal Mota, Serra do Cipó, sede da fazenda Monjolos, 19°06'44"S, 43°41'53"W, 24 September 2002 (fl), *Yamamoto & Kinoshita 02-84* (UEC); estrada para o Morro do Breu, 27 September 2002 (fl), *Yamamoto et al. C-192* (UEC); Lapinha, Pico do Breu, 19°6'44"S, 43°41'53"W, 27 September 2002 (fl), *Kinoshita & Yamamoto 02-226* (UEC); Serra do Cipó, km 115 (antigo 108) da rodovia MG 010, 9 June 2002 (fl), *Groppo et al. 1090* (SPF); Parque Nacional da Serra do Cipó, trilha da Cachoeira da Farofa, 11 August 2005 (fl), *Sato & Oliveira 55* (RB, SPF); Serra do Cipó, km 126, rodovia Santana do Riacho -

Conceição do Mato Dentro, 3 February 2006 (st), *Borges 41* (SPF); Serra do Cipó, rod. Belo Horizonte - Conceição do Mato Dentro, 2 km da estrada da Usina, 11 January 2006 (fr), *Savassi-Coutinho et al. 927* (ESA); Próximo ao segundo portão depois da Sede do IBAMA, 19º20'57"S, 43º37'22"W, 8 January 2008 (fl, fr), *Rando & Shimizu 508* (ESA, SPF); Próximo ao segundo portão depois da Sede do IBAMA, 43º37'22"W, 19º20'57"S, 8 January 2008 (fl), *Rando & Shimizu 512* (SPF, ESA); próximo ao segundo portão depois da Sede do IBAMA, 8 January 2008 (st), *Rando 508* (SPF); Rodovia Lagoa Santa - Conceição, ca. de 1 km após o córrego Vitalino, aproximadamente km 113, margem esquerda, 29 October 2008 (st.), *Rando et al. 612* (SPF); antigo km 113 da rodovia Belo Horizonte – Conceição do Mato Dentro (MG010), 19º20'54.8"S, 43º38'14.3"W, 1079 m, 22 July 2009 (fl), *Siniscalchi et al. 1* (SPF). **Serra do Cipó**, 5 August 1936 (fl), *Archer 5027* (US); ibidem., 4 April 1958 (fl), *Atala 32* (R); same local., 4 April 1958 (fl), *Atala 46* (R); ibidem., 24 July 1966 (fl), *Emygdio & Andrade 2233* (R); ibidem., 18 February 1972 (fl), *Anderson et al. 36263* (RB, UB, US); ibidem., 9 November 1987 (st), *Schmeda 1052* (US); ibidem., 17 September 1994 (fl), *Fernandes s.n.* (BHCB 100040);17 September 1994 (fl), *Fernandes 3* (BHCB); Parque Nacional da Serra do Cipó, Canyon, Ribeirão Bandeirinhas, 30 August 1988, *Kameyama et al. CFSC 11218* (SPF). **No locality**, Cachoeiras do Campos, 1839 (fl), *Claussen & Delessert s.n.* (K 000839156); 1840 (fl), *Claussen 800* (G); Serra da Piedade, 28 July 1940 (fl), *Barreto 10846* (BHCB, SPF); from Belo Horizonte to Serra do Cipó, 5 August 1960 (fl), *Maguire et al. 49002* (NY, R, US); Gandarela, 1170 m, 15 July 1972 (fl), *Emygdio et al. 3368* (R); Base do Capanema, 31 August 1973 (fl), *Badini s.n.* (OUPR 16877); Serra da Mesquita, 31 August 1977 (fl, fr), *Badini s.n.* (OUPR 16875); ao longo da rodovia MG 10 km112.5, 11 October 1996 (fl), *Malaguth et al. s.n.* (BHCB 35.366); Parque Nacional da Serra do Cipó, trilha sede do IBAMA - Canyon das Bandeirinhas, 24 September 1999 (fl), *Costa et al. 82* (SPF); Rio Acima, Serra Água Limpa, 20°6"16.1S, 43°42"5"W, 1390 m, 25 July 2009 (fl), *Carmo 4916* (BHCB).

Irwin & Barneby (1982) synonymized *Cassia arrojadoana* Harms described in 1924 in *Chamaecrista mucronata*. In that same monograph they described a new species, *Chamaecrista papillata*, similar to *Cassia arrojodoana* in many aspects. Here we propose the new combination *Chamaecrista arrojadoana* and the reduction of *C. papillata* to its synonymy. *Chamaecrista arrojadoana* is morphologically closed to *C. mucronata*, from which it can be set apart through the characters presented in the key, as well as by its allopatric distribution. *C. arrojadoana* is a commum species in *campos rupestres* along the "Espinhaço Range" from south of Minas Gerais state north to Bahia state, while *C. mucronata* is restrict to south of Minas Gerais state extending easter to Linhares in Espírito Santo state. Leaflets of specimens from Serra do Cipó (Minas Gerais state) have a papilate epiderm, which explain the epithet *papillata*. However most plants from Bahia lack papillae, and weremistakenly determined as *C. mucronata* in several herbaria. *C. arrojadoana* occurs in *campo rupestre* vegetation at elevations around 720 – 1450 m.

4. *Chamaecrista burchellii* (Benth.) H. S. Irwin & Barneby, Mem. New York Bot. Gard. 2: 690, 1982. *Cassia burchellii* Benth. in Mart., Fl. bras. 15(2): 165, 1870.—TYPE: BRAZIL

“Habitat Goyaz - Cavalcante”, s.d. (fl, fr), *Burchell 7582* (lectotype designed by Irwin & Barneby [1982:690] from syntypes cited by Bentam [1870:165]: K!, photo of lectotype [NY neg. 1527]: NY!); “prope S. José prov. S. Paulo” (= Niquelândia, Goiás), 1837 (fl, fr), *Pohl 2126* (paratype: K!).

Figure 5C, 8C

Specimens Examined—BRAZIL. **Minas Gerais**: **Campinaçu**, estrada Niquelândia - Campinaçu, 540 m, 6 October 1995 (fl), *Cavalcanti et al. 1788* (CEN, K); **Colinas do Sul**, Colinas do Sul a Niquelândia, km 20, 600m, 18 February 2000 (fl), *Hatschbach et al. 70380* (MBM); **Niquelândia,** 15 km sul de Niquelândia, 1000 m, 21 January 1972 (fl, fr), *Irwin et al. 34613* (NY, SPF, UB); ca. 14 km S. of Niquelândia, 1000 m, 21 January 1972 (fl), *Irwin et al. 34703* (K, NY, RB, UB, US); 25 km leste de Niquelândia, 21 January 1992 (fl), *Hatschbach et al. 56321* (NY); ca. 8 km da cidade, Fazenda Traíras, 14°29'19"S, 48°33'26"W, 29 May 1996 (fl), *Aparecida & Jesus 2948* (NY); Fazenda Engenho, ca. 11 km de Niquelândia em direção a Dois Irmãos, 14°41'43"S, 48°21'32" W, 730, 2 October 1997 (fl), *Fonseca et al. 1597* (EAC, NY, RB); Fazenda Engenho, ca. 11 km de niquelândia em direção a Dois Irmãos, 14°41'54"S 48°25'24" W, 730, 20 November 1997 (fl, fr), *Fonseca et al. 1689* (NY, RB); 31 km de Niquelândia em direção a Muquém, 14°28'32"S, 48°10'42"W, 470 m, 8 May 1998 (fl, fr), *Fonseca et al. 1834* (NY); estrada Niquelândia - Colinas, 17 September 1998 (fl), *Forzza et al. 1058* (CEN, SPF); Fazenda Engenho, ca. 11 km de Niquelândia em direção a Dois Irmãos, 14°41'43' S, 48°21'32' W, 730, 2 October 1999 (fl), *Fonseca et al. s.n.* (EAC 28.613); estrada Niquelândia - Colinas do Sul, 28 km da saída de Niquelândia na bifurcação para Colinas do Sul, bacia do Rio Bagagem, 14°27'51"S, 48°11'06' W, 517 m, 1 February 2003 (fl), *Mello-Silva et al. 2244* (HUEFS, K, RB, SPF); Estrada Niquelândia - Colinas do Sul, 28 km da saída de Niquelândia, na bifurcação para Colinas do Sul, lado direito da estrada, 14°27'51'S, 48°11'06'W, 23 October 2011 (fl, fr), *Rando et al. 1092* (HUEFS, SPF).

Chamaecrista burchellii is the only species of *C.* ser. *Coriaceae* that occurs outside the “Espinhaço” Range. Its distribution is restrict to a small area comprising three localities (Campinaçu, Colinas do Sul and Niquelândia) in Goiás state. *C. burchellii* occurs in open areas of cerrado at elevations of 517 – 1000 m.

5. *Chamaecrista cardiostegia* H.S. Irwin & Barneby, Mem. New York Bot. Gard. 2: 678, 1982.—TYPE: BRAZIL. Minas Gerais: between Tejuco to Veraba legítima (=Uberaba,), 13 September 1827 (fl, fr), *Burchell 5756* (holotype: K!, photos of holotype [IPA neg.1116, NY neg. 9188] = NY!, isotypes: LE!, P!)

Figure 2A, 5F, 8D

Specimens Examined—BRAZIL. **Goiás: Cristalina**, Rod. BR 040 a 2 km de Cristalina, 13 August 1980 (fl), *Hatschbach 43050* (K, MBM, NY, UEC, US); Serra do Cristais, 1175, 6 November 1965 (fr), *Irwin et al. 10000* (K, NY, RB, UB, US); Serra dos Cristais, cerca de 10 km ao sul de Cristalina, 1125 m, 2 November 1965 (fl),

Irwin et al. 9801 (NY, RB, US); **Minas Gerais**: **Buenópolis,** Serra Cabral, região do Cuba, Lapa da Dança, 1 August 2006 (fl), *Pangaio et al. 696* (RB); Serra do Cabral, região do Tanque, próximo ao Buritizal, 17°53'06.3"S, 44°20'04.8"W, 12 September 2009 (fl), *Pangaio et al. 1219* (RB). **Carmo do Paranaíba**, 16 July 1947 (fl), *Magalhães 5435* (RB); **Delfinópolis**, estrada de Delfinópolis e o Parque Nacional da Serra da Canastra, ca. de 5km antes da entrada do Parque, 20°06'08"S, 47°01'08"W, 7 September 1998 (fl), *Souza, et al. 21242* (BHCB, ESA, HUFU); Estrada Delfinópolis sentido Sacramento, 63 km da saída, borda da estrada, depois do povoado, 20°06'03.1"S, 47°04'29"W, 6 January 2012 (st), *Rando & Nogueira* 1125 (HUEFS, SPF); **Ibitimirim**, próximo de Alto Campos, 31 January 1959 (st), *Irwin, H.S. 2520* (K, NY, US); **Joaquim Felício**, Serra do Cabral, 31 August 1985 (fl), *Zappi et al. CFCR 2043* (MBM); Serra do Cabral, 31 August 1985 (fl), *Zappi et al. CFCR 8043* (K, MBM, NY, SPF); Serra do Cabral, entre os rios Embaiassaia e Rio Preto, 18 August 2002 (fl), *Hatschbach et al. 73494* (MBM); Serra do Cabral, Rio Embaiassaia, 7 June 2004 (fl), *Hatschbach et al. 77473* (MBM); Serra do Cabral, 20 September 2005 (fl, fr), *Hatschbach & Barbosa 79393* (MBM); Serra do Cabral, 16 August 2007 (fl), *Hatschbach & Silva 80054* (MBM); 17 August 2007 (fl), *Silva & Hatschbach 5904* (MBM); **Montes Claros**, 2 km de Água Boa, Serra do Espinhaço, 950 m, 25 February 1969 (fr), *Irwin et al. 23897* (K, NY, RB, UB, US); **Patos de Minas**, entre Catiara e Patos de Minas, 1220 m, 18 August 1950 (fl), *Duarte 2802* (NY, RB); entre Patos de Minas e a cidade de Araguari, 1 July 1964 (st), *Magalhães, 19933* (NY); **Patrocínio**, 15 km norte, estradade rodagem, 20 October 1946 (fl), *Magalhães 5434* (RB); ibidem., 1050 m, 28 January 1970 (fl, fr), *Irwin et al. 25482* (B, G, NY, RB, UB, US, SP); **Sacramento**, Guarita do Sacramento, 8 August 1996 (fl), *Nakajima et al. 1830* (DIAM, HUFU, NY); ibidem., 26 July 2001 (fl), *Jeannine 27* (HRCB); **São Roque de Minas**, Estrada para São Roque, 3 km da guarita de Sacramento, Parque Nacional da Serra da Canastra, 19 August 1997 (fl), *Romero et al. 4425* (HUFU); guarita do Sacramento, PARNA Serra da Canastra, 14 July 1995 (fl), *Nakajima et al. 1204* (HUFU, NY); guarita do Sacramento, PARNA Serra da Canastra, 19 August 1997 (fl), *Romero et al. 4391* (HUFU); **Uberaba,** In campis Chapadão inter Tejuco et Uberaba legitima, August 1834 (fl, fr), *Riedel & Luschnatt 2449* (LE, NY, US); ibidem., 1990 (fl), *Teixeira & Brina s.n.* (BHCB35818); Barreira do Eli, RPPN da Magnesita, S.A., 13 March 2003 (fl), *Roshel & Silva s.n.* (OUPR 17016); ibidem., 1870 (fl, fr), *Warming* (NY00959407). No locality: Voyage d'Auguste de Saint-Hilaire, s.d. 1816-1821 (fl, fr), *Saint-Hilaire 933* (P). **Paraná: Jaguariaíva**, Parque Estadual do Cerrado, 30 September 1992 (fl), *Cervi 3766* (MBM); Parque Estadual do Cerrado, 30 March 2012 (st), *Ribas et al. 8590* (MBM, RB).

Chamaecrista cardiostegia shows a peculiar disjunct pattern: It occurs in the "Espinhaço" Range in Minas Gerais state, in some mountains in Goiás state, and in Paraná state (ca. 520 km in distance from the two former areas). *C. cardiostegia* occurs in *cerrado* sensu strictu and in *campo rupestre* vegetation around elevations of 950 – 1175 m.

6. *Chamaecrista choriophylla* (Vogel) H.S. Irwin & Barneby, Mem. New York Bot. Gard. 2: 691, 1982. *Cassia choriophylla* Vogel, Syn. Gen. Cass. 56 & Linnaea 11:706, 1837. —TYPE: BRAZIL. Minas Gerais: Serra do Galheiro, 1836 (fl, fr), *Sellow s.n.* (lectotype K! [K000555332] designed by Irwin & Barneby [1982: 691], isolectotype P! [P00835982, fragment]).

Figure 5D, 8E

Specimens Examined—**BRAZIL. Minas Gerais: Diamantina**, 6 October 1972 (fl), *Duarte 14011* (RB); 40-50 km sudoeste de Diamantina, na BR 259, 23 February 1975 (fl), *Anderson et al. 11539* (NY); estrada Diamantina a Araçuaí, 6 June 1985 (fl), *Semir et al. 17752* (UEC); Estrada Gouveia – Curvelo, ca. de 20 km de Diamantina, 18°33'36"S, 43°51'14"W, 1060 m, 23 September 2008 (fl), *Mello et al. 415* (HUFU); **Delfinópolis**, Estrada para Casinha Branca, 25 October 2003 (fl), *Nakajima et al. 3703* (HUFU, SP); **Gouveia**, BR 249, 1200 m, 5 September 1971 (fl), *Hatschbach 26994* (NY, MBM); Fazenda Contagem, 29 August 1981 (fl), *Giulietti et al. CFCR 1745* (UEC, K, SPF); Serra do Espinhaço, 12 September 1985 (fl), *Hatschbach & Kummrow 49591* (K, INPA, NY, MBM, SPF, US); Barro Preto, 14 September 1985 (fl), *Hatschbach & Kummrow 49683* (MBM); **Santana de Pirapama**, Serra do Cipó, Fazenda Toucan Cipó, trilha da captação de água, 19°00'21.56"S, 43°45'32.29"W, 605 m,18 November 2009 (st), *Rando et al. 906* (SPF); ibidem, 19°00'20.9"S, 43°46'1.18"W, 26 November 2009 (fr), *Lewis et al. 3842* (K, RB, SPF); ibidem, 19°59'40.74"S, 43°46'18.6”W, 695 m elev., 20 November 2009 (st), *Rando et al. 911* (SPF); ibidem, Vilarejo de Inhame, trilha da Senhorinha, 16 October 2011 (fl), *Rando & Barbosa 1034* (HUEFS, SPF); ibdem, distrito de São José da Cachoeira, trilha do João Carrinho, 18 February 2007 (st), *Souza et al. 32697* (ESA).

Chamaecrista choriophylla is one of five bifoliolate species of *C.* ser. *Coriaceae*. Bentham (1870) recognized two varieties: *Cassia choriophylla* var. *choriophylla* and *Cassia choriophylla* var. *latifolia*. Irwin & Barneby (1982) proposed a third one: *Chamaecrista choriophylla* var. *rossicorum*. Analyses of herbarium specimens and fieldwork led by Rando et al. (2013) to recognize three distinct species. *C. choriophylla* is recognized by its features of the extrafloral nectaries and branches, stipules shape and pedicel length. It is probably closely related to *C. lagotois.* Despite some collections nearby Diamantina, large populations of *C. choriophylla* are found mostly on the southwestern side of the “Espinhaço” Range (Santana de Pirapama, Minas Gerais state), in *campo rupestre* vegetation at elevations around 750 – 1290 m.

7. *Chamaecrista cinerascens* (Vogel) H.S. Irwin & Barneby, Mem. New York Bot. Gard. 2: 672, 1982. *Cassia cinerascens* Vogel, Syn. Gen. Cass. 60 & Linnaea 11: 711, 1837. —TYPE: BRAZIL. Minas Gerais: in Serra do Santo Antônio, 1884, *Sellow s.n.*, (holotype: B destroyed, photo [F neg. 1673]: F! no isotypes found), Minas Gerais, Serra do Cipó, km 117 ao longo da Rodovia Lagoa Santa - Conceição do Mato Dentro, 27 May 1972 (fl, fr), *Joly et al. CFSC 2198* (neotype designated here: SPF!, isoneotypes: K!, NY!, SP!, UEC!).

Figure 2B, 4E, 5E, 8F

Synonym: *Cassia rotundata* var. *angustifolia* Benth. in Mart., Fl. bras. 15(2): 167.1870. — TYPE: BRAZIL. Minas Gerais, in graminosis locis altis Serra da Lapa (=Serra do Cipó) et ad Caxoeira do Campo, January 1825 (fl), *Riedel 558* (holotype: K!, isotype: LE!).

Specimens Examined—BRAZIL. **Minas Gerais**: **Barão de Cocais**, Cerca de 10 km de Barão de Cocais, 1500 m, 24 January 1971 (fr), *Irwin et al. 29012* (NY, UB, US); **Catas Altas**, Parque Natural da Serra do Caraça, Trilha para a Capelinha, Mata montana e afloramentos rochosos com campos rupestres, 18°16'48"S, 43°31'58"W, 1298 m, 12 February 2009 (fl), *Rando et al. 875* (SPF); Serra do Caraça, perto da Gruta do Padre Caio, 15 April 2000 (fl), *Mota 201* (BHCB, MBM); **Conceição do Mato Dentro**, Serra do Cipó, km 141 estrada de Conceição do Mato Dentro, 6 July 1936 (st), *Archer & Barreto 4907* (NY, SP, US); Serra do Cipó, 6 July 1936 (fl), *Archer et Barreto 4942* (US); Serra do Cipó, km 140 estrada de Conceição do Mato Dentro, 25 November 1938 (fl), *Barreto 8535* (SP); ca. 3-5 km leste da Serra, estrada de Conceição para Diamantina, 9 August 1960 (fl), *Maguire et al. 49123* (RB); Parque Natural Municipal do Ribeirão do Campo, 19 March 2003 (fl), *Mota & Viana 2117* (BHCB); **Congonhas do Norte**, Serra Talhada, 9 km S de Congonhas do Norte na estrada para Conceição do Mato Dentro, entrada para Extrema seguindo 11 km – Fazenda Imbaúbas, 18°56'23"S, 43°40'55.7"W, ca. 1130 m, 3 February 2009 (st), *Rando 661* (SPF); **Itabirito**, 10 km da cidade em direção a Belo Horizonte, 14 October 1995 (fl), *Souza et al. 213* (BHCB; ESA); **Jaboticatubas**, Serra do Charco, 23 November 1942 (fl), *Magalhães 2631* (BHCB); ibidem, 1942 (fl), *Renno 911* (BHCB); Serra do Cipó, fazenda Palácio, 8 August 1972 (fl, fr), *Hatschbach 30058* (MBM, NY, SPF); Serra do Cipó, km 127 ao longo da Rodovia Lagoa Santa - Conceição do Mato Dentro, 21 May 1974 (fl), *Semir & Giulietti CFSC 5032* (K, SP, UEC); **Ouro Preto**, estrada Ouro Preto, km 144, 13 September 1964 (fl), *Pereira et al. 9218* (RB); **Santa Barbára**, Serra do Caraça, s.d. (fl), *Casaretto 2940* (G); ibidem, Voyage d'Auguste de Saint-Hilaire, s.d. 1816-1821 (fl, fr), *Saint-Hilaire s.n.* (P 00684340); Caraça, 1600 m, 20 July 1972 (fl), *Emygdio et al. 3523* (NY, R); Caraça, caminho para Piscina, 23 May 1987 (fl), *Trindade 32* (BHCB); Serra do Caraça, caminho para o mirante, 23 May 1987 (fl, fr), *Zappi & Scatena CFCR 10901* (NY, SPF); Caraça, 11 September 1990 (fl), *Stehmann s.n.* (BHCB 18959, NY); Serra do Caraça, trilha do Pico da Carapuça, 23 May 1997 (fl, fr), *Kawasaki et al. 973* (NY, SP, SPF); Serra do Caraça, Padre Caio, 8 July 2001 (fl, fr), *Ordones 823* (BHZB); **Santa Luzia**, Serra do Cipó, 1 June 1933 (fl), *Barreto 5939* (BHCB, SP); **Santana do Riacho**, km 124 da Rodovia BH - Conselheiro Mata, Alto do Palácio, curva da estrada ao Sul da estátua do Velho Juca, 31 May 1991 (fl), *Pirani et al. CFSC 12353* (NY, SPF); Parque Nacional da Serra do Cipó, 1300 m, 27 June 1991 (fl), *Pereira et al. 1028* (BHCB, NY); Parque Nacional da Serra do Cipó, 20 June 1993 (fl), *Lucca 83* (BHCB); Parque Nacional da Serra do Cipó, N da Base do Ibama do Palácio,1 May 1993 (fr), *Pirani et al. CFSC 13041* (SPF); Serra do Cipó, km 119 da Rodovia Belo Horizonte - Conceição do Mato Dentro, estrada da Usina, 6 May 1997 (fl), *Hervencio & Soffiatti 77* (SPF); Serra do Cipó, km 118 (antigo 125) rodovia Belo Horizonte - Conceição do Mato Dentro, 19°15'49"S, 43°33'29"W, 1309 m, 9 June 2002 (fl), *Pirani et al. 5093* (SPF); **Santo Antônio do Itambé**, Itambé, Voyage d'Auguste de Saint-Hilaire, s.d. 1816-1821 (fl), *Saint-Hilaire s.n.* (P 00684350). **Serra do Cipó**, in graminosis Serra da Lapa, January 1845 (fr), *Riedel s.n.* (US 372666); km 131, 15 April 1935 (fl), *Barreto et Brade 1225* (B, BHCB, RB); km 135, 1100-1250 m, 21 April 1955 (fl), *Duarte 2676* (NY, RB, UB); km 140, 6 April 1957 (fl), *Pereira & Pabst 2895* (NY, RB, UB); Serra do Cipó, km 134, 15 March 1962 (fl), *Duarte 6526* (RB); km 120, ca. de 145 km de Belo Horizonte, 1300 m, 21 February 1968 (st), *Irwin et al. 20624* (K, NY, RB,

UB, US); km 110 -131, 27 May 1970 (fl), *Occhinoni s.n.* (MBM 11903); 1200 m, 17 February 1972 (st), *Anderson et al. 36123* (NY, UB); próximo ao entrocamento da estrada para Conceição do Mato Dentro, 19°13'13"S, 43°29'57"W, 1100 m, 26 April 1978 (fl), *Lima 478* (RB); Serra do Cipó, 17 September 1994 (fl, fr), *Fernandes 4* (BHCB, NY); Serra do Cipó, 17 September 1994 (fl), *Fernandes 8* (NY); Serra do Cipó, 1997 (fl), *Fernandes 39* (NY); **No locality**, 1817 (fr), *Langsdorf 2438* (LE); s.d. (fl), *Damazio 2017* (RB); 1840 (fl), *Claussen s.n.* (BM); s.d. (fl, fr), *Gounella s.n.* (P 02946325).

Chamaecrista cinerascens is restricted to Minas Gerais state. It is easily recognized by the format and shape of its deciduous stipules. Irwin & Barneby (1982) could not trace any possible isotypes, however they cited an image in Field Museum (Berlin types) as a reference. Since this image shows none of the diagnostic characters of the species, we decided to designate a neotype, *Joly et al. CFSC 2198*, which matches the original description. *C. cinerascens* occurs in *campo rupestre* vegetation, and sometimes in margins of gallery forest associated to that vegetation, at elevations around 1100 – 1600 m.

8. *Chamaecrista distichoclada* (Mart. ex Benth.) H.S. Irwin & Barneby, Mem. New York Bot. Gard. 2: 674, 1982. *Cassia distichoclada* Mart. ex Benth. in Mart., Fl. bras. 15(2): 168, 1870.—TYPE: BRAZIL. Minas Gerais, in altis montibus ad Va. Rica (= Ouro Preto), May 1818 (fl, fr), *Martius s.n.* (holotype: M! [M-0217179], photo of holotype [F neg. 6234]: F, NY!).

Figure 4C, 8G

Specimens Examined—BRAZIL. **Minas Gerais**: **Diamantina**, Biribiri, 23 March 1892 (fl, fr), *Schwacke 8580* (OUPR); Biribiri, September 1892 (fl), *Glaziou 19084* (K, LE, MG, NY, P, RB, UB); 12 km ao noroeste de Diamantina, estrada para Mendanha, 1300 m, 27 January 1969 (st), *Irwin et al. 22733* (K, NY, RB, UB, US); rod. para Couto Magalhães, 17 September 1985 (fl), *Hatschbach & Zelma 49777* (MBM, NY, SPF, US); 15 km de Diamantina, 4 July 1989 (fl, fr), *Vasconcelos et al. 21729* (RB, UEC); 15km de Diamantina, 4 August 1989 (fl, fr), *Queiroz 2368* (HUEFS); Biribi, estrada ao longo do Córrego Soberbo, Cachoeira dos Cristais, 2 October 1997 (fl), *Kawasaki et al. 1046* (NY, SP); Parque Estadual do Biribiri, Cachoeira dos Cristais, 18°09'26"S, 43°36'05"W, 1164 m, 18 May 2008 (fl), *Mello et al. 317* (HUFU); Parque Estadual do Biribiri, Cachoeira dos Cristais, 18°09'42'3"S, 43°36'0.72"W, 1054 m, 21 September 2010 (fl, fr), *Hensing et al. 243* (HUFU); ibidem, 18°09'42.3"S, 43°36'0.72"W, 1054 m, 21 September 2010 (fl, fr), *Romero et al. 8351* (HUFU); Campus da Universidade UFVJM, próximo ao córrego Soberbo, seguindo pela trilha que passa por trás do antigo apiário da Universidade, sobre o morro à esquerda, 18°11'52.3"S, 43°34'7.3"W, 9 June 2012 (fl), *Rando et al. 1230* (HUEFS, SPF); Campus da Universidade UFVJM, próximo ao córrego Soberbo, seguindo pela trilha que passa por trás do antigo apiário da Universidade, 9 June 2012 (fl), *Rando et al. 1231* (HUEFS, SPF); **São Gonçalo do Rio Preto**, Parque Estadual do Rio Preto, IEF, 18 May 1999 (fl), *Amaral s.n.* (OUPR 8495); **São João da Chapada**, 3 km ao norte da cidade, 1200 m, 24 March 1970 (fl), *Irwin et al. 28269* (M, NY, P, UB).

The holotype of *Chamaecrista distichoclada* was probably collected in Vila Rica, current Ouro Preto, in Minas Gerais state. However, all other collections of this species were made on the Diamantina Plateau, not in the southern Ouro Preto area. *C. distichoclada* is closely related to *C. potentilla*, from which it is distinct by its smaller habit,form leaflets smaller and fewer, and by its distinct apex of stipules and leaflets. It occurs in *campo rupestre* vegetation at elevations around 1050 – 1300 m.

9. *Chamaecrista lagotois* H.S. Irwin & Barneby, Mem. New York Bot. Gard. 2: 694, 1982. — TYPE: BRAZIL. Minas Gerais: w. slope of Serra do Cipó, near km 105 (ca. 130 km n. of Belo Horizonte), 1150m, 17 November 1968 (st), *Irwin, Maxwell & Wasshausen 20356* (holotype: UB!; isotypes: F, K!, LE!, M!, NY!, R!, US!).

