# A review of the *genus Crotalaria* L. (Crotalarieae, Fabaceae)

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***Abstract-*** A review of the genus *Crotalaria* is presented, the genus is one of the largest genera in angiosperms with ca. 700 species distributed globally. The main centre of biodiversity is Africa with ca. 540 species. Carolus Linnaeus was the first to describe the genus *Crotalaria;* he named 13 species in his Species Plantarum of 1753. The first infrageneric classification of the species within the genus was given by (Lamarck 1786), he divided the genus into two groups which are simple leaved group and trifoliate, digitate leaved group. Polhill gave an account of the history and development of the classification systems for African Species and reported eleven sections and seven sub sections based on vegetative and floral parts. Later Ansari accommodate Indian species and revise Polhll's classification, he reported nine sections. Recently, Le Roux used morphological and molecular data and reported global Infrageneric classification of the genus. She classified the species into eleven sections and raised some sub section of Polhill into sections due to non monophyly. This system is the one currently in use.

***Index Terms***- Crotalaria, Review, Infrageneric classification, Molecular data, Morphology.

## I. INTRODUCTION

The family Fabaceae taxonomically comprises of three subfamilies which includes Ceasalpiniodeae, Mimosoideae and Papilionoideae. The family is considered to be more closely related to Connaraceae and Sapindaceae based on anatomy, morphology and biogeographical distributions (Polphil and Raven 1981). The emergence of the three subfamilies is based on the floral parts which include the size and symmetry of the flower, arrangement of petals in the flower bud, having united or free sepals, number of stamens, presence of pleugram, embryo radicle shape and presence of rood nodules (Lewis *et al*., 2005). Based on the differences in the above mentioned characteristics, it is believed that Mimosoideae and Papilionoideae are unique distinct lineage in the family which arose independently within a paraphyletic basal caesalpiniod assemblage (Polhill, 1994).

Before the advent of family-wide molecular phylogenetic studies, Polhill (1994) in his last formal classification recognized 39 tribes, 670 genera and 16, 850 species within the family. After intensive research of more than 10 years in molecular phylogenetics studies of the family, the tribal and generic classification of the family has been updated which recognizes 36 tribes, 727 genera and 19, 327 species (Lewiz *et al*., 2005). The genera with 500 or more species within the family includes (*Acacia*, *Astragalus*, *Crotalaria* and *Indigofera*) and about 40 genera have 100 species or more, the family also contain nearly 500 genera that contain up to 10 species (Lewis *et al*., 2005).

There has been disagreement on whether the family Fabaceae should be treated as one (composed of Ceasalpiniodeae, Mimosoideae and Papilionoideae) or each sub family should be treated as individual family, evidence from morphology and molecules support the legumes being one monophyletic family. This view has been supported by recent molecular phylogenetic studies (Doyle *et al*., 2000; Kajita *et al*., 2001; Wojciechowski, 2003; Wojciechowski *et al*., 2004) showing strong support for a monophyletic group that is more closely related to Polygalaceae, Surianaceae and Quillajaceae, which together form the order Fabales (Sensu Angiosperm Phylogeny Group, 2003)

## II. TAXONOMIC HISTORY OF THE TRIBE CROTALARIEAE

The tribe Crotalarieae (Benth.) Hutch. is a member of the sub family Papilionoideae (Fabaceae) (Lewis *et al.*, 2005*)*. Members of Crotalarieae are monophyletic believed to have evolved from the tribe Liperieae (Goldblatt (981, Boatwright *et al*., 2008). It is the largest tribe within the paipilionoid legumes in Africa and also within the genistoid alliance, comprising about 51% of the genistoid legumes (Lewis *et al*., 2005). The reason why the tribe is large is because the genus *Crotalaria* which is a member in the tribe contains ca. 690 species (Polhill 1982). The tribe belongs to the core genistoids (Crisp *et al*., 2000) and currently comprises of 11 genera and ca. 1204 species (Van Wyk 2005) and ca 83% occurs in African continent and the other four genera (*Aspalathus* L., . Thunb., *Rafnia* Thunb. And *Wiborgia Thunb.*) occurs in the Cape Floristic Region (Van Wyk, 1991; Boatwright *et al*., 2008).

The members of the tribe occur largely in Africa, with some of the species like *Crotalaria*, *Lotonis* and *Rothia* occurring on other continents. *Aspalathu*, *Rafnia* and *Wiborgia* are endemic to the Cape Floristic Region, while the genus *Lebeckia* is widely distributed throughout the cape and extends to some parts of Namibia (Boatwright *et al*., 2008).

Polhill (1976) excluded the tribe Crotalarieae from Genistae (Adans.) Benth. *s.l.*, following an in depth study of Geniseae He excluded the tribe based on the presence of a stamina tube that is open along the upper side (forming a closed tube in the Genisteae s.s.). *Anarthrophyllum* Benth., *Dichilus* DC., *Melolobium* Eckl. and Zeyh. and *Sellocharis* Taub. were

also included in the Crotalarieae, but (Van Wyk and Schutte, 1995) moved back the genera to their previous tribe Genisteae.

