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Analysis of metabolites from plants of the Swartzia genus using chemical indexes: evolutionary tendencies

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Abstract: The chemical indexes, suggested by Gottlieb et al., have not been used before regarding evolutionary tendency of species in the *Swartzia* genus. However, the importance of this work encouraged for an analysis of the *Swartzia* genus using the metabolites isolated from nine species. The analysis, based on calculated chemical indexes, provided an evolutionary tendency for these plants, which correlates with the classification based on morphological analysis.

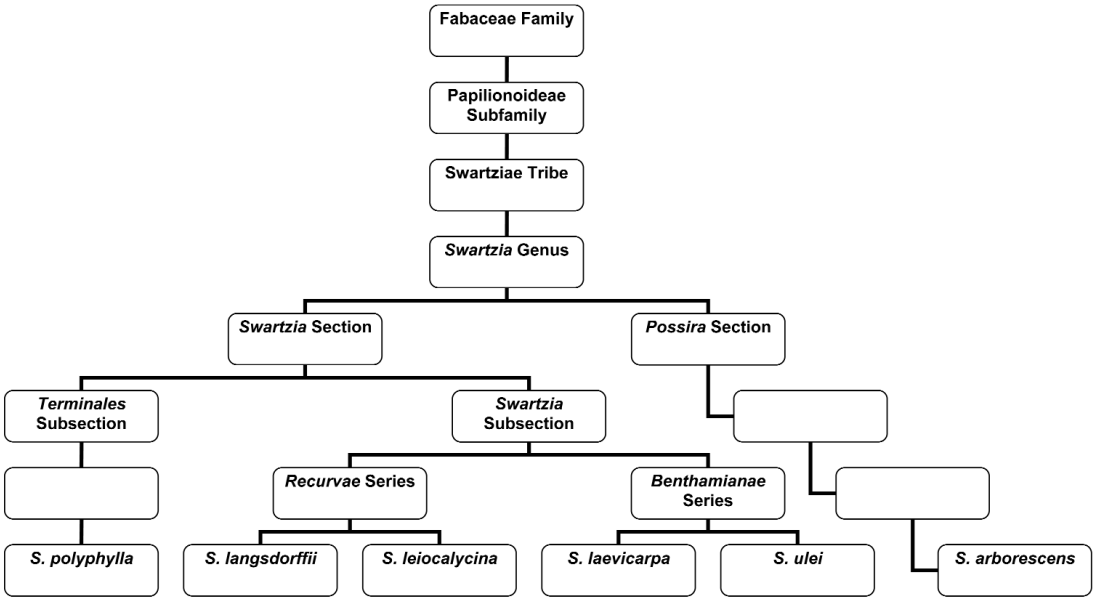
Keywords: Swartzia; Leguminosae; plant evolution; chemical index; chemotaxonomy.

Introduction

According to Gottlieb, among other authors, the profile of secondary metabolites in plants can be of taxonomic significance. Thus, chemotaxonomy correlates the profile of secondary metabolites in plants with the botanical classification based on the vegetal morphology. Gottlieb et al. developed a methodology to evaluate the evolutionary tendency of plants based on the biosynthetic route followed by their secondary metabolites as well as the degree of oxidation of these metabolites in each route [1].

The genus *Swartzia* Schreb. belongs to tribe Swartzieae, subfamily Papilionoideae (Faboideae) of the Leguminosae (Fabaceae), and consists of about 140 species distributed in tropical America [2]. However, only nine species of *Swartzia* genus have been studied from the phytochemical point of view: *S. arborescens, S. laevicarpa, S. langsdorffii, S. leiocalycina, S. madagascariensis, S. polyphylla, S. simplex, S. schomburkii* and *S. ulei*. Most of these studies are about the heartwood flavonoids. The leaves, fruits and seeds of three species were studied looking for saponins. In only two species, *S. arborescens* and *S. langsdorffii* were the roots chemically studied, producing abieta-8,11,13-triene diterpenoids [3].

