

## PHYTOGEOGRAPHICAL PATTERNS OF *CROTALARIA* SPECIES (LEGUMINOSAE-PAPILIONOIDEAE) IN BRAZIL

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### ABSTRACT

(Phytogeographical patterns of *Crotalaria* L. species (Leguminosae-Papilionoideae) in Brazil) The phytogeography and preferred habitat of *Crotalaria* species from Brazil are studied. Four species are widely distributed in Brazil, while *C. goiasensis* and *C. irwinii* are endemic to the state of Goiás, *C. clauseni* to São Paulo, *C. rufipila* to Minas Gerais and *C. brachycarpa* and *C. harleyi* to Bahia. *Crotalaria* species occurs in the following biogeographical provinces: Amazonian, Atlantic, Caatinga, Cerrado, Chaqueña, Guayana, Pampeana and Paranaense. The Cerrado province presents the largest number of species with restricted distribution, followed by the Paranaense province. The geographical distribution of species in Brazil shows higher species diversity in the highlands (800 – 2000 m.s.m.), such as the Serra Geral de Goiás, Chapada dos Veadeiros, Espinhaço Range (15-16 spp.), Serra da Mantiqueira and Serra do Mar (14 spp.). As well as the altitude, vegetation and climate influence the distribution of *Crotalaria* in Brazil.

**Key words:** cerrado, Papilionaceae, endemism, highlands, preferred habitat, biogeographical provinces.

### RESUMO

(Padrões fitogeográficos das espécies de *Crotalaria* L. (Leguminosae-Papilionoideae) no Brasil) Este estudo apresenta a fitogeografia e os hábitos preferenciais das espécies de *Crotalaria* no Brasil. Quatro espécies são amplamente distribuídas no Brasil. Por outro lado, *C. goiasensis* e *C. irwinii* são endêmicas de Goiás, *C. clauseni* de São Paulo, *C. rufipila* de Minas Gerais e *C. brachycarpa* e *C. harleyi* da Bahia. As espécies de *Crotalaria* ocorrem nas seguintes províncias biogeográficas: cerrado, paranense, atlântica, amazônica, caatinga, chaquenha, guayana e pampeana. A província do cerrado apresenta o maior número de espécies exclusivas seguida da província paranense. A distribuição geográfica das espécies brasileiras mostra que a maior diversidade ocorre em áreas elevadas (800 – 2000 m.s.m.), como a Serra Geral de Goiás, Chapada dos Veadeiros, Cadeia do Espinhaço (15-16 spp.), Serra da Mantiqueira e Serra do Mar (14 spp.). As elevadas altitudes, bem como as características vegetacionais e climáticas influenciam a distribuição das espécies de *Crotalaria* no Brasil.

**Palavras-chave:** cerrado, endemismos, altitudes elevadas, hábito preferencial, províncias biogeográficas.

### INTRODUCTION

The genus *Crotalaria* L. is considered to be the third largest genus of Papilionoideae, with around 600 species distributed throughout the tropics and subtropics (Polhill 1982). The Neotropics has approximately 70 species occurring from southern United States to subtropical Argentina and Uruguay (Lewis 1987; Polhill *et al.* 2001). The centers of diversity of the genus are eastern and southern tropical Africa and India, with two additional centers in Mexico and Brazil (Palomino & Vásquez 1991).

*Crotalaria* comprises herbaceous and shrubby species with simple, unifoliolate or

digitately 3–(4–5)-foliolate leaves, stamens monadelphous with the sheath split at least at the very base, dimorphic anthers and inflated legumes. The genus was subdivided into eight sections by Polhill (1968) and Bisby & Polhill (1973), based on floral morphology of African species. Native species in Brazil are grouped in two sections, *Crotalaria* sect. *Chrysocalycinae* (Benth.) Baker f. and *Crotalaria* sect. *Calycinae* Wight & Arn. (Flores 2004). These sections have a west-east distribution, the former mainly in western Africa and America tropics, and the latter extending from there to Asia, Australia and the New World (Polhill 1982).

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The great majority of *Crotalaria* species is adapted for a tropical climate and only a restricted number of species occurs in temperate regions. *Crotalaria* species have a wide tolerance of edaphic conditions. The majority of species have a high light requirement, therefore they are absent from forest's interior, but are relatively common in clearings and forest margins (Polhill 1968, 1982). Moreover, some species are reasonably competitive in closed herbaceous vegetation and disturbed areas, with some species, often the exotic ones, persist as weeds and are able to invade field crops.