Results from morphological, chemotaxonomic studies (Van Wyk and Schutte, 1995) and recently molecular systematic studies (Boatwright *et al*., 2008, 2009, 2011) lead to the change in the generic delimitations within the tribe. Some lineage are raised to generic status and some there is also some nomenclatural changes (Boatwright *et al.,*2008, 2011). Currently 16 genera in three valid clades are recognized.

The Cape clade comprises of seven genera which includes *Aspalathus*, *Wiborgia, Wiborgiella* Boatwr. and B.-E. van Wyk, *Calobota* Eckl. and Zeyh., *Lebeckia, Rafnia* and *Ezoloba* B.-E. van Wyk and Boatwr.

The *Lotonis* clade comprises of six general: *Lotonis* (D.C) Eckl. and Zeyh., *Leobordea* Del., *Listia* E. Mey., *Pearsonia* Dummer, *Robynsiophyton* R. Wilczek and *Rothia* Pers

The *Crotalaria* clade comprises of only three genera: *Euchlora* Eckl. and Zeyh., *Crotalaria L.*, and *Bolusia* Benth.

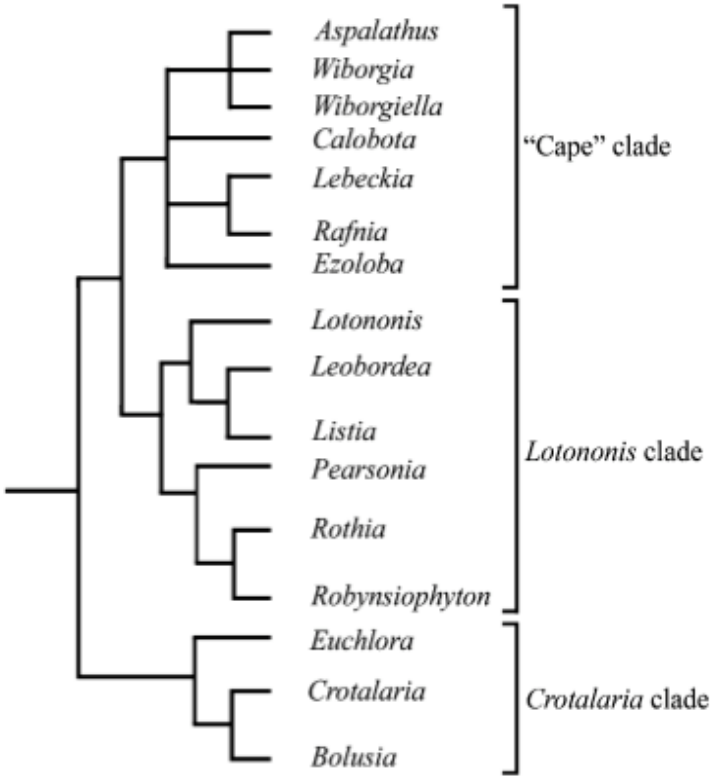


Figure 2. 1. A cladogram showing the relationships of the three clades and 16 genera from an analysis of combined morphological and molecular evidence (Boatwright *et al*., 2008 and Le Roux *et al.*, 2013)

Some of the species within the tribe are of important commercially such as *Aspalathus linearis*, which is used for the production of rooibos tea (Van Wyk *et al*., 1997), and *Lotonis bainesii* Bak., is used as important fodder for animals (Bryan 1961). While some of the species within genus *Crotalaria* and *Lotononis* have been reported to have medicinal properties (Van Wyk 2005) and a few species are in traditional medicine in Lesotho to cure or ease a broken heart (Moteetee and Van Wyk 2007), other species from the same genera are toxic (WHO, 1988)

## III. TAXONOMIC HISTORY OF THE GENUS CROTALARIA

Carolus Linnaeus was the first to described the genus *Crotalaria*, he named 13 species in his Species Plantarum of 1753 which are *Crotalaria perfoliata* L., *C. sagitalis* L., *C. juncea* L., *C. triflora* L., *C. villosa* L., *C. verrucosa* L., *C. lotifolia* L., *C. lunaris* L., *C. laburnifolia* L., *C. micans* L., *C. albanand* L. *C. quinquefolia* L. (Linnaeus 1753). The number of the species within the genus increased to 37 (Lamarck, 1786). De Candolle (1825) reported 137 species. Thereafter the numbers increased to the total of 700 species that is accounted for at present (Le Roux *et al*., 2013). The genus is listed as one of the fifty largest seed plant genera (Mabberley, 2008).

