

**Taxonomy and invasive potential of the Cassiinae in southern Africa
(Caesalpinioideae, Fabaceae)**

by

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Signed this day...05 May.... of ...2019.....at...University of the Western Cape.

Signature:

.....

DEDICATION

I dedicate my dissertation to my beloved parents Rendani Elsie and Dowelani Bethuel Musandiwa, who always believed, encouraged and supported me throughout my studies.

To my grandmother, Mushaisano Phaswana, and to my late grandmother, Tshavhungwe Nemaguvhuni Musandiwa, who raised me to be the person that I am today.



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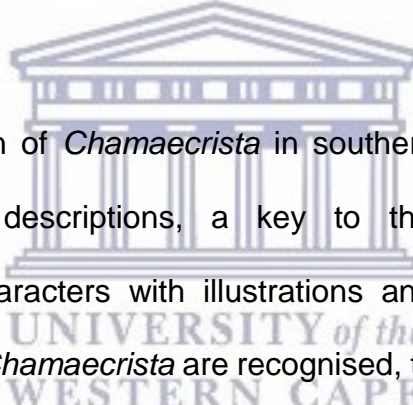
ABSTRACT

Cassiinae is a large subtribe of the tribe Cassieae (Caesalpinioideae) that comprises ca. 700 species distributed throughout the Americas, Africa, Eurasia and Australia. The southern African species of Cassiinae (indigenous, naturalised and cultivated) were all treated under *Cassia* L. in Gordon-Gray's (1977) treatment for the Flora of southern Africa. However, given the subsequent generic recircumscriptions in the subtribe and the expansion of collections of these taxa since, this treatment is now outdated. The aim of the present study was to provide an overview of the subtribe Cassiinae in southern Africa, assess the invasive potential of all naturalized species (viz. *Cassia* s.s., and *Senna* Mill.) and conduct a detailed taxonomic revision of the species of *Chamaecrista* (L.) Moench. indigenous to southern Africa.

Extensive fieldwork was carried out to study the taxa in their natural environment and morphological characters were studied using herbarium material from BNRH, NBG (including SAM), NH, NU, PRE and WIND. The invasion risk of sixteen Cassiinae species naturalized to southern Africa was evaluated using the risk analysis framework developed in South Africa and Australian Weed Risk Assessment. Of these, 15 species (94%) were shown to have a high risk of invasion in southern Africa. Evidence from this study suggested that eight species (*Cassia fistula* L., *Senna alata* (L.) Roxb., *S. corymbosa* (Lam.) H.S.Irwin & Barneby, *S. multiglandulosa* (Jacq.) H.S.Irwin & Barneby, *S. multijuga* (Rich.) H.S.Irwin & Barneby, *S. obtusifolia* (L.) H.S.Irwin & Barneby, *S. spectabilis* (DC.) H.S.Irwin & Barneby, and *S. surattensis* (Burm.f.) H.S.Irwin & Barneby) should be listed as Category 1a under the National Environment Management: Biodiversity (NEM:BA) Alien and Invasive Species (A&IS) regulations. Six species (*Senna bicapsularis* (L.) Roxb., *S. didymobotrya* (Fresen.) H.S.Irwin & Barneby, *S. hirsuta* (L.) H.S.Irwin & Barneby, *S. occidentalis* (L.) Link, *S.*

pendula var. *glabrata* (Vogel) H.S.Irwin & Barneby and *S. septemtrionalis* (Viv.) H.S.Irwin & Barneby) should be listed under 1b and only one species (*Senna siamea* (Lam.) H.S.Irwin & Barneby) is recommended for listing under Category 3.

The two core barcoding regions (*rbcLa* and *matK*) were sequenced for invasive *Cassia* and *Senna* species to establish a DNA library. This library will facilitate the identification process of invasive species each time the morphology-based identification is problematic, time consuming or doubtful. In addition an electronic key, together with accurate descriptions, known geographical distributions (both native range and southern Africa invasive range) as well as notes on environmental and invasion risk were compiled for all *Cassia* and *Senna* taxa currently found in southern Africa.



A taxonomic revision of *Chamaecrista* in southern Africa is also presented, including comprehensive descriptions, a key to the species, nomenclature, typifications, diagnostic characters with illustrations and geographical distribution maps. Thirteen species of *Chamaecrista* are recognised, three of which are described as new, i.e. *Chamaecrista grandiglandulata* Musandiwa & Boatwr., *C. gordon-grayei* Musandiwa & Boatwr. and *C. falcata* Musandiwa & Boatwr. In addition, one new subspecies is described, namely *C. gordon-grayei* Musandiwa & Boatwr. subsp. *longipedicellata* Musandiwa & Boatwr., and *Chamaecrista comosa* E.Mey. var. *capriconia* Stayaert is raised to the rank of subspecies viz. *Chamaecrista comosa* E.Mey. subsp. *capriconia* (Stayaert) Musandiwa & Boatwr.

Finally, the placement of the southern African species of *Chamaecrista* was evaluated against a global phylogeny for the genus and confirms its monophyly. The southern Africa species of *Chamaecrista* are closely related to one other and are

placed together with some South American species related to *Chamaecrista nictitans* (L.) Moench.



CHAPTER 1

GENERAL INTRODUCTION AND OBJECTIVES OF THE STUDY

1.1 General introduction

Fabaceae (bean or pea family) is the third largest family of flowering plants, and comprises ca. 770 genera and ca. 19 325 species (Lewis et al., 2005; LPWG, 2013, 2017). The family is well represented in many parts of the world (Lewis et al., 2005), including the Flora of southern Africa (FSA) (Koekemoer et al., 2014). The phylogeny of legumes has been the focus of several studies across the globe (Doyle et al., 2000; Wojciechowski, 2003; Cardoso et al., 2012; LPWG, 2013, 2017). Traditionally Fabaceae was divided into three subfamilies, i.e. Caesalpinioideae, Mimosoideae and Papilionoideae, but these were recently increased to six by the Legume Phylogeny Working Group (LPWG, 2017) due to the polyphyly of Caesalpinioideae demonstrated by DNA sequence data. The currently recognised subfamilies are Caesalpinioideae, Cercidoideae, Detarioideae, Dialioideae, Duparquetioideae, and Papilionoideae (LPWG, 2017). In its revised circumscription the subfamily Caesalpinioideae comprises 148 genera and ca. 4400 species world-wide (LPWG, 2017).

Within Caesalpinioideae, the large subtribe Cassiinae comprises ca. 700 species distributed throughout the Americas, Africa, Eurasia and Australia (Irwin and Barneby, 1982; Bruneau et al., 2001; Herendeen et al., 2003; Lewis, 2005). The species of Cassiinae were at one time all treated within the genus *Cassia* L. (Irwin and Barneby, 1981). However, Irwin and Barneby (1982) in their revision of Cassiinae in the New World divided *Cassia* into three genera, *Cassia* s.s., *Chamaecrista* (L.) Moench., and *Senna* Mill. This classification and subdivision of *Cassia* was supported by the phylogenetic studies of Bruneau et al. (2001) and Herendeen et al. (2003), as well as several taxonomic studies (Randell, 1990; Dulberger et al., 1994; Singh, 2001). These

three genera were segregated based on differences in their androecia, pedicels and inflorescences (Irwin and Barneby, 1981, 1982). Subsequently, additional differences have been reported between the three genera, viz. seed ontogeny (De-Paula et al., 2012), carpels (De-Paula et al., 2007), leaflet number, dimensions and apices, foliaceous stipules, degree of hairiness of the sepals, shape of the petals, fruit shape and length (Saheed and Illoh, 2011), stigma orifices (Dulberger et al., 1994), floral development (Tucker, 1996) and extrafloral nectaries (Conceição et al., 2009).

Extrafloral nectaries are commonly found within Fabaceae (Gonzalez and Marazzi, 2018). These secretory structures produce carbohydrate rich secretions that attract ants and other arthropods which, in return, protect the plant against invertebrate predators (Weber and Keeler, 2012; Marazzi et al., 2013; Gonzalez and Marazzi, 2018). The morphology and location of the extrafloral nectaries on plants are exceptionally diverse (Marazzi et al., 2013) and taxonomically useful, especially within Fabaceae (Gonzalez and Marazzi, 2018). Extrafloral nectaries, typically found on the leaves and rarely on the pedicels (Marazzi et al., 2006), are an important taxonomic character for recognising series in the classification of *Senna* by Irwin and Barneby (1982). Extrafloral nectaries also play a key role in the separation of closely related species of *Chamaecrista* (Brenan, 1967). In this genus they vary widely in their shape and size (i.e. sessile, subsessile or raised on short stalk or well developed stalk) (Brenan, 1967; Gordon-Gray and Schorn, 1975; Gordon-Gray, 1977; Brummitt et al., 2007). In contrast extrafloral nectaries are completely lacking in the species of *Cassia* (Irwin and Barneby, 1982; Conceição et al. 2009).

Chamaecrista is the largest genus in the Cassiinae comprising ca. 330 species. Although the genus is most diverse in South America with ca. 266 species (Dos Santos et al., 2017), it also occurs in mainland Africa (ca. 36 species, Brenan, 1967), Australia

(ca. 12 species, Lewis et al., 2005) and Madagascar (6 species, Lewis et al., 2005). Species of *Chamaecrista* can be herbs, shrubs and even trees (Lewis et al., 2005), but in the FSA region the genus is represented mostly by annual or perennial herbs (Gordon-Gray and Schorn, 1975; Gordon-Gray, 1977). Irwin and Barneby (1982) divided the genus into six morphologically distinguishable sections based on a combination of glandular hair type, presence or absence of extrafloral nectaries and inflorescence structure: (1) Section *Absus* (Collad.) Irwin and Barneby, (2) Section *Apoucouita* (Benth.) Irwin and Barneby, (3) Section *Calciopsis* Irwin and Barneby, (4) Section *Chamaecrista*, (5) Section *Grimaldia* (Schrank) Irwin and Barneby, and (6) Section *Xerocalyx* (Benth.) Irwin and Barneby. Species from only two of these sections (*Chamaecrista* and *Grimaldia*) are present in the FSA region. Section *Grimaldia* is represented by only one species in the region (*Chamaecrista absus* (L.) H.S. Irwin & Barneby) (Irwin and Barneby, 1982) and the remaining species fall under Section *Chamaecrista* (Gordon-Gray and Schorn, 1975). The species of Section *Chamaecrista* are distinguished from the species of Section *Grimaldia* in having sessile or stipitate extrafloral nectaries (extrafloral nectaries lacking in *Grimaldia*), numerous leaflets (2 pairs of leaflets in *Grimaldia*), and most often 10 stamens (2–7 stamens in *Grimaldia*) (Irwin and Barneby, 1982; Conceição et al., 2009).

Senna is the second largest genus in the subtribe with ca. 300 species, found mostly in the Americas, Australia and Africa (Lewis et al., 2005). The name of the genus was derived from the Arabic word *Sanna*, for species with cathartic and laxative properties in the leaves and fruits (Lewis et al., 2005). The species of *Senna* display a large diversity of growth forms ranging from herbs, sub-shrubs, shrubs to trees (Gordon-Gray, 1977; Lewis et al., 2005; Brummitt et al., 2007). Most of the species are used for ornamental (Henderson, 2001; Brummitt et al., 2007) and medicinal

purposes (Hennebelle et al., 2009; Ibrahim and Islam, 2014). Despite their invasive potential, they are frequently cultivated due to their economic value (Brummitt et al., 2007; Gordon-Gray, 1977; CABI, 2018). In South Africa, the genus is represented by 16 species and one hybrid. However, of these only two taxa, *Senna petersiana* (Bolle) Lock and *Senna italica* Mill. subsp. *arachoides* (Burch.) Lock, are native to South Africa (Hyde et al., 2018). The remaining 14 species are naturalised and of these six have been listed as Category 1b invaders according to the most recent version of the National Environment Management: Biodiversity (NEM:BA) Alien and Invasive Species (A&IS) regulations (NEM:BA 2014). Category 1b indicates that these species must be controlled, where possible removed and destroyed, and may not be sold (Henderson, 2001).

Cassia s.s. comprises ca. 30 species of trees and occasionally shrubs (Lewis et al., 2005; Brummitt et al., 2007). Of these, 12 species are native to the Americas, 10 to Africa, 3 to India, 2 to Australia and only 1 to Madagascar and Myanmar, respectively (Lewis et al., 2005). The genus *Cassia* is distinguished by the filaments that are longer than the anthers, two bracteoles at or above the base of the pedicel, the lack of extrafloral nectaries, and pods that are elongate, cylindrical or compressed, and pulpy on the inside (Irwin and Barneby, 1982). In the FSA region Gordon-Gray (1977) recognised only one native taxon, *Cassia abbreviata* subsp. *beareana* (Holmes) Brenan. Like many *Senna* species, those of *Cassia* are widely cultivated for ornamental (Brummitt et al., 2007) and medicinal purposes (Lewis et al., 2005). None of the *Cassia* species are currently listed as invaders under the latest NEM:BA legislation (NEM:BA 2014).

The species of *Cassia*, *Chameacrista*, and *Senna* have been well documented in other countries (e.g. Luckow, 1996), while in South Africa Gordon-Gray (1977)

completed a floristic account which included cultivated and naturalised species. This is now largely outdated and in need of revision, especially due to the fact that all the species were treated under *Cassia*. Moreover, several introduced species of Cassiinae are recorded as invasive in other countries, while in South Africa there are gaps in the knowledge of these species and their statuses. There is thus a clear lack of up to date information for the Cassiinae in southern Africa and a detailed study of the indigenous and introduced taxa is necessary.

1.2 Objectives of the study

Given the lack of adequate information on the subtribe Cassiinae in southern Africa, this study aims to provide a comprehensive overview of the genera and species, both native and introduced, within the FSA region. It aims specifically to:

1. Compile an updated list of both native and introduced species of the genera *Cassia* and *Senna*.
2. Assess the invasive potential and provide dossiers of all naturalised Cassiinae taxa.
3. Improve identification of the species of naturalised and indigenous Cassiinae species by (1) producing a digital key to the species, with distribution data and images, and (2) generating and analysing the core barcoding regions for the introduced species.
4. Revise the taxonomy of genus *Chamaecrista* in southern Africa, including nomenclature, typification, descriptions, distribution maps and illustrations of diagnostic characters.
5. Determine the placement of the southern Africa species of the genus *Chamaecrista* in the context of a global phylogeny for the genus.

CHAPTER 2

MATERIALS AND METHODS

Authorities for scientific plant names are provided at first mention in each of the chapters. Similarly, abbreviations used in this thesis are provided at first mention in each of the chapters. A taxonomic revision of *Chamaecrista* (L.) Moench is presented in chapter 5, in which species names are arranged alphabetically.

The Flora of southern Africa (FSA) region includes the following countries; Botswana, Lesotho, Namibia, South Africa, and Swaziland (Eswatini) (Mittermeier et al., 2005; Koekemoer et al., 2014). The region contains a rich floristic diversity (ca. 23 000 species), representing more than 10% of the world's plants (Mittermeier et al., 2005; Koekemoer et al., 2014). The centre of diversity is in South Africa with ca. 20 000 species, of which 57% is endemic to the country (Steenkamp and Smith, 2006). The floral richness in the region is associated with the diverse climate and landscape. Aizoaceae, Asteraceae, Iridaceae, Fabaceae and Poaceae are the five largest families recognised in the region (Koekemoer et al., 2014).

2.1 Species listing

A list of species for the non-native genera *Cassia* s.s. and *Senna* Mill. in southern Africa were compiled using herbarium records, as well as data retrieved from online resources (e.g. Southern African Plant Invader Atlas (SAPIA) and Plants of Southern Africa: an online checklist (POSA)), and literature (Gordon-Gray and Schorn, 1975; Gordon-Gray, 1977; Glen, 2002; Brummitt et al., 2007; Appendix 1).

2.2 Herbarium specimens

Herbarium specimens for the genera *Cassia*, *Chamaecrista* and *Senna* from the following herbaria were studied either on loan or on site: BNRH, NBG (including SAM), NH, NU, PRE, and WIND (abbreviations according to Thiers, 2019). The distribution of each species was mapped using herbarium material together with the information from field notes. The specimens examined for each taxon was recorded using the Quarter Degree Reference System for South Africa (Edward and Leistner, 1971).

2.3 Fieldwork

Extensive field work was carried out to study the taxa *in situ*. The majority of native species were observed in the field, providing crucial insights into species concepts. Fresh leaf material was collected and stored in silica gel for molecular studies. Voucher specimens are housed at the Compton Herbarium (NBG). Photographs were taken to record habitat and certain features of gross morphology. Plants were mapped using a hand-held GPS.

2.4 Gross morphology

Mature flowers selected from material-rich herbarium specimens were rehydrated, dissected and mounted in glycerol. Specimens used for floral dissections are listed in Table 2.1. The following floral characters were measured: length of pedicels, length of bracts, length and width of sepals, length and width of petals, length of stamens, length of ovaries and length and width of pods. Measurements done on the vegetative and reproductive structures are illustrated in Fig. 2.1. All the drawings presented in this study were done by myself. Measurements were taken across the distribution range of each species to ensure full representation of the variation within each taxon.

Extrafloral nectaries were visualised under a ZEISS stemi 305 stereomicroscope with a ZEISS Axiocam 105 colour camera.

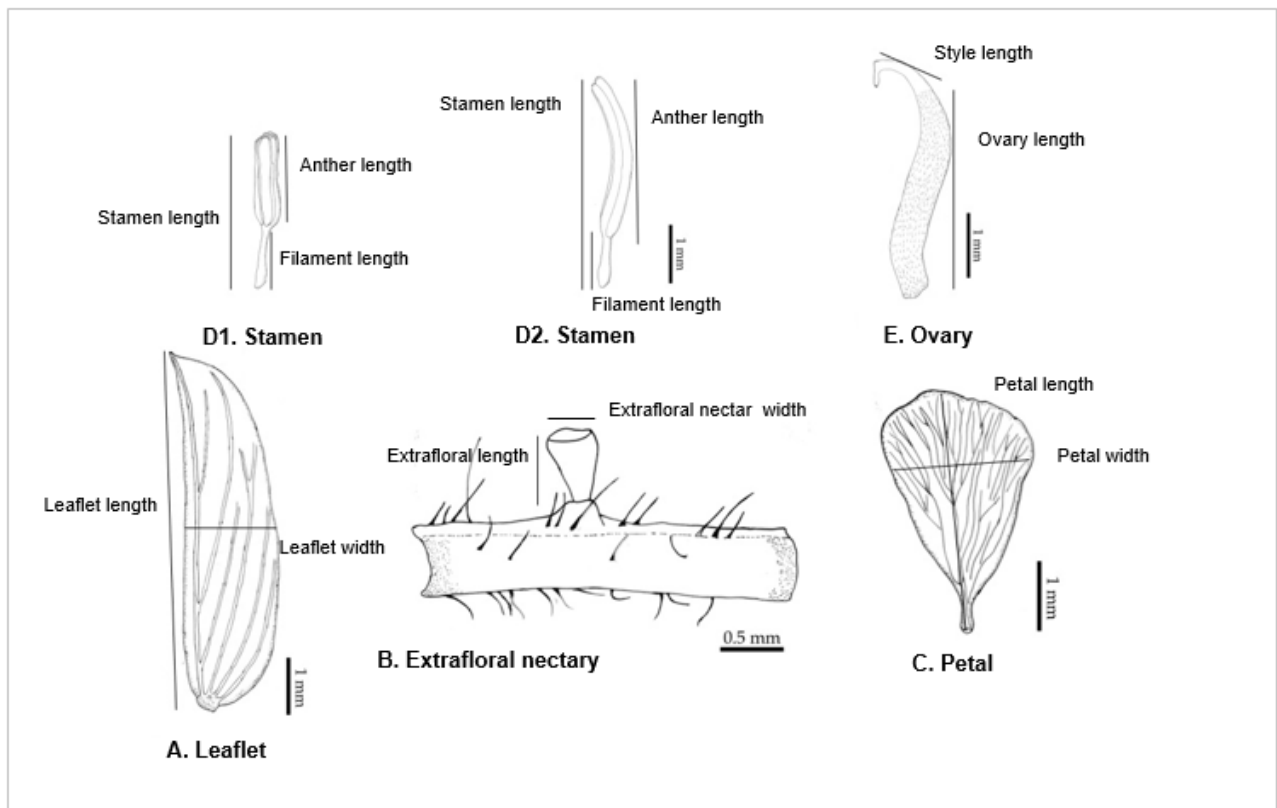


Figure 2.1 Measurements of leaflets (A), extrafloral nectary (B) and floral parts (C-E) used for morphological descriptions.

2.5 Digital DELTA key for Cassiinae species

A digital key for the southern African Cassiinae was produced using the DELTA software package (Dallwitz et al., 1999) to provide a user-friendly tool for identification of the species. Data coded for each species was obtained from species described in the present study, field observations and literature (Brenan, 1967; Gordon-Gray and Schorn, 1975; Gordon-Gray, 1977; Irwin and Barneby, 1982; Brummitt et al., 2007). In addition, photographs of diagnostic characters and distribution maps were included. The digital key is available at: <https://musandiwaliada.wixsite.com/cassiinae-delta-key>.

2.6 Weed Risk Assessment

2.6.1 Australian Weed Risk Assessment (A-WRA)

A weed risk assessment was conducted using the template of the Australian Weed Risk Assessment (A-WRA; Pheloung et al., 1999). All the species of *Cassia* and *Senna* were assessed for their invasiveness, with the exception of three native species; *Cassia abbreviata* subsp. *beareana* (Holmes) Brenan, *Senna petersiana* (Bolle) Lock and *Senna italica* subsp. *arachoides* (Burch.) Lock. The A-WRA system is based on answering 49 questions that address the (a) ecology (e.g. traits that enable plants to reproduce, spread and persist), (b) biogeography (e.g. climate suitability, distribution, cultivation history and weediness the plants elsewhere) and (c) undesirable attributes (e.g. fruit toxicity and invasive behaviour) of the species (Pheloung et al., 1999). For the A-WRA system to give an evaluation and recommendation, at least ten questions from three sections need to be answered (Pheloung et al., 1999). The answering of questions gives potential scores that are added up to provide an overall score. A high-risk invasion is indicated by a score above 6, scores between 1 and 6 indicate that further evaluation is required before recommendations are given and a score less than 1 indicates low invasion risk (Pheloung et al., 1999; Gordon et al., 2008). This risk assessment tool was developed in the context of pre-border entry and it has been proven useful also for post-entry incursions (Pyšek and Richardson 2008).

2.6.2 Risk Analysis Framework

The risk analysis framework was designed specifically for listing alien species under NEM:BA A&IS regulations (Kumschick et al., in press). The framework comprises of

five sections: background, likelihood, consequences, risk management and reporting (Kumschick et al., in press).

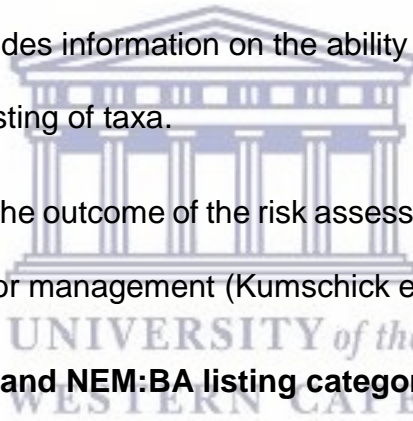
(a) Background: Provides details of the assessor and taxon under consideration.

(b) Likelihood: Provides information on the ecological, biological and behavioural characters of the taxon that can lead to its introduction, establishment and spread (Kumschick et al., in press). Invasive relatives and invasiveness in other countries are good predictors of the likelihood of invasion in the region of interest (Pheloung et al., 1999).

(c) Consequences: Provides information on the impact of taxon.

(d) Risk management: Provides information on the ability to control the taxon, leading to the recommendation of listing of taxa.

(e) Reporting: Summarises the outcome of the risk assessment and management, and provides recommendation for management (Kumschick et al., in press).



2.6.3 Data compilation and NEM:BA listing categories

A thorough literature review was conducted to find all relevant information of naturalized species of *Cassia* and *Senna*. National and international databases were used to extract information.

Once the risk of the species is determined, invasive species are listed under NEM:BA regulations in four categories (1a, 1b, 2 and 3) (NEM:BA, 2014). Category 1a lists invasive species that must be eradicated and no trade or cultivation is permitted, whereas Category 1b lists invasive species that are widespread and require a management plan (Bromilow, 2010). Category 2 lists invasive species deemed to be potentially invasive, in which a permit is required to carry out restricted activity whereas

Category 3 lists invasive species that may remain, however, further planting or trade is prohibited (NEM:BA, 2014).

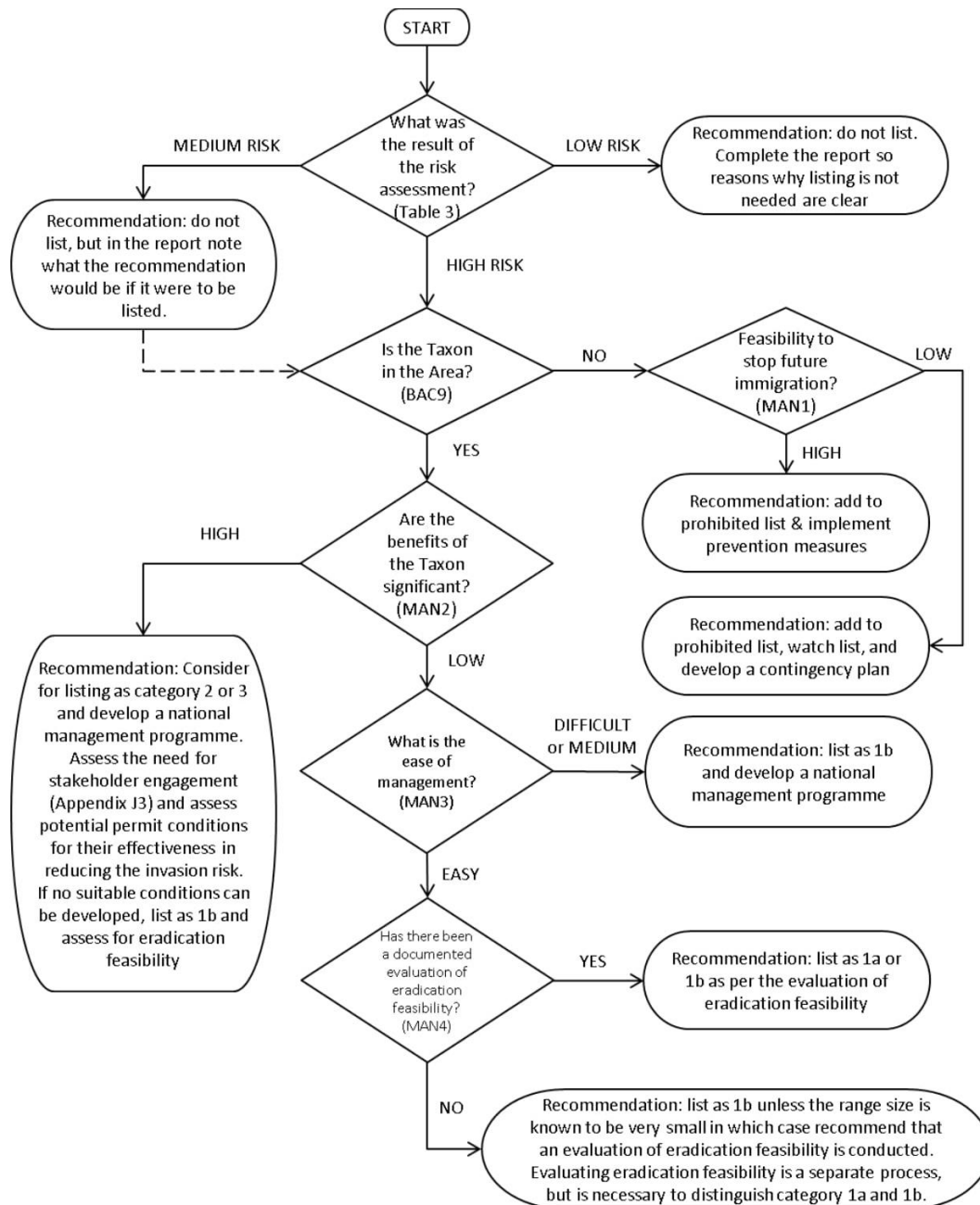


Figure 2.2. The listing categories (1a, 1b, 2 and 3) under NEM:BA A&IS regulations in South Africa (from Kumschick et al., in press).

2.7 DNA Extraction, Amplification and Sequencing

Total DNA was isolated from 0.2 g of silica-dried leaves or herbarium material using the DNeasy Plant Mini Kit (Qiagen Inc, Valencia, CA, USA) following manufacturer's instructions. The sources of plant material and voucher specimen information are listed in Table 2.2. All other accessions not extracted in the present study but included in the analyses are listed in Table 2.3.

The internal transcribed spacer (ITS) of nuclear ribosomal DNA was amplified using the primer combination of Sun et al. (1994): AB 101 (5'-ACG AAT TCA TGG TCC GGT GAA GTG TT-3') and AB 102 (5'-TAG AAT TCC CCG GTT CGC TCG CCG TT-3'). The *trnL-trnF* region (consisting of the adjacent *trnL* intron and *trnL-F* intergenic spacer) was amplified using the exon primers: c (*trnL-F*) (5'-CGA AAT CGG TAG ACG CTACG-3') and f (*trnL-F*) (5'-ATT TGA ACT GGT GAC ACG AG-3') (Taberlet et al., 1991). Two regions, known as the core DNA barcodes (*matK* and *rbcLa*) (CBOL Plant Working Group, 2009), were also amplified. The *matK* region was amplified using the primers: 3FKIM (5'-CGT ACA GTA CTT TTG TGT TTA CGA G-3') and 1RKIM (5'-ACC CAG CAG TCC ATC TGG AAA TCT TGG TTC-3') (Cuénoud et al., 2002). The *rbcLa* region was amplified using the primers: *rbcLa-F* (5'-ATG TCA CCA CAA ACA GAG ACT AAA GC-3') and *rbcLa-R* (5'-GTA AAA TCA AGT CCA CCY CG-3') (Elansary, 2013).

Amplification was carried out using Polymerase Chain Reactions (PCR) in 25 µl reactions containing: 12.5 µl Emerald GT PCR Master Mix, 0.3 µl of both forward and reverse primers, 0.5 µl of bovine serum albumin (BSA), 0.5 µl of dimethyl sulfoxide (DMSO, used for ITS only), 0.5-1.5 µl of DNA template and sterile distilled water to make up volume of 25 µl. The PCR reactions for ITS were carried out using the

following thermal conditions: 2 min denaturation at 95° C, 35-40 cycles of 30 s annealing at 95° C, 30 s extension at 50° C, and 60 (80) s final extension at 72° C. The PCR reactions for *rbcLa*, *matK* and *trnL-F* were carried out using the following thermal conditions: 2 min denaturation at 94° C, 35-40 cycles of 60 s annealing at 94° C, 60 s extension 53° C, and 8 min final extension at 72° C. An ENDURO GDS Documentation System was used to visualise PCR products. Successfully amplified samples were purified using the ExoSAP PCR clean-up process following Werle et al. (1994) using 5 units of Exonuclease I (EXO) and 0.5 units of Shrimp Alkaline Phosphatase (SAP). The cleaned PCR products were sent to Macrogen (Europe) for sequencing.

2.8 Sequence alignments and phylogenetic analysis

Complementary strands of the sequenced genes were edited and aligned manually using MEGA version 6.06 (Tamura et al., 2013). Phylogenetic analyses on the nuclear dataset, the plastid dataset and the combined nuclear and plastid dataset were conducted using the maximum parsimony (MP) algorithm of PAUP* version 4.0b1 (Swofford, 2002) with character transformations treated as unordered and equally weighted (Fitch, 1971) and treating gaps as missing data. The matrix was analysed using a heuristic search with 1000 random sequence additions, TBR (tree bisection reconnection) branch swapping, with the MULTREES option turned on. A limit of 10 trees per replicate was set to reduce the time spent on swapping in each replicate. Internal support was assessed with 1000 bootstrap replicates (Felsenstein, 1985) using TBR swapping but holding 10 trees per replicate. Bootstrap percentage (BP) values greater than 50% are reported in the results using the following scale to

evaluate support percentages: 50%–74%, weak; 75%–84%, moderate; and 85%–100%, strong.

Bayesian Inference (BI) was performed for the three datasets: (1) plastid data, (2) nuclear data and (3) total combined data. The individual combined nuclear, combined plastid and combined nuclear and plastid datasets were analysed for 15 million generations with a sample frequency of 1000. The analyses were performed using the CIPRES Portal version 3.3 (Miller et al., 2010). The standard deviation of split frequencies stabilized below 0.01, providing evidence that a sufficient number of generations had been completed. Using MrEnt 2.5, suboptimal trees were discarded as the “burn-in” phase. Only support values greater than 0.5 were retained, and the following scale was used to evaluate support values: 0.50–0.94 weak; and 0.95–1.0 strong. Appropriate models of nucleotide evolution were selected for each gene region based on the Akaike information criterion (AIC) of jModelTest (Posada, 2008). The following models of evolution were selected: T1M2+1+G was applied for *trnL-F*, T1M1+G was applied for ITS, HKY+G was applied for *rbcla* and TPM1UF+I+G was applied for *matK*.

Table 2.1. Voucher specimens of materials used for floral dissections to measure sepals, petals, stamens and ovaries.

Taxon	Voucher specimen
<i>Cassia abbreviata</i> Oliv. subsp. <i>beareana</i> (Holmes) Brenan	<i>Meyer 4149</i> (PRE)
	<i>Retief 259</i> (PRE)
<i>Cassia fistula</i> L.	<i>Styles 2200</i> (NH)
	<i>Musandiwa 01</i> (NBG)
<i>Chamaecrista absus</i> (L.) H.S.Irwin & Barneby	<i>Germishuizen 5127</i> (PRE)
	<i>Barker 625</i> (PRE)
<i>Chamaecrista biensis</i> (Stayaert) Lock	<i>Musandiwa 08</i> (NBG)
	<i>Musandiwa 10</i> (NBG)
	<i>Van Wyk 742</i> (PRE)
	<i>Smook 10067</i> (PRE)
<i>Chamaecrista falcata</i> Musandiwa & Boatwr.	<i>Ward 2439</i> (NU)
	<i>Germishuizen 01016</i> (PRE)
<i>Chamaecrista capensis</i> (Thunb.) E. Mey. var. <i>capensis</i>	<i>Hutchinson 1559</i> (PRE)
<i>Chamaecrista capensis</i> (Thunb.) E. Mey. var. <i>flavescens</i> E. Mey.	<i>Gordon-Gray 6145</i> (NU)
	<i>Balkwill & Cadman 1198</i> (NU)
<i>Chamaecrista comosa</i> E.Mey. subsp. <i>capricornia</i> (Stayaert) Musandiwa & Boatwr.	<i>Hilliard 6029</i> (NU)
<i>Chamaecrista comosa</i> E.Mey. subsp. <i>comosa</i>	<i>Arnold 792</i> (NU)
<i>Chamaecrista grandiglandulata</i> Musandiwa & Boatwr.	<i>Ward 1219</i> (NH)
	<i>Arnold 1408</i> (PRE)

<i>Chamaecrista mimosoides</i> (L.) Green	MacDonald 495 (NU)
	Ward 6527 (NU)
<i>Chamaecrista gordon-grayei</i> Musandiwa & Boatwr. subsp. <i>gordon-grayei</i>	Muller & Giess 554 (WIND)
<i>Chamaecrista gordon-grayei</i> Musandiwa & Boatwr. subsp. <i>longipedicellata</i> Musandiwa & Boatwr.	Story 6439 (WIND)
	Strohbach BS5275 (WIND)
<i>Chamaecrista plumosa</i> E.Mey. var. <i>erecta</i> (Schorn & Gordon-Gray) Lock	Hilliard 2722 (NU)
<i>Chamaecrista plumosa</i> E. Mey. var. <i>plumosa</i>	Abraham 31 (NU)
<i>Chamaecrista stricta</i> E. Mey.	Bredenkamp 388 (PRE)
	Germishuizen 3923 (PRE).
<i>Senna bicapsularis</i> (L.) Roxb.	Balkwill 1710 (NU)
	Ward 12625 (NU)
	Ross s.n (NU)
<i>Senna corymbosa</i> (Lam.) H.S.Irwin & Barneby	Van Meersbergen 18 (NU)
<i>Senna didymobotrya</i> (Fresen.) H.S.Irwin & Barneby	Wagg 1197 (NU)
	Musandiwa 02 (NBG)
	Van Rensburg 04 (NU)
<i>Senna hirsuta</i> (L.) H.S.Irwin & Barneby	Ward 6275 (NU)
<i>Senna italica</i> Mill. subsp. <i>arachoides</i> (Burch.) Lock	Musandiwa 12 (NBG)
<i>Senna multiglandulosa</i> (Jacq.) H.S.Irwin & Barneby	Bayliss 7025 (PRE)

<i>Senna obtusifolia</i> (L.) H.S.Irwin & Barneby	<i>Van Rooyen and Bredenkamp 470</i> (PRE)
<i>Senna occidentalis</i> (L.) Link	<i>Wells 1271</i> (NU)
	<i>Zambatis 1389</i> (PRE)
	<i>Musandiwa 05</i> (NBG)
<i>Senna pendula</i> (Willd.) Irwin & Barneby var. <i>glabrata</i> (Vogel) H.S.Irwin & Barneby	<i>Pretorius 20</i> (PRE)
	<i>Jaca 226</i> (PRE)
<i>Senna petersiana</i> (Bolle) Lock	<i>Ward 2035</i> (PRE)
<i>Senna siamea</i> (Lam.) H.S.Irwin & Barneby	<i>Ward 4515</i> (PRE)
	<i>Scheepers s.n.</i> (PRE)
<i>Senna septemtrionalis</i> (Viv.) H.S.Irwin & Barneby	<i>Henderson 1186</i> (PRE)
	<i>Musandiwa 07</i> (NBG)
	<i>McDonald 203</i> (NU)
	<i>Morris 59</i> (NU)

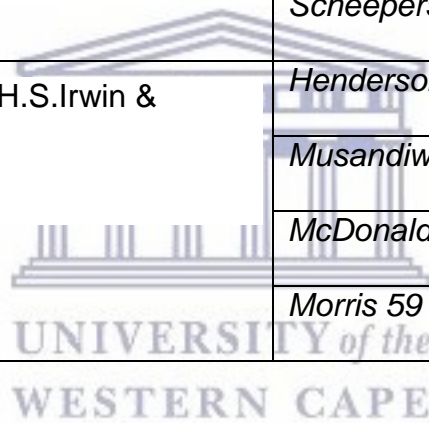


Table 2.2. Voucher specimens of materials used for DNA extraction and sequencing in this study.

Taxon	Voucher specimen
<i>Cassia abbreviata</i> Oliv. subsp. <i>beareana</i> (Holmes)	Onderstall 778 (PRE)
Brenan	Allison 207 (PRE)
<i>Cassia fistula</i> L.	Musandiwa 01 (NBG)
	Styles 2200 (NH)
<i>Chamaecrista absus</i> (L.) H.S.Irwin & Barneby	McMurtry14805 (BNRH)
<i>Chamaecrista biensis</i> (Stayaert) Lock	Boatwright 721 (NBG)
<i>Chamaecrista falcata</i> Musandiwa & Boatwr.	Germishuizen 01016 (PRE)
<i>Chamaecrista capensis</i> (Thunb.) var. <i>capensis</i>	Nemando 42 (NBG)
<i>Chamaecrista capensis</i> (Thunb.) E.Mey. var.	Nemando 17 (NBG)
<i>flavescens</i> E.Mey.	Musandiwa 19 (NBG)
<i>Chamaecrista comosa</i> E.Mey. subsp. <i>capriconia</i> (Stayaert) Musandiwa & Boatwr.	Boatwright 731 (NBG)
<i>Chamaecrista comosa</i> E.Mey. subsp. <i>comosa</i>	Arnold 792 (NU)
<i>Chamaecrista grandiglandulata</i> Musandiwa & Boatwr.	Musandiwa 17 (NBG)
<i>Chamaecrista mimosoides</i> (L.) Green	Germishuizen 1072 (PRE)
<i>Chamaecrista paralias</i> (Brenan) Lock	Burrows 12490 (BNRH)
<i>Chamaecrista plumosa</i> E.Mey. var. <i>erecta</i> (Schorn & Gordon-Gray) Lock	Musandiwa 18 (NBG)

<i>Chamaecrista plumosa</i> E.Mey. var. <i>plumosa</i>	Styles 3909 (NH)
<i>Chamaecrista stricta</i> E.Mey.	Van der Bank and Burgoyne OM 360 (BNRH)
<i>Senna artemisioides</i> (Gaudich. ex DC.) Randell	Bester 13490 (BNRH)
<i>Senna bicapsularis</i> (L.) Roxb.	Musandiwa 06 (NBG)
	Ward 12625 (NH)
<i>Senna corymbosa</i> (Lam.) H.S.Irwin & Barneby	Stirton 6911 (PRE)
	Van Meersbergen 18 (NU)
<i>Senna didymobotrya</i> (Fresen.) H.S.Irwin & Barneby	Van Rensburg 04 (NU)
	Musandiwa 02 (NBG)
<i>Senna hirsuta</i> (L.) H.S.Irwin & Barneby	Cheek 07 (NH)
	Styles 1253 (NU)
<i>Senna italica</i> Mill. subsp. <i>arachoides</i> (Burch.) Lock	Musandiwa 12 (NBG)
	Germishuizen 3718
<i>Senna multiglandulosa</i> (Jacq.) H.S.Irwin & Barneby	Van Wyk 5600 (PRE)
	Bayliss 7025 (PRE)
<i>Senna obtusifolia</i> (L.) H.S.Irwin & Barneby	Musandiwa 04 (NBG)
	Musandiwa 16 (NBG)
<i>Senna occidentalis</i> (L.) Link	Musandiwa 05 (NBG)
	Uiras MU658 (PRE)
	Pretorius 20 (PRE)

<i>Senna pendula</i> (Willd.) Irwin & Barneby var. <i>glabrata</i> (Vogel) H.S.Irwin & Barneby	<i>Jaca 226</i> (PRE)
<i>Senna petersiana</i> (Bolle) Lock	<i>Musandiwa 03</i> (NBG)
	<i>Aremu 07</i> (NU)
<i>Senna septemtrionalis</i> (Viv.) H.S.Irwin & Barneby	<i>Musandiwa 07</i> (NBG)
	<i>Maserumule 212</i> (PRE)
<i>Senna spectabilis</i> (DC.) H.S.Irwin & Barneby	<i>Cass Cs 121</i> (PRE)



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Table 2. 3. Voucher specimen information of sequences obtained from Genbank
(*ITS* and *trnL-F*).