The great diversity of climate, soil and geomorphology found in Brazil is reflected by the variety of vegetation types, making it a very interesting area for phytogeographical studies. Many authors proposed different biotic subdivisions of tropical America. Cabrera & Willink (1980) proposed a biogeographical classification based on flora and fauna composition of Latin America, which was divided into dominions and subdivided into provinces. According to this classification, there are three dominions and nine provinces represented in Brazil.

The phytogeographical aspects of *Crotalaria* species were studied in southern Brazil (Flores & Miotto 2005). The present study aims to analyze the distribution and preferred habitat of the *Crotalaria* species from Brazil and to compare the species distribution with the biogeographical classification proposed by Cabrera & Willink (1980).

## MATERIAL AND METHODS

This study was based on data from the taxonomic treatment of *Crotalaria* (Flores 2004), obtained from analysis of herbarium specimens from ALCB, BHCB, BHMH, BM, BR, C, CEN, CEPEC, CGMS, CPAP, CTES, CVRD, FUEL, FUFMT, GH, HAS, HB, HBG, HBR, HEPA, HRCB, HUEFS, ICN, IAC, IAN, INPA, IPA, L, LP, MBM, MG, MO, NY, PACA, PEL, PEUFR, PMSP, R, RB, S, SJRP, SP, SPF, SPFR, SPSF, U, UB, UEC, US, and VIC (acrônimos segundo Holmgren *et al.* 1990) and extensive fieldwork in different regions of Brazil.

Distribution data of the species in extra Brazilian areas were obtained from literature.

The distribution of Brazilian *Crotalaria* species was plotted in maps (modified from Flora Neotropica monographs) and compared to detected patterns of species distribution with the biogeographical classification proposed by Cabrera & Willink (1980).

## RESULTS AND DISCUSSION

No phylogenetic study is available to *Crotalaria*, but while it is straightforward to ascribe the origin of the genus to Africa or Asia, its evolutionary and diversification history remains unclear. For *Crotalaria* species from New World, cytological studies indicate that polyploidy is at the least one of the evolutionary strategies of this genus in this area, suggesting that the New World could have been the last area to be colonized by *Calycinae* species, with an increase in ploidy level (Flores *et al.* 2006).

Brazil possesses the majority of the *Crotalaria* species occurring in South America, with 31 native and 11 introduced or naturalized (Flores 2004). The naturalized species are native mostly to Africa and Asia; only *C. longirostrata* Hook & Arn. is native to North and Central America. These species are found in various habitats, usually competing with the native species for the same environment, mainly the African *C. lanceolata* E. Mey. and *C. pallida* Aiton and the Asian species *C. juncea* L., *C. spectabilis* Roth and *C. retusa* L. The other naturalized species are found under culture or as adventitious along the roadsides and fallow fields. *Crotalaria incana* is found in disturbed areas and is referred as native to Africa by Polhill (1968; 1982). However, the fact that this species was originally described from Jamaica, with its varieties distributed in Central and South America (Senn 1939; Windler *et al.* 1992), suggests that *C. incana* is native to the Neotropics.