Detailed review of African species was given by (Baker, 1914), He revised and described 309 species in the continent. The most extensive study in the history of *Crotalaria* taxonomy was by (Polhill 1982), he conducted a thorough taxonomic revision on species in Africa and Madagascar where he reported 511 species. In Africa Thunberg (1823), reported 11 species from the Cape, South Africa. Similarly Harvey (1862) described 24 new species from the same region, which are now seen in other part of Africa (Le Roux *et al*., 2013). 21 species are enumerated from region of Empire of Ethiopia which comprises of Southern Egypt, Eastern Sudan, Yemen and Western Saudi Arabia by (Richard 1847). Verdoorn (1928) published a taxonomic revision of the genus where he recognized and reported 124 species in Southern Africa and South Tropical Africa, excluding Angola. Baker (1876) in his work on the genus in Tropical Africa, he treated 106 species. 24 species were collected in East Africa by Hildebrand and their description was published by (Vatke 1879). 24 years later, Taubert (1893) increases West African species to 56 in his publication. Milne-Redhead (1961) and polhil (1968, 1976) conduct an in depth studies and revised the species within the genus in East Tropical Africa and reported 199 species in the area, 56 species from the same region were also published by (Taulbert 1895). In Angola 62 new species were described by (Wilczek, 1953a), he also revised 189 species from the same country (Wilczek, 1953b).

Hepper (1958) revised the species of West Africa and reported 51 species and Da Torre (1960) described 36 new species and revised 138 species (1962) from the region, 26 species were treated in Namibia. In Ethiopia 85 species were treated (Thulin, 1983) similarly he reported enumerated 39 species in Somalia (Thulin, 1989). Du Puy and Labat (2002) conducted a research on Madagascar species and enumerated 53 species.

Roy and Sharon (2005) described and illustrated new species of the genus *Crotalaria mwangulangoi* from the Udzungwq Mountains, Tanzania.

Two new species of *Crotalaria*, *C. cupricola* Leteinturier and *C. serpentinicola* Leteinturier are reported from metallifeorus sites in Zimbabwe by (Leteinturier and Polhill 2003).

A new species known as *Crotalaria arrecta* Hemp and Polhill was reported from Kenya, the species was previously

confused with C. *rhizoclada* Polhill, the new species was described and illustrated by (Andreas and Polhill 2009). Odewo *et al*., (2015) reported 36 species in Nigeria in their studies on ecological distribution of the genus *Crotalaria* in Nigeria.

Several literatures have been reported from Asia continent. Wight and Walker-Arnott (1834) conducted taxonomic revision of Indian species and reported 58 species in the country. Roxburgh (1832) described 7 new species in his Flora Indica. Descriptions of 77 species in British India were published by (Baker, 1876). 15 species are listed in the Red Data Book of Indian Plants (Nayar and Sastry 1987). According to (Ansari, 2008; Sibichen and Nampy, 2007) *Crotalaria* is the largest Fabacea genus in India with 92 species. De Munk (1962) in his revision of Malaysian legume, he published a list of 38 species within the genus. Adema (2006) in his work on taxonomic treatment for Malaysian species, he published some notes on the species that are endemic in the country. Wu *et al*., (2003) reported 6 species in their study on herbarium records, actual distribution, and critical attributes of invasive plants: genus *Crotalaria* in Taiwan. A detailed description of 42 species that occurs in china was reported by (Jianqiang *et al*., 2010).
Lee (1979) investigate the species endemic to Australia and reported 7 species, while extensive studies on the native species was conducted by (Holland, 2002) and he reported 36 species in region.

Important literature from Western Hemisphere includes: revision of the new world species by (Humbold, *et al*., 1824) where they described nine new species. 32 species in Brazil were treated by (Bentham 1859); Andreia and Ana (2005) described and illustrated new species from Southeastern Brazil; Senn (1939) revised 31 species from North America and found that majority of the species are endemic to Mexico and West Indies. 12 unifoliate species were treated by (Windler 1974) from the same region; Windler and McLaughlin (1980) reported 11 species in the Panama region; nine newly species were reported by (Windler and Skinner, 1981) in America, they also described seven nomenclatural changes on the existing species.. *Crotalaria avonensis* DeLaney and Wunderlin was described for the first time as a new species from the xeric white sand scrub habitat of Highlands County, Florida by (Kris and Richard 1989). Lindsay and Michael (2012) reported 7 species in Alabama, in their studies: the genus *Crotalaria* (Fabaceae) in Alabama.

The genus have the following characters which include a rostrate keel, highly inflated fruit, a hairy style, a 5+5 anther configuration, paired callosities on the standard petal and the presence of macrocyclic pyrrolizidine alkaloids (Polhill, 1982, Van Wyk and Verdoorn, 1990; Van Wyk, 2005). The closely sister to crotalaria which is the genus *Bolusia* differs from *Crotalaria* by having a helically coiled keel with a single callosity restricted to the standard petal blade (Van Wyk *et al*., 2010; Le Roux and Van Wyk, 2012). While with the other sister *Euchlora* differs from *Crotalaria* by lacking standard petal callosities and also has an obtuse to somewhat rostrate keel beak (Le Roux and Van Wyk, 2012).

## IV. INFRAGENERIC CLASSIFICATION

The first infrageneric classification of the species within the genus was given by (Lamarck 1786), he divided the genus into two groups which are simple leaved group and trifoliate, digitate leaved group. Wight and Walker-Arnott (1834) used reproductive characters and reported 13 sub divisions with the two groups reported by Lamarck. Bentham (1843) used leaf shape and divided the genus into two groups which are simple leaved and trifoliate leaved, he further divided the simple leaved into seven sections and trifoliate leaved into 11 sections, this classification is similar to (Wight and Walker-Arnott 1834). Harvey (1862) maintained the simple leaved group and divides the species within the trifoliate group into *Oliganthe* and *Racemosae*, based on number of flower per raceme, thereby dividing the genus into three sections.