Figure 2D, 5G, 8H

Specimens Examined—BRAZIL. **Minas Gerais**: Parque Nacional da Serra do Cipó, Serra das Bandeirinhas, 10 Sepetember 1987 (fl, fr), *Simão-Bianchini et al. CFSC 10565* (SP, SPF); ibidem, 28 July 1991 (fl), *Giulietti et al. CFSC 12625* (SPF); Córrego Gavião, 1100 m, 13 September 1993 (fl), *Lucca 91* (BHCB, UEC); Santana do Riacho, Serra do Cipó, 25 Sepetember 1996 (fl), *Pereira et al. 1023* (BHCB, UEC); Parque Nacional da Serra do Cipó, 25 Sepetember 1996 (fl), *Pereira et al. 1024* (BHCB); Córrego Gavião, afloramento rochoso, 30 October 2008 (fr), *Rando et al. 617* (ESA, SPF); Parque Nacional da Serra do Cipó, trilha dos Escravos, encosta de morro, 961 m, 19º18'53"S, 43º36'09"W, 25 July 2008 (fl), *Shimizu et al. 97* (UEC); ibidem, 15 October 2011 (fl), *Rando et al. 1029* (HUEFS, SPF); ibidem, 10 January 2012 (st) *Rando et al. 1033* (SPF).

Chamaecrista lagotois is one of five bifoliolate species of *C.* ser. *Coriaceae,* and its epithet suggests a resemblance of the bifoliolate leaves to rabbit ears. It is easily recognized by the elliptical shape of leaflets and symmetrical position of the midvein. *Chamaecrista lagotois* is only known from the six collections cited above, all from the Serra do Cipó in Minas Gerais state where it is found in *campo rupestre* vegetation at elevations around 960 – 1100 m.

10. *Chamaecrista latifolia* (Benth.) Rando, Phytotaxa 97(1): 19, 2013. Basionym: —*Cassia choriophylla* var. *latifolia* Benth. in Mart., Fl. bras. 15(2): 165, 1870. TYPE: —BRAZIL. Minas Gerais: 1843 (fr), *Claussen 208* (lectotype P!, designated by Irwin & Barneby [1982: 693], isolectotypes G!, P!, LE!).

Figure 5H, 8I

Synonym: *Chamaecrista choriophylla* (Benth.) H.S. Irwin & Barneby var. *latifolia* (Benth.) H.S. Irwin & Barneby, Mem. New York Bot. Gard. 2: 693, 1982.

Specimens Examined—BRAZIL. **Minas Gerais**: **Catas Altas**, Serra do Caraça, campo rupestre, 9 October 2000 (fl), *R.C. Motta 983* (BHCB). **Conceição do Mato Dentro**, Serra do Cipó, km 140, estrada de Conceição, 16 April 1935 (fl), *Barreto & Brade 1227* (BHCB); Serra do Cipó, km 141, estrada de Conceição, 6 August 1936 (fl), *Archer & Barreto 4911* (BHCB); Parque Natural Municipal de Ribeirão do Campo, margem rochosa de riacho, 19°06'20.9"S, 43°35'50.9"W, 13 September 2002, (fl) *Motta 2110* (BHCB). **Diamantina**, Biribiri, 30 March 1892 (st), *Glaziou 19103* (P); ca. 27 km S.W. of Diamantina on road to Gouveia, 13 January 1968 (fr), *Irwin et al. 21881* (K, RB, US); Estrada para Conselheiro Mata, campo rupestre, 13 July 1996 (fl), *Atui et al. 55* (SPF); Rodovia Guinda - Conselheiro Mata, campo rupestre, 25 July 1998 (fl, fr), *Hatschbach et al. 68259* (BHCB, G, HUEFS, MBM, SP, UB). **Gouveia**, BR 259, em direção a Datas, campo rupestre, 16 September 1985 (fl), *Hatschbach & Zelma 49747* (MBM); próximo ao trevo para Datas, 1100 m, campo rupestre, 22 May 1989 (fl), *Hatschbach & Nicolack 53098* (MBM). **Jaboticatubas**, Serra do Cipó, km 137, estrada de Conceição, entre pedras no campo, 12 July 1940 (fl), *Foster & Barreto 10850* (BHCB); Serra do Cipó, km 132 ao longo da Rodovia Lagoa Santa - Conceição do Mato Dentro, 7 June 1970 (fl), *Joly et al. 260* (SP, UEC); ibidem, 30 April 1972 (fl), *Semir & Sazima 2040* (UEC); ibidem, 28 May 1972 (fl), *Semir et al. 2374* (K, SP, UEC); ibidem, 21 August 1972 (fl, fr), *Joly & Semir 3112* (UEC, SP, SPF); Serra do Cipó, km 139 ao longo da Rodovia Lagoa Santa - Conceição do Mato Dentro, 17 April 1972 (fl), *Joly et al. 1864* (SP, UEC); ibidem, 17 April 1972 (fl), *Joly et al. 1904* (SP); ibidem, 27 May 1972 (fl), *Joly et al. 2168* (SP); Serra do Cipó, km 142 ao longo da Rodovia Lagoa Santa - Conceição do Mato Dentro, 22 July 1972 (fl), *Semir & Sazima 2731* (SP); Serra do Cipó, Palácio, campo rupestre, 8 August 1972 (fl), *Hatschbach 30077* (MBM, NY); Serra do Cipó, km 142 ao longo da Rodovia Lagoa Santa - Conceição do Mato Dentro, 22 August 1972 (fl), *Joly et Semir 3185* (SP, UEC); ibidem, 22 September 1972 (fl), *Semir & Sazima 2791* (UEC); Serra do Cipó, campo rupestre, 6 May 1997 (fl), *Filliettaz 97-08* (UEC). **Morro do Pilar**, Parque Nacional da Serra do Cipó, MG -010 ca. de 100 m do trevo que vai para Morro do Pilar, 06 June 2012 (st), *Rando et al. 1226* (SPF). **Patrocínio**, January 1951 (fr), *Ferrari 4143* (BHCB). **Santa Luzia**, 25 June 1933 (fl), *Barreto 5944* (BHCB); Serra do Cipó, 7 August 1933 (fl), *Barreto 5947* (BHCB, SP); Serra do Cipó, km 131, 24 August 1933 (fl), *Barreto 5945* (BHCB, SP); Serra do Cipó, 2 Sepetember 1933 (fl, fr), *Barreto 5946* (SP, UB); Serra do Cipó, km 143, estrada do Pilar, 17 August 1936 (fl), *Barreto 5950* (SP). **Santana do Riacho**, Serra do Cipó, km 131, Palácio, entre pedras, 18 August 1940 (fl., fr.), *Oliveira 136* (BHCB); km 138 da estrada Conceição de Mato Dentro, campo rupestre, 6 December 1949 (fr), *Duarte 2107* (RB); Serra do Cipó, 60 km oeste de Morro do Pilar em sentido à São José de Almeida, campo rupestre, 13 January 1959 (fl, fr), *Irwin 2447* (NY, US); Serra do Cipó km 136, 1290 m, campo rupestre, 21 April 1950 (fl), *Duarte 2607* (RB, SPF, UB); km 112-128, próximo ao Hotel Chapéu de Sol, campo rupestre, 7 August 1960 (fl, fr), *Maguire et al. 49056* (NY, RB, US); Serra do Cipó, s.d. 1960, Magalhães 18150 (UB); km 137, 15 March 1962 (fl, fr), *Duarte 6501* (F, NY, RB, UB); km 135, ca. 150 km N of Belo Horizonte, campo rupestre, 19 February 1968 (fl), *Irwin et al. 20500* (K, NY, RB, UB, US); Serra do Cipó, 15 July 1971 (fl), *Rizzini s.n.* (RB 151070); Serra do Cipó, s.d 1976 (fl), *Rizzini s.n.* (RB 1761199); Serra do Cipó, km 138 ao longo da Rodovia Belo Horizonte - Conceição do Mato Dentro, elev., 15 August 1979 (fl), *Giulietti et al. 5626* (SP, SPF); Serra do Cipó, km 138 da rodovia Belo Horizonte - Conceição do Mato Dentro, campo rupestre, 11 July 1987 (fl, fr), *Zappi et al. 10396* (K, SPF); Serra do Cipó, Fazenda Cachoeira da Capivara, campo rupestre, 4 August 1990 (fl), *Sakuragui & Souza 139* (ESA); Serra do Cipó, km 125 da Rodovia Belo Horizonte - Conceição do Mato Dentro,

elevação em frente a estátua do Velho Juca, campo rupestre, 26 April 1991 (fl), *Pirani et al. CFSC 12245* (NY, SPF); Serra do Cipó, km 124 da Rodovia Belo Horizonte - Conceição do Mato Dentro, curva da estrada ao sul do velho Juca, campo rupestre, 31 May 1991 (fl, fr), *Pirani et al. 12337* (NY, SPF); Serra do Cipó, 17 September 1994 (fl, fr), *Fernandes 6* (BHCB, NY); Parque Nacional da Serra do Cipó, coletada à 3 km da portaria do IBAMA - Alto do Palácio, região das canelas de ema gigantes, campo rupestre, 16 August 1992 (fl), *Pereira & Lucca 1015* (BHCB); Serra do Cipó, campo rupestre, 3 July 1995 (fl), *Hervencio et al. 6* (SPF); Serra do Cipó, campo rupestre, 3 July 1995 (fl), *Hervencio et al. 7* (SPF); Serra do cipó, estrada MG-010, km 125, Belo Horizonte - Conceição do Mato Dentro, próximo à estátua do Velho Juca, 3 September 1995 (fl), *Hervencio et al. 12* (SPF); Serra do Cipó, Fazenda Cachoeira da Capivara, campo rupestre, 4 July 1996 (fl), *Souza et al. 11609* (BHCB, ESA, MBM, SPF); Serra do Cipó, Estrada MG-10, Rodovia Belo Horizonte-Conceição do Mato Dentro, km 119, estrada adjacente para a Serra da Salitreira, ca. 3 km adentro, afloramento rochoso, 25 June 1997 (fl), *Hervencio et al. 92* (SPF); Serra do Cipó, Fazenda Cachoeira da Capivara, 19°14'57"S, 43°32'42"W, campo rupestre, 5 July 2001 (fl), *Souza et al. 25158* (ESA, SPF); Rodovia Belo Horizonte- Conceição do Mato Dentro, próximo à bifurcação do Morro do Pilar, 19°13'13" S, 43°29'57" W, campo rupestre, 5 July 2001 (fl), *Souza et al. 25093* (BHCB, ESA, HUEFS, M, MBM, RB, SP, SPF); Serra do Cipó, Alto do Palácio, atrás da sede do IBAMA, 1100 m, 9 June 2002 (fl), *Groppo et al. 1077* (SPF); Serra do Cipó, Rodovia MG -10, sentido Santana do Riacho - Morro do Pilar, ca. de 1,3 km depois da Estátua do Juquinha, depois da curva com da plantação de *Eucalyptus*, margem esquerda da Rodovia, 19°15'06"S, 43°32'27,2"W, campo rupestre, beira de estrada, 14 October 2011 (st), *Rando et Barbosa 1024* (HUEFS, SPF); atrás da Estátua do Juquinha, coletada na margem do córrego, área parcialmente sombreada, 19°15'34"S, 43°33'14.5"W, 1277 m, borda de mata de galeria, 09 January 2012 (fr), *Rando & Nogueira 1127* (SPF). **Santo Antônio do Itambé,** lado leste do Pico do Itambé, campo rupestre, solo arenoso, 11 February 1972 (fr), *Anderson et al. 35811* (NY, UB); Parque Estadual Santo Antônio do Itambé, subida ao Pico do Itambé, na trilha, 12 June 2012 (fl), *Rando et al. 1250* (SPF).

Chamaecrista latifolia is one of five bifoliolate species of *C.* ser. *Coriaceae*, and has the largest stipules of all. Despite some collections from the Diamantina Plateau, *C. latifolia* is frequently found in South part of the "Espinhaço" Range (Serra do Cipó, Santana do Riacho, in Minas Gerais state) and in Itambé mountain (Pico do Itambé). It occurs on *campo rupestre* vegetation and on rocky *cerrados* (a transition from *cerrado* sensu strict to *campo rupestre*), and is also frequently found near to the margins of gallery forests associated with *campo rupestre* vegetation, at elevations around 1290 – 1700 m.

11. *Chamaecrista mucronata* (C. Sprengel) H.S.Irwin & Barneby, Mem. New York Bot. Gard. 2: 684, 1982. *Cassia mucronata* C. Sprengel, Syst. veg. ed. 16, 2: 341.1825. TYPE: — BRAZIL. "Brasilia: *Sellow s.n.*" and labelled by Sprengel "*Cassia mucronata*. Brasil. Otto" (holotype: B destroyed), "In Brasilia, Serra da Piedade", November 1834 (fl), *Riedel 2901* (neotype designated here: G!, isoneotype: LE!).

Figure 2C, 6A, 8J

Specimens Examined—BRAZIL. **Espírito Santo: Linhares**, Entre Linhares e São Matheus, 14 December 1943 (fl), *Kuhlmam 6671* (RB); Reserva Natural de Linhares da CVRD, 1 February 1972 (fl, fr), *Sucre 8371* (NY, RB); ibidem, 14 July 1985 (fl), *Farias 76* (ESA, K, RB); ibidem, 27 January 1992 (fr), *Folli 1569* (ESA, K, RB); **Minas Gerais: Barão de Cocais**, Pilha do cavalo, mina Brucutu, 31 January 2002 (fl), *Oliveira & Stehmann 5* (BHCB, SPF); Mina Brucutu, 26 March 2002 (fl), *Oliveira 55* (BHCB); **Brumadinho**, Serra da Piedade, November 1834 (fl), *Riedel 2901* (G, LE); Serra da Piedade, 19 November 1893 (fl), *Glaziou 20287* (R); Serra da Calçada, trecho da Serra da Moeda, 1400 m, 10 August 1989 (fl), *Martens 47* (SPF); Serra da Calçada, trecho da Serra da Moeda, retiro das Pedras, 1400 m, 15 September 1989 (fl), *Martens 147* (SPF); Retiro das Pedras, 20°05'35"S, 43°59'01"W, 1480 m, 12 August 1997 (fl), *Barros & Stehmann 2* (HUEFS, BHCB); **Caeté**, Serra da Piedade, 30 November 1933 (fr), *Barreto 5972* (BHCB, SP); ibidem, 29 November 1933 (fl, fr), *Barreto 5971* (R, SP); ibidem, 28 July 1933 (fl), *Barreto 5969* (BHCB, R, SP, SPF); ibidem, 28 June 1936 (fl), *Barreto 5968* (BHCB, SP); ibidem, 24 September 1936 (fl), *Barreto 5970* (UB); ibidem, 8 January 1959 (fl, fr), *Irwin 2405* (NY, R, US); ibidem, ca. 35 km de Belo Horizonte near BR 31, 1800 m, 15 January 1971 (fl), *Irwin et al. 30378* (K, NY, RB, UB, US); ibidem, 20 October 1973 (fl), *Koczicki 286* (MBM, NY); ibidem, 27-31 August 2001 (fl), *Souza 26962* (ESA); **Catas Altas**, região da Mina de Fábrica Nova, 20°11'50"S, 43°55'26"W, 1011 m, 7 March 2008 (fl, fr), *Rezende & Dourado 2402* (BHCB); MG 129 - rodovia de Catas Altas para Mariana, cerrado pedregoso à beira da rodovia, perturbado, 20°05'S, 43°28'W, 958 m, 12 February 2009 (fl, fr), *Rando et al. 879* (SPF); **Conselheiro Pena,** Serra do Padre Ângelo, subindo pela crista sul da montanha, 19°19'46.14"S, 41°34'26.43"W, 1025 m, 27 November 2013, *Gonela & Rivadavia 636* (SPF). **Diamantina**,1833 (fr), *Vauthier 144* (G, K); **Itabira**, 8 April 1934 (fl), *Farrey 5* (R); **Lavras**, 24 February 1944 (fl), *Black 23438* (RB); **Mariana**, 10 km noroeste de Mariana, estrada para Camargo, 22 January 1959 (fl, fr), *Irwin 2502* (K, NY, R, US); 3 km ao Norte de Mariana sentido Santa Barbara, 1500 m, 2 February 1971 (fr), *Irwin et al. 29680* (M, NY, UB); 4 December 1978 (fl), *Furlo s.n.* (OUPR 17023); Estrada Simitri, 17 September 2000 (fr), *Faria et al. 2090* (RB); Mina Samitri, 7 September 2000 (fl, fr), *Mota & Viana 517* (BHCB); 17 February 2000 (fr), *Faria 1968* (RB); trevo da Alegria, 14 October 2003 (fl, fr), *Faria et al. 2473* (RB, SPF); Mina 1010, 22 April 2006 (fr), *Faria 2513* (RB); Mina de Alegria, 10 October 2006 (fl, fr), *Mota 3196* (BHCB); **Nova Lima**, Mina do Capão Xavier, s.d. (fl), *Tameirão Neto 3419* (BHCB); **Ouro Preto**, 12 October 1903 (fl), *Cardoso 896* (BHCB); Morro do São Sebastião, 1912 (fl), *Araújo 106* (R); July 1940 (fl), *Badin 2611* (OUPR); Saramenha, 7 September 1952 (fl), *Macedo 3787* (SP, SPF, US); Pico do Itacolomí, 20°25'32"S, 43°28'59"W, 1600 m, 30 January 1971 (fl, fr), *Irwin et al. 29343* (MBM, NY, R, SPF, UB); Antonio Pereira, 4 December 1978 (fl, fr), *Zurlo s.n.* (OUPR 24745); September 1987 (fl), *Sobral et al. 5667* (BHCB); Campus da Universidade, 11 December 1990 (fr), *Faria & Silva 360* (RB); Parque Estadual do Itacolomi, mata do manso, base do Itacolomi, 1300 m, 12 December 1990 (fr), *Lima et al. 4052* (OUPR, RB); Três Moinhos, 11 December 1990 (st), *Faria et al. 351* (RB); Alegria Sul, Samarco, mineradora Antônio Pereira, 18 September 1996 (fr), *Roschel & Craig 246* (OUPR); Antonio Pereira, 1 October 1996 (fl), *Rosche & Craig 255* (OUPR); Cachoeira das Andorinhas, 28 August 1999 (fl), *Ferreira 30* (OUPR); Estação Ecológica do Tripuí-Trilha do apiário Vila, 19 September 2001 (fl), *Carvalho 1238* (BHZB); caminho para o Pico do Itacolomi, 1224 m, 13 January 2003 (fl, fr), *Araujo et al. 371* (ESA, SPF); Parque Estadual do Itacolomi, estrada de cima, margem da estrada, 30 September 2003 (fl, fr), *Dutra et al. 138* (OUPR, RB); Gambá, s.d. (fl), *Lisboa 2090* (OUPR); s.d. (fl), *Godoy 925* (OUPR); s.d. (fl), *Godoy 926* (OUPR); s.d., (fl, fr), *Peckott s.n.* (R 65759); s.d. (fl, fr), *Cubas R-64675* (NY); Morro do São

Sebastião, s.d. (fl), *Barbosa 1161* (NY); **Realeza**, 15 October 1983 (fl), *Hatschbach et al. 46849* (EAC, INPA, MBM, NY, UEC, US); **Sabará**, Mina do Segredão, 1200 m, 9 November 2007 (fl), *Mota 3427* (BHCB); **Rio Piracicaba,** Pilha de Itabirito concentrável, 12 May 1990 (fl, fr), *Rollo s.n.* (SPF 68321); **Santa Bárbara**, Catas Altas, 4 February 1943 (fl), *Barreto 3538* (BHCB); Capanema, 9 August 1950 (fl), *Oliveira s.n.* (BHCB); **Serra do Caparaó**, trecho nas proximidades da guarita, 10 September 1991 (fl, fr), *Brandão 20036* (PAMG); **No locality**, s.d. (fl), *Langsdorf 2391* (LE); s.d. (fl), *Langsdorf s.n.* (K 000839161); s.d. (fl), *Pohl 402* (LE); Itambé, s.d. (fl, fr), *Pohl 5296* (NY); s.d. (fl), *Riedel 554* (LE); s.d., (fl), s.d. (fl), *Sellow s.n.* (B);*Sellow s.n.* (G); s.d. (fl), *Sellow s.n.* (K 000839100); s.d., (fl), *Sellow s.n.* (LE); s.d. (fl), *Sellow s.n.* (M); s.d. 1839 (fl, fr), *Pohl s.n.* (M); 1842-1845 (fl, fr), *Claussen 156* (LE); 1843 (fl, fr), *Claussen 148* (G); Probably Serra da Piedade, N.E. of Belo Horizonte, September 1892 (fr), *Glaziou 19072* (NY); September 1892 (fl), *Glaziou 19086* (K, LE); Morro do Cruzeiro, 1963 (fl), *Pfeiffer s.n.* (R 171528); Serra do Espinhaço, 6 September 1971 (fl), *Hatschbach 27271* (INPA); Serra Bico de Pedra, October 1990 (fl), *Alves & Becker 1627* (K).

The holotype of *Chamaecrista mucronata* is a specimen collected by Sellow with no number, which was destroyed in the Berlin herbarium, during World War II. Only an image of that specimen remains, in the Field Museum. Irwin & Barneby (1982) a presumed isotype housed at M herbarium (M-0217421); however its label data and a tag numbered “670” attached to the branch make it look not like a Sellow collection. Thus we doubt it is an isotype. Many European herbaria have specimens of *Chamaecrista mucronata* labelled “Brasilia, Sellow legit.” (e.g. B, G, K, LE, P), and it is difficult to assume whether or not some of them could be actually an isotype. For this reason we decided to choose a neotype among specimens matching the protologue description. *C. mucronata* has a core-area in Minas Gerais state, and reaching an eastern area in Linhares, Espírito Santo state. Rando & Pirani (2011) considered its distribution disjunct, but now collections from some intermediate areas are available. These intermediate areas have several scattered mountains, which are still underexplored. Only recently we obtained more informations about one of this areas, collection of *C. mucronata* from Conselheiro Pena and Serra do Caparaó (Gonela & Rivadavia 636 and Brandão 20036). In Minas Gerais the species is found at high altitudes, on *campo rupestre* and on iron rocks substrates called “canga”, at elevations around 1011- 1800 m. In the intermediate areas as Conselheiro Pena, southeastern Minas Gerais, it also inhabits rocky soils, while in Linhares it occurs on sandy soils at the sea level, in vegetation locally called “campo nativo”.

12. *Chamaecrista multinervia* (Mart. ex Benth.) H.S. Irwin & Barneby, Mem. New York Bot. Gard. 2: 685, 1982. *Cassia multinervia* Mart. ex Benth. in Mart., Fl. bras. 15(2): 166, 1870.— TYPE: BRAZIL. Diamantina, “in campis altis Prov. Minarum prope Tejuco”(= Diamantina), May 1818 (fl, fr), *Martius s.n.* (lectotype designed by Irwin & Barneby [1982:685] from

syntypes cited by Bentham [1870:166]: M! [M-0217399], photo of holotype [NY neg. 9205]: NY!). “In inter Serro Frio prope Tejuco, 1818, *Martius s.n.*” and other without locality and data (isolectotypes: M! [M-0217401], M [M-0217400]).

Specimens Examined—BRAZIL. **Bahia: Afrânio Peixoto**, Estrada Tanquinho, Morro do Chapéu, 18 May 1982 (fl), *Fernandes s.n.* (EAC 13482, HUEFS 11406); **Ibicoara**, 13°31'09'S, 41°13'33"W, 22 June 1978 (fl), *Vaillant et. al. 55* (HUEFS, MG, RB); **Rio de Contas**, Mato Grosso, 16 May 1983 (fl, fr), *Hatschbach 46500* (K, MBM, NY, RB).

Chamaecrista multinervia was described based on specimens from Diamantina, Minas Gerais state. However no further record of this species has been made in Minas Gerais so far; the three available collections are from Bahia state. Irwin & Barneby (1982) had already suggested that *C. multinervia* could be just a variation of *C. mucronata*, considering that the two species are distinct essentially by leaflet number (2 or rarely 3 pairs in *C. multivernia* x 3 - 4 pairs in *C. mucronata*). Here we consider two distinct species, based also on features as the number of leaflet veins and the rachis extension (see the key). *C. multinervia* is known from very few specimens, and it seems to be a rare species. *C. multinervia* occurs in *campo rupestre* vegetation, but the label of the specimen *Fernandes s.n.* report “forest” as habitat, with no information on elevation.

13. *Chamaecrista olesiphylla* (Vogel) H.S. Irwin & Barneby, Mem. New York Bot. Gard. 2: 670, 1982. *Cassia olesiphylla* Vogel, Syn. Gen. Cass. 68, 1837 & Linnaea 11: 714, descr. ampliat. 1837. —TYPE: BRAZIL. Minas Gerais, Itambé, 1836 (fl, fr), *Sellow s.n.* (holotype: B destroyed; lectotype designated by Irwin & Barneby [670:1982]: K! [K000555330]; isolectotype: LE! [LE00002356], P![P00836079])

Figure 6B, 8K

Specimens Examined—BRAZIL. **Minas Gerais**: **Barão de Cocais**, Serra do Garimpo, 13 January 1921 (fl), *Hoehne s.n.* (SP 4935, SPF 147715); **Conceição do Mato Dentro**, Serra do Cipó, 17 March 1963 (fl), *Magalhães 18926* (NY); **Conceição do Mato Dentro**, Parque Natural Municipal do Ribeirão do Campo, 19°06'12.3"S, 43°34'28.3"W, 7 July 2002 (fl, fr), *Mota et al. 2106* (BHCB); Estrada da APA do Intendente, 19°08'37"S, 43°33'11"W, 1355 m, 19 February 2004 (fl), *Van den Berg et al. 1350* (HUEFS); Tabuleiro, 19°05'09"S, 43°33'59"W, 1146 m, 31 March 2005 (fl), *Nacimento et al. 508* (HUEFS); **Congonhas do Norte**, Serra Talhada, 9 km S de Congonhas do Norte, na estrada para Conceição do Mato Dentro, entrada para Extrema, seguindo ca. 11 km – Estrada para Lapinha, ca. 1250 m, 20 January 2007 (fl), *Pirani et al. 5627* (SPF); ibidem, 3 February 2009 (fl), *Rando et al. 632* (SPF); ibidem, 3 February 2009 (fl), *Rando et al. 633* (SPF); Serra Talhada, estrada vicinal saindo da estrada Congonhas do Norte – Gouveia, ca. 3,7 km NW de Congonhas do Norte, perto da ponte sobre o rio Preto, 18°47'57"S, 43°42'35"W, ca. 1000 m., 4 February 2009 (fl), *Rando et*

al. 676 (SPF); **Diamantina**, Biribiri, 28 March 1892 (st), *Glaziou 19082* (R, LE); June 1934 (fl), *Brade 13676* (B, RB); ibidem, 5 November 1937 (fl), *Barreto 9525* (R, SP); 9 km ao norte de Diamantina na Estrada para Mendanha, 17 January 1959 (st), *Irwin 2467* (K, NY, US); entre a Serra de Diamantina, 1 February 1965 (fl), *Duarte 9065* (NY, RB); 2 km S.W. of Diamantina, 18 January 1969 (fr), *Irwin et al. 22154* (K, NY, RB, UB); Serra do Espinhaço, ca. 10 km norte de Diamantina em sentido a Mendanha, 26 February 1975 (st), *Anderson 11596* (MBM, NY); Estrada Diamantina- Conselheiro Mata, 30 August 1981 (fl, fr), *Giulietti et al. CFCR 1840* (K, MBM, NY, RB, SPF, UEC); Rod. Guinda - Conselheiro, 15 September 1985 (fl), *Hatschbach et.al. 49737* (EAC, MBM, NY, US); Estrada para Conselheiro Mata, km 174 (Gruta), 10 September 1986 (fl), *Menezes et al. CFCR 10300* (K, NY, SPF); Estrada para Três Barras, próximo ao vilarejo de Três Barras, 15 April 1987 (fl), *Scatena et al. CFCR 10534* (K, NY, SPF); 17 km da entrada da Rodovia para Conselheiro Mota, 3 July 1989 (fl), *Zickel et al. 21703* (UEC); Rod. Diamantina-Cuervelo, 4 August 1990 (fl), *Sakuragui et Souza 162* (ESA); Biribiri, 16 October 1999 (fl), *Tameirão Neto 3171* (MBM); Estrada para Biribi, 29 July 1999 (fl), *Costa et al. 64* (SPF); APA "Pau-de-Fruta", 8 October 2002 (fl), *Isaias et al. s.n.* (MBM 276868, BHCB 75003); estrada Diamantina-Conselheiro Mata, km 172, 18°17'7.53"S, 43°50'3.95"W, 22 September 2010 (fl), *Hemsing et al. 265* (HUFU); estrada Diamantina-Conselheiro, km 172, 18°17'7.53"S, 43°50'3,95"W, 22 September 2010 (fl), *Rezende et al. 111* (HUFU); Parque Nacional das Sempre Vivas, 17°46'38.16"S, 43°37'59.34"W, 10 July 2010 (fl), *Costa et al. 38* (DIAM); Mendanha, ca. 5 km da ponte que passa sobre o rio Jequitinhonha, estrada à direita, sobre afloramento rochoso, propriedade particular, 12 January 2012 (st), *Rando & Nogueira 1147* (SPF); **Gouveia**, Serra do Espinhaço, 6 September 1971 (fl), *Hatschbach 27271* (BM, INPA, MBM, NY, UEC, SPF, UB, US); Serra do Espinhaço, 35 km de Diamantina, rodovia BR-259, 24 February 1975 (fl, fr), *Anderson 11567* (MBM, NY, US); Corrego do Tigre, 14 September 1985 (fl), *Hatschbach & Kummrow 49660* (MBM); **Itambé do Mato Dentro**, Serra Cabeça de Boi, a 7 km da cidade, 13 January 1982 (fl), *Hensold et al. CFCR 2824* (K, NY, SPF); **Itapanhoacanga**, Alvorada de Minas, estrada Itapanhoacanga - Cachoeira Campinas, 3 km de Itapanhoacanga, 18°47'51"S, 43°26'35"W, 14 November 2007 (fl), *Forzza et al. 4844* (K, HUEFS, RB, SPF); Alvorada da Serra, estrada para Cachoeira Campina, a 3 km de Itapanhoacanga, 18°47'54"S, 43°26'36"W, 24 May 2009 (fl, fr), *Menini Neto et al. 707* (K, RB, SPF); **Jaboticatubas**, Serra do Cipó, 6 km north of Palácio, October 1953 (fl), *Segadas et al. 1105* (R, NY, US); Serra do Cipó, 7 June 1970 (fl), *Joly et al. CFSC 255* (SP, UEC); Serra do Cipó, 6 March 1972 (fl), *Joly et al. CFSC 1360* (SP, UEC); **Jaboticatubas**, Serra do Cipó, 28 May 1972 (fl), *Semir et al. CFSC 2356* (SP); Serra do Cipó, 21 August 1972 (fl), *Joly & Semir CFSC 3135* (SP); Serra do Cipó, km 132 ao longo da rodovia Lagoa Santa - Conceição do Mato Dentro, 30 April 1972 (fl), *Semir et Sazima CFSC 2028* (SP, UEC); ibidem, 28 May 1972 (fl), *Semir et al. CFSC 2956* (UEC); Serra do Cipó, 24 February 1973 (fl), *Sazima et Semir CFSC 3867* (SP); Serra do Cipó, km 115 ao longo da rodovia Lagoa Santa - Conceição do Mato Dentro - Diamantina, 29 April 1973 (fl), *Semir et al. CFSC 4099* (K, SP, UEC); **Santa Bárbara**, Serra do Congo Socco, 12 April 1933 (fr), *Barreto et al. 5938* (SP, BHCB); **Santa Luzia**, Serra do Cipó, 3 February 1934 (fl), *Sampaio, 6720* (SP, BHCB); Serra do Cipó, 15 April 1935 (fl), *Barreto & Brade 1228* (B, BHCB, RB); **Santana do Riacho**, Serra do Cipó, km 117, 25 April 1978 (fl), *Martinelli 4266* (RB); Serra do Cipó, próximo ao Palácio, km 135, 25 April 1978 (fl), *Lima 355* (RB); Estrada para Conceição do Mato Dentro, km 126, Alto do Palácio, 2 February 1987 (fl), *Costa & Wendt 44-A* (RB); Serra do Cipó, 10 September 1987 (fl), *Zappi et al. CFSC 10550* (SP); Serra do Cipó, km132, 9 March 1987 (fl, fr), *Sazima et al. CFSC 18951* (UEC); Serra do Cipó, Alto do palácio, arredores da sede do Ibama, 1 May 1993 (fl, fr), *Souza et*