Taxon	Voucher specimen	Accession no:		Reference
		<i>ITS</i>	<i>trnL-F</i>	
<i>Chamaecrista absus</i> (L.) H.S.Irwin & Barneby var. <i>absus</i>	Serriaha dos Pintos, RN; <i>Conceição</i> 1056	FJ009832	FJ009886	Conceição et al., 2009
<i>Chamaecrista amorimii</i> Barneby	Itacaré, BA; <i>Conceição 795</i>	FJ009823	FJ009878	Conceição et al., 2009
<i>Chamaecrista anamariae</i> Conc., L.P.Queiroz & G.P. Lewis	Abaíra, BA; <i>Conceição 787</i>	FJ009826	FJ009881	Conceição et al., 2009
<i>Chamaecrista belemii</i> (H.S.Irwin & Barneby) H.S.Irwin & Barneby var. <i>belemii</i>	Casa Nova, BA; <i>Queiroz 9151</i>	FJ009825	FJ009880	Conceição et al., 2009
<i>Chamaecrista blanchetii</i> (Benth.) Conc., L.P.Queiroz & G.P.Lewis	Morro do Chapéu, BA; <i>Andrade 607</i>	FJ009846	FJ009900.	Conceição et al., 2009
<i>Chamaecrista botryoides</i> Conc., L.P.Queiroz & G.P.Lewis	Abaíra, BA; <i>Conceição 541</i>	FJ009836	FJ009890	Conceição et al., 2009

<i>Chamaecrista brachystachya</i> (Benth.) Conc., L.P. Queiroz & G.P. Lewis	Grão Mogol, MG; <i>Conceição</i> 713	FJ009847	FJ009901	Conceição et al., 2009
<i>Chamaecrista calycioides</i> (Collad.) Greene	Natal, RN; <i>Queiroz</i> 11	FJ009863	FJ009917	Conceição et al., 2009
<i>Chamaecrista campestris</i> H.S. Irwin & Barneby	General Cardoso, MT; <i>Queiroz</i> 10440	FJ009829	FJ009883	Conceição et al., 2009
<i>Chamaecrista cathartica</i> (Mart.) H.S. Irwin & Barneby	Goveia, MG; <i>Conceição</i> 789	FJ009841	FJ009895	Conceição et al., 2009
<i>Chamaecrista chapadae</i> (H.S. Irwin & Barneby) H.S. Irwin & Barneby	Mucugê, BA; <i>Costa</i> 129	FJ009828	–	Conceição et al., 2009
<i>Chamaecrista</i> aff. <i>cavalcantina</i> (H.S. Irwin & Barneby) H.S. Irwin & Barneby	Jaborandi, BA; <i>Queiroz</i> 10265	FJ009830	FJ009884	Conceição et al., 2009
<i>Chamaecrista choriophylla</i> (Vogel) H.S. Irwin & Barneby	Itacambira, MG; <i>Conceição</i> 733	FJ009860	FJ009914	Conceição et al., 2009

<i>Chamaecrista confertifomis</i> (H.S.Irwin & Barneby) Conc., L.P. Queiroz & G.P.Lewis	Mucugê, BA; <i>Costa 132</i>	FJ009848	FJ009902	Conceição et al., 2009
<i>Chamaecrista coriacea</i> (Benth.) H.S.Irwin & Barneby	Conc. Mato Dentro, MG; <i>Conceição 869</i>	FJ009843	FJ009897	Conceição et al., 2009
<i>Chamaecrista cytisoides</i> (Collad.) H.S.Irwin & Barneby	Sta. Bárbara do M. Verde, MG; <i>Conceição 870</i>	FJ009844	FJ009898	Conceição et al., 2009
<i>Chamaecrista dalbergiifolia</i> (Benth.) H.S.Irwin & Barneby	Planaltina, GO; <i>Queiroz 10318</i>	FJ009837	FJ009891	Conceição et al., 2009
<i>Chamaecrista decora</i> (H.S.Irwin & Barneby) Conc., L.P.Queiroz & G.P.Lewis	Grão Mogol, MG; <i>Conceição 810</i>	FJ009849	FJ009903	Conceição et al., 2009
<i>Chamaecrista depauperata</i> Conc., L.P.Queiroz & G.P.Lewis	Mucugê, BA; <i>Conceição 863</i>	FJ009850	FJ009904	Conceição et al., 2009
<i>Chamaecrista desvauxii</i> (Collad.) Killip var. <i>desvauxii</i>	Chapada dos Guimarães, MT; <i>Queiroz 10453</i>	FJ009864	FJ009918	Conceição et al., 2009

<i>Chamaecrista desvauxii</i> var. <i>langsдорffii</i> (Kunth ex Vogel) H.S.Irwin & Barneby	Abaíra, BA; <i>Conceição 674</i>	FJ009866	FJ009920	Conceição et al., 2009
<i>Chamaecrista desvauxii</i> var. <i>latistipula</i> (Benth.) G.P.Lewis	Guaraparí, ES; <i>Conceição 912</i>	FJ009867	FJ009921.	Conceição et al., 2009
<i>Chamaecrista desvauxii</i> var. <i>mollissima</i> (Benth.) H.S.Irwin & Barneby	Morro do Chapéu, BA; <i>Santos 356</i>	FJ009865	FJ009919	Conceição et al., 2009
<i>Chamaecrista diphylla</i> (L.) Greene	Jaborandi, BA; <i>Queiroz 10269;</i>	FJ009868	FJ009922	Conceição et al., 2009
<i>Chamaecrista flexuosa</i> (L.) Greene var. <i>flexuosa</i>	Santana do Riacho, BA; <i>Giulietti 2344</i>	FJ009858	FJ009912	Conceição et al., 2009
<i>Chamaecrista glaucofilix</i> (H.S.Irwin & Barneby) H.S.Irwin & Barneby	Mucugê, BA; <i>Conceição 861</i>	FJ009834	FJ009888	Conceição et al., 2009
<i>Chamaecrista hispidula</i> (Vahl) H.S.Irwin & Barneby	Feira de Santana, BA; <i>Conceição 914</i>	FJ009833	FJ009887	Conceição et al., 2009
<i>Chamaecrista jacobinea</i> (Benth.) H.S.Irwin & Barneby	Morro do Chapéu, BA; <i>Andrade 610</i>	FJ009827	FJ009882	Conceição et al., 2009

<i>Chamaecrista mucronata</i> (Spreng.) H.S.Irwin & Barneby	Abaíra, BA; <i>Conceição</i> 653	FJ009861	FJ009915	Conceição et al., 2009
<i>Chamaecrista nictitans</i> subsp. <i>brachypoda</i> (Benth.) H.S.Irwin & Barneby	Iporá, GO; <i>Queiroz</i> 10335	FJ009855	FJ009909	Conceição et al., 2009
<i>Chamaecrista nictitans</i> var. <i>disadena</i> (Steud.) H.S.Irwin & Barneby	Junco de Minas, MG; <i>Conceição 790</i>	FJ009852	FJ009906	Conceição et al., 2009
<i>Chamaecrista nictitans</i> var. <i>ramosa</i> (Vogel) H.S.Irwin & Barneby	Barra do Garças, MT; <i>Queiroz 10406</i>	FJ009853	FJ009907	Conceição et al., 2009
<i>Chamaecrista olesiphylla</i> (Vogel) H.S.Irwin & Barneby	Grão Mogol, MG; <i>Nascimento</i> 508	FJ009862	FJ009916	Conceição et al., 2009
<i>Chamaecrista onusta</i> H.S.Irwin & Barneby	Itacaré, BA; <i>Conceição 800</i>	FJ009824	FJ009879	Conceição et al., 2009
<i>Chamaecrista</i> aff. <i>pasuorum</i> (Benth.) H.S.Irwin & Barneby	Barra do Bugres, MT; <i>Queiroz 10569</i>	FJ009854	FJ009908	Conceição et al., 2009

<i>Chamaecrista pascuorum</i> (Benth.) H.S.Irwin & Barneby	laçu, BA; Queiroz 9169	FJ009851	FJ009905	Conceição et al., 2009
<i>Chamaecrista philippi</i> (H.S.Irwin & Barneby) H.S.Irwin & Barneby	Rio de Contas, BA; <i>Giulietti 2245</i>	FJ009838	FJ009892	Conceição et al., 2009
<i>Chamaecrista pilosa</i> (L.) Greene	Barreiras, BA; <i>Queiroz 10221</i>	FJ009856	FJ009910	Conceição et al., 2009
<i>Chamaecrista potentilla</i> (Benth.) H.S.Irwin & Barneby	Diamantina, MG; <i>Queiroz 7606</i>	FJ009859	FJ009913	Conceição et al., 2009
<i>Chamaecrista rotundifolia</i> (Pers.) Greene var. <i>grandiflora</i> (Benth.) H.S.Irwin & Barneby	Mucugê, BA; Costa 128	FJ009857	FJ009911	Conceição et al., 2009
<i>Chamaecrista rupestrum</i> H.S.Irwin & Barneby	Rio de Contas, BA; <i>Santos 390</i>	FJ009835	FJ009889	Conceição et al., 2009
<i>Chamaecrista setosa</i> (Vogel) H.S.Irwin & Barneby	Chapada dos Guimarães, MT; <i>Queiroz 10460</i>	FJ009842	FJ009896	Conceição et al., 2009
<i>Chamaecrista speciosa</i> Conc., L.P.Queiroz & G.P.Lewis	Abaíra, BA; <i>Conceição 546</i>	FJ009839	FJ009893	Conceição et al., 2009

<i>Chamaecrista supplex</i> (Benth.) Britton & Rose ex Britton & Killip	Barreiras, BA; <i>Queiroz 10217</i>	FJ009869	FJ009923	Conceição et al., 2009
<i>Chamaecrista unijuga</i> (Benth.) Conc., L.P.Queiroz & G.P.Lewis	Sto. Amaro das Brotas, SE; <i>Conceição 694</i>	FJ009845	FJ009899	Conceição et al., 2009
<i>Chamaecrista urophyllidia</i> (H.S.Irwin & Barneby) H.S.Irwin & Barneby	Rio de Contas, BA; <i>Harley</i> <i>54656</i>	FJ009840	FJ009894	Conceição et al., 2009
<i>Cassia grandis</i> L.f.	Feira de Santana, BA; <i>Queiroz 2878</i>	FJ009820	FJ009875	Conceição et al., 2009
<i>Cassia javanica</i> L.	Feira de Santana, BA; <i>Queiroz 11039</i>	FJ009821	FJ009876	Conceição et al., 2009
<i>Senna gardneri</i> (Benth.) H.S.Irwin & Barneby	Campo Alegre de Lurdes, BA; <i>Queiroz</i> <i>7860</i>	FJ009822	FJ009877	Conceição et al., 2009
<i>Bauhinia unguolata</i> L.	Crateús, CE; <i>Araújo</i> <i>1569</i>	FJ009818	FJ009873	Conceição et al., 2009
<i>Copaifera coriacea</i> Mart.	Casa Nova, BA; <i>Queiroz 7918</i>	FJ009816	FJ009871	Conceição et al., 2009

<i>Hymenaea courbaril</i> L.	Campo Alegre de Lurdes, BA; <i>Queiroz</i> 7833	FJ009817	FJ009872	Conceição et al., 2009
<i>Martiodendrum mediterraneum</i> (Mart.ex Benth.) Köeppen	Köeppen; Oeiras, PI; <i>Queiroz</i> 10162	FJ009815	FJ009870	Conceição et al., 2009



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Table 2.4. Voucher specimen information of sequences obtained from Genbank
(*matK* and *rbcLa*).

Taxon	Voucher specimen	Accession no:		Reference
		<i>Matk</i>	<i>rbcLa</i>	
<i>Caesalpinia pulcherrima</i> (L.) Sw.	JABL-UB-20	–	KY228851	–
<i>Caesalpinia sappan</i> L.	–	KP093492	–	Liu et al., 2015
	–	–	KP094413	Liu et al., 2015
<i>Caesalpinia decapetala</i> (Roth) Alston	PS1589MT01	HM049555	–	Gao et al., 2011
<i>Cassia abbreviata</i> Oliv.	OM2047	JX517898	JX572384	–
	OM3388	JX518172	JX572385	–
<i>Cassia fistula</i> L.	ATREE102	KJ638430	–	Seethapathy et al., 2015
	ATREE101	KJ638429	–	Seethapathy et al., 2015
	QRI 512	–	MH287281	–
<i>Cassia javanica</i> L.	–	–	JQ301851	Purushothaman et al., 2014
	–	–	JX856678	Tripathi et al., 2013
	–	–	JX856679	Tripathi et al., 2013

<i>Chamaecrista absus</i> (L.) H.S.Irwin & Barneby	–	–	JQ301863	–
<i>Chamaecrista nictitans</i> (L.) Moench	–	–	GQ248565	–
	–	–	KX385952	–
<i>Chamaecrista kleinii</i> (Wight & Arn.) K.M.Matthew	RRCBI- MUS132A	KJ638456	–	Seethapathy et al., 2015
<i>Senna tora</i> (L.) Roxb.	ATREE114	KJ638441	–	Seethapathy et al., 2015
	CIMAP:C030	KY549329	–	–
	CIMAP:C037	KY549330	KY464124	–
	RNG:1958	–	KX119325	Oshingboye et al., 2016
<i>Senna surattensis</i> (Burm.f.) H.S.Irwin & Barneby	RRCBI- 13905A	KJ638453	–	Seethapathy et al., 2015
	S4	–	JF975367	–
	1076420372	–	KM895940	Shapcott et al., 2015
<i>Senna siamea</i> (Lam.) H.S.Irwin & Barneby	ATREE110	KJ638438	–	Seethapathy et al., 2015
	–	JQ301882	JQ301862	Purushothaman et al., 2014

<i>Senna polyphylla</i> (Jacq.) H.S.Irwin & Barneby	RRCBI- MUS133A	KJ638450	–	Seethapathy et al., 2015
	RRCBI- MUS133B	KJ638451	–	Seethapathy et al., 2015
<i>Senna polyphylla</i> (Jacq.) H.S.Irwin & Barneby var. <i>polyphylla</i>	0118735315	–	KJ082563	–
<i>Senna occidentalis</i> (L.) Link	ATREE118	KJ638445	–	Seethapathy et al., 2015
	ATREE117	KJ638444	–	Seethapathy et al., 2015
	Abbott 25191 (FLAS)	–	KJ773879	–
	SCBGP509_ 1	KP094110	–	Liu et al., 2015
	–	JQ301880	–	Purushothaman et al., 2014
<i>Senna alata</i> (L.) Roxb.	ATREE106	KJ638434	–	Seethapathy et al., 2015
	ATREE104	KJ638432	–	Seethapathy et al., 2015
	–	–	U74250	–
	LUH:6546	–	KX119319	Oshingboye et al., 2016

<i>Senna uniflora</i> (Mill.) H.S.Irwin & Barneby	RRCBI-15069A	KJ638447	–	Seethapathy et al., 2014
	CIMAP:C043	–	KY464122	–
	CIMAP:C036	–	KY464121	–
<i>Senna didymobotrya</i> (Fresen.) H.S.Irwin & Barneby	UC1952665	MF963528	MF963163	Thornhill et al., 2017
<i>Senna petersiana</i> (Bolle) Lock	OM987	JF270938	JF265596	–
	OM2515	JX517765	–	–
<i>Senna bicapsularis</i> (L.) Roxb.	Li ZY, Xiang XG, Xu SZ 201509183	–	MF135382	Xu et al., 2017
<i>Senna hirsuta</i> (L.) H.S.Irwin & Barneby	LUH:6363	–	KX119320	–
	–	–	JQ301859	Purushothaman et al., 2014
	–	JQ301879	–	Purushothaman et al., 2014
<i>Senna septemtrionalis</i> (Viv.) H.S.Irwin & Barneby	OM910	–	JX572983	–
	–	AM086896	–	Marazzi et al., 2006
	1076420388	–	KM895619	Shapcott et al., 2015

<i>Senna sophera</i> (L.) Roxb.	–	–	JQ301855	Purushothaman et al., 2014
	S17	–	JF975373	–
<i>Senna spectabilis</i> (DC.) H.S.Irwin & Barneby	–	–	JQ301856	Purushothaman et al., 2014
	A. Chaveerach 835	–	KC414135	–
	0118737385	–	KJ082565	–
<i>Senna italica</i> Mill.	LUH:5202	–	KX119321	–
	OM417	–	JQ025090	–
	–	–	JQ301864	Purushothaman et al., 2014
<i>Senna obtusifolia</i> (L.) H.S.Irwin & Barneby	Abbott 23038 (FLAS)	–	KJ773878	–
	–	–	KX385989	–
	JG 1342	–	MF135419	Xu et al., 2017
	LUH:4138	KX119409	–	–
	PS1588MT06	GQ434282	–	Chen et al., 2010
<i>Senna alexandrina</i> Mill.	CIMAP:C032	–	KY464109	–
	CIMAP:C028	–	KY464117	–

<i>Senna auriculata</i> Roxb.	CIMAP:C035	–	KY464118	–
	CIMAP:C042	–	KY464119	–
<i>Senna montana</i> (B.Heyne ex Roth) V.Singh	–	–	JQ301854	–
<i>Senna pallida</i> (Vahl) H.S.Irwin & Barneby	–	–	JQ301849	Purushothaman et al., 2014
	AG-148	–	JQ594869	–
<i>Senna pendula</i> (Willd.) H.S.Irwin & Barneby	S.B. Davis 0496 (FLAS)	GU135101	GU135268	–
	J.R. Abbott 23862 (FLAS)	GU135008	–	–
<i>Senna sulfurea</i> (Coll) H.S.Irwin & Barneby	–	–	JQ301853	Purushothaman et al., 2014
<i>Senna corymbosa</i> (Lam.) H.S.Irwin & Barneby	–	AM086856	–	Marazzi et al., 2006

CHAPTER 3

THE INVASIVE POTENTIAL OF *CASSIA* AND *SENNA* IN SOUTH AFRICA

3.1 Introduction

Since the increase of trade, tourism and technology the introduction of invasive species has increased dramatically across the globe (McNeely et al., 2001; Dogra et al., 2010; Boy and Witt, 2013). Human activities (e.g. agriculture, aquaculture, and forestry) have either accidentally or deliberately enhanced the spread of invasive species across natural barriers to new environments (Kolar and Lodge, 2001). While many of these taxa are highly beneficial (Andersen et al., 2004), some pose a serious threat to the environment, biodiversity and the economy world-wide (Brooks and D'Antonio, 2004; Vilà et al., 2011; Boy and Witt, 2013).

To counter the problems posed by invasive species (Pheloung et al., 1999), various screening systems have been developed to identify potential invaders throughout the world (Daehler et al., 2004). The development of country-level risk assessments for pre-border, border and post-border use has become an important tool for managing invasive species (Moodley et al., 2017). If a species is found to have a high risk of invasion, the next consideration is how decision-makers manage it (Panetta, 2016). Managing and controlling invasive species is essential for the restoration of native vegetation (Holmes and Richardson, 1999). In the present study the most recently developed framework for analysing the risk of alien species under NEM:BA A&IS regulations in South Africa (Kumschick et al., in press) and the most widely adopted risk analysis, the Australian Weed Risk Assessment (Pheloung et al., 1999), are applied to assess the invasive potential of naturalised species of the genera *Cassia* s. s., and *Senna* Mill. in South Africa.

Most of the *Cassia* and *Senna* species in South Africa are under cultivation for ornamental (Henderson, 2001; Brummitt et al., 2007) and medicinal purposes (Marazzi et al., 2006; Hennebelle et al., 2009; Ibrahim and Islam, 2014). The species have been widely introduced and become invasive in other parts of the world as well (Irwin and Barneby, 1982). In South Africa six species are listed as Category 1b according to recently promulgated NEM:BA A&IS regulations (NEM:BA 2016), i.e. *Senna bicapsularis* (L.) Roxb., *S. didymobotrya* (Fresen.) H.S.Irwin & Barneby, *S. hirsuta* (L.) H.S.Irwin & Barneby, *S. occidentalis* (L.) Link, *S. pendula* var. *glabrata* (Vogel) H.S.Irwin & Barneby, and *S. septemtrionalis* (Viv.) H.S.Irwin & Barneby. None of the *Cassia* species are currently listed as invaders under the latest NEM:BA legislation (NEM:BA 2014). Species listed under Category 1b must be controlled, removed and destroyed, and planting or trading of these species is strictly prohibited (Henderson, 2001).

Although few species are listed as invasive under NEM:BA, there is limited information on the invasive potential of naturalized Cassiinae species in South Africa and the current NEMBA listing can therefore be treated as provisional until studies provide more definitive information about the invasiveness of these species. The risk assessment of these species would be beneficial to prevent further spread and potential impacts. This chapter aims to present a comprehensive assessment of the invasive potential of the naturalised Cassiinae species in South Africa and to provide accurate descriptions and known geographical distributions of the species.

3.2 Results

3.2.1 Australian Weed Risk Assessment (A-WRA)

Sixteen Cassiinae species were assessed for their invasive potential in South Africa. Of these, 15 (94%) species scored above six, indicating a high risk of invasion (Table 3.1). A recommendation for *Senna sophora* (L.) Roxb could not be made due to a lack of information. The system requires a minimum of ten questions from three sections to be addressed in order to make recommendations (Pheloung et al., 1999). Scores for assessments ranged from 11-32, with an average of 30 questions out of 49 answered (Appendices 2.1-2.16). Eight taxa (50%) obtained scores above 20, namely: *Senna siamea* (score = 21), *S. spectabilis* (score = 22), *S. pendula* var. *glabrata* (score = 22), *S. alata* (score = 25), *S. occidentalis* (score = 28), *S. obtusifolia* (score = 28), *S. didymobotrya* (score = 28), and *S. septemtrionalis* (score = 32). Factors and traits that contributed to the high-risk scores of these taxa included adaptability to various soil types, rapid growth, invasion elsewhere, formation of dense thickets, prolific and persistent seed production.

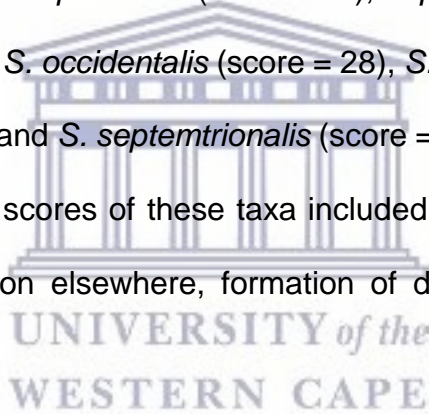


Table 3.1. Invasion risk of *Cassia* and *Senna* species introduced to and naturalising in South Africa evaluated using Pheloung et al. (1999) as modified for South Africa.

Species Names	A-WRA score	A-WRA outcome
<i>Cassia fistula</i> L.	18	High
<i>Senna alata</i> (L.) Roxb.	25	High
<i>Senna bicapsularis</i> (L.) Roxb.	15	High
<i>Senna corymbosa</i> (Lam.) H.S.Irwin & Barneby	11	High
<i>Senna didymobotrya</i> (Fresen.) H.S.Irwin & Barneby	28	High
<i>Senna hirsuta</i> (L.) H.S.Irwin & Barneby	19	High
<i>Senna multiglandulosa</i> (Jacq.) H.S.Irwin & Barneby	14	High
<i>Senna multijuga</i> (Rich.) H.S.Irwin & Barneby	15	High
<i>Senna obtusifolia</i> (L.) H.S.Irwin & Barneby	28	High
<i>Senna occidentalis</i> (L.) Link	28	High
<i>Senna pendula</i> (Willd.) Irwin & Barneby var. <i>glabrata</i> (Vogel) H.S.Irwin & Barneby	22	High
<i>Senna septemtrionalis</i> (Viv.) H.S.Irwin & Barneby	32	High
<i>Senna siamea</i> (Lam.) H.S.Irwin & Barneby	21	High
<i>Senna spectabilis</i> (DC.) H.S.Irwin & Barneby	22	High
<i>Senna surattensis</i> (Burm.f.) H.S.Irwin & Barneby	18	High

3.2.2 Risk Analysis Framework

The risk analysis framework independently indicated high risk for the 15 species of Cassiinae introduced to South Africa (Table 3.2) with high risk according to the A-WRA. The outcomes of the risk analyses are summarised in Appendices 3.1–3.15. Risk analysis performed here (Kumschick et al., in press) is meant to serve as evidence for the listing of the species under the NEM:BA A&IS regulations for South Africa or could serve as evidence against the current listing with an alternative listing recommendation. Evidence from this analysis suggested that eight taxa (*Cassia fistula*, *Senna alata*, *S. corymbosa*, *S. multiglandulosa*, *S. multijuga*, *S. obtusifolia*, *S. spectabilis*, and *S. surattensis*) should be listed under Category 1a (Table 3.2). Six taxa (*Senna bicapsularis*, *S. didymobotrya*, *S. hirsuta*, *S. occidentalis*, *S. pendula* var. *glabrata* and *S. septemtrionalis*) should be listed under 1b and only one species (*Senna siamea*) is recommended for listing under Category 3. The listing of these taxa

are based on risk analysis alone, but further analysis would support a more robust policy decision.

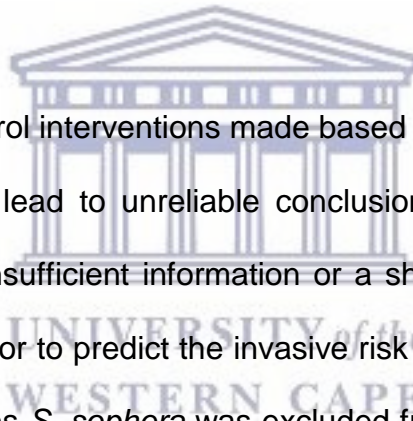
Table 3.2. Invasive status of *Cassia* and *Senna* species introduced to and naturalising in South Africa evaluated using Risk Analysis Framework of Kumschick et al. (in press).

Species Name	Risk score	NEM:BA Category
<i>Cassia fistula</i> L.	High	1a
<i>Senna alata</i> (L.) Roxb.	High	1a
<i>Senna bicapsularis</i> (L.) Roxb.	High	1b
<i>Senna corymbosa</i> (Lam.) H.S.Irwin & Barneby	High	1a
<i>Senna didymobotrya</i> (Fresen.) H.S.Irwin & Barneby	High	1b
<i>Senna hirsuta</i> (L.) H.S.Irwin & Barneby	High	1b
<i>Senna multiglandulosa</i> (Jacq.) H.S.Irwin & Barneby	High	1b
<i>Senna multijuga</i> (Rich.) H.S.Irwin & Barneby	High	1a
<i>Senna obtusifolia</i> (L.) H.S.Irwin & Barneby	High	1a
<i>Senna occidentalis</i> (L.) Link	High	1b
<i>Senna pendula</i> (Willd.) Irwin & Barneby var. <i>glabrata</i> (Vogel) H.S.Irwin & Barneby	High	1b
<i>Senna septemtrionalis</i> (Viv.) H.S.Irwin & Barneby	High	1b
<i>Senna siamea</i> (Lam.) H.S.Irwin & Barneby	High	3
<i>Senna spectabilis</i> (DC.) H.S.Irwin & Barneby	High	1a
<i>Senna surattensis</i> (Burm.f.) H.S.Irwin & Barneby	High	1a

3.3 Discussion

The two risk assessment frameworks used in the present study led to the conclusion that Cassiinae species have high invasion risk in South Africa. This outcome is consistent with previous studies conducted elsewhere. The Pacific Island Ecosystems at Risk assessments (PIER, 2014) concluded that *Senna alata*, *S. bicapsularis*, *S. hirsuta*, *S. obtusifolia*, *S. multijuga*, and *S. spectabilis* posed high invasion risk to the islands where they have been introduced. The high invasion risk is associated with the rapid growth, production of dense thickets, prolific production of seeds and seeds that remain viable for several years (Weber, 2003; CABI, 2018).

The outcome of the present study, however, contradicts previous studies that indicated the low invasive risk for *Cassia fistula* and *Senna siamea*. These two taxa scored 3 and 5, respectively, in the analysis of PIER (2014). This is in contrast to the A-WRA scores provided in the present study of 18 for *C. fistula* and 21 for *S. siamea*. The findings of the present study provides evidence that both *C. fistula* and *S. siamea* are prolific producers of seeds and are capable of vegetative regrowth. Furthermore, evidence supporting nitrogen-fixing capability, ability to infest infertile soils and agricultural weediness in other countries substantiates the high invasion risk proposed here for *C. fistula*. Evidence of coppicing, water facilitated seed dispersal and formation of dense thickets substantiates the high invasion risk proposed here for *S. siamea*.



Management or control interventions made based on limited information about species invasiveness may lead to unreliable conclusions (Negussie et al., 2013). Some species may have insufficient information or a short introduction history that does not enable the assessor to predict the invasive risk of the species (Negussie et al., 2013). For these reasons *S. sophora* was excluded from the current assessment list due to a lack of information.

The weed risk assessment protocols used in the present study are designed primarily to assess the risk of potential invaders with high accuracy and predictive power of about 90-95% (Pheulong et al., 1999; Gordon et al., 2008). However, the different data sources used in the A-WRA may result in contradictory conclusions, for example in the PIER (2014) risk analysis the “nitrogen fixing woody plants” question was answered “no” based on Pokhriyal et al. (1990), whereas Barthakur et al. (1995) indicated that *C. fistula* is a nitrogen fixing plant. Negussie et al. (2013) suggested that invasive risk assessment protocols should increase the minimum number of ecological

and climate questions that need to be addressed and should require tangible information from field observation in the species' known range. Furthermore, risk assessment protocols should be supported by experimental facts to reduce uncertainty (Negussie et al., 2013).

The A-WRA is designed primarily as a precautionary method to prevent entry of potential invaders (Pheloung et al., 1999). However, it can also be used as a management tool for species that have entered new areas without being pre-screened (Hulme, 2012; Kumschick and Richardson, 2013). As *Cassia* and *Senna* species are already present in South Africa, this risk assessment can be used as a management tool for prioritising control interventions against potentially invasive and naturalising *Cassia* and *Senna* species by ranking them according to their level of risk.

The Risk Analysis Framework protocol may be used to predict potential invasion risks and it further suggests the listing of species under NEM:BA alien and invasive lists and the steps that need to be taken to manage the risk of particular species (Kumschick et al., in press). Evidence in the present study is consistent with the listing of six *Senna* species under Category 1b according to the recently promulgated NEM:BA A&IS regulations (NEM:BA 2016). *Senna bicapsularis*, *S. didymobotrya*, *S. hirsuta*, *S. occidentalis*, *S. pendula* var. *glabrata* and *S. septemtrionalis* are widely distributed in South Africa (mainly KwaZulu-Natal, Eastern Cape and Limpopo). *Senna bicapsularis*, *S. didymobotrya*, *S. hirsuta* and *S. pendula* var. *glabrata* have the ability to outcompete indigenous vegetation in the areas where they are found by either forming dense thickets or climbing over natural vegetation and restricting their growth. Therefore, they should be prioritised for control, if possible eradicated, and further trading or planting of these species should be prohibited.

The Risk Analysis Framework undertaken in the present study further recommends the listing of eight Cassiinae species under Category 1a. *Cassia fistula*, *Senna alata*, *S. corymbosa*, *S. multiglandulosa*, *S. multijuga*, *S. obtusifolia*, *S. spectabilis* and *S. surattensis* are known from very small distribution ranges in South Africa. *Senna multijuga*, *S. obtusifolia*, *S. spectabilis* and *S. surattensis* were found to have prolific seed production and long term seed viability in the present study (CABI, 2018), which are traits attributed to invasiveness (Lake and Leishman, 2004). Most invasive species have the ability to adapt to different habitats and some even alter the habitats to better suit their requirements. *Senna alata*, *S. multijuga* and *S. surattensis* were found to have the ability to do so, which increases their potential invasiveness (Hulme, 2008). This suggests that if the eight species are planted more widely their populations would have the ability to successfully overcome barriers to invasion.

Senna siamea is recommended for Category 3 listing under NEM:BA. Although the species has a high risk of invasion, it has significant economic impact in the country as it increases nitrogen into the soil (Kwesiga et al., 2003). In countries such as the United State of America it is used for the production of high quality timber, fodder, mulch, fuel and medicine (Irwin and Barneby, 1982). The species should perhaps be allowed under permit conditions considering the potential positive economic impacts, and measures should be taken to prevent potential invasiveness and impact.

3.4 Dossiers of species

Information for all *Cassia* and *Senna* species currently found naturalising in southern Africa is provided below and can be used in conjunction with the electronic key for accurate identification.

***Cassia abbreviata* Oliv. subsp. *beareana* (Holmes) Brenan**

Synonym(s): *Cassia abbreviata* var. *glabrifrutifera*, *Cassia abbreviata* var. *granitica*, *Cassia beareana*

Common name(s): Long-tail cassia, *Muvhonelathangu* (Tshivenda), sjambokpod; *Sambokpeul* (Afrkaans), *Monêpênêpê* (Tswana), *Numanyama* (Tsonga).

Description:

Tree to 13 m tall. **Stems** erect, rough, bearing brownish-grey bark, branchlets glabrous, or densely pubescent with short, appressed, curved white hairs. **Leaves** paripinnate, 100–210 mm long; stipules 3 mm long, narrowly triangular; rachis channelled; extrafloral nectaries lacking. **Leaflets** 5–9 jugate, 30–60 × 10–30 mm, ovate-elliptic to oblong-elliptic; base rounded to obtuse; apex rounded or obtuse; margins slightly thickened. **Inflorescence** terminal, multi-flowered; bract 7–15 mm × ±2 mm. **Pedicels** 35–85 mm at flowering, at fruiting ± 90 mm long. **Sepals** 5, obtuse, 8–12 × 3–5 mm, pubescent to glabrescent. **Petals** 5, obovate, 10–22 × 5–15 mm. **Stamens** 10, staminodes 3, ± 4 mm long; medium-sized stamens 4, 9–12 mm long, anthers straight; large stamens 3, with very long filaments 20–35 mm long. **Ovary** densely pubescent, curved in the middle, 20–40 mm long; style hardly developed. **Pods** 30–80 × ± 20 mm, cylindrical, slightly curved or straight, dark brown to black. **Seeds** elliptic, 8–10 × 8–9 mm, brown to blackish.

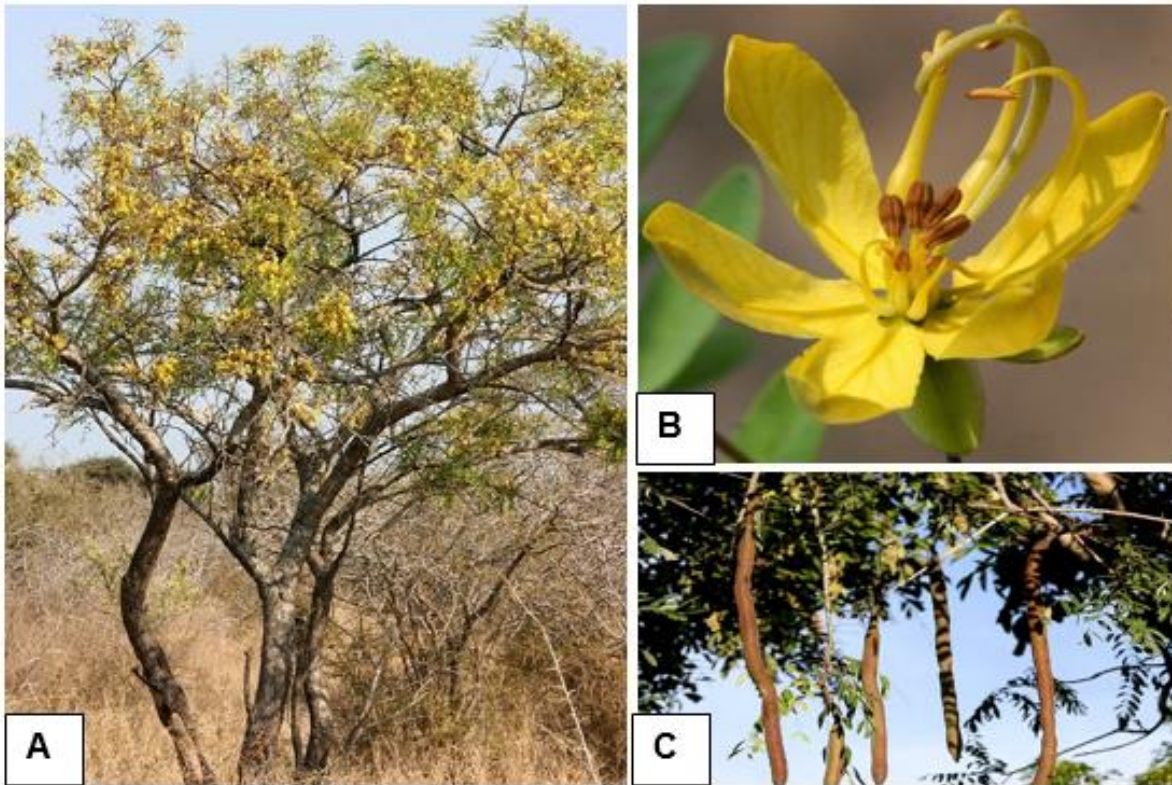


Figure 3.1. (A) *Cassia abbreviata* subsp. *beareana* plant, (B) flower and (C) pods.

Photographs taken by Joan Young (<http://natureswow2.blogspot.com/>).

Native range:

Cassia abbreviata is widespread in eastern Africa. Two subspecies are recognised, *Cassia abbreviata* subsp. *abbreviata* is known from Tanzania, Zimbabwe, Zaire, Zambia and Mozambique (Brenan, 1967; Gordon-Gray, 1977; Brummitt et al., 2007), while *Cassia abbreviata* subsp. *beareana* extends to the Flora of southern Africa region (Gordon-Gray, 1977).

Distribution in South Africa:

Cassia abbreviata subsp. *beareana* is most common from Vhembe through Phalaborwa to Arconhoek in Limpopo, extending to Mashishing (Lydenburg) in Mpumalanga (Fig. 3.2).

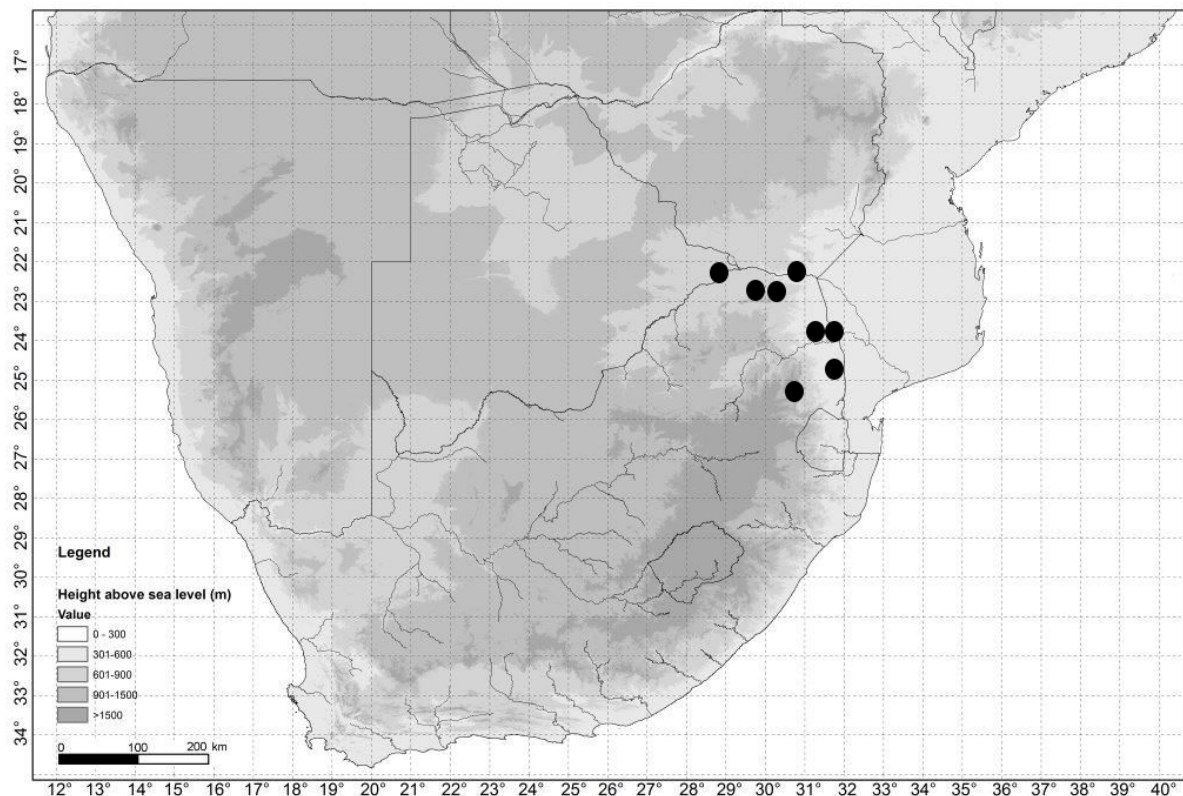


Figure 3.2. Distribution of *Cassia abbreviata* subsp. *beareana* in South Africa.

Habitat:

Cassia abbreviata subsp. *beareana* occurs in lowveld bush, open savanna and along river banks (Gordon-Gray, 1977).

Additional specimens examined:

South Africa. LIMPOPO: **2228 (Masstroom)** Tswehe 31 MR Mawana Nature Reserve (–BD), 29 September 2004, *Baytopp 05* (PRE). **2229 (Waterpoort)** Louis Trichardt (–DD), 22 March 1994, *Rossouw 89* (PRE). **2230 (Messina)**: Malonga flats on road between Tshipise and Mabiligwe (–BD), 22 August 2000, *Van Wyk EVW0113* (PRE); Nwanedi Nature Reserve (–CB), without date, *Chadwick 270* (PRE). **2331 (Phalaborwa)**: 10 km from North of Phalaborwa (–CC), 10 October 1984, *Retief 259* (PRE). Letaba rest Camp (–DC), 24 September 1932, *Lang s.n* (PRE); 14.4 km from Letaba towards Olifant Camp (–DC), 14 May 1973, *Nel 319* (PRE). **2431 (Acornhoek)**

Kruger National Park (-DD), 22 June 1992, *Allison 207* (PRE); main road from Skukuza to Tshokwane, ca. 5 km from SW of Tshokwane (-DD), 09 September 1982, *Onderstall 778* (PRE).

MPUMALANGA: **2530 (Lydenburg)** Lowveld Botanical Garden (-BD), 18 September 2002, *Meyer 4149* (PRE).



Cassia fistula L.

Synonym(s): *Cassia fistuloides* Collad.

Common name(s): Golden tree, Golden shower tree, Cassia stick tree.