Baker (1876) followed Harvey system of classification and adopts it but used fruit shape, flower arrangement and excluded *Racemosae* and create four additional groups (*Chrysocalycinae*, *Sphaerocarpae*, *Oocarpae* and *Cylindrocarpae*). Four sections were created based on leaf character (*Simplicifoliae*, *Unifoliolatae*, *Trifoliolatae* and *Multifoliolatae*) by (Taubert 1893) following Bentham's classification. He also used vegetative and reproductive morphological characters to further divide the *Simplicifoliae* into seven series and *Trifoliolatae* into ten series. Baker (1914) adopted previous sections *Simplicifoliae*, *Sphaerocarpae* and *Chrysocalycinae* reported by (Baker 1876) and created three additional new sections and five subsections, the sections are *Spinosae*, *Farctae* and *Eucrotalaria* and the subsections are (*Grandifloraei*, *Mediocriflorae*, *Oliganthae*, *Parviflorae* and *Stipulasae*).

Harms (1915), Senn (1939) and Peltier (1959) adopted the previous system of classification which was based on leaf, but Harms (1917) modified the section *Chrysocalycinae*, He removed *C. niginas* from the section and placed it in the newly created section *Tetralobocalyx* Harms. Wilczek (1953b) is not satisfied with using leaf as a tool for sectional classification because some species have both unifoliolate and trifoliolate leaves, therefore he disagreed with previous classification systems. He erected seven groups using petiole length, presence or absence of stipules and their size, which he named the groups "Group I-VII".

Polhill (1968) is not satisfied with any of the classification systems, and he also reported the difficulty of infrageneric classification of the species within the genus. He gave an account of the history and development of the classification systems for African Species (Polhill, 1968), He used a combination of flower morphology, legume and bracteole shape and divided the genus into 11 sections and seven sub sections.

Bisby (1970, 1973) included 273 species and 52 characters that are similar to those used by Polhill (1968) which include floral characters, habit and stipule characters and conducted taximetric analyses. His findings were similar to that of Polhill's (1968) classification system. Data from Polhill (1968) and Bisby (1973) were combined for the infrageneric classification system and found some discrepancies that were re-evaluates (Bisby and Polhill, 1973). Their finding resulted to an improved classification system (Bisby and Polhill, 1973; Polhill, 1982) which comprised of eight sections and nine subsections. The sections are: *Grandiflorae*, *Chrysocalycinae*, *Incanae*, *Stipulosae*, *Hedriocarpae*, *Geniculatae*, *Schizostigma*, *Calycinae*, and *Crotalaria.*

Ansari (2008) used modified infrageneric classification system of (Wight and Walker-Arnott, 1834; Bentham, 1843 and Baker 1876) which are based on leaf and revised the taxonomy of Indian species. In his publication Ansari (2002) he reported nine sections and six subsections; which are not formally described. He considered Polhill's classification system and updated his previous system of 2002 using the same sections as Polhill (1982), but listed only sections that are in India and included six sections and 12 subsections (Ansari, 2006, 2008). In his work he recognized four subsection within section *Calycinae* and four subsection within the section *Crotalaria*

Le Roux *et al*., (2013) proposed sectional classification system for the entire genus for the first time based on morphological and morphometric studies and phylogenetic approach. Her new system comprises of eleven sections: *Amphitrichae*, *Calycinae*, *Crotalaria*, *Geniculatae*, *Glaucae*, *Grandiflorae*, *Hedriocarpae*, *Incanae*, *Schizostigma*, *Borealigeniculatae* and *Stipulosae*. She modified *Geniculatae*, *Calycinae* and *Crotalaria* sections. The subsections *Stipulosae*, *Glaucae* and *Incanae* are raised to sectional level, while some groups previously recognized as subsections are abandoned due to non-monophyly (subsections *Chrysocalycinae*, *Hedriocarpae*, *Macrostachyae* and *Tetralobocalyx*). Two new sections are recognized, *Amphitrichae* and *Borealigeniculatae*

## V. ECONOMIC IMPORTANCE OF CROTALARIA

*Crotalaria* species are annual shrubs very useful in agriculture (Magingo, 1992), as green manure and cover plants in plantations. They are also used as a source of diet for livestock. Many of the species are known to be nodulated with soil Rhizobia (Allen and Allen 1981, Faria *et al*., 1989) and they are also good in fixing atmospheric nitrogen. Sustainable crop production is achieved through the management of soil fertility and cover crops play a key role in soil fertility through a reduction in synthetic nutrients applied. Legumes are effective in the fixation of nitrogen and can accumulate large amounts of biomass that help to increase the nutrient availability and organic matter in the soil. Some of the long term benefits obtained from the use of cover crops include weed suppression through competition or allelopathy and possible insect control (Phatak *et al.*, 2002). While some species of *Crotalaria* are poisonous, others like *C. retusa*, *C. micronata*, *C. falcata* and *C. vogelii* remain some of the important fodder plants for cattle and small ruminants. (Nuhu *et al*., 2000) also reported that *Crotalaria* species are widely used in Zaria, Nigeria in feeding of sheep and cattle.

