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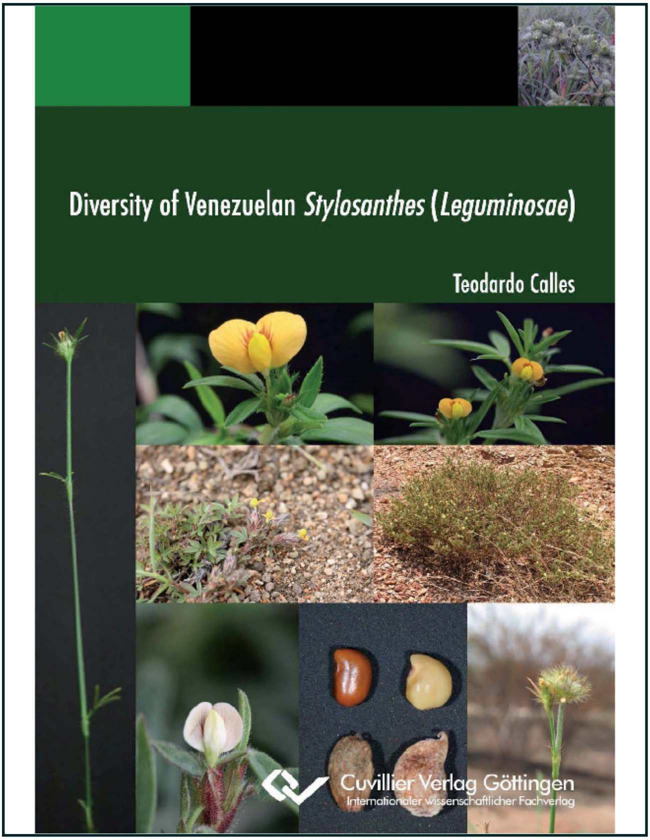
Diversity of Venezuelan Stylosanthes (Leguminosae)



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1. Introduction

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State of the art

Stylosanthes Sw. is a mainly Neotropical legume genus which comprises about 25 species (Klitgaard & Lavin 2005) of annual, biennial, and perennial herbs and sub-shrubs inhabiting tropical, subtropical and warm-temperate regions. In the Americas, *Stylosanthes* species are distributed from New York State, USA, to Santa Fe Province, Argentina, *i.e.*, from approximately 41° N to 36° S (Williams *et al.* 1984). Outside the Americas, only *S. fruticosa* (Retz.) Alston (including *S. suborbiculata* Chiov. see Thulin 1993), *S. erecta* P. Beauv. and *S. sundaica* Taub. have been reported (Nooteboom 1960; Mannetje 1984).

As long ago as 1914 the potential of *Stylosanthes* species for improving tropical grassland was recognised in Australia after the accidental introduction and subsequent naturalisation of *S. humilis* Kunth into northern Australia in the 1900s (Edye 1997). In the late 1940s, Australian scientists were the first who started to systematically collect *Stylosanthes* germplasm aiming at the development of new cultivars (Hartley 1949). Later, other important germplasm collections were carried out in tropical America by the International Center for Tropical Agriculture (CIAT), Empresa Brasileira de Pesquisa Agropecuária (Embrapa), Empresa de Pesquisa Agropecuária de Minas Gerais (EPAMIG) and the Agricultural Research Center of the University of Florida (Schultze-Kraft *et al.* 1984). *Stylosanthes* germplasm collection and subsequent evaluation and characterisation resulted in the release of a number of cultivars, thus giving the genus worldwide importance (Edye 1997). Since some species are adapted to marginal production conditions, the genus is perceived as one of the most important tropical forage legumes (Burt *et al*. 1983; Stace & Edye 1984; Chakraborty 2004). There are about 25 species, among them the well-researched *S. capitata* Vogel, *S. guianensis* (Aubl.) Sw., *S. hamata* (L.) Taub., *S. humilis*, *S. scabra* Vogel, and *S. macrocephala* M.B. Ferreira & Sousa Costa.