Sakuragui 3367 (ESA, SPF); Serra do Cipó, entrada para Cachoeira da Anta, April 1997 (fl, fr), *Souza et al. 2204* (ESA, MBM, SPF); Serra do Cipó, rod. Belo Horizonte - Conceição do Mato Dentro, km 119, 19°14'58.1"S 43°32'41.0"W, 28 February 2002 (fl), *Souza et al. 28615* (ESA); Serra do Cipó, Fazenda da Capivara, ca. 300 m do portão, afloramento rochoso à esquerda, 9 January 2012 (fr), *Rando et Nogueira 1128* (SPF); **São João Del Rey**, March 1818 (fl), *Martius s.n.* (M); **Serra do Cipó,** November 1824 (fl), *Riedel 1074* (LE, NY, US); 1938 (fl), *Badin 2032* (OUPR); 1938 (fl), *Badin et Barreto 2183* (OUPR); September 1839 (fl), *Riedel 560* (K); July 1949 (fl), *Vidal s.n.* (R 108257); estrada de Conceição, 6 December 1949 (fl), *Duarte 2146* (NY, RB, UB); km 140, 6 April 1957 (fl), *Pereira et Pabst 2893* (M, NY, RB, UB); km 55 W. of Morro do Pilar on road to São José do Almeida, 13 January 1959 (fl), *Irwin 2446* (NY); Serra do Cipó, km 140 mais ou menos, 23 March 1966 (fl), *Duarte 9628* (NY); 22 February 1968 (fl), *Irwin et al. 20635* (M, NY, UB); 27 May 1970 (fl), *Occhioni et al. s.n.* (MBM 76220); **Serro**, ca. de 11 km de Serro em direção à Milho Verde, 11 March 1995 (fl, fr), *Souza et al. 8294* (BHCB, ESA, MBM, SPF); estrada para Gouveia, 11 October 1996 (fl, fr), *Marcondes-Ferreira et al. 1342* (UEC); estrada entre Serro e 3 Barras, 18°17'30.2"S, 43°00'25.9"W, 9 April 2011 (fl), *Andrino et al. 123* (DIAM); Estrada Diamantina - Serro, Estrada Real, ca. 8 km depois de Milho Verde, margem da estrada, lado esquerdo, 11 June 2012 (fl, fr), *Rando et al. 1249* (HUEFS, SPF); **No locality**, s.d. (st), *Sellow s.n.* (B); 66 km S.W. of Diamantina on road to Curvelo, 19 January 1959 (fr), *Irwin 2494* (NY, R, US); entre Quartel e Sopa, 21 March 1892 (fl, fr), *Schawek 8588* (OUPR).

Chamaecrista olesiphylla is the species with the highest number of leaflets in *C.* ser. *Coriaceae* (11-20 pairs). It shows a morphological variation related to habit and leaflets: in general it is a ramose shrub, but a population found nearby Diamantina (*Rando & Nogueira 1147*) and some other specimens examined have erect and taller branches, as well as larger leaflets. It is restricted to Minas Gerais state, occurring on *campo rupestre* and *cerrado rupestre* vegetation (transition from *cerrado* to *campo rupestre*), at elevations around 648 – 1370 m.

14. *Chamaecrista potentilla* (Mart. ex Benth.) H.S. Irwin & Barneby, Mem. New York Bot. Gard. 2: 674, 1982. *Cassia potentilla* Mart. ex Benth. in Mart., Fl. bras. 15(2): 168: 1870. TYPE: —BRAZIL, Minas Gerais: in saxosis districtus Adamantium, 1869 (fl, fr), *Martius s.n.* (lectotype designated by Irwin & Barneby [1982: 674] from syntypes cited by Bentham (1870: 168): M! [M-0217490], photo of lectotype [F neg. 6254]: F, NY!).
Figure 6D, 8L

synonym: *Chamaecrista potentilla* (Benth.) H.S. Irwin & Barneby var. *specuum* H.S. Irwin & Barneby, Mem. New York Bot. Gard. 2: 674, 1982. TYPE: —BRAZIL, Minas Gerais: Furnas, mun. Alpinópolis, 25 July 1972 (fl, fr), *Emygidio et al. 3605* (holotype R!, isotype NY!).

Specimens Examined—BRAZIL. **Minas Gerais**: **Alpinópolis**, Furnas, área em torno das eclusas da represa, 1 July 1994 (fl), *Lombardi 553* (BHCB, NY); ibidem, 13 September 1994 (fl), *Wilson Fernandes 12* (BHCB, K, NY); **Capitólio,** Paraíso Perdido, região da represa de Furnas, 29 September 2005 (fr), *Romero et al. 7234* (HUFU); estrada para a Pedreira de Souza, ca. de 2 km da Rodovia MG 050, região da represa de Furnas, 30 Sepetember 2005 (fr), *Nakajima et al. 3960* (HUFU); trilha da Pedreira Souza, ca. de 2 km da BR050, região da Represa de Furnas, 12 July 2006 (fl), *Arantes et al. 1935* (HUFU); Paraíso Perdido, ca. 5 km da rodovia MG 050, região da Represa de Furnas, 12 July 2006 (fl, fr), *Romero et al. 7734* (HUFU); região de Furnas, 22 May 2007 (fl), *Nakajima et al. 4435* (HUFU); estrada para a Pedreira de Souza, ca. 2 km do lago azul, região de Furnas, 7 November 2007 (fl), *Romero et al. 7987* (HUFU, NY); Pousada do Rio Turvo, estrada mineradora, 20°36'14"S, 46°17'31"W, 5 November 2008 (fr), *Kinoshita et al. 08-73* (UEC, HUFU); ibidem, 5 November 2008 (st), *Kinoshita et al. 08-86* (UEC, HUFU); **Carmo do Rio Claro,** Serra da Tormenta, 3 November 1990 (fl), *Campos s.n.* (HRCB 13357); **Datas,** Vila do Palmital, 9 September 1971 (fl, fr), *Hatchsbach 27498* (MBM, NY, SPF, US); **Delfinópolis,** fazenda José Antunes, 20°26'04"S, 46°38'72"W, 841 m elev., 11 Octuber 2002 (fl), *Romero et al. 6439* (HUFU); condomínio de Pedra, 20°21'64"S, 46°44'83"W, 1178 m, 17 May 2003 (fl, fr), *Volpi et al. 720* (HUFU); Paraíso Perdido, trilha das Cachoeiras, fazenda Zé Antunes, 20°26'33"S, 46°46'02"W, 996 m, 23 May 2003 (fl), *Nakajima et al. 3598* (HUFU); estrada para a mineradora Gabi Extrações, depois do terceiro córrego, região da Represa de Furnas, 26 May 2006 (fl, fr), *Nakajima et al. 4338* (HUFU); Complexo Canastra, Serras de Delfinópolis, 23 June 2010 (fl), *Rosa et al. 1315* (HUFU, NY); **Diamantina,** Tejuco, 1833 (fl), *Vauthier 154* (P); August 1840 (fl), *Gardner 4529* (BM); Diamantina à Formação, 9 April 1892 (st), *Glaziou 19083* (K, P, R); entre Diamantina e Formação, 09 April 1892 (st), *Schwacke 8579* (OUPR); Serra do Rio Grande, 1260 m elev., 2 May 1931 (fl), *Mexia 5740* (BM, K, M, NY, R, US); nos rochedos, June 1934 (fl, fr), *Brade 13684* (B, RB); Bom Sucesso - Extração, 09 November 1937 (fr), *Mello Barreto 9661* (BHCB, SP); 19 km of Diamantina on old road to Mendanha, spreading shrub with numerous horizontal branches, among rocks on gentle slope, 17 January 1959 (fl), *Irwin 2473a* (K); Piruruca, 28 May 1965 (fl), *Pereira 1598* (NY, RB, UB); Espinhaço, Lapinha, ca. 18 km Norte de Serro na Estrada para Diamantina, 1200 m, 23 February 1968 (fr), *Irwin et al. 20653* (MBM, NY, R, UB); Sand river bank, gallery forest on sand and low sclerophyllous vegetation on outcroups, Rio Jequití, ca. 20 km E. of Diamantina, 790 m, 13 March 1970 (st), *Irwin et al. 27413* (NY, UB); cerrado on brown sand interspersed with extensive outcrops, ca. 8 km of Diamantina, road to Extração, 16 March 1970 (st), *Irwin et al. 27635* (M, NY, P, UB); creek margin, steep slopes with cut-over gallery forest and adjacent cerrado with interspersed outcroups, ca. 23 km E. of Diamantina, ca. 900 m, 17 March 1970 (st), *Irwin et al. 27721* (NY); ca. 18 km E. of Diamantina, rocky summits and intervening gallery forest, 20 March 1970 (st), *Irwin et al. 27960* (K, NY, RB, UB); Serra do Espinhaço, quartzite cliffs overlooking (North of) Diamantina, ca. 1300 m, 26 February 1975 (st), *Anderson et al. 11602* (MBM, NY, US); east of Serra, road from Conceição to Diamantina, 09 August 1980 (fl), *Maguire et al. 49123* (K, NY, RB, SP, US); estrada para o povoado de 3 Barras, 3 km de Diamantina, 15 April 1987 (fl), *Scatena et al. CFCR 10512* (K, NY, SPF); Trinta Réis, Rodovia Datas-Serro (MG 2) km 433, ca. 1160 m elev., 18°34'S, 43°35'W, 20 July 1987 (fl), *Zappi et al. CFCR 11128* (BHCB, K, SPF); Milho Verde, 01 September 1989 (fl), *Sobral et al. 6284* (MBM); Curralzinho, km 7, 14 September 1994 (fl, fr.), *Silva 2868* (CEN, K, UFG); Diamantina to São Gonçalo, near junction to Curralzinho, 1020 m, 14 September 1994 (fl, fr.), *Silva 2887* (K, INPA); Extração, 15 July 1996 (fl),

Roque et al. 259 (CTES, SPF); estrada para Extração, ca. 9 km S de Diamantina, ca. 1236 m elev., 18°15'29"S, 43°30'57"W, 11 January 2003 (fr), *Queiroz et al. 7606* (HUEFS); nascentes do Rio Jequitinhonha, 18°34'35"S, 43°29'23"W, 25 July 2005 (fl), *Lima et al. 6366* (RB, SPF); estrada para Extração (Curralinho), ca. 2 km W da igreja de Extração,18°18'27"S, 43°53'51"W, ca. 1170 m, 8 February 2009 (fr), *Rando et al. 814* (SPF); em direção a Curralinho, 28 June 2011 (fl), *Cota et al. 97* (DIAM); **Joaquim Felício,** Armazém de Lage, sloping pasture strew with arenaceous rocks along and above floodplain of small stream ca. 15 km NNW de Joaquim Felício, 7 July 1985 (fl, fr), ca. 1100 m, *Kral 72663* (SP, SPF, US); Serra do Cabral, estrada Joaquim Felício - Várzea da Palma, ca. 24 km de Joaquim Felício, 17°42'08"S, 44°17'46"W, 1030 m, afloramento rochoso com campo arenoso adjacente, 10 July 2001 (fl), *Souza et al. 25641* (ESA, K, MBM, RB, SPF, UEC); ibidem, 10 April 2004 (fl), *Hatschbach et al. 77730* (G, MBM, SP); **Juscelino Kubitschek**, ca. 250 m da entrada para Juscelino Kubitschek, 18°34'35.1"S, 43°34'44.9"W, 1186 m, 11 January 2012 (st), *Rando et Nogueira 1142* (SPF); **Pedro Lessa**, 5 July 1996 (fl, fr), *Souza et al. 11777* (ESA, K, MBM, RB, SPF, UEC); **Rio Vermelho**, Morro do Ambrósio, 15 July 1984 (fr), *Furlan et al. 4499* (SP); Topo da Serra da Pedra Menina, ca. 1400 m elev., 1 August 2000 (fl), *Fiaschi & Costa 397* (SP); **São Roque de Minas**, Parque Nacional da Serra da Canastra, Cachoeira da Casca D'Anta, 17 July 1995 (fl), *Romero et al. 2502* (HUFU, NY); ibidem, Chapadão do Diamante, 20 November 1995 (fl, fr), *Romero et al. 3127* (HUFU); ibidem, cachoeira do Rolinhos, 21 March 1996 (fl), *Nakajima & Romero 1655* (HUFU); ibidem, Chapadão do Diamante, após a antena 9 July 1996 (fl), *Nakajima et al. 1908* (HUFU); ibidem, 22 September 1996 (fl), *Romero & Nakajima 3616* (HUFU); ibidem, 29 June 1997 (fl), *Romero et al. 4335* (HUFU); Parque Nacional da Serra da Canastra, estrada São Roque - Sacramento, morro após a nascente do rio São Francisco, 20 August 1997 (fl), *Nakajima et al. 2681* (HUFU); Parque Nacional da Serra da Canastra, Cachoeira da Casca D'Anta, parte de cima, 23 August 2007 (fl, fr), *Romero et al. 4505* (HUFU); ibidem, 1200 m, 30 September 1999 (fl, fr), *Mello-Silva et al. 1672* (HUFU, SPF); **São Gonçalo do Rio Preto**, estrada até Milho Verde e Três Barras, 20 July 1980 (fl, fr), *Semir et al. CFCR 224* (NY, SPF); **São Gonçalo do Rio das Pedras**, 18°25'55"S, 43°28'35"W, 1109 m, 20 June 2008 (fl, fr), *Almeida 1392* (BHCB); **Serro**, 18°33'S, 43°29'W, 22 May 1982 (fl), *Bautista 622* (HUEFS, K, MG, UB, RB, SPF); estrada para Gouveia, ca. 10 km de Serro (km 425), 980 m, 18°34'26.4"S, 43°28'42.9"W, 27 February 2002 (st), *Souza et al. 28512* (ESA); estrada para Milho Verde, à 2 km do trevo da estrada para Capivari, campo rupestre, 18°29'17"S, 43°28'16"W, 1047 m, 25 May 2009 (fl), *Menini Neto 719* (K, RB, SPF); estrada para Gouveia, entre km 424 e 425, ca. 1000 m, 18°34'26.4"S, 43°28'42.9"W, 11 January 2012 (st), *Rando & Nogueira 1139* (SPF); **No locality**, Voyage d'Auguste de Saint-Hilaire, s.d. 1816-1821 (fl, fr), *Saint-Hilaire 471* (P); no locality, s.d. 1841 (fl), *Gardner s.n.* (K 000555601); no locality, s.d. 1894 (fl, fr), *Glaziou 20267* (K).

Chamaecrista potentilla can be recognized by the stipules format and by number of leaflets (9-16 pairs). In 1982, Irwin & Barneby proposed two varieties for this species, however after several analyses of a larger sample of herbarium specimens led Rando et al. (2013) proposed the variety *C. potentilla* var. *specuum* as synonym. It is restricted to Minas Gerais state, commonly found in the Diamantina Plateau, but with records also from the Serra do Cabral, Serra do Ambrósio and Serra da Canastra. It is found in cerrado or in campo rupestre vegetation, between 790–1400 m elevation.

15. *Chamaecrista rossicorum* (H.S. Irwin & Barneby) Rando, Phytotaxa, 97(1): 23, 2013. Basionym: —*Chamaecrista choriophylla* (Vogel) H.S. Irwin & Barneby var. *rossicorum* H.S. Irwin & Barneby, Mem. New York Bot. Gard. 2: 693, 1982. TYPE: —BRAZIL. Minas Gerais: Diamantina, rocky cerrado, 1300 m, 15 km northwest of Diamantina on Road to Mendanha, 26 January 1969 (fr), *Irwin et al. 22621* (holotype UB!, isotypes C, F!, GH, K!, NY!, RB!, S, UC, US!).

Figure 2D, 6F, 8M

Synonym: *Chamaecrista choriophylla* (Vogel) H.S. Irwin & Barneby var. *rossicorum* H.S. Irwin & Barneby, Mem. New York Bot. Gard. 2: 693, 1982.

Specimens Examined—BRAZIL. **Minas Gerais**: **Conceição do Mato Dentro,** Serra da Ferrugem, Fazenda do Toninho, canga, 19 August 2006 (fl), *Viana & Silva 2287* (BHCB); **Congonhas do Norte,** ca. de 5 km da entrada para Congonhas do Norte, 18°35'40"S, 43°40'37"W, 1151 m, 13 September 2003 (fl), *Conceição et al. 741* (HUEFS); Serra Talhada, estrada vicinal saindo da estrada Congonhas do Norte – Gouveia, ca. 3.7 km N.W. de Congonhas do Norte, 18°55'78"S, 43°40'42"W, ca. 1000 m, 4 February 2009 (fr), *Rando et al. 667* (SPF); **Datas,** estrada de Tombador para Datas, ca. 6 km S do entroncamento com a rodovia Datas-Serro (BR259), 18°47'57"S, 43°42'35"W, ca. 1073 m, 5 February 2009 (fr), *Rando et al. 726* (SPF); **Diamantina,** s.d. 1824 (fl), *Riedel 1207* (NY, US); s.d. 1833 (fl), *Vauthier 161* (G, P); s.d. 1892 (fl), Glaziou 19103 (K); June 1934 (fl), *Brade 13683* (B, RB); 12 November 1937 (fl), *Mello Barreto 9740* (RB); 28 May 1955 (fl), *Pereira 1596* (RB); Serra do Biribiri, 7- 10 km de Diamantina, 15 July 1965 (fl), *Glassman & Gomes 8141* (SP); entre Diamantina e Mendanha, 12 January 1966 (fr), *Lima 61-3894* (OUPR); Ribeirão da Pedras, 1200 m elev., 14 November 1971 (fl, fr), *Hatschbach & Pelanda 27919* (NY, MBM); Estrada de Diamantina à Mendanha, 2 km ao Norte de Diamantina, 17 January 1959 (fr), *Irwin 2464* (NY, US); ca. 15 km NE. of Diamantina, on road to Mendanha, cerrado com pedras, 26 January 1969 (fr), *Irwin et al. 22621* (F, NY, RB,UB, US); estrada para o Distrito de Mendanha, BR 367, campo rupestre, 2 October 1997 (fl), *Kawasaki et al. 1048* (NY, SP, SPF); Road from Conceição to Diamantina, 9 August 1960 (fl), *Maguire et al. 49142* (NY, RB); Arranca rabo, 3 November 1937 (fl), *Barreto 9372* (BHCB, SPF); Rodovia Diamantina - São Gonçalo km 12, 18°21'00"S, 43°34'00"W, 14 September 1994 (fl), *Silva et al. 2888* (CEN, HUEFS, K); APA Pau de Fruta, September 2002 (fl), *Isaias et al. s.n.* (BHCB 74089); rodovia Diamantina - Curvelo, km 4, 15 September 1994 (fr), *Silva et al. 2891* (K, HUEFS); estrada de Diamantina à Mendanha, 5.5 km ao Norte de Diamantina, solo arenoso e pedregoso, 21 March 1995 (st), *Splett 994* (NY, UB); Cachoeira dos Cristais, 29 July 1999 (fl), *Sano et al. 1005* (BHCB, SPF); Cristais, 18°9'39"S, 43°35'48"W, 12 September 2003 (fl), *Conceição et al. 739* (HUEFS, RB, SPF); Cristais, 18°10'0"S, 43°35'57"W, 20 September 2004 (fl), *Conceição et al. 852* (HUEFS); Campos da UFVJM, descendo o lado esquerdo da estrada de terra atrás do Apiário, em direção ao córrego Soberbo, 18°12'4.6"S, 43°34'2.7"W, 7 August 2010 (fl), *Franco & Araújo 558* (DIAM, HUFU); **Gouveia,** córrego do Tigre, campo rupestre, 5 September 1971 (fl, fr), *G. Hatschbach 27025* (MBM, NY); ibidem, campo rupestre, 14 September 1984 (fl), *Hatschbach & Zelma 49649* (B, MBM); Serra de Grão-Mogol, 16°13'15"S, 42°35'22"W, 1397 m, February 2007

(fl), *Conceição et al. 539* (HUEFS); trevo de Gouveia para Datas, vindo de Diamantina ao lado direito da estrada, 12 October 2011 (fl), *Rando et al. 1007* (SPF, HUEFS); **Presidente Kubitscheck,** BR 259, próximo ao trevo para Presidente Kubitschek, campo rupestre, 25 July 1998 (fl), *Hatschbach et al. 68225* (ESA, MBM, RB); **São João da Chapada,** estrada Guinda - São João da Chapada, 15.5 km depois do asfalto, 18°10'S, 43°50"W, solo arenoso, 24 September 1994 (fl), *Splett 660* (NY, SPF, UB); ***Serro,*** entre Serro e Datas, campo rupestre, 19 January 1972 (fl, fr), *Hatschbach et al. 28959* (MBM); **No locality**, Voyage d'Auguste de Saint-Hilaire, s.d. 1816-1821 (fl, fr), *Saint-Hilaire 460* (P); campo rupestre, 20 July 1987 (fl), *Mello-Silva et al. CFCR 11122* (SPF); ca. 15 km em direção à Datas, campo rupestre, 12 January 2006 (fl), *Savassi-Coutinho et al. 1030* (ESA).

Chamaecrista rossicorum was first described by Irwin & Barneby (1982) as a variety of *C. choriophylla*, and further raised to the rank of species by Rando et al. (2013). It is a bifoliolate taxon and can be recognized mainly by the length of the stipule and of the pedicels. It is a common species along the Diamantina Plateau, occurring in *campo rupestre* vegetation at elevations aound 1020 – 1397 m.

16. *Chamaecrista rotundata* (Vogel) H.S. Irwin & Barneby, Mem. New York Bot. Gard. 2: 676, 1982. *Cassia rotundata* Vogel, Syn Gen. Cass. 58 & Linnaea 11: 709, descr. ampliat. 1837. Type indication in infrageneric category 16.2.

Synonym: *Chamaecrista rotundata* (Vogel) H.S. Irwin & Barneby var. *grandistipula* (Vogel) H.S. Irwin & Barneby (1982:676). *Cassia grandistipula* Vogel, Syn Gen. Cass. 58 & Linnaea 11:710, descr. ampliat. 1837. *syn. nov.* TYPE: —Brazil: in Serra do Galheiro, *Sellow s.n.* (holotype: B destroyed), Brazil: in districtu Diamantina, August 1840 (fl, fr), *Gardner 4528* (neotype designated here from syntypes cited by Bentham in Mart. Fl. bras. 15(2) 167:1870: K!, isoneotype: BM!).

Cassia rotundata and *C. grandistipula* were described by Vogel (1837) at the same publication. Bentham (1870) considered the latter as a variety of the former, and created a second variety, *C. rotundata* var. *angustifolia*. Irwin & Barneby (1982) followed Bentham's circumscription for *C. rotundata* var. *grandistipula*, synonymized *C. rotundata* var. *angustifolia* under *Chamaecrista cinerascens*, and created a new variety (*C. rotundata* var. *interstes*) based essentially on the shape and number of veins of the stipules. Our study shows that plants matching the typical variety are totally sympatric with plants matching *C. rotundata* var. *grandistipula* including several specimens with overlapping measures. On the other hand, *C. rotundata* var. *interstes* is found in Diamantina and mostly in localities (Couto Magalhães, Monte Azul and Rio Vermelho) where no populations of the other varieties are

known. For this reason, we are here proposing *C. rotundata* var. *grandistipula* as a new synonym of the typical variety, and we maintain *C. rotundata* var. *interstes* as a distinct taxon. The holotype of *Cassia grandistipula* was destroyed in Berlin herbarium; since no isotypes were found we are proposing a neotypification of this taxon.

Identification Key for the varieties

1. Stipules 7.45 – 16.0 mm, with 12 – 22 veins, apex acute; extrafloral nectaries below the first pair of leaflets; rachis 5.5 – 18.1 mm long ..... 16.1.*C. rotundata* var. *interstes*

1' Stipules 9.17 – 28.0 mm, with 14 – 37 veins, apex rounded; extrafloral nectaries at the middle of petiole; rachis 15 – 43.0 mm long ..... 16.2. *C. rotundata* var. *rotundata*

16.1. *Chamaecrista rotundata* (Vogel) H.S. Irwin & Barneby var. *interstes* H.S. Irwin & Barneby, Mem. New York Bot. Gard. 677: 1982. TYPE: —Brazil, Minas Gerais, cerrado, 790 m, 25 km by road N.E. of Diamantina, 2 km W. of Rio Jequití, 9 April 1973 (fl), *Anderson 8376* (holotype UB!, isotypes F!, K!, NY!, RB!, US!).