*Crotalaria* species are widely used in veterinary pharmacy in preventing liver disease (Nwude and Ibrahim, 1980, Nuhu, 1999). In Tanzania *Crotalaria comosa* Bak provides nitrogen to the crops intercropped with and assist in the control of weeds and nematodes (Mukurasi, 1986). The species within the genus like *Crotalaria recta* L. are used as food source by larvae of Lepidoptera species, the insect also used the plant as defense against their predators (Thomas 2003).

Cook and White (1996) revealed that *C. retusa* L. seeds as source of fibres, silage and green manure when removed from pods by pounding. According to Akintayo, (1997) oils derived from *Crotalaria bongensis* Bak, *C. naragutensis* Hutch and *C. lachnophora* Desu. Seeds are not suitable for use as edible oil and soap production but many however, are useful for the production of paint and shampoos. *Crotalaria* is also used in the treatment of diabetics (Pullaiah and Chandrasukha, 2008), skin infection, snake bit and stomach ache prevention (Verdhana, 2008).

## REFERENCES

[1] Allen, O.N. and E.K. Allen. (1981). The Leguminosae: a source book ofcharacteristics, uses and Andreas, J. H. and Roger, M. P. (2009). A new species of Crotalaria (Leguminosae) from Kenya. Systematic and Geography of Plant 79 (1):97-101.

[2] Andreia, S. F. and Ana M. G. de A. T. (2005). A new species of Crotalaria(Leguminosae, Papilionoideae) from Southeastern Brazil. Novon 15(3): 418-420.

[3] Ansari, A.A. (2002). Taxonomic studies on the genus Crotalaria L. in India. In: R.R. Rao and H.J. Chowdhary (ed), Advances in Legume Research in India. Dehra Dun: Bishan Singh Mahendra Pal Singh, pp.157-167.

[4] Ansari, A.A. (2006). Taxonomic studies on the genus Crotalaria L. in India– II: Infrageneric classification. Journal of Economic and Taxonomic Botany 30: 570–582.

[5] Ansari, A.A. (2008). Crotalaria L. in India. Dehra-Dunn: Bishen Singh Mahendra Pal Singh, 376p.

[6] Baker, E.G. (1914). The African species of Crotalaria. Journal of the Linnean Society Botany 42: 241–425.

[7] Baker, J.G. (1876). Crotalaria. In: J.D. Hooker (ed), Flora of British India. London: Reeve and Co Limited. Vol. 2. pp. 65-85.

[8] Baker, J.G. (1876). Crotalaria. In: J.D. Hooker (ed), Flora of British India. London: Reeve and Co Limited. Vol. 2. pp. 65-85.

[9] Bentham, G. (1843). Enumeration of the Leguminosae indigenous to southern Asia and central and southern Africa XV. Crotalaria. London Journal of Botany 2: 472–481, 559–593.

[10] Bentham, G. (1859). Crotalaria. In: C.F.P. De Martius (ed), Flora Brasiliensis. Munich: R. Oldenbourg. Vol.15. pp.17-32.

[11] Bisby, F.A, and Polhill, R.M. (1973). The role of taximetrics in angiosperm taxonomy II. Parallel taximetric and orthodox studies in Crotalaria L. New Phytologist 72:727–742.

[12] Bisby, F.A. (1970). The evaluation and selection of characters in angiosperm taxonomy: An example from Crotalaria. New Phytologist 69: 1149–1160.

[13] Bisby, F.A. (1973). The role of taximetrics in angiosperm taxonomy I. Empirical comparisons of methods using Crotalaria L. New Phytologist 72: 699–726.

[14] Boatwright, J.S., Le Roux, M.M., Wink, M., Morozova, T. and Van Wyk, B.-E. (2008). Phylogenetic relationships of tribe Crotalarieae (Fabaceae) inferred from DNA sequences and morphology. Systematic Botany 33: 752–761.

[15] Boatwright, J.S., Tilney, P.M. and Van Wyk, B.-E. (2009). The generic concept of Lebeckia (Crotalarieae, Fabaceae): Reinstatement of the genera Colobota and the new genus Wiborgiella. South African Journal of Botany 75: 546-556.

[16] Boatwright, J.S., Wink, M. and Van Wyk, B.-E. (2011). The generic concept of Lotononis (Crotalarieae, Fabaceae): Reinstatement of the genera Euchlora, Leobordea and Listia and the new genus Ezoloba. Taxon 60: 161–177.

[17] Bryan, W.W. (1961). Lotonis bainesii Baker – a legume for subtropical pastures. Australian Journal of Experimental Agriculture and Animal Husbandry 1: 4-10

[18] Cook, G.C and White, G. A. (1996). Crotalaria juncea: A potential multi-purpose fibre crop. In: Janic (ed), A potential multipurposefiber crop. Arlington: ASHS pess, pp. 389-394.