Description:

Tree to 6 m tall. **Stems** erect, branchlets brown, pubescent when young, becoming glabrous with age. **Leaves** paripinnate, 20–85 mm long, glabrous; stipules not seen; extrafloral nectaries lacking. **Leaflets** 4–6 (8) jugate, 85–220 × 20–60 mm, ovate to lanceolate; base obtuse; apex acute; margins entire. **Inflorescence** axillary, multi-flowered; bracts ± 5 mm long, linear, puberulous; bracteoles ± 2.0 × 0.5 mm, linear, puberulous. **Pedicels** 15–50 mm at flowering, at fruiting ± 60 mm long. **Sepals** 5, obovate, 6–10 × 4–6 mm. **Petals** 5, ovate, 10–20 × 7–10 mm. **Stamens** 10; staminodes 3, 5–6 mm long, filaments straight; medium-sized stamens 4, 10–13 mm; 3 large stamens, filaments 25–30 mm long, slightly curved. **Ovary** pubescent, curved in the middle, ± 30 mm long; style glabrous, 5 mm long. **Pods** 40–85 × 10–17 mm, cylindrical, many seeded, straight or slightly curved, dark brown to black. **Seeds** circular flattened, 5–6 × 3–4 mm, brown.

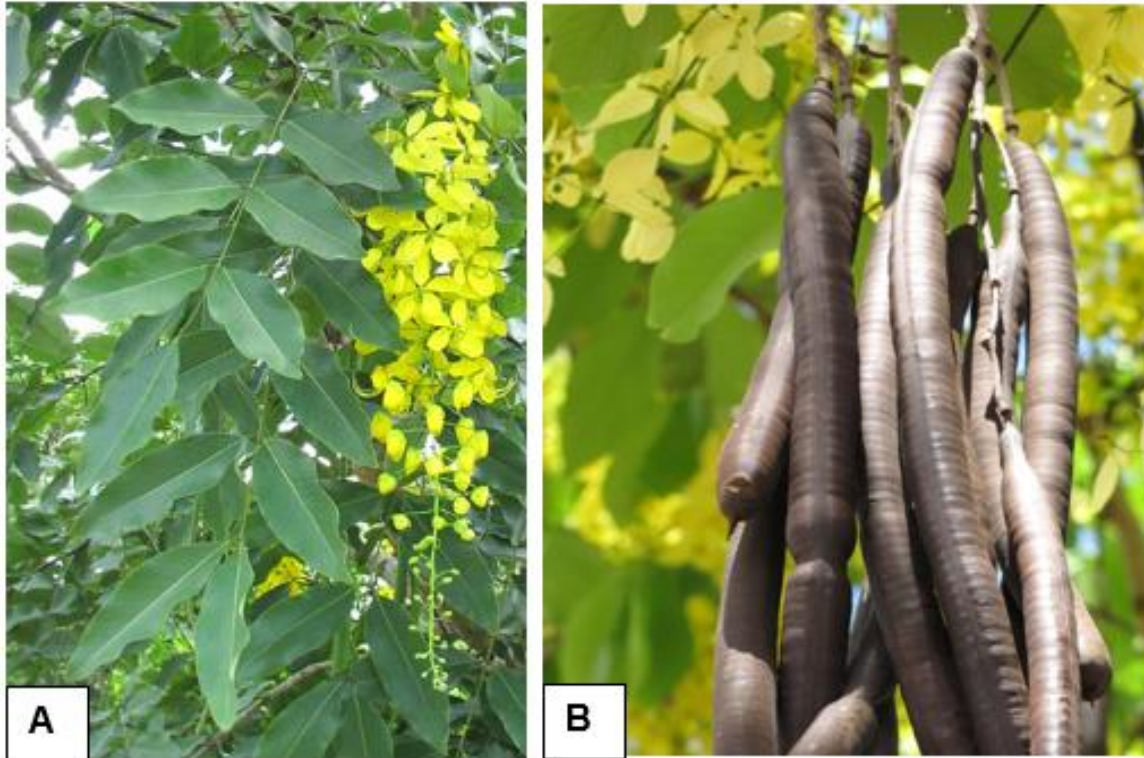


Figure 3.3. (A) *Cassia fistula* leaves and flower, and (B) pods. Photographs taken by (A) Jim Conrad and (B) Kim Starr (<https://www.feedipedia.org/node/325>).

Native range:

Cassia fistula is native to south-east Asia and dispersed throughout India, Malesia, Micronesia, tropical, and northern east subtropical Africa (Irwin and Barneby, 1982).

Distribution in South Africa:

Cassia fistula is distributed from Messina in the Limpopo Province, to Mbabane in Swaziland (Eswatini), to Stanger in KwaZulu-Natal Province (Fig. 3.4).

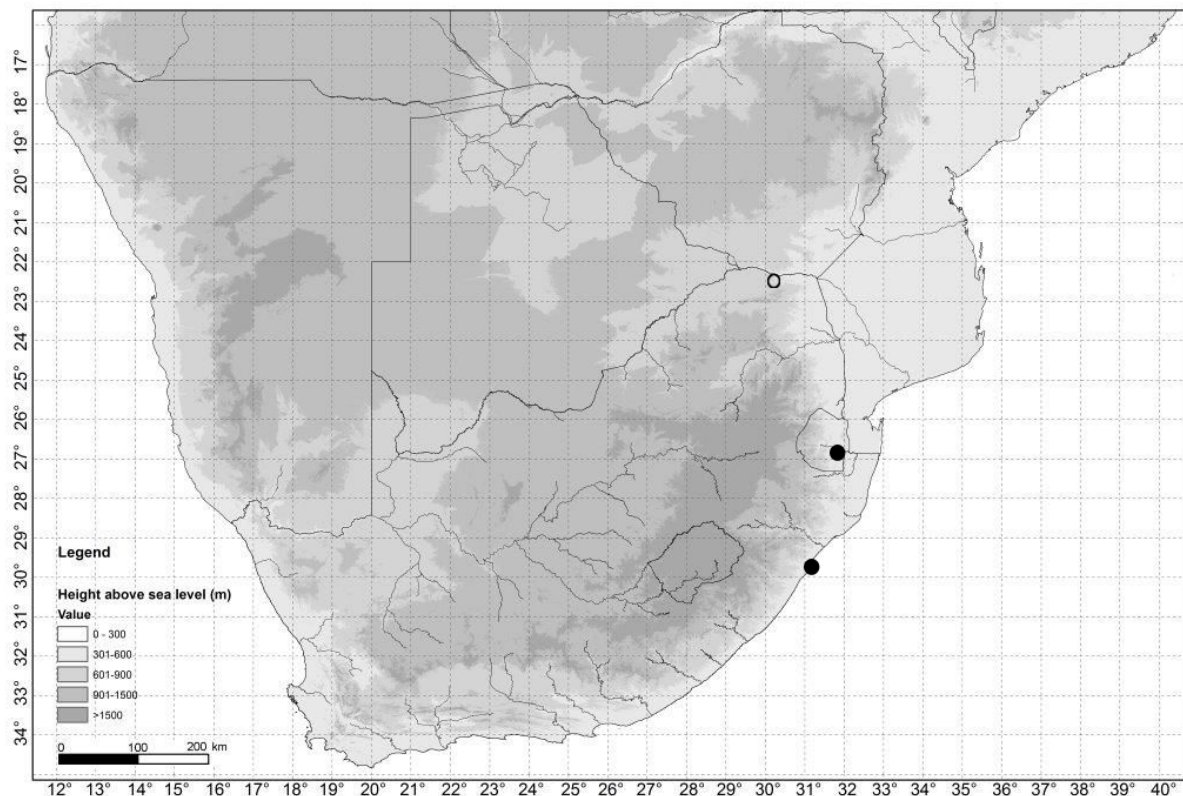


Figure 3.4. Distribution of *Cassia fistula* in South Africa (SANBI DBI (South African National Biodiversity Institute Directorate on Biological Invasions) record (o), herbarium records (●)).



Habitat:

Cassia fistula occurs in open forest and is widely planted in gardens, streets and parks (Irwin and Barneby, 1982).

How it spreads:

Cassia fistula is spread intentionally by humans for its ornamental and medicinal properties (Irwin and Barneby, 1982; CABI, 2018). Furthermore, the species can be propagated by seeds and vegetatively through cutting and layering (CABI, 2018).

Invasion category:

This species has not been listed under the (NEM:BA 2014) regulations of alien and invasive species in South Africa.

Environmental impacts:

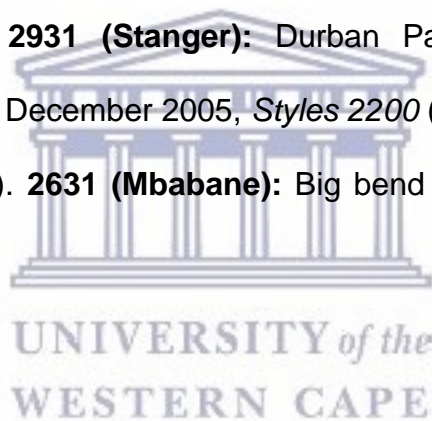
Cassia fistula is considered an environmental weed (Randall, 2012), however, its impact has not been quantified. It is also known to be a host of serious pests such as *Eurema blanda* and *Xyleutes persona* (PIER, 2014; CABI, 2018). *Xyleutes persona* bore holes into the woody stems and branches of different species, while *Eurema blanda* feeds on young plantations and young plants in nurseries (CABI, 2018).

Additional specimens examined:

South Africa. LIMPOPO: **2230 (Messina)**: opposite Messina Spar (–AA), 06 December 2017, *Musandiwa 01* (NBG); Tshakhuma (–AB), 09 May 1951, *Van Warmelo 5159/10* (PRE).

KWAZULU-NATAL: **2931 (Stanger)**: Durban Parks Department, next to Essenwood road (–CC), 12 December 2005, *Styles 2200* (NH).

Swaziland (Eswatini). **2631 (Mbabane)**: Big bend (–DD), 27 February 1974, *Donaldson 10* (PRE).



***Senna alata* (L.) Roxb.**

Synonym(s): *Cassia alata* L., *Herpetica alata* (L.) Raf.

Common name(s): Emperor's candlesticks.

Description:

Shrub \pm 3 m tall. **Stems** pubescent when young, becoming glabrous with age. **Leaves** paripinnate, up to 600 mm long; stipules triangular, $6-14 \times \pm 10$ mm; rachis widely channelled; extrafloral nectaries lacking. **Leaflets** 7–12 jugate, $65-80 \times 5-60$ mm, oblong elliptic to obovate elliptic; base oblique to acute; apex rounded or mucronate; uppermost pair the largest, margins entire. **Inflorescence** axillary, multi-flowered, up to 600 mm long. **Pedicels** ± 5 mm at flowering, at fruiting ± 10 mm long. **Sepals** 5, obovate to cuneate, $13-15 \times 7-10$ mm wide. **Petals** 5, broadly obovate, $12-15 \times 5-10$ mm. **Stamens** 10; staminodes 3, 4 mm long, anthers c-shaped, filaments straight; medium-sized stamens 4, 5–6 mm long, anthers slightly curved at the top; large stamens 3, 1 reduced, straight, up to 10 mm long, 2 with broad anthers, 12 mm long, curved, filaments very short, ± 2 mm long. **Ovary** densely pubescent, curved in the middle, ± 15 mm long; style glabrous, 5 mm long. **Pods** 4-winged, $80-110 \times 15-25$ mm, flattened, straight, dark brown to black. **Seeds** obovate, $5-6 \times 3-4$ mm, brown, with ridged on each face.

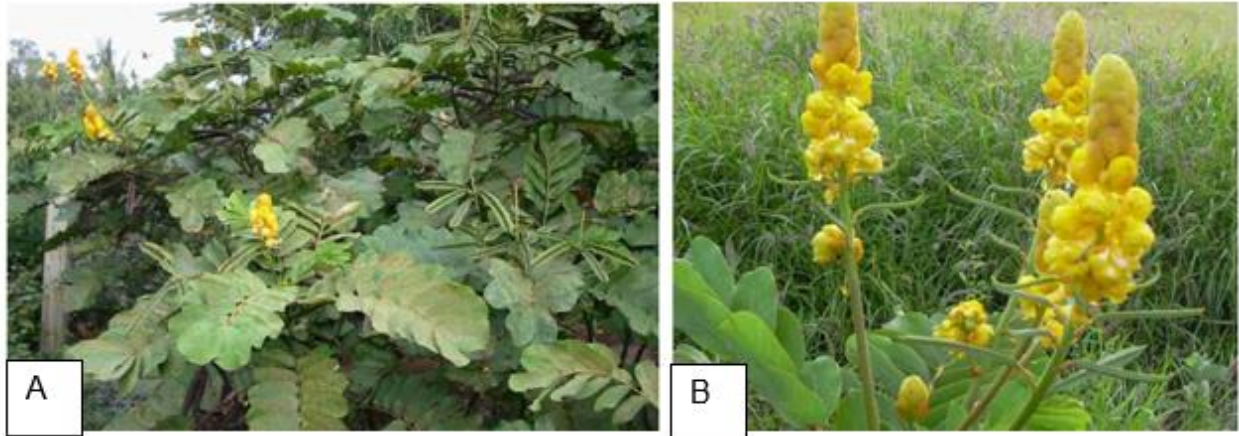


Figure 3.5. (A) *Senna alata* plant and (B) flowers. Photographs taken by Kim Starr.

(<https://keyserver.lucidcentral.org/weeds/data/media/Html/fshelp.htm>).

Native range:

Native to Orinoco, Amazon basin in Venezuela, Brazil, and Colombia in South America (Irwin and Barneby, 1982).

Distribution in South Africa:

Senna alata is distributed in Pietermaritzburg and Jozini in KwaZulu-Natal Province (Fig. 3.6).



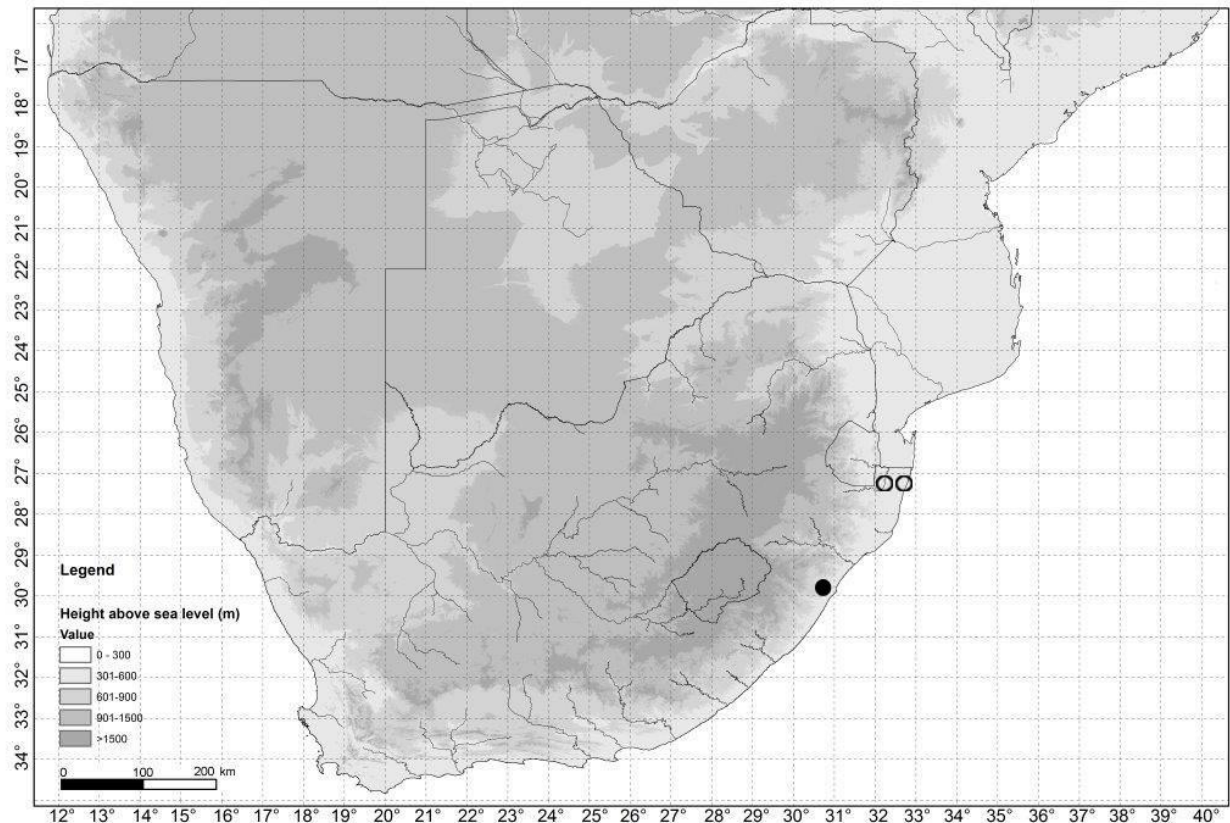


Figure 3.6. Distribution of *Senna alata* in South Africa (SAPIA (Southern African Plant Invader Atlas) records (o), herbarium records (●)).

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Habitat:

Senna alata invades disturbed areas, humid ravines, riverbanks, grassland, forest and forest edges (Irwin and Barneby, 1982; Weber, 2003).

How it spreads:

The species is planted for ornamental and medicinal purposes (Irwin and Barneby, 1982). It has the ability to escape cultivation (Irwin and Barneby, 1982; CABI, 2018).

Invasion category:

This species has not been listed under the (NEM:BA 2014) regulations of alien and invasive species in South Africa.

Environmental impacts:

Senna alata forms dense thickets and shades out most indigenous species (Weber, 2003). It reduces species richness of native species and competes with native species for space and nutrients (Weber, 2003).

Additional specimens examined:

South Africa. KWAZULU-NATAL: **2930 (Pietermaritzburg)**: Avoca, growing in garden (-DD), 01 April 1976, *Michael s.n.* (NU).



***Senna bicapsularis* (L.) Roxb.**

Synonyms: *Cassia bicapsularis* L., *Cassia emarginata* L.

Common name(s): Rambling senna, Money bush, Christmas bush.

Description:

Shrub to 4.5 m tall, often spreading, climbing or scrambling. **Stems** woody, cylindrical, glabrous, becoming grey. **Leaves** paripinnate, petiole and rachis 20–45 mm long; rachis channelled; stipules linear, acute up to 3 mm long. **Leaflets** (2)3 jugate, 40 × 25 mm, obovate; base broadly cuneate to rounded; rounded at apex, uppermost pairs often largest; margin glabrous; extrafloral nectaries located between the lowest pairs of leaflets, stalked clavate. **Inflorescence** axillary, racemes 35–90 mm long, peduncle well developed, 3–15 flowered, multiple flowers towards the end of the branches. **Pedicels** 3–5 mm long at flowering, 8–10 mm long at fruiting. **Sepals** 5, acute to obtuse, 6–10 × 2–4 mm. **Petals** 5, obovate, 10–12 × 4–6 mm, bright yellow. **Stamens** 10, staminodes 3, 4 mm long, anthers Y-shaped, filaments straight; medium-sized stamens 4, 5–6 mm long, anthers straight; large stamens 3, 6–7 mm long, 1 reduced, up to 6 mm long, anthers slightly curved, filaments long, 5–7 mm long. **Ovary** curved, glabrous; styles 2–4 mm long. **Pods** straight, oblong linear, rounded at apex, 40–135 mm long. **Seeds** broadly elliptic to rhomboid, 3–5 × 2–4 mm, brown.

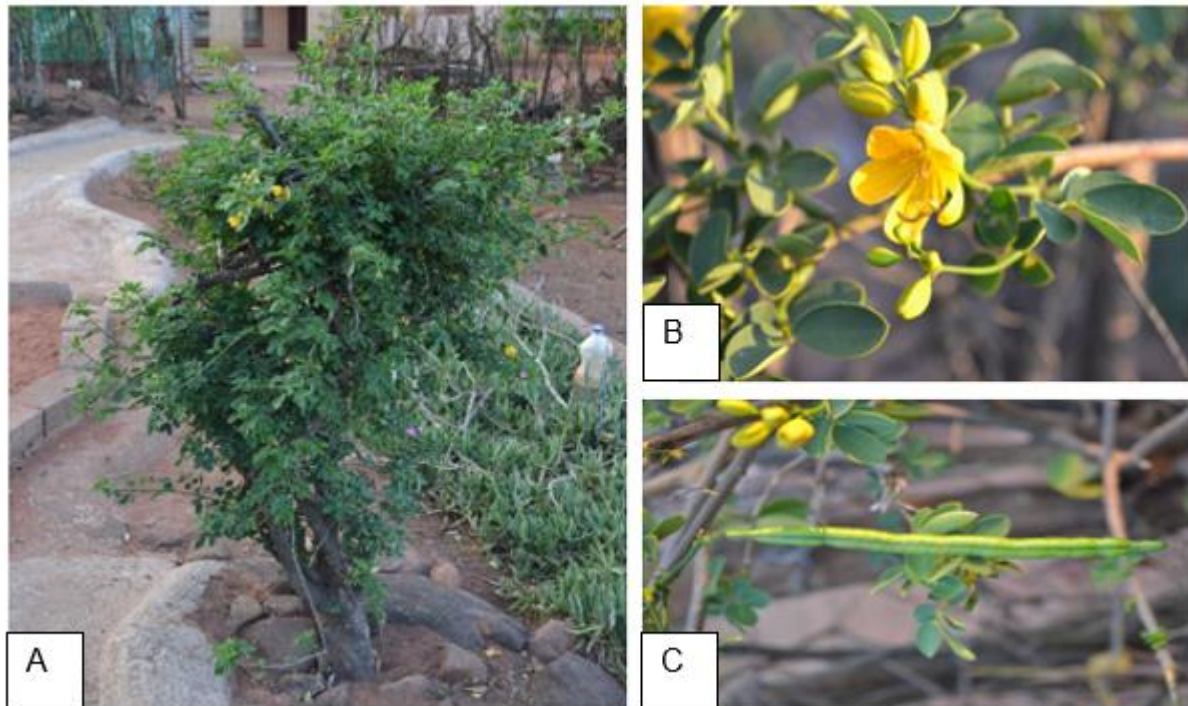


Figure 3.7. (A) *Senna bicapsularis* plant, (B) flower, and (C) pod. Photographs by Liada Musandiwa.

Native range:

Native to western South America and the West Indies (Brenan, 1967; Gordon-Gray, 1977).

Distribution in South Africa:

Senna bicapsularis is widely distributed from Phalaborwa to Polokwane in the Limpopo Province, extending to Pilgrim's Rest in Mpumalanga across to Mbabane in Swaziland (Eswatini) and Ingwavuma through Nkandla to Port Shepstone in KwaZulu-Natal (Fig. 3.8).

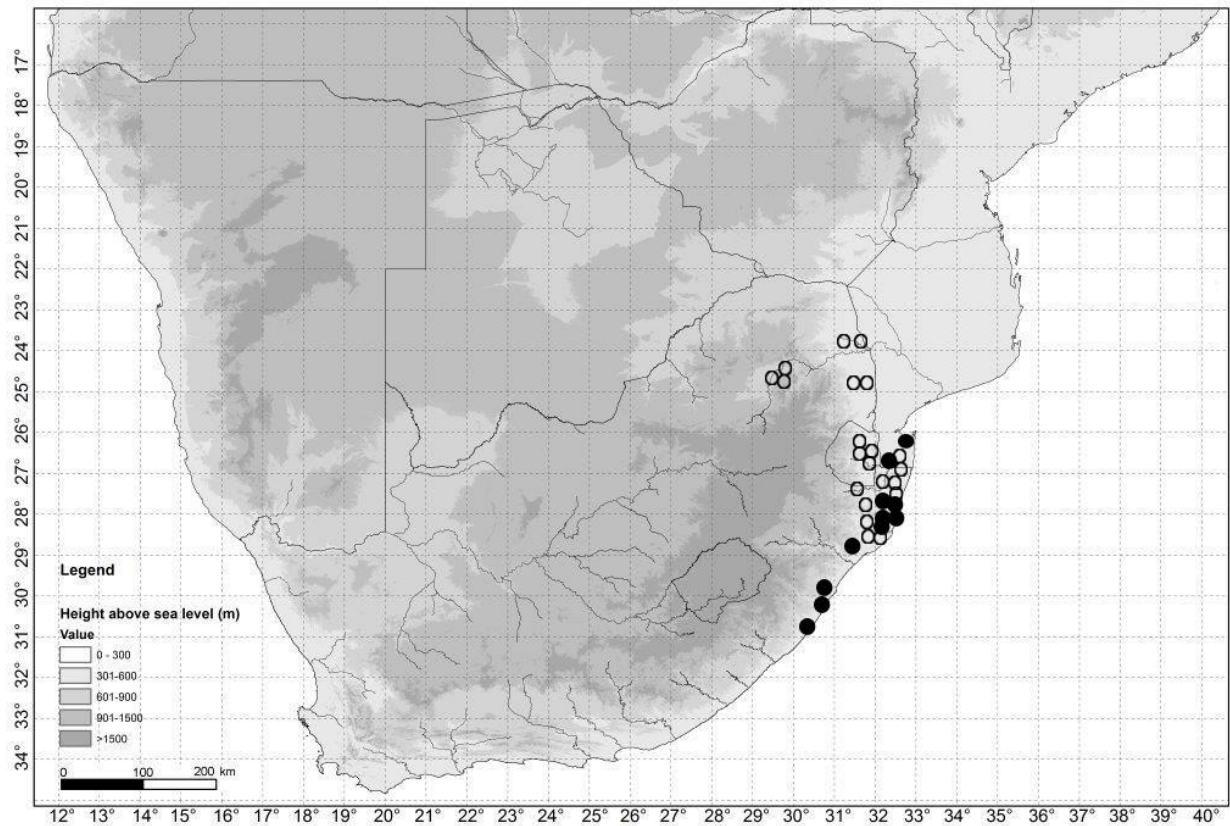
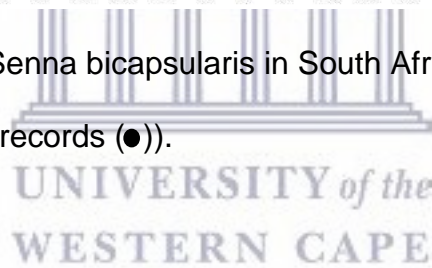


Figure 3.8. Distribution of *Senna bicapsularis* in South Africa (SAPIA and SANBI DBI records (o), herbarium records (●)).



Habitat:

Senna bicapsularis occurs in disturbed areas, woodlands, riparian areas and coastal bush (Gordon-Gray, 1977, Mak et al., 2013).

How it spreads:

The species is frequently cultivated (Gordon-Gray, 1977). It is spread intentionally by human activities, e.g. ornamental or medicinal purposes (Gordon-Gray, 1977), and seeds (<http://invasives.org.za/>).

Invasion category:

The species is listed as a Category 1b invader under (NEM:BA 2014) regulations of alien and invasive species in South Africa.

Environmental Impacts:

Senna bicapsularis forms dense thickets and climbs over indigenous species, impeding growth and regeneration of native species (Weber, 2003). Dense thickets restrict wildlife access to water (Weber, 2003). It is also known to be poisonous to chickens, birds and bees (Henderson, 2001).

Additional specimens examined:

South Africa. LIMPOPO: **2431 (Acornhoek)**: at 7 SAAI army base along Tsutsispruit (–AA), 31 May 1995, Cass CS1 (PRE).

KWAZULU-NATAL: **2632 (Bela Vista)**: North of Jozini on new road from Ingwavuma to Jozini at Joulous Down Store (–BD), 31 August 1978, Smook 1334 (PRE); Ndumo Game Reserve, Mankobolo's kraal Usuthu banks (–CD), 28 July 1969, Pooley 641 (NU); Bella vista: Ndumo Game reserve (–CD), 21 October 1971, Moll and Nell 5554 (PRE); Usutu forest, Ndumo Game Reserve (–CD), 28 July 1969, Pooley 641 (NH). **2732 (Ubombo)**: Between Mkuze and Hluhluwe on N2 iNtendele Farm (–CC), 18 October 2001, Meyer 3982 (PRE); Maputaland, Lower Mkuze on floodplain next to Lower Mkuze road (–CD), 20 June 1996, Felton and Thornhill 78 (PRE). **2831 (Nkandla)**: Ngoye Forest Reserve (–CD), 10 June 1984, Ward 718 (NH). **2832 (Mtubatuba)**: St. Lucia Estuary Game Park (–AD), 02 May 1979, Pooley 2276 (NU), Hluhluwe Game Reserve near memorial Gate (–AA), 19 May 1984, Balkwill 1710 (NU); 3 km from Mission Rocks, St. Lucia (–AB), 12 December 1973, Grobberlaar 1826 (PRE). **2930 (Pietermaritzburg)**: Isipingo beach (–DD), June 1949, Ward 883

(NU). **3030 (Port Shepstone)**: Port Shepstone area (–CD), July 1957, *Sidey* 3219 (NU); South coast, Mkomazi River, ca. 550 m above weir at Delos Estate 10342 (–BA), 10 August 1994, *Ward* 12625 (PRE).



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***Senna corymbosa* (Lam.) H.S.Irwin & Barneby**

Synonym(s): *Cassia corymbosa* Lam., *Cassia bonariensis* hort. ex Colla

Common name(s): Argentine senna, Buttercup bush.

Description:

Shrub, up to 3 m tall. **Stems** woody, erect, glabrous. **Leaves** with petiole and rachis 20–75 mm; stipules linear to lanceolate, 2.5–4.0 mm long; rachis channelled. **Leaflets** 2–3 jugate, 65 × 20 mm, lanceolate; base cuneate to rounded; apex acute, uppermost pair the largest, lowest pair the smallest; margin glabrous; extrafloral nectaries located between the lowest pair of leaflets, linear. **Inflorescence** axillary, racemes 25–50 mm. **Pedicels**, 15–20 mm long at flowering, at fruiting 20–25 mm long. **Sepals** 5, obtuse, 5–8 × 3–4 mm. **Petals** 5, obovate, 5–10 × 5–6 mm sub-equal, bright yellow. **Stamens** 10: 3 equal staminodes, 4 mm long, anthers rounded, filaments straight; 4 medium stamens, 4–5 mm long, anthers slightly curved; 3 large stamens 6–8 mm long, anthers slightly curved, with very short filaments, 2 mm long. **Ovary** slightly curved, glabrous; style 2–4 mm long. **Pods**, ± 120 mm long, rounded, linear or slightly curved. **Seeds** elliptic, 4–5 × 4 mm, brown.

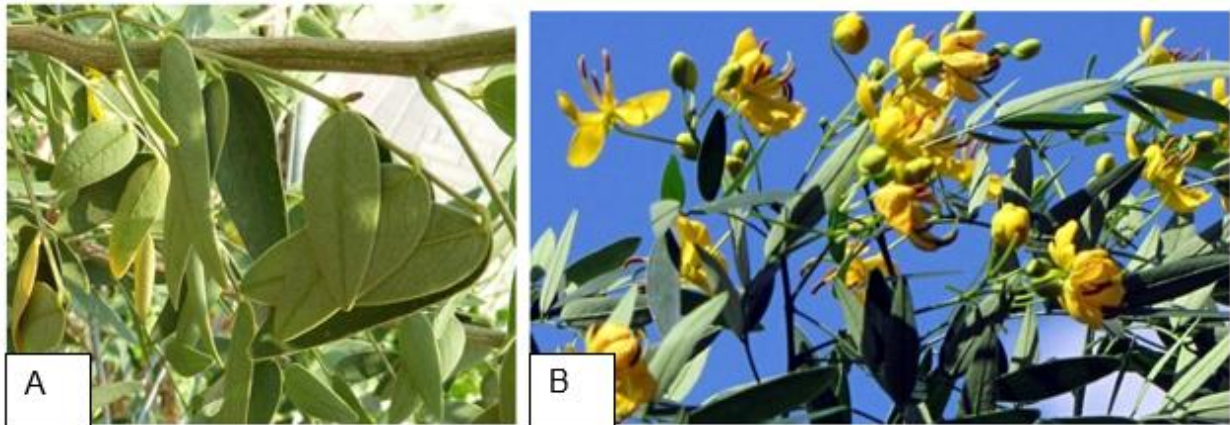


Figure 3.9. (A) *Senna corymbosa* plant, and (B) flowers. Photographs by (A) By Phil Marin and (B) by Debbie Magnes (<https://garden.org/plants/photo/231453/>).

Native range:

Senna corymbosa is native to Parana and Uruguay (Irwin and Barneby, 1982).

Distribution in South Africa:

Senna corymbosa is distributed in Pilgrim's Rest in Mpumalanga, extending to Pretoria in Gauteng through Kroonstad in the Free State, and across Pietermaritzburg in KwaZulu-Natal to Makhanda in the Eastern Cape (Fig. 3.10).

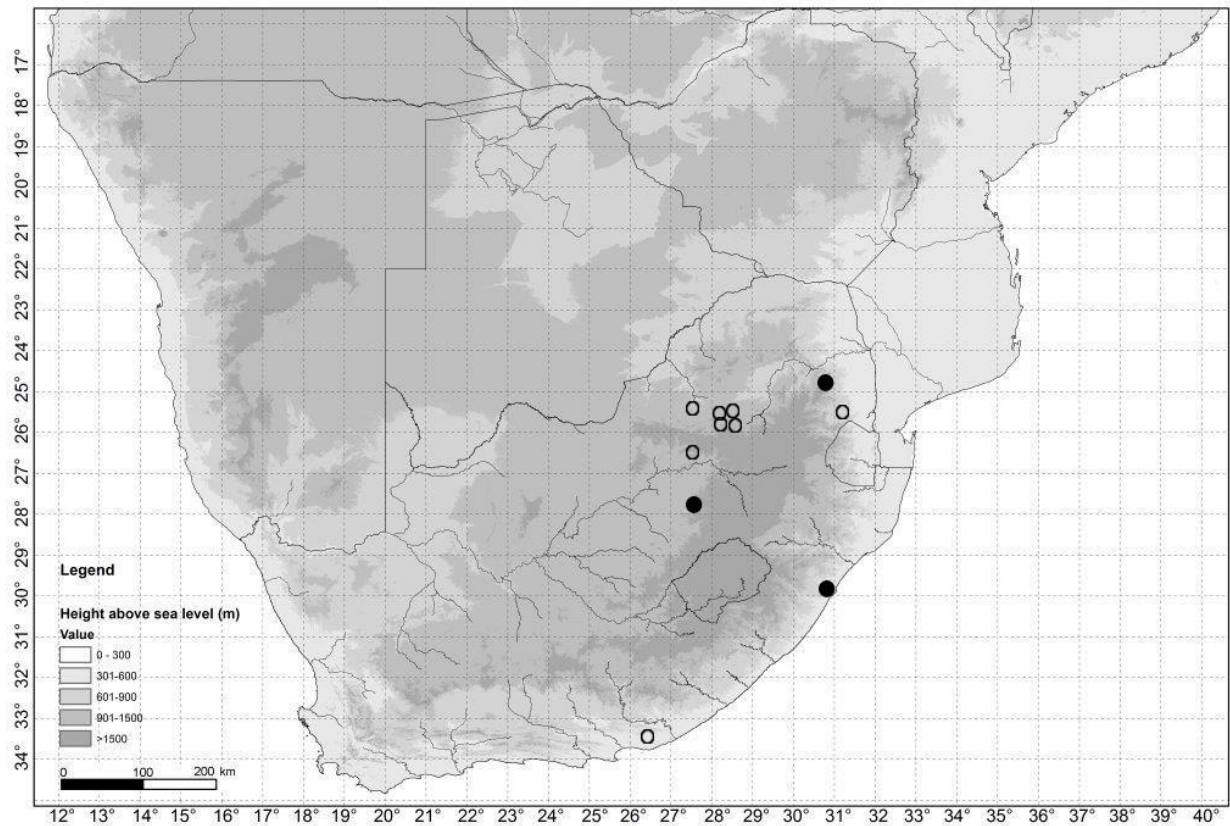


Figure 3.10. Distribution of *Senna corymbosa* in South Africa (SAPIA records (○), herbarium records (●)).



Habitat:

Senna corymbosa is a garden subject (Gordon-Gray, 1977). It also grows along streams and riverbanks (Irwin and Barneby, 1982).

How it spreads:

The species has escaped cultivation in disturbed places in warm temperate western Europe and South Africa (Irwin and Barneby, 1982, Gordon-Gray, 1977).

Invasion category:

Senna corymbosa has not been listed under the (NEM:BA 2014) regulations of alien and invasive species in South Africa.

Environmental impacts:

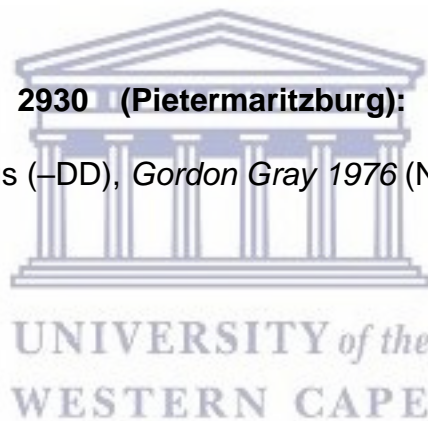
The species possesses invasive traits such as high production of viable seeds, ability to reproduce by vegetation propagation (Irwin and Barneby, 1982) and formation of dense thickets (Boa and Lenne, 1994). These dense thickets impede the growth and regeneration of native plants (Weber, 2013; CABI, 2018).

Additional specimens examined:

South Africa. MPUMALANGA: **2430 (Pilgrim's Rest)**: Kowyn's Pass (–DD), 22 February 1977, *Stirton 6911* (PRE).

FREE STATE: **2727 (Kroonstad)**: Wilgenhof (–DC), 19 January 1926, *Van Meersbergen 18* (NU).

KWAZULU-NATAL: **2930 (Pietermaritzburg)**: Scotsville, University of KwaZulu Natal main campus (–DD), *Gordon Gray 1976* (NU).



***Senna didymobotrya* (Fresen.) H.S.Irwin & Barneby**

Synonym(s): *Cassia didymobotrya* Fresen.

Common name(s): Peanut butter cassia, African senna.

Description:

Woody shrub to 6 m to tall. **Stems** woody, multiple stemmed from the ground to form rounded shrub, cylindrical, with soft short hairs. **Leaves** paripinnate, 60–350 mm long, with short hairs; stipules, 10–15 × 5–10 mm, broadly cordate; apex acuminate to caudate; extrafloral nectaries lacking. **Leaflets** 12–16 jugate, 10–55 × 5–22 mm, oblong, base oblique, apex apiculate; margin entire. **Inflorescence** axillary, dense racemes, 140–350 mm long, multiple flowered. **Sepals** 5, obovate to elliptic, 10–15 × 4–10 mm, sub-equal. **Petals** 5, broadly oblong, 12–17 × 7–10 mm, bright yellow, rounded at apex. **Stamens** 10: staminodes 3, 4 mm long, medium-sized stamens 4, 5–6 mm long, anthers slightly curved at the top; large stamens 3, 1 reduced, slightly curved, filaments very short 1 mm long. **Ovary** ± 120 mm long, curved, with soft patent hairs; style curved, glabrous, 12 mm long. **Pods** linear, flattened, 90–100 × 5–12 mm, green, becoming blackish when dry. **Seeds** oblong, 5–9 × 4–5 mm, light brown, flattened.

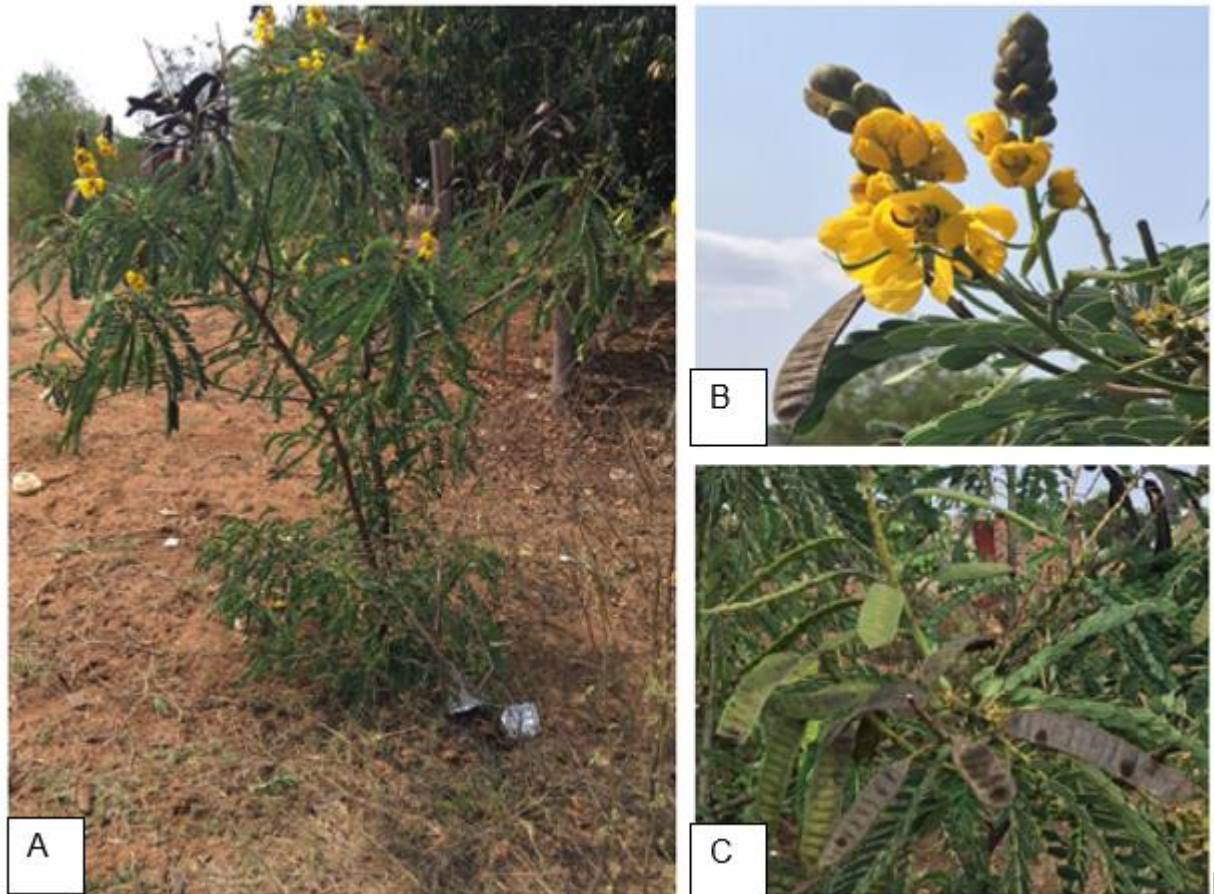


Figure 3.11. (A) *Senna didymobotrya* plant, (B) flower, (C) pods and seeds. Photographs taken by Liada Musandiwa.

Native range:

Senna didymobotrya is native to Kenya, Uganda and Tanzania (Gordon-Gray, 1977).

Distribution in South Africa:

Senna didymobotrya is widely distributed in Limpopo through to Mpumalanga and Gauteng, extending to the coastal areas of KwaZulu-Natal, Eastern and Western Cape (Fig. 3.12).