Couto Magalhães, Couto Magalhães - Mendanha, 5 June 1967 (fl), *Duarte 10430* (M, MBM, NY, RB, SPF); **Diamantina**, 25 May 1955 (fl), *Pereira 1457* (UB); 29 km N. of Diamantina on old road to Mendanha,17 January 1959 (st), *Irwin 2475* (NY, US); ca. 25 km N.E. of Diamantina on road to Mendanha, 1200 m, 30 January 1969 (fr), *Irwin et al. 22901* (K, NY, RB, UB, US); Serra do Espinhaço, 8 September 1971 (fl, fr), *Hatschbach 27443* (MBM, NY); 25 km by road N.E. of Diamantina, 2 km W of Io Jequití, 9 April 1973 (fl, fr), *Anderson 8376* (NY, RB, UB); 25 km by road NE of Diamantina, ca. 1.5 km from Rio Jequití, 790-900 m, 12 April 1973 (fl), *Anderson 8716* (F, K, NY, RB, UB, US); estrada Turmalina – Diamantina, 1300 m, 13 May 1979 (fl, fr), *Lima de et al. 1069* (RB); estrada Diamantina - Couto Magalhães, km 19, cerrado com afloramento de rocha, 800 m, 6 April 1983 (fl, fr), *Martinelli & Leuenberger 9199* (B, RB); Rio Jequitinhonha - Diamantina km 4, 13 September 1994 (fl), *Silva 2852* (CEN, UFG); **Monte Azul,** Serra da Formosa em frente ao Pico da Formosa, 15°13'48"S, 42° 48'14"W, 1341 m, 27 October 2010 (fr), *Queiroz et al. 15003* (HUEFS, RB, SPF); **Rio Vermelho**, Pedra Menina, Morro do Ambrósio, 15 July 1984 (fl), *Furlan et al. CFCR 4499* (K, SPF); Pedra Menina, Faz. Vargem do Anjo - Morro espiga do Meio, 18°06'S, 43°08'W, 13 October 1984 (fl, fr), *Isejima et al. CFCR 5409* (K, NY, SPF); Pedra Menina, Morro do Ambrósio, 18°06'S, 43°08'W, 15 July 1984 (fl, fr), *Harley et al. CFCR 4505* (NY, SPF); Morro do Ambrósio, 15 July 1984 (fl, fr), *Harley et al. CFCR 4506* (K, NY, SPF); ibidem, 31 March 1985 (fl), *Menezes et al. CFCR 7690* (SPF); Serra do Ambrósio, 18°07'47"S, 43°02'38"W, 990 m, 28 April 2013 (fl), *Brotto et al. 1212* (MBM); estrada para a Vila de Pedra Menina, ramificação à esquerda, ca. de 4 km apos a vila, 1400 m, 1 August 2000 (fl, fr), *Fiaschi & Costa 410* (SPF).

Chamaecrista rotundata var. *interstes* can be recognized by the acute apex of its stipules,

which also have less veins than the typical variety. It occurs in *campo rupestre* vegetation at elevations around 790 -1300 m.

16.2. *Chamaecrista rotundata* (Vogel) H.S. Irwin & Barneby var. *rotundata*, Mem. New York Bot. Gard. 2: 676, 1982. *Cassia rotundata* Vogel, Syn Gen. Cass. 58 & Linnaea 11: 709, descr. ampliat. 1837. TYPE: —Brazil: s.d. (fl, fr), *Sellow s.n.* (lectotype K! [K000555326], designated by Irwin & Barneby [1982: 676], isolectotype F [fragment, image seen], G! [G00371054], LE! [LE00002380])

Figure 6E, 8N

Specimens Examined—BRAZIL. **Minas Gerais**: **Bocaiúvas**, Parque Nacional das Sempre Vivas, caminho entre Campos de São Domingos e a Serra do Landi, passando pelo córrego do Landi, 17°54'7.5"S, 43°46'22.6"W, 29 April 2007 (fl), *Almeida et al. 847* (BHCB); **Conselheiro Mata**, 4 April 1985 (fl), *Barros 1100* (NY, SP); **Diamantina**, s.d. (fr), *Claussen 295* (G); 1833 (fl), *Vauthier 153* (G, K); Biribiri, 1892 (st), *Schwacke 8577* (OUPR); entre Diamantina e Biribi, 6 April 1872 (st), *Schwacke 8578* (OUPR); Tombador, 6 October 1892 (st), *Glaziou 19087* (LE, K, US); Biribiri, Serra do Mocobo, September 1892 (fl), *Glaziou 19085* (LE, NY, OUPR, US); June 1934 (fl, fr), *Brade 13418* (B, RB); 6 February 1947 (st), *Romariz 112* (RB 59874); 16 km N. of Diamantina on old road to Mendanha, 17 January 1959 (st), *Irwin 2470* (NY, US); 15 km W. of Diamantina on road to Conselheiro Mata, 18 January 1959 (st), *Irwin et al. 2483* (K, NY, US); 19 September 1965 (fl), *Duarte & Pereira 8946* (RB); ca. 23 km S.W. of Diamantina, road to Gouveia, 1250 m, 18 January 1969 (st), *Irwin et al. 22216* (F, K, NY, RB, UB, US); Guinda, 1200 m, 7 September 1971 (fl, fr), *Almeida de 27393* (MBM, NY); ca. 5 km SW of Diamantina, km 305 on MG 259, 1300 m, 4 February 1972 (st), *Anderson 35431* (NY); Serra do Espinhaço, ca. 10 km SW. of Diamantina on BR-259, 1400 m, 24 February 1978 (fr), *Anderson 11563* (MBM, NY); Valley of Biribi, 1100 m, 25 February 1978 (fr), *Anderson 11590* (MBM, NY); 13 August 1979 (fr), *Furlo s.n.* (OUPR 25186); estrada Conselheiro Mata, 4 June 1985 (fl), *Leitão et al. 17296* (UEC, INPA, RB); estrada Diamantina - Mendanha, km 578, 6 June 1985 (fl), *Tamashiro et al. 17491* (UEC); 16 km da entrada da rodovia para Conselheiro Mota, 3 July 1989 (fl), *Leitão, H.F. et al. 21814* (UEC, INPA, MG); estrada entre Diamantina e Conselheiro Mata, 6 August 1990 (fl, fr), *Sakuragui & Souza 230* (ESA, HUEFS); Biribiri near córrego Sentinela, ca. 6.5 km of Diamantina, 25 September 1990 (st), *Esteves CFCR 15515* (K, SPF); BR 259, São João da Chapada km 05, margem direita do Ribeirão da Pedras., 18°13'S, 43°39'W, 15 September 1994 (fr), *Silva et al. 2905* (CEN, INPA); estrada secundária São João da Chapada - Inhaí km 20, 18°07'S, 43°46'W, 15 September 1994 (fr), *Silva et al. 2926* (CEN, INPA); Rodovia Diamantina - Curvelo, 1020 m, 15 September 1994 (st), *Silva et al. 2894* (CEN); 2 km de Diamantina em direção a Mendanha, 6 July 1996 (fl), *Souza et al. 11825* (ESA); estrada para Conselheiro Mata, km 182, em afloramento rochoso à direita da estrada, 13 July 1996 (fl, fr), *Atui et al. 20* (SPF); estrada entre Diamantina e Curvelo, ca. de 7 km de Diamantina, 7 July 2001 (fl, fr), *Souza et al. 25290* (ESA); estrada para Conselheiro Mata, km 188-189, 18°17'33.4"S, 43°42'45.9"W, 1434 m, 26 June 2001 (fl), *Semir et al. 01/121* (UEC); APA Pau de Fruta, 8 October 2002 (fr), *Isaias et al. s.n.* (BHCB 74087); Parque Estadual do Biribiri, cachoeira dos Cristais, 18°09'42.3"S, 43°36'0.72"W, 1054 m, 21 September 2010 (fr), *Hemsing 242* (HUFU); sentido Curralinho, 18°12'48"S, 43°39'11.6"W, 1228 m, 28 April 2011 (fl, fr),

Cota et al. 104 (DIAM); Parque Estadual do Biribiri, trilha para o alto da cachoeira Sentinella, 18°12'57"S, 43°36'28.1"W, 1219 m, 1 April 2011 (fl), *Cota & Andrino 85* (DIAM); Parque Estadual do Biribiri, trilha para o alto da cachoeira Sentinella, 18°12'26"S, 43°36'36"W, 1237 m, 1 April 2011 (fl), *Cota & Andrino 88* (DIAM); estrada Diamantina – Couto Magalhães, 12 km de Diamantina, 18°11'04.1"S, 43°32'15.1"W, 1278 m, 11 January 2012 (fr), *Rando & Nogueira 1145* (SPF); Parque Estadual de Biribiri, 18°11'34.0"S, 43°37'35.8"W, 1114 m, 11 January 2012 (st), *Rando & Nogueira 1144* (SPF); estrada Diamantina – Couto Magalhães, 14 km de Diamantina, 11 January 2012 (st), *Rando & Nogueira 1151* (SPF); **Gouveia**, Reservatório, PCH Quartel 1, 18°39'58.3"S, 43°52'49.6"W, 9 June 2007 (fl, fr), *Souza et al. 226* (BHCB); **Lavras**, 9 December 1985 (fl), *Chiea 459* (SP, US); **Nazareno,** 21°18'20"S, 44°35'29"W, 2 May 2011(fl, fr), *Saddi et al. 500* (RB); **Patrocínio**, Fazendas da Terra, December 1998 (fl), *Farah et al. 540* (ESA, SPF); **Ouro Preto**, 7 October 1894 (fl), *Pinho s.n.* (OUPR 3640); Parque Estadual do Itacolomi, 20°25'32"S, 43°28'59"W, 17 June 2004 (fl), *Dutra & Pereira 239* (OUPR, RB); Parque Estadual do Itacolomi, Morro do Cachorro, 20°25'03.7"S, 43°30'18.9"W, 8 August 2004 (fr), *Dutra et al. 257* (OUPR, RB); Itacolomi, s.d. (fl, fr), *Casaretto 2622* (G); Morro do Baú, s.d, *s. col.* (fl) (OUPR); **Santa Cruz de Minas**, Estrada Santa Cruz de Minas - Tiradentes, lado direito na base do morro, 21°07'19.8"S, 44°12'27.5"W, 19 October 2006 (fl, fr), *Marquete et al. 3982* (RB); **Santana do Pirapama**, acesso por Inhame, trilha do João Carrinho, 28 November 2009 (fl, fr), *Rando et al. 825* (K, RB, SPF); **São João D'el Rei**, In saxosis mont., June 1824 (fl, fr), *Riedel 248* (G, LE, NY, US); Serra do Lenheiro, 10 October 1893 (fl, fr), *Gomes & Gomes 1655* (OUPR); s.d. (fl, fr), *Glaziou, 20268* (LE, K, NY); 1893 (fl, fr), *s.col.* (OUPR 3583); Serra do Lenheiro, 10 December 1893 (fl, fr), *Barros s.n.* (OUPR 4191); Serra do Lenheiro, 1894 (st), *Glaziou 20269* (G, K, LE, NY); s.d., (fl, fr), *Pohl 546* (G, K, NY); Serra do Lenheiro, 19°3.7'59"S, 43°44'32.5"W, 12 September 1960 (st), *Duarte 5127* (M, RB); **São João da Chapada**, ca. 10 km N. of São João da Chapada, road to Inhaí, 1050 m, 22 March 1970 (fl, fr), *Irwin 28101* (K, M, MBM, NY, RB, UB, US); ca. 3 km N of São João da Chapada,1200 m, 24 March 1970 (fr), *Irwin et al. 28262* (NY, RB, US); ca. 7 km N. of São João da Chapada, road to Campo do Sampaio, 1150 m, 29 March 1970 (st), *Irwin 28589* (NY, UB); ca. de 15 km N de São João da Chapada, 975 m, 23 March 1970 (fr), *Irwin et al. 28107* (NY); **Serra do Cipó**, km 114, 19 June 1964 (fl), *Duarte 8139* (RB); **Tiradentes**, Serra de São José, 21 September 1989 (fl, fr), *Alves & Wolker 734* (RB, SPF); ibidem, 23 September 1992 (fl, fr), *Alves & Becker 4033* (RB); ibidem, 20 November 1993 (fl), *Alves 4336* (RB); **No locality**, August 1818 (fl), *Martius s.n.* (M 0186319); 1813-1829 (st), *Langsdorf 248* (NY); s.d. (fr), *s.col.* (RB 38699); (st), *Glaziou 1609* (OUPR); Morro do Baú, 1933 (fl, fr), *Almeida s.n.* (OUPR 18604); Serra de Tiradentes, 8 January 1965 (fl), *Duarte 8728* (RB); ca. 18 km E. of Diamantina, 900 m, 18 Mach 1970 (st), *Irwin, 27848* (K, NY, UB); s25 km by road NE. of Diamantina, 2 km W. of Rio Jequití, 790 m, 9 April 1973 (fl), *Anderson 8377* (NY, UB); s.d. (fl), *s.col.* (RB 38658); s.d. (fl), *Pohl 949* (LE); Taquaral, 7 October 1984 (fl), *Pinto, s.n.* (OUPR 3640).

Chamaecrista rotundata var. *rotundata* can be recognized by stipules rounded at apex and with a larger number of veins than the ones in *C. rotundata* var. *interstes*. It is restricted to Minas Gerais state, being a common species on the Diamantina Plateau and in the Ouro Preto region (southern portion of the "Espinhaço" Range). It occurs in *campo rupestre* vegetation and near to the margins of gallery forests associated with this vegetation, at elevations around 790 – 1434 m.

17. *Chamaecrista simplifacta* H.S. Irwin & Barneby, Mem. New York Bot. Gard. 2: 694, 1982. TYPE: —BRAZIL. Minas Gerais: Diamantina, Conselheiro Mata, campo pedregoso, 12 August 1972 (fl), *Hatschbach 30215* (holotype: MBM!; isotypes: G!, INPA!, NY!).

Figure 4A, 6G, 8P

Specimens Examined—BRAZIL. **Minas Gerais**: **Diamantina**, Conselheiro Mata, 12 August 1972 (fl), *Hatschbach 30215* (MBM, NY); estrada Diamantina à Corinto, 1 December 1976 (fl), *Shepherd et al. 3950* (NY, UEC); estrada para Conselheiro Mata, 18 July 1987 (fl), *Zappi et al. CFCR 11279* (K, SPF); Rod. Guinda-Conselheiro Mata, 21 May 1989 (fl), *Hatschbach et al. 53039* (MBM, NY); estrada Diamantina - Conselheiro Mata, 14 March 1999 (fl), *Souza et Souza 22263* (ESA); estrada Diamantina - Conselheiro Mata, 25 km da Estrada Diamantina - Gouveia, 8 July 2001 (fl), *Souza et al. 25443* (ESA, SPF); estrada para Biribi, 27 November 2002 (fl, fr), *Udulutsch & Temponi 1447* (ESA, SPF); estrada para Conselheiro Mata, 29 November 2002 (fl), *Temponi, et al. 242* (SPF); Conselheiro Mata, trilha para o Telésforo, 18°11'20"S, 43°55’32”W, 915 m, 21 October 2007 (fl), *Rosa et al. 915* (HUFU); km 165 da MG 220 na direção de Conselheiro Mata, 18°35’26”S, 43°40’53”W, 1200 m., 7 February 2009 (st), *Rando et al. 802* (SPF); ibidem, s.d. (fl), *s.col.* (RB 38647); km 166 da MG 220, na direção Diamantina - Conselheiro Mata, ca. 25 km da estrada Diamantina - Gouveia, 12 January 2012 (st), *Rando & Nogueira 1146* (HUEFS, SPF); km 166 da MG 220, na direção Diamantina - Conselheiro Mata, ca. 25 km da estrada Diamantina - Gouveia, 10 June 2012 (fl), *Rando et al. 1242* (HUEFS, SPF).

Chamaecrista simplifacta is the only species of *C.* ser. *Coriaceae* having orange petals and peculiar extrafloral nectaries. It is restricted to a small area in the Diamantina Plateau, known from only three populations, inhabiting *campo rupestre* vegetation at elevations around 915 – 1200 m.

18. *Chamaecrista tragacanthoides* (Benth.) H.S. Irwin & Barneby, Mem. New York Bot. Gard. 2: 687, 1982. Type indication in infrageneric category 18.2.

Chamaecrista tragacanthoides can be recognized mainly by the number of leaflets, persistent stipules, and by its curved leaf rachis. It is a ramose shrub. Irwin & Barneby (1982) recognized two varieties, as they changed the status of *Cassia pachyphylla* Mart. ex Benth. to a variety of *C. tragacanthoides*. That proposition was based on the fact that the two taxa are very similar and sympatric, the only difference basically related to indumentum aspect. Here, we follow this concept, even though the current known distribution of *C. tragacanthoides* var. *rasa* is wider and most collections of both varieties come from nearby areas.

Identification Key for varieties

1. Leaflets and branches completely covered by greyish hairs; rachis 4.0 – 10.0 mm long; leaflets in 3 – 6 pairs, 4.0 – 10.0 x 1.5 – 3.0 mm .....

.....18.2. *C. tragacanthoides* var. *tragacanthoides*

1'. Leaflets and branches glabrous or sparsely pubescent; rachis 8.0 – 25.0 mm long; leaflets in 3 – 9 pairs, 4.1 – 26.7 x 1.1 – 4.6 mm ..... 18.1. *C. tragacanthoides* var. *rasa*

18.1. *Chamaecrista tragacanthoides* (Benth.) H.S. Irwin & Barneby var. *rasa* H.S.Irwin & Barneby, Mem. New York Bot. Gard. 2: 688, 1982. *Cassia pachyphylla* Mart. ex Benth. in Mart., Fl. bras. 15(2): 166. 1870. TYPE: —BRAZIL. Minas Gerais: "Habitat in altis Serra de Itambé", May 1818 (fl, fr), *Martius s.n.* (lectotype designated by Irwin & Barneby from syntypes cited by Bentham [166:1870]: M! [M-0217544], photo of lectotype [NY neg. 9209]: NY!, isolectotypes: M! [M-0217545 and M-0217546]).

Figure 6H, 8O

Specimens Examined—BRAZIL. **Bahia: Guanambí**, Serra do Espinhaço, 23 July 1980 (fl), *Miranda 332* (RB); **Igaporã**, Estrada Igaporã-Caetité, ca. de 38 km de Caetité, Serra do Curva do Vento, 1050 m, 13°48'26"S, 42°39'27"W, 18 July 2005 (fl, fr), *Forzza 4089* (RB, SPF). **Minas Gerais: Berilo**, 800 m, 19 July 1991 (fl), *col. anonymous 395* (RB); **Bocaiúva**, Bocaiúva - Diamantina, próximo do Rio Jequitinhonha, 17 March 1997 (fl), *Hatschbach et al. 66412* (MBM, NY); ibidem, 23 July 1998 (fl), *Hatschbach et al. 68118* (ALCB, B, ESA, G, HRCB, MBM, RB, SP, UB); **Diamantina**, ca. 20 km de Diamantina, 1300 m, 21 January 1969 (st), *Irwin et al. 22366* (NY, RB, US); estrada p/ Conselheiro Mata, 18 July 1980 (fl), *Menezes et al. CFCR 116* (NY, SPF); estrada para Biribi, 18°10'S, 43°37'W, 8 April 1982 (fl), *Hensold et al. CFCR 3129* (NY, SPF); estrada para Conselheiro Mata, km 166, 23 February 1986 (fl), *Semir et al. CFCR 9545* (NY, SPF); **e**strada para Conselheiro Mata, km 183, 10 September 1986 (fl), *Menezes et al. CFCR 10288* (NY, SPF); **e**strada para Conselheiro Mata, 18°17'S, 43°45'W, 18 July 1987 (fl), *Mello-Silva & Pirani CFCR 11028* (NY, SPF); estrada para Biribi, 18°10'S, 43°47'W, 25 September 1990 (fl), *Esteves et al. CFCR 15510* (SPF); estrada para Conselheiro Mata, 13 July 1996 (fl), *Atui et al. 2* (SPF); estrada entre Diamantina e Conselheiro Mata, km 185-186, próximo à entrada do Sítio Pica-Pau, 8 July 2001 (fl, fr), *Souza et al. 25389* (ESA); **Francisco Sá**, estrada para Salinas, 11 February 1969 (fl), *Irwin et al. 23107* (NY, UB); **Gouveia**, Córrego do Tigre, 14 September 1985 (fl, fr), *Hatschbach & Zelma 49661* (MBM, NY, US); estrada para Barão de Guaçaí, 24 July 1998 (fl), *Hatschbach et al. 68167* (MBM); **Grão-Mogol**, BR 152, sentido Montes Claros- Salinas, km 396, 16°14'46.8"S, 42°51'4.2"W, 900 m, 11 April 2011 (fr), *Rando & Nogueira 969* (SPF); **Juramento**, estrada de Itacambira - Juramento, 6 km antes de Juramento, 25 July 1985 (fl), *Martinelli et al. 11295* (RB); **Montes Claros**, Fazenda Vieira do Mato, July 1820 (fl), *Pohl 3152* (G, K, M, NY); ca de 30 km ao Norte de São Francisco, 16 August 1960 (fl), *Maguire et al.*

49230 (NY); **Riacho Verde**, entre Riacho Verde e Francisco de Sá, 20 September 1963 (st), *Santos et al. 24298* (NY, R).

Chamaecrista tragacanthoides var. *rasa* is completely glabrous and some specimens have larger dimensions (larger leaves, more number of leaflets) than the typical variety. It occurs in *campo rupestre* vegetation from the Diamantina Plateau to northern Minas Gerais state, with two collections known from Bahia, at elevations around 800 – 1300 m.

18.2. *Chamaecrista tragacanthoides* (Benth.) H.S. Irwin & Barneby var. *tragacanthoides*, Mem. New York Bot. Gard. 2: 687, 1982. *Cassia tragacanthoides* Mart. ex Benth. in Mart., Fl. bras. 15(2): 166, 1870, t. XLV, fig. 1, sens. str. TYPE: —BRAZIL. Minas Gerais: "Habitat in campis desertis inter Formigas et Contendas, August 1818 (fl, fr), *Martius s.n.* (holotype: M! [M-0217542], photo of holotype [neg. NY 9210]: NY!).

Specimens Examined—BRAZIL. **Minas Gerais**: **São João da Chapada**, 14 February 1947 (fl), *Romariz 122* (RB); 4 km ao norte de São João da Chapada, 1200 m, 23 March 1970 (fl), *Irwin et al. 28165* (B, G, NY, RB, UB, US); **Diamantina**, Biribiri, 23 March 1892 (fl), *Glaziou 19094* (K, NY, US); ibidem, m, 15 February 2001 (fl), *Lombardi 4291* (MBM); ibidem, 24 January 2004 (fl), *Mendonça 1193* (DIAM); Mendanha, 1300 m, 31 January 1969 (fr), *Irwin et al. 22927* (NY, RB, UB, US); ca. de 8 km de São João da Chapada, 19 May 1990 (fl), *Arbo et al. 4451* (SPF); estrada para Biribi, 18°09'S, 43°36'W, 14 February 1991 (fl), *Arbo et al. 5061* (SPF); entre Soupa – São João da Chapada, 25 January 1978 (fl), *Hatschbach et al. 40901* (MBM, NY, US); estrada Diamantina - São José da Chapada, perto da ponte, 18°12'01.9"S, 43°42'31.3"W, 1136 m, 19 November 2010 (fl), *Cota et al. 56* (DIAM); estrada Guinda-São João da Chapada, 18°08'51"S, 43°43'15"W, 10 December 1997 (fl), *Sano et al. 755* (SPF); estrada Guinda-São João da Chapada, 18°08'51" e 43°43'15"W, 22 January 2007 (fl), *Pirani et al. 5668* (SPF); estrada para Biribi, 18°10'S, 43°37'W, 8 April 1982 (fl), *Hensold et al. CFCR 3129* (NY, SPF); estrada para Biribi, 18°10'S, 43°47'W, 25 September 1990 (fl), *Esteves et al. CFCR 15510* (SPF); estrada para Biribi, 18°09'S, 43°36'W, 14 February 1991 (fl), *Arbo et al. 5061* (SPF); estrada para Biribi, próximo da cachoeira Sentinela, 18°09'26"S, 43°37'06"W, 21 September 2000 (fl), *Stehmann et al. 2671* (MBM); estrada para São João da Chapada, 18°10'19.7"S, 43°42'23.2"W, 1141 m, 7 October 2003 (fl, fr), *Giordano & Bovini 2660* (RB); Morro do Cruzeiro, 18°13'52.7"S, 43°35'17.3"W, 28 August 2003 (fl), *Fernandes s.n.* (DIAM 1088); on old road to Mendanha, 17 January 1959 (fl), *Irwin et al. 2468* (NY, US); Parque Estadual de Biribiri, 18°13'18.43"S, 43°39'33"W, 1309 m, 19 August 2010 (fl), *Cota et al. 48* (DIAM); São João da Chapada, 18°07'00"S, 43°46'00"W, 15 September 1994 (fl, fr), *Silva et al. 2919* (CEN, RB); **Gouveia**, Serra do Espinhaço, rodovia para Barão do Guaçuí, 1300 m, 24 October 1999 (fl), *Hatschbach, G. et al. 69636* (ESA); **Itamarandiba**, 10 August 1999 (fl), *Fernandes s.n.* (BHCB 48914, NY).

Chamaecrista tragacanthoides var. *tragacanthoides* is distinguished mostly by its leaflets and branches completely covered by greyish hairs. Its ramose habit and peculiar indumentum make these plants look like grayish cushions among rocks. It is a species restricted to *campo rupestre* vegetation in Diamantina Plateau at elevations of 1136 – 1309 m.

19. *Chamaecrista ulmea* H.S. Irwin & Barneby, Mem. New York Bot. Gard. 2: 689, 1982. TYPE: —BRAZIL. Minas Gerais: ca. 15 km de Grão Mogol, 19 February 1969 (fr), *Irwin et al. 23535* (holotype: UB!; isotypes: F, LE!, K!, NY!, P!, R!, S, US).

Specimens Examined—BRAZIL. **Minas Gerais**: **Botumirim**, estrada Botumirim – povoado do "Canta Galo"-várzea da Estiva, 17°8'30.6"S, 43°5'6.9"W, 12 November 2011 (fl), *Santos et al. 650* (SPF). **Grão-Mogol**, ca. de 15 km oeste de Grão-Mogol, 950 m, 19 February 1969 (fr), *Irwin et al. 23535* (NY); Córrego do Pasto, 21 October 1978 (fl), *Hatschbach 41627* (MBM, NY); 16°32'S, 42°55'W, 27 May 1988 (fl, fr), *Zappi et al. CFCR 12000* (K, SPF); 16°33'S, 42°54'W, 15 June 1990 (fl, fr), *Pirani et al. CFCR 13034* (K, SPF); trilha dos Garimpeiros, 14 June 1990 (fl), *Hatschbach et al. 54297* (BM, MBM, SPF); Serra de Grão-Mogol, várzea da Coronha, 12 November 1938 (fl), *Markgraf et al. 3464* (MBM).

Chamaecrista ulmea is easily recognized by its flexuous branches bearing leaves with two pairs of narrowly oblong leaflets (11.0 – 21.1 mm x 2.3 – 4.1 mm). Specimens of this species are frequently determined as *Chamaecrista desvauxii* (Killip.) Collad. a species belonging to *C.* sect. *Xerocalyx,* which also has two pairs of leaflets and extrafloral nectaries. *C. ulmea* is known from a few collections from the Grão-Mogol and Botumirim area in the northeastern part of Minas Gerais state. It occurrs on *campo rupestre* vegetation at elevations around 950 – 1100 m.

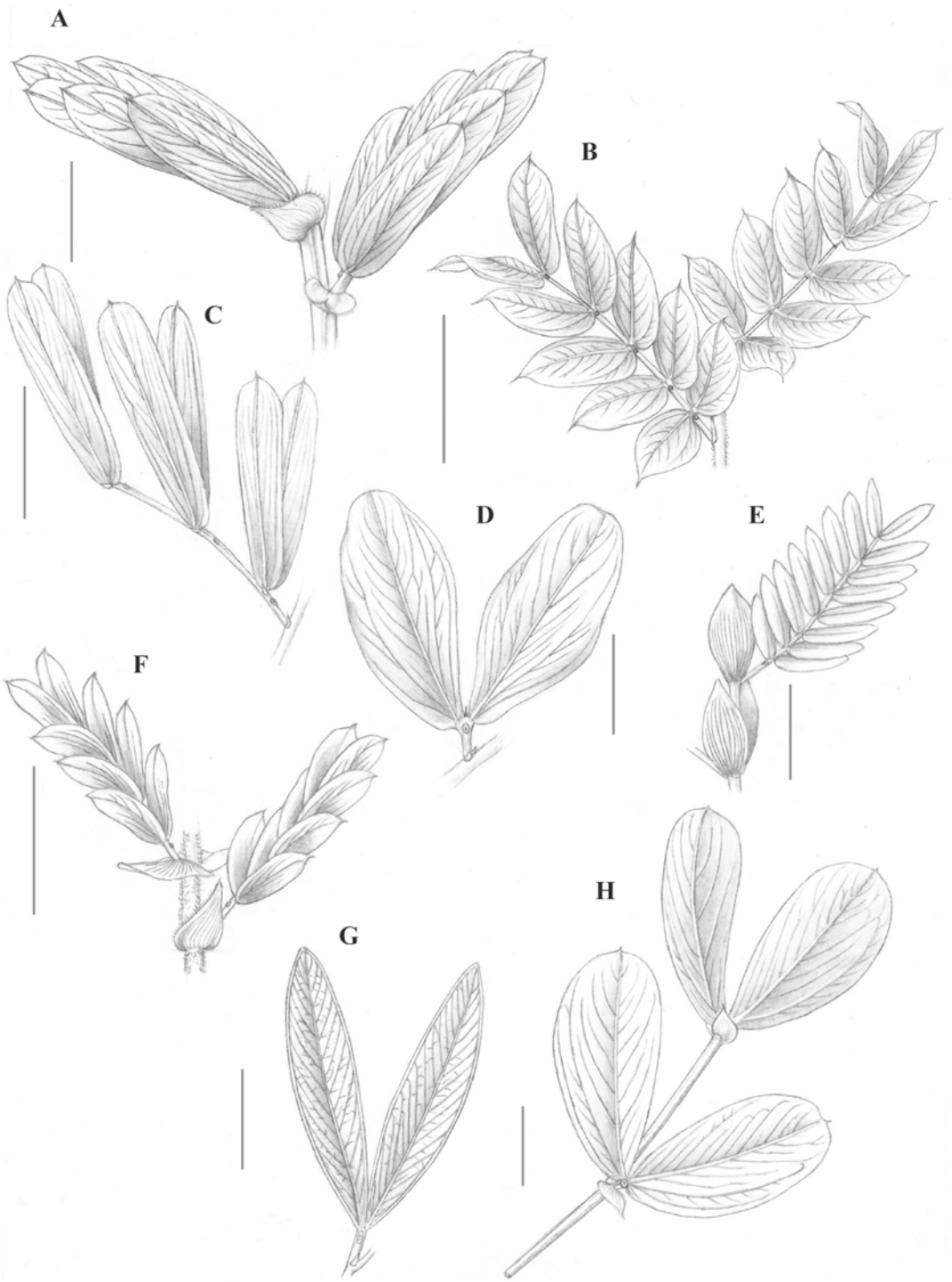


Fig. 5. *Chamaecrista anceps* (Farinaccio et al. 60, SPF). A. Leaves and stipules. *C. aristata* (Mello-Silva et al. 451, SPF). B. Leaves and stipules. *C. burchellii* (Rando et al. 1092, SPF). C. Leaf and stipule. *C. choriophylla* (Rando et al. 906, SPF). D. Leaf and stipule. *C. cinerascens* (Pirani et al. 5093, SPF). E. Leaf and stipules. *C. distichoclada* (Rando et al. 1230, SPF). F. Leaves and stipules. *C. lagotois* (Rando et al. 1033, HUEFS, SPF). G. Leaf and stipule. *C. latifolia* (Rando et al. 1226, SPF). H. Leaves and stipules. Scale bars: A, D, E and F=1 cm; B, G and H= 2 cm. Ilustrator: Hiroe Sasaki.