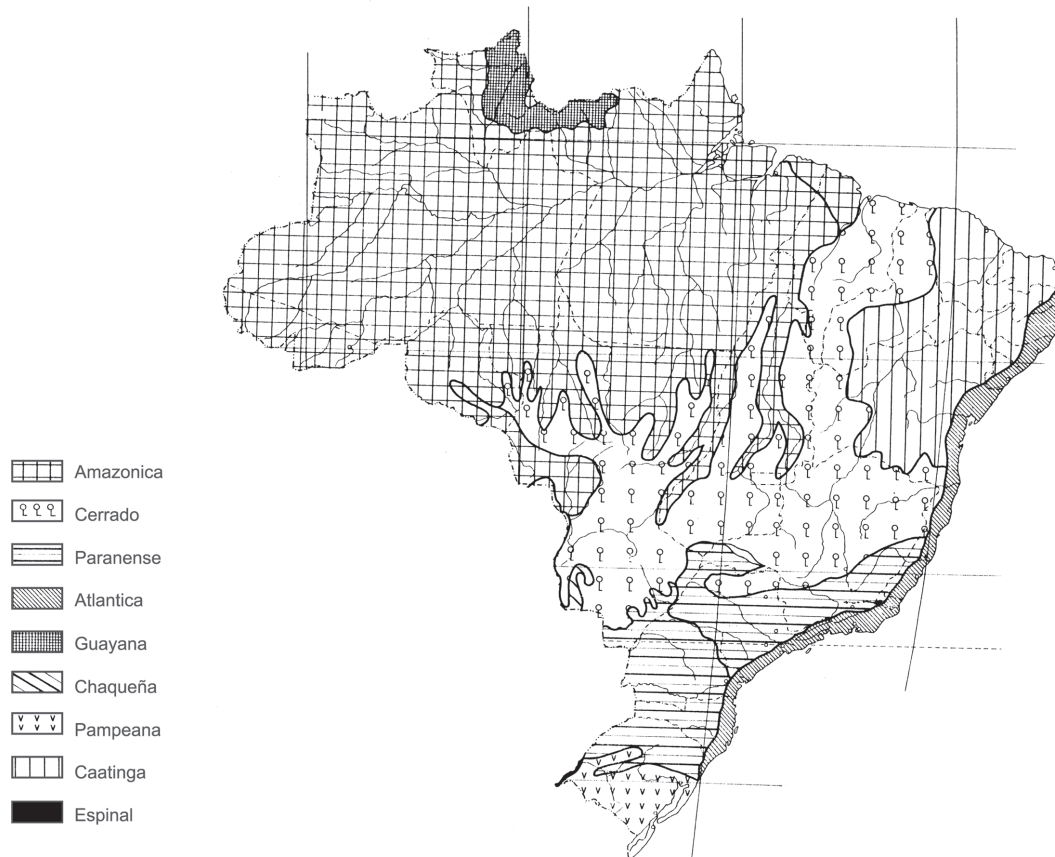
Of the 31 native *Crotalaria* species found in Brazil, 17 are endemic, six are distributed in South America and eight are widespread throughout the Neotropics. These species are

mainly found in open areas of savannas, 'campo rupestre' and 'restinga' vegetation, as well as along margins of gallery forests (Table 1). The recently described *C. miottoae* (Flores & Tozzi 2005) is the only species that occurs in the interior of altitudinal forests, an unusual habitat for the genus.

According to Cabrera & Willink (1980), in Brazil the Amazonian Dominion is represented by four phytogeographic provinces (Amazonian, Cerrado, Paranaense, and Atlantic), Guayana Dominion is represented only by the Guayana province, and the Chaqueña Dominion by four provinces: Caatinga, Chaqueña, Espinal, and Pampeana (Fig. 1). There are records of the occurrence of *Crotalaria* species in all of these biogeographical provinces, except in the Espinal (Table 2). The species *C. stipularia*, *C. maypurensis*, *C. incana* and *C. micans* (Fig. 2) are widespread throughout six or seven

provinces (Table 2). On the other hand, 12 species are restricted to one province (Fig. 3), some of them with a very restricted distribution probably representing micro-endemism in Cerrado, Atlantic or Caatinga provinces (Fig. 4).

The Amazonian Dominion is the largest one in Brazil, where the Leguminosae are considered the most important family because of their representativity in terms of the floristic composition. The Guayana Dominion has a low proportion in Brazil, occupying highlands above 2,000 m in the extreme North, between 0° and 4°N. Its flora is considered similar with the one of the Cerrado province and the montane areas of southern Brazil, but shows a high degree of endemism of family and genera (Cabrera & Willink 1980). In Brazil, the Guayana Dominion has an annual precipitation from 1,100 to 2,000 mm and a mean annual temperature from 16 to 25°C, with a pronounced dry season from December to February.



**Figure 1** – Dominions and provinces represented in Brazil according to Cabrera & Willink (1980). (Modified map of Cabrera & Willink 1980).

**Table 1** – Geographical distribution, preferred habitats and frequency of collections of Brazilian *Crotalaria* species. ARG: Argentina; BRA: Brazil, COL: Colombia; PAR: Paraguay; URU: Uruguay; VEN: Venezuela; NEOTR: Neotropics. Frequency of collections: very rare: 1–3 registers; rare: 4–10; occasional: 11–20; common: over 20 registers.