The genus *Swartzia* was revised by Cowan [4], who recognized two sections, *Swartzia* sect. *Possira* (Aubl.) DC. and *Swartzia* sect. *Swartzia*. The species *S. arborescens* is in the section *Possira*, and the species *S. laevicarpa, S. langsdorffii, S. polyphylla,* and *S. ulei* are classified in the section *Swartzia*, which is divided into two subsection and seven series. *S. polyphylla* belongs to the subsection *Terminales* Cowan, which is more primitive. *S. leiocalycina* and *S. langsdorffii* are in the series *Recurvae* Cowan, the species *S. laevicarpa* and *S. ulei* are located in the series *Benthamianae* Cowan, that is more recent, Fluxogram 1. The species *S. madagascariensis* was reclassified and renamed as *Bobgunnia madagascariensis* [5].



Fluxogram 1. Botanical classification of *Swartzia* species which produced flavonoids and abietane diterpenoids.

In this paper the metabolites furnished by *S. langsdorffii* Raddi (Synonymous: *Mimosa pulchra* Vell., *Swartzia brasiliensis* Vogel and *Tounatea langsdorfii* (Raddi) Kuntze), a native Brazilian tree [2], included in *Swartzia* ser. *Recurvae* of the section *Swartzia,* were compared with those of other *Swartzia* species reported in the literature in order to establish infrageneric chemotaxonomic correlations.

Experimental details

Comparing the secondary profile reported for *Swartzia* species it is possible to observe one group characterized by the presence of flavonoids and another one by the presence of abieta-8,11,13-triene diterpenoids. So, the presence of these classes of metabolites could be used, in addition to morphological data, to define the chemical profile

Table 1. Chemical indexes calculated for species of *Swartzia* [6] which produced flavonoids.

Section	Subsection	Series	Species	I_{Ox} [a]	I_{Me} [b]
Swartzia	*Terminales*		*S. polyphylla*	0,9	-2
	Swartzia	Benthamianae	*S. ulei*	5,0	2,0
			S. laevicarpa	4,0	1,5
		Recurvae	*S. leiocalycina*	4,0	1,5
S. madagascariensis (*B. mandagascariensis*)				2,0	1,6

[a] I_{Ox} = mean oxidation degree index

[b] I_{Me} = mean methylation degree index

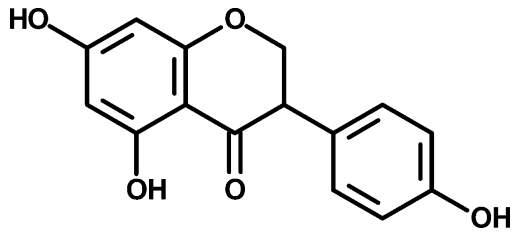


Figure 1. Flavonoid structure taken as biosynthetic precursor to calculate the chemical index.

in *Swartzia* sections: *Swartzia* sect. *Possira* characterized by abieta-8,11,13-triene diterpenoids while *Swartzia* sect. *Swartzia* by flavonoids. The triterpenoidal saponins could not be used as markers since they appear in both sections.

The flavonoids furnished by the species of *Swartzia* sect. *Swartzia* showed a great diversity, which was adequate to evaluate the evolution of these plants according to chemical indexes [6] based on the degree of mean oxidation versus methylation of the flavonoid skeleton (Table 1). The structure showed in Figure 1 was considered as the biosynthetic precursor to calculate the indexes. A higher oxidation versus methylation degree correlates with a higher degree of the plant evolution. *S. langsdorffii* was excluded because this plant produces abieta-8,11,13-triene diterpenoids [3] and do not produces flavonoids.

In the *Swartzia* sect. *Possira* only one species was considered, *S. arborescens* [7], and its metabolites were compared to the metabolites isolated from *S. langsdorffii,* using the same proposed parameters [1], because they were very similar.

Results and Discussion

Section and subsection Swartzia:

Figure 2 shows the graph obtained for the correlation of the mean value of oxidation degree versus methylation degree of the flavonoids, calculated for each *Swartzia* species. Figure 3 shows the same correlation, excluding the species *S. madagascariensis*, which has been reclassified as *Bobgunnia madagascariensis*. A much better correlation is obtained.