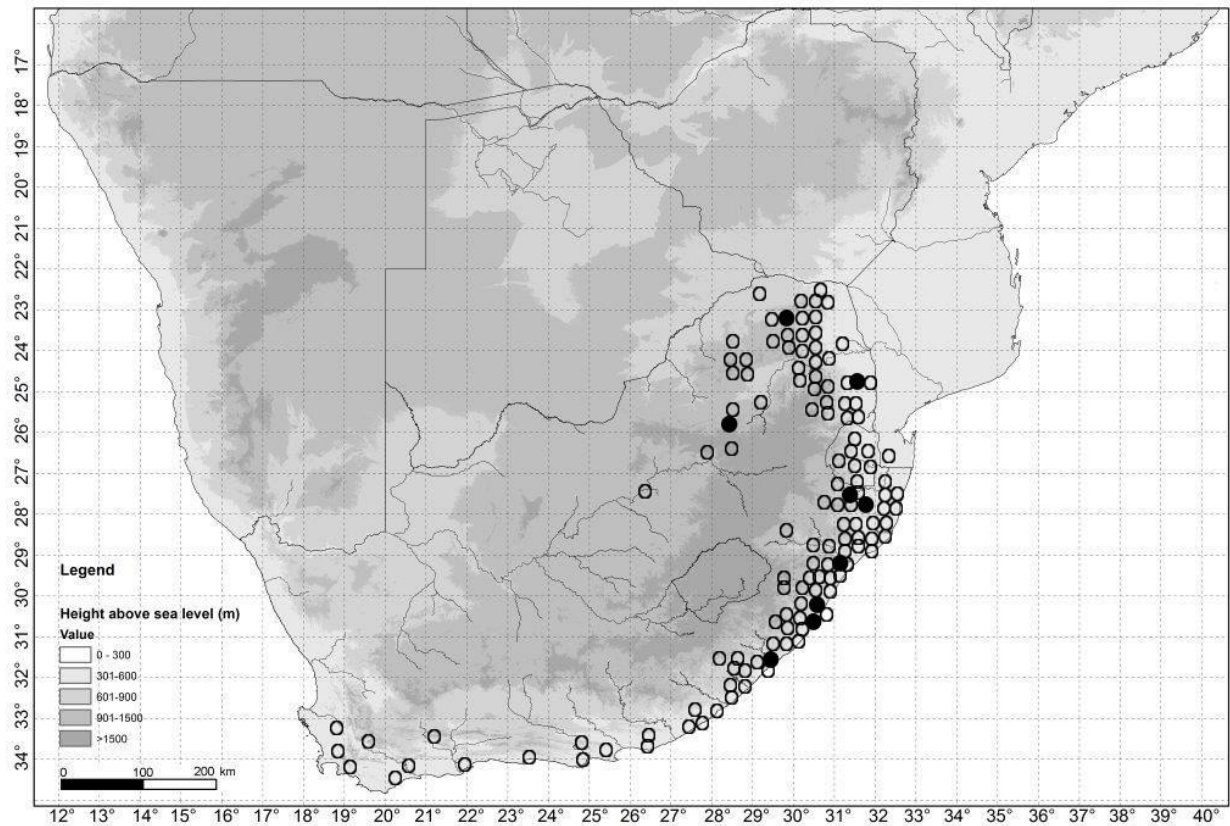
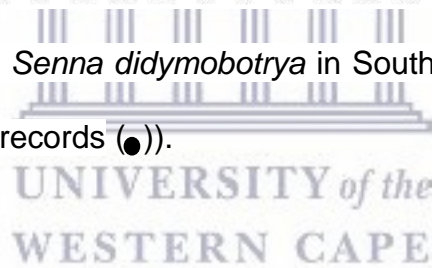


Figure 3.12. Distribution of *Senna didymobotrya* in South Africa (SAPIA and SANBI DBI records (○), herbarium records (●)).



Habitat:

Senna didymobotrya grows as a ruderal in shady or moist areas and along roadsides (Gordon-Gray, 1977).

How it spread:

Senna didymobotrya is widely cultivated as an ornamental and for medicine (Brummitt et al., 2007). It has escaped cultivation in many places. The species spreads through seeds (<http://invasives.org.za/>).

Invasion category:

Senna didymobotrya is listed as Category 1b invader under (NEM:BA 2014) regulations of alien and invasive species in South Africa.

Environmental impacts:

The species forms dense thickets that impedes the growth and regeneration of native vegetation (Weber, 2003) and is poisonous to fish (Brummitt et al., 2007).

Additional specimens examined:

South Africa. LIMPOPO: **2230 (Messina)**: Dzumbama (–CB), 06 December 2017, *Musandiwa 02* (NBG). **2329 (Pietersburg)**: Louis Trichardt langs paaie (–BB), 12 June 1973, *Pienaar 38* (PRE).

GAUTENG: **2528 (Pretoria)**: University Experimental Farm, Hatfield (–CD), 18 August 1972, *Schlieben 12848* (PRE).

MPUMALANGA: **2431 (Acornhoek)**: Kruger National Park (–DC), 12 August 1961, *Pienaar 4507* (PRE).

KWAZULU-NATAL: **2731 (Louwsburg)**: on roadside 30 km from Nongoma on HluHluwe road (–DD), 04 October 1974, *Rensburg 4* (NU), Isipingo Beach (–DD), June 1949, *Ward 882* (NU). **2930 (Pietermaritzburg)**: Grassland between Rabie Saunders building and Golf road at University of KwaZulu-Natal, Scottsville (–CB), 19 February 2005, *Wagg 1197* (NU), garden in Hayfield suburb home (–CB), 30 September 1984, *Nicholas 2011* (NH), Men Res (–DD), 25 May 1960, *Ross s.n.* (NU); Reservoir Hills (–DD), 15 July 1963, *Govender 23* (NU). **2931 (Stanger)**: Maphumulo Municipality area, Dayimane village ca. 5 m NE of Tugela river edge (–AA), 03 October 2007, *Mnxati 37* (NH). **3030 (Port Shepstone)**: Dumisa ca. 300 m from the east of Vulamehlo Community Poultry Project Umphambanyoni (–AB), 28 July 2006, *Magubane 848*

(NH); dune bush on white sand, facing sea (–CB), 03 June 1976, *Du Toit 1225* (NH, PRE), 8 km from Port Shepstone on road to St. Faiths (–CB), 19 January 1980, *Henderson 78* (PRE). EASTERN CAPE: **3129 (Port St. Johns)**: 17 km West of Port St. Johns on road to Umtata (–CB), 12 December 2001, *Meyer BP01078* (PRE).



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Senna hirsuta (L.) H.S.Irwin & Barneby

Synonym(s): *Cassia hirsuta* L.

Common name(s): Hairy senna, Woolly senna.

Description:

Shrub up to 2.5 m tall. **Stems** densely covered with greyish hairs. **Leaves** paripinnate, 85–195 mm long; stipules linear 8–10 mm long, with long straight hairs, narrowly acute, apex acuminate; extrafloral nectaries, sessile, cylindrical, up to 2.5 mm long, blackish, narrow at base. **Leaflets** 3–4 jugate, 50–75 × 20–40 mm, obovate; base oblique to rounded; apex acute to acuminate; the uppermost pair is the largest, hairy on both surface; margin ciliate. **Inflorescence** in axils of upper and middle leaves, ± 30 mm long, multiple flowered. **Pedicels** 10–15 mm long at flowering, at fruiting 15–17 mm long. **Sepals** 5, obovate, 6–8 × 3–4 mm, hairy. **Petals** 5, obovate, 10–15 × 4–8 mm, bright yellow. **Stamens** 10, staminodes 3, 4 mm long, anthers rounded, filaments straight; medium-sized stamens 4, 1 reduced, straight, 5 mm long; large stamens 3, slightly curved, ± 15 mm long, with broad anthers, filaments 8 mm long. **Ovary** densely hairy; style 2 mm long. **Pods** straight or slightly curved, 60–140 × 2–5 mm, densely covered with whitish or greyish hairs. **Seeds** elliptic oblong, 3–4 × 2.5–3 mm, greenish to brown.

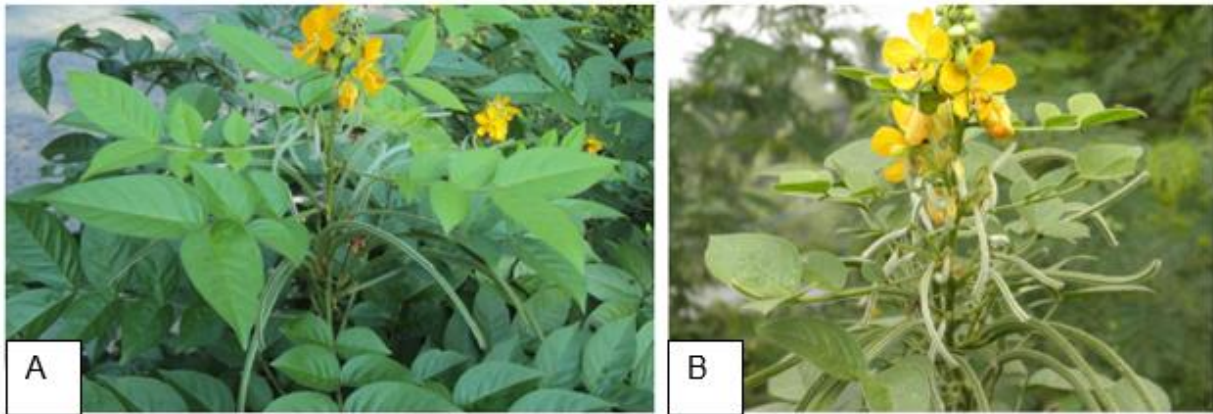


Figure 3.13. (A) *Senna hirsuta* plant, and (B) flower. Photographs taken by Lalithamba Nellore (<http://tropical.theferns.info/>).

Native range:

Senna hirsuta is native to the West Indies and western South America (Gordon-Gray, 1977).

Distribution in South Africa:

Senna hirsuta is restricted to KwaZulu-Natal from Nkandla to Mtubatuba, through Pietermaritzburg extending to Port Shepstone (Fig. 3.14).

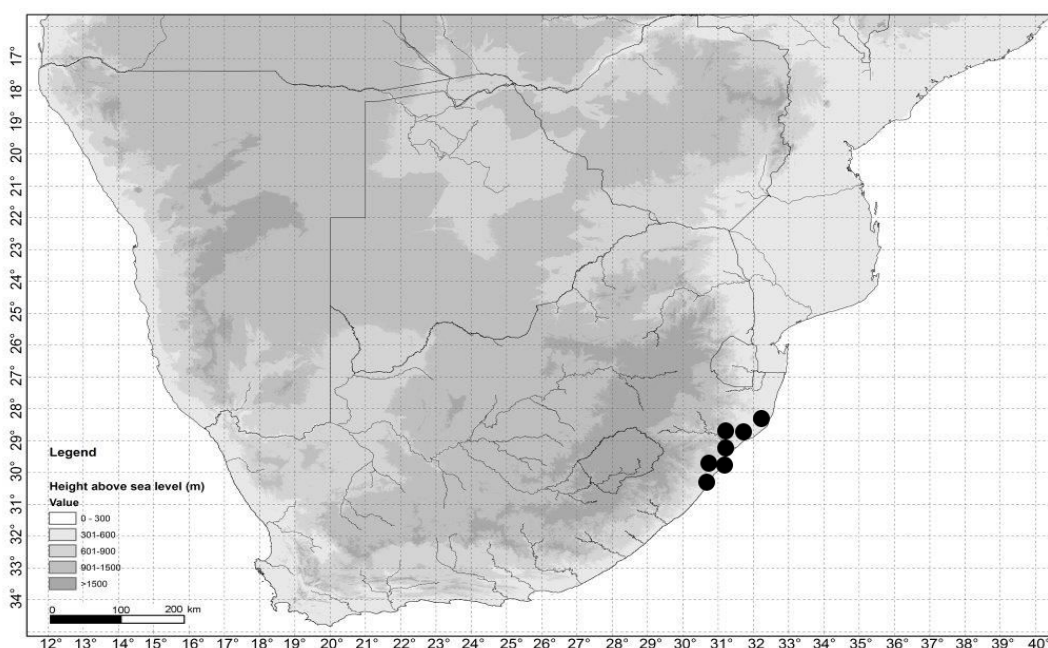


Figure 3.14. Distribution of *Senna hirsuta* in South Africa.

Habitat:

The species occurs in disturbed grassland or forest margins (Gordon-Gray, 1977).

How it spread:

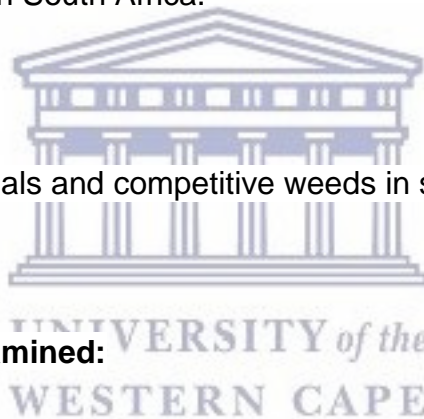
The seeds of *Senna hirsuta* are spread by animals and water. They are also spread as contaminants in agriculture produce or by sticking to animals, footwear and machinery (<http://invasives.org.za/>).

Invasion category:

Senna hirsuta is listed as a Category 1b invader under NEM:BA (2014) regulations of alien and invasive species in South Africa.

Environmental impacts:

The species is toxic to animals and competitive weeds in summer rainfall areas (<http://invasives.org.za/>).

**Additional specimens examined:**

South Africa. KWAZULU-NATAL: **2831 (Nkandla)**: Lower Umfolozi (–DD), 15 May 1909, *Bromilow 05* (NU); Nkandla Empangeni village (–DB), 01 June 1966, *Venter 2448* (NU); 17 km from Empangeni to Richard Bay (–DD), 11 May 1981, *Stirton 8811* (PRE). **2832 (Mtubatuba)**: Mtubatuba, Monzi (–AD), 10 May 1987, *Henderson 886* (PRE, NH). **2930 (Pietermaritzburg)**: Cato ridge (–DA), April 1958, *Edwards 13* (NU); 100 m of the shore of Inanda Dam (–DB), 20 October 2002, *Styles 1253* (NU); Albert falls (–DD), 15 May 1952, *Comins 414* (NU); Reservoir hills off Burlington drive (–DD), 21 May 1967, *Baijnath 442* (NU); Isipingo flats SW of Umbongintwini valley (–DD), 09 May 1967, *Ward 6275* (NU); Isipingo flats (–DD), 12 March 1967, *Ward 6171* (NU). **2931 (Stanger)**: Durban, hillside near Duffis Road station (–CC), 09 July 1932,

Galpin 12122 (PRE); Verulam Canalands (–CA), May 1989, *Von Blottnitz 173* (NH).

3030 (Port Shepstone): Ixopo (–AD), May 1943, *Fisher 494* (NU); Little Amanzimtoti

River (–BB), 01 June 2009, *Cheek 07* (NH).



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***Senna italica* subsp. *arachoides* (Burch.) Lock**

Synonym(s): *Cassia italica* subsp. *arachoides* (Burch.) Lock, *Cassia arachoides* Burch.

Common name(s): Italian senna.

Description:

Herb to 0.6 m tall. **Stems** prostrate to decumbent, arising from a woody rootstock, glandular-pubescent when young, becoming glabrous with age. **Leaves** paripinnate, petiole and rachis, 50-110 mm long; stipules ovate-triangular, 0.5–10 × 1–3 mm; base oblique to rounded; apex narrowly acuminate; rachis channel well developed; extrafloral nectaries lacking. **Leaflets** 3–9 jugate, obovate-elliptic, 12–30 × 6–15 mm, base obtuse, apex rounded, the uppermost pairs is largest; margin entire or ciliate. **Inflorescence** axillary, racemes 150–160 mm long, multiple flowered. **Pedicels** 2–4 mm long at flowering, 4–5 mm long at fruiting. **Sepals** 5, elliptic to obovate 4–6 × 4–6 mm. **Petals** 5, obovate, 7–15 × 4–6 mm bright yellow. **Stamens** 10: staminodes 3, 3 mm long, filaments straight; medium-sized stamens 4, 1 reduced 5 mm long; large stamens 2, up to 10 mm long, filaments 5 mm long. **Ovary** glabrous, flattened; style up to 7 mm long. **Pods** flattened, oblong, ± 40 × 10-25 mm, slightly curved in the middle. **Seeds** rhomboid, 4–5 × 3–4 mm, dark brown.

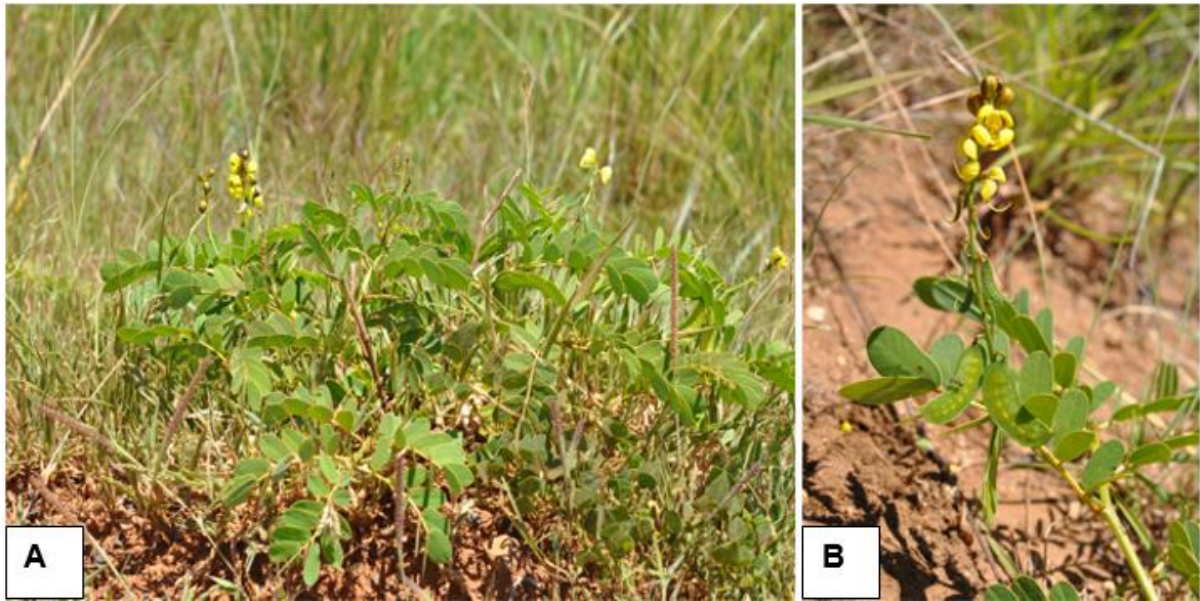


Figure 3.15. (A) *Senna italica* subsp. *arachoides* plant (A), flowers and pods (B).
Photographs taken by Anthony Magee.

Native range:

Recorded from North Africa to South Africa, and the Middle East to India (Gordon-Gray, 1977).

Distribution in South Africa:

Senna italica subsp. *arachoides* is widely distributed in the northern parts of South Africa, extending to the KwaZulu-Natal Province (Fig. 3.16).

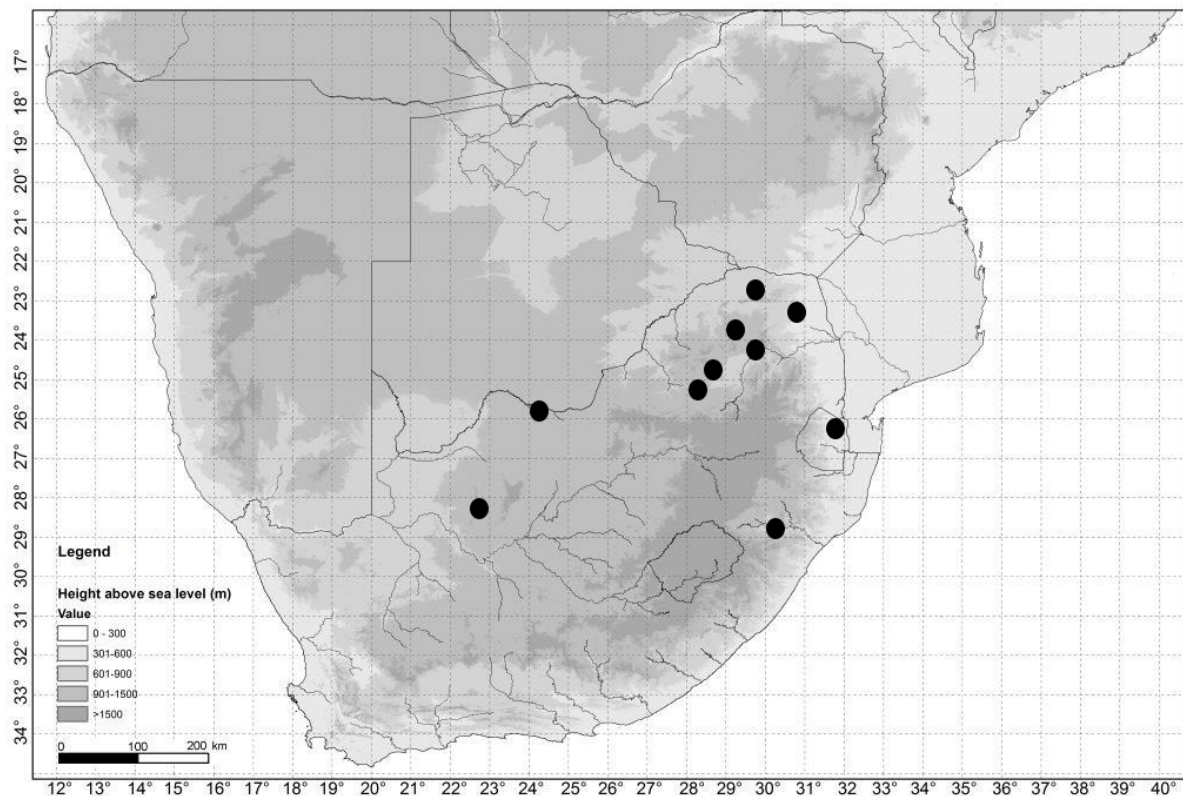


Figure 3.16. Distribution of *Senna italica* subsp. *arachoides* in South Africa.

Habitat:

Senna italica subsp. *arachoides* often grows in dry habitats throughout Africa, extending to south-western Asia to India (Brenan, 1967; Gordon-Gray, 1977). It also occurs in rocky and gravelly soil in dry woodland (Hyde et al., 2018).

Additional specimens examined:

South Africa. LIMPOPO: **2229 (Waterpoort):** Tshikuwi village near the sportsground along the river bank (–DD), 09 December 2010, *Nkuna 2774* (PRE). **2329 (Pietersburg):** near Zebediala turn-off on Pretoria to Pietersburg road (–CD), 05 December 1975, *Crawford 360* (PRE). **2330 (Tzaneen):** Huston Ntsonwisi dam near Giyani 70m from dam edge (–BC), 15 May 1981, *Killian 33* (PRE). **2428 (Nylstroom):** 3 km from Malapayane on road to Groblersdal (–DD), *Germishuizen 3718* (PRE). **2429**

(Zebediela): Sekhukhune district, Burgersfort N.W. of town, Atok mine (–BD), 17 November 1999, *Riddles 529* (PRE).

NORTH WEST: **2524 (Vergelee):** Corowa farm on the Molopo River (Botswana border) (–CA), 22 March 2001, *Meyer 3577* (PRE).

GAUTENG: **2528 (Pretoria):** 3.5 miles north of Pienaars River on road to Warmbaths (–AB), 16 December 1966, *Mogg 37195* (PRE)

KWAZULU-NATAL: **2830 (Dundee):** Tugela Ferry, Msinga (–CB), 02 January 2005, *Styles 2391* (NH); Muden KwaLeja, ca. 2 km from Lutheran Church towards east (–CD), 18 February 2006, *Magubane 253* (NH).

NORTHERN CAPE: **2822 (Glen Lyon):** Beeshoek along R385 NW of Beeshoek ca. 300m SW of turn to Wildealspruit Farm (–BB), 30 December 2003, *Ramdhani and Proches 430* (NH).

Swaziland (Eswatini). **2631 (Mbabane):** Hlane Wildlife Sanctuary (–BB), 18 December 1972, *Stephen 1436* (PRE); Farm Mlawulla 2 miles south of Mlawulla station (–BD), 06 November 1976, *Culverwell 0276* (PRE).

***Senna multiglandulosa* (Jacq.) H.S.Irwin & Barneby**

Synonym(s): *Cassia multiglandulosa* Jacq; *Cassia tomentosa* L. f.

Common name(s): Glandular senna.

Description:

Shrub to 4 m tall. **Stems** woody, pilose-tomentulose with fine straight spreading and matted hairs. **Leaves** greyish-green, petiole and rachis 35–120 mm long; stipules linear, \pm 10 mm long, narrowly triangular; apex acute to acuminate. **Leaflets** 6–8 jugate, oblong; acute at the apex; extrafloral nectaries between all pairs of leaflets, \pm 1 mm long, the uppermost pairs the largest, the lower pairs is the smallest. **Inflorescence** in axil of upper leaves, peduncles, up to 40 mm long at flowering, \pm 50 mm long at flowering. **Pedicles** 12–20 mm long at flowering, 20–23 mm long at fruiting. **Sepals** 5, obtuse, \pm 10 mm long, apex rounded to acute. **Petals** 5, yellow, obovate, or elliptic, 15–18 \times 5–11 mm. **Stamens** 10, staminodes 3, 4 mm long, anthers rounded, filaments straight; medium-sized stamens 4, 4–5 mm long; large stamens 3, up to 10 mm long, filaments long, 7 mm long. **Ovary** with fine, white, spreading hairs; style glabrous, 4 mm long. **Pods** linear or slightly curved towards the end, 70–100 \times 4–9 mm, with short hairs. **Seeds** 4–5 \times 2–3 mm long, light brown.



Figure 3.17. (A) *Senna multiglandulosa* plant, (B) flowers and (C) pods.

Photographs taken by Mona Bourell

(https://www.sfbotanicalgarden.org/garden/bloom_15_06.shtml).

Native Range:

Senna multiglandulosa is native to the Andes, cordilleran Mexico and Central America (Irwin and Barneby, 1982).

Distribution in South Africa:

Senna multiglandulosa is most common in the Eastern Cape from Sutterheim through Port Elizabeth to Makhanda extending to Riversdale in the Western Cape (Fig. 3.18).

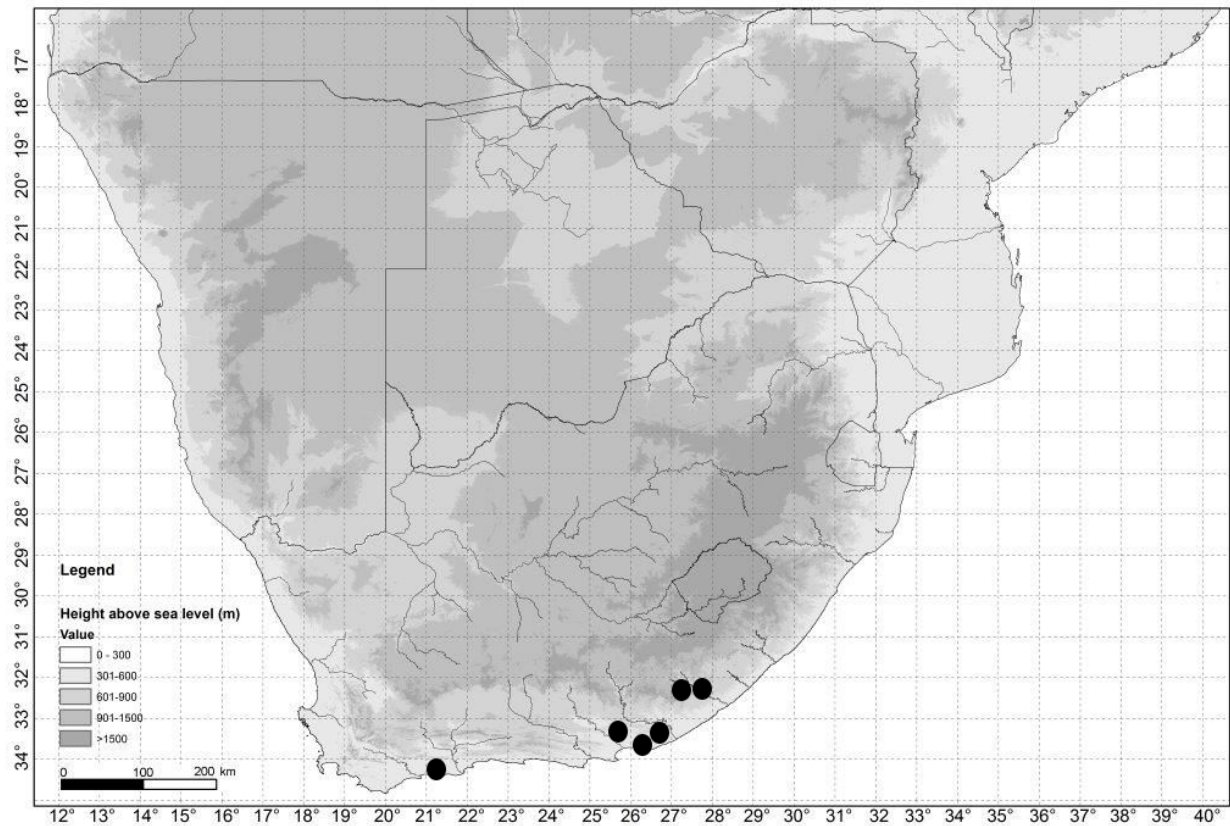


Figure 3.18. Distribution of *Senna multiglandulosa* in South Africa.



Habitat:

Grows in disturbed forest, rocky riverbanks, and pine plantations (Irwin and Barneby, 1982).

How it spreads:

Senna multiglandulosa is frequently cultivated and seeds are dispersed intentionally by humans (Irwin and Barneby, 1982).

Invasion category:

This species has not been listed under the (NEM:BA 2014) regulations of alien and invasive species in South Africa.

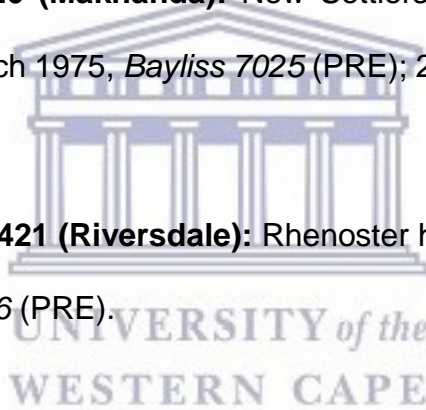
Environmental impact:

Senna multiglandulosa is a prolific seed producer, easy to cultivate and prone to colonize disturbed habitats with the ability to grow in different climates (broad climate suitability) (Irwin and Barneby, 1982), which constitutes the high invasive risk of the species. It has been recorded as a garden weed (Teketay, 1996).

Additional specimens examined:

South Africa. EASTERN CAPE: **3227 (Stutterheim):** Stutterheim (–AD), 28 May 1898, *Galpin 2442* (PRE); Stutterheim (–BC), without date, *Sim 1304* (NU). **3325 (Port Elizabeth):** Addo Elephant National Park, planted in garden (–BC), April 1976, *Van Wyk 5600* (PRE). **3326 (Makhanda):** New Settlers Dam near Grahamstown, stream edge (–CB), 02 March 1975, *Bayliss 7025* (PRE); 20c African Street (–BC), 06 May 1969, *Brink 36* (PRE).

WESTERN CAPE: **3421 (Riversdale):** Rhenoster hills north of town (–AB), 05 August 1927, *Marloth 13076* (PRE).



***Senna multijuga* (Rich.) H.S.Irwin & Barneby**

Synonym(s): *Cassia multijuga* Rich.

Common name(s): False sicklepod, Glandular senna.

Description:

Tree 6–15 m tall. **Stems** glabrous to densely pubescent, branchlets reddish when dry. **Leaves** paripinnate, 70–310 × 20–30 mm long; stipules linear, 3–14 mm long, asymmetrical at base; rachis with finger like extrafloral nectaries between lower pair of the leaflets. **Leaflets** 10–26(56) jugate, 12–20 × 5–7 mm long, linear or linear oblong, oblong elliptic, with appressed pubescence; apex retuse or rounded. **Inflorescence** axillary, peduncles up to 60 mm long, up to 5 flowered. **Sepals** 5, obovate, 5–6 × 4–5 mm, sub-equal, bright yellow. **Petals** 5, obovate to oblong, 15–20 × 6–10 mm. **Stamens** 10, staminodes 3, 3 mm long, anthers flattened, filaments straight; medium-sized stamens 4, straight, 5 mm long, anthers curved; large stamens 3, slightly curved, ± 7 mm long, with broad anthers, filaments very short 1 mm long. **Ovary** linear or curved, glabrous; style glabrous, 2 mm long. **Pods** linear, flattened, dark brown in colour. **Seeds** not seen.

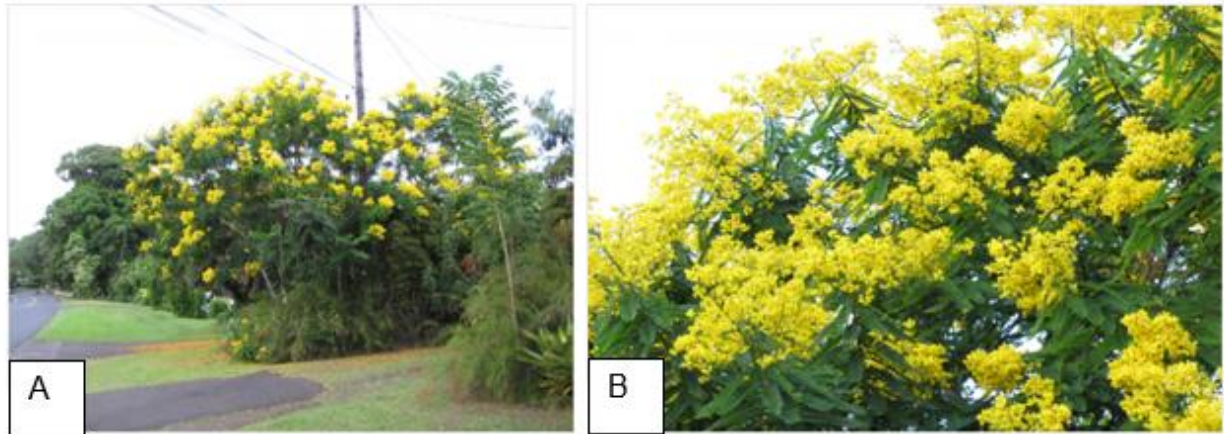


Figure 3.19. (A) *Senna multijuga* plant and (B) flowers. Photographs taken by Kim Starr (<http://tropical.theferns.info/>).

Native range:

Senna multijuga is native to the northern parts of South America (Brummitt et al., 2007; CABI, 2018).

Distribution in South Africa:

Senna multijuga is currently known from Pietermaritzburg in KwaZulu-Natal (Fig. 3.20).



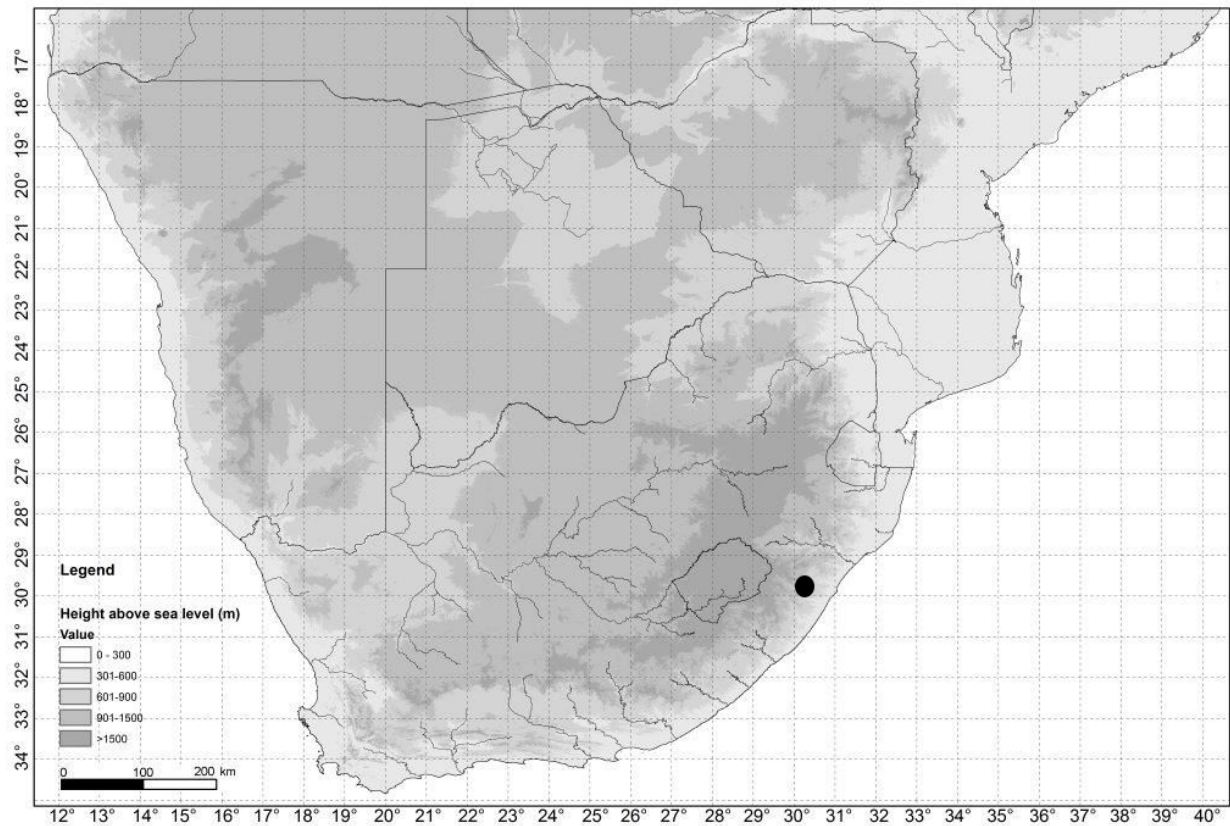


Figure 3.20. Distribution of *Senna multijuga* in South Africa.



Habitat:

Most common in gardens (Brummitt et al., 2007). Grows in riverine forest, riverbanks, and disturbed forest (Irwin and Barneby, 1982).

How it spread:

Intentionally introduced for cultivation purposes, e.g. planted in the American tropics for ornamental purposes (Irwin and Barneby, 1982).

Invasion category:

Senna multijuga has not been listed under the (NEM:BA 2014) regulations of alien and invasive species in South Africa.

Environmental impact:

Negatively affects agriculture and reduces native biodiversity (CABI, 2018).

Additional specimens examined:

South Africa. KWAZULU-NATAL: 2930 (**Pietermaritzburg**): Richmond (–CD), March 1966, without collector name and number (NU).



***Senna obtusifolia* (L.) H.S.Irwin & Barneby**

Synonym(s): *Cassia obtusifolia* L., *Cassia tora* sensu auct. mult. Bak.f., Steyaert, Mendoca and Torre, non L.

Common name(s): Sicklepod, Java bean.

Description:

Sub-shrub or herb to 1.5 m tall. **Stems** cylindrical, with small dark glands, glabrescent to glabrous. **Leaves** paripinnate, 30–60 × 20–40 mm long; stipules linear, 5–10 mm long, acuminate at base; rachis channelled, with reddish extrafloral nectaries between the lower pairs of the leaflets, 1–2 mm long. **Leaflets** 3 jugate, 30–50 × 10–25 mm, obovate-elliptic, uppermost pair the largest; margin strigose or entire. **Inflorescence** axillary, racemes 1–2 flowered. **Pedicels**, at flowering 10–40 mm long, at fruiting 20–50 mm long. **Sepals** 5, obtuse, 5–8 × 2–4 mm long, apex rounded. **Petals** 5, obovate, 8–12 × 3–5 mm, pinkish to yellow. **Stamens** 10, staminodes 3, 3 mm long, anthers lobes reduced, filaments straight; medium-sized stamens 4, 4 mm long, anthers rounded; large stamens 3, ± 7 mm long, filaments 4 mm long fertile. **Ovary** ± 15 mm long, curved, appressed with white hairs; style curved, 2 mm long. **Pods** straight, linear, curved, 10–200 × 2–4 mm, tapering at base and apex. **Seeds** not seen.

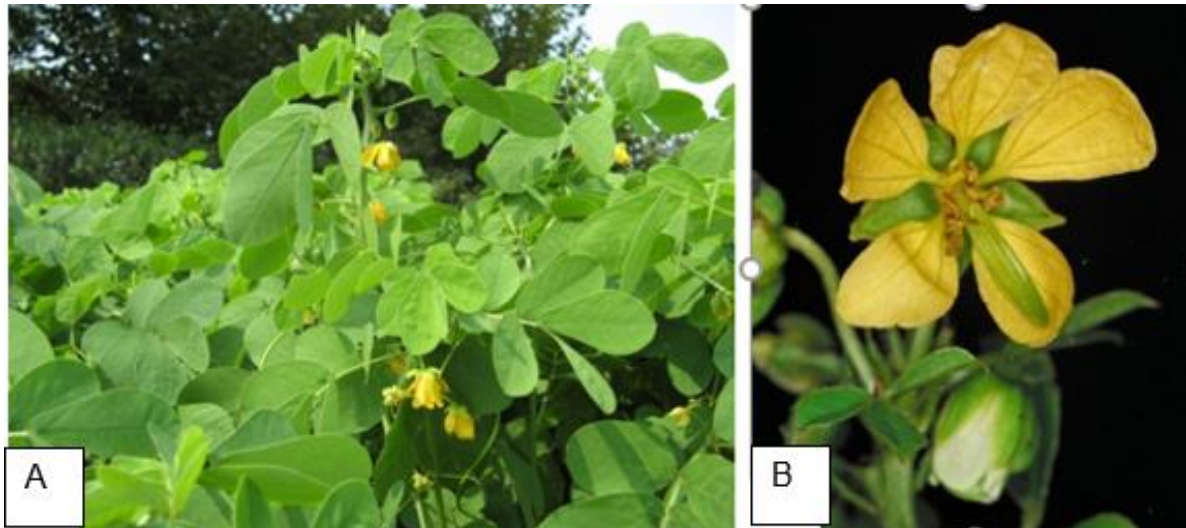


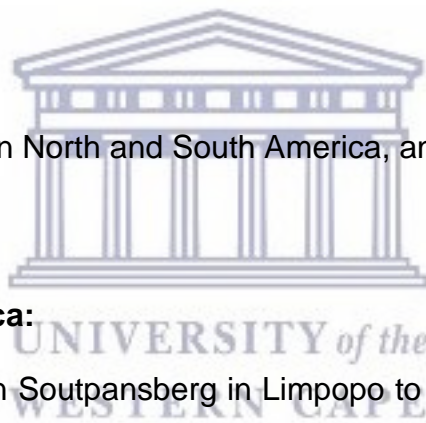
Figure 3.21. (A) *Senna obtusifolia* plant and (B) flower. Photographs taken by Ahmad Fuad Morad (<http://tropical.theferns.info/>).