South America is considered as the main centre of diversity of *Stylosanthes* species (Gama-López *et al.* 2007) and its centre of origin probably lies in this sub-continent (Williams *et al.* 1984). Venezuela has a high *Stylosanthes* species richness and 12 species have been reported in the country, namely *S. capitata*, *S. diartha* S.F. Blake, *S. gracilis* Kunth, *S. guianensis*, *S. hamata*, *S. humilis*, *S. mexicana* Taub., *S. nervosa* J.F. Macbr., *S. scabra*, *S. sericeiceps* S.F. Blake, *S. tuberculata* S.F. Blake and *S. viscosa* (L.) Sw. (Pittier 1944; Mohlenbrock 1957; Rodríguez 1981). However, until now the taxonomic status of some of these species remains unclear.

The current importance of *Stylosanthes* is reflected by the numbers of released cultivars. So far, there are 38 formally and informally released cultivars, mainly within the well-researched species (Barnard 1972; CIAT 1972; Oram 1990; Williams *et al.* 1993; Tarawali *et al.* 1998; Loch & Ferguson 1999; Verzignassi & Fernandes 2001; Guodao *et al.* 2002; Guodao *et al.* 2004; Cook *et al.* 2005). Some of them, however, have never been used to any significant extent. Currently, there are no other legume genera with such a large number of released cultivars for purposes other than grain production (*e.g.*, forage, soil cover, soil improvement) (Loch & Ferguson 1999).

According to a recent survey on *Stylosanthes* (Chakraborthy 2004), the genus *Stylosanthes* is economically important in Australia where some locally adapted cultivars have been developed and are used for improving native grasslands and in ley farming. The genus is also important in Asia, particularly in Southern China where it is used in mixed grass-legume pastures for grazing, as a source of quality hay and leaf meal, and as a cover crop in fruit plantations. In India, different *Stylosanthes* species are used as fodder crops, in silvopastoral systems and for revegetation of degraded land. Cultivar Verano (*S. hamata*) and germplasm accession CIAT 184 (*S. guianensis*) are important species in Thailand where they are used for improving communal grazing land, in mixed pastures and in cut-and-carry systems. In West Africa, although adoption is yet limited, *S. guianensis* and *S. hamata* have increasingly been used in fodder banks and as improved fallow. In South America, *Stylosanthes* technology has been poorly adopted; Brazil is the only country where the genus is used, to some extent, in protein banks, mixed grass-legume pastures for grazing, and for recuperation of degraded pastures.

In Venezuela, germplasm of *Stylosanthes* species was systematically collected between 1973 and 1983 within a collaborative project between CIAT and Instituto Nacional de Investigaciones Agrícolas (INIA, formerly known as Fondo Nacional de Investigaciones Agropecuarias, FONAIAP) (Flores & Schultze-Kraft 1994). Part of this germplasm was used to conduct multilocational evaluations through the International Network of Tropical Pastures Evaluation (RIEPT, its Spanish acronym) (Nores 1983). One result of these evaluations was cultivar Capica, released in Colombia by the Instituto Colombiano Agropecuario (ICA). This cultivar was introduced in Venezuela and promoted as "Alfalfa Criolla" (Flores & Rodríguez 1998) for use as forage (Fig. 1, left) and cover crop (Fig. 1, right). However, adoption has been low and currently only few farmers use *S. capitata* in mixed grass-legume pastures for grazing (A. Flores, pers. comm.). Nevertheless, Venezuela seems to have an important role in future *Stylosanthes* technology development as shown by *S. hamata* cv. Verano, which originates from the country, and is nowadays one of the most widely used *Stylosanthes* species worldwide (Chakraborty 2004).

Taxonomy and nomenclature

Stylosanthes species have a high morphological plasticity, which leads to uncertainties regarding species delimitation. Differences among *Stylosanthes* taxonomical revisions are based on the respective author's species concept, *i.e.*, floral morphology (Mohlenbrock 1957, 1963; Mannetje 1984) *versus* vegetative characters (Pittier 1944; Ferreira & Costa 1979). An example of these different viewpoints is the so-called *Stylosanthes guianensis* complex where most members are treated as separate species by Ferreira and Costa (1979) and as varieties by Mannetje (1984).

Fig. 1. Mixed pasture of *Brachiaria brizantha* and *Stylosanthes capitata* in Venezuela (left) and *S. capitata* used as cover crop in a mango plantation in eastern Venezuela (right). Photographs by Rainer Schultze-Kraft.