Species	DISTRIBUTION	PREFERRED HABITATS	FREQUENCY
<i>C. bahiaensis</i> D.R. Windler & S.G. Skinner	BRA	grassland	occasional
<i>C. balansae</i> Micheli	BRA, PAR	grassland	common
<i>C. brachycarpa</i> Benth.	BRA	grassland	very rare
<i>C. breviflora</i> DC.	BRA	grassland, forest margin	common
<i>C. claussemi</i> Benth.	BRA	grassland	rare
<i>C. flavicoma</i> Benth.	BRA	grassland	common
<i>C. goiasensis</i> D.R. Windler & S.G. Skinner	BRA	forest margin	rare
<i>C. grandiflora</i> Benth.	BRA	forest margin	occasional
<i>C. harleyi</i> D.R. Windler & S.G. Skinner	BRA	grassland	occasional
<i>C. hilariana</i> Benth.	BRA	grassland	common
<i>C. holosericea</i> Nees & Mart.	BRA	grassland, forest margin	common
<i>C. incana</i> L.	NEOTR	grassland, forest margin	common
<i>C. irwinii</i> D.R. Windler & S.G. Skinner	BRA	grassland	very rare
<i>C. laeta</i> Mart. ex Benth.	BRA	grassland, forest margin	common
<i>C. martiana</i> subsp. <i>martiana</i> Benth.	BRA	grassland, forest margin	common
<i>C. martiana</i> subsp. <i>mohlenbrockii</i> (D.R. Windler & S.G. Skinner) Planchuelo	BRA, PAR	grassland, forest margin	common
<i>C. maypurensis</i> Kunth	NEOTR	grassland	common
<i>C. micans</i> Link	NEOTR	grassland, forest margin	common
<i>C. miottoae</i> A.S. Flores & A.M.G. Azevedo	BRA	grassland, forest margin and understory	common
<i>C. nitens</i> Kunth	NEOTR	grassland	occasional
<i>C. otoptera</i> Benth.	BRA	grassland, forest margin	rare
<i>C. paulina</i> Schrank	BRA, VEN	grassland, forest margin	common
<i>C. pilosa</i> Mill.	NEOTR.	grassland	common
<i>C. rufipila</i> Benth.	BRA	grassland, forest margin	occasional
<i>C. sagittalis</i> L.	NEOTR	grassland	occasional
<i>C. stipularia</i> Desv.	NEOTR	grassland	common
<i>C. subdecurrens</i> Mart. ex Benth.	BRA	forest margin	common
<i>C. tweediana</i> Benth.	BRA, URU, PAR, ARG	grassland	common
<i>C. unifoliolata</i> Benth.	BRA	grassland	common
<i>C. velutina</i> Benth.	BRA, COL	grassland	common
<i>C. vespertilio</i> Benth.	BRA, ARG	grassland, forest margin	common
<i>C. vitellina</i> Ker-Gawler	NEOTR	grassland, forest margin	common

**Table 2** – Brazilian species of *Crotalaria* occurring in the phytogeographical provinces proposed by Cabrera & Willink (1980). (ESP: Espinal; PAM: Pampeana; GUA: Guayana; CHA: Chaqueña; CAA: Caatinga; AMA: Amazonian; ATL: Atlantic; PAR: Paranaense; CER: Cerrado).

	ESP	PAM	GUA	CHA	CAA	AMA	ATL	PAR	CER
<i>C. bahiaensis</i> D.R. Windler & S.G. Skinner					X				
<i>C. balansae</i> Micheli							X	X	X
<i>C. brachycarpa</i> Benth.					X				
<i>C. breviflora</i> DC.							X	X	X
<i>C. claussenii</i> Benth.							X		
<i>C. flavicoma</i> Benth.									X
<i>C. goiasensis</i> D.R. Windler & S.G. Skinner									X
<i>C. grandiflora</i> Benth.									X
<i>C. harleyi</i> D.R. Windler & S.G. Skinner					X				X
<i>C. hilariana</i> Benth.		X					X	X	
<i>C. holosericea</i> Nees & Mart.					X		X		X
<i>C. incana</i> L.				X	X	X	X	X	X
<i>C. irwinii</i> D.R. Windler & S.G. Skinner									X
<i>C. laeta</i> Mart. ex Benth.				X	X				X
<i>C. martiana</i> subsp. <i>martiana</i> Benth.									X
<i>C. martiana</i> subsp. <i>mohlenbrockii</i> (D.R. Windler & S.G. Skinner) Planchuelo						X	X	X	X
<i>C. maypurensis</i> Kunth.			X	X	X	X	X	X	X
<i>C. micans</i> Link			X		X	X	X	X	X
<i>C. miottoae</i> A.S. Flores & A.M.G. Azevedo							X	X	X
<i>C. nitens</i> Kunth						X			
<i>C. otoptera</i> Benth.									X
<i>C. paulina</i> Schrank							X	X	X
<i>C. pilosa</i> Mill.			X			X		X	X
<i>C. rufipila</i> Benth.									X
<i>C. sagittalis</i> L.			X	X		X			X
<i>C. stipularia</i> Desv.			X	X	X	X	X	X	X
<i>C. subdecurrens</i> Mart. ex Benth.									X
<i>C. tweediana</i> Benth.		X						X	
<i>C. unifoliolata</i> Benth.								X	X
<i>C. velutina</i> Benth.							X	X	X
<i>C. vespertilio</i> Benth.							X	X	X
<i>C. vitellina</i> Ker-Gawler					X		X	X	X
n° spp total/province	0	2	5	5	10	8	15	16	25
n° spp. exclusive/province	0	0	0	0	1	1	1	0	8