Native range:

Senna obtusifolia is native in North and South America, and Asia (Irwin and Barneby, 1982).

Distribution in South Africa:

The species is distributed in Soutpansberg in Limpopo to Barberton in Mpumalanga, across to Hluhluwe in the KwaZulu-Natal Province (Fig. 3.22).



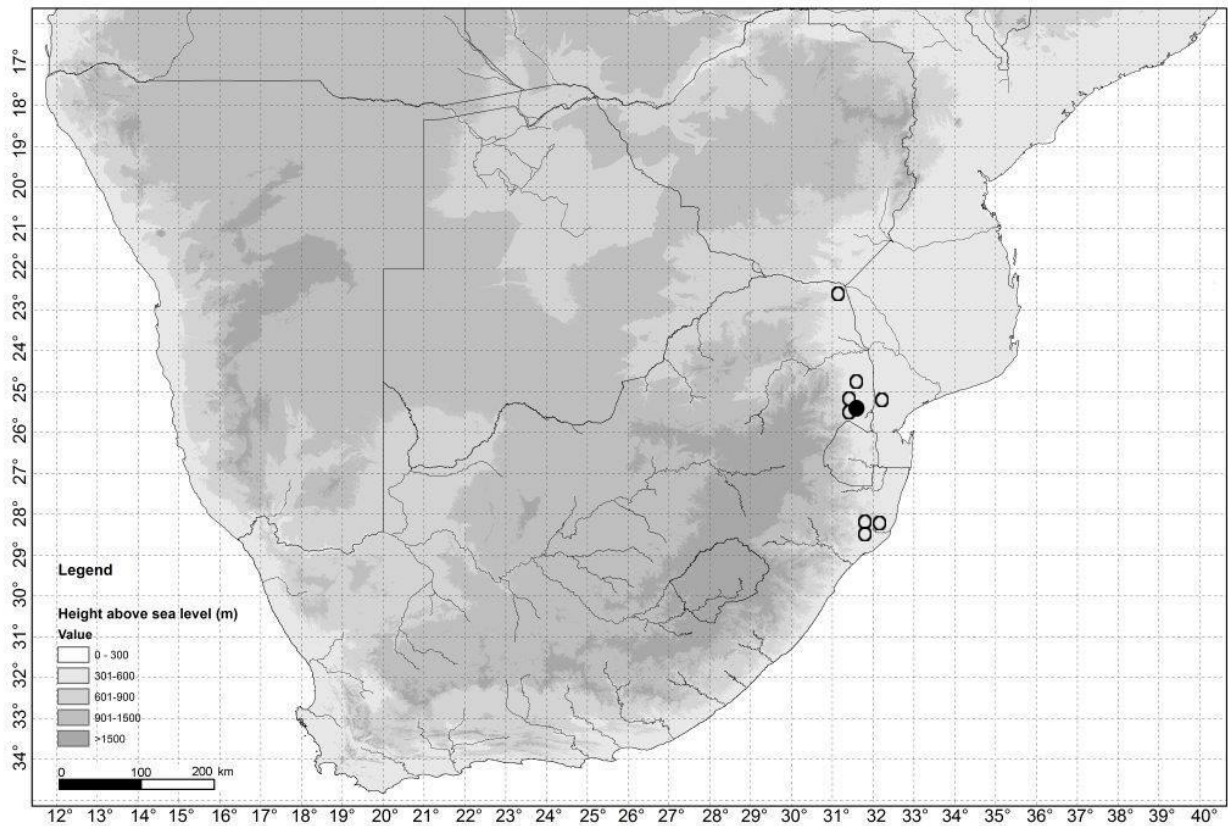
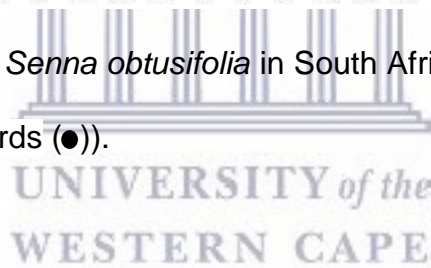


Figure 3.22. Distribution of *Senna obtusifolia* in South Africa (SAPIA and SANBI DBI records (o), herbarium records (●)).



Habitat:

Senna obtusifolia grows in woodlands, coastal beaches, riparian areas, riverbanks, orchards, disturbed areas and along roadsides (Irwin and Barneby, 1982, Weber, 2003).

How it spread:

Senna obtusifolia spreads through the gut of domestic animals and motor vehicles (CABI, 2018).

Invasion category:

Senna obtusifolia has not been listed under the (NEM:BA 2014) regulations of alien and invasive species in South Africa.

Environmental impacts:

The species is a significant agricultural weed that invades natural vegetation (Weber, 2003). It forms dense thickets, competing with indigenous plants for light, water and nutrients (Weber, 2003).

Additional specimens examined:

South Africa. MPUMALANGA: **2531 (Komatipoort)**: Kruger National Park, Malelane, Crocodile River (–BC) 16 April 1993, *Van Rooyen and Bredenkamp 470* (PRE).



***Senna occidentalis* (L.) Link**

Synonym(s): *Cassia occidentalis* L.

Common name(s): Coffee senna, Septicweed.

Description:

Herb to 1.5 m tall. **Stems** woody at base, sub-glabrous when young becoming glabrous with age. **Leaves** paripinnate, 50–165 mm long ; stipules, up to 5 mm long; base oblique; acuminate at apex; rachis with well-developed channelled; with large extrafloral nectaries located at the distal end of pulvinus, \pm 10 mm long, slightly rounded. **Leaflets** (3)4–5 jugate, ovate; base oblique to rounded; apex acute to acuminate, 25–11 \times 10–35 mm, uppermost pairs are largest; margin ciliate. **Inflorescence** from axil of upper leaves, with 2-4 flowers, racemes very short, peduncles, up to 5 mm long. **Sepals** 5, glabrous, obovate, 5–15 \times 3–4 mm, acute or rounded at apex. **Petals** 5, obovate, pale yellow, 9–16 mm long, up to 8 mm wide. **Stamens** 10, 3 staminodes 4–5 mm long, anthers flattened, filaments straight, up to 4 mm long; medium-size stamens 4, 5–7 mm long, slightly curved; large stamens 3, 10–12 mm long, filaments straight 5–6 mm long. **Ovary** with appressed white hairs; style glabrous, 5 mm long. **Pods** 40–130 \times 4–8 mm, flattened, straight or slightly curved, with white scattered appressed hairs. **Seeds** elliptic, 4–5 \times 3–5 mm, greyish to brownish.



Figure 3.23. (A) *Senna occidentalis* plant, (B) flowers and pods. Photographs taken by Liada Musandiwa.



Native range:

Senna occidentalis is native to South America, Central America and the Caribbean, extending to Mexico (CABI, 2018).

Distribution in South Africa:

Senna occidentalis is widely distributed in the Limpopo Province, through Gauteng and Free State and across Mpumalanga, extending to the coastal areas of KwaZulu-Natal, Eastern Cape and the Western Cape (Fig. 3.24).

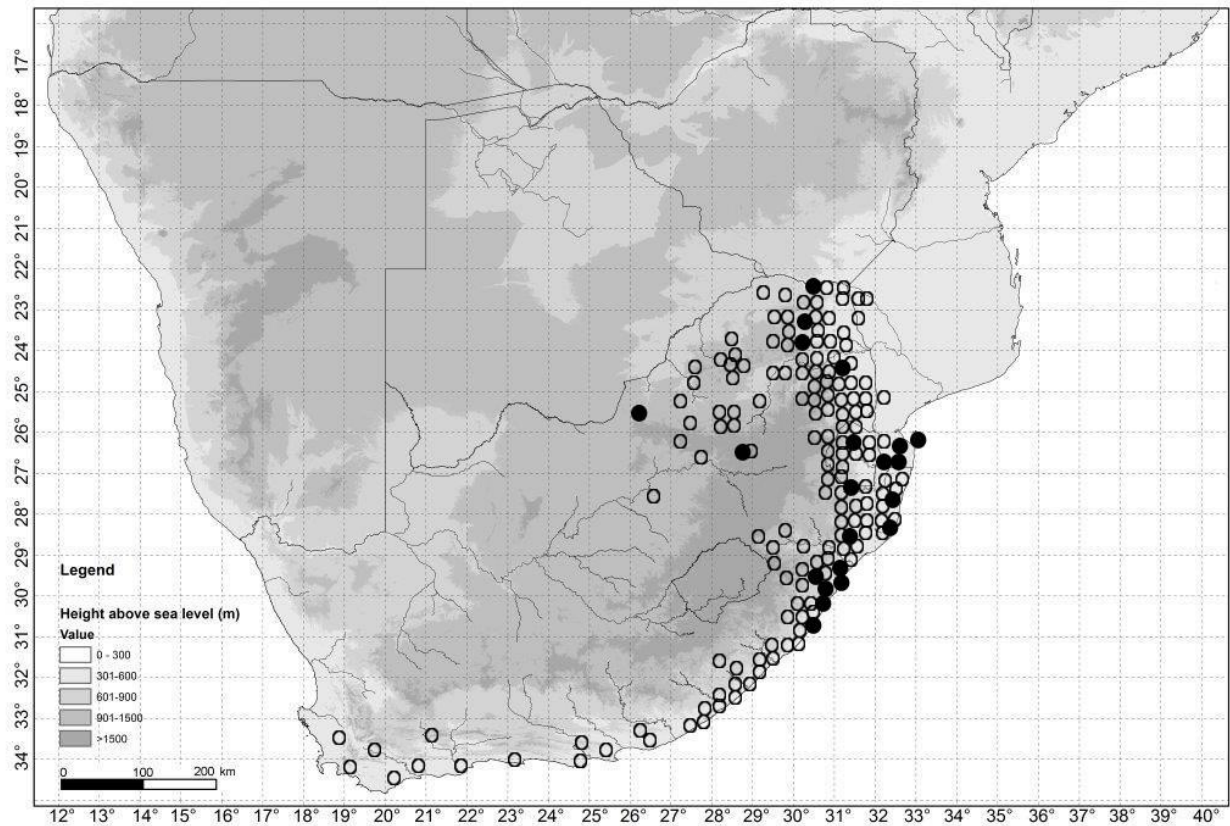
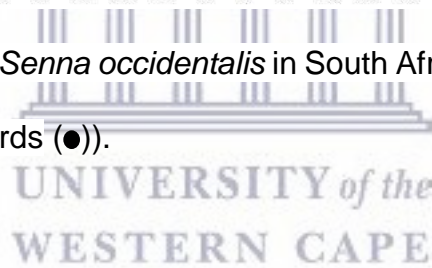


Figure 3.24. Distribution of *Senna occidentalis* in South Africa (SAPIA and SANBI DBI records (o), herbarium records (●)).



Habitat:

Senna occidentalis grows in disturbed areas, along riverbanks, coastal sands, old lands and roadsides (Gordon-Gray, 1977).

How it spreads:

Seeds are mainly dispersed by water and animals (CABI, 2018).

Invasion category:

Senna occidentalis is listed as a Category 1b Invader under (NEM:BA 2014) regulations of alien and invasive species in South Africa.

Environmental impacts:

Senna occidentalis has negative impacts on crops and plantations (CABI, 2018). It is poisonous to animals (Simpson et al., 1971, Henderson, 2001, CABI, 2018).

Additional specimens examined:

South Africa. LIMPOPO: **2230 (Messina)**: Tshakhuma (–AB), November 1931, *Obermeyer 980* (PRE); Tshakhuma (–AB), 09 May 1951, *Van Warmelo 5159/10* (PRE); Tshakhuma (–AB), November 1931, *Obermeyer 980* (PRE); Mufulwi (–BC), 06 December 2017, *Musandiwa 05* (NBG). **2330 (Tzaneen)**: Valdezia, 30 km east of Louis Trichardt (–AA), 28 Apr 1977, *Liengme 44* (PRE); 13 miles from Tzaneen on path to Letsitele (–CC), 28 February 1970, *Grobbelaar 1314* (PRE).

NORTH WEST: **2526 (Zeerust)**: Zeerust (–CA), April 1912, *Jenkins TRV 13947* (PRE).

MPUMALANGA: **2431 (Acornhoek)**: Farm Guernsey 81 KU, NE of Klaserie (–AC), 13 March 1982, *Zambatis 1389* (PRE). **2628 (Johannesburg)**: Leslie area (–BD), February 1979, *Van Gass PRE-61817* (PRE).

KWAZULU-NATAL: **2632 (Bela Vista)**: Ingwavuma Poort (–CC), 06 March 1959, *Compton 28638* (PRE); Ndumo Game Reserve, old field between Usutu forest (–CD), 19 February 1969, *Pooley 405* (NU); Makanes drift (–CD), 06 March 1970, *Ross 2378* (NH). 2930 (Cato ridge): near Nagle dam on roadside (–DA), 25 March 1987, *Henderson 885* (PRE). **2731 (Louwsburg)**: north bank of Mkuze river at road bridge on Mkuze road (–AD), 25 April 1964, *Gordon-Gray 4684* (NU); Graigadam farm, Itala Nature Reserve northern natal, 15 January 1978, *Donald 447* (NU). **2732 (Ubombo)**: Mtuzi Game reserve, Dagela (–CB), 13 April 1976, *Goodman 575* (NU). **2831 (Nkandla)**: Zululand, Gingindlovu (–CB), 18 March 1949, *Lawn 38445* (NH).

2832 (Mtubatuba): St. Lucia Estuary (–AD), 02 April 1979, *Pooley 2285* (NU). **2930 (Pietermaritzburg):** Camperdown Nagle Dam (–DA), 10 April 1957, *Wells 1271* (NU); Pietermaritzburg, Merebank south west (–DD), 19 February 1967, *Baijnath 142* (PRE); Durban (–DD), 03 May 1962, *Nair 7* (NU); Isipingo beach (–DD), June 1949, *Ward 885* (NU); Mereland south (–DD), February 1967, *Baijnath 173* (NU). **2931 (Stanger):** Umhlanga rocks (–CA), 30 January 1966, *Ross 1599* (NU); Durban North (–CC), 21 March 1976, *Kruger 31* (NU). **3030 (Durban):** Umboqintwini Athlone (–BB), 19-Feb-67, *Baijnath 142* (NU). **3030 (Port Shepstone):** Amanzimtoti south coast (–BB), February 1950, *Harvey 6* (NU); Margate (–CD), February 1931 *Rump s.n.* (NU).

Namibia. **1716 (Eenhana):** Makanga in omuramba (–DB), 06 April 2002, *Uiras MU658* (PRE). **1724 (Katima Mulilo):** Eastern Caprivi by Bosbou se Kwekery langs rivier (–CD), 15 March 1976, *Du Preez 20* (PRE).

Botswana. **1923 (Maun):** Matlapaneng bridge, Thamalakane River (–CD), 28 March 1977, *Smith 1959* (PRE). **2424 (Dikgomo da Kae):** S.E. Botswana, Jwaneng, Kalahari sandveld (–DB), 20 February 1997, *Cole 1201* (PRE).

Swaziland (Eswatini). **2631 (Mbabane):** Endingeni, middle by roadside (–AB), 18 February 1970, *Barret 531* (PRE), north bank of Komati river, east of Mhlatane river (–AB), 05 March 93, *Germishuizen 6147* (PRE). **2633 (Blue Jay Ranch):** 3 miles south west entrance to Umbuluzi Gorge, Lubombo mountains (–AA), 11 April 1977, *Culverwell 746* (PRE).

***Senna pendula* (Willd.) Irwin & Barneby var. *glabrata* (Vogel) H.S.Irwin &**

Synonym(s): *Cassia indecora* Kunth var. *glabrata* Vogel, *Cassia coluteoides* Collad.

Common name(s): Christmas senna, Climbing cassia.

Description:

Shrub to 4 m tall. **Stems** with soft white hairs, becoming glabrous with age. **Leaves** paripinnate, 20–70 mm long; stipules acute, linear, 6–8 mm long; rachis channelled; with extrafloral nectaries between the lower pair of the leaflets, acute at apex. **Leaflets** 4-5 jugate, 20–45 × 8–19 mm, obovate; base asymmetrical; rounded at apex, uppermost pairs largest; margin ciliate, or glabrous, becoming yellowish. **Inflorescence** axillary, racemes (including peduncles), ±100 mm long, 2–10 flowered. **Pedicels** at flowering 10–25 mm long, at fruiting 25–30 mm long. **Sepals** 5, obtuse, 8–12 × 5–7 mm, rounded at apex. **Petals** 5, obovate, 17–20 × 10–15 mm, bright yellow. **Stamens** 10, staminodes 3, 4 mm long, anthers flattened; medium-sized stamens 4, 5 mm long, filaments very short 1 mm long; large stamens 2, anthers broad, filaments very long, 20 mm long; 1 stamen reduced. **Ovary**, with white hairs; style glabrous, 4 mm long. **Pods**, up to 200 × 3-10 mm, straight or curved. **Seeds** not seen.



Figure 3.25. (A) *Senna pendula* var. *glabrata* flowers, (B) pods and (C) leaf.

Photographs taken by Sheldon Navie

(<https://keyserver.lucidcentral.org/weeds/data/media/Html/fshelp.htm>).

Native range:

Senna pendula var. *glabrata* is native to southern Brazil (Henderson, 2001), and on the Amazonian slopes of the Andes (Irwin and Barneby, 1982).

Distribution in South Africa:

The species is distributed from Phalaborwa in Limpopo to Pretoria in Gauteng, extending to Komatipoort in Mpumalanga through Ubombo to Fort Beaufort in the Eastern Cape (Fig. 3.26).

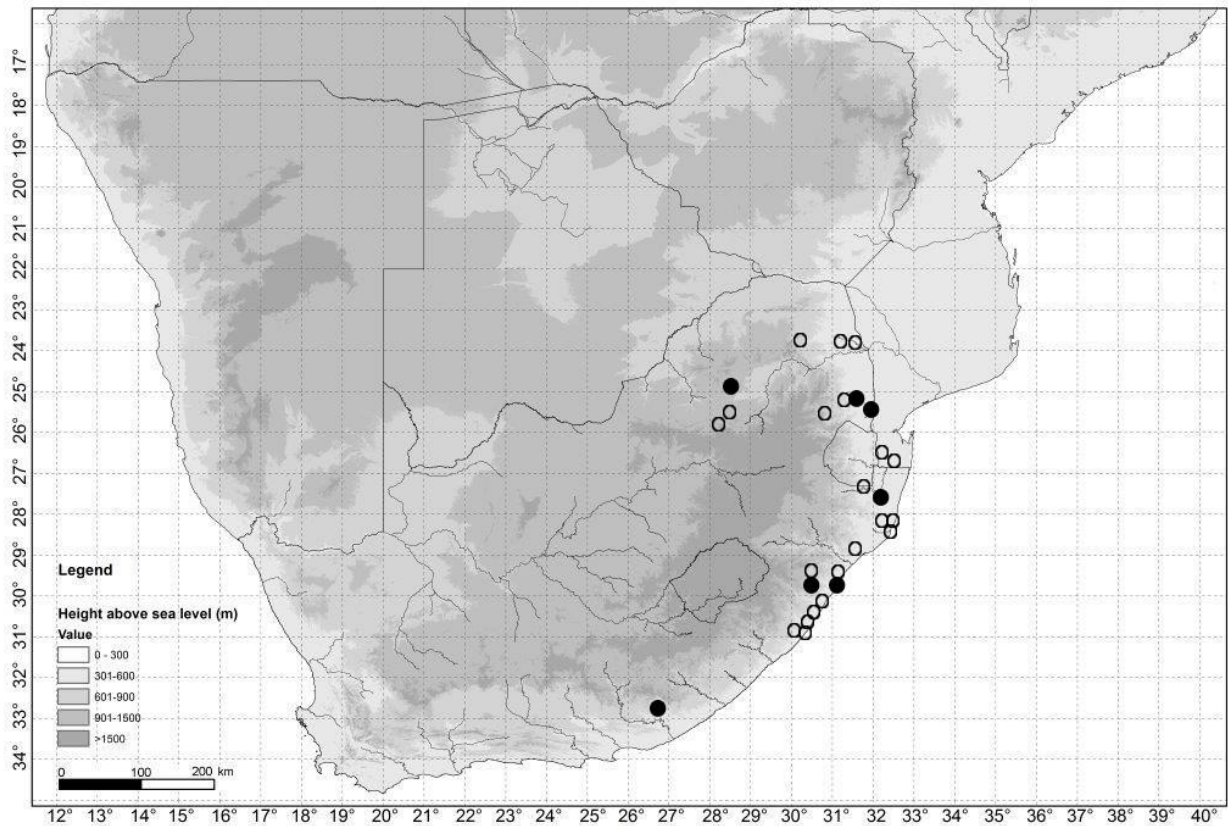
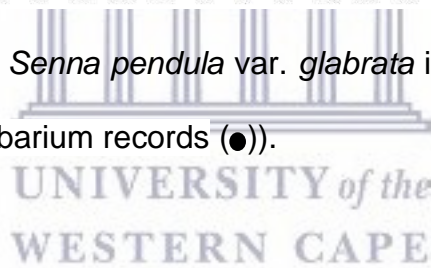


Figure 3.26. Distribution of *Senna pendula* var. *glabrata* in South Africa (SAPIA and SANBI DBI records (o), herbarium records (●)).



Habitat:

The species is most common in woodlands, coastal and riparian areas (Weber, 2003).

How it spreads:

Senna pendula var. *glabrata* is most common found under cultivation, and is popular as garden subject (Gordon-Gray, 1977).

Invasion category:

Senna pendula var. *glabrata* is listed as Category 1b Invader under (NEM:BA 2014) regulations of alien and invasive species in South Africa.

Environmental impacts:

Senna pendula var. *glabrata* is a fast growing plant and has the ability to climb over indigenous species, suppressing growth and displacing them (Weber, 2013).

Additional specimens examined:

South Africa. LIMPOPO: **2428 (Nylstroom)**: Klein Kariba (–CD), 06 May 2011, *Jaca* 226 (PRE).

GAUTENG: **2528 (Pretoria)**: Pretoria (–CC), 26 April 1934, *Mogg* 14932 (PRE).

MPUMALANGA: **2531 (Komatipoort)**: Plaston-Kanyamazane path behind Lowveld National Botanical Garden (–AC), 15 June 1984, *Pretorius* 20 (PRE); Garden of Dr le Roux in Nelspruit (–BD), June 1973, *Le Roux* 790 (PRE).

KWAZULU-NATAL: **2732 (Ubombo)**: about 1 km out of Mkuze on old road to Candover (–CA), 04 May 1987, *Henderson* 867 (NH). **2930 (Pietermaritzburg)**: along the R56 Pietermaritzburg Ixopo road (–CD), 30 June 2010, *Cheek* 717 (NH). **2931 (Stanger)**: Natal Herbarium Garden section 13 (–CC), 15 May 1991, *Sikhakhane* 137 (NH).

EASTERN CAPE: **3226 (Fort Beaufort)**: Fort Hare Campus, new commerce block (–DD), 14 March 1977, *Dlova* 30 (PRE).

Senna petersiana (Bolle) Lock

Synonym(s): *Cassia petersiana* Bolle

Common name(s): Eared senna, Monkey pod.

Description:

Small tree or shrub to 6 m tall. **Stems** with multiple branches, subglabrous to densely pubescent, becoming greyish. **Leaves** paripinnate, 55-195 mm long; stipules, leafy, broadly cordate, up to 15 mm wide; rachis with well-developed channel; extrafloral nectaries between all pairs of leaflets or few pairs of the leaflets, linear, reddish, up to 2 mm long. **Leaflets** 5-11 jugate, 35-90 × 7-15 mm, lanceolate to ovate or ovate-elliptic; base acute to rounded; apex acute; margin entire. **Inflorescence** paniculate, racemes ± 90 mm long. **Pedicels**, at flowering 15-30 mm long, at fruiting 25-30 mm long. **Sepals** 5, up to 12 mm long, obtuse, rounded at apex. **Petals** 5, obovate, 15-25 × 15 mm, apex rounded, bright yellow. **Stamens** 10; staminodes 3, 3 mm long, anthers flattened, filaments straight; medium-sized stamens 4, 5-6 mm long, anthers slightly curved; large stamens 3, up to 10 mm, with broad anthers, filaments 4-7 mm long. **Ovary** up to 12 mm long, straight or curved, with short white hairs; style glabrous, 5-6 mm long. **Pods**, 80-235 × 5-13 mm, flattened, straight or curved, black with brown margin. **Seeds** ovate, 3-5 × 3-4 mm, smooth or dotted, dark brown.



Figure 3.27. (A) *Senna petersiana* plant and (B) flowers. Photographs taken by Bart Wursten (<https://www.zimbabweflora.co.zw/>).

Native range:

Senna petersiana is native in east Africa, Sudan, Ethiopia, Zimbabwe, Mozambique and South Africa (Gordon-Gray, 1977).

Distribution in South Africa:

Senna petersiana is most common in Vhembe in Limpopo, to Pretoria in Gauteng, extending to Pilgrim's Rest in Mpumalanga through Ingwavuma to Pietermaritzburg in Kwazulu Natal (Fig. 3.28).

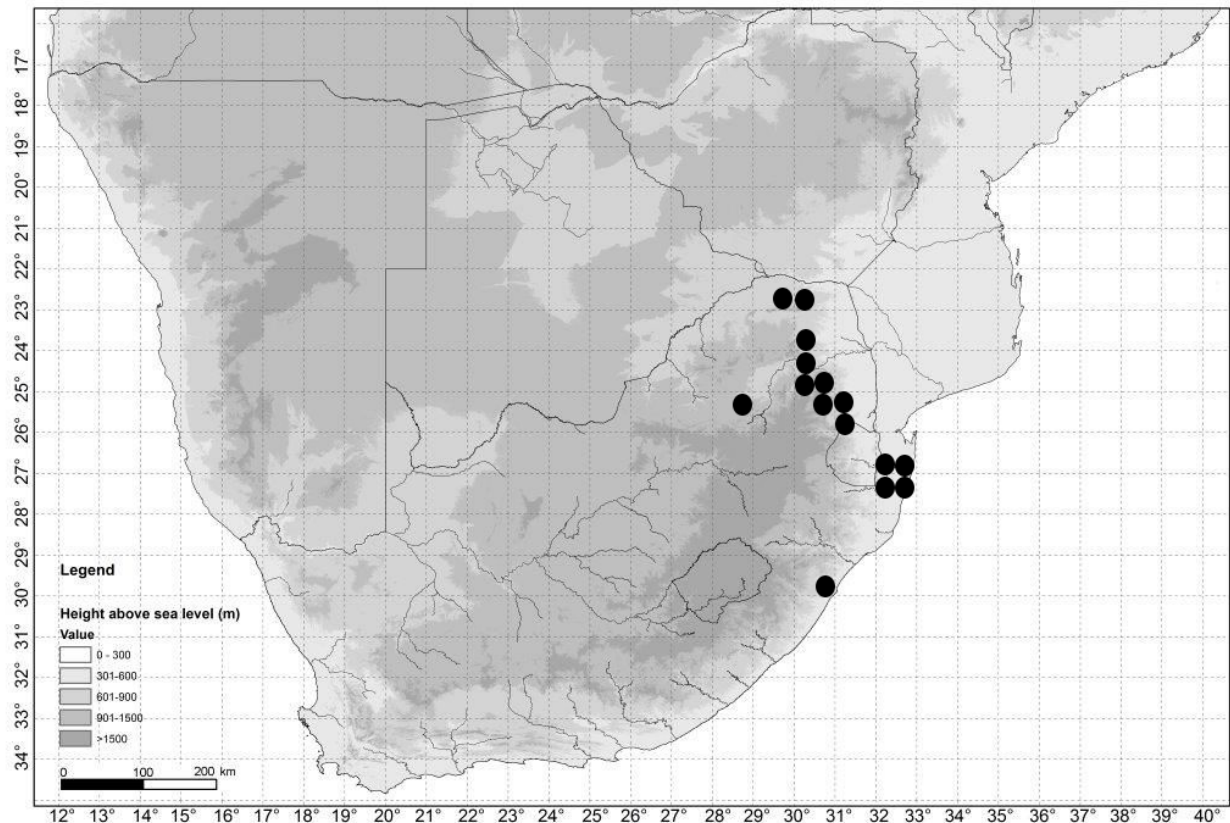


Figure 3.28. Distribution of *Senna petersiana* in South Africa.

Habitat:

Senna petersiana is mostly found in sandy soil, along streambanks (Gordon-Gray, 1977).

Additional specimens examined:

South Africa. LIMPOPO: **2229 (Waterpoort):** Wylies Poort (–DD), 23 May 1962, *Hardy 956* (PRE), Soutpansberg on farm Frans Hoek on river bank (–DD), 03 July 1935, *Galpin 14872* (PRE). **2230 (Messina):** Tshitandani Tshaanda (–CB), 06 December 2017, *Musandiwa 03* (NBG); Thathe Vondo Tea Estate on roadside (–CD), 26 April 1980, *Henderson 195* (PRE); North of Levubu, ca. 40 km east of Louis Trichardt, Levubu Farm (–AB), 02 June 1997, *Nienaber 201* (PRE). **2330 (Tzaneen):** Duiwelskloof: NW of Fairy Glen waterfall (–CA), 29 May 1958, *Scheepers 346* (PRE).

GAUTENG: **2528 (Pretoria)**: In Botanical Garden, Brummeria (–CB), 19 April 2001, *Meyer BP00676* (PRE).

MPUMALANGA: **2430 (Pilgrim's Rest)**: (–DB): Between Mariepskop and Green valley, 29 June 1971, *Vorster 1949* (PRE); Lydenburg, 6 miles S.W. of Penge mine (–AD), 25 March 1953, *Codd 7743* (PRE). **2530 (Lydenburg)**: Mauricedale farm, 9.3 km on Jeppes reef road going to Swaziland (Eswatini) direction (–BD), 30 June 1980, *Oliver 50* (PRE). **2531 (Komatipoort)**: on road to Nelspruit at Uitkyk Farm (–CA), 04 March 1999, *Meyer 1925* (PRE).

KWAZULU NATAL: **2632 (Bela Vista)**: Zululand, Ndumo Game Reserve (–CC), 10 January 1954, *Ward 2035* (PRE, NH, NU); Bella Vista, 8 miles from Makanes bridge on road to Sihangwa (–CD), 27 March 1971, *Vista 2428* (NH); 1 mile Mukanes pont on Kosi Bay road (–DD), 30 January 1963, *Edwards 2985* (NU); Bella Vista: Ndumo Hill, 1 km S.E of police station (–CD), 25 May 1972, *Stephen 700* (PRE); north of Zululand, Ndumo Game Reserve, Ndumo Hill (–BB), 24 April 1969, *Pooley 499* (PRE). **2732 (Ubombo)**: Bella Vista: Makatini flat (–CD), 20 April 1968, *Strey 8254* (NU); Sihangwane Stone (–AB), 14 June 1939, *Gerstner 3425* (NU). **2930 (Pietermaritzburg)**: UKZN, Medicinal Garden, Botanical Garden (–DD), 20 March 1909, *Aremu 7* (NU).

Swaziland (Eswatini): **2632 (Bela Vista)**: Next to Umbeluzi River in Umbuluzi gorge (–AA), 11 June 1977, *Culverwell 863* (PRE).

***Senna septemtrionalis* (Viv.) H.S.Irwin & Barneby**

Synonym(s): *Cassia septemtrionalis* Viv., *Cassia laevigata* Willd.

Common name(s): Arsenic bush, Dooleyweed, Laburnum.

Description:

Small tree to 5 m tall. **Stems** erect, often branching in the middle, glabrous. **Leaves** paripinnate, 50–180 mm long, glabrous; stipules linear, 5–10 mm long, narrowly acute, apex acute to acuminate, rachis channelled, with extrafloral nectaries between each pair of leaflets, 1–2 mm long. **Leaflets** 3–4 jugate, 35–100 × 15–32 mm, ovate; base cuneate; apex acute; margin entire. **Inflorescence** in axil of the upper leaves, racemes (including peduncles), up to 85 mm long, 6-10 flowered. **Pedicels**, 25–50 mm long at flowering, 25–60 mm long at fruiting. **Sepals** 5, obtuse, 6–10 × 2–5 mm, glabrous. **Petals** obtuse, 10–15 × 7–13 mm, bright yellow. **Stamens** 10, staminodes 3, 3 mm long, anthers rounded, filaments straight; medium-sized stamens 4, 5 mm long, with very short filaments; large stamens 3, 1 reduced, slightly curved, fertile 5–10 mm long. **Ovary** ± 15 mm long, curved, glabrous; style glabrous, 5 mm long. **Pods** 70–95 × 10-13 mm, glabrous, cylindrical, straight or slightly curved. **Seeds** oblong elliptic, 3–5 × 3–4 mm, dark brown.



Figure 3.29. (A) *Senna septemtrionalis*. Photograph taken by Musandiwa Liada.

Native range:

Senna septemtrionalis is native to Mexico along the Gulf Slope of Sierra Madre Oriental from south-east of San Luis Potosi to Oaxaca and Veracruz, through montane Guatemala, Honduras and Nicaragua (Irwin and Barneby, 1982).

Distribution in South Africa:

Senna septemtrionalis is widespread in Limpopo, Gauteng, Mpumalanga, extending to the coastal regions of KwaZulu-Natal and Eastern Cape (Fig. 3.30)

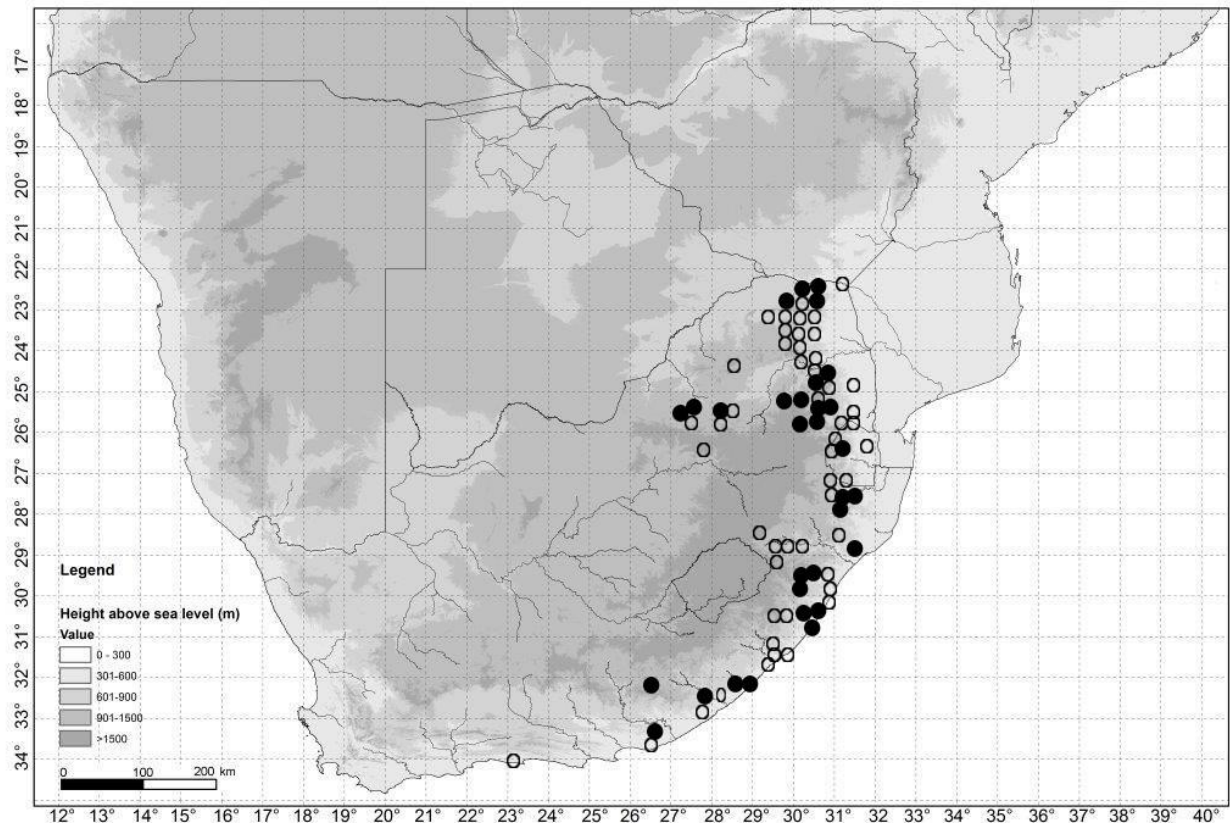


Figure 3.30. Distribution of *Senna septemtrionalis* in South Africa (SAPIA and SANBI DBI records (O), herbarium records (●)).

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Habitat:

Prolific shrubby weed of old pastures, abandoned orchards, roadsides (Irwin and Barneby, 1982), disturbed areas and forest margins (Brummitt et al., 2007).

How it spread:

Senna septemtrionalis is dispersed mainly by seeds carried by water or animals, humans or machinery (CABI, 2018).

Invasion category:

The species is listed as Category 1b invader under (NEM:BA 2014) regulations of alien and invasive species in South Africa.

Environmental impacts:

According to the Global Compendium of Weeds, *Senna septemtrionalis* is an agricultural and environmental weed (Randal, 2012). It is poisonous to fish (Neuwinger, 2004), and threat to endangered species and native vegetation (CABI, 2018).

Additional specimens examined:

South Africa. LIMPOPO: **2229 (Waterpoort)**: Louis Trichardt, Hanglip Reserve (–DD), December 1983, *Van Wyk 6643* (PRE). **2230 (Messina)**: On riverbank, near Giyani (–BC), 15 May 1981, *Killian 24* (PRE); Duiwelskloof, road skirting Merensky Dam (–CA), 14 Jan 1958, *Scheepers 13* (PRE); Thathe Vondo (–CD), 25 April 1977, *Hemm 87* (PRE).

NORTH WEST: **2527 (Rustenburg)**: Tierkloof on Baviaanskrans (–CA), 13 May 1977, *Germishuizen 384* (PRE); Rustenburg (–AD), without date, *Curator Pretoria Botanical Garden 04* (PRE).

GAUTENG: **2528 (Pretoria)**: Fountainvalley (–CA), 13 March 1929, *Verdoorn 757* (PRE).

MPUMALANGA **2430 (Pilgrim's Rest)**: Boerboomkraal 353 KT (–CD), 03 February 1982, *Raal 43* (PRE); Pilgrim's Rest (–DB), 11 December 1963, *Ward 6368* (PRE). **2529 (Witbank)**: Mapoch cave, Roossenekal about 7 km NE of Roossenekal (–BB), 18 January 2005, *Maserumule 212* (PRE). **2530 (Lydenburg)**: 18 km from the turn off to Lydenburg Machadodorp road, Badfontein farm opposite the braam Kwena Dam (–AD), 17 April 1997, *Marinus 17* (PRE); 107 Viljoen street (–BC), 13 January 2017, *Musandiwa 07* (NBG); Witklip, groei tussen dennebome langs pad (–BD), 06 May 1975, *Kluge 725* (PRE); Wilde struik (–DA), 04 February 1982, *Ueckermann 7417*

(PRE); 6 km from Escarpment on road top Snymansbult (–DB), 26 October 1982, *Henderson 639* (PRE). **2531 (Komatipoort)**: townlands outskirts of Barberton, north of town (–BD), 14 January 1974, *De Villiers 101* (PRE); Barberton to Shiyalongubo Dam, on roadside (–CC), 05 November 1996, *Henderson 1186* (PRE). **2931 (Stanger)**: about 8 miles from Doornkop on Maputa road (–AA), 01 December 1956, *Gordon-Gray 1712* (NU).

KWAZULU-NATAL: **2731 (Louwsburg)**: Itala Nature Reserve, Craigadam farm, north of Natal (–CA), 08 December 1977, *MacDonald 203* (NU); Itala Nature Reserve (–CB) 08 December 1977, *McDonald 203* (PRE); Near Vryheid about 3 km from Beverson on road to Gluckstadt (–CC), 25 November 1986, *Henderson 757* (NH). **2831 (Nkandla)**: Hlinza (–CD), 13 December 1973, *Grobbelaar 1787* (PRE). **2930 (Pietermaritzburg)**: Albert falls, uMngeni river (–AD), 25 April 1952, *Comins 364* (NU); Pietermaritzburg (–BC), 03 February 1963, *Hilliard 1223* (NU); Riverside about 3 miles from Howick (–CA), November 1962, *Morris 59* (NU); Bishopstowe (–CB), May 1972, *Bampton s.n.* (NU); Town bush valley (–CB), 21 April 1964, *Ross 989* (NU); Bryne, valley bottom (–CC), 28 January 1968, *Galpin 11906* (PRE). **3030 (Port Shepstone)**: Mgayi (–BC), 28 January 1968, *Ward and Van der Schiff 6368* (NU, PRE); Oribi Nature Reserve (–CA), January 1979, *Vassilatos and Mantell 461* (PRE).

EASTERN CAPE: **3226 (Fort Beaufort)**: About 8.4 miles from Botanical Research Unit, Makhanda (–AB), 08 February 1977, *Brink 589* (PRE). **3227 (Sutterheim)**: Fort Cunynghame (–BD), without date, *Sim 1303* (NU). **3228 (Butterworth)**: The Haven (–BA), 06 April 1966, *Gordon-Gray 265* (NU); The Haven (–BB), 07 December 1966, *Gordon-Gray 1108* (NU). **3326 (Makhanda)**: Settler's Dam on riverbank (–BC), 26 December 1972, *Bayliss BRI B 147* (PRE).

Swaziland (Eswatini): **2631 (Mbabane)**: mountain east of Mbabane (–AC), 10
February 1977, *Kemp 654* (PRE).



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Senna siamea (Lam.) H.S.Irwin & Barneby

Synonym(s): *Cassia siamea* Lam.

Common name(s): Siamese cassia.

Description:

Tree up to 10 m tall. **Stems** with a grey smooth bark densely pubescent with white short hairs, when young, becoming glabrous with age. **Leaves** 75–200 mm long, pubescent; stipules linear, up to 5 mm long; acuminate at apex; rachis faintly channelled; extrafloral nectaries lacking. **Leaflets** 5–8 jugate, 20–60 × 25 mm, oblong or ovate-elliptic; base acute to rounded; apex rounded or obtuse. **Inflorescence** terminal, racemes ± 65 mm long; bracts up to 7 mm long, linear, pubescent. **Pedicels** 10–25 mm long, at flowering, at fruiting 25–30 mm long. **Sepals** 5, broadly ovate, 9–10 × 3–5 mm. **Petals** 5, obovate, 7–12 × 5–7 mm, yellow. **Stamens** 10. 3 staminodes 3, 4 mm long, anthers slightly flattened; medium-sized stamens 4, 5–6 mm long, filaments short 1 mm long; large stamens 2, 1 reduced, up to 10 mm long, with broad anthers, filaments 2–3 mm long. **Ovary** curved, ± 5 mm long; stigma narrowed. **Pods** 120–210 × 11 mm, linear, or slightly curved, flattened. **Seeds** not seen.