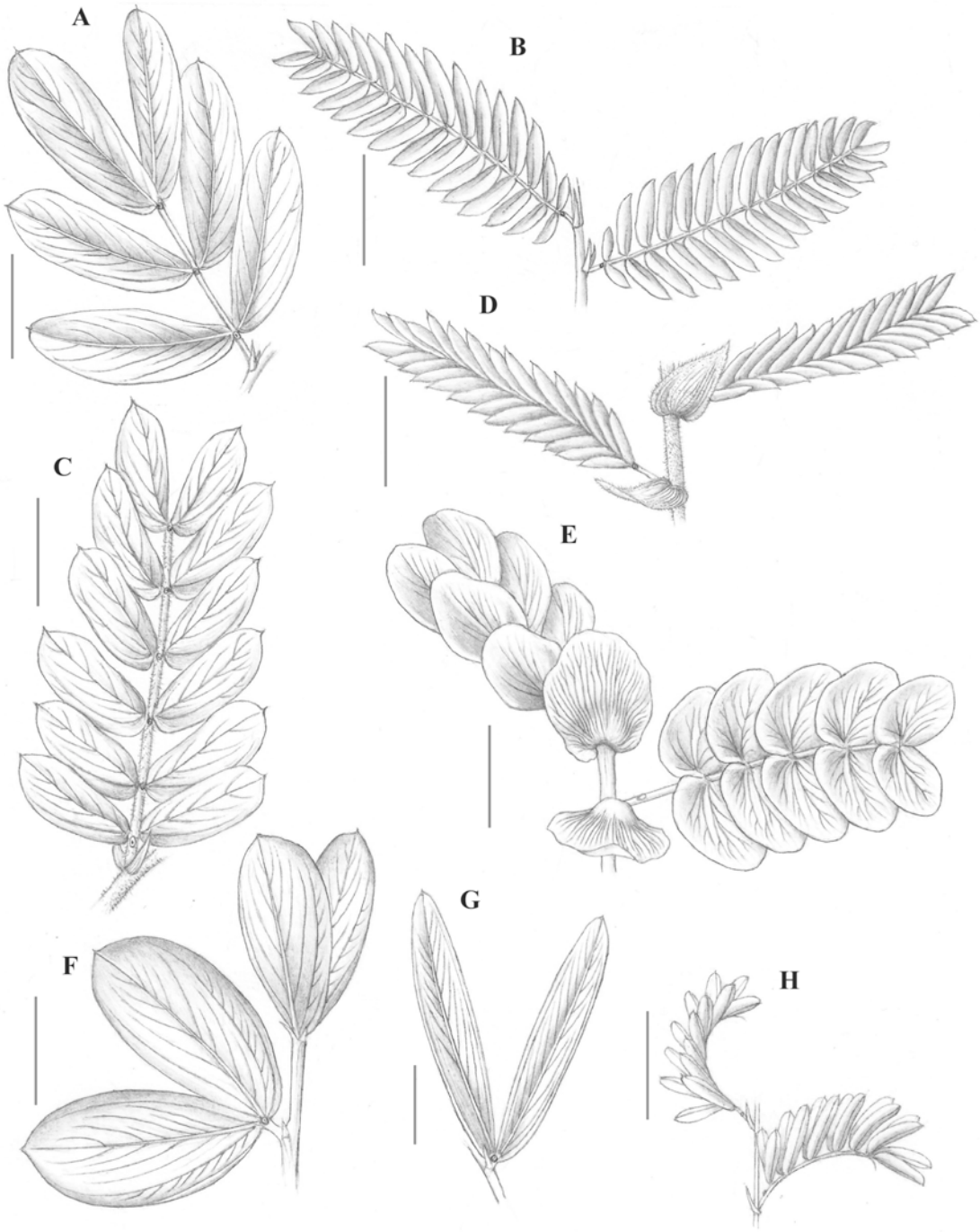


Fig. 6. *Chamaecrista mucronata* (Irwin et al. 29343, SPF). A. Leaf and stipule. *C. olesiphylla* (Rando et al. 1128, SPF). B. Leaves and stipules. *C. arrojadoana* (Rando et al. 1009, HUEFS, SPF). C. Leaf and stipules. *C. potentilla* (Rando et al. 1245, SPF). D. Leaves and stipules. *C. rotundata* (Rando et al. 925, SPF). E. Leaves and stipules. *C. rossicorum* (Rando et al. 1007, HUEFS, SPF). F. Leaves and stipules. *C. simplifacta* (Rando et al. 1242, SPF). G. Leaf and stipule. Scales bars: A, B, C, D, G and H = 1 cm; E and F= 2 cm. Ilustrator: Hiroe Sasaki.

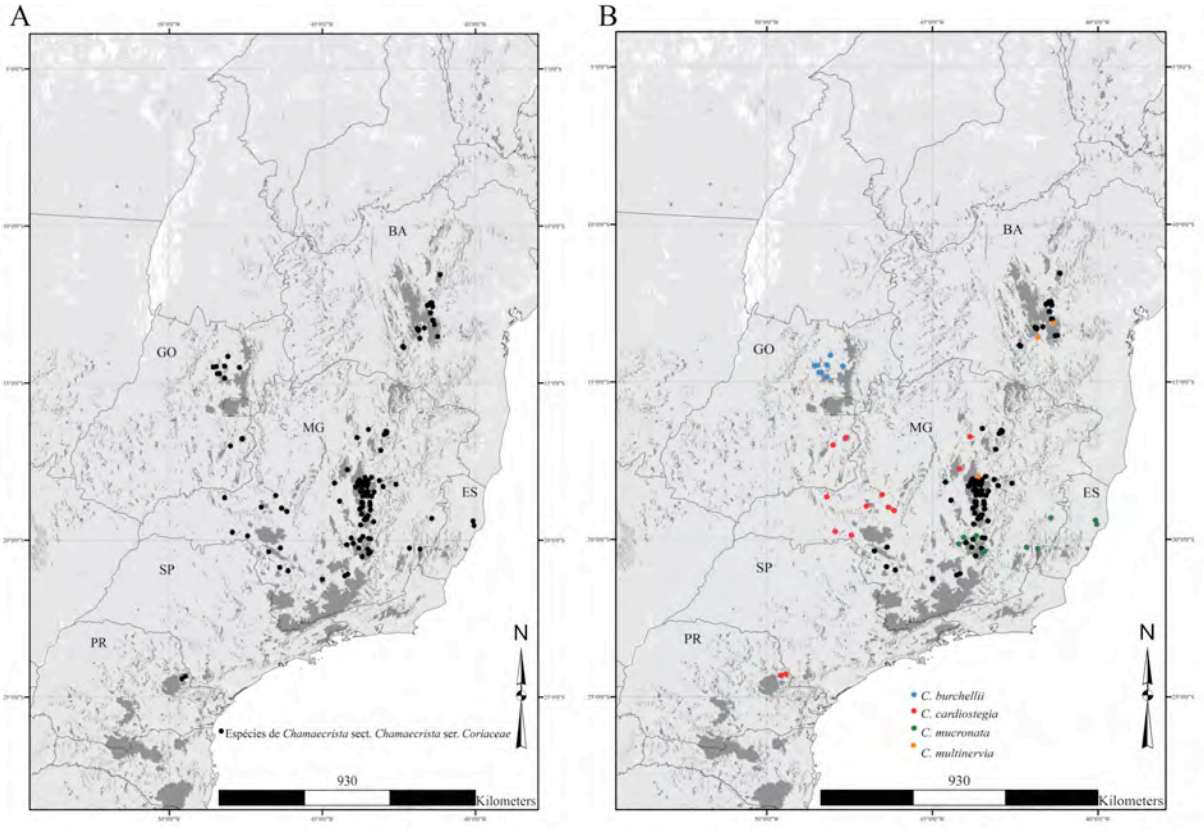


Fig. 7. Map A. Geographical distribution of all species of *Chamaecrista* ser. *Coriaceae* (black spots). Map B. Geographical distribution highlighting the disjunct species and the only ones that occurs out of the *Espinhaço* Range (blue spots *C. burchelli*, red spots *C. cardiostegia*, green spots *C. mucronata* and orange spots *C. multinervia*).

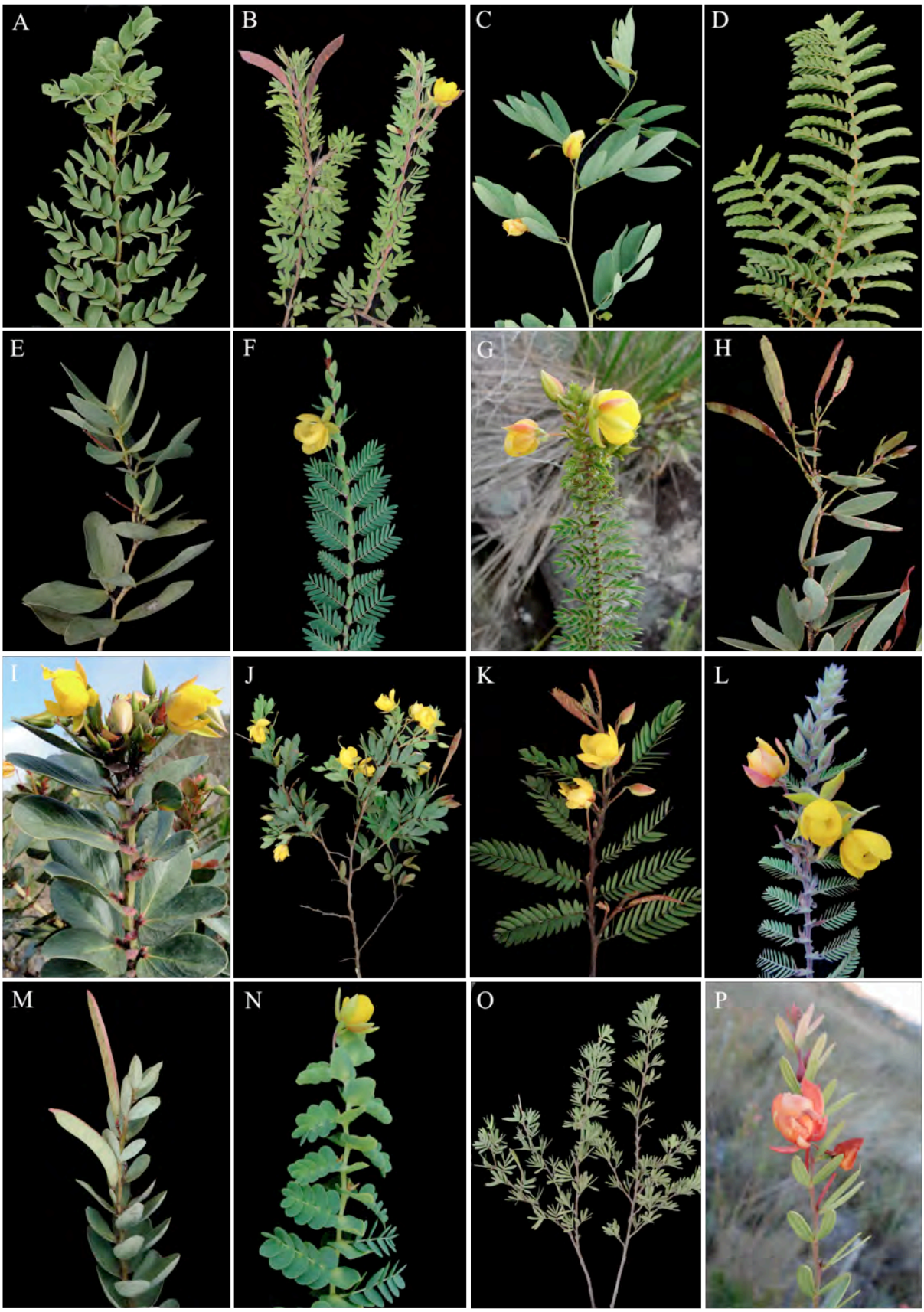


FIG. 8. *Chamaecrista aristata* (Rando & Nogueira 976, SPF) A. Steril branch. *C. arrojadoana* (Rando et al. 1109, HUEFS). B. Branches with fruit and flower. *C. burchellii*

(Rando et al. 1092, HUEFS). C. Branch with flower. *C. cardiostegia* (Rando & Nogueira 1125, SPF). D. Steril branch. *C. choriophylla* (Rando et al. 938, SPF). E. Steril branch. *C. cinerascens* (Rando et al. 875, SPF). F. Steril branch. *C. distichoclada* (Rando et al. 1230, SPF). G. Branch with flowers. *C. lagotois* (Rando et al. 617, SPF). H. Branch with fruits. *C. latifolia* (Rando et al. 1250, SPF). I. Branch with flowers. *C. mucronata* (Rando et al. 879, SPF). J. Branch with flower. *C. olesiphylla* (Rando et al. 632, SPF). K. Branch with flowers. *C. potentilla* (Rando et al. 1245, SPF). L. Branch with flower. *C. rossicorum* (Rando et al. 667, SPF). M. Branch with fruits. *C. rotundata* (Rando et al. 825, SPF). N. Branch with flower. *C. tragacanthoides* (Rando & Nogueira 969, SPF). O. Steril branches. *C. simplifacta* (Rando et al. 1242, SPF). P. Branch with flower.

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Appendix 1.

Numerical List of Species – 1. *C. anceps* (Benth.) H. S. Irwin & Barneby; 2. *C. aristata* (Benth.) H. S. Irwin & Barneby; 3. *C. arrojadoana* (Harms) Rando; 4. *C. burchellii* (Benth.) H. S. Irwin & Barneby; 5. *Chamaecrista cardiostegia* H.S. Irwin & Barneby; 6. *C. choriophylla* (Vogel) H.S. Irwin & Barneby; 7. *C. cinerascens* (Vogel) H.S. Irwin & Barneby; 8. *C. distichoclada* (Mart. ex Benth.) H.S. Irwin & Barneby; 9. *C. lagotois* H.S. Irwin & Barneby; 10. *Chamaecrista latifolia* (Benth.) Rando; 11. *C. mucronata* (C. Sprengel) H.S. Irwin & Barneby; 12. *C. multinervia* (Mart. ex Benth.) H.S. Irwin & Barneby; 13. *C. olesiphylla* (Vogel) H.S. Irwin & Barneby; 14. *C. potentilla* (Mart. ex Benth.) H.S. Irwin & Barneby; 15. *C. rossicorum* (H.S. Irwin & Barneby) Rando; 16. *C. rotundata* (Vogel) H.S. Irwin & Barneby; 16.1. *C. rotundata* var. *interstes* H.S. Irwin & Barneby; 16.2. *C. rotundata* var. *rotundata*; 17. *C. simplifacta* H.S. Irwin & Barneby; 18. *C. tragacanthoides* (Benth.) H.S. Irwin & Barneby; 18.1. *C. tragacanthoides* var. *rasa* H.S. Irwin & Barneby; 18.2. *C. tragacanthoides* var. *tragacanthoides*; 19. *C. ulmea* H.S. Irwin & Barneby.

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CFSC 3867* (13), *Scatena, V.L. et al. CFCR 10512* (14), *CFCR 10534* (13), *Schmeda, G. 1052* (3), *Schwacke, C.A.W. 8577* (16.2), *8578* (16.2), *8579* (14), *8580* (8), *8588* (13), *Segadas, F. et al. 1105* (13), *Sellow, F. s.n.* (11), *s.n.* (11), *s.n.* (11), *s.n.* (11), *s.n.* (11), *s.n.* (13), *Semir, J. et al. 2040* (6), *2711* (6), *17572* (6), *01-121* (16.1*CFCR 224* (14), *CFCR 9545* (18.1), *CFSC 2356* (13), *CFSC 2374* (10), *CFSC 2956* (13), *CFSC 4099* (13), *Semir, J. & Sazima, M. CFSC 648* (3), *CFSC 676* (3), *CFSC 703* (3), *CFSC 709* (3), *2791* (10), *CFSC 2028* (13), *CFSC 2040* (10), *CFSC 2616* (3), *CFSC 2664* (3), *CFSC 2667* (3), *CFSC 2686* (3), *CFSC 2731* (10), *CFSC 2790* (3), *Semir, J. & Giulietti, A.M. 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C-192* (3), *Zappi, D.C. & Scatena, V.L. CFCR 10901* (7), *Zappi, D.C. et al. CFCR 11128* (14), *CFCR 11279* (17), *CFCR 12000* (19), *CFCR 2043* (5), *CFCR 8043* (5), *CFCR 9858* (2), *CFSC 10396* (10), *CFSC 10550* (13), *Zickel, C.S. et al. 21703* (13).

Capítulo 2

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Taxonomic novelties in *Chamaecrista* (Leguminosae: Caesalpinioideae) from Brazil

JULIANA G. RANDO*, BENOIT LOEUILLE & JOSÉ RUBENS PIRANI
Instituto de Biociências, Departamento de Botânica, Universidade de São Paulo, Rua do Matão 277, São Paulo, Brazil
**Corresponding author, email: ju_rando@hotmail.com*

Abstract

In the light of taxonomic studies of *Chamaecrista* sect. *Chamaecrista* ser. *Coriaceae* the status of several varieties is re-evaluated: Three former varieties are recognized at the specific level, two new combinations and one synonymization are here proposed. The geographic distribution and taxonomic affinities of these species are discussed.

Key words: campos rupestres, Fabaceae, systematics

Introduction

Chamaecrista Moench (1794: 272) is one of the largest genera of the subfamily Caesalpinioideae, with more than 330 species distributed mainly in tropical America (Lewis 2005). In Brazil 252 species are known, of which 203 are restricted to the country (Souza & Bortoluzzi 2013); many are narrow endemics. This high diversity of *Chamaecrista* is centered in the Cerrado Domain, mainly in the *campos rupestres* (Souza & Bortolluzi 2013) that are highland areas with many rock outcrops surrounded by sandy or rocky soils, which are mostly covered by a low, herbaceous or shrubby vegetation (Giulietti *et al.* 1997). This formation is located in the Brazilian Central plateau. In the last taxonomic revision of the genus, Irwin & Barneby (1982) recognize 120 varieties in native Brazilian species. In current taxonomy, the category 'variety' is commonly used for sympatric taxa showing a morphological differentiation that is not sufficient to deserve species level recognition (McDade 1995). But in most of Rupert Barneby's treatments the category 'variety' usually reflects a lack of knowledge due to scarce collection or to few observations in natural environment (e.g. Barneby 1991). Barneby (1991) in his monograph of the genus *Mimosa* Linnaeus (1753: 516) stated: "Where appropriate I have drawn attention to some of the unsolved taxonomic problems which can best be addressed by Latin American botanists living within easy access to the living plants". Similar taxonomic problems occur in *Chamaecrista* sect. *Chamaecrista* ser. *Coriaceae* (Bentham 1870: 165) Irwin & Barneby (1982: 667) the target of this study. The series is composed of shrubs with a xylopodium, petiolar glands, thick-textured leaflets and axillary peduncles (Irwin & Barneby 1982). It comprises 20 species (with 10 varieties), distributed mainly in the Espinhaço Range of mountains in Minas Gerais and Bahia states (Rando & Pirani 2011). Based on morphological analysis and field observations, we here propose two new combinations and one new synonym regarding four taxa belonging to this series.

Material and methods

The present morphological analysis is based on field observations and on several collections from the main herbaria housing specimens from Central Brazil, which provided the data upon which the conclusions were

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Capítulo 3

Biogeography history of *Chamaecrista*: ancient occupation versus recent radiation in Brazilian mountains

Biogeographic history of *Chamaecrista*: ancient occupation versus recent radiation in the Brazilian mountains

Juliana Gastaldello Rando[1], Luciano Paganucci de Queiroz[2], Anselmo Nogueira[1] & José Rubens Pirani[1]

1. Instituto de Biociências, Departamento de Botânica, Universidade de São Paulo, Rua do Matão 277, 05508-900, São Paulo, Brazil.

2. Universidade Estadual de Feira de Santana, Departamento de Ciências Biológicas, Laboratório de Sistemática Molecular de Plantas, Km 03 BR 116, Campus, 44031-460, Feira de Santana, Bahia, Brazil.

Corresponding author: ju_rando@hotmail.com (author for correspondence)

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ABSTRACT

The South American Cerrado is the second largest formation in the Neotropical Region, and is the species-richest savannas in the world. However, biogeographyc studies focused on the biogeographic history and diversification of organisms in the Neotropical savannas are still scarce. The plant family Leguminosae stands as the most representative group in the Cerrado, with almost half of its species being endemic to this biome. *Chamaecrista* is one of most diverse genus in the Cerrado and considered a model group for biogeographical and evolutionary studies in Cerrado and Campos Rupestres vegetation. The main objective of this study was to estimate the biogeographical history of *Chamaecrista* in order to answer when, where, and how did take place the diversification of the genus; how biogeographical processes have interacted during its diversification; and if are there evidences of habitat shift associated with morphological transitions during the its diversification. For this, we estimated the divergence times with fossil calibration, ancestral character states, and ancestral ranges based in maximum likelihood inference for the genus. These estimates provide important general insights into the history of *Chamaecrista*. Our analyses suggest a complex biogeographic history of *Chamaecrista*, since the diversification of each clade within the genus seem to have been influenced by distinct processes. An origin of the genus in tropical forests in South America is strongly indicated by the analysis, however the ancestral area reconstruction is somewhat uncertain due to the low value of relative probability obtained for the MRCA of *Chamaecrista*. The most likely ancestral range for the *Chamaecrista* from open areas is the *campos rupestres*, with posterior expansion to the whole extension of Neotropical savannas, where the group suffered a high, and in several of its groups, a recent diversification. The transition of a *Chamaecrista* lineage from forest to savannas is congruent with some morphological transitions observed within the genus, as habit shift, changes in the inflorescence type, gain/loss of extrafloral nectaries and of sticky glandular trichomes.

Key words: South America biogeography, savannas, Cerrado, Campos Rupestres, Leguminosae.

INTRODUCTION

Biogeographic history of South America was marked mainly by the isolation as an "island continent" for a long geological period, by the Andes uplift, by the landbridge formation through the raise of the Panama istmus, and by paleoclimatic fluctuations, great events that may have lead to changes in plant cover and to diversification of plant and animal groups (Burnham & Graham 1999). Besides those, several other factors listed as "biotic" and "abiotic" forces leading to diversification have been also discussed in attempt to explain the high number of species existing in the Neotropical region (Antonelli & Sanmartín 2011). The huge diversity found throughout the vegetation coverage in the Amazonian region explain the emphasis given to this system in evolutionary and biogeographic studies in South America (Wesselingh et al. 2010). However, there is a lack of studies focused on the biogeographic history and diversification of organisms from drier and species-rich ecosystems such as Neotropical savannas. *Cerrado* is a term applied to the prevailing formation within the Neotropical savanna dominium, and it includes several phytophysiognomies ranging from open grasslands to closed woodlands (Oliveira-Filho & Ratter 1995, Gottesberger & Gottesberger 2006). The Cerrado extends from Northeastern Brazil into Paraguay and Bolivia, reaching its more extensive area in Central Brazil where it originally covered more than 2 million km^2 (Ratter 2003, Gottesberger & Gottesberger 2006). After Amazon, the cerrado is the largest formation in the Neotropics, and is considered a global biodiversity hotspot area (Myers et al. 2000), currently with only 21% of its original extension (Castro et al. 1999).

The initial development of Neotropical savannas and cerrados is estimated between 25 to 28 million years (Graham 1991, Burnham & Graham 1999), but the establishment of the vegetation with typical elements as found today is believed to be more recent, around 4 million years, during the late Quarternary (Gottesberger & Gottesberger 2006). The origin of Neotropical savannas is likely related to the retraction of forest vegetation and the global increase of plant biomass with C_4 photosynthesis (Cerling et al. 1997, Cerling et al. 1998, Bouchenak-Khelladi et al. 2010, Arakaki et al. 2011). Additionally, the fire regime is an important eco-evolutionary force in this biome (Oliveira-Filho & Ratter 1995, Ratter et al. 1997, Pennington et al. 2000, Simon et al. 2009, Simon & Pennington 2012), where the natural accumulation of plant biomass becomes the fuel material for occasional fires. Evidences for plant adaptations to the fire regime were observed in several cerrado species such as thick leaves corky bark, xylopodia and the larger ability of plants to sprout from

lateral buds when the growing apex is destroyed by fire (Pennington et al. 2000, Simon & Pennington 2012).

The cerrado formation has more than 10.000 vascular plant species, in which 44% are endemics (Ratter et al. 2011, Forzza et al. 2014). The high levels of endemism are not uniformly distributed in the cerrado landscape, but are most found along mountain areas, such as the Chapada do Veadeiros (in Goiás state) and the Espinhaço Range (along Central Bahia and Minas Gerais states), throughout a vegetation type known as *campos rupestres* (Prance 1994, Giulietti et al. 1997, Simon & Proença 2000, Fiaschi & Pirani 2009). Despite the *campos rupestres* of the Espinhaço Range do not occur entirely inside the cerrado Domain, but in contact zones between the cerrado, Atlantic forest as well as in caatinga area (Vasconcelos 2008, 2009), they have been considered as part of the cerrado by most botanists and plant ecologists (Ribeiro & Walter 1998, Gottesberger & Gottesberger 2006, Simon & Proença 2000, Simon et al. 2009). However, Prance (1994) distinguished the "campo rupestre archipelago" as a distinct phytocoria or floristic province of South America, accounting on its rich flora and high level of plant endemism.

Leguminosae is the richest plant family in the cerrado vegetation with about 1,175 species, of which ca. 528 are endemics (Lima et al. 2014). *Mimosa* and *Chamaecrista* together comprise more than 1/3 of the Leguminosae diversity in the cerrado; and after *Mimosa*, *Chamaecrista* is the most diverse genus in the cerrado comprising 207 species, 150 endemics (Souza & Bortulozzi 2014). Additionally, *Chamaecrista* is a monophyletic genus (Conceição et al. 2009) and its evolutionary history probably involved the habitat transitions of lineages between forests and open areas, evolutionary changes of habit (trees to shrubs) and the appearance of new traits such as xylopodia and sticky glandular trichomes (Conceição et al. 2009). For example, dated phylogenies provide evidence indicating that the cerrado lineages probably descend from ancestors of the adjacent Amazonian forest (e.g. *Andira*) or descend from dry forest ancestors (e.g. *Mimosa*) (Simon et al. 2009). In the case of *Chamaecrista*, habitat shift could be related with several morphological modifications. Indeed, *Chamaecrista* has been speculated to be a model group for biogeographical and evolutionary studies in cerrado and *campos rupestres* vegetation (Fiaschi & Pirani 2009, Queiroz et al. 2009).

The main objective of this study was to estimate the biogeographical history of *Chamaecrista*, a plant group with a high number of species in cerrado and campos rupestres. Using a well-sampled phylogeny of *Chamaecrista*, we addressed three main questions: (1)

When, where and how did take place the diversification of *Chamaecrista*? (2) How biogeographical processes (dispersion, vicariance and extinction) have interacted during its diversification? (3) Are there evidences of habitat shift associated with morphological transitions during the *Chamaecrista* diversification?