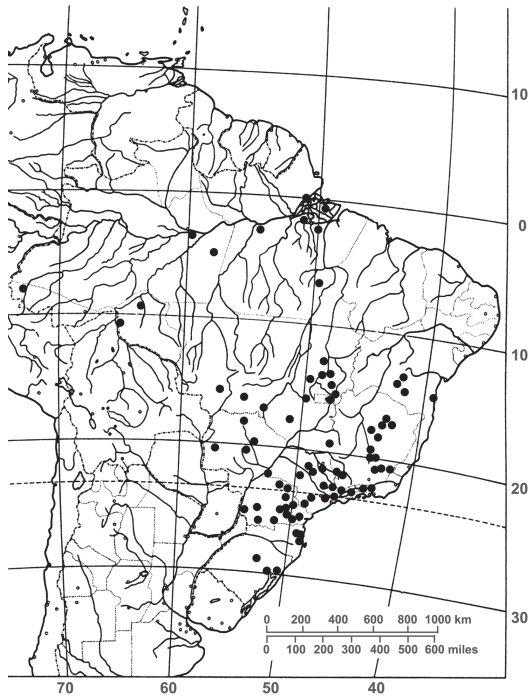


Figure 2 – Geographical distribution of *Crotalaria micans*.

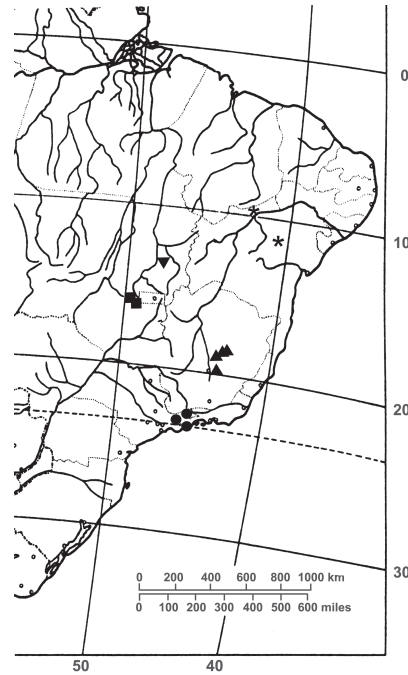


Figure 4 – Species of *Crotalaria* with very restricted distribution in Brazil. \* *C. brachycarpa*, ▼ *C. irwinii*, ■ *C. goiasensis*, ▲ *C. rufipila*, ● *C. clausenii*.

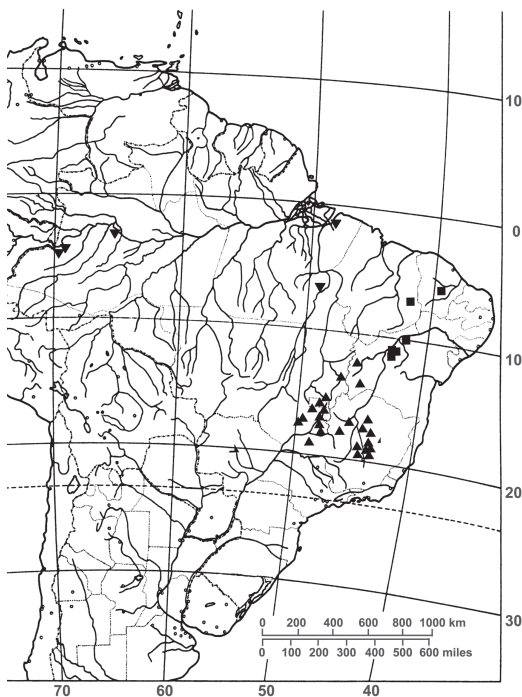


Figure 3 – Some species of *Crotalaria* with distribution restricted to one province in Brazil. ▲ *C. flavicoma* (Cerrado province), ■ *C. bahiaensis* (Caatinga province), ▼ *C. nitens* (Amazonian province).