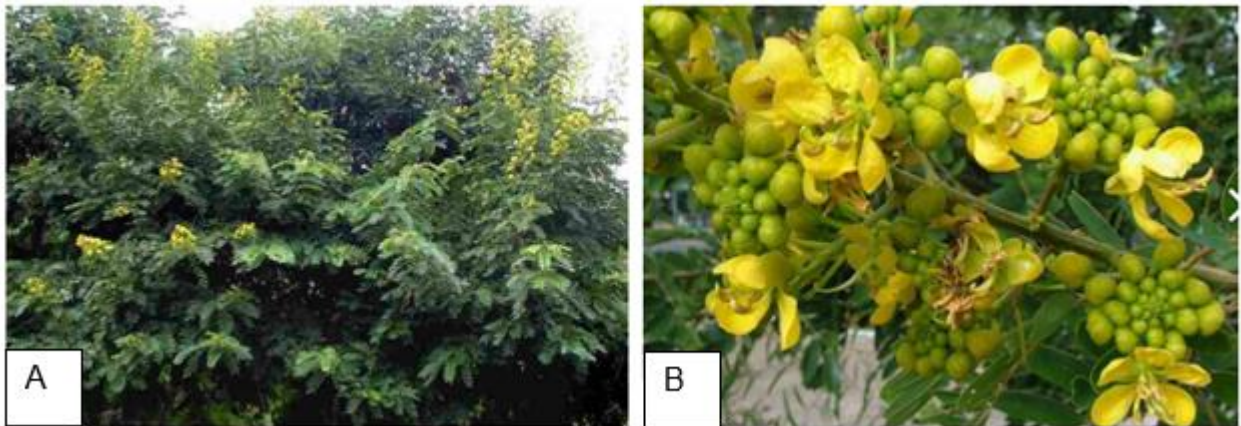


Figure 3.31. (A) *Senna siamea* plant, (B) flowers and flower buds. Photographs taken by Sheldon Navie

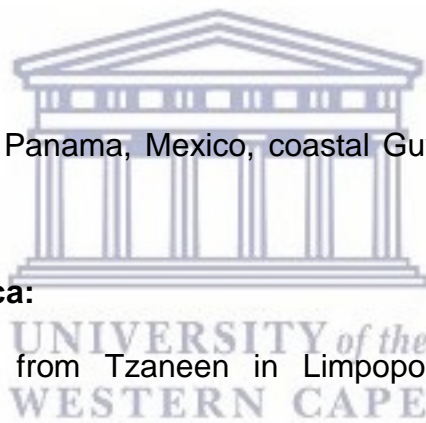
(<https://keyserver.lucidcentral.org/weeds/data/media/Html/fshelp.htm>).

Native range:

Senna siamea is native to Panama, Mexico, coastal Guyana and Brazil (Irwin and Barneby, 1982).

Distribution in South Africa:

Senna siamea is known from Tzaneen in Limpopo Province to Mashishing (Lydenburg) in Mpumalanga extending to Bela Vista in Kwazulu-Natal (Fig. 3.32).



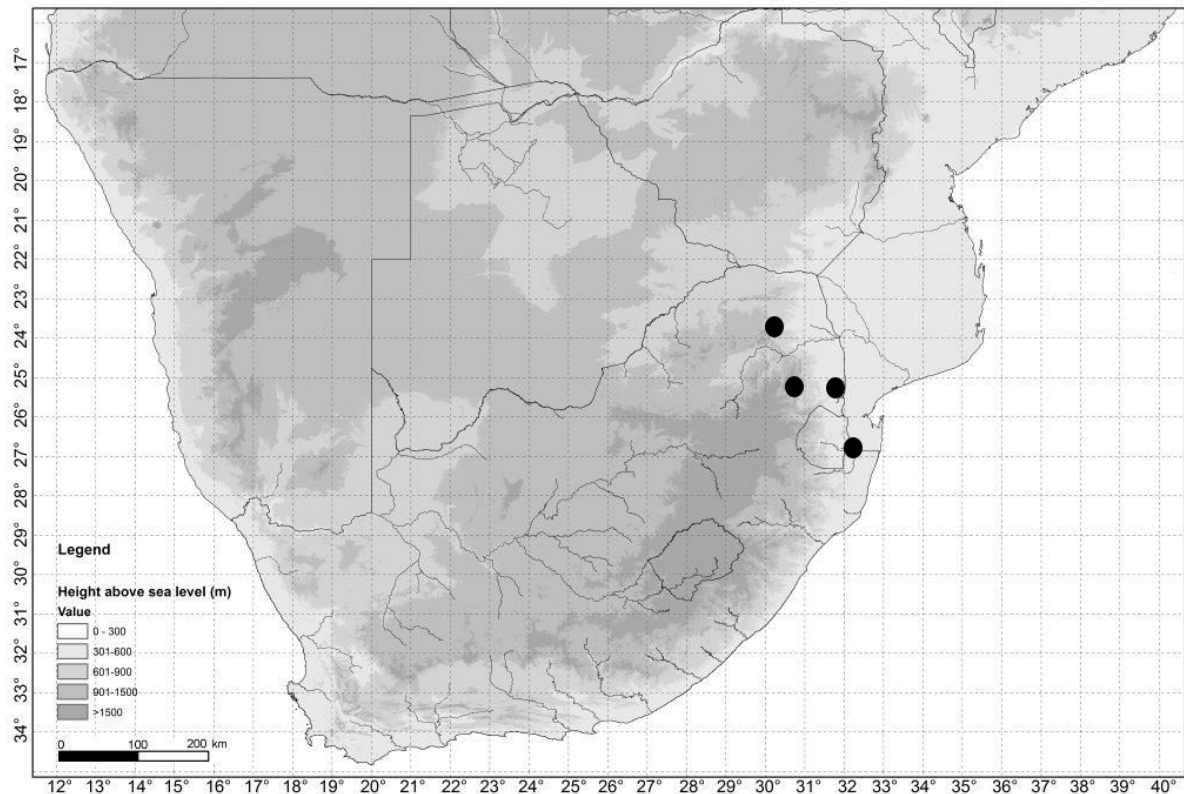


Figure 3.32. *Senna siamea* distribution in South Africa.

Habitat:

Senna siamea occurs along roadside, and in old fields, disturbed areas, forests and forest margins (Irwin and Barneby, 1982).

How it spread:

This species is fast growing and spreads through seeds. It is widely planted as an ornamental tree (Irwin and Barneby, 1982).

Invasion category:

Senna siamea has not been listed under the (NEM:BA 2014) regulations of alien and invasive species in South Africa.

Environmental impacts:

The species is reported to have potential of habitat alteration and outcompeting native vegetation (CABI, 2018).

Additional specimens examined:

South Africa. LIMPOPO: **2330 (Tzaneen)**: School grounds Merensky Agriculture High School near Tzaneen (–CD), 28 March 1962, *Scheepers s.n.* (PRE).

MPUMALANGA: **2530 (Lydenburg)**: Lydenburg (–BD), July 1905, *Legat 2832* (PRE); **2531 (Komatipoort)**: Komatipoort (–BD), November 1913, *Rogers 12618* (PRE).

KWAZULU-NATAL: **2632 (Bela Vista)**: Ndumo Game Reserve (–CC), 14 November 1962, *Ward 4515* (PRE); Ndumo Game Reserve (–CC), 29 February 1989, *Ward 2538* (NH).



***Senna sophera* (L.) Roxb.**

Synonym(s): *Cassia sophera* L.

Common name(s): African senna.

Description:

Shrub to 3 m tall. **Stems** with slender woody stems, subglabrous to glabrous. **Leaves** paripinnate, 80–160 mm long, stipules triangular, 3 × 1–2 mm; extrafloral nectaries on petiole, sessile, cylindrical or somewhat pointed, 1.5 × 1 mm. **Leaflets** 4–10 jugate, 20–90 × 4–9 mm, lanceolate to oblong lanceolate; acute or cuneate at the base; apex acute, margin ciliate when young, becoming glabrous with age. **Inflorescence** in axil of upper leaves, racemes 20–60 mm long, peduncles 8–40 mm long. **Pedicels** at flowering 5–20 mm long, at fruiting ± 20 mm long. **Sepals** 5, obtuse, 4–7 × 2.5–3.5 mm pubescent or glabrous. **Petals** 5, obovate, 7–10 × 4–6 mm. **Stamens** 10, staminodes 4, 2 mm long, anthers rounded; medium-sized stamens 6, 5 mm long, straight or slightly curved, filaments 2 mm long. **Ovary**, glabrous, slightly curved; style ± 1.5 mm long. **Pods**, 35–50 × 3–5 mm, cylindrical, straight or slightly, glabrous. **Seeds** not seen.

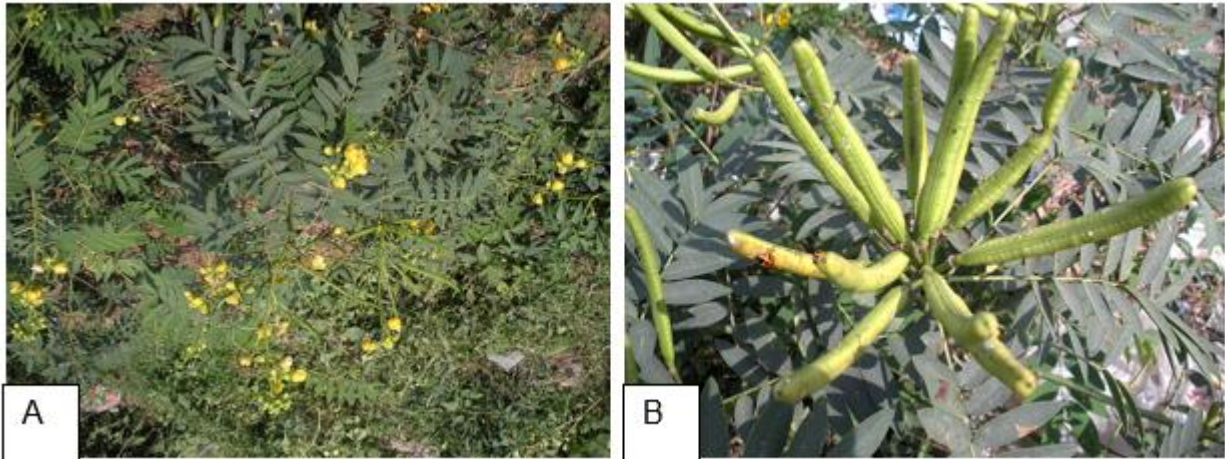


Figure 3.33. (A) *Senna sophera* plant and (B) pods. Photographs taken by Surajit Koley

(<https://sites.google.com/site/efloraofindia/species/a---l/f/fabaceae/senna/senna-sophera>).

Native range:

Senna sophera is common in Asia, rarely in Africa and America (Gordon-Gray, 1977). Its native range is uncertain (Brummitt et al, 2007).

Distribution in South Africa:

Senna sophera is currently known from Pietermaritzburg in KwaZulu-Natal Province (Fig. 3.34).

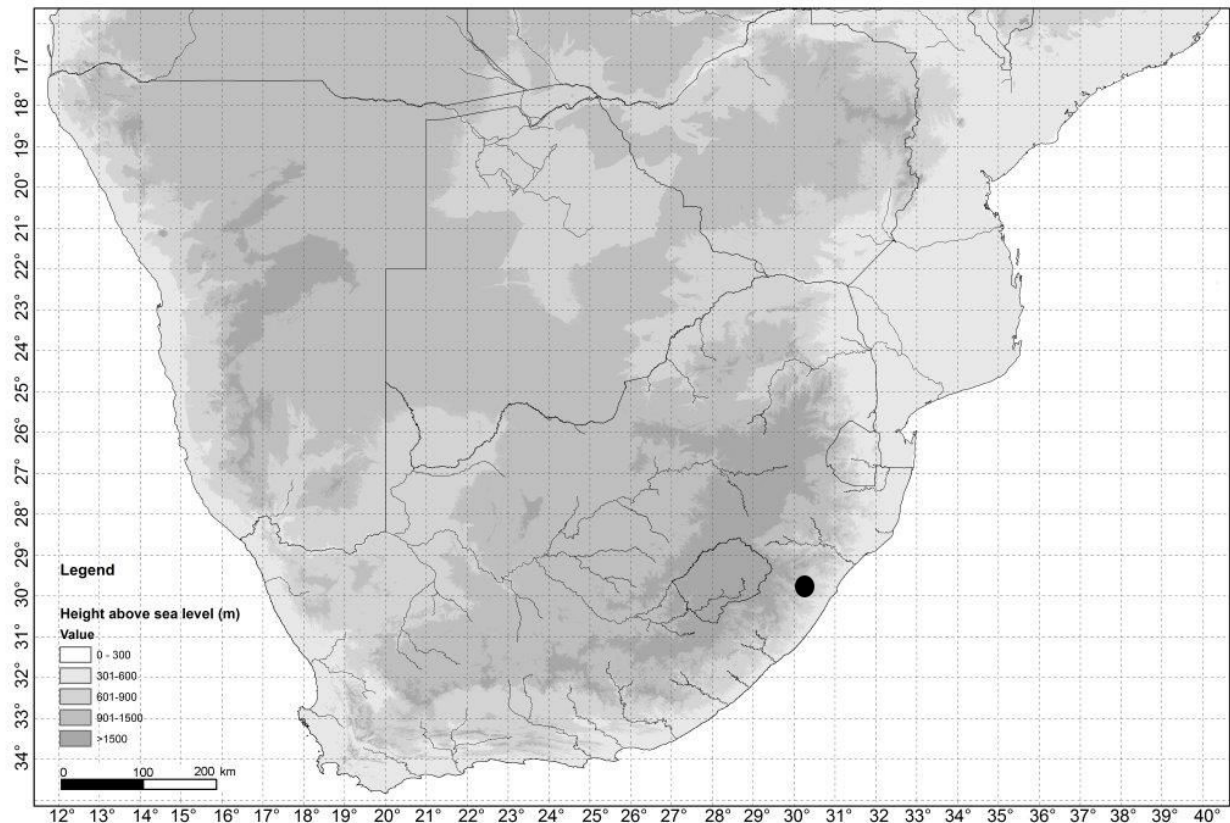


Figure 3.34. Distribution of *Senna sophera* in South Africa.

Habitat:

The species mostly occurs along roadsides, disturbed places, old fields and ditches (Irwin and Barneby, 1982).

How it spread:

Senna sophera is spread through seeds (Irwin and Barneby, 1982).

Invasion category:

The species has not been listed under the (NEM:BA 2014) regulations of alien and invasive species in South Africa.

Environmental impacts:

There is lack of information on the environmental impact of *Senna sophera*, however, the species is member of the problematic genus *Senna* (CABI, 2018).

Additional specimens examined:

South Africa. KWAZULU-NATAL: **2930 (Pietermaritzburg)**: Murry Road (–CB), 11

April 1971, *Borthwick 15B* (NU).



Senna spectabilis (DC.) H.S.Iwrin & Barneby

Synonym(s): *Cassia spectabilis* DC.

Common name(s): Spectacular cassia.

Description:

Tree to 10 m tall. **Stems** densely pubescent, branchlets dark brown. **Leaves** paripinnate, up to 400 mm long, pubescent, stipules 6–10 mm long, linear, extrafloral nectaries lacking, rachis faintly channelled. **Leaflets** 10–15 jugate, 25–60 × 20 mm, ovate lanceolate, acute or narrowly elliptic, densely pubescent, the upper pairs the largest. **Inflorescence** axillary, many flowered, racemes ± 50 mm long. **Pedicels** at flowering 10–25 mm long, pubescent, at fruiting ± 30 mm long. **Sepals** 5, ovate elliptic, 5–10 mm long. **Petals** 5, obvate, 10–20 × 8–10 mm, one obovate, larger than all. **Stamens** 10: 4 Staminodes, 4 mm long, anthers rounded; 6 medium-sized stamens, fertile, 8–10 mm long, filaments short, 2 mm long, with broad anthers. **Ovary** curved, glabrous; style glabrous, 2 mm long. **Pods** up to 300 mm long, ± 12 mm wide, cylindrical, glabrous, brownish to blackish. **Seeds** not seen.

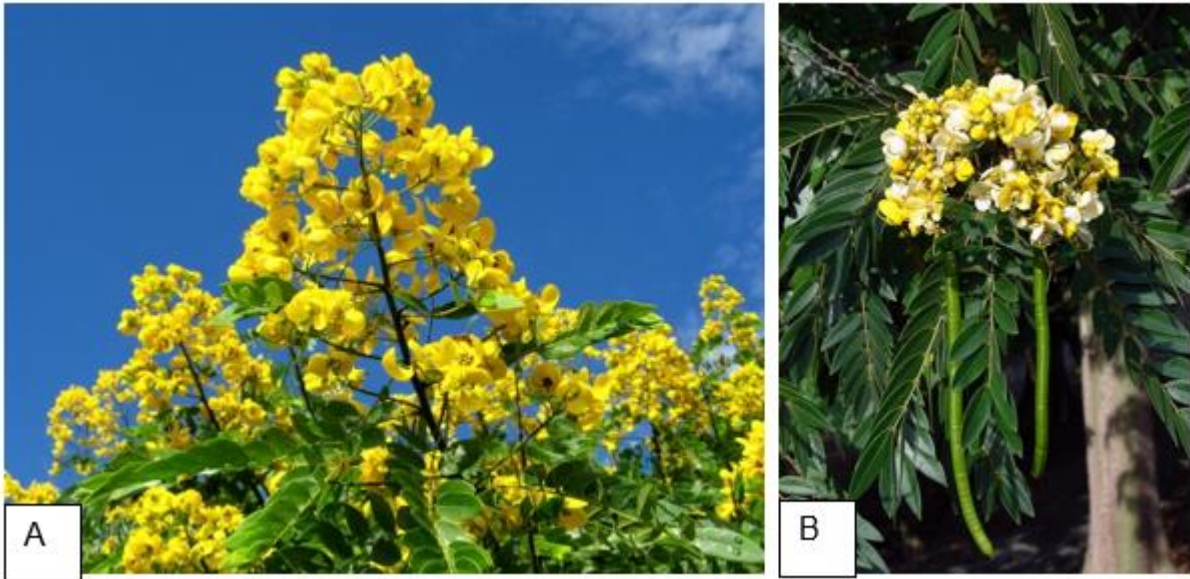


Figure 3.35. (A) *Senna spectabilis* flowers and (B) pods. Photographs taken by (A) Mauro Guanandi and (B) Tatiana Gerus (<http://tropical.theferns.info/>).

Native range:

Senna spectabilis is native to the Magdalena and Cauca valleys in Colombia, extending to Pacific slope in Valle and Orinoco basin in Venezuela (Irwin and Barneby, 1982).

Distribution in South Africa:

Senna spectabilis is distributed in Acornhoek in Mpumalanga and across Mbabane in Swaziland (Eswatini) extending to St. Lucia in KwaZulu-Natal (Fig. 3.36).

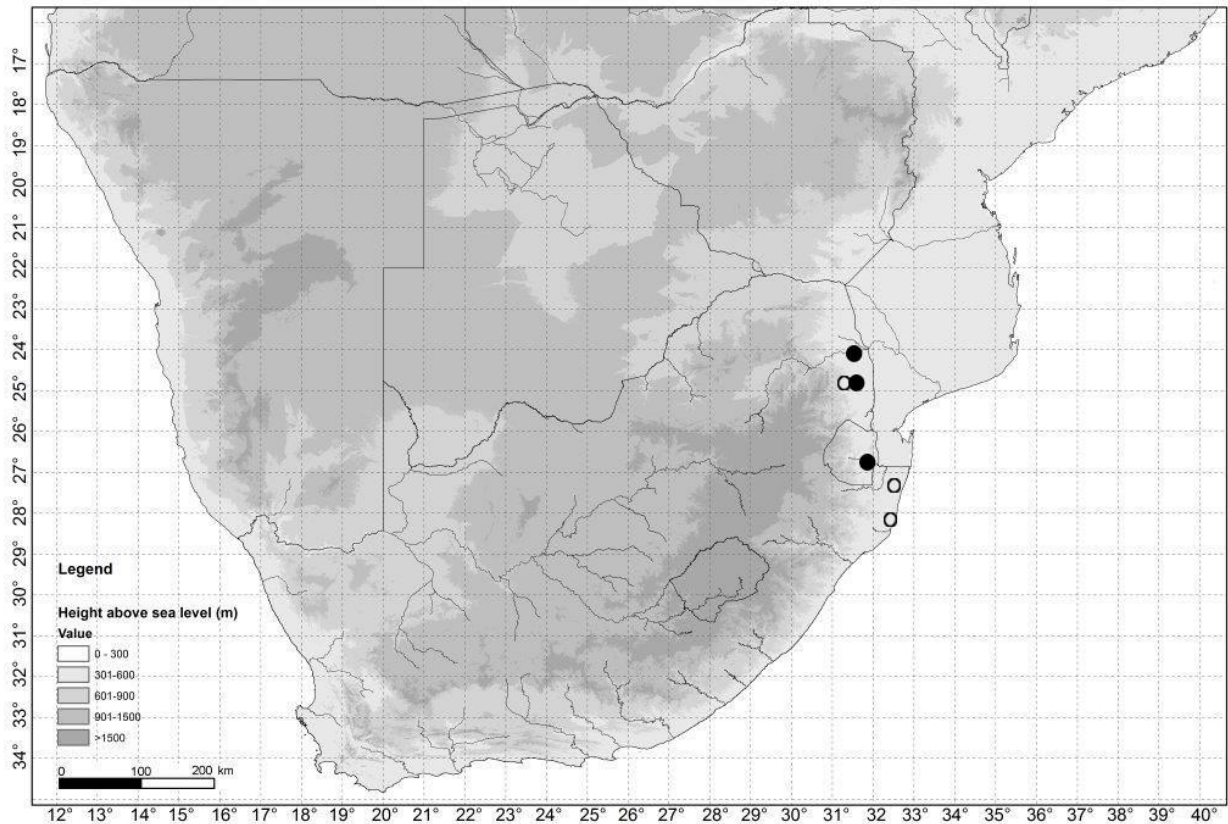
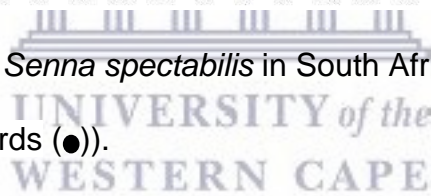


Figure 3.36. Distribution of *Senna spectabilis* in South Africa (SAPIA and SANBI DBI records (o), herbarium records (●)).



Habitat:

The species grows in coastal areas, moist and seasonal dry forests (Irwin and Barneby, 1982).

How it spread:

Senna spectabilis is spread through seeds (PIER, 2014).

Invasion category:

The species has not been listed under the (NEM:BA 2014) regulations of alien and invasive species in South Africa.

Environmental impacts:

The impact of *Senna spectabilis* include habitat alteration, native vegetation reduction, and loss of endangered and native species (CABI, 2018).

Additional specimens examined:

South Africa. MPUMALANGA: **2431 (Acornhoek)**: Next to Doctor's office in staff village (-DC), 13 May 1996, Cass CS 121 (PRE); Houtboschrand, rangers garden near water tanks (-AB), 01 October 1992, Zeller D. Z. 7 (PRE).

Swaziland (Eswatini). **2631 (Mbabane)**: Big Band (-DD), 29 February 1974, Donaldson 08 (PRE).



***Senna surattensis* (Burm. f.) H.S.Irwin & Barneby**

Synonym(s): *Cassia surattensis* Burm. f.

Common name(s): Glossy shower.

Description:

Small multi-stemmed tree, ± 6 m tall. **Stems** appressed with white short hairs, becoming woody, reddish or grey when dry. **Leaves** paripinnate, petiole and rachis, 70–170 mm long; stipules linear, ± 10 mm long, rachis slightly channelled, extrafloral nectaries often between 1–3 pairs of leaflets, short stalked, ± 2 mm long, slightly rounded at the top. **Leaflets** (3)4–6 jugate, 30–70 \times 10–30 mm, obovate, or elliptic obovate, two uppermost pairs largest. **Inflorescence** axillary, racemes 30–90 mm long. **Pedicels** at flowering, 10–25 mm long, at flowering up to ± 30 mm long. **Sepals** 5, obtuse, 7–10 mm long. **Petals** 5, bright yellow, ovate to oblong ovate, 10–25 mm long. **Ovary** curved, densely covered with greyish hairs; style glabrous. **Stamens** 10: fertile, with very short filaments ± 20 mm long, straight, anthers ± 10 mm long. **Pods** 110–150 \times (± 15) mm, flattened, glabrous.

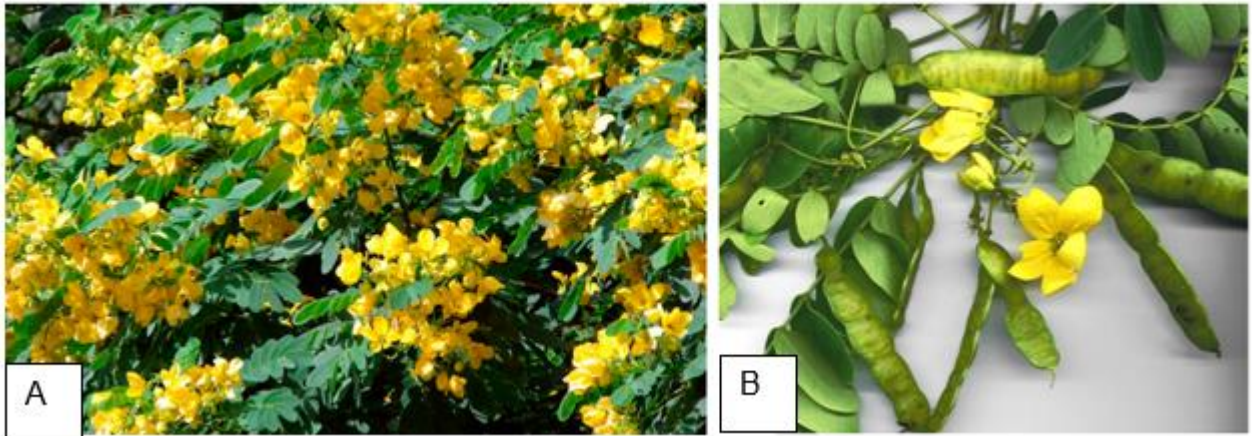


Figure 3.37. (A) *Senna surattensis* flowers and (B) pods. Photographs taken by Kim Starr (CABI, 2018).

Native range:

Senna surattensis native to Sri Lanka and India (Gordon-Gray, 1977).

Distribution in South Africa:

Senna surattensis is currently known from Pietermaritzburg and Stanger in KwaZulu-Natal (Fig. 3.38).



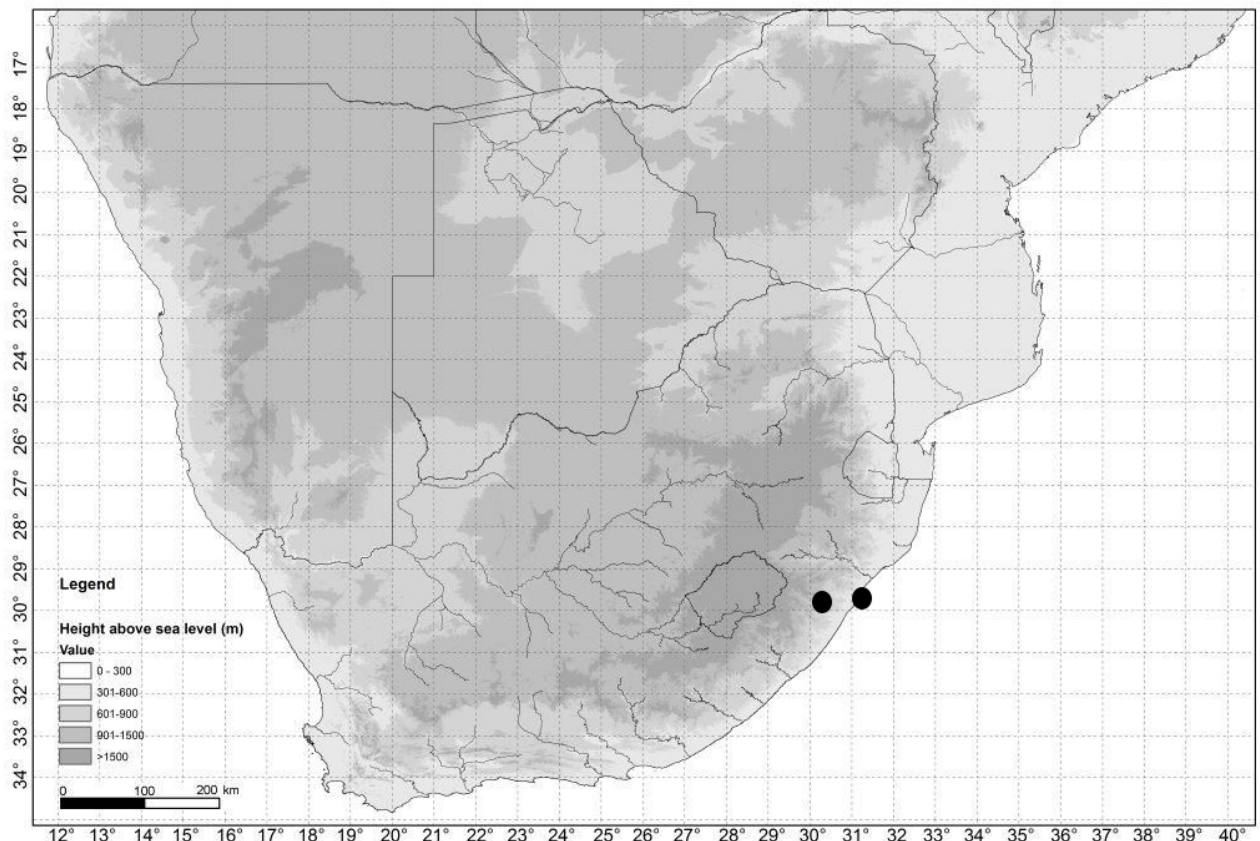
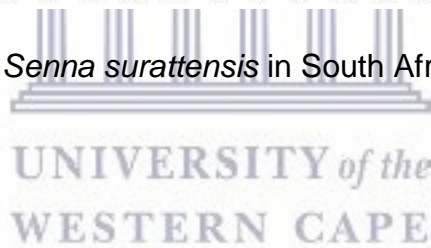


Figure 3.38. Distribution of *Senna surattensis* in South Africa.



Habitat:

Senna surattensis invades roadsides, coastal and disturbed areas (CABI, 2018).

How it spread:

Senna surattensis is dispersed internationally for cultivation purposes. It is reported to have escaped cultivation in South Africa (Brummitt et al., 2017).

Invasion category:

The species has not been listed under the (NEM:BA 2014) regulations of alien and invasive species in South Africa.

Environmental impacts:

Senna surattensis is an environmental, agricultural or garden weed. The species is known to outcompete native vegetation by shading (CABI, 2018).

Additional specimens examined:

South Africa. KWAZULU-NATAL: **2930 (Pietermaritzburg):** University of KwaZulu-Natal campus (–CB), 28 May 1971, *Michael s.n.* (NU); Kayeni (–CB), 25 March 1961, *Ross s.n.* (NU). **2931 (Stanger):** Stanger (–CC), 18 May 1993, *Ngwenya 1171* (NH).



CHAPTER 4

PHYLOGENY AND DNA BARCODING OF SOUTHERN AFRICAN CASSIINAE

4.1 Introduction

The subtribe Cassiinae comprises three genera, *Cassia* s.s., *Chamaecrista* (L.) Moench. and *Senna* Mill. (Irwin and Barneby, 1982). Phylogenetic analyses of the Cassiinae have yet to confirm its monophyly (Cavalari et al., 2012) and shed light on the relationships between *Cassia*, *Chamaecrista* and *Senna*. There is disagreement regarding the relationships between the genera (Torres et al., 2011). Morphological and molecular data of Herendeen et al. (2003) regarded *Chamaecrista* and *Senna* as sister taxa, and *Cassia* as a separate clade. However, Conceição et al. (2009) consider *Chamaecrista* to be a separate clade from *Cassia* and *Senna*, which they consider sister taxa.

The genus *Chamaecrista* traditionally comprises six sections (Irwin and Barneby, 1982). Previous literature has focused on the relationship between these sections in the New World (Conceição et al., 2009; Torres et al., 2011) and as a result the phylogenetic relationships of the southern African congeners in relation to those across the globe remain unknown. The present study utilises ITS and *trnL-F* data to clarify phylogenetic relationships within *Chamaecrista*, focusing on the placement of the southern Africa species within the global phylogeny for the genus (Conceição et al., 2009).

The species of *Cassia* and *Senna* are largely introduced in South Africa (Gordon-Gray, 1977), the majority of which have become invasive. Invasive species should be identified, controlled and eradicated, although it is often difficult to identify these taxa outside of their native range (Hebert et al., 2003; Van de Wiel et al., 2009;

Pyšek et al., 2013). As such, DNA barcoding has been proposed to facilitate and accelerate the identification of invasive plants (Ghahramanzadeh et al., 2013). In this chapter, I propose that DNA barcoding would be an important tool to accelerate the identification process of invasive species of *Cassia* and *Senna* in South Africa (supported by findings of Chase et al., 2005 and Ghahramanzadeh et al., 2013). Two regions known as the DNA barcodes for land plants (*rbcLa* and *matK*) were identified (CBOL Plant Working Group, 2009). The two-locus barcode combination offers high universality, good discriminating power, and higher resolution (CBOL Plant Working Group, 2009). Researchers have estimated the discriminatory power of the core DNA barcodes to be 70-80% (CBOL Plant Working Group, 2009; Fazekas et al., 2009; Kress and Erickson, 2007). The DNA barcoding regions have been tested on the three Cassiinae genera by Seethapathy et al. (2015). This study will assess the southern Africa species using these regions.

This chapter aims to determine the placement of the southern Africa species of the genus *Chamaecrista* in the context of a global phylogeny for the genus, and to establish a DNA barcoding library that will facilitate the identification process of invasive species of *Cassia* and *Senna* in South Africa.

4.2 Results

4.2.1 Phylogeny of *Chamaecrista*

Combined ITS and *trnL-F* dataset– The combined ITS and *trnL-F* dataset contained 64 taxa comprising a total of 2064 aligned positions, resulting in 400 variable and 831 parsimony informative characters. The maximum parsimony analysis resulted in 58 649 trees, with a tree length of 4 432 steps, retention index (RI) of 0.7028 and consistency index (CI) of 0.5026 (Table 4.1). The Bayesian Inference majority rule

consensus tree (Fig. 4.1A) and maximum parsimony strict consensus tree (Fig. 4.1B) differ slightly in topology. The genus *Chamaecrista* was strongly supported (B.P. 91, P.P. 1.00) as monophyletic in both. The relationships among the taxa are similar to those of Conceição et al. (2009). Sections *Chamaecrista* and *Absus* (Collad.) Irwin and Barneby are paraphyletic, whereas *Apoucouita* (Benth.) Irwin and Barneby and *Xerocalyx* (Benth.) Irwin and Barneby are monophyletic. Section *Grimaldia* (Schrank) Irwin and Barneby is embedded within section *Absus* and sections *Caliciopsi* Irwin and Barneby and *Xerocalyx* are embedded in section *Chamaecrista*. The southern Africa species group together within section *Chamaecrista*. The southern Africa species form a clade with *Chamaecrista nictitans* (L.) Moench and its related species. The Bayesian majority rule consensus tree and strict consensus tree of the ITS and *trnL-F* analyses are shown in the Fig. 4.1.



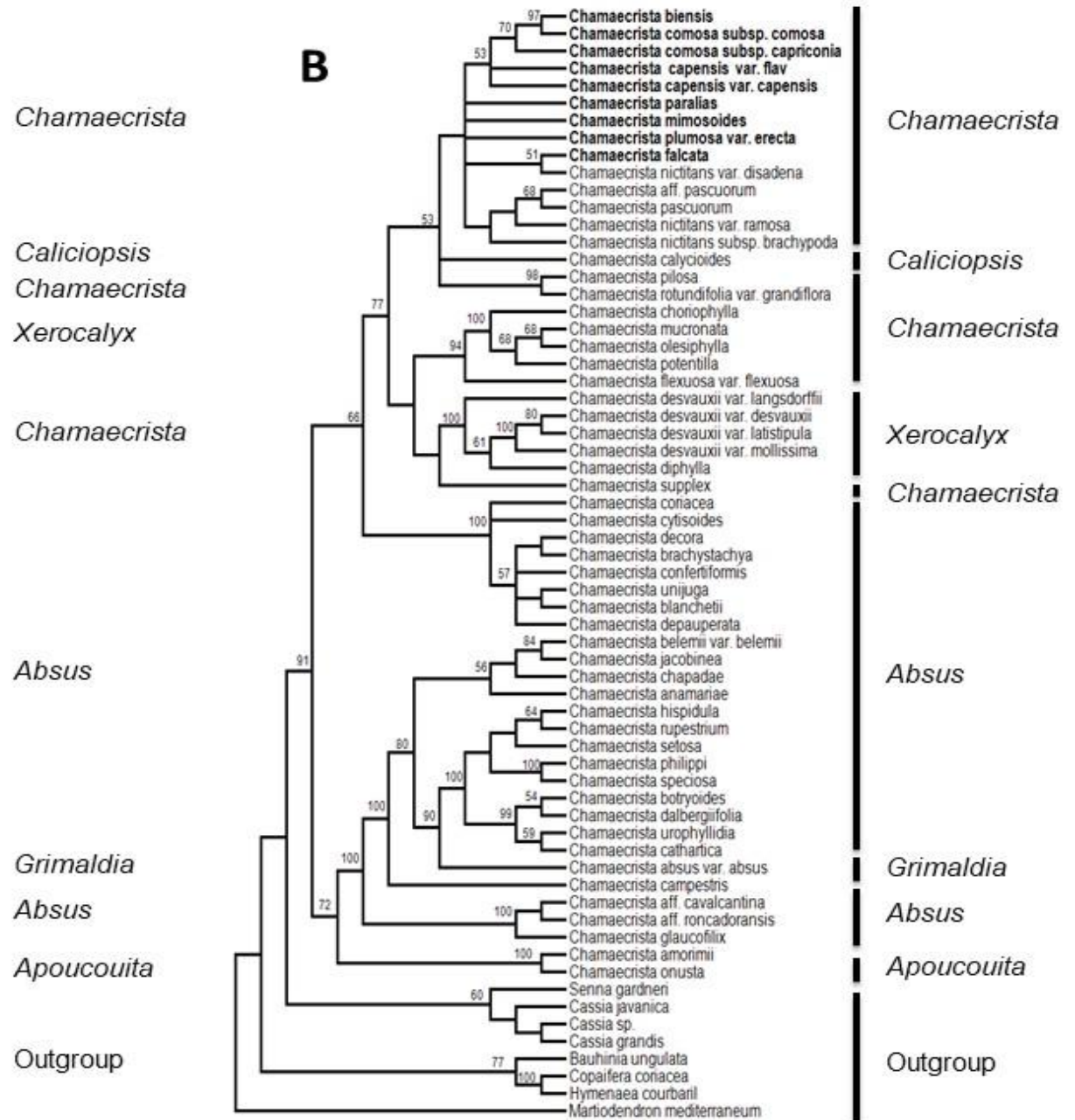
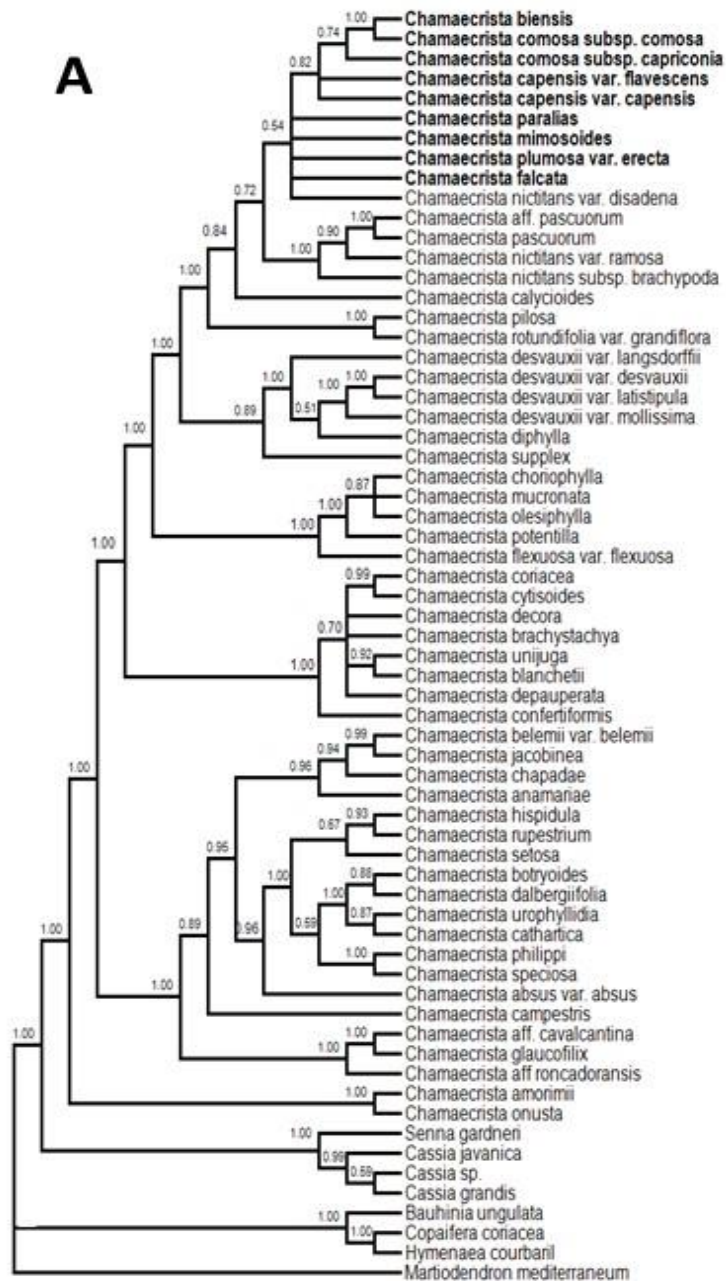


Figure 4.1. Bayesian majority rule consensus tree (A) and strict consensus tree (B) showing relationships within *Chamaecrista* resulting from analyses of the combined ITS/*trnL-F* data. Posterior probability values above 0.5 and bootstrap support values above 50% are provided. The southern African taxa are highlighted in bold text and the current sections of *Chamaecrista*, following Irwin & Barneby (1932), are marked on the trees.

4.2.2 DNA barcoding of invasive *Cassia* and *Senna*

***matK* dataset**– The *matK* matrix consisted of a total of 695 unambiguously aligned positions resulting in 43 variable and 106 parsimony informative characters. Maximum parsimony analysis retained 3 181 trees with tree length of 213 steps (CI= 0.79; RI= 0.93; Table 4.1). The Bayesian majority rule consensus tree from the *matK* analysis is shown in the Fig. 4.2. The barcode region *matK* was especially able to differentiate between species. As such, multiple representatives of the same species were grouped together as a single clade and consequently formed well supported clades in most cases. In the analyses using *matK*, the genera *Cassia*, *Chamaecrista* and *Senna* were recovered as separate monophyletic groups. *Senna* was recovered as a monophyletic assemblage (PP 1.0), and was found to be successively sister to a monophyletic *Cassia* (PP 0.95).