Vogel (1838) divided the genus into two sections based in the presence or absence of a floral axis rudiment. Since then, there has been some controversy regarding the name of the sections and the generic type. Another nomenclatural problem, concerning a Venezuelan species, is that the name *S. gracilis* is placed by some authors at species level and by others at infra-specific level.

In the last two decades, scientists have started to use DNA data in an attempt to overcome the taxonomical problems of the genus *Stylosanthes*. Genetic markers such as

Random Amplified Polymorphic DNA (RAPD) (*e.g.*, Kazan *et al.* 1993a, b, c; Glover *et al.* 1994), Restriction Fragment Length Polymorphism (RFLP) (*e.g.*, Curtis *et al.* 1995; Liu & Musial 1995), and Amplified Fragment Length Polymorphism (AFLP) (*e.g.*, Sawkins *et al.* 2001; Jiang *et al.* 2005) have been used to yield DNA information. However, most of these studies concentrate on DNA data alone and do not consider morphological data. As emphasised by Stuessy and Lack (2011), botanical monographs that comprise taxonomy, distribution, ecology, nomenclature and evolutionary relationships, reveal relationships among species that should subsequently be tested by DNA analyses. Therefore, without botanical monographs there are no hypotheses to be tested. For this reason, botanical monographs are seen as cornerstones to understand plant and animal evolution. DNA studies should be viewed as a complementary tool to botanical monographs.

Importance of diversity studies

Biological diversity is drastically declining due to human activities like agriculture and urban development. In 1998, the Convention on Biological Diversity acknowledged that for the sound management of biodiversity, inventories based on a good understanding of taxonomy are needed and recognised that there are many taxonomic information gaps combined with a shortage of trained taxonomists (SCBD 2005). This so-called “taxonomic impediment” hinders the ability of decision makers to determine how to conserve biological diversity and sustainably use it. Therefore, more knowledge about the taxonomy and geographic distribution of most taxonomic groups is needed in order to reduce or remove this taxonomic impediment. Part of the latter is that most taxonomists are located in industrialised countries (where biological diversity is relatively low) and that in tropical countries with so-called megadiversity there is a shortage of expert taxonomists (Gaston & May 1992).

The study presented here attempts to contribute to the generation of knowledge about the diversity of an important tropical genus within the *Leguminosae* Juss. family, a plant group considered to be of particularly high importance for humankind (Lewis *et al.* 2005), focusing on Venezuela, one of the tropical megadiversity countries. Here, the main issues regarding conservation and sustainable use of *Stylosanthes* species are: (a) lack of an updated taxonomic revision and (b) the lack of biogeographical information about the genus, including species distribution and ecological conditions.

Aims of the research

The present study aims to: (a) make a taxonomic inventory of *Stylosanthes* species occurring in Venezuela, by means of a morphological analysis, (b) create an easy-to-handle identification key with illustrations of Venezuelan *Stylosanthes* species to facilitate identifications in the field, (c) document the geographic distribution of *Stylosanthes* in the country, (d) evaluate *Stylosanthes* species richness in Venezuela, and (e) assess delimitation of Venezuelan *Stylosanthes* species using both genetic markers and morphological characters.

Outline

Chapter 2 deals with the taxonomy and nomenclature of the genus *Stylosanthes* in Venezuela, including some contributions to solving nomenclatural problems beyond the Venezuelan species. The Chapter consists of four subchapters representing four published research articles. The first two describe new species whereas the third one re-establishes a *Stylosanthes* taxon at the species level, including its neotypification. The forth subchapter, supported by a comprehensive exsiccatae list, is a taxonomic revision of all eleven Venezuelan *Stylosanthes* species and includes a key and illustrations.

In Chapter 3, geo-referenced information is used to show the geographic distribution of Venezuelan *Stylosanthes* as well as the species richness in the country. Information about the climate was compiled to identify environmental preferences of the species. In addition, a rarity classification of Venezuelan *Stylosanthes* species is presented. The Chapter ends with the formulation of a hypothesis on the historical biogeography of the genus *Stylosanthes.*

Chapter 4 deals with the delimitation of Venezuelan *Stylosanthes* species using both genetic markers and morphological characteristics.

Chapter 5 consists of concluding remarks and an analysis of future research needs for the genus in Venezuela.

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