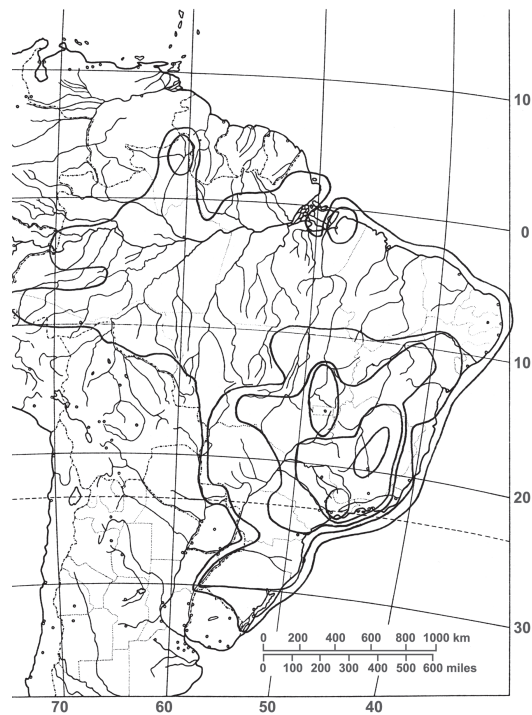


Figure 5 – Geographical distribution and centers of diversity of *Crotalaria* species in Brazil. a. 14-16 spp., b. 11-13 spp., c. 7-10 spp. d. 4-6 spp., e. 1-3 spp.

The Cerrado province occupies central and eastern Brazilian regions between 3°S and 23°S with an area of approximately 2,000,000 km<sup>2</sup>. It has a great environmental diversity, with many heterogeneous vegetation types. This province has a mean annual precipitation of 1,200 to 2,000 mm, with a pronounced dry season from May to September, a mean annual temperature from 21 to 25°C and a tropical climate (Cabrera & Willink 1980). Most of the cerrado consists of seasonal savannas where corridors of mesophytic evergreen forests occur along the rivers (gallery forests) (Joly *et al.* 1999). Some physiognomic forms of savanna can be recognized in the cerrado vegetation, such as 'campo limpo' (grassland), 'campo sujo' (wood savanna), 'cerrado *sensu stricto*' (savanna), 'cerradão' (woodland), and 'campo rupestre'.

This province shows the highest number of native species of *Crotalaria*, with seven species and one subspecies restricted to this area. Among them, *C. flavicoma* has the highest frequency in cerrado, while some species have a very restricted distribution, as *C. irwinii*, *C. rufipila* and *C. goiasensis*.

The *Crotalaria* species occurs in all physiognomy types of savanna but some are restricted to a single location. *C. irwinii* is a rare species, with two collections, and it occurs in the border of gallery forests and outcrops and rocky slopes. *C. goiasensis* has been recorded only in the surroundings of the Serra dos Pirineus (GO), occurring on highlands, gallery forests and forest margins, from 900 to 1,200 m. *Crotalaria rufipila* is an occasional species restricted to 'campo rupestre' in the Serra do Cipó and Serra da Piedade (MG).

The Paranaense province occupies areas from southern São Paulo to northern Rio Grande do Sul, between 18°S and 30°S, with a dominance of *Araucaria angustifolia* (Bert.) O. Kuntze forests mixed with open vegetation. This province has a mean annual precipitation of 1,500 to 2,000 mm, a mean annual temperature between 16 and 22°C and an essentially warm-temperate or subtropical climate (Cabrera & Willink 1980). There are

no restricted species in this province, but *C. hilariana* is a widespread species found on the highlands of Rio Grande do Sul, Santa Catarina and Paraná states. This species shows a phytogeographical distribution pattern similar to species of some temperate genera of Leguminosae, being limited to the south of the Tropic of Capricorn (Flores & Miotto 2005).

The Atlantic province occupies Brazilian coast between 7°S and 30°S, including 'restinga', or coastal vegetation and a small proportion of highland open vegetation. This province has a mean annual precipitation higher than 2,000 mm, a mean annual temperature between 19 and 25°C and a tropical climate (Cabrera & Willink 1980). In this province, *Crotalaria vitellina* is found occurring associated to restinga vegetation, coastal hillsides and adjacent sandy dune along most of the Brazilian coast. On the other hand, *C. claussemi* is endemic in highlands above 1,000 ms.m. of Serra da Bocaina (São Paulo state).