***rbcLa* dataset**– The *rbcLa* matrix consisted of a total of 524 unambiguously aligned positions resulting in 62 variable and 49 parsimony informative characters. Maximum parsimony analysis retained 3 139 trees with the length of 238 steps (CI=0.5294; RI= 0.6706; Table 4.1). Unlike *matK*, *rbcLa* has lower discriminatory power and the resulting phylogenetic trees were poorly resolved (Fig. 4.3). The genus *Chamaecrista* was found embedded in a well supported clade (PP 1.0) that includes species from the *Senna artemisioides*-*Senna sulfurea* cluster and those from the *Cassia abbreviata*-

Cassia abbreviata subsp. *bereana* species cluster. The genus *Senna* was, however, found to be unresolved with species of the genus found scattered throughout the tree.



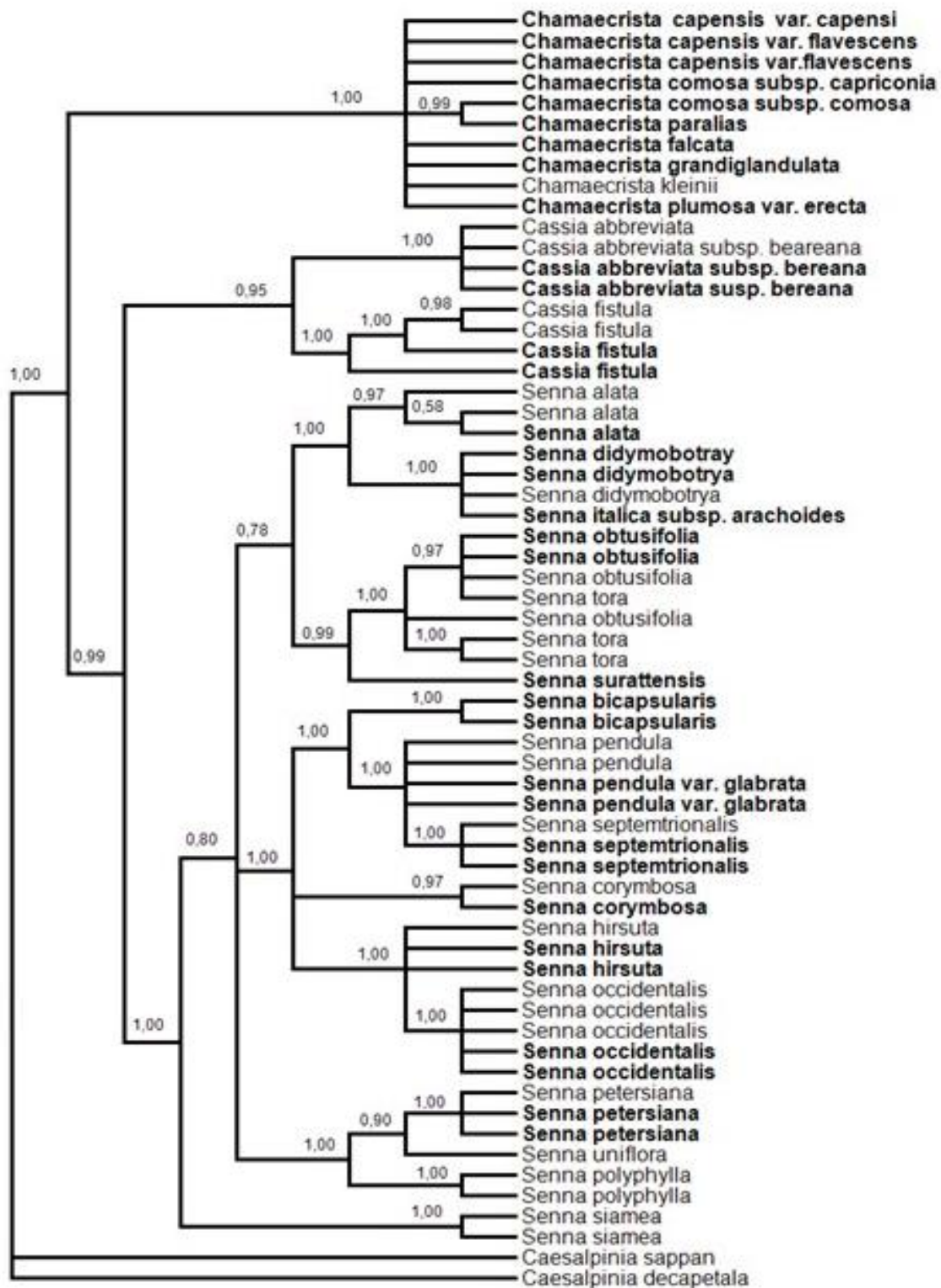


Figure 4.2. . The Bayesian majority rule consensus tree resulting from analysis of the *matK* data of the Cassiinae with posterior probability values above branches. The southern African species of Cassiinae are highlighted in bold text.

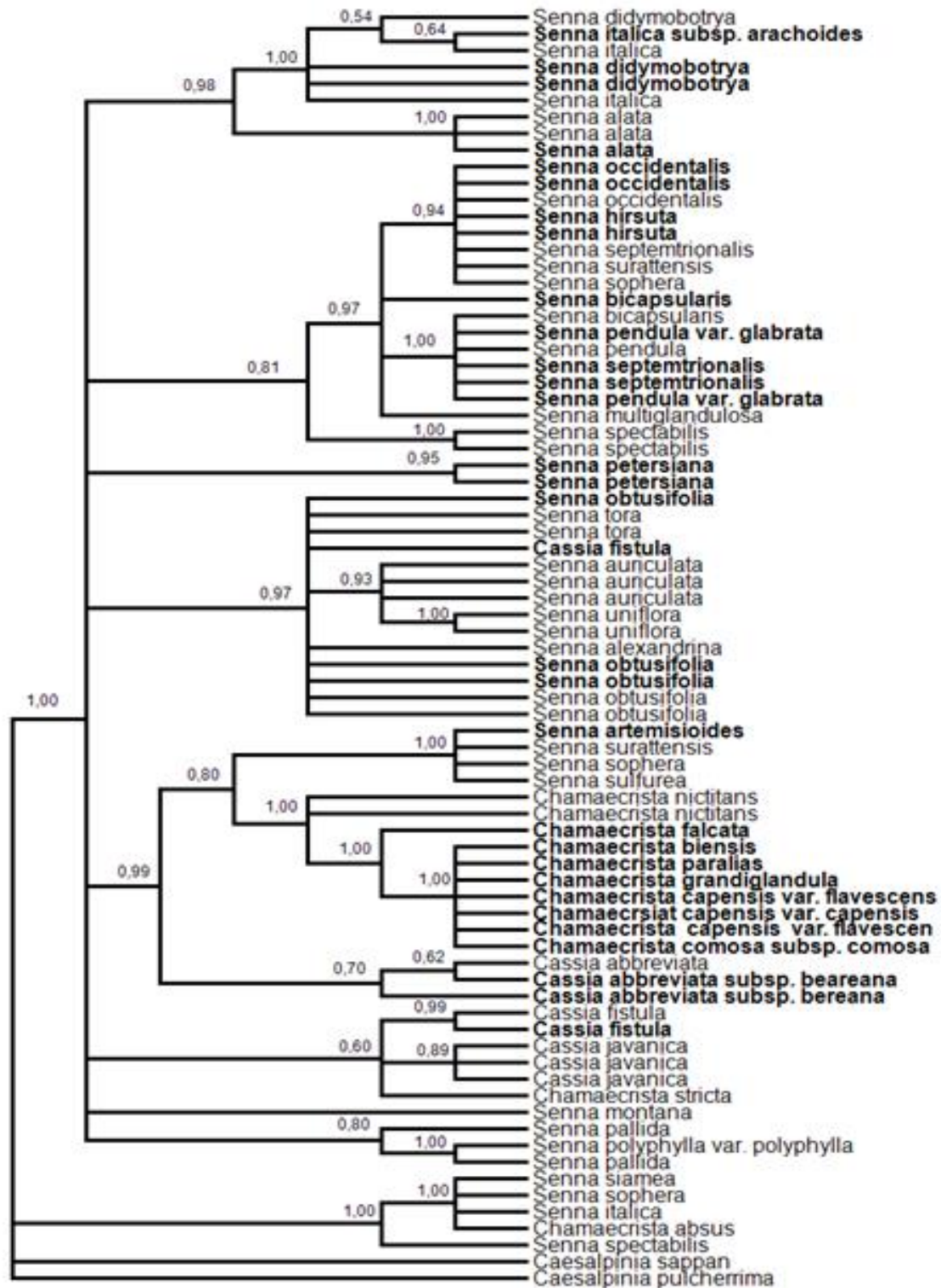


Figure 4.3. The Bayesian majority rule consensus tree resulting from analysis of the *rbcLa* data of the Cassiinae with posterior probability values above branches. The southern African species of Cassiinae are highlighted in bold text.

Table 4.1. Statistics and sequence characteristics of the regions *matK*, *rbcLa*, and combined ITS and *trnL-F* data.

DNA region	Combined (ITS & <i>trnL-F</i>)	<i>matK</i>	<i>rbcLa</i>
No. of taxa	64	62	77
No. of included positions in matrix	2062	695	524
No. of constant characters	801	546	413
No. of parsimony informative characters	831	106	49
No. of variable sites	400	43	62
No. of trees (Fitch)	58649	3181	3139
Tree length	4432	213	238
CI	0.5036	0.7934	0.5294
RI	0.7028	0.9300	0.6706
Average number of changes per variable site	11.08	4.9	3.9
Model selected by Akaike information Criterion	<i>trnL-F</i> : T1M2+1+GT ITS: T1M1+G	TPM1UF+I +G	HKY+G

4.3 Discussion

4.3.1 *Chamaecrista*

Both analyses of the combined *trnL-F*/ITS data supported *Chamaecrista* as a monophyletic genus. The Bayesian Inference majority rule consensus and maximum parsimony strict consensus trees are highly consistent with previous studies based on cpDNA *trnE-trnT* intergenic spacer and nrDNA ITS/5.8S data (Torres et al., 2011), and ITS/5.8S and *trnL-F* plastid data (Conceição et al., 2009), in which the sections *Apoucouita* and *Xerocalyx* were supported as monophyletic, while sections *Absus* and *Chamaechrista* were paraphyletic.

The species of section *Apoucouita* (*Chamaecrista amorimii* and *C. onusta*) are recovered in a clade with species from the sections *Grimaldia* and *Absus*, as shown

by Conceição et al. (2009). Species of section *Apoucouita* are large trees, characterized by the presence of extrafloral nectaries on the inflorescence and pubescent anthers (Conceição et al., 2009). The species of this group are most diverse in tropical America (Amazonia, Brazil and Guianas; Irwin and Barneby, 1982).

Section *Grimaldia*, represented by only one species, is embedded within section *Absus*, as observed by Conceição et al. (2009) and Torres et al. (2011). The species of section *Absus* (particularly subsection *Absus*) and *Grimaldia* share glandular hairs and a lack of extrafloral nectaries (Conceição et al., 2009; Irwin and Barneby, 1982). Section *Grimaldia* is distinct from section *Absus* in the arrangement of the leaves, stamens 2–7, the long filaments of the anthers, and a thick short style. The species of section *Grimaldia* are distributed in tropical America, extending to Africa, Asia and Australia (Irwin and Barneby, 1982), while section *Absus* is most diverse in Central Brazil and the Espinhaço Mountain range (Conceição et al., 2009).

Sections *Caliciopsis* and *Xerocalyx* are embedded within section *Chamaecrista*. These sections consist of mostly herbaceous to shrubby species (Conceição et al., 2009). The species of section *Chamaecrista* are characterised by few or multiple leaflets, sessile or stipulate extrafloral nectaries, and axillary or supra-axillary inflorescences with 5 to 10 stamens (Brenan, 1967; Gordon-Gray, 1977; Irwin and Barneby, 1982; Brummitt et al., 2007). Section *Caliciopsis* is similar to the herbaceous members of section *Chamaecrista* in morphology, number of chromosomes and few-nerved leaflets (Irwin and Barneby, 1982).

The present study attempted to elucidate the phylogenetic relationships of the southern Africa species of *Chamaecrista* in the global generic phylogeny. In both analyses, the southern Africa species of *Chamaecrista* are placed together with South

American species (*Chamaecrista nictitans* var. *branchypoda*, *C. nictitans* var. *didadena*, *C. nictitans* var. *ramosa*, and *C. pascuorum*) in section *Chamaecrista*. The species of the *Chamaecrista nictitans* clade (including the southern Africa species) share sessile, sub-sessile or stipitate extrafloral nectaries, multiple leaflets, axillary or supra-axillary inflorescences comprising 1– to few-flowered racemes, stamens in two or three pairs and seeds that are obovoid or rhomboid.

4.3.2 DNA barcoding invasive Cassiinae

The results from the DNA barcoding regions presented in this study indicate that this may be a useful tool in the identification of invasive species of Cassiinae in South Africa. *matK* especially was able to discriminate between species and recover strongly supported clades with multiple representatives of the same species grouping together in most cases. One of the greatest advantages of using DNA barcodes in invasive species programmes (e.g. SANBI-DBI) is the ability to rapidly identify invasive species early (Cross et al., 2011). Emerging invaders are often overlooked since they have a lower substantial impact to the ecosystem, but should be recognised as future threats, and hence warrant management attention before becoming widespread (Nel et al., 2004; Olckers, 2004). Early and rapid identification of invasive species, with the aim of eradication, is considered as a second line of defence after prevention of alien introduction (Wilson et al., 2013). Rapid genetic identification of invasive species, without requirement for any morphologically mature characters (e.g. reproductive or vegetative morphology), means that detection of invasive species can be conducted at any stage of their life cycles (Cross et al., 2011).

DNA barcoding alone will not solve all taxonomic issues, especially in difficult groups (Cross et al., 2011). However, from a management perspective, identifying

invasive species using the barcoding regions will provide a more precise genetic reference to identify introduced species, invasive and naturalized taxa correctly, and distinguish them from close relatives (Cross et al., 2011). Identification of invasive species using DNA barcoding reduces costs in the long term and is less time consuming than conventional identification in many cases (Cross et al., 2011).



CHAPTER 5

A TAXONOMIC REVISION OF *CHAMAECRISTA* (L.) MOENCH. IN SOUTHERN AFRICA

5.1 Introduction

The genus *Cassia* L. was divided into three genera (viz. *Cassia* s.s., *Chamaecrista* (L.) Moench. and *Senna* Mill.) in the subtribal classification of the Cassiinae by Irwin and Barneby (1982). Prior to this classification the species of *Chamaecrista* were included within the large polymorphic genus *Cassia*. The subdivision of *Cassia* was later supported by phylogenetic data (Bruneau et al., 2001, Herendeen et al., 2003) and several taxonomic studies (Randell, 1990, Dulberger et al., 1994, Singh, 2001).

Chamaecrista is a large diverse genus consisting of trees, shrubs and herbs (Lewis et al., 2005). Members of the genus are largely found in open grasslands (Brenan, 1967; Gordon-Gray, 1977; Brummitt et al., 2007). The genus is most diverse in South America with ca. 259 spp. (see Flora do Brazil, 2019), in Africa with ca. 36 spp., in Australia with ca. 12 spp. and in Madagascar with about six spp. (Lewis et al., 2005). The morphological diversity in *Chamaecrista* has led to the division of the genus into six morphologically diagnosable sections. This sectional classification of the genus is based largely on the type of glandular hairs, presence or absence of extrafloral nectaries and the structure of the inflorescence (Irwin and Barneby, 1982).

The species of the genus *Chamaecrista* in Africa have been treated in several floristic studies, viz. Flora of Tropical Africa (Oliver, 1871), Flora of Tropical East Africa (Brenan, 1967), Flora of Southern Africa (Gordon-Gray, 1977) and Flora Zambesiaca (Brummitt et al., 2007). Gordon-Gray (1977) laid a sound taxonomic foundation of *Chamaecrista* in her treatment of the southern African *Cassia* species. In her

treatment, however, *Chamaecrista* species were all still treated under *Cassia*, which is now outdated and in need of revision given the subsequent generic subdivision. Several species complexes also remain problematic. Within South Africa *Chamaecrista* has, until now, been considered to comprise eight species, distributed widely in South Africa (mainly Limpopo, Gauteng, Mpumalanga, KwaZulu-Natal and Eastern Cape) (Gordon-Gray, 1977).

The aim of this chapter is to present a taxonomic revision of *Chamaecrista*, including detailed descriptions and illustrations, key to the species, nomenclature and typifications, as well as known geographical distribution of all the species.

5.2 Vegetative morphology

5.2.1 Habit and branches

Species of *Chamaecrista* are single or multi-stemmed perennial or annual herbs usually ca. 0.3–0.8 m high, but *C. gordon-grayei* Musandiwa & Boatwr. and *C. grandiglandulata* Musandiwa & Boatwr. can reach a height of up to 1.5 m, and *C. plumosa* var. *erecta* (Schorn & Gordon-Gray) Lock up to 1.8 m. *Chamaecrista biensis* (Steud.) Lock and *C. capensis* var. *capensis* are low growing plants, with multiple decumbent or prostrate stems arising from a woody rootstock (Figure 5.1F). Some taxa of *Chamaecrista*, such as *C. capensis* var. *flavescens* E. Mey., *C. grandiglandulata* and *C. plumosa* var. *erecta* are usually single stemmed with branching only in the upper half (Fig 5.1B, C and D). Branches are either glabrous, subglabrous, or covered with short curved and/or long patent hairs.

5.2.2 Leaves

Leaves of *Chamaecrista* are paripinnate, with multiple leaflets (rarely two in *C. absus* (L.) H.S. Irwin & Barneby), slightly tapering distally. The number and shape of leaflets is an important diagnostic character when distinguishing species. The leaf rachises of the species are channelled along the upper surface, or rarely crested with an upright wing of tissue forming a ridge along the mid-line of the upper surface (e.g. in *C. gordon-grayeri*, *C. grandiglandulata*, *C. mimosoides* (L.) Green and *C. plumosa* E. Mey.).

The leaves are characterised by the presence of extrafloral nectaries on the petioles (rarely on the rachis between the lower pair of leaflets in *Chamaecrista falcata* Musandiwa & Boatwr.), except in *C. absus*. The extrafloral nectaries are an important character to distinguish species of *Chamaecrista*. The extrafloral nectaries vary widely among the species in their shape and size (Fig. 5.2). They are either sessile (in *C. comosa* E. Mey., *C. grandiglandulata*, *C. kirkii* var. *kirkii*, *C. parva* (Steyaert) Lock, *C. plumosa*, *C. stricta* E. Mey. and *C. mimosoides*), subsessile or raised on short (in *C. biensis* and *C. capensis*) or well developed stalks up to 1.5 mm long (in *C. falcata*). The extrafloral nectaries in *C. falcinella* var. *parviflora* (Steyaert) Lock and *C. gordon-grayeri* are sessile and/or subsessile.

5.3 Reproductive morphology

5.3.1 Inflorescences and flowers

The inflorescences in *Chamaecrista* are usually supra-axillary or axillary. Those of all the species vary in the length and number of flowers. The largest flowers are found in *C. capensis*, *C. comosa* (7–20 mm long) and *C. plumosa* (7.0–17.0 mm long). *Chamaecrista parva* has flowers up to 13 mm long, while those of the remaining

species are less than 10 mm long. The bracts resemble the stipules, and are often triangular (narrowly falcate in *C. falcinella* var. *parviflora*). Bracteoles are paired, located above the upper half or towards the top of pedicels below the sepals. The length of the pedicels ranges from as short as 3 mm in *C. absus* and *C. mimosoides* to as long as 45 mm in *C. capensis* and *C. falcata*. The pedicels are usually covered with short curved or long patent hairs. The sepals are often pubescent on the outer surface. The petals are usually obovate, and most often bright yellow, occasionally pale yellow (in *C. stricta* and *C. grandiglandulata*). There are eight to 10 stamens present, with the exception of *C. absus* which has only five. The anthers are often in two or three series, straight or slightly curved, and filaments are mostly ± 1 mm long. Ovaries are densely covered with greyish to whitish hairs and the style is slightly curved or straight and glabrous.

5.3.2 Fruits

The pods in *Chamaecrista* are fairly uniform in structure. They are generally flattened, straight or slightly curved and many seeded. Within the southern African species the pods may vary slightly in size and degree of hairiness. Most *Chamaecrista* species have pods that range from 20–63 mm long, with the exception of *C. kirkii* var. *kirkii* where they can be up to 90 mm long. *Chamaecrista absus* is the only species within the genus with glandular pods.

5.3.3 Seeds

The seeds in *Chamaecrista* species are usually rhomboid and vary from light brown to black. The surface is smooth, sometimes with dark brown or light brown dots.

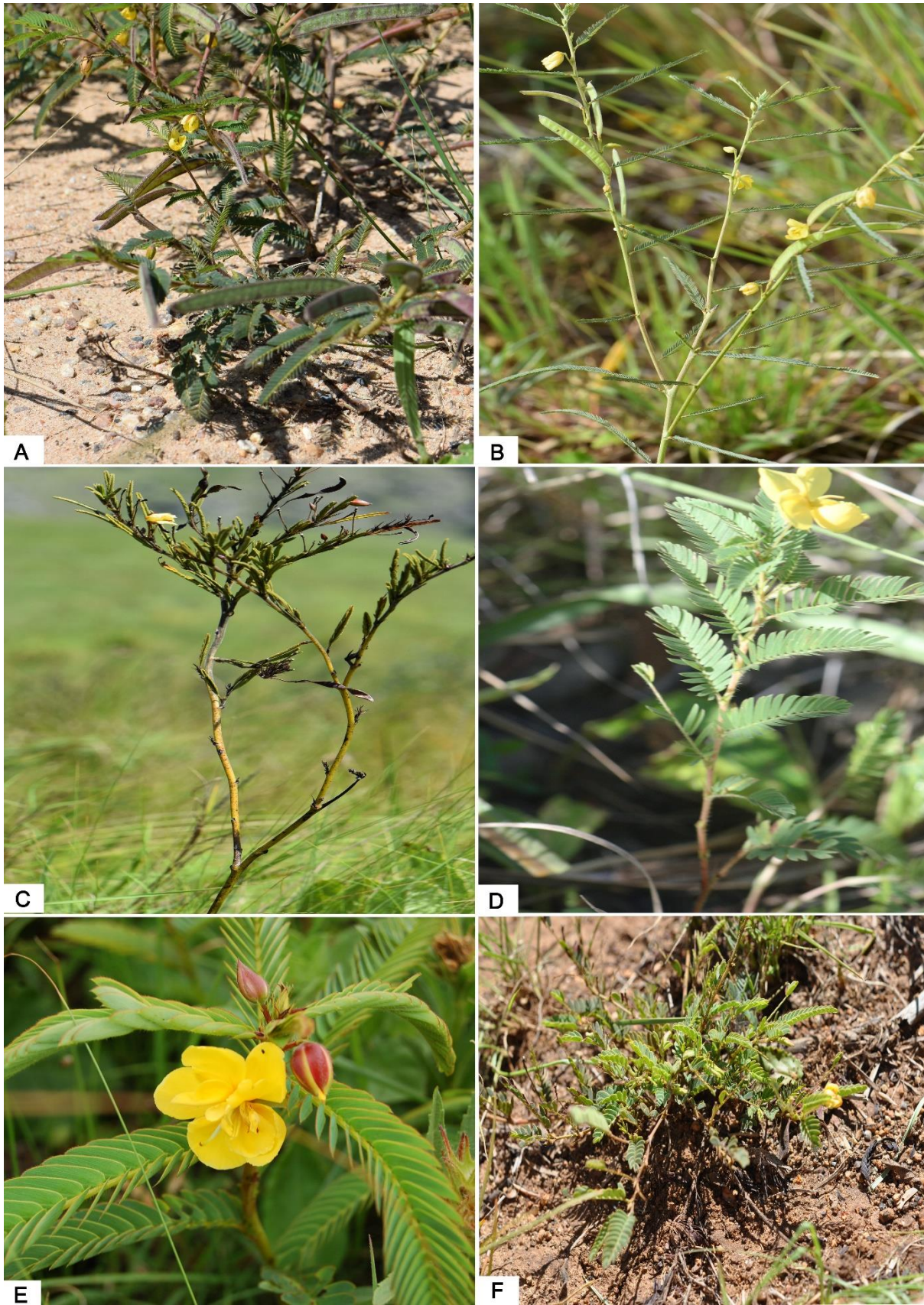


Figure 5.1. General morphology of *Chamaecrista*. Detailed caption on following page.

Figure 5.1. General morphology of *Chamaecrista*. (A) Habit of *C. mimosoides* showing a low-growing growth form. (B) Habit of *C. grandiglandulata* branching in the upper half, showing small pedicles and small pale flowers. (C) Habit of *C. plumosa* var. *erecta*. (D). Habit of *C. capensis* var. *flavescens* showing a large flower. (E) Habit of *C. comosa* subsp. *comosa* showing large leaves and broad leaflets, 2–5 mm wide. (F) Habit of *C. biensis* showing a prostrate or decumbent growth form and small flowers. Photographs (A-E) taken by Liada Musandiwa, (F) taken by Anthony Magee.



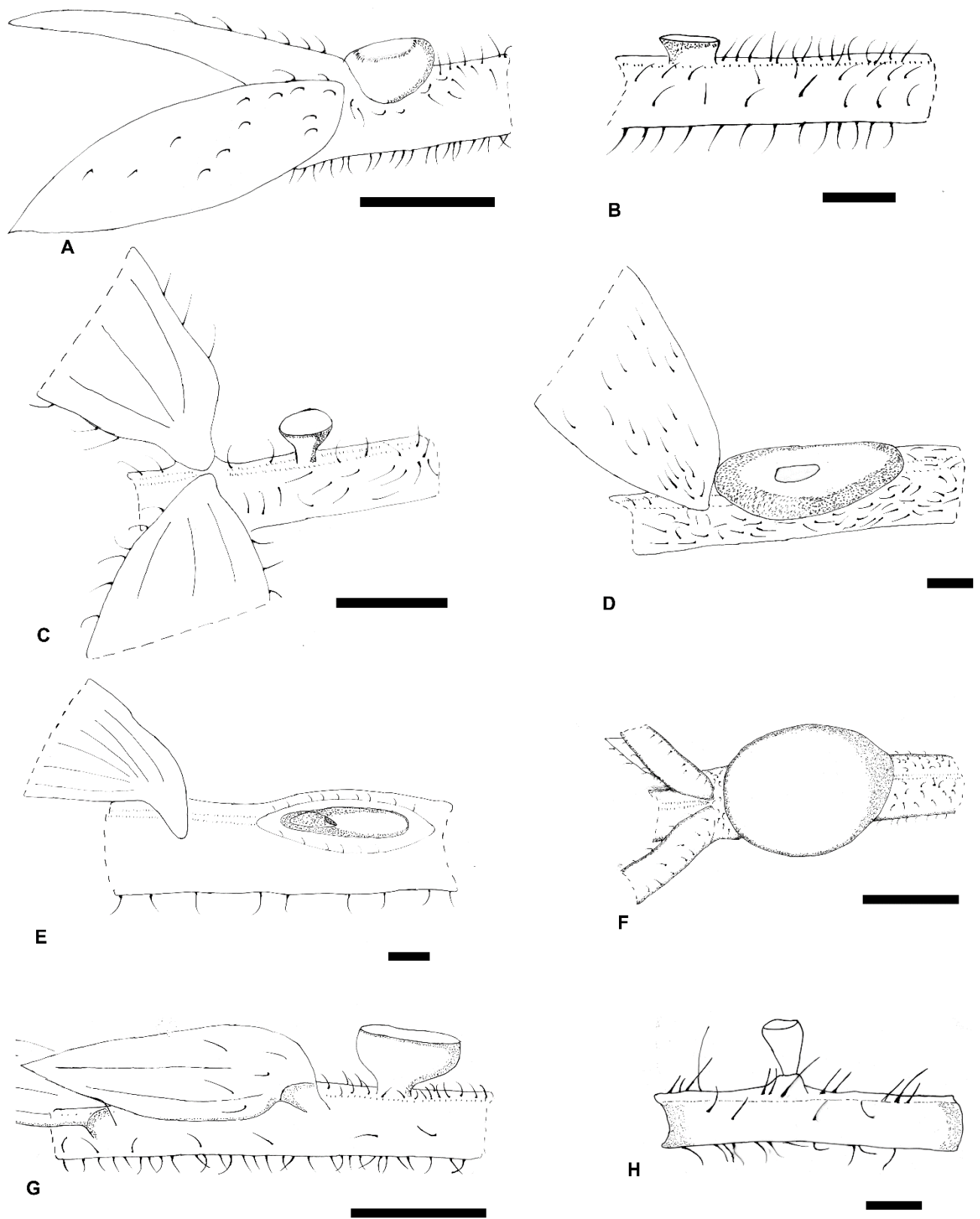


Figure 5.2. Extrafloral nectaries of *Chamaecrista* species. Detailed caption on following page.

Figure 5.2. Extrafloral nectaries of *Chamaecrista* species. (A) *C. mimosoides*, sessile, circular or circular-elliptic. (B) *C. capensis* var. *capensis*, circular, sub-sessile or attached on small stalk. (C) *C. biensis*, circular, concave, sub-sessile or raised on small stalk. (D) *C. comosa* subsp. *capricornia*, elliptic, sessile, spreading over the petiole. (E) *C. comosa* subsp. *comosa*, sessile, slightly sunken in petiole. (F) *C. grandiglandulata*, large, sessile, elliptic, overlapping the sides of petiole. (G) *C. gordon-grayei* subsp. *longipedicellata*, sub-sessile to sessile, circular. (H) *C. falcata*, extrafloral nectaries, long stalked, concave on top. Vouchers: (A) *Burt & Hilliard 3215* (NU); (B) *Walker 119* (PRE); (C) *Phelan 1120* (PRE); (D) *Burger 292* (PRE); (E) *Arnold 792* (NU); (F) *Ward 1219* (NH); (G) *de Winter and Wiss 4423* (PRE); (H) *Ward 2439* (PRE). (Scales: A–I= 5 mm).



5.4 Taxonomy

5.4.1 Generic description

Chamaecrista (L.) Moench. *Meth. Pl. Bot. Marburg.*: 272 (1794); H.S. Irwin & Barneby, *Mem. New York Bot. Gard.* 35 (2): 664 (1982); Brummitt in *Fl. Zambesiaca* 3 (2): 121 (2007). Type: *C. nictatis*, lecto., designated by Pennell in *Bull. Torrey Bot. Club* 44: 365 (1917).

Annual or perennial herbs, up to 1.8 m high. **Stems** erect or semi-erect, simple or sub-simple, sometimes with a woody base; branched at or above ground level, glabrous or sub-glabrous, eglandular or rarely glandular (in *C. absus*), reddish to purplish on one side (in *C. plumosa*), often with short curved and/or long straight, patent greyish or whitish hairs. **Leaves** paripinnate, 7–150 × 3–25 mm, slightly tapering distally; rachis channelled or crested; stipules straight, or curved, often

narrowly triangular; extrafloral nectaries often present on petiole, sometimes between the pairs of leaflets (in *C. falcata*), sessile, sub-sessile or raised on distinct stalk, often brown or dark brown. **Leaflets** in numerous pairs, rarely 2 (in *C. absus*), oblong or obovate, linear, rarely falcate (in *C. falcata*), base often oblique, apex acuminate or mucronate, midrib sometimes excentric towards anticous margin, glabrous or subglabrate or with long or short scattered hairs, margins often ciliate. **Inflorescence** usually axillary or supra-axillary, often 1 to 3 flowered, sometimes up to 8-flowered; bracts and bracteoles resembling stipules; bracteoles 2, above the middle or towards the top of pedicels. **Pedicels** 3–30 mm long, rarely up to 45 mm long (in *C. capensis* and *C. falcata*), slightly longer at fruiting, often with short and long patent hairs. **Sepals** 5, ovate, often with spreading hairs. **Petals** 5, obovate. **Stamens** 9 or 10, rarely 5 (in *C. absus*). **Ovaries** densely covered with long or short curved hairs. **Pods** (15) 20–63 (90) × 3–8 mm, flattened, straight or slightly curved, often with appressed hairs. **Seeds** 2.5–5.0 × 1–3 mm, rhomboid or elliptic, flattened, brown, or light brown to blackish.

Thirteen species are found in southern Africa, two of which are described as new.

5.4.2 Key to the species of *Chamaecrista* in southern Africa

1a. Leaflets in two pairs; plants glandular; stamens 5.....**1. *C. absus***

1b. Leaflets in more than two pairs; plants eglandular; stamens 8 to 10:

2a. Leaf rachis crested, with an upright wing of tissue forming a ridge along the mid-line of the upper surface:

3a. Stems glabrous or with appressed curved or straight hairs, often purplish or reddish on one side (**12. *C. plumosa***):

4a. Prostrate and diffusely branched herb, multistemmed, forming spreading mat to 0.4 m in diameter; glabrous to glabrescent, or with appressed curved hairs; leaves 10–45 mm.....**12a. *C. plumosa* var. *plumosa***

4b. Erect herb to 1.8 m tall; often single-stemmed, stems unbranched or few branched in the upper half, glabrous or densely covered with greyish or yellow hairs; leaves 15–90 mm.....**12b. *C. plumosa* var. *erecta***

3b. Stems pubescent with short curved, appressed hairs, green or becoming blackish:

5a. Extrafloral nectaries large, 1–2 mm in diameter, overlapping the sides of the petiole.....**8. *C. grandiglandulata***

5b. Extrafloral nectaries small, 0.2–0.8 mm in diameter, not overlapping the sides of the petiole:

6a. Flowers bright yellow; extrafloral nectaries sessile, rounded; widely spread in eastern provinces of South Africa and Swaziland.....**10. *C. mimosoides***

6b. Flowers pale yellow; extrafloral nectaries sub-sessile (rarely sessile), restricted to Namibia and Zimbabwe, absent in South Africa (**7. *C. gordon-grayei***):

7a. Pedicels ≤ 10 mm long at flowering, ≤ 15 mm long at fruiting ...**7a. *C. gordon-grayei* subsp. *gordon-grayei***

7b. Pedicels ≥ 15 mm long at flowering, ≥ 15 mm long at fruiting ...**7b. *C. gordon-grayei* subsp. *longipedicellata***



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2b. Leaf rachis channelled along the upper surface:

8a. Extrafloral nectaries present on petiole and between leaflet pairs, raised on distinct stalk 1.0-1.5 mm long; leaflets falcate...**5. *C. falcata***


8b. Extrafloral nectaries present on petiole only, sessile, or sub-sessile, or raised on small stalk less than 1 mm long; leaflets linear, oblong, obovate or elliptic:


9a. Stipules narrowly falcate...**6. *C. falcinella***

9b. Stipules narrowly triangular:

10a. Flowers pale yellow; pedicels \leq 10 mm long.....**13. *C. stricta***

10b. Flowers bright yellow; pedicels \geq 10 mm long:

 11a. Extrafloral nectaries circular and concave, short stalked:

 12a Flowers generally small (to 10 mm long); inflorescence 1 or 2 flowered.....**2. *C. biensis***

12b. Flowers generally large (to 17 mm long); inflorescence 2 to 4 flowered (**3. *C. capensis***):

13a. Perennial herbs, to 0.3 m high; multi-stemmed, glabrous or covered with silky straight or curved greyish hairs...**3a. *C. capensis* var. *capensis***

13b. Perennial herbs, to 0.6 m high; usually single-stemmed and branching in the upper half, with straight or curved greyish or yellowish hairs...**3b. C. capensis var. flavescens**

11b. Extrafloral nectaries elliptic, sessile:

14a Leaflet apices mucronate; stamens 10; plants pubescent with short curved and/or long greyish spreading hairs:



15a. Plants annual; sepals lanceolate; leaflets 7- to 36-jugate...**11. C. parva**

15b. Plants perennial; sepals ovate; leaflets 18- to 48-jugate...**9. C. kirkii**

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14b. Leaflet apices rounded to obtuse; stamens 9; plants glabrous or if pubescent then with whitish to yellowish spreading hairs

(4. C. comosa):

16a. Extrafloral nectaries sunken in rachis channel; restricted to coastal regions of KwaZulu-Natal and Eastern Cape...**4a. C. comosa subsp. comosa.**

16b. Extrafloral nectaries not sunken in rachis channel, spreading over the petiole; not occurring in coastal regions, distributed in northern and drier parts of South Africa (Limpopo, North West, Mpumalanga and Gauteng) to Swaziland and Zimbabwe...**4b. *C. comosa* subsp. *capriconia***

5.4.3 The species of *Chamaecrista* in southern Africa

1. ***Chamaecrista absus*** (L.) H.S. Irwin & Barneby, Mem. New York Bot. Gard. 35 (2): 664 (1982); Brummitt in Fl. Zambesiaca 3 (2): 125 (2007). *Cassia absus* L., Sp. Pl. 1: 376 (1753); Oliv. in F. T. A. 2: 297 (1871); Steyaert in F.C.B. 3: 507 (1952); Brenan in F.T.E.A Legum.-Caesalp.: 81 (1967); Gordon-Gray in F.S.A. 16(2): 95 (1977); Brummitt in Fl. Zambesiaca 3(2): (2007). Type: India, Aegyptio, Linn. No. 528.4 (LINN, lecto.–designated by De Wit (1956)).

Annual herb to 0.55 m tall, whole plant glandular. **Stems** erect, slightly woody at base, densely covered with fine, short, curved and straight scattered hairs. **Leaves** paripinnate, 15–55 (70) × 10–45 (95) mm; stipules linear, 2–4 × 0.5 mm, covered with long soft hairs; extrafloral nectaries on the petiole lacking; rachis faintly channelled, with linear extrafloral nectaries between each pair of leaflets, ± 1 mm long. **Leaflets** 2-jugate, 7–45 × 3–35 mm, with black pitted dots on lamina, elliptic to obovate, base oblique, rounded at apex, uppermost pair usually the largest; margin ciliate. **Inflorescence** terminal, 1–8 flowered; flowers 4–6 × 3–4 mm; bracts ± 3 × 1.0–1.5

mm, ovate, cordate at base, apex acuminate; bracteoles 2, glandular. **Pedicels** with long straight hairs, at flowering 3–5 mm long, at fruiting 5–8 mm long. **Sepals** 5, oblanceolate, 4–6 × 1–2 mm, glandular on the outside. **Petals** 5, broadly obovate, ± 6 × 1.5–2.0 mm, yellow or reddish. **Stamens** 5, straight or slightly curved, anthers in two series, 1(2) small 1.5–2.0 mm long, 4(3) large 3 mm long, filaments ± 2 mm long. **Ovary** ± 5 mm densely covered with white hairs; style glabrous, 2 mm long, slightly curved. **Pods** oblong, 30–50 × 6–8 mm, glandular, flattened, straight to slightly curved, with scattered straight hairs. **Seeds** 3–5 × 3–4 mm, elliptic, sub-rhomboid, flattened, shiny, black or brown.

Diagnostic characters: *Chamaecrista absus* is unique among the species of *Chamaecrista*, distinguished by its glandular stems, two pairs of leaflets, the absence of extrafloral nectaries on the petiole and 5 stamens. The flowers are small with yellow or reddish petals. Usually 5 or up to 6 stamens have been recorded for this species (e.g. Brummitt et al., 2007), whereas other *Chamaecrista* species in southern Africa have 8 to 10 stamens. The pods are glandular, with scattered hairs.

Distribution and ecology: *Chamaecrista absus* is widespread in tropical Africa, South Asia and Australia (Brummitt et al., 2007). In southern Africa, *C. absus* is widespread and common from Namutoni in Namibia, extending to Botswana (Maun and Gaborone), across to Zimbabwe. The species is also common in South Africa, largely distributed in the Limpopo Province, along Mpumalanga and extending to Rustenburg in the North West Province (Fig. 5.3). It grows in open grassland or forest areas, often on rocky or sandy soil at elevations below 1550 m. Flowering from December to July.

Additional specimens examined

Namibia. **1714 (Ruacana Falls)**: ca. 60 km NW of Oshakati on the Ruacana Road (–DA), Mar 1975, *Vahrmeijer 2613* (PRE); Etoto hill, on S slope (–CA), 7 Mar 2003, *Schubert SS60* (WIND). **1717 (Omboloko)**: communal land, E of Plot 1 outside Agriculture extension office fence (–CA), 6 Apr 2000, *TPS798* (WIND). **1718 (Nkurenkuru)**: Calcrete Road between Mpambi and Mpungu Vlei, ca 10 km S of Okavango river (–AD), 7 Feb 1999, *Burke 994* (WIND). **1720 (Sambo)**: Ndonga camp at junction of Omuramba Omatako and Okavango river (–CD), 12 Dec 1956, *De Winter 4617* (WIND). **1723 (Singalamwe)**: near Kwando river, at turn off to Bum Hill campsite (–CD), 5 Mar 2006, *Horn HOR2/384* (WIND). **1724 (Katima Mulilo)**: Forestry Reserve, W of Katima Mulilo (–AD), 12 Feb 1988, *Maggs 231* (WIND); ca. 11.26 km S of Katima Mulilo on road to Ngoma (–DC), 22 Feb 1958, *Killiok & Leistner 3022* (WIND); Bukana to Lusikili (–DA), 1 Mar 1982, *Muller 1837* (WIND). **1816 (Namutoni)**: next to main road Oshivelo/Ondwangwa (–BD), 26 Mar 1999, *Mannheimer 687* (PRE). **1819 (Karakuwisa)**: along road next to Mile 46 Research Station at Observatory (–AD), 8 Feb 2002, *Strohbach BS5330* (WIND). **1916 (Gobaub)**: near Merwe Farm, ca. 20 km W of Otavi on road to Outjo (–DB), 9 Mar 1997, *Germishuizen 9529* (PRE). **1918 (Grootfontein)**: Farm Olievenhof, GR 215 Palmenflache (–CB), 26 Apr 1963, *Giess, Volk & Bleisssner 6513* (WIND). **1920 (Tsumkwe)**: ca. 8 km E of the Dorsland Boom (–BC), 21 Jan 1987, *Hines 898* (PRE). **2016 (Otjiwatongo)**: Farm Jan Helpman (–BB), 29 Apr 2001, *Strohbach 931* (WIND); Farm Okonjima (–DC), 26 Mar 2004, *Hoffman LH1102* (WIND). **2017 (Waterberg)**: Tjozondjupa (–AB), 20 Jun 2008, *Lushetile 170* (WIND). **2018 (Gunib)**: Omuramba Omatako (–DA), 9 May 2001, *Uiras MU312* (WIND). **2118 (Steinhausen)**: Farm Kalidona OK 277 (–AC), 23 Apr 1961,

Gaerdes 4 (WIND). **2219 (Eiseb)**: next to road Elandsbult-Babi Babi area (–BD), 19 Mar 1999, *Theron 4a* (WIND).