The basal position of subsection

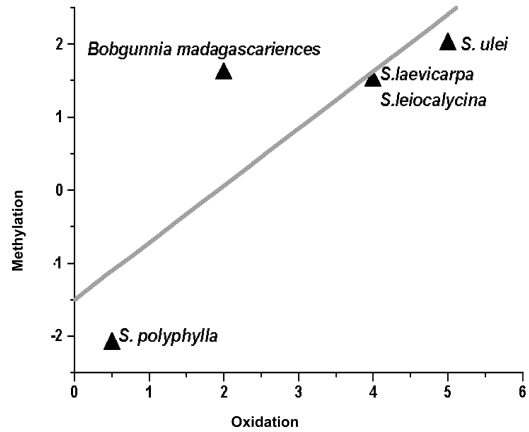


Figure 2. Evolutionary tendencies observed for species belonging to section *Swartzia* subsection *Swartzia* which produces flavonoids.

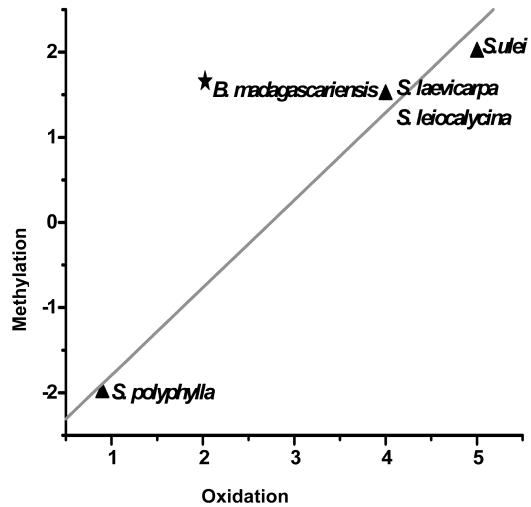


Figure 3. Evolutionary tendencies observed for species belonging to section *Swartzia* subsection *Swartzia* which produces flavonoids excluding *S. madagascariensis* (*Bobgunnia madagascariensis*).

Terminales was confirmed by the calculated indexes and by the position on the graphs.

Section Possira

In the section *Possira* the comparation of *S. arborescens* with *S. langsdorffii* led to three important evolutionary tendencies. The first is

that the presence of abietane diterpenoids, and the absence of flavonoids in these species indicate that these species have substituted the shikimate biosynthetic route by the acetate biosynthetic route, which means that these two species are, in the evolutionary sense, more recent than the species belonging to subsection *Swartzia*.

The second is that, based on *S. langsdorffii* morphology such as pattern venation, slender, auxiliary and shorter leaf raceme, calyx shape and androecium's characteristics, together with the presence of very similar abietane diterpenoids and the absence of flavonoids, *S. langsdorffii* is more related to the species of *Swartzia* sect. *Possira,* specifically to *S. arborescens,* suggesting the transfer of *S. langsdorffii* from section *Swartzia* to section *Possira*. The third is that *S. arborescens* is more recent than *S. langsdorffii* since its metabolites are more highly oxidized than the metabolites of *S. langsdorffii*.

Conclusions

The application of chemical indexes according to the methodology proposed by Gottlieb et al. [1, 6] confirmed that (1) *S. madagascariensis* (renamed *Bobgunnia madagascariensis*) should not be included in the *Swartzia* genus, and proposed that (2) *Swartzia langsdorffii* should be transfer to section *Possira*.

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A. F. Magalhães , A. M. G. A. Tozzi , C. C. Santos , E. G. Magalhães . Análise dos metabólitos de plantas do gênero *Swartzia* usando índices químicos: tendências evolutivas.

Resumo: Os índices químicos sugeridos por Gottlieb et al. não têm sido empregados com respeito à tendência evolutiva das espécies no gênero *Swartzia*. A importância desse trabalho, entretanto, motivou uma análise usando os metabólitos isolados de nove espécies. A análise baseada nos índices químicos forneceu uma tendência evolutiva para estas plantas que se relaciona com a classificação baseada na análise morfológica.

Palavras-chave: *Swartzia;* Leguminosae; evolução de plantas; índices químicos; quimiotaxonomia.

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