MATERIAL AND METHODS

Taxon sampling

We assembled 148 taxa comprising 120 species of *Chamaecrista* from which data on two plastids DNA regions (*trnD-T* and *trnL-F*) and one for nuclear region (ITS) were obtained. Of these total, ITS sequences from 46 taxa and *trnL-F* sequences from 47 taxa were obtained from GenBank (sequences generated by Conceição et al. 2009). An effort has been taken to sample species from all Brazilian floristic regions (Amazon, Caatinga, Cerrado and Paranaense subregion, according to Morrone 2006) and a carefully sampling was performed in different physiognomies of the cerrado, which is the diversity center of the genus (Figure 1). The outgroup taxa were species from two closely related genera, *Cassia* and *Senna* (Bruneau *et al.* 2008). The sampling of *Chamaecrista* represented more than 1/3 of all species in the world, and almost half of species that occur in Brazil. Genbank accession numbers for DNA sequences generated in this study are associated with voucher specimens (Appendix 1).

DNA extraction, amplification, and sequencing

Total DNA was extracted mostly from fresh or silica-gel dried leaflets using an adapted 2 X CTAB procedure of Doyle & Doyle (1987) or by Invitek mini plant kit (Invitek, Berlin, Germany). The regions chosen are the same used in others phylogenetic analyses for the genus (Conceição et al. 2009, Chapter 1). *Nuclear region*: For amplification of ITS we used the primers 17SE and 26SE and for sequencing the primers ITS4 and ITS92 (Desfeaux et al. 1996); We performed the amplification using the following reaction: 30 µl PCR mix containing: 3.0 µl of supplied buffer, 1.5 µl of MgCl2 (50 mM), 0.6 µl of dNTPs (10mM, GE Healthcare Life Sciences), 0.3 µl of each primer (15µM), 0.6 of µl BSA (Invitrogen), 6.0 µl of betaine (COMPANY), 1.0 µl DMSO (1%, Merck) and 0.15 µl Taq DNA polymerase (5U/µl, Phoneutria), 15.85 µl H20 (q.s.p.) and 1.0 µl of DNA at 20-40 ng of concentration. *Plastid regions*: for amplification and sequencing of trnL-F, we used two universal primers (C, F) of Taberlet et al. (1991). For amplification and sequencing of trnD-T, we used the primers and

trnD (F) (Yang et al. 2000) and *trnT* (R) (Demesure et al. 1995). For all plastid regions, we used the Toptaq Master Mix (Qiagen, Dusseldorf, Germany) scaled to 15 µl, containing: 7.5 µl pre-made mix, 0.2 µl of each primer (15µM), 6.6 µl of H2O (Qiagen) and 0.5 µl of DNA at 20-40 ng of concentration. Table 1 shows the sequences of the primers used, as well as the PCR cycles used for each reaction. PCR products were purified using enzymatic reaction with Exonuclease I and Shrimp Alkaline Phosphatase enzymes (Affymetrix, USB products, Ohio, U.S.A.) or with PEG 20% (Polyethylene Glycol). The samples were sequenced in both directions using the Spectrumedix SCI SCE9624 automated sequencer at Universidade Estadual de Feira de Santana (UEFS). In some cases the PCR products were sequenced at Macrogen Inc. (Korea). There are some differences in numbers of sequences obtained among the different regions amplified, mainly for *trnD-T*, which its amplification was not successful for all accessions despite several attempts (Table 2).

Table 1. Primers used for PCR and/or sequencing and the PCR cycle.

Region (reference)	Name (usage)	Sequence	PCR Cycle
ITS	ITS17SE (PCR)	ACG AAT TCA TGG TCC GGT GAA GTG TTC G	
(Desfeaux *et al.* 1996)	ITS26SE (PCR)	TAG AAT TCC CCG GTT CGC TCG CCG TTA C	28 X (45”/94°C – 60”/52°C – 180”/72°C)
	ITS92 (sequencing)	AAG GTT TCC GTA GGT GAA C	
	ITS4 (sequencing)	TCC TCC GCT TAT TGA TAT GC	
trnD-T			
(Yang et al. 2000)	trnD (F)	ACC AAT TGA ACT ACA ATC CC	36 X (50”/94°C – 50”/54°C – 90”/72°C)
(Demesure et al. 1995)	trnT (R)	CTA CCA CTG AGT TAA AAG GG	
trnL-F			
(Taberlet et al. 1991)	trnL-F (C)	CGA AAT CGG TAG ACG CTA CG	35 X (30”/94°C – 40”/53°C – 40”/72°C)
	trnL-F (F)	ATT TGA ACT GGT GAC ACG AG	

Alignment

Forward and reverse sequencing reads were assembled into contigs and edited in Geneious software (Biomatters 2013). Sequences of all loci were aligned by Muscle (Edgar 2004a, 2004b), with manual edition in Geneious software to correct obvious alignment errors and to remove sections of dubious quality. The total alignment comprises 3068 base pairs, partitioned in five different regions (Table 2).

Table 2. Number of species, taxa (including varieties), sequences, base pairs and the nucleotide substitution model selected for each region.

Region	**Number of species *Chamaecrista* + outgroup (*Cassia* and *Senna*)**	**Number of sequences (all taxa, including the varieties)**	**Number of base pairs in the alignment**	**Model**
ITS 1	116 + 4	148	426	HKY+G
ITS 5.8S	116 + 4	148	192	K80+G
ITS 2	116 + 4	148	366	K80+G
TrnD-T	104 + 0	113	1040	TPM1uf+I+G
TrnL-F	120 + 4	145	1044	TPM1uf+I+G

Bayesian divergence age estimation

Bayesian divergence time estimation was performed using BEAST v. 1.7.4 (Drummond & Rambaut, 2007). The dataset was partitioned into five partitions (nuclear ribosomal ITS regions 1 and 2, and the intervening 5.8S, *trnD-T* spacer and *trnL-F* spacer). Model parameters and molecular clocks were unlinked across partitions. The nucleotide substitution model (Table 1) was selected based on the Akaike information criterion values using JModeltest 2.1 (Guindon & Gascuel 2003, Darriba et al. 2012). The analysis was performed using an uncorrelated-rates relaxed molecular clock model (UCLD). We opted by the Yule tree model, which is appropriate for species-level. For the BEAST analysis, we constrained the ages of two nodes. For the root node (*Cassia* + *Senna* + *Chamaecrista*) the age estimates were taken from Bruneau et al. (2008), 53 mya and standard deviation 1.567, assuming a normal prior of distribution rate. The fossil calibration was based on fruits from the Southeast of USA and Mexico, described as *Senna* (Herendeen 1992), also used by Bruneau et al. (2008). We therefore assigned this fossil to the crown node of *Senna* species included in the analysis (*S. alata* and *S. gardneri*) and we applied the constraint age using a log-normal prior

with a value of 45.0 of mean and standard deviation of 0.005. The estimated age for Bruneau et al. (2008) for the *Cassia* clade (53.0 mya) were obtained with 19 points of calibration using 18 fossil of Legumes of different genera.

Independent runs were performed with 50,000,000 generations each. The convergence of individual runs was assessed using Tracer v.1.6 (Drummond & Rambaut, 2007b). All analyses were combined in LogCombiner v1.8.0 program, the burning was established for 10%. All trees were summarized in the TreeAnnotator v1.8.0 program.

Morphological and habitat evolution

Morphological evolution estimates were conducted upon a majority consensus tree derived from BEAST analysis. Six characters variable among *Chamaecrista* species were selected and codified as following: **1.** Extrafloral nectaries (EFNs) on petiole – (0) absent, (1) present; **2.** EFNs on inflorescence – (0) absent (1) present; **3.** Glandular trichomes - (0) absent, (1) present; **4.** Inflorescence – (0) composed (raceme and panicle), (1) reduced (reduced axilar racemes 1-7 flowers); **5.** Habit – (0) tree, (1) shrub, (2) subshrub; **6.** Habitat – (0) forest, (1) open areas; Ancestral character state reconstructions were carried out using Mesquite 2.74 (Maddison and Maddison, 2010) under Maximum likelihood criteria.

For binary traits, two evolutionary models were considered, the models Mk1 (one rate) and Mk2 (two rates). For multistate characters only Mk1 were applied. Models were chosen using the likelihood ratio test (LRT).

Biogeographic Analyses

To evaluate the biogeographic history of *Chamaecrista* we employed maximum-likelihood inference of geographic range using the Dispersal, Extinction, and Cladogenesis model (DEC) (Ree et al. 2005; Ree and Smith 2008) implemented in RASP 3.0 beta (Reconstruct Ancestral State in Phylogeny; Yu et al. 2014). For this analysis, we defined eight broad biogeographical areas, mostly based on Morrone (2001): (A) Amazon Subregion, (B) Cerrado Province, (C) Caatinga Province, (D) Paranaense Subregion, (G) Caribbean Subregion, (H) Neartic region; with two additional areas: (E) Restinga - a particular physiognomy on Quaternary coastal sandy areas included in the Atlantic Forest Dominium (Paranaense Subregion), and (F) Campos rupestres – a sandy and rocky vegetation type occurring above of 900 m elevation on mountain tops included in the Caatinga, Cerrado, and Paranaense subregion (Figure 1). The recognition of the Restingas and the Campo rupestre as

distinct operacional areas for the analysis is based on the high diversity of *Chamaecrista* taxa in these vegetation types. Prance (1994) recognized the latter as "campo rupestre archipelago province", while the restingas are consistently treated as a special vegetation type (e.g. Veloso 1992). Species distribution was assigned based on data available in Irwin & Rogers (1967), Irwin & Barneby (1978, 1982), Rando & Pirani (2011), Rando et al. (2013a, 2013b, Chapter 2), and on data collections available in the web (Species Link 2014) considering just specimen identified by experts or with digitalized images of exsiccates. A map was prepared for each taxon in order to define its geographical distribution range (Appendix 1), all maps were elaborated in QGis v. 1.8.1 software (Quantum Gis).

To study geographic range evolution through time, we evaluated alternative biogeographical hypotheses by modeling area connectivity in three ways (Figure 2). *Model A*: We defined a simple model with no dispersal constraint (with no information based on paleogeography). According to this model, the rate of dispersal had a value of 1 (the highest dispersal rate) between all areas along the whole diversification period of *Chamaecrista*. Additionally, we defined two alternative hypotheses (*Models B* and *C*) with spatio-temporal dispersal constraints reflecting the likely paleogeographic history of tropical America from the Eocene onward (Gottesberger & Gottesberger 2006, Pennington et al. 2006, Antonelli et al. 2009). *Model B*: First, we defined three time frames: time frame 1 (53.9 – 28 mya, Eocene and early Olygocene), time frame 2 (28 – 10 mya, Oligocene and late Miocene), and time frame 3 (10 mya – until to present, from Oligocene and all Quartenary) (Figure 2). For each time frame we applied different rates of dispersal between areas. For the time frame 1 we considered a low dispersal rate from Amazon Region (area A) to the other biogeographical areas (rate=0.1), based mainly on the putative lack of savannas (areas B and C), restingas (area E) and of a connection between South America and the rest of Americas (Panama isthmus not yet stablished, area G). On the other hand, dispersal between Amazon (area A) and Paranaense Subregion (area D) was probably facilitated by the existence of larger extensions of forests during that period, so we accept the value 1 only between these two areas. In the time frame 2 we considered the arising of Neotropical savannas defined as a higher dispersal rate between Amazon and savannas (rate=1). At the same time dispersal from the Amazon to the Paranaense Subregion would be more difficult in a putative scenario of retraction of rainforests and expansion of savannas (rate=0.1). For the time frame 3 we considered a high dispersal rate between almost all areas due to the effective connection between Americas and the establishment of the biogeographical regions within South

America known today. In this case the dispersal to Central and North America from the South could be easier and the dispersal among Cerrado (area B), Caatinga (area C), Campos rupestres (area F), and Restingas (area E) could also be facilitated (rate =1). *Model C*: In this model we used the same time frame from *Model B*. The differences between *Model C* and *B* are in the time frame 1 and 2. In the time frame 1 we hypothesized that ancestral species could disperse from Amazon region to Paranaense subregion (similar *Model B*) and also to Campos rupestres (rate=1). This hypotheses was implemented for considering that geological history of Espinhaço Range (the main area presenting campo rupestre vegetation) is very old, probably arise in the proterozoic (Marshak et al. 2006). And in the time frame 2 we considered just dispersion from campos rupestres to savanna areas (rate=1) using a lower dispersal rate (rate=0.1) between Amazon subregion and savannas areas. The best biogeographic model was chosen using the likelihood ratio test (LRT) comparing the pairwise models. Detailed dispersal rates for each model are available in Appendix 2.

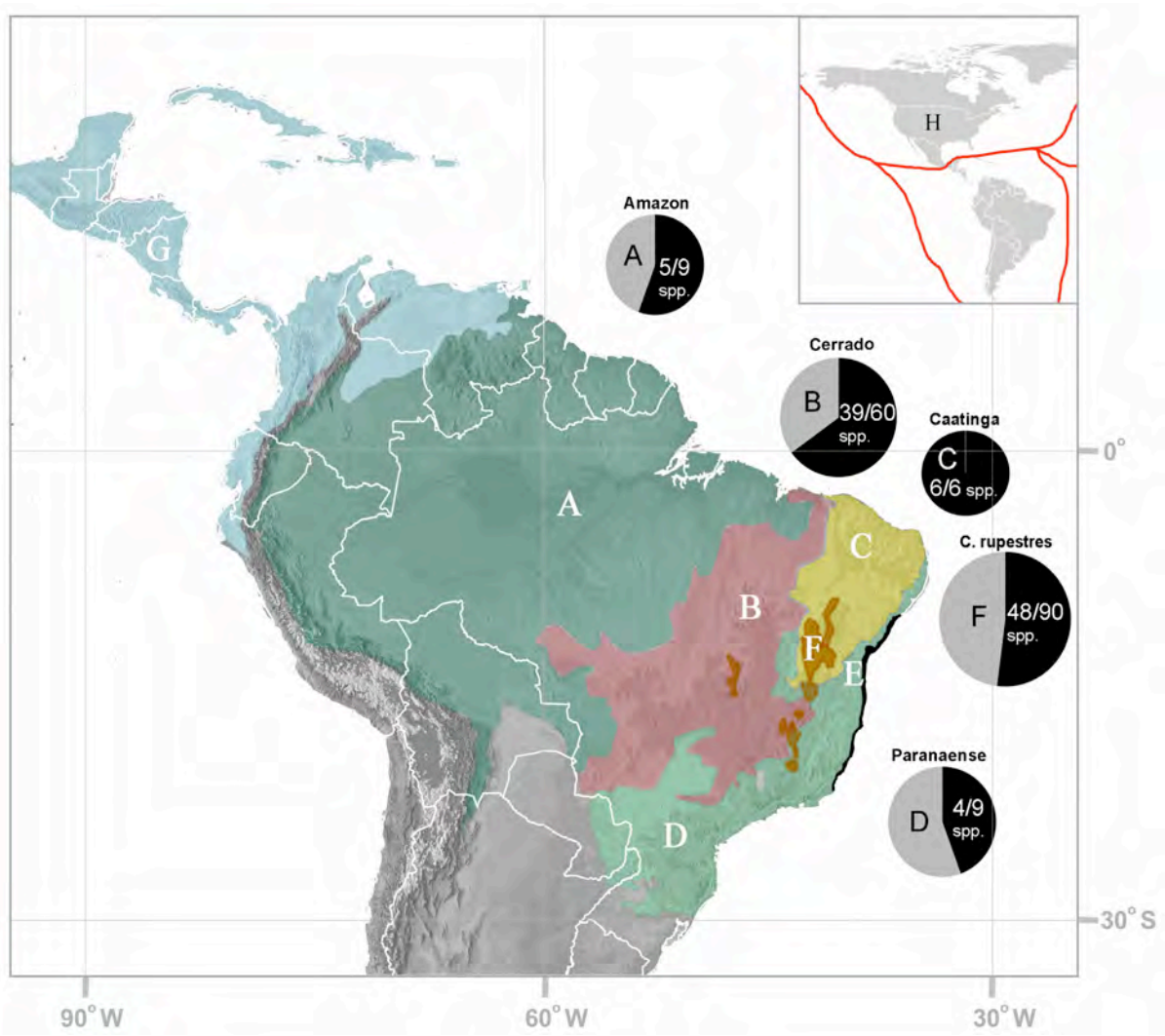


Figure 1. Map of Central and South America depicting the eight biogeographic areas adopted in the present analysis (see text for detailed explanation). For each biogeographic area the total number of endemic species of *Chamaecrista* is listed on a pie chart, together with the total number of species from that region that were included in the phylogenetic study, aiming to demonstrate that our sampling effort is distributed evenly across biogeographic areas. These totals do not include the several species widely distributed and the infraspecific categories that are also included in our phylogenetic analysis (see Appendix 1). A. Amazon Subregion; B. Cerrado Province; C. Caatinga Province. D. Paranaense Subregion; E. Restinga; F. Campos rupestres; G. Caribbean Subregion; H. Neartic.

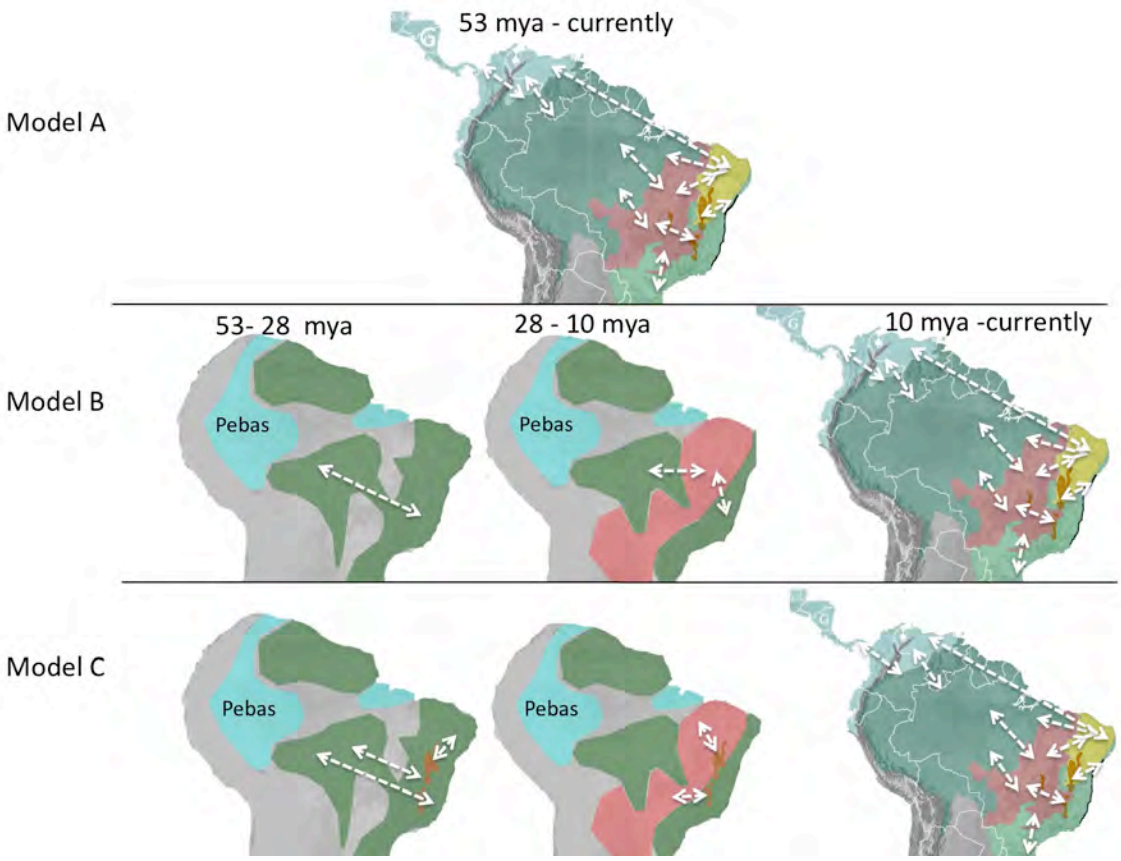


Figure 2. The three geographic range models tested using the Dispersal, Extinction, and Cladogenesis model (DEC). *Model A* (simplest model), with the same dispersal rate between biogeographic areas along the whole diversification of *Chamaecrista*. *Model B* and *C* with three time frames (detailed in the appendix 2). Distinct dispersal rates were applied in the time frame 1 [53 – 28 mya] and 2 [28 -10 mya]. Time frame 1: predominant warm, humid tropical climate. Time frame 2: forest contraction, and initial development of Neotropical savannas. Maps based on Antonelli et al. (2009) and additional information from Gottesberger & Gottesberger (2006).

RESULTS

Bayesian divergence age estimation

Estimated parameters had adequate effective sample size after four runs. Age estimates for relevant crown nodes (mean and 95% credibility intervals, HPD) are given in Table 3. Our divergence age estimation suggests that earliest diverging contemporary lineages in

Chamaecrista arose between late Eocene and Oligocene [HPD 48.0 – 31.4] (Figure 3). From this point, the genus diverged in two main clades: (i) a clade B composed by forest species and (ii) a clade C with composed by species of open formation. Despite the crown node of the open areas clade seems to be the first to diverge within the genus [HPD 45.0 – 28.9], its major diversification is estimated to have started only from the Miocene on [22.0 – 7.0], in a similar period indicated for the forest clade diversification [28.9 – 15.2]. More than half of species sampled in our analysis probably had a recent diversification [3.0 – 1.0].

Table 3. Estimated ages of clade for some nodes of *Chamaecrista*.

Node	Most recent common ancestor (MRCA) of	Age estimated [Ma], and 95% HPD	Standard deviation
A	*Chamaecrista*	39.7, 48.0 – 31.4	4.2514
B	Sect. *Apoucouita* - forest species	21.5, 28.9-15.2	3.5814
C	*Chamaecrista* open areas	36.7, 45.0 -28.9	4.0818
D	Ser. *Baseophyllum*	12.3, 21.1 – 6.5	3.918
E	Sect. *Chamaecrista* + Sect. *Xerocalyx*	24.6, 30.7 – 18.8	3.0455
F	Sect. *Absus*	13.8, 20.0 -9.3	2.9324

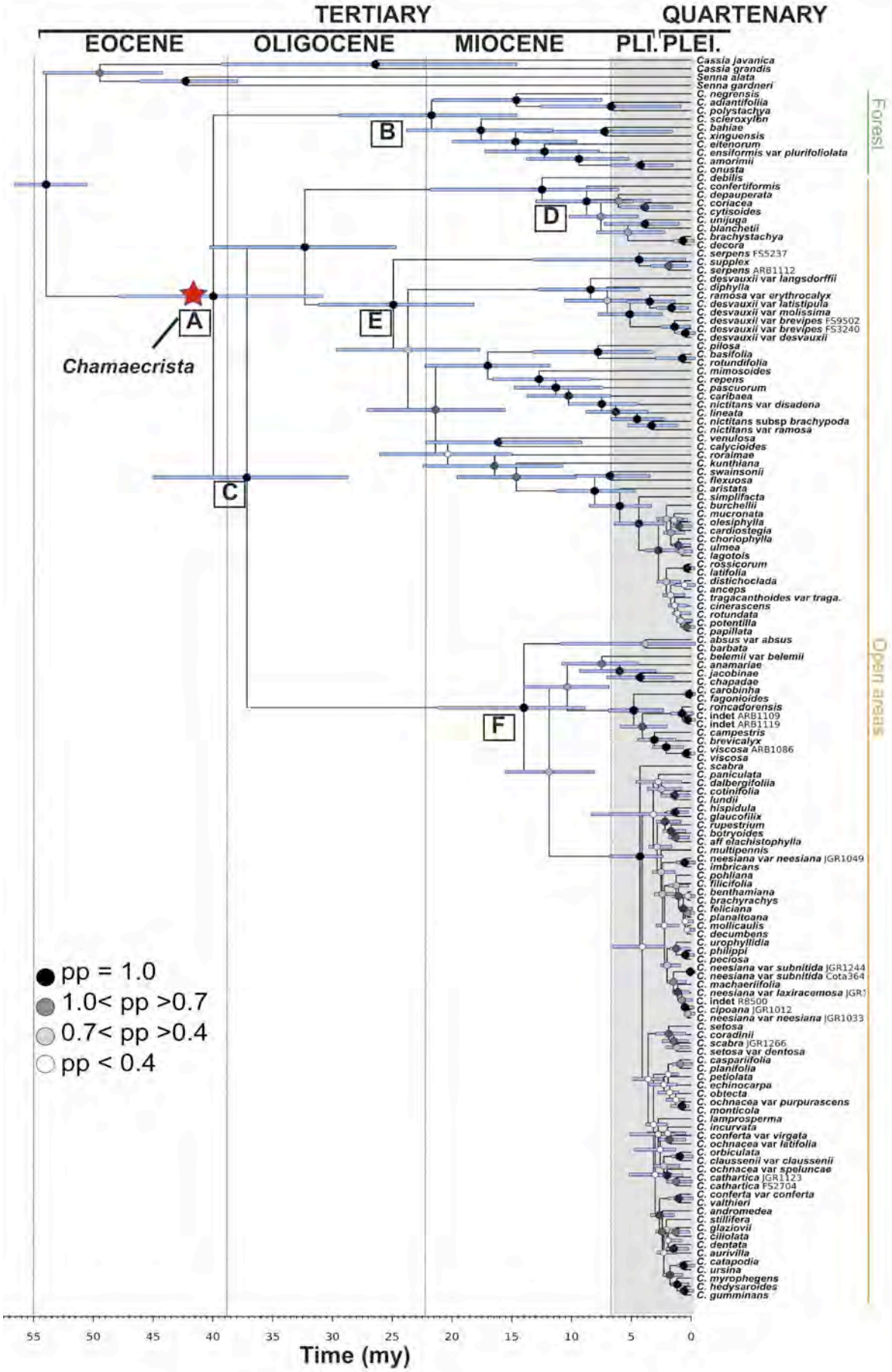

TERTIARY
QUARTENARY
EOCENE
OLIGOCENE
MIOCENE
PLI.
PLEI.
A
B
C
D
E
F
Chamaecrista
Forest
Open areas
pp = 1.0
1.0< pp >0.7
0.7< pp >0.4
pp < 0.4
55
50
45
40
35
30
25
20
15
10
5
0
Time (my)

Figure 3. Maximum clade credibility tree for *Chamaecrista*. The fossil-calibration age estimates for each node are presented in blue, with a time scale on the x-axis, with gray shading corresponding to the period of the highest diversification of the genus. Legend on left depicts the posterior probability obtained for each node. Capital letters correspond to relevant crown nodes cited on Table 3 and in the main text.

Morphological and habitat evolution

The ML ancestral character state reconstruction based on Mk1 (one rate) was the best model for all characters analyzed (Table 4). These analyses indicate that extrafloral nectaries on petiole (0.91), composed inflorescence (racemes or panicles) (0.99), and shrub habit (0.82) were already present in the most recent common ancestral (MRCA) of *Chamaecrista*. According to our results the MRCA of *Chamaecrista* probably occupied the forest habitat (0.51). EFNs on inflorescence, reduced inflorescence and glandular trichomes probably arose later in distinct clades. EFNs on inflorescence arose two times independently (Clade A and D, 0.99 for each), reduced inflorescence (Clade E, 0.97) and the glandular trichomes arose only one time (Clade F, 0.99). According to our results, the gain of glandular trichomes was seemingly associated to the loss of EFNs on petiole (Clade F absence of EFNs 0.99) (Figure 4).