Botswana. **1922 (Nukaneng)**: Xamatshaa Island (–BB), 18 Feb 1975, *Smith 1263* (PRE). **1923 (Maun)**: on road from Moremi to Chobe (–BC), 29 Jan 1994, *Roodt 39* (PRE); Island, Boro Floodplain (–CA), 22 Feb 1974, *Biggs M512* (PRE). **2425 (Gaborone)**: Polokwe Hills (–CD), 12 Apr 1995, *Acocks 43* (PRE); river bank north west of Runtu (–DA), 4 Mar 1956, *Marais 1128* (PRE). **2426 (Mochudi)**: Bechuanaland Protectorate (–AC), Apr 1914, *Harbor 6584* (PRE).

Zimbabwe. **1731 (Harare)**: Makabuzi hillside (–AB), 19 Jan 1963, *Moll 520* (NU).

South Africa. LIMPOPO. **2229 (Waterpoort)**: Greefswaldt (–AB), 8 Jan 1974, *Theron 2886* (PRE); Breslau farm 3.2 km, near Pontdrift (–AC), 7 May 2000, *Straub 788* (PRE); Matolege E of Groot Kop (–BB), 20 Jan 2006, *Van der Walt 273* (PRE). **2327 (Ellisras)**: Ellington Ranch, Toulon farm (–DA), 25 Mar 1990, *Schmidt 300* (PRE); 33 km S of Ellisras on road to Thabazimbi (–DC), 1 May 2004, *Meyer 4387* (PRE). **2428 (Nylstroom)**: Farm Doornkraal (–AA), 5 Feb 2004, *Sebothoma 507* (PRE); 15 km from Vaalwater on road to Melkriver side (–AB), 08 Mar 1978, *Germishuizen 706* (PRE); 9 km NE of Vaalwater on road to Malkrivier (–AC), 5 Mar 1985, *Welman 518* (PRE); Nylstroom Sterkriver Dam Nature Reserve (–BC), 10 Feb 1972, *Jacobsen 2213* (PRE); Vaalwater, Mooimeisiesfontein farm (–BD), 23 Mar 1991, *Glen 2607* (PRE).

NORTH WEST: **2527 (Rustenburg)**: Beestekraal Game Reserve (PPC property) ca. 40 km N of Brits (–BA), 28 May 1989, *Barker 625* (PRE).

MPUMALANGA: **2431 (Acornhoek)**: Kruger National Park (–BC), Mar 1975, *Gertenbach 5051* (PRE). **2531 (Komatipoort)**: Kruger National Park (–AB), 11 Feb 1953, *Van der Schijff 2080* (PRE); ca. 8 km East of Malalane on Komatipoort road (–

AC), 20 Jan 1966, *Buit 3618* (NU); 25.7 km South of Skukuza on Malalane road (–AC), 7 Feb 1949, *Codd & De Winter 5110* (PRE); Kaapmuiden (Cape Mouth) 2 km from Kudu Lodge on road to Komatipoort (–CB), 11 Mar 1989, *Germishuizen 5127* (PRE).

KWAZULU-NATAL. **2731 (Louwsburg)**: Nongoma, Bululwane (–DB), 25 Apr 1975, *Rensburg 28* (NU).

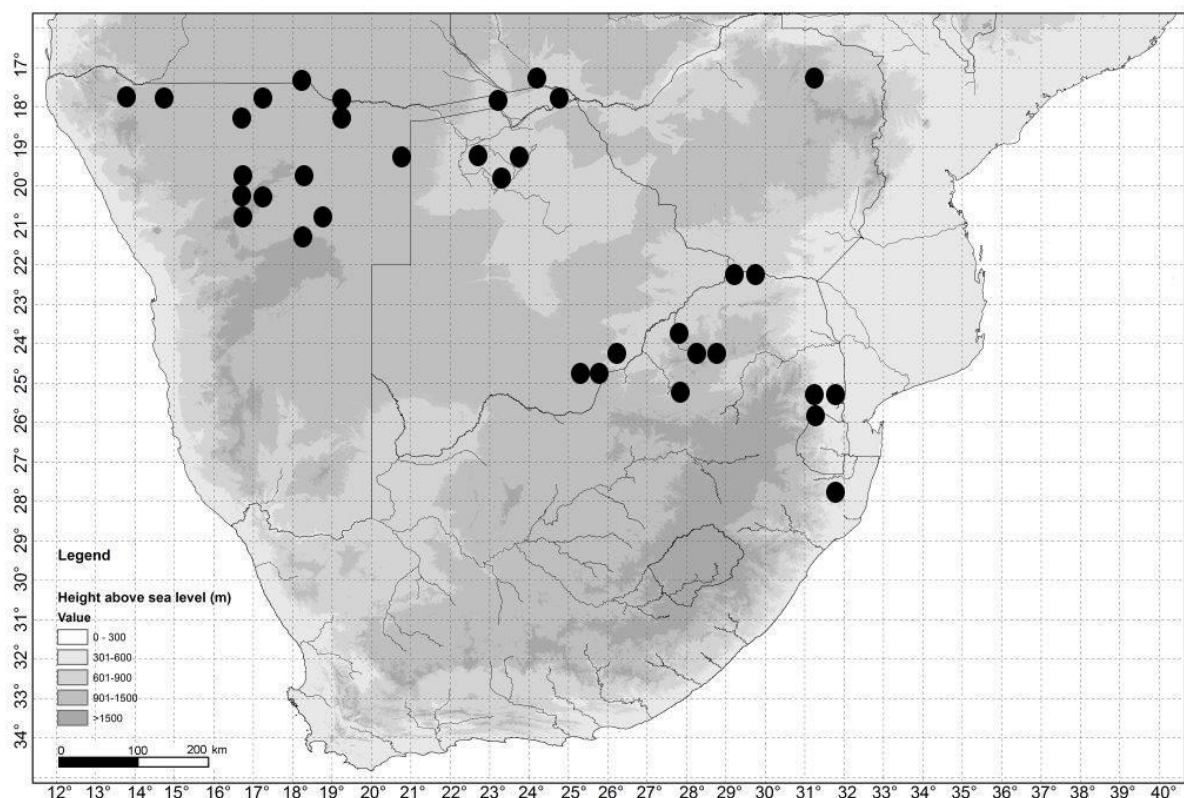


Figure 5.3. Known distribution of *Chamaecrista absus* in southern Africa.

2. *Chamaecrista biensis* (Steyaert) Lock Kew Bull. 43 (2): 335 (1988); Brummitt in Fl. Zambesiaca 3 (2): 130 (2007). *Cassia katangensis* (Ghesq.) Steyaert var. *biensis* Steyaert., Bull. Jard. Bot. État 20: 260 (1950). *Cassia biensis* (Steyaert) Mendonça & Torre., Bol. Soc. Brot. Sér. 29 (2): 33 (1955); Scriber in F.S.W.A. 59: 11 (1956);

Gordon-Gray in F.S.A. 16 (2): 100 (1977). Type: Angola, Bie Province, Dec 1932, Gossweiler 9 (BR [BR08918918], holo.–image!).

Perennial herb, to 0.5 m tall. **Stems** producing multiple branches from a woody rootstock, prostrate or decumbent, pubescent, with small curved appressed hairs. **Leaves** paripinnate, 10–65 × 5–20 mm, oblong to linear oblong, tapering slightly distally; stipules straight, 5–10 mm long, base oblique, apex acuminate; rachis channelled; extrafloral nectaries on petiole, circular, concave, ± 0.3 × 0.2–0.5 mm, attached with short stalk. **Leaflets** 6–25 jugate, 5–10 × 1–2 mm, linear oblong, base oblique, apex apiculate, margin ciliate, midrib strongly excentric towards anticous margin. **Inflorescence** axillary, 1–2 flowered; flowers 5–10 × 4–6 mm, bract ± 3 mm long, base oblique, apex acuminate; bracteoles 2, glabrous, towards top of pedicels. **Pedicels** with short, straight or curved hairs, 15–20 mm at flowering, 20–25 mm at fruiting. **Sepals** 5, ovate, 4–8 × 2–3 mm, pubescent on the outer surface. **Petals** 5, obovate 7–10 × 3–5 mm, bright yellow. **Stamens** 10, straight or slightly curved, anthers vary in sizes, often in two (5 medium and 5 large) or three series (3 small, 4 medium and 3 large), 2–7 mm long, filaments very short, 1 mm long. **Ovary** 6–9 mm long, densely covered with white hairs, slightly curved or straight, glabrous. **Pods** 20–50 × 3–5 mm, flattened, straight or curved, with small curved suppressed hairs. **Seeds** 2.5–4.0 × 1–2 mm, rhomboid, flattened, brown to light brown.

Diagnostic characters: *Chamaecrista biensis* shares a low growth form and leaf structure with *C. capensis* (particularly *C. capensis* var. *capensis*). However, *C. biensis* can be distinguished by its extrafloral nectaries on the petiole attached with a very short stalk, ± 0.3 × 0.2–0.5 mm (Fig. 5.2C) (well developed in *C. capensis*); the strongly excentric leaflets midrib towards the anticous margin, and short pedicels 15–

25 mm (up to 45 mm in *C. capensis*) bearing small flowers 5–10 × 4–6 mm (large flowers in *C. capensis*).

Distribution and ecology: The species is widespread from the north-eastern parts of Namibia, extending to South Africa with a wide distribution in the North West Province through to the Northern Cape, Witbank in Mpumalanga and along the drier northern parts of the country across to Botswana (Fig. 5.4). *Chamaecrista biensis* grows on sandy or drained soil at elevations below 1538 m. Flowering from October to March.

Additional specimens examined

Namibia. **1817 (Tsitsabis):** along the main road from farm Sachsenheim to Oshivelo (–CA), 3 Apr 2002, *Uiras MU547* (PRE). **1918 (Grootfontein):** Taranaki, 80 km from Grootfontein on road to Rundu (–BA), 5 Mar 1995, *Germishuizen 7510* (PRE); on road to Sonap Research Station, 4 km from Taranaki farm (–BB), 6 Mar 1995, *Germishuizen 7617* (PRE). **1919 (Kanovlei):** on road to Tsumkwe, 50 km NE of Grootfontein (–AC), 7 Mar 1995, *Germishuizen 7643* (PRE). **1920 (Tsumkwe):** southern Bushmanland, Revele BL 3.2 km W of Kremetartkop (–DD), 26 Feb 1986, *Hines 578* (PRE). **2017 (Waterburg):** Waterburg (–AA), 21 Dec 1970, *Rutherford A12* (PRE). **2116 (Okahandja):** Thorn tree farm 80 km from Okahandja on road Otjiwarongo (–BD), 6 Mar 1983, *Germishuizen 2596* (PRE). **2118 (Steinhausen):** Hennopsrus farm, on R16 road to Steinhausen (–BB), 5 Mar 1997, *Germishuizen 9360* (PRE); Kaokoveld (–BD), Oct 1972, *Giess 9781* (PRE). **2217 (Windhoek):** Windhoek (–CA), 1 Feb 1976, *Giess 13927* (PRE). **2218 (Omaheke):** Omaheke, road D1793, 21 km N of junction with D1792 (–CB), 22 Apr 1998, *Kolberg HK 915* (PRE); Hennopsrus Farm, on R16 road to Steinhausen (–BB), 5 Mar 1997, *Germishuizen 9360* (PRE). **2219 (Sandfontein):** Sandfontein (–CC), 21 Feb 1955, *De Winter 2443* (PRE); 5 km

from turn off on road to Rietfontein from Buitepos/Gobabis road (–BC), 6 Mar 1997, *Germishuizen 9493* (PRE).

Botswana. **1824 (Kachikau)**: 1.75 km South of the Seronga/Savuti track junction near the Sandridge gap (–CC), 21 Jan 1979, *Smith 2631* (PRE). **2220 (Kalkfontein)**: 6 km North of Okwa Valley along the track between Ncojane and Mamuno (–AC), 31 May 1905, *Skarpe S-448* (PRE). **2326 (Kgatleng)**: Masana Ranch (–CD), 10 Nov 1978, *Hansen 3545* (PRE). **2324 (Mahalapye)**: Dinojane to Salajwe road on sand (–DD), 10 Dec 1987, *Barnard 409* (PRE). **2325 (Lephepe)**: central Kalahari, Dinojane (–BC), 12 Dec 1986, *Barnard 218* (PRE).

South Africa. LIMPOPO: **2327 (Ellisras)**: Njala Nature Reserve (–DA), 5 Feb 1994, *Swartz PPS 94-22* (PRE). **2329 (Pietersburg) [Polokwane]**: Pietersburg [Polokwane] (–BB), Mar 1919, *Breijer 19556* (PRE). **2429 (Zebediela)**: Sunningdale Private Nature Reserve (–AC), 3 Jan 1970, *Hofmeyer 158* (PRE).

NORTH WEST: **2526 (Zeerust)**: Zeerust (–CA), Oct 1972, *Leendertz 11303* (PRE); Zeerust (–CA), Jan 1928, *Thode 1402* (PRE). **2527 (Rustenburg)**: Saulspoort, Kwa-Ramoga in kloof on side of Mountain (–AA), 28 Nov 1977, *Germishuizen 00486 (20032)* (PRE); Klipvoordam (–BB), 8 Jan 1978, *Peters, Gericke and Burelli 3536* (PRE). **2624 (Morokweng)**: ca. 12 km N of Stella, on road to Papiessvlakte (–BD), 3 Mar 1998, *Smook 10067* (PRE). **2626 (Klerksdorp)**: *Witstinkhoutboom* (–AB), 28 Jan 1926, *Liebenberg 26* (PRE). **2724 (Taung)**: Zoet Vley (–AA), 10 Nov 1988, *Speedy 208* (PRE); near Vryburg, Farm Palmyra, 97 km northwest of Vryburg (–CA), 5 Feb 1948, *Rodin 3499* (PRE); Andalusia (–DD), 7 Jan 1941, *Herre 60661* (PRE). **2725 (Bloemhof)**: Leeuwfontein, 10 km W of Wolmaransstad (–BB), 17 Dec 1974, *Van Wyk 742* (PRE).

GAUTENG: **2528 (Pretoria)**: Bultfontein Verena (–BD), 27 Dec 1972, *Grobbelaar 1679* (PRE); Christianville, Springbokvlakte road, NW of Montana Secondary School (–CA), 6 Feb 2005, *Bester and Archer 5645* (PRE); Arcadia (–CA), 1926 Jan, *Smith 2089* (PRE); Verwoerdburg, De Hoeve Farm (–CC), 1 Feb 1776, *Victoria 12* (NU); Farm Annoda, 56 km N East of Pretoria (–DA), 20 Oct 2005, *Meyer 4542* (PRE).

MPUMALANGA: **2431 (Acornhoek)**: beyond Blyde River Nature Reserve camp (–CA), 21 Jan 1968, *Hilliard 6031* (NU). **2529 (Witbank)**: Loskopdam-Donkerhoek (–CA), 11 Feb 1968, *Theron 1673* (PRE). **2630 (Carolina)**: Nooitgedach (–CD), 31 Dec 1926, *Henrici 1388* (PRE).

FREE STATE: **2727 (Kroonstad)**: Klipspruit (–CA), Feb 1928, *Pont 294* (PRE); Klipspruit (–CA), Jan 1928, *Pont 352* (PRE). **2728 (Frankfort)**: 6 km from Reitz on the road to Rietpan (–CD), 25 Jan 1983, *Retief 888* (PRE). **2826 (Brandfort)**: Glen (–CD), Mar 1926, *Glen School of Agriculture 3449* (PRE).

NORTHERN CAPE: **2723 (Kuruman)**: 11.3 km from Kuruman on road to Hotazel (–AD), without date, *Brenda 602* (PRE). **2824 (Kimberly)**: Barkly West, Panplaas (near Boetsap) (–AB), 20 Feb 1974, *Hanekom 2233* (PRE); Rooipoort NW corner of Rooipoort farm (–CA), 19 Feb 1991, *Phelan 1120* (PRE); Barkley West, Vaalbos National Park (–CB), 23 Feb 1994, *Zietsman 2365* (PRE).

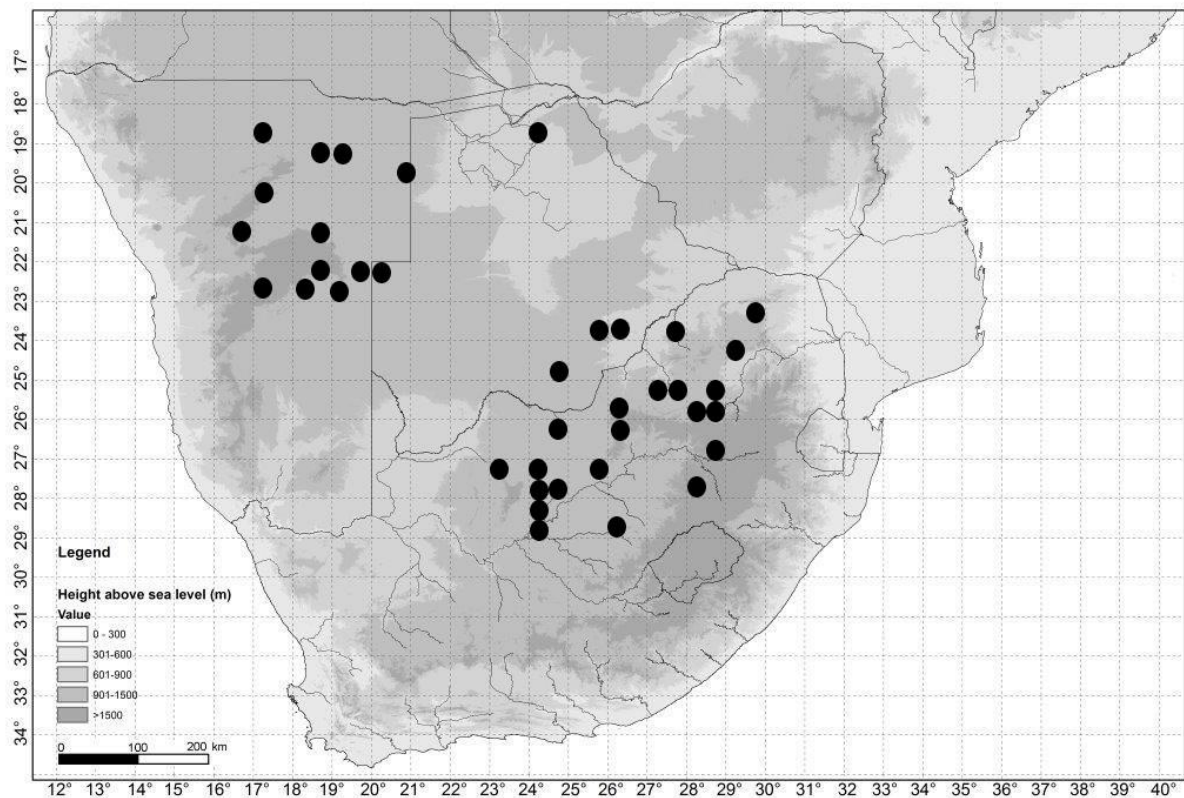


Figure 5.4. Known distribution of *Chamaecrista biensis* in southern Africa.

3. *Chamaecrista capensis* (Thunb.) E. Mey., *Comm. Pl. Afr. Austr.* 1: 158 (1836); Brummitt in *Fl. Zambesiaca* 3(2): 131 (2007). *Cassia capensis* Thunb., *Prodr. Pl. Cap.* 1: 79 (1794); Thunb in *Fl. Cap. ed. Schult.* 388 (1823); Vogel in *Syn. Gen. Cassiae* 64 (1837); Steyaert in *Bull. Jard. Bot. Brux.* 20: 250 (1950); Gordon-Gray in *F.S.A.* 16 (2): 98 (1977). Type: South Africa, Eastern Cape, Stutterheim (3227), between Loerie and Sundays (Sontags) River [Kunukama River] (–AD), *Thunberg s.n.* (UPS, holo.).

Perennial herb, to 0.6 m high. **Stems** prostrate, erect to semi-erect, single or multi-stemmed, arising from a woody rootstock, often branched in the upper half, glabrescent or covered with short and long greyish, or yellow hairs. **Leaves** paripinnate, 20–50 × 10–25 mm, linear or linear oblong, glabrous or with greyish hairs, slightly tapering distally; stipules, up to 14 mm, base oblique, apex acuminate,

narrowly to broadly triangular, surface sub-glabrous or with short and long patent hairs; extrafloral nectaries towards the top of petioles, circular, concave, sub-sessile or attached with short stalk, sometimes lacking; rachis channelled. **Leaflets** 5–24 jugate, 2–10 × 1–3 mm, linear to linear oblong, base rounded to oblique, apex mucronate, margin with long hairs. **Inflorescence** axillary or supra axillary; flowers, 10–17 × 5–15 mm, (1)2–4 flowered; bract 2–4 mm long, base oblique, apex acuminate; bracteoles 2, glabrous, up to 4 mm long, towards top of pedicels. **Pedicels** with short curved and long patent hair, at flowering 18–40 mm, at fruiting, 10–45 mm long. **Sepals** 5, ovate, 6–10 × 2–4 mm, with short and long spreading hairs. **Petals** 5, bright yellow, 9–17 × 3–10 mm, obovate. **Stamens** 10, straight or slightly curved, anthers in two series, 5 small 2–4 mm long, 5 large 6–8 mm long, filaments very short, 1 mm long. **Ovary** up to 7 mm long, slightly curved, glabrous. **Pods** straight or slightly curved, (20) 30–50 × 3–5 mm, flattened, with long or short greyish hairs, densely covered with long hairs when pods are young. **Seeds** ± 4 × 2 mm, rhomboid, flattened, brownish to blackish.

Diagnostic characters: *Chamaecrista capensis* shares long pedicels with *C. falcata*, but is distinguished from that species by its small, circular extrafloral nectaries that are sub-sessile or attached to a small stalk (Fig. 5.2B) (long stalked in *C. falcata*), linear to linear oblong leaflets (falcate in *C. falcata*), multiple and narrow leaflets (fewer and wider leaflets in *C. falcata*) and large flowers (10–17 × 5–15 mm in *C. capensis* vs 7–10 × 6–9 mm in *C. falcata*).

Two varieties are recognised:

3a. *Chamaecrista capensis* (Thunb.) E. Mey. var. *capensis*, Gordon-Gray in F.S.A. 16 (2): 98 (1977).

Perennial herb to 0.3 m long. **Stems** prostrate or decumbent, multiple stemmed, with short appressed or long scattered greyish hairs. Leaves with circular or concave, extrafloral nectaries raised on small stalk. **Leaflets** 5–22 jugate. **Pedicels** (15)20–38 mm long.

Diagnostic characters: *Chamaecrista capensis* var. *capensis* has prostrate or decumbent stems, with appressed or short hairs, sometimes with a few long scattered hairs, and extrafloral nectaries that are raised on small stalk.

Distribution and ecology: *Chamaecrista capensis* var. *capensis* is widespread from Pomfret in North West, through Nkandla and Port Edward in KwaZulu-Natal to Peddie in the Eastern Cape extending to Pilgrim's Rest in Mpumalanga (Fig. 5.5). Grows in grassland in loamy soil, at elevations below 1600 m. Flowering from October–March.

Additional specimens examined

South Africa. NORTH WEST: **2523 (Pomfret)**: near Bathurst (–CB), 18 Nov 1928, *Hutchinson 1559* (PRE).

MPUMALANGA: **2430 (Pilgrims Rest)**: Blyde Nature Reserve (–DB), 7 Mar 2000, *Lotter 772* (PRE).

KWAZULU-NATAL: **2831 (Nkandla)**: Nkadla forest (–CA), 2 Jan 1964, *Hilliard 2649* (NU). **3130 (Port Edward)**: Umtamvuna Nature Reserve (–AA), 19 Mar 2018, *Musandiwa 19* (NBG); Mzamba Engonyama River (–AA), 08 Jan 1987, *Abbott 3445* (NH).

EASTERN CAPE: **3227 (Stutterheim)**: NE of Stutterheim (–BC), 17 Mar 1995, *Victor 922* (PRE). **3325 (Port Elizabeth)**: Steynsburg (–DC), 16 Feb 1909, *Paterson 479* (PRE); Port Elizabeth (–DC), 10 Jan 1949, *Theron 574* (PRE) **3326 (Makhanda)**: Boknesstrand, ca. 7 km SW of Kenton-on Sea (–DA), 11 Nov 1984, *Burrows 2503* (PRE). **3327 (Peddie)**: East London (–DC), Dec 1981, *Hilner 154* (PRE).

3b. *Chamaecrista capensis* var. *flavescens* E. Mey., *Comm. Pl. Afr. Austr.* 1: 158 (1836). *Cassia capensis* var. *flavescens* (E. Mey) Vogel, *Syn. Gen. Cassiae* 64 (1837); Gordon-Gray in *F.S.A.* 16 (2): 99 (1977). Type: South Africa, Transkei [Eastern Cape], between Gekau (Geua) and Bashee Rivers [Mbashe], *Drège s.n.* (B†?. holo.). Type not seen.

Cassia capensis var. *keiensis* Steyaert in *Bull. Jard. Bot. Brux.* 20: 251 (1950). Type: South Africa, Eastern Cape, King William's Town, Kei Road, *Dyer 1703* (K [K00417584], holo.–image!; PRE!; GRA–image!, iso.).

Perennial herb, to 0.6 m high. **Stems** prostrate, decumbent or erect, single or few stemmed, arising from woody rootstalk, branching on the upper half, with long, straight or curved greyish or yellow hairs. **Leaves** with circular extrafloral nectaries, attached with very small stalk, sometimes lacking. **Leaflets** 11–24 jugate. **Pedicels** 18–40 mm long.

Diagnostic characters: *Chamaecrista capensis* var. *flavescens* was established within *C. capensis*, which is distinguished from *C. capensis* var. *capensis* by erect stems that are branching in the upper half, with short or long patent hairs intermixed, greyish or yellow indumentum, and extrafloral nectaries that are raised of small stalk or sometimes lacking.

Distribution and ecology: *Chamaecrista capensis* var. *flavescens* is widespread in KwaZulu-Natal from Pietermaritzburg to Port Edward, extending to Lady Frere to Peddie in the Eastern Cape (Fig. 5.5). Grows in grassland in well drained sandy soil, at elevations below 1300 m. Flowering from October–March.

Additional specimens examined

KWAZULU-NATAL: **2930 (Pietermaritzburg):** 8 km from Richmond along Hela Hela Road (–CC), 23 Jan 1974, *Stirton 711* (NU); Camperdown (–DC), 12 Feb 1968, *Gordon-Gray 6145* (NU); *Pietermaritzburg* (–DC), 15 Feb 1973, *Strey 11105* (NU). **3030 (Port Shepstone):** Umzinto, Vernon Crookes Nature Reserve (–BC), 8 Feb 1984, *Balkwill & Cadman 1198* (NU); cliff above Otterburn halt (–DA), 22 Feb 1964, *Hilliard 2751* (NU). **3130 (Port Edward):** Umtamvuna Nature Reserve, Beacon Hill (–AA), 05 Feb 1984, *Abbott 1709* (NH).

EASTERN CAPE: **3127 (Lady Frere):** 25 km from Cala at turn off to Engcobo (–DB), 12 Jan 1997, *Sebothoma 29* (PRE). **3128 (Umtata):** Maclear commonage ca. 2 km NNE of Maclear (–AA), 12 Nov 1993, *Bester 1634* (PRE); Umtata aerodrome (–DA), 15 Feb 1976, *Cooper 180* (PRE); Umtata Waterfalls (–DB), 31 Dec 1920, *Schonland 3804* (PRE); Unitra Campus (–DB), 7 Nov 2001, *Nombekela 49* (NH). **3227 (Stutterheim):** ca. 19.3 km N of Stutterheim on road to Grahamstown (–AD), *Grobbelaar 639* (PRE); 3.2 km from Keiskama Hoek on road to Debenek (–CA), 18 Mar 1948, *Story 3369* (PRE). **3228 (Butterworth):** ca. 16 km before East London from Butterworth (–AC), Oct 1973, *Arnold 564* (NU); Kei mouth (–BC), Mar 1890, *Flanagan 54* (PRE). **3327 (Peddie):** East London (–BA), Dec 1926, *Smith 3757* (PRE); Komga (–DB), 4 Mar 1956, *Theron 1882* (PRE).

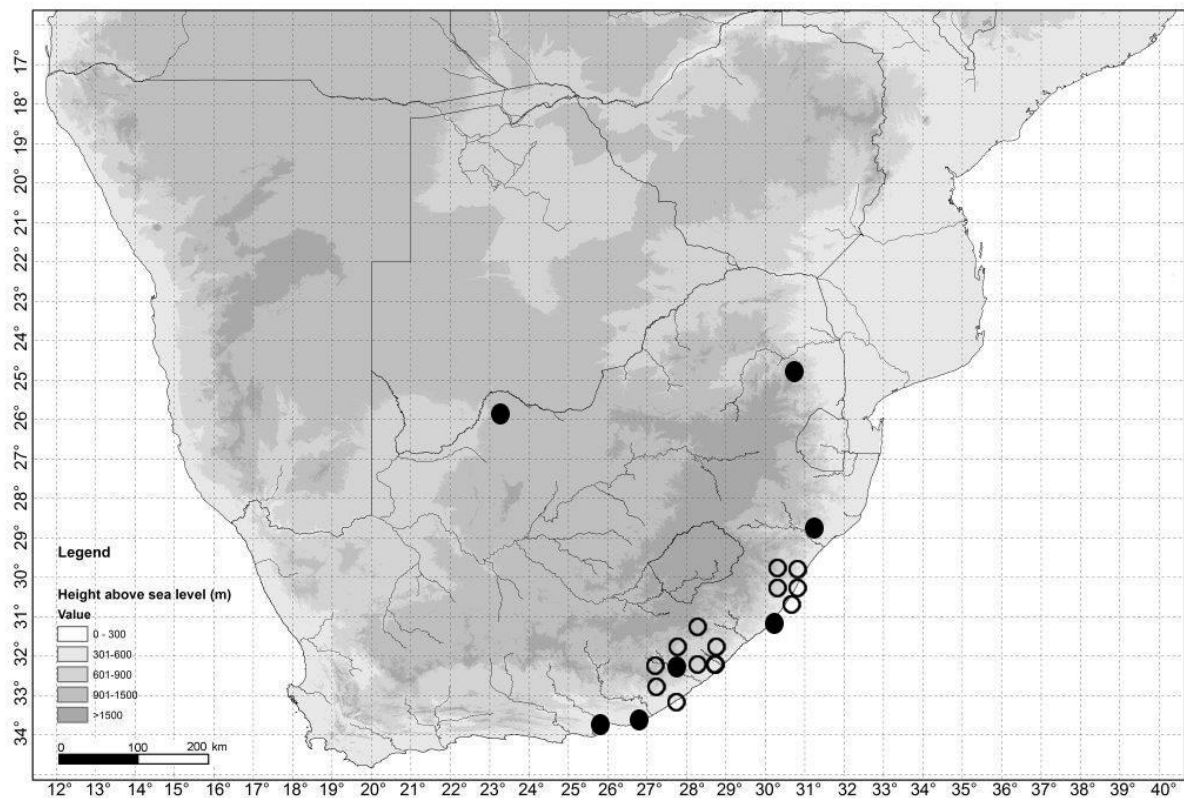


Figure 5.5. Distribution of *Chamaecrista capensis* var. *capensis* (●), and *Chamaecrista capensis* var. *flavescens* (○) in southern Africa.

4. *Chamaecrista comosa* E. Mey., *Comm. Pl. Afr. Austr.* 1: 160 (1836); Brummitt in *Fl. Zambesiaca* 3 (2): 142 (2007). *Cassia comosa* (E. Mey.) Vogel, *Syn. Gen. Cassiae* 65. (1837); Ghesquiere in *Bull. Jard. Bot.* 9: 153 (1932); Steyaert in *Bull. Jard. Bot. Brux.* 20: 251 (1950); Brenan in *F.T.E.A Legum.-Caesalp.*: 89 (1967); Gordon-Gray in *F.S.A.* 16(2): 96 (1977). Type: South Africa, Eastern Cape, between Umzimvubu River [Omsamwubo] and Umsikaba River [Omsamcaba], *Drège* (?B, holo.). Type not seen.

Perennial herb, to 0.6 m high. **Stems** erect, simple or sub-simple, glabrous to pubescent or densely covered with whitish to yellowish spreading hairs, arising from a woody rootstock. **Leaves** paripinnate, 20–150 × 10–25 mm, oblong to linear oblong, slightly tapering distally; stipules 5–15 × 1–4 mm, narrowly triangular, base oblique,

apex acuminate, margin ciliate; extrafloral nectaries at or below the top of petiole, 1.2–6.0 × 0.4–4.0 mm, sessile, elliptic, depressed in the middle, often with dark centre; rachis channelled, channel margin ciliate. **Leaflets** (5) 11–36 jugate, 4–17 × 2–5 mm, oblong, base oblique, apex rounded to obtuse, margin hairy. **Inflorescence** supra-axillary, 2–6 flowered; flowers 6–17 × 7–20 mm; bracts 3–4 (5) mm long, base oblique, apex acuminate; bracteoles 2, glabrous, towards top of pedicels. **Pedicels** glabrous or with spreading hairs, at flowering 10–26 mm long, at fruiting 15–27 mm long. **Sepals** 5, ovate, 6–12 × 3–5 mm, with spreading hairs on the outer surface. **Petals** 5, obovate, 7–15 × 4–8 mm, bright yellow. **Stamens** 9, straight or slightly curved, anthers in two series, 6 (5) medium ± 5 mm long, 3 (4) others often the largest, up to 9 mm long, filaments very short ± 1 mm long. **Ovary** ± 10 mm long, densely covered with white hairs, style glabrous, slightly curved. **Pods** 33–65 × 3–7 mm, spreading pubescent, straight, flattened. **Seeds** 3–5 × 1–3 mm, rhomboid, flattened, light brown to blackish, margin often with a thin line.

Diagnostic characters: *Chamaecrista comosa* is the most easily recognised species of *Chamaecrista* in southern Africa. It shares the large flowers with *C. capensis* but is readily distinguished by the long leaves up to 150 mm long (to 50 mm long in *C. capensis*) with leaflets 2–5 mm wide (1–3 mm wide in *C. capensis*) and large, sessile extrafloral nectaries, 1.2–6.0 × 0.4–4.0 mm, depressed in middle or sunken in rachis (circular, concave, sub-sessile or attached with short stalk in *C. capensis*).

Note: Meyer (1836) described *Chamaecrista comosa*, one of the most easily recognisable southern Africa species, by its large, sessile extrafloral nectaries, large leaves bearing broad leaflets and large flowers. In his treatment of the African and Asian species of *Chamaecrista* Steyaert (1950) recognised two varieties (viz.

Chamaecrista comosa var. *capriconia* and *Chamaecrista comosa* var. *lanata*). *Chamaecrista comosa* var. *lanata* was established based on its lanate indumentum and *C. comosa* var. *capriconia* for its smaller morphology. Gordon-Gray and Schorn (1975) later included *Chamaecrista comosa* var. *lanata* within *C. comosa* var. *comosa*, a decision which is supported by the present study. Following examination of available herbarium material, two varieties were recognised; one that occurs in coastal areas and one that occurs in drier areas. Based on field studies and examination of herbarium material *C. comosa* var. *capriconia* and *C. comosa* var. *comosa* need to be raised to subspecific level on the basis of different habitat preferences (*C. comosa* var. *comosa* is restricted to open grassland with high water table on granite soil or sand, and *C. comosa* var. *capriconia* on grassland in drier areas usually on sandy soil (Gordon-Gray and Schorn, 1975)), distribution patterns (i.e. *C. comosa* var. *comosa* is restricted to the coastal areas of KwaZulu-Natal and Eastern Cape, while *C. comosa* var. *capriconia* has a more northern distribution extending to Zimbabwe) and morphological differences (*C. comosa* var. *capriconia* is smaller in its general morphology).

Two subspecies are recognised:

4a. *Chamaecrista comosa* E. Mey. subsp. *comosa*. *Cassia comosa* var. *comosa* Steyaert in Bull. Jard. Bot. Brux. 20: 251 (1950); Gordon-Gray in F.S.A. 16 (2): 97 (1977).

Cassia comosa var. *lanata* Steyaert in Bull. Jard. Bot. Brux. 20: 252 (1950).
Type: Natal, Mtunzini, Myezaan Zulu Reserve, near Ngonyi, Wood 3855 (K [K000417586], holo.–image!, NH!., iso.).

Perennial herb, to 0.5 m tall. **Stems** simple, single stemmed, arising from woody rootstock. **Leaves** paripinnate, 30–150 × 10–20 mm; leaflets 6–36 jugate, 6–17 × 2–5 mm; stipules 8–14 mm; large, sessile extrafloral nectaries, sunken in rachis channel. **Pedicels** 10–25 mm long. **Pods** 44–65 × 4–7 mm.

Diagnostic characters: *Chamaecrista comosa* subsp. *comosa* is distinguished by large, sessile extrafloral nectaries that are sunken on the rachis (Fig. 5.2E), and larger general morphology (i.e. leaves 30–150 × 10–20 mm; leaflets 6–17 × 2–5 mm; stipules 8–14 mm, pedicels 10–25 mm long and pods 44–65 × 4–7 mm).

Distribution and ecology: *Chamaecrista comosa* subsp. *comosa* is widely distributed in the coastal regions of KwaZulu-Natal from Mtubatuba, through Port Edward, extending to Butterworth in the Eastern Cape (Fig. 5.6). It grows in open grassland with a high water table on granite soil or sand at altitude below 1000 m. Flowering from September–March.

Additional specimens examined

South Africa. KWAZULU-NATAL: **2732 (Ubombo):** Ubombo, St. Lucia Eastern (–DC), 21 Sep 1982, *Cawood 149* (NH). **2831 (Nkandla):** just outside Hlinza Forest (–CD), 10 Dec 1973, *Stirton 423* (NU). **2832 (Mtubatuba):** Mtubatuba, W of St. Lucia Estuary (–AA), 30 Nov 1959, *Ward 5* (NU); Dukuduku forest (–AD), 4 Oct 1961, *Hitchins 75* (NU); north coast Lake Nhlabane (–CB), 3 Jan 1992, *Ward 11595* (NU). **2931 (Stanger):** Ngoye forest (–BA), 21 Nov 1965, *Hilliard 3179* (NU). **3030 (Port Shepstone):** ca. 8 km from Port Edward on Izingolweni road (–CD), 1 Sep 1963, *Hilliard 1655* (NU). **3130 (Port Edward):** Port Edward (–AA), 25 Oct 1975, *Stirton 5641* (PRE).

EASTERN CAPE: **3228 (Butterworth)**: at turn off to Mzamba River mouth, 5 km S of Port Edward (–CA), Oct 1973, *Arnold 792* (NU).

4b. *Chamaecrista comosa* subsp. *capriconia* (Stayaert) Musandiwa & Boatwr., *stat. nov.* *Cassia comosa* var. *capriconia* Stayaert in Bull. Jard. Bot. Brux. 20: 252 (1950); Brenan in F.T.E.A Legum.-Caesalp.: 90 (1967); Gordon-Gray in F.S.A. 16(2): 97 (1977); Lock in Kew Bull 43 (2): 336 (1988). Type: Zaire, Katanga, Elizabethville, 15 May 1950, *Rogers 10184* (BR, [BR0000008917614], holo–image!).

Perennial herb, to 0.6 m tall. **Stems** simple or sub-simple, or branched from the woody rootstock. **Leaves** paripinnate, 30–90 × 10–20 mm; leaflets 5–34 jugate, 4–13 × 2–4 mm; stipules 5–10 mm; large, sessile extrafloral nectaries, often spreading over the sides of the petiole. **Pedicels** 10–20 mm long. **Pods** 33–55 × 4–5 mm.

Diagnostic characters: *Chamaecrista comosa* subsp. *capriconia* is distinguished by large, sessile extrafloral nectaries that are often spreading over the sides of the petiole (Fig. 5.2D), and smaller general morphology (i.e. leaves 30–90 × 10–20 mm; leaflets 4–13 × 2–4 mm; stipules 5–10 mm; large, pedicels 9–20 mm long and pods 33–55 × 4–5 mm).

Distribution and ecology: *Chamaecrista comosa* subsp. *capriconia* is an inland species, distributed in the drier, northern parts of South Africa, from Tzaneen through Rustenburg to Pretoria and Johannesburg in Gauteng Province, extending to Zimbabwe (Fig. 5.6). Grows in grasslands in dried areas, usually on sandy soil, at altitude below 1828.8 m. Flowering from Flowering from –February.

Additional specimens examined

South Africa. LIMPOPO: **2330 (Tzaneen)**: New Agatha Forest Reserve (–CC), 13 Nov 1918, *McCallum 548* (PRE). **2428 (Nylstroom)**: Tafelkop Private Nature Reserve at Geelhoutkop and Melkriver (–AB), 19 Feb 1972, *Coetzee 1035* (PRE); near Loubadspruit bridge on road between Nylstroom and Alma (–CA), without date, *Welman 506* (PRE); Vaalwater Farm Driefontein (–DA), without date, *Westfall 1531* (PRE);

NORTH WEST: **2527 (Rustenburg)**: Buffelskloof farm (–AA), *Germishuizen 597* (PRE); Rustenburg Kloof (–AB), 27 Dec 1949, *Steyn 895* (NBG).

GAUTENG: **2528 (Pretoria)**: Groenkloof (–CC), 15 Feb 1922, *Phillips s.n.* (PRE); Olievenhoutbos extension 13 (–CC), without date, *Masombuka 15* (PRE). Cornhill Ridge (–CC), 3 Feb 2009, *Ramalekana 18* (PRE). 31.1 km E of Pretoria (–CD), 14 Jan 1959, *Mauve s.n.* (NU). **2628 (Johannesburg)**: Melville Koppies (–CC), 27 Dec 1971, *Macnae s.n.* (NBG).

MPUMALANGA: **2430 (Pilgrims Rest)**: on road from Machadodorp to Sabie via Houtbosloop (–DB), 16 Jan 1969, *Hilliard 5954* (NU); Blyde River Nature Reserve (–DB), 21 Jan 1969, *Hilliard 6029* (NU). **2529 (Witbank)**: Farm Doornrug ca. 16 km West of Witbank next to the N4 (–CC), 18 Dec 2003, *Nkosi 74* (PRE). **2530 (Lydenburg)**: Witklip (–BD), without date, *Kluge 370* (PRE).

Swaziland (Eswatini). **2631 (Mbabane)**: ca. 20.9 km turnoff to Piggs Peak from Mbabane (–AB), 19 Jan 1966, *Hilliard 3561* (NU).

Zimbabwe. **1831 (Marondera)**: Nyanga village (–DA), 2 Jan 1975, *Nicholas 302* (NU).