[19] Crisp, M.D., Gilmore, S. and Van Wyk, B.E. (2000). Molecular phylogenetics of the genistoid tribes of papilionoid legumes. In: P.S. Herendeen and A. Brubeau (ed), Advances in Legume Systematics. Kew: Royal Botanical Gardens. Vol. 9. pp. 249-276

[20] Da Torre A.R. (1960). Taxa angolensia nova vel minus cognita. Junta de Investigacoes do Ultramar. Vol. 19. pp. 21-49

[21] Da Torre A.R. (1962). Crotalaria. In: A.W. Excell and A. Fernandes (ed), Conspectus Florae Angolensis. Lisboa: Junta de Investigacoes do Ultramar. Vol. 3. pp. 6-76.

[22] de Candolle, A.P. (1825). Prodromus Systematis Naturalis Regni Vegetabilis, Vol. 6. Paris: Crapelet, pp 340–437.

[23] De Munk, W.G. (1962). Prelimary revisions of some genera of Malaysian Papilionaceae III – a census of the genus Crotalaria. Reinwardtia 6:193–223.

[24] Doyle, J. J., Chappill, J. A. Bailey, C. D. and Kajita, T. (2000). Towards a comprehensive phylogeny of legumes: evidence from rbcL sequences and non-molecular data. In: P.S. Herendeen and A. Bruneau (ed), Advances in legume systematic. Kew: Royal Botanic Gardens. Vol 9. pp. 1-20.

[25] Du Puy, D.J. and Labat, J-N. (2002). 3. Crotalaria. In: D.J. Du Puy (ed), The Leguminosae of Madagascar. Kew: Royal Botanic Gardens, pp. 672-708.

[26] Faria, S.M. De, G.P. Lewis, J.I. Sprent and J.M. Sutherland. (1989). Occurrence of nodulation in Leguminosae. New Phytol., 111: 607-619

[27] Goldblatt, P. (1981). Cytology and the phylogeny of Leguminosae. In: R.M. Polhill and P.H. Raven(ed), Advances in Legume Systematics. Kew: Royal Botanical Gardens. Vol. 2. pp. 427 – 463.

[28] Harms, M.H. (1917). Leguminosae africanae IX. In: A. Engler (ed), Botanische Jahrbucher 54: 379-384.

[29] Harms, W.H. (1915). Leguminosae. In: A. Engler (ed), Die Pflanzen. Afrikas. Leipzig: Wihelm Engelmann. Vol. 3. pp. 327-968.

[30] Harvey, W.H. (1862). Leguminosae. In: W.H. Harvey and O.W. Sonder (ed), Flora Capensis. Dublin: Hodges, Smith, and Co. Vol. 2. pp. 39-47.

[31] Harvey, W.H. (1862). Leguminosae. In: W.H. Harvey and O.W. Sonder (ed), Flora Capensis. Dublin: Hodges, Smith, and Co. Vol. 2. pp. 39-47.

[32] Hepper, F.N. (1958). Papilionaceae, Crotalaria. In: R.W.J. Keay (ed), Flora of West Africa. London: Crown Agents, pp.544-553.

[33] Holland, A.E. (2002). A review of Crotalaria L. (Fabaceae: Crotalarieae) in Australia. Austrobaileya 6: 293-424.

[34] Humboldt, F., Bonpland, A., Kunth C. (1824). Voyage aux regions equinoctials du Noveau Continent. Nova Genera et Species Plantarum 6: 397-406.

[35] Jianqiang, L., Sun, H., Polhill, R.M. and Gilbert, M.G. (2010). Crotalarieae: Crotalaria. In: Z.Y. Wu, P.H. Raven, D.Y. Hong (ed), Flora of China 10 (Fabaceae). Beijin: Science Press and St. Louis: Missouri Botanical Garden Press, pp.105-117.

[36] Kajita, T., Ohashi, H., Tateishi, Y., Bailey, C. D. and Doyle, J. J. (2001). rbcL and legume phylogeny, with particular reference to Phaseoleae, Millettieae, and allies. Systematic Botany 26: 515-536.

[37] Kris, R. D. and Richard, P. W. (1989). A new species of Crotalaria (Fabaceae) from the florida central ridge. SIDA (13)3:315-324.

[38] Lamarck J.B.A.P.M. de (1786). Encyclopedie Methodique. Botanique Vol. 2. Paris: Panckoucke, 774p.

[39] Le Roux, M.M. & Van Wyk, B.-E. (2012). The systematic value of flower structure in Crotalaria and related genera of the tribe Crotalarieae (Fabaceae). Flora 207: 414–426.

[40] Le Roux, M.M. & Van Wyk, B.-E. (2013). A taxonomic revision of Amphitrichae, a new section of Crotalaria (Fabaceae). Systematic Botany 38: 638–652.

[41] Lee, A.T. (1979). Some species of Crotalaria in Australia. Telopea 1: 319-356.

[42] Leteinturier, B. & Polhill, R. (2003). Two New Species of Crotalaria (Fabaceae) from Metalliferous Sites in Zimbabwe Syst. Geogr. Pl. 73(2) Page 287.