In Brazil, Amazonian province occupies the north between 4°N and 18°S. Its climate is warm and humid, an average rainfall between 2,000 and 2,600 mm evenly distributed through the year and a mean annual temperature around 26°C (Cabrera & Willink 1980). Despite Amazonian province being characterized by the presence of rainforest, there are isolated areas of cerrado-like vegetation in northern (Amapá and Roraima states) and southern areas. In this province *Crotalaria* species are found in cerrado-like vegetation, disturbed or associated to course of river open areas. In Brazil, *Crotalaria nitens* is restricted to this province; it is widespread in Neotropics from North America to northern South America and its southern limit of distribution is northern of Mato Grosso state and Bolivia. This species occurs in open fields or 'capoeiras de terra firme' and also in border of 'mata de terra firme' on clay soils.

Caatinga province occupies the northern of Minas Gerais state and the greatest part of northeastern Brazil, from Bahia to Ceará and Piauí in part between 3°S and 15°S. It shows a semiarid or arid climate with vegetational formations as forest like, arboreal, park,

gramineous-woody, and ecological tension areas with cerrado to west and with Atlantic forest to east (Veloso *et al.* 1991). This province has a mean annual precipitation of 400 to 750 mm and a mean annual temperature between 26 and 27°C (Cabrera & Willink 1980). Rainfall is unevenly distributed and the dry season (May–November) is pronounced and long. *Crotalaria brachycarpa* and *C. bahiaensis* are endemic in this province. *C. brachycarpa* is represented by two collections, of which one is the holotype. Moreover, it can be considered extinct because it has been not collected since 1907. *C. bahiaensis* is usually found in cerrado and cerrado transition to caatinga, on shallow rocky soils. Besides, *C. harleyi* and *C. holosericea* are widely found in areas of caatinga and transition cerrado-caatinga vegetation in Caatinga province. *C. harleyi* occurs only in Bahia state where it is restricted to areas of cerrado and caatinga on sandy soils above 800–1800 ms.m., near to Chapada Diamantina. *C. holosericea* has a wide distribution in northeastern region of Brazil in areas of cerrado, caatinga and some sites of the coast. This species is found in the border gallery forest and disturbed areas.

The remaining provinces, which have smaller areas in Brazil, concentrated a low number of *Crotalaria* species. In Brazil, the Chaquenha province is restricted to the extreme western edge around Corumbá (Mato Grosso do Sul state) near the 22°S, but it occupies extra Brazilian areas of northern Argentina, western Paraguay and southeastern Bolívia (Prado 1993). This province has average rainfalls between 500 and 1,200 mm, a mean annual temperature of 20 to 23°C and a deciduous xeromorphic vegetation (Cabrera & Willink 1980). *Crotalaria incana*, *C. laeta*, *C. maypurensis*, *C. sagittalis* and *C. stipularia* have been collected in Corumbá vicinity, and no one of which is endemic to this province. In Guayana and Pampeana provinces only three and two species, respectively, are registered and no one is endemic to these provinces.

In Brazil, Pampeana province occupies southern Rio Grande do Sul state between 28°S

and 33°S where there are fields with a lower grass cover showing a dominant herbaceous physiognomy associated with forest pocket into wetter areas along rivers margins (Cabrera & Willink 1980, Joly *et al.* 1999). This province has a mean annual precipitation of 600 to 1,200 mm, a mean annual temperature between 13 and 17°C and a warm-temperate climate (Cabrera & Willink 1980). In this province, *Crotalaria tweediana* has a wide distribution and only few populations of *C. hilariana* occur. In Brazil, *C. tweediana* is found in rocky soils and on the top of mountains; it is restricted to south Brazil but its distribution extends to Argentina, Paraguay and Uruguay occupying four provinces: Chaquenha, Paranaense, Pampeana and Espinal.

Espinal province occupies an inexpressive portion in Rio Grande do Sul state, between 31°S and 30°S. It is characterized by the presence of a dry forest, an average rainfalls between 340 and 1,170 mm and an average temperature of 15 to 20°C (Cabrera & Willink 1980). In Brazil none of *Crotalaria* species have been already recorded, but three species are found in areas of this province in Argentina: *C. stipularia*, *C. incana* and *C. tweediana* (Gómez-Sosa 2000). The absence of *Crotalaria* species in the Brazilian portion of Espinal province may be explained by its restricted area in Brazil or might be due an artifact of low collecting effort in this region (Flores & Miotto 2005).