Table 4. Evolutionary rates, likelihoods and the estimated ancestral character state of five intrinsic characters (1-5) and one extrinsic character (6) of *Chamaecrista*. Multiple independent gains are identified with an asterisk (*). The estimated parameters of the favored evolutionary model are present in bold letter.

		one rate		two rates		Estimated ancestral character states for the MRCA of *Chamaecrista*
	Character	Mk1	Likelihood	Mk2	Likelihood	
1	EFNs on petiole	**0.00453524**	**13.72884077**	0.003739066, 0.004885151	13.69771242	Presence (0.91)
2	EFNs on inflorescence	**0.00229732**	**10.65285266**	0.002138286, 0.003424772	10.59299109	Absence (0.99) *
3	Glandular trichomes	**0.00104997**	**5.41593073**	0.001719807, 0.008792552	5.31580551	Absence (0.99)
4	Inflorescence type	**0.00707379**	**32.70798528**	0.003572117, 0.014342246	31.10990871	Composed (0.99)
5	Habit	**0.00857549**	**51.10915899**	NA	NA	Shrub (0.82)
6	Habitat	**0.00394951**	**12.86864531**	0.008149601, 0.001808577	11.90147577	Forest (0.51)

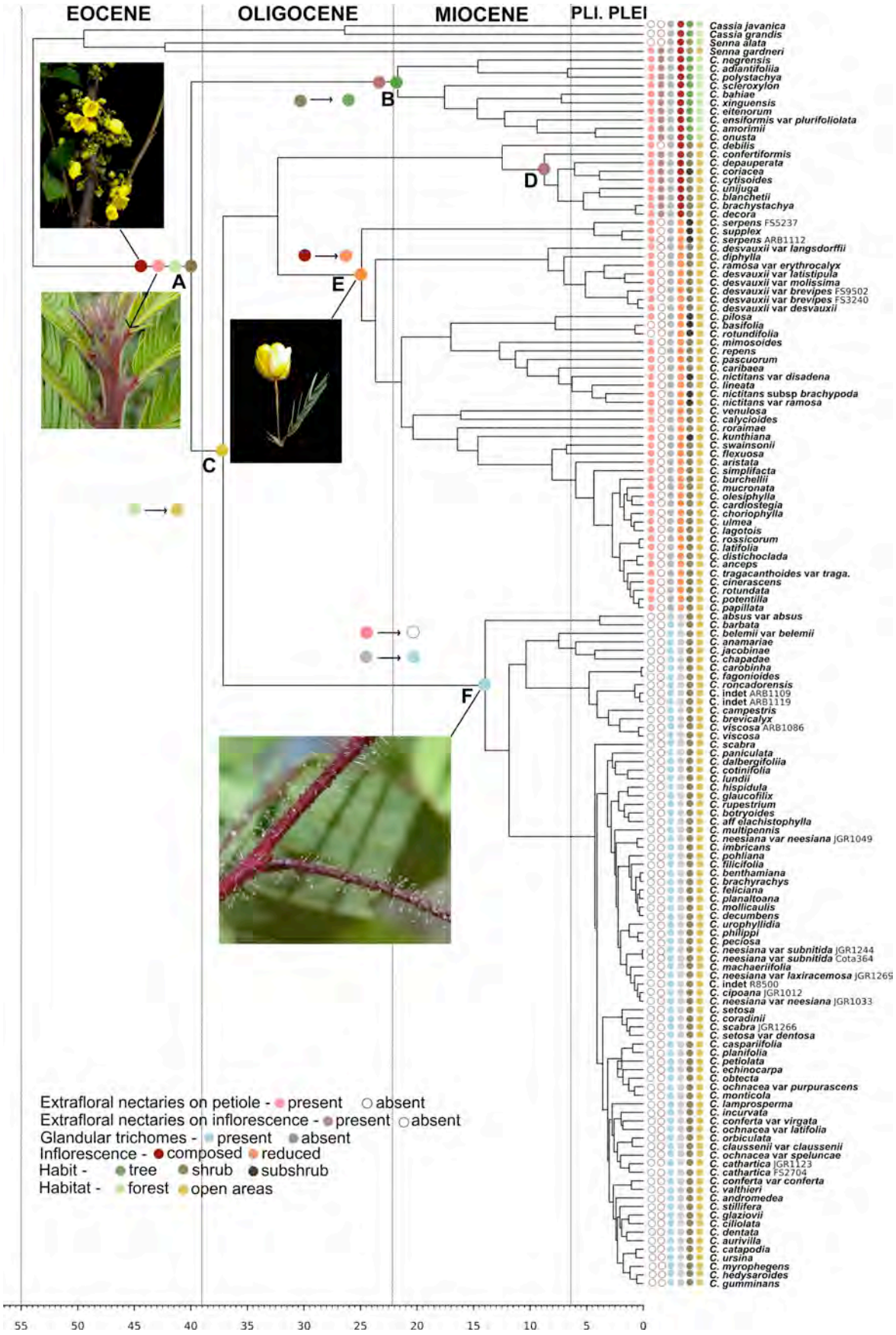

EOCENE
OLIGOCENE
MIOCENE
PLI. PLEI
A
B
C
D
E
F
Cassia javanica
Cassia grandis
Senna alata
Senna gardneri
C. negrensis
C. adiantifolia
C. polystachya
C. scleroxylon
C. bahiae
C. xinguensis
C. eitenorum
C. ensiformis var plurifoliolata
C. amorimii
C. onusta
C. debilis
C. confertiformis
C. depauperata
C. coriacea
C. cytisoides
C. unijuga
C. blanchetii
C. brachystachya
C. decora
C. serpens FS5237
C. supplex
C. serpens ARB1112
C. desvauxii var langsdorffii
C. diphylla
C. ramosa var erythrocalyx
C. desvauxii var latistipula
C. desvauxii var molissima
C. desvauxii var brevipes FS9502
C. desvauxii var brevipes FS3240
C. desvauxii var desvauxii
C. pilosa
C. basifolia
C. rotundifolia
C. mimosoides
C. repens
C. pascuorum
C. caribaea
C. nictitans var disadena
C. lineata
C. nictitans subsp brachypoda
C. nictitans var ramosa
C. venulosa
C. calycioides
C. roraimae
C. kunthiana
C. swainsonii
C. flexuosa
C. aristata
C. simplifacta
C. burchellii
C. mucronata
C. olesiphylla
C. cardiostegia
C. choriophylla
C. ulmea
C. lagotois
C. rossicorum
C. latifolia
C. distichoclada
C. anceps
C. tragacanthoides var traga.
C. cinerascens
C. rotundata
C. potentilla
C. papillata
C. absus var absus
C. barbata
C. belemii var belemii
C. anamariae
C. jacobinae
C. chapadae
C. carobinha
C. fagonioides
C. roncadorensis
C. indet ARB1109
C. indet ARB1119
C. campestris
C. brevicalyx
C. viscosa ARB1086
C. viscosa
C. scabra
C. paniculata
C. dalbergifoliia
C. cotinifolia
C. fundii
C. hispidula
C. glaucofilix
C. rupestrium
C. botryoides
C. aff elachistophylla
C. multipennis
C. neesiana var neesiana JGR1049
C. imbricans
C. pohliana
C. filicifolia
C. benthamiana
C. brachyrachys
C. feliciana
C. planaltoana
C. mollicaulis
C. decumbens
C. urophyllidia
C. philippi
C. peciosa
C. neesiana var subnitida JGR1244
C. neesiana var subnitida Cota364
C. machaeriifolia
C. neesiana var laxiracemosa JGR1269
C. indet R8500
C. cipoana JGR1012
C. neesiana var neesiana JGR1033
C. setosa
C. coradinii
C. scabra JGR1266
C. setosa var dentosa
C. caspariifolia
C. planifolia
C. petiolata
C. echinocarpa
C. obtecta
C. ochnacea var purpurascens
C. monticola
C. lamprosperma
C. incurvata
C. conferta var virgata
C. ochnacea var latifolia
C. orbiculata
C. claussenii var claussenii
C. ochnacea var speluncae
C. cathartica JGR1123
C. cathartica FS2704
C. conferta var conferta
C. valthieri
C. andromedea
C. stillifera
C. glaziovii
C. ciliolata
C. dentata
C. aurivilla
C. catapodia
C. ursina
C. myrophegens
C. hedysaroides
C. gumminans
Extrafloral nectaries on petiole - present absent
Extrafloral nectaries on inflorescence - present absent
Glandular trichomes - present absent
Inflorescence - composed reduced
Habit - tree shrub subshrub
Habitat - forest open areas
55
50
45
40
35
30
25
20
15
10
5
0

Figure 4. ML ancestral character states reconstruction in *Chamaecrista*. Each character state is represented by a particular color, some of them illustrated by pictures. Colored circles on the tree nodes indicate the most likely character state resulted of ML analyses (proportional likelihood > 0.8, except to the shrub habit in the node A with the proportional likelihood equal to 0.51); black arrows indicate character transitions. . The scale below is million of years ago.

Biogeographic reconstructions

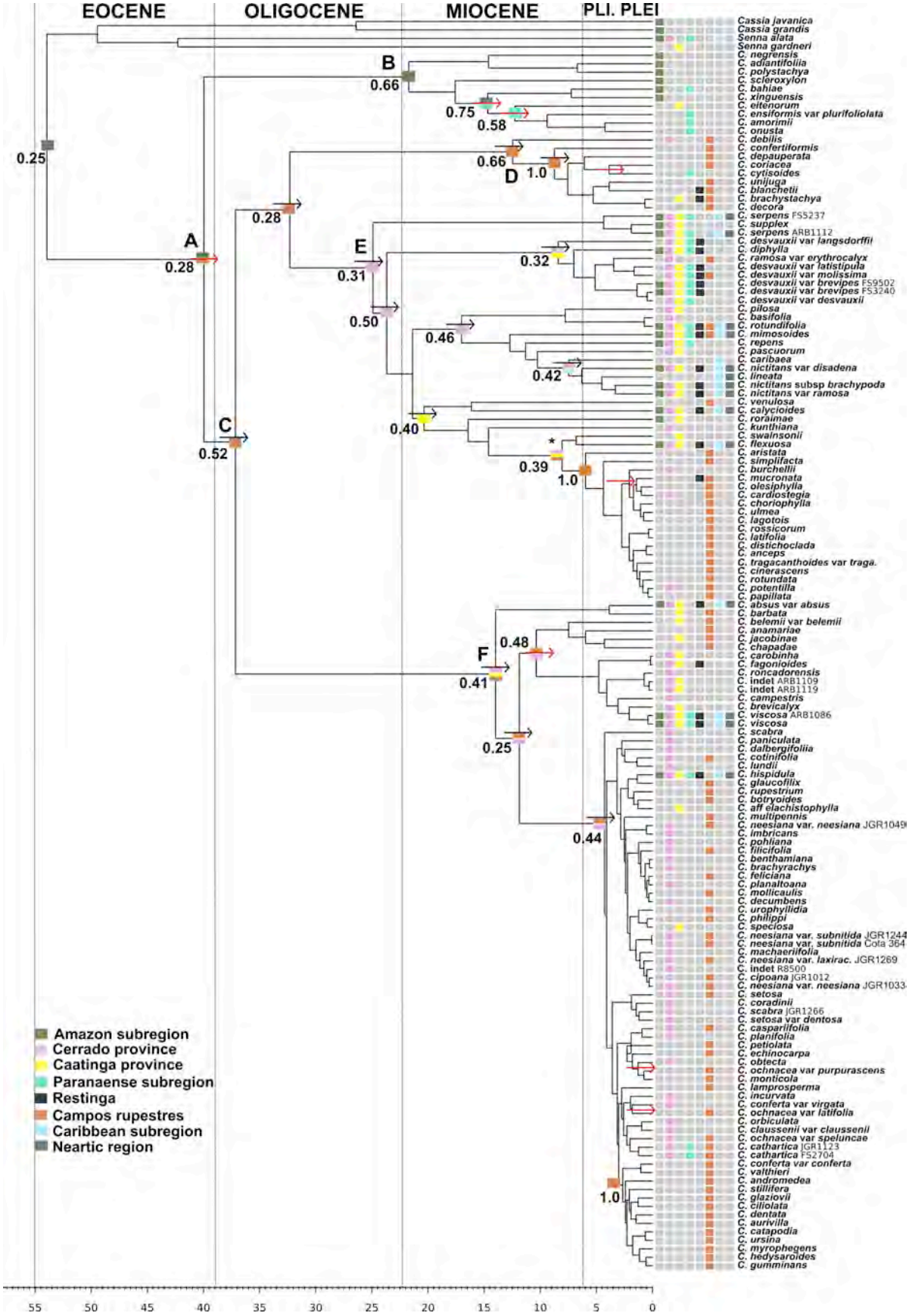
The *Model C* hypothesis fit to the data better than the other hypotheses (Table 5, Figure 5). According to this model, the most likely ancestral range for *Chamaecrista* encompasses two areas: Amazon subregion + Campos rupestres (Cadeia do Espinhaço) with support for a vicariance event between them; however this reconstruction is somewhat uncertain. Uncertainty is here defined when the relative probability is < 0.5 following the same criterion used by Fine et al. (2014). In this context, we focused our results and discussion for the most likely reconstructions (relative probability > 0.5). The most likely ancestral range for Clade B is Amazon subregion with high probability (0.66) for posterior vicariance events, first splitting Amazon subregion / Paranaense subregion, and later splitting Caatinga province / Paranaense subregion. For the Clade C (0.52) and D (0.66), the most likely ancestral range is Campos rupestres where dispersal events seem to prevail. The most likely ancestral range for the Clade E is the Cerrado with low probability; however the next cladogenesis shows a better value (0.5) for the same ancestral range area. Dispersal events are the most common in Clade E, in which a unique extinction event may have also taken place. For the Clade F all reconstructions for the period of 15 – 6 mya are uncertain, but they always involve three or two ranges of areas: Cerrado/Caatinga/Campos rupestres, and Cerrado/Campos rupestres. Number of events for each internal clades are presented in the table 6.

Table 5. Likelihoods and estimated parameters of three distinct models using the dispersal, extinction, and cladogenesis (DEC) model. The favored model is highlighted in bold (model C).

Model	**Dispersal rates**	**Extinction rates**	**Likelihood**
A (simple model)	0.02057	0.0120186	526.716
B	0.0327844	0.00672364	490.208
C	**0.0350782**	**0.00766463**	**486.273***

Table 6. Dispersion, vicariance and extinction events estimated for clades B, D, E and F based on the favored model C (clades are available in the phylogeny of Figs. 3 and 4).

Events	**Clades (number of terminals)**			
	B (10)	D (9)	E (46)	F (79)
Dispersal	5	6	99	69
Vicariance	2	1	2	11
Extinction	0	0	1	0


EOCENE
OLIGOCENE
MIOCENE
PLI. PLEI
Cassia javanica
Cassia grandis
Senna alata
Senna gardneri
C. negrensis
C. adiantifolia
C. polystachya
C. scleroxylon
C. bahiae
C. xinguensis
C. eltenorum
C. ensiformis var plurifoliolata
C. amorimii
C. onusta
C. debilis
C. confertiformis
C. depauperata
C. coriacea
C. cytisoides
C. uniijuga
C. blanchetii
C. brachystachya
C. decora
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C. desvauxii var brevipes FS3240
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C. pilosa
C. basifolia
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C. kunthiana
C. swainsonii
C. flexuosa
C. aristata
C. simplifacta
C. burchellii
C. mucronata
C. olesiphylla
C. cardiostegia
C. choriophylla
C. ulmea
C. lagotois
C. rossicorum
C. latifolia
C. distichoclada
C. anceps
C. tragacanthoides var traga.
C. cinerascens
C. rotundata
C. potentilla
C. papillata
C. absus var absus
C. barbata
C. belemii var belemii
C. anamariae
C. jacobinae
C. chapadae
C. carobinha
C. fagonioides
C. roncadorensis
C. indet ARB1109
C. indet ARB1119
C. campestris
C. brevicalyx
C. viscosa ARB1086
C. viscosa
C. scabra
C. paniculata
C. dalbergifolia
C. cotinifolia
C. lundii
C. hispidula
C. glaucofilix
C. rupestrium
C. botryoides
C. aff elachistophylla
C. multipennis
C. neesiana var. neesiana JGR1049
C. imbricans
C. pohliana
C. filicifolia
C. benthamiana
C. brachyrachys
C. feliciana
C. planaltoana
C. mollicaulis
C. decumbens
C. urophyllidia
C. philippi
C. speciosa
C. neesiana var. subnitida JGR1244
C. neesiana var. subnitida Cota 364
C. machaerilfolia
C. neesiana var. laxirac. JGR1269
C. indet R8500
C. cipoana JGR1012
C. neesiana var. neesiana JGR1033
C. setosa
C. coradinii
C. scabra JGR1266
C. setosa var dentosa
C. casparilfolia
C. planifolia
C. petiolata
C. echinocarpa
C. obtecta
C. ochnacea var purpurascens
C. monticola
C. lamprosperma
C. incurvata
C. conferta var virgata
C. ochnacea var latifolia
C. orbiculata
C. claussenii var claussenii
C. ochnacea var speluncae
C. cathartica JGR1123
C. cathartica FS2704
C. conferta var conferta
C. valthieri
C. andromedea
C. stillifera
C. glaziovii
C. ciliolata
C. dentata
C. aurivilla
C. catapodia
C. ursina
C. myrophegens
C. hedysaroides
C. gumminans
A
B
C
D
E
F
0.25
0.28
0.66
0.75
0.58
0.66
1.0
0.28
0.31
0.32
0.50
0.46
0.42
0.40
0.52
0.39
1.0
0.48
0.41
0.25
0.44
1.0
Amazon subregion
Cerrado province
Caatinga province
Paranaense subregion
Restinga
Campos rupestres
Caribbean subregion
Neartic region
55
50
45
40
35
30
25
20
15
10
5
0

Figure 5. Reconstruction of geographic range evolution under the favored *Model C* hypothesis, based on DEC model. Ancestral ranges are shown at the nodes; rectangles with more than one color indicate the ancestral occurrence in more than one area. The events are show as black arrow for dispersal; red arrow for vicariance; and * for extinction. The values correspond to the relative probability of the most likely reconstruction.

DISCUSSION

In this study, we estimated divergence times, ancestral character states, and ancestral ranges for *Chamaecrista*. These estimates provide important general insights into the history of the genus. Our analyses suggest a complex biogeographic history of *Chamaecrista,* since the diversification of each clade within the genus seem to have been influenced by distinct processes. An origin of the genus in tropical forests in South America is strongly indicated by the analysis, however the ancestral area reconstruction is somewhat uncertain due to the low value of relative probability obtained for the MRCA of *Chamaecrista*. The most likely ancestral range for the Clade C (*Chamaecrista* from open areas) is the *campos rupestres*, with posterior expansion to the whole extension of Neotropical savannas, where the group suffered a high, and in several of its groups, a recent diversification. Such a general pattern of savanna clades diverging from forest ancestors has been recently recorded for other neotropical woody groups (e.g. *Mimosa, Andira,* Microlicieae - Simon et al. 2009; Bignonieae – Lohmann et al. 2013; Lychnophorinae - Loeuille et al. in press). The transition of a *Chamaecrista* lineage from forest to savannas is congruent with some morphological transitions observed within the genus, as habit shift, changes in the inflorescence type, gain/loss of extrafloral nectaries and of sticky glandular trichomes. Below, we discuss some general patterns recovered and their potential explanations.

Biogeographic History of *Chamaecrista*

Our calibrated phylogeny and biogeographic reconstruction show that although the *Chamaecrista* stem age dates back to late Eocene and early Oligocene, the crown node dates to the late Oligocene and whole Miocene (25-6 mya). In our calibrated phylogeny it is possible to recognized two main groups with different diversification time estimates: (1) Clades B, D, and E with an older crown age; (2) Clade F with a recent crown age.

(1) Clade B, composed by forest species, shows diversification mostly during the Miocene in Amazon subregion, and a most recently cladogenesis between (6-3 mya) in

Paranaense subregion (in this case in Atlantic Forest). These results matchto similar patterns found in Protieae (Burseraceae, Fine et al. 2014), and agree with the synthesis provided in Hoorn & Wesselingh (2010), according to whom the diversification of Neotropical forests was especially stimulated during the Miocene period. The most likely ancestral range for Clade B was inferred as Amazon subregion, with strong support for vicariance as a process influencing the diversification within this clade. Several evidences indicate a past contact of Amazon to Atlantic Rainforests during the Miocene (Antonelli et al. 2009, Batalha-Filho et al. 2013), and a posterior contraction of these wide vegetations concomitant to the expansion of the Neotropical savannas (e.g. Gottesberger & Gottesberger 2006). Events of forest contractions and expansion of savannas turned the Amazon and the Atlantic Rainforests as isolated areas (Batalha-Filho et al. 2013), even though some authors point to a possible persisting connection between them, during dry paleoclimate phases, through a dendrict net of gallery forests crossing the Cerrado dominium, as observed nowadays (e.g. Oliveira-Filho & Ratter 1995). Many current forest species show an Amazon-Atlantic disjunct distribution (e.g. mammals: Vivo 1997; vascular plants: Rizzini 1979, Andrade-Lima 1982, Prance 1982 and Martini et al. 2007; birds: Batalha-Filho et al. 2013). Increasing evidence from paleoclimatic/paleogeological data and from some paleontological data also indicate that a past corridor or connection between Amazon and Atlantic rainforests may have existed during umid climates (e.g. Oliveira et al. 1999) and so an event of vicariance splitting the two biomes has been inferred as a driving force leading to cladogenetic events for some groups of plants and animals (e.g. Amorim & Pires 1996, Martins et al. 2009, Carvalho & Couri 2011).

The diversification of organisms not associated with the Andes uplift (Late Miocene to Pliocene) is an exception in the Amazon basin and is poorly understood. The *Chamaecrista* rainforest clade (Amazon and Atlantic forests) seem to be a good example of lower diversification (or higher extinction) during the Andes uplift. Moreover, this plant clade diversified mostly during the early Miocene, contrasting with previous results from other plant groups not linked with the Andes uplift (Antonelli et al. 2009).

In Clade E there is only a group restricted to Campos rupestres vegetation: *Chamaecrista* sect. *Chamaecrista* ser. *Coriaceae* (as defined in Chapters 1 and 2), which shows the most recent diversification within Clade E. However, the remaining lineages in Clade E comprise mostly widespread species, which may have achieved expansion after several dispersal events (99 events in our topology). According to our results dispersal events within Clade E probably started during the Miocene. Our biogeographical reconstruction also

shows that current taxa endemic to the Caribbean subregion and Neartic region (*Chamaecrista caribaea* and *Chamaecrista lineata*) may have migrated from South America, most likely from savannic areas. The rise of a land connection between Central America and South America is estimated as a recent event, ca. 4-3 mya (Burham & Graham 1999, Antonelli et al. 2009, Egbert et al. 2014, Fine et al. 2014) and it is usually assumed to have allowed a "Great Biotic Interchange" ever since (Cody et al. 2010, Bacon et al. 2012). But even before a full completion of the landbridge, it is estimated that around 22 mya the Isthmus was almost formed, with only 200 km missing to its complete closure (Egbert et al. 2014). The lack of connectivity between Central and South Americas during that time may have not been a strong barrier for dispersal of several taxa, which are likely to have dispersed among both areas across the ocean, through the wind and "stepping stones" (Renner 2004, Thorne 2004, Lomolino et al. 2006). Recently, Bacon et al. (2013) testing geological models of evolution proposed an older formation of the Isthmus than traditionally accepted, in this case a migration diffusion by landbridge would be the easier route taken by the ancestral of Caribbean and North American *Chamaecrista* species.

(2) The high diversity of *Chamaecrista* is found in Clade F. Biogeographical reconstructions shows that the most likely ancestral range for Clade F was a widespread range including Campos rupestres + Caatinga + Cerrado. The widespread species are grouped within Clade F (with one exception – *C. hispidula*) where the events of dispersal would have prevailed. Endemic species grouped within Clade F are mostly restrict to Campos rupestres, and have the crown age within 5-2 mya; the posterior probability supporting the relationships within this group is very low because there are few genetic variability, and this may be due to a recent diversification.

Recent diversification of some Neotropical woody lineages has been commonly related to a recent invasion of open areas (mostly savannic) from forest ancestors (Hughes & Eastwood 2006, Simon et al. 2009, Fine et al. 2014). However according to our analyses the model that best fit our data shows an ancient occupation followed by a recent radiation of *Chamaecrista* in the campos rupestres region. Diversification analysis performed for *Calliandra* (Leguminosae-Mimosoideae) exhibits a similar pattern of broom topology for a clade from campos rupestres vegetation (Koenen et al. 2013). Besides higher speciation rates, *Calliandra* seem to have experiences also higher extinction rates. The authors speculate two competing hypotheses: a signature of *high species turnover*, influenced by high extinction rates throughout the history of the Campos rupestres *Calliandra* clade; or it would simply be a

case of recent rapid radiation from an ancient lineage (Koenen et al. 2013). In the last hypothesis, climatic fluctuations of the Quartenary might have been a driving force influencing this diversification pattern. More dated phylogenies are necessary in order to achieve a stronger support to these hypotheses and to allow us to adopt them as a feasible biogeographic pattern in the history of diversification of the Neotropical biota.

Evidences of evolutionary changes associated with the transition from forests to savannas

The main evolutionary changes that could be associated with habitat transition based on our results were the shift in habit, the presence/absence of EFNs and glandular trichomes, and the reduction of the inflorescence. Homoplasies are very rarely observed in the topology. For the characters here analysed the petiolar EFNs were independently lost on the putative ancestror of a species pair formed by *C. basifolia* and *C. rotundifolia* (Clade E); plus two independent emergences of EFNs on inflorescences (Clade B and D).

According to our ancestral character state reconstruction, the MRCA of *Chamaecrista* had a shrubby habit with an important transition to trees in the Clade B, and several independent shifts to subshrubs in the Clade E. In general, as compared to shrubs and herbs, trees undergo a longer growing term until attaining reproductive age. Short life-cycle may promote higher number of generations per population per time (as compared to trees) (Raven et al. 1999). In this case is usually expected a higher accumulation of genetic variability, and a predisposition for a higher rate of diversification. This might be the case of *Chamaecrista*, in which shrubby and subshrubby species have an evident shorter life-cycle than arboreal species do. In a greenhouse at the Universidade de São Paulo we observed a sharp difference in the life-cycle among selected species of *Chamaecrista*. Subshrubs as *C. nictitans* and *C. mimosoides* have successfully been grown from seeds to fully mature plants in bloom within three months, while two Amazon Rainforest tree species (*C. bahiae* and *C. xinguensis*) barely surpassed the seedling phase two years after germination.

The emergence of glandular trichomes in *Chamaecrista* seems to be associated to the loss of extrafloral nectaries (Clade F). A similar pattern was observed in other plant groups. In the Bignonieae clade (Bignoniaceae), there are evidences of multiple independent evolutions of the sticky glandular trichomes being associated to a reduction of the number of EFNs during the diversification of the clade (Nogueira et al. 2012). This suggested an evolutionary

trade-off between these structures. Additionally, the habitat transition can also be related to morphological changes. EFN function is intrinsically associated with the ant and herbivore interactions, and changes in habitat from forest to drier environments could modify the assemblages of ants and herbivores, consequently leading to deviations in the evolution of these secretory structures (e.g. Nogueira et al. 2012). This could be also the case of the Clade F of *Chamaecrista* along its transitions to drier areas. However, almost all species of Clade E are widely distributed and well diversified in dry areas, and provided with EFNs on the petiole. In this clade the main change that took place seem to be related to a reduction of composed inflorescences to one or few flowers.

Concluding remarks

The Campos rupestres show one of the highest levels of plant endemism in Brazil (Giulietti & Pirani 1988, Giulietti et al. 1997, Echternacht et al. 2011, Bitterncourt & Rapini 2013). The distribution of species of *Chamaecrista* is mainly concentrated in the campos rupestres of the southern portion of the Espinhaço Range (Minas Gerais state), with most species restricted to previously identified centers of endemism accounting on several angiosperm groups (Echternacht et al. 2011, Rando & Pirani 2011, Bitterncourt & Rapini 2013). Prance (1994) distinguished the “campo rupestre archipelago” as a distinct phytocoria or floristic province of South America, and several authors have suggestedthat these isolated formations might be considered as evolutionary islands within the Cerrado Dominium (e.g. Harley 1988, Giulietti et al. 1997). According to this idea, pulses of expansions and retractions of the extension of each “campo rupestre island”, driven by paleoclimtic fluctuations, may have lead to successive cycles of isolation vs. contact among populations, resulting in interruption of gene flow and consequent diversification, under a model usually referred to as “species pump” in mountain regions (e.g. Morton 1972, Winkworth et al. 2005).

Additionally, our data on *Chamaecrista* contribute with further evidence supporting current ideas about the campo rupestre flora housing important precursors of several taxa of cerrado flora, the species-richest savannas in the world (e.g. Koenen et al. 2013, Loeuille et al. in press). A conquest of the campo rupestre habitat by descendents of a forest lineage, accomplished before the colonization of the cerrado, seems to make sense on account of the close contact observed along most of the Western limits of the Atlantic Forest Dominum to the “Campo Rupestre achipelago”. Future studies dealing on diversification of the Neotropical floras, mainly focused on groups rich in savannic and campo rupestre taxa, will

to elucidate these biogeographical hypotheses about evolutionary history of the Brazilian savannic biota.

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Appendix 1. Voucher information and GenBank accession numbers of the sequences included in this study. And areas of distribution for each one.