[43] Lewis, G., Schrire B., Mackinder B. and Lock, M. (2005). Legumes of the world. Kew: Royal Botanical Gardens, 577p.

[44] Lindsay, D. L. and Michael W. (2012). The genus Crotalaria (Fabaceae) in Alabama. The Journal of the Southern Appalachian Botanical Society 77(4): 364-374.

[45] Linnaeus C. (1753). Species Plantarum. Stockholm: Laurentius Salvius, 1200p.

[46] Mabberley D.J. (1987). Mabberley's plant-book (ed. 3, 2008). Cambridge: Cambridge University Press.

[47] Magingo, F.S.S. (1992). CrotaIaria ochroleuca a promising biofertiliser for the small-scale african farmer. ABN Symposium on Biotechnology for Rapid Development in Africa, Nairobi, February 17-21.

[48] Milne-Redhead, E. (1961). Miscellaneous Notes on African Species of Crotalaria L. Kew Bulleting 15: 157-167.

[49] Moteetee, A.N and van Wyk B.E.. (2007). The concept of Musa-pelo and the medicinal use of shrubby legumes (Fabaceae) in Lesotho. Bothalia 37: 75-77.

[50] Mukurasi, N.J. (1986), Agricultural attributes of Crotalaria zanzibaries, UgoleAgric Centre, Mbeya 6 Tanzania. Journal of Agricultural Research 47(2): 617-625.

[51] Nayar, M.P. and Sastry, A.R.K. (1987). Red data book of Indian plants, Botanical Survey of India, Calcutta. Vol. 1.

nodulation. The University of Wisconsin Press, Madison.

[52] Nuhu H. (1999). Pharmacognostic evaluation and toxicity studies of three Crotalaria species (Leguminosae). Ph.D Thesis. Dept. of Pharmacognosy and Drug Development. Ahmadu Bello University, Zaria.

[53] Nuhu, H., Shock M., Abdurahman, E.M. and Ibrahim, N.D.G. (2000). Alkaloids composition and toxicity studies of three Nigerian Crotalaria species. Nigeria Journal of Natural Products and Medicine 4(1): 43-45.

[54] Nwude, N. and Ibrahim M.A. (1980). Plants used in traditional veterinary practice in Nigeria. Journal of veterinary Pharmacology and Therapeutics 72(12): 1294-1296.

[55] Odewo, S.A., Ajani, B. A., Soyewo. L.T, Omiyale O. A. (2015). Ecological Distribution Of The Genus Crotalaria In Nigeria. International Journal of Scientific and Technology Research. 4(8): 348-355

[56] Peltier, M.A.G. (1959). Notes sur les Legumineuses-Papilionoidees de Madagascar et dos Comores I – Le genre Crotalara L. Journal D'Agriculture Tropicale Et De Botanique Appliquee 6:185-486.

[57] Phatak, S.C., Dozier, J.R., Bateman, A.G., Brunson, K.E. and Martini, N.L. (2002). Cover Crops and Conservation Tillage in Sustainable Vegetable Production. Proceedings 25th Annual Southern Conservation Tillage Conference for Sustainable Agricultural Aubum, AL 24 – 26 June 2002. Special Report No. 1. Alabama Agricultural Experiment Station and Aubum University, AL.

[58] Polhill, R. M. (1994). Classification of the Leguminosae. In: F. A. Bisby, J. Buckingham, and J. B. Harborne (ed), Phytochemical Dictionary of the Leguminosae. New York: Chapman and Hall.

[59] Polhill, R. M., and Raven P. H. (1981). Advances in legume systematics, parts 1 and 2. Kew: Royal Botanic Gardens.

[60] Polhill, R.M. (1968). Miscellaneous notes on African species of Crotalaria L. Kew Bulletin 22: 169 – 348.

[61] Polhill, R.M. (1976). Genisteae (Adans.) Benth. and related tribes (Leguminosae). In: V.H. Heywood (ed), Botanical systematic. London: Academic Press. Vol. 1. pp. 143-368

[62] Polhill, R.M. (1976). Genisteae (Adans.) Benth. and related tribes (Leguminosae). In: V.H. Heywood (ed), Botanical systematic. London: Academic Press. Vol. 1. pp. 143-368

[63] Polhill, R.M. (1982). Crotalaria L. in Africa and Madagascar. Kew:Royal Botanical Garden, 389p.

[64] Polhill, R.M. (1982). Crotalaria L. in Africa and Madagascar. Kew:Royal Botanical Garden, 389p.

[65] Polhill, R.M. (1982). Crotalaria L. in Africa and Madagascar. Kew:Royal Botanical Garden, 389p.

[66] Pullaiah, T.C. and.Chandrasukha, N.K. (2008). Antidiabetic plants in India and herbal based research. New Delhi: Regency publication, 125p.

[67] Richard, A. (1847). Tentamen Florae Abyssinicae 1. Paris: A. Bertrand.

[68] Roxburgh, W. (1832). Flora Indica. Serampore: W. Thacker, 745p.

[69] Roy, E. G. and Sharon, B. (2005). Crotalaria mwangulangoi (Fabaceae, Faboideae), a New Species from the Udzungwa Mountains, Tanzania. Novon. 15(2): 286-289.