*Crotalaria* species are represented in all Brazilian Regions, prevailing in southeast, central and part of northeastern regions, where they are found in open native vegetation, mainly comprising cerrado and coastal vegetation (Fig. 5). On the other hand, the low frequency of *Crotalaria* species in Amazon basin and extreme south regions may be associated with the predominance of rain forests and occurrence of a temperate climate, respectively.

Central and southeast Brazil have a predominance of cerrado vegetation, mainly in Minas Gerais and Goiás states, in which the highest number of *Crotalaria* species are found in Brazil (19 spp. each). In the northeast, Bahia state concentrates numerous species of the genus (ca. 15), of which two are endemic.



This state has the major area in Northeast Region and possesses a great diversity of vegetation kinds, like cerrado, caatinga and Atlantic forest. It may explain the large number of *Crotalaria* species in this state. Moreover, the family Leguminosae was very collected for the preparation of Legumes of Bahia (Lewis 1987).

The high altitude is an important factor to the distribution of *Crotalaria* species in Brazil. The largest number of species is found in three areas with high altitudes (among 800–2,000 m) in central and southern Brazil. Two of these areas are localized in areas of cerrado, mainly in Goiás and Minas Gerais states, and the third one in the Atlantic forest in São Paulo, Rio de Janeiro and Minas Gerais states (Fig. 5). The first two regions are situated in Serra Geral de Goiás and Chapada dos Veadeiros (Goiás state), and in the Espinhaço Range (Minas Gerais state). Both regions concentrate 15–16 species of *Crotalaria*, which have the most important occurrence in campo rupestre, where *C. rufipila*, *C. irwinii* and *C. goiasensis* are only found in these areas.

The campo rupestre forms a mosaic of related vegetation communities under the control of local topography, microclimatic influences and the nature of the substrate (Giulietti & Pirani 1988). The flora of campos rupestres has an elevated number of endemic taxa because of your isolated position on the top of the mountains. These mountain areas are distinct by different ecological conditions extant in lowlands, which operate as barrier for the migration (Harley 1995).

The third region of major species diversity (14 species) of the genus in Brazil is localized in Serra da Mantiqueira and Serra do Mar in São Paulo, south of Rio de Janeiro and the plateau south of Minas Gerais states. In this region, *Crotalaria* species mainly occur at high elevations (campos de altitude), where *C. claussenii* is only found in Serra da Bocaina in Serra do Mar. The 'campo de altitude' is found on the top of woodland mountains above 1,500 m high and its physiognomy is characteristic of areas with a high degree of outcropping and reduction of soil depth with

low forests bordering this formation (Lima & Guedes-Bruni 1997).

In conclusion, the main factors that have influence on the species distribution of *Crotalaria* in Brazil are climate, vegetation types, and altitude. The species are concentrated in regions with tropical climate, especially in savanna vegetation at high altitudes. The geographical distribution of species in Brazil shows that Serra Geral de Goiás, Chapada dos Veadeiros, Espinhaço Range – in Central Brazil, and Serra da Mantiqueira and Serra do Mar – in southeast Brazil, are the centers of diversity of the genus in Brazil.

Cerrado province shows the greatest richness of species as well as the major number of restricted and endemic species, mainly in areas of campos rupestres. This fact can be explained by the great environmental diversity in this region, where heterogeneous vegetation types can be found, mainly in the areas of campos rupestres, which have a great degree of endemism.

Endemic *Crotalaria* taxa are concentrated mainly in areas of campos rupestres in Espinhaço Range (*C. rufipila*, *C. martiana* subsp. *martiana*, *C. harleyi*) and mountain ridges of Goiás (*C. irwinii*, *C. goiasensis*), where they generally are confined to one or two mountains. These areas present similar geological, physical and climatic features (Giulietti & Pirani 1988) with campos rupestres interrupted by patches of cerrado and gallery forest. These associations of open areas and forest margin, wet or dry soils, and high elevations seem to be of great importance for speciation of the genus in Brazil. Studies on genetic diversity using molecular procedures and breeding systems should prove to be interesting and informative for understanding of species boundaries and processes of speciation of Brazilian species of *Crotalaria*.

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