Taxon	**Locality, State; collector and number**	**ITS**	**trnL-F**	**trnD-T**	**Areas**
Chamaecrista absus var. *absus* (L.) H.S. Irwin & Barneby	Serrinha dos Pintos, RN; Conceição 1056	FJ009832	FJ009886		ABCEGH
Chamaecrista adiantifoliia (Spruce ex Benth.) H.S. Irwin & Barneby	Manaus, AM; Rando 1197	x	x	x	A
Chamaecrista aff. *elachistophylla* (Harms) H.S. Irwin & Barneby	Barra da Estiva, BA; Cardoso 2810	x	x	x	C
Chamaecrista amorimii Barneby	Itacaré, BA; Conceição 795	FJ009823	FJ009878	x	D
Chamaecrista anamariae Conc., L.P. Queiroz & G.P. Lewis	Abaíra, BA; Conceição 787	FJ009826	FJ009881		F
Chamaecrista anceps (Benth.) H.S. Irwin & Barneby	Diamantina, MG; Cota 410		x	x	F
Chamaecrista andromedea (Mart. ex Benth.) H.S. Irwin & Barneby	Santo Antônio do Itambé, MG; Rando 1251	x	x	x	F
Chamaecrista aristata (Benth.) H.S. Irwin & Barneby	Grão Mogol, MG; Rando 976	x	x	x	F
Chamaecrista aurivilla (Mart. ex Benth.) H.S. Irwin & Barneby	Joaquim Felício, MG; Borges 650	x	x	x	F
Chamaecrista bahiae (H.S. Irwin) H.S. Irwin & Barneby	Salinópolis, PA; Rando 1213		x	x	AD
Chamaecrista barbata(Nees & Mart.) H.S. Irwin & Barneby	falta localidade			x	CF
Chamaecrista basifolia (Vogel) H.S. Irwin & Barneby	falta localidade			x	B
Chamaecrista belemii var. *belemii* (H.S. Irwin & Barneby) H.S. Irwin & Barneby	Casa Nova, BA; Queiroz 9151	FJ009825	FJ009880		CF
Chamaecrista benthamiana (Harms) H.S. Irwin & Barneby	Brasília, DF; Rando 1262	x	x	x	B
Chamaecrista blanchetii (Benth.) Conc., L.P.Queiroz & G.P.Lewis	Morro do Chapéu, BA; Andrade 607	FJ009846	FJ009900		FE
Chamaecrista botryoides Conc., L.P. Queiroz & G.P. Lewis	Abaíra, BA; Conceição 541	FJ009836	FJ009890		F
Chamaecrista brachyrachys (Harms) H.S. Irwin & Barneby	Brasília, DF; Rando 1272	x	x		B
Chamaecrista brachystachya Conc., L.P. Queiroz & G.P. Lewis	Grão Mogol, MG; Conceição 713	FJ009847	FJ009901	x	FCE
Chamaecrista brevicalyx (Benth.) H.S. Irwin & Barneby	falta localidade	x	x	x	BC
Chamaecrista burchellii (Benth.) H.S. Irwin & Barneby	Niquelândia, GO; Rando 1092	x	x	x	B
Chamaecrista calycioides (DC. ex Collad.) Greene	Natal, RN; Queiroz 11	FJ009863	FJ009917		ABCEGH
Chamaecrista campestris H.S. Irwin & Barneby	General Cardoso, MT; Queiroz 10440	FJ009829	FJ009883	x	B
Chamaecrista cardiostegia H.S. Irwin & Barneby	Delfinópolis, MG; Rando 1125	x	x	x	BF
Chamaecrista caribaea var. *lucayana* (Britton) H.S.Irwin & Barneby	Great Exuma Island, Bahamas; Rando 963	x	x	x	G
Chamaecrista carobinha (H.S. Irwin & Barneby) H.S. Irwin & Barneby	FS9135	x	x		BC
Chamaecrista caspariifolia Barneby	Serra da Canastra, MG; Pastore 3969	x	x	x	BF
Chamaecrista catapodia (H.S. Irwin & Barneby) H.S. Irwin & Barneby	Diamantina, MG; Cota 346		x	x	F
Chamaecrista cathartica (Mart.) H.S. Irwin & Barneby	Goveia, MG; Conceição 789	FJ009841	FJ009895	x	BDF
Chamaecrista cathartica (Mart.) H.S. Irwin & Barneby	Delfinópolis, MG; Rando 1123			x	BDF
Chamaecrista chapadae (H.S. Irwin & Barneby) H.S. Irwin & Barneby	Mucugê, BA; Costa 129		FJ009828		F
Chamaecrista choriophylla (Vogel) H.S. Irwin & Barneby	Santana de Pirapama, MG; Rando 1034	x	x	x	F
Chamaecrista ciliolata (Benth.) H.S. Irwin & Barneby	Delfinópolis, MG; Rando 1115	x	x	x	BF
Chamaecrista cinerascens (Vogel) H.S. Irwin & Barneby	Congonhas do Norte, MG; Rando 661	x	x	x	F
Chamaecrista cipoana (H.S. Irwin & Barneby) H.S. Irwin & Barneby	Santana do Pirapama, MG; Rando 1012	x	x		F

Chamaecrista claussenii var. *claussenii* (Benth.) H.S. Irwin & Barneby	Pirenópolis, GO; Rando 1079	x	x	x	B
Chamaecrista conferta var. *conferta* (Benth.) H.S. Irwin & Barneby	Santana do Pirapama, MG; Rando 1043	x	x	x	F
Chamaecrista conferta var. *virgata* (H.S. Irwin & Barneby) H.S. Irwin & Barneby	Cristalina, GO; Rando 1064	x	x	x	B
Chamaecrista confertiformis (H.S. Irwin & Barneby) Conc., L.P. et al.	Mucugê, BA; Costa 132	FJ009848	FJ009902		F
Chamaecrista coradinii H.S. Irwin & Barneby	FS9122	x	x	x	B
Chamaecrista coriacea (Bong. ex Benth.) H.S. Irwin & Barneby	Conc. Mato Dentro, MG; Conceição 869	FJ009843	FJ009897		F
Chamaecrista cotinifolia (G. Don) H.S. Irwin & Barneby	Diamantina, MG; Rando 1243	x	x	x	BF
Chamaecrista cytisoides (DC. ex Collad.) H.S. Irwin & Barneby	Sta. Bárbara do M. Verde, MG; Conceição 870	FJ009844	FJ009898		D
Chamaecrista dalbergiifolia (Benth.) H.S. Irwin & Barneby	Planaltina, GO; Queiroz 10318	FJ009837	FJ009891	x	B
Chamaecrista debilis (Vogel) H.S. Irwin & Barneby	FS5082		x	x	BF
Chamaecrista decora (H.S. Irwin & Barneby) Conc., L.P. Queiroz & G.P. Lewis	Grão Mogol, MG; Conceição 810	FJ009849	FJ009903	x	F
Chamaecrista decumbens (Benth.) H.S. Irwin & Barneby	Brasília, DF; Borges 1000	x	x	x	B
Chamaecrista dentata (Vogel) H.S. Irwin & Barneby	FS3283		x	x	F
Chamaecrista depauperata Conc., L.P. Queiroz & G.P. Lewis	Mucugê, BA; Conceição 863	FJ009850	FJ009904		F
Chamaecrista desvauxii var. *brevipes* (Benth.) H.S. Irwin & Barneby	FS9502	x	x		ABCDE
Chamaecrista desvauxii var. *brevipes* (Benth.) H.S. Irwin & Barneby	FS3240		x		ABCDE
Chamaecrista desvauxii var. *desvauxii* (Collad.) Killip	Chapada dos Guimarães, MT; Queiroz 10453	FJ009864	FJ009918	x	BCD
Chamaecrista desvauxii var. *langsdorffii* (Kunth ex Vogel) H.S. Irwin & Barneby	Abaíra, BA; Conceição 674	FJ009866	FJ009920	x	BCDE
Chamaecrista desvauxii var. *latistipula* (Benth.) G.P. Lewis	Guaraparí, ES; Conceição 912	FJ009867	FJ009921	x	BCDE
Chamaecrista desvauxii var. *mollissima* (Benth.) H.S. Irwin & Barneby	Morro do Chapéu, BA; Santos 356	FJ009865	FJ009919	x	BCDEF
Chamaecrista diphylla (L.) Greene	Jaborandi, BA; Queiroz 10269	FJ009868	FJ009922	x	ABCDE
Chamaecrista distichoclada (Mart. ex Benth.) H.S. Irwin & Barneby	Diamantina, MG; Rando 1230	x	x	x	F
Chamaecrista echinocarpa (Benth.) H.S. Irwin & Barneby	Diamantina, MG; Cota 327	x	x	x	F
Chamaecrista eitenorum (H.S. Irwin & Barneby) H.S. Irwin & Barneby	Natal, RN; Cardoso XXXX	x	x		BC
Chamaecrista ensiformis var. *plurifoliolata* (Hoehne) H.S. Irwin & Barneby	FS8778	x	x	x	D
Chamaecrista fagonioides (Vogel) H.S. Irwin & Barneby	FS9118	x	x	x	BCE
Chamaecrista feliciana (H.S. Irwin & Barneby) H.S. Irwin & Barneby	Alto Paraíso de Goiás, GO; Queiroz 15162	x	x		F
Chamaecrista filicifolia (Mart. ex Benth.) H.S. Irwin & Barneby	Chapada do Veadeiros, GO; Rando 1099	x	x		BF
Chamaecrista flexuosa var. *flexuosa* L.	Feira de Santana, BA; Barbosa XXXX	x	x	x	ABCEGH
Chamaecrista glaucofilix (H.S. Irwin & Barneby) H.S. Irwin & Barneby	Mucugê, BA; Conceição 861	FJ009834	FJ009888		F
Chamaecrista glaziovii (Taub. ex Harms) H.S. Irwin & Barneby	Diamantina, MG; Cota 328	x		x	F
Chamaecrista gumminans H.S. Irwin & Barneby	Diamantina, MG; Rando 1246	x	x		F
Chamaecrista hedysaroides (Vogel) H.S. Irwin & Barneby	Diamantina, MG; Rando 1239	x	x	x	F
Chamaecrista hispidula (Vahl) H.S. Irwin & Barneby	Feira de Santana, BA; Conceição 914	FJ009833	FJ009887	x	ABCDEGH
Chamaecrista imbricans (H.S. Irwin & Barneby) H.S. Irwin & Barneby	Brasília, DF; Rando 1261	x	x	x	B
Chamaecrista incurvata (Benth.) H.S. Irwin & Barneby	Delfinópolis, MG; Romero 8498		x	x	B
Chamaecrista indet	Barbosa 1112	x	x	x	ABCDGH

Chamaecrista indet	Barbosa 1086	x		x	ABCDEGH
Chamaecrista indet	Barbosa 1109		x	x	BC
Chamaecrista indet	Barbosa 1119		x	x	BC
Chamaecrista indetRomero	Delfinópolis, MG; Romero 8500	x	x		B
Chamaecrista jacobinae (Benth.) H.S. Irwin & Barneby	Morro do Chapéu, BA; Andrade 610	FJ009827	FJ009882	x	CF
Chamaecrista kunthiana (Schltdl. & Cham.) H.S. Irwin & Barneby	FS9263	x	x	x	B
Chamaecrista lagotois H.S. Irwin & Barneby	Santana do Riacho, MG; Rando 1029	x	x	x	F
Chamaecrista lamprosperma (Mart. ex Benth.) H.S. Irwin & Barneby	Diamantina, MG; Cota 352	x	x		F
Chamaecrista latifolia (Benth.) Rando	Santana do Riacho, MG; Rando 1024	x	x	x	F
Chamaecrista lineata (Sw.) Greene	Great Exuma Island, Bahamas; Rando 858	x	x	x	GH
Chamaecrista lundii (Benth.) H.S. Irwin & Barneby	Brasília, DF; Rando 1263	x	x	x	B
Chamaecrista machaerifoliia (Benth.) H.S. Irwin & Barneby	FS9166	x	x	x	B
Chamaecrista mimosoides (L.) Greene	Rando 1259	x	x	x	ABCDEGH
Chamaecrista mollicaulis (Harms) H.S. Irwin & Barneby	Brasília, DF; Rando 1268	x	x	x	F
Chamaecrista monticola (Mart. ex Benth.) H.S. Irwin & Barneby	Diamantina, MG; Rando 1227	x	x	x	F
Chamaecrista mucronata (Spreng.) H.S. Irwin & Barneby	Catas Altas, MG; Rando 879	x	x	x	FE
Chamaecrista multipennis (H.S. Irwin & Barneby) H.S. Irwin & Barneby	Santana do Riacho, MG; Rando 1130	x	x	x	F
Chamaecrista myrophegens (H.S. Irwin & Barneby) H.S. Irwin & Barneby	Diamantina, MG; Rando 1228	x	x	x	F
Chamaecrista neesiana var. *laxiracemosa* (Harms) H.S. Irwin & Barneby	Brasília, DF; Rando 1269	x		x	B
Chamaecrista neesiana var. *neesiana* (Mart. ex Benth.) H.S. Irwin & Barneby	Santana de Pirapama, MG; Rando 1033	x	x		BF
Chamaecrista neesiana var. *neesiana* (Mart. ex Benth.) H.S. Irwin & Barneby	Cristalina, GO; Rando 1049		x		BF
Chamaecrista neesiana var. subnitida (Taub.) H.S. Irwin & Barneby	Diamantina, MG; Cota 364	x	x	x	BF
Chamaecrista neesiana var. subnitida (Taub.) H.S. Irwin & Barneby	Diamantina, MG; Rando 1244	x	x		BF
Chamaecrista negrensis (H.S. Irwin) H.S. Irwin & Barneby	AM; Cardoso 3395	x	x	x	A
Chamaecrista nictitans subsp. *brachypoda* (Benth.) H.S. Irwin & Barneby	Iporá, GO; Queiroz 10335	FJ009855	FJ009909		ABCEGH
Chamaecrista nictitans var. *disadena* (Steud.) H.S. Irwin & Barneby	Junco de Minas, MG; Conceição 790	FJ009852	FJ009906		ABCEGH
Chamaecrista nictitans var. *ramosa* (Vogel) H.S. Irwin & Barneby	Barra do Garças, MT; Queiroz 10406	FJ009853	FJ009907		ABCEGH
Chamaecrista obtecta (Benth.) H.S. Irwin & Barneby	GO, Queiroz		x	x	B
Chamaecrista ochnacea var. *latifolia* (Benth.) H.S. Irwin & Barneby	Santana do Riacho, MG; Rando 1016	x	x	x	F
Chamaecrista ochnacea var. *purpurascens* (Benth.) H.S. Irwin & Barneby	Santana do Riacho, MG; Rando 1134	x	x	x	F
Chamaecrista ochnacea var. *speluncae* (H.S. Irwin & Barneby) H.S. Irwin & Barneby	Delfinópolis, MG; Rando 1121	x	x	x	BF
Chamaecrista olesiphylla (Vogel) H.S. Irwin & Barneby	Congonhas do Norte, MG; Rando 632	x	x	x	F
Chamaecrista onusta H.S. Irwin & Barneby	Itacaré, BA; Conceição 800	FJ009824	FJ009879		D
Chamaecrista orbiculata (Benth.) H.S. Irwin & Barneby	Alto Paraíso de Goiás, GO; Rando 1101	x		x	B
Chamaecrista paniculata (Benth.) H.S. Irwin & Barneby	Bela Vista da Santíssima Trindade, MT; Borges 769	x	x	x	B
Chamaecrista papillata H.S. Irwin & Barneby	Palmeiras, BA; Rando 1109	x	x	x	F
Chamaecrista pascuorum (Mart. ex Benth.) H.S. Irwin & Barneby	Iaçu, BA; Queiroz 9169	FJ009851	FJ009905	x	BC

Chamaecrista sp. new	Diamantina, MG; Rando 1149			x	F
Chamaecrista philippi (H.S. Irwin & Barneby) H.S. Irwin & Barneby	Rio de Contas, BA; Giulietti 2245	FJ009838	FJ009892		F
Chamaecrista pilosa (L.) Greene	Barreiras, BA; Queiroz 10221	FJ009856	FJ009910		BC
Chamaecrista planaltoana (Harms) H.S. Irwin & Barneby	Brasília, DF; Rando 1258b	x	x	x	B
Chamaecrista planifolia (H.S. Irwin & Barneby) H.S. Irwin & Barneby	Delfinópolis, MG; Rando 1124	x	x	x	B
Chamaecrista pohliana (Benth.) H.S. Irwin & Barneby	Brasília, DF; Rando 1259		x	x	B
Chamaecrista polystachya (Benth.) H.S. Irwin & Barneby	Pacaraima, RO; Rando 1150	x	x	x	A
Chamaecrista potentilla (Mart. ex Benth.) H.S. Irwin & Barneby	Diamantina, MG; Rando 1245	x	x	x	BF
Chamaecrista ramosa var. *erythrocalyx* (Benth.) H.S. Irwin & Barneby	Diamantina, MG; Cota 336	x	x		BF
Chamaecrista repens (Vogel) H.S. Irwin & Barneby	FS301	x	x	x	ABCD
Chamaecrista roncadorensis (H.S. Irwin & Barneby) H.S. Irwin & Barneby	FS3231	x	x	x	B
Chamaecrista roraimae (Benth.) Gleason	Amajari, RO; Rando 1154	x	x	x	AC
Chamaecrista rossicorum (H.S. Irwin & Barneby) Rando	Santana de Pirapama, MG; Rando 1045	x	x	x	F
Chamaecrista rotundata var. *interstes* (H.S. Irwin & Barneby) H.S.Irwin & Barneby	Diamantina, MG; Rando 1236	x	x	x	F
Chamaecrista rotundifolia (Pers.) Greene	Mucugê, BA; Costa 128	FJ009857	FJ009911	x	ABCDEGH
Chamaecrista rupestrium H.S. Irwin & Barneby	Rio de Contas, BA; Santos 390	FJ009835	FJ009889		F
Chamaecrista rupestrium H.S. Irwin & Barneby	Católes, BA; Rando 1255			x	F
Chamaecrista scabra (Pohl ex Benth.) H.S. Irwin & Barneby	Brasília, DF; Rando 1266	x	x	x	B
Chamaecrista scabra (Pohl ex Benth.) H.S. Irwin & Barneby	LMB906		x		B
Chamaecrista scleroxylon (Ducke) H.S. Irwin & Barneby	Santarém, PA; Rando 1205	x	x	x	A
Chamaecrista serpens (L.) Greene	falta localidade		x		ABCDGH
Chamaecrista setosa (Vogel) H.S. Irwin & Barneby	Chapada dos Guimarães, MT; Queiroz 10460	FJ009842	FJ009896		BF
Chamaecrista setosa var. *detonsa* (Benth.) H.S. Irwin & Barneby	falta localidade	x			B
Chamaecrista simplifacta H.S. Irwin & Barneby	Diamantina, MG; Rando 1148	x	x	x	F
Chamaecrista speciosa Conc., L.P. Queiroz & G.P. Lewis	Abaíra, BA; Conceição 546	FJ009839	FJ009893		C
Chamaecrista stillifera (H.S. Irwin & Barneby) H.S. Irwin & Barneby	Serra do Cabral, MG; Borges 645	x	x		F
Chamaecrista supplex (Mart. ex Benth.) Britton & Rose ex Britton & Killip	Brasília, DF; Rando 1271	x	x	x	ABC
Chamaecrista swainsonii (Benth.) H.S. Irwin & Barneby	falta localidade	x	x	x	C
Chamaecrista tragacanthoides var. *tragacanthoides* (Mart. ex Benth.) H.S. Irwin & Barneby	Diamantina, MG; Pirani 6334	x	x	x	F
Chamaecrista ulmea H.S. Irwin & Barneby	Itacambira, MG; Santos 650	x	x	x	F
Chamaecrista unijuga (Benth.) Conc., L.P. Queiroz & G.P. Lewis	Sto. Amaro das Brotas, SE; Conceição 694	FJ009845	FJ009899	x	F
Chamaecrista urophyllidia (H.S. Irwin & Barneby) H.S. Irwin & Barneby	Rio de Contas, BA; Harley 54656	FJ009840	FJ009894		F
Chamaecrista ursina (Mart. ex Benth.) H.S. Irwin & Barneby	Diamantina, MG; Cota 330	x	x	x	F
Chamaecrista vauthieri (Benth.) H.S. Irwin & Barneby	Santana do Pirapama, MG; Rando 1036	x	x	x	F
Chamaecrista venulosa (Benth.) H.S. Irwin & Barneby	Santana do Riacho, MG; Rando 1015	x	x	x	F
Chamaecrista viscosa (Kunth) H.S. Irwin & Barneby	Santarém, PA; Rando 1207	x	x	x	ABCDEGH
Chamaecrista xinguensis (Ducke) H.S. Irwin & Barneby	Belterra, PA; Rando 1208	x	x	x	A

Cassia grandis L. f.	Feira de Santana, BA; Queiroz 2878	FJ009820	FJ009875		A
Cassia javanica L.	Feira de Santana, BA; Queiroz 11039	FJ009821	FJ009876		A
Senna alata (L.) Roxb.	falta localidade	checar			ABCD
Senna alata (L.) Roxb.	Feira de Santana, BA; Rando XXXXX		x		ABCD
Senna gardneri (Benth.) H.S. Irwin & Barneby	Campo Alegre de Lurdes, BA; Queiroz 7860	FJ009822	FJ009877		C

Appendix 2. Detailed dispersal rates for each model tested. Shading gray is the main differences between models.

Model A. Simplest model.

	a	**b**	**c**	**d**	**e**	**f**	**g**
a	1	1	1	1	1	1	1
b	1	1	1	1	1	1	1
c	1	1	1	1	1	1	1
d	1	1	1	1	1	1	1
e	1	1	1	1	1	1	1
f	1	1	1	1	1	1	1
g	1	1	1	1	1	1	1

Model B. Dispersal rates facilitated from Amazon subregion to Cerrado and Caatinga province.

10 mya - currently

	a	**b**	**c**	**d**	**e**	**f**	**g**
a	1	1	1	0.5	0.5	0.1	1
b	1	1	1	1	1	1	1
c	1	1	1	1	1	1	0.5
d	0.5	1	1	1	1	1	0.5
e	0.5	1	1	1	1	1	0.5
f	0.1	1	1	1	1	1	0.1
g	1	1	0.5	1	1	1	1

28 mya – 10 mya

	a	b	c	d	e	f	g
a	1	1	1	0.1	0.1	0.1	0.1
b	1	1	1	0.1	0.1	1	0.1
c	1	1	1	0.1	0.1	1	0.1
d	0.1	0.1	0.1	1	0.1	0.1	0.1
e	0.1	0.1	0.1	0.1	0.1	0.1	0.1
f	0.1	1	1	0.1	0.1	1	0.1
g	0.1	0.1	0.1	0.1	0.1	0.1	0.1

28 mya -53.9729 mya

	a	b	c	d	e	f	g
a	1	0.1	0.1	1	0.1	0.1	0.1
b	0.1	0.1	0.1	0.1	0.1	0.1	0.1
c	0.1	0.1	0.1	0.1	0.1	0.1	0.1
d	1	0.1	0.1	1	0.1	0.1	0.1
e	0.1	0.1	0.1	0.1	0.1	0.1	0.1
f	0.1	0.1	0.1	0.1	0.1	0.1	0.1
g	0.1	0.1	0.1	0.1	0.1	0.1	0.1

Model C. Dispersal rates facilitated from Amazon subregion to Campos rupestres. After Campos rupestres to Cerrado and Caatingas province.

10 mya - currently

	a	b	c	d	e	f	g
a	1	1	1	0.5	0.5	0.1	1
b	1	1	1	1	1	1	1
c	1	1	1	1	1	1	0.5
d	0.5	1	1	1	1	1	0.5
e	0.5	1	1	1	1	1	0.5
f	0.1	1	1	1	1	1	0.1
g	1	1	0.5	1	1	0.1	1

28 mya – 10 mya

	a	b	c	d	e	f	g
a	1	0.1	0.1	0.1	0.1	0.1	0.1
b	0.1	1	1	0.1	0.1	1	0.1
c	0.1	1	1	0.1	0.1	1	0.1
d	0.1	0.1	0.1	1	0.1	0.1	0.1
e	0.1	0.1	0.1	0.1	0.1	0.1	0.1
f	0.1	1	1	0.1	0.1	1	0.1
g	0.1	0.1	0.1	0.1	0.1	0.1	0.1

28 mya -53.9729 mya

	a	b	c	d	e	f	g
a	1	0.1	0.1	1	0.1	1	0.1
b	0.1	0.1	0.1	0.1	0.1	0.1	0.1
c	0.1	0.1	0.1	0.1	0.1	0.1	0.1
d	1	0.1	0.1	1	0.1	1	0.1
e	0.1	0.1	0.1	0.1	0.1	0.1	0.1
f	1	0.1	0.1	1	0.1	0.1	0.1
g	0.1	0.1	0.1	0.1	0.1	0.1	0.1

CONSIDERAÇÕES FINAIS E PERSPECTIVAS

A tese de doutorado contém três capítulos, quatro manuscritos, um já publicado e outros três em formato de manuscritos para publicação. A tese está estruturada de modo a manter uma ligação entre os capítulos: Filogenia, Taxonomia e Biogeografia e, de acordo com essa estrutura, temos as seguintes conclusões:

Capítulo 1. *Chamaecrista* ser. *Coriaceae*, como atualmente circunscrita, não constitui um clado. Sua nova definição como grupo monofilético, aqui proposta, envolve a exclusão de três espécies: *Chamaecrista caribea*, *C. roraimae* e *C. venulosa*. *C.* ser. *Coriaceae strictu sensu* é formada agora por 19 espécies exclusivas do Brasil e restritas aos Campos Rupestres. Tais espécies apresentam como sinapomorfia molecular diversas deleções no DNA plastidial, e como sinapomorfias morfológicas uma disposição espacial peculiar dos estames e a presença de xilopódio. Embora as análises filogenéticas se baseiem em quatro marcadores moleculares e em dados morfológicos, as relações dentro do clado *Coriaceae s. s.* têm baixa sustentação e pouca resolução, o que pode estar fortemente relacionada a uma recente diversificação do grupo.

Capítulo 2. Neste tratamento taxonômico, propomos a nova circunscrição de *Chamaecrista* ser. *Coriaceae,* baseada nos resultados da filogenia apresentada no Capítulo 1. As análises morfológicas revelaram que alguns caracteres antes negligenciados possuem valor taxonômico. A sinopse inclui as informações taxonômicas fundamentais acerca das 19 espécies agora reconhecidas na série, todas exclusivas do Brasil e restritas aos Campos Rupestres. Propomos três neotipificações, dois novos sinônimos e uma nova combinação. Apresentamos também uma chave de identificação das espécies, comentários taxonômicos, nomenclaturais e sobre a distribuição geográfica, assim como ilustrações de caracteres diagnósticos.

Capítulo 3. O estudo biogeográfico de *Chamaecrista* baseia-se em uma amostragem de mais de um terço das espécies conhecidas no gênero, utilizando três marcadores moleculares. A datação molecular dos eventos cladogenéticos, aqui realizada por meio de calibração baseada em um registro fóssil, possibilita a geração de hipóteses robustas sobre história biogeográfica do gênero, cuja origem parece remontar ao Terciário Inferior mas com diversificação mais recente. A reconstrução ancestral de áreas e de caracteres no cronograma, efetuada por meio de critérios de máxima verossimilhança, aponta que *Chamaecrista* provavelmente teve origem em áreas florestais e, posteriormente, conquistou áreas abertas, savânicas, onde teria experimentado sua maior diversificação. Um padrão previamente esperado envolvia hipótese de migração de *Chamaecrista* diretamente de florestas para o Cerrado e para a Caatinga e posteriormente colonização dos Campos Rupestres, onde está concentrada a maior diversidade do gênero. No entanto, os dados aqui obtidos sugerem que a invasão dos habitats abertos deve ter ocorrido inicialmente ao longo de áreas ligadas à Cadeia do Espinhaço, que efetivamente é um sistema orográfico geologicamente antigo. A partir dos Campos Rupestres, algumas espécies de *Chamaecrista* teriam expandido para outros ambientes, como o Cerrado e a Caatinga. Essa hipótese é instigante por mostrar uma ocupação antiga dos *Campos Rupestres* por um táxon cuja diversificação seria bem recente. A ideia é congruente com alguns trabalhos documentando eventos de extinção e substituição das espécies (*species turnover)* nos Campos Rupestres, mas ainda são necessários mais estudos filogenéticos com abordagens integradas sobre outros grupos de plantas para corroboração.

Como perspectivas futuras, acreditamos que o primeiro e o segundo capítulo estejam bem estruturados necessitando de poucas alterações para serem submetidos para publicação. No entanto, o terceiro capítulo necessita de mais esforços visando a obter algumas sequências faltantes, incrementar as análises e aprofundar a discussão. Por muito tempo as análises de Biogeografia Histórica basearam-se em padrões espaciais (*e.g.* análise de

parcimônia de Brooks, análises de componentes) ou em eventos (*e.g.* DIVA – *Dispersal-vicariance analysis*). Entretanto, até mesmo o criador de DIVA, Frederick Ronquist, interpreta como "um grande retrocesso na área acadêmica que pesquisadores ainda usem DIVA". Isso se deve principalmente ao fato de muitos biogeógrafos modernos (e.g. Michael Donoghue) afirmarem que a história biogeográfica sem incorporação de tempo nas análises podem gerar hipóteses pouco consistentes, sendo imprescindível que sejam feitas comparações apenas entre topologias cujos eventos tenham boa evidência de contemporaneidade. Mais recentemente, o grande incremento de dados moleculares disponíveis, o desenvolvimento de análises de verossimilhança e de métodos bayesianos, e a possibilidade de incorporação da temporalidade nas topologias, levaram a grande avanço nas análises biogeográficas, que estão mais refinadas e robustas. Na tese de doutorado testamos três modelos e três *time frames*, mas isso pode ser melhor detalhado e outras hipóteses podem ser adicionadas ou melhor elaboradas. Atualmente outras ferramentas para análises biogeográficas também já estão disponíveis, como o pacote na linguagem R, o BioGeoBears, que além de todos os parâmetros testados no programa Lagrange (*Likelihood Analysis of Geographic Range Evolution*) traz a opção de adicionar o efeito fundador nas análises. Enfim, esse terceiro capítulo ainda deverá ser explorado mais amplamente nas análises biogeográficas e de diversificação, e assim provavelmente trará boa contribuição para história biogeográfica da biota neotropical.