[70] Senn, H.A. (1939). The North American Species of Crotalaria. Rhoda 41: 317-367.

[71] Sibichen, M.T and Nampy, S. (2007). Crotalaria kurisumalayana Sibichen & Nampy (Fabaceae), a new species from India. Candollea 62(1):105–108.

[72] Taubert, P. (1893). Crotalaria. In A. Engler and K. Prantl (ed), Die Naturlichen Pflanzanfamilien III. Leipzig: W. Engelmann, pp. 177-180.

[73] Thomas, E. (2003). For the love of insects. London: Belknap Press. 324p.

[74] Thulin, M. (1983). Leguminosae of Ethiopia. Opera Botanica 68: 154-178.

[75] Thulin, M. (1989). Crotalaria L. In: M. Thulin (ed), Flora of Somalia. Kew: Royal Botanic Gardens. Vol.1. pp. 447-458.

[76] Thunberg, C.P. (1823). Flora Capensis (ed. Schultes JA). Litteris Uppsala, J.F. Edman

[77] Van Wyk, B.-E. & Verdoorn, G. (1990). Alkaloids as taxonomic characters in the tribe Crotalarieae (Fabaceae). Biochemical Systematics and Ecology 18: 503–515.

[78] Van Wyk, B.-E. (1991). A review of the tribe Crotalarieae (Fabaceae). Contr. Bolus Herb. 13: 265-288.

[79] Van Wyk, B.-E. (2005). Tribe Crotalarieae. In: G. Lewis, B. Schrire, B. Mackinder and M. Lock, (ed), Legumes of the World. Kew: Royal Botanic Gardens, pp. 273–281.

[80] Van Wyk, B.-E. and Schutte, A.L. (1995). Phylogenetic relationships in the tribes Podalyrieae, Liparieae and Crotalarieae. In: M. Crisp and Doyle J. Doyle (ed), Advances in legume systematic. Kew: Royal Botanic Gardens. Vol. 7. pp. 283–308.

[81] Van Wyk, B.E., van Oudshoorn, F., and Gerickle. N.. (1997). Medicinal Plants of South Africa. Pretoria: Briza Publications.

[82] Van Wyk, B.-E., Venter, M. & Boatwright, J.S. (2010). A revision of the genus Bolusia (Fabaceae, Crotalarieae). South African Journal of Botany 76: 86–94.

[83] Vardhana, R. (2008). Direct uses of medicinal plants and their identification. New Delhi: Sarup and Sons publication.

[84] Vatke, W. (1879). Plantas in itinere africano ab J.M. Hildebrandt collectas. Osterreichische Botanische Zeitschrift 28: 218-220.

[85] Verdoorn, I.C. (1928). A revision of the Crotalaria s of South and South-East Tropical Africa. Bothalia 2: 371-420.

[86] W.H.O. (1988). Guidelines for the practice of traditional medicine TRM/Geneva.

[87] Wight, R. and Walker-Arnott, G.A. (1834). Prodromus Florae Peninsulae Indiae Orientalis. London: Parburry, Allen and Co.

[88] Wilczek, R. (1953a). Papilionaceae Genisteae Congolanae Novae (Robynsiophyton, Crotalaria, Argyrolobium). Bulletin du Jardin Botanique de IEtat a Bruxellest 23: 125-211.

[89] Wilczek, R. (1953b) Crotalaria. In: W. Robyns, P. Staner, F. Demaret, R. Germain, G. Gilbert, L. Hauman, M. Homes, F. Jurion, J. Lebrun, M. Van den Abeele and R. Boutique (ed), Flore du Congo Belge et du Ruanda-Urundi Vol. 4. Brussels: Institut National pour I'Etude Agronomique du Congo belge, pp. 43-273.

[90] Windler, D.R. (1974). A systematic treatment of the native unifoliolate Crotalaria of North America. Rhodora 76: 151-204.

[91] Windler, D.R. and McLaughlin, L. (1980) Flora of Panama, part V. Family 83. Leguminosae. Subfamily Papilionoideae. Annals of the Missouri Botanical Gardens 67: 599-613

[92] Windler, D.R. and Skinner, A.G. (1981). New taxa and new combinations in the American Crotalarias (Fabaceae). Phytologia 50: 185-206.

[93] Wojciechowski, M. F. (2003). Reconstructing the phylogeny of legumes (Leguminosae): an early 21st century perspective. In: B. B. Klitgaard and A. Bruneau (ed), Advances in Legume Systematics, part 10, higher level systematic. Kew: Royal Botanic Gardens, pp. 5-35.

[94] Wojciechowski, M. F., Lavin, M. and Sanderson, M. J. (2004). A phylogeny of legumes (Leguminosae) based on analysis of the plastid matK gene resolves many well-supported subclades within the family. American Journal of Botany 91: 1846-186.

[95] Wu, S., Shu-Miaw, C. and Marcel, R. (2003). Naturalized Fabaceae (Leguminosae) species in Taiwan: the first approximation. Botanical Bulletin of Academia Sinica 44:59-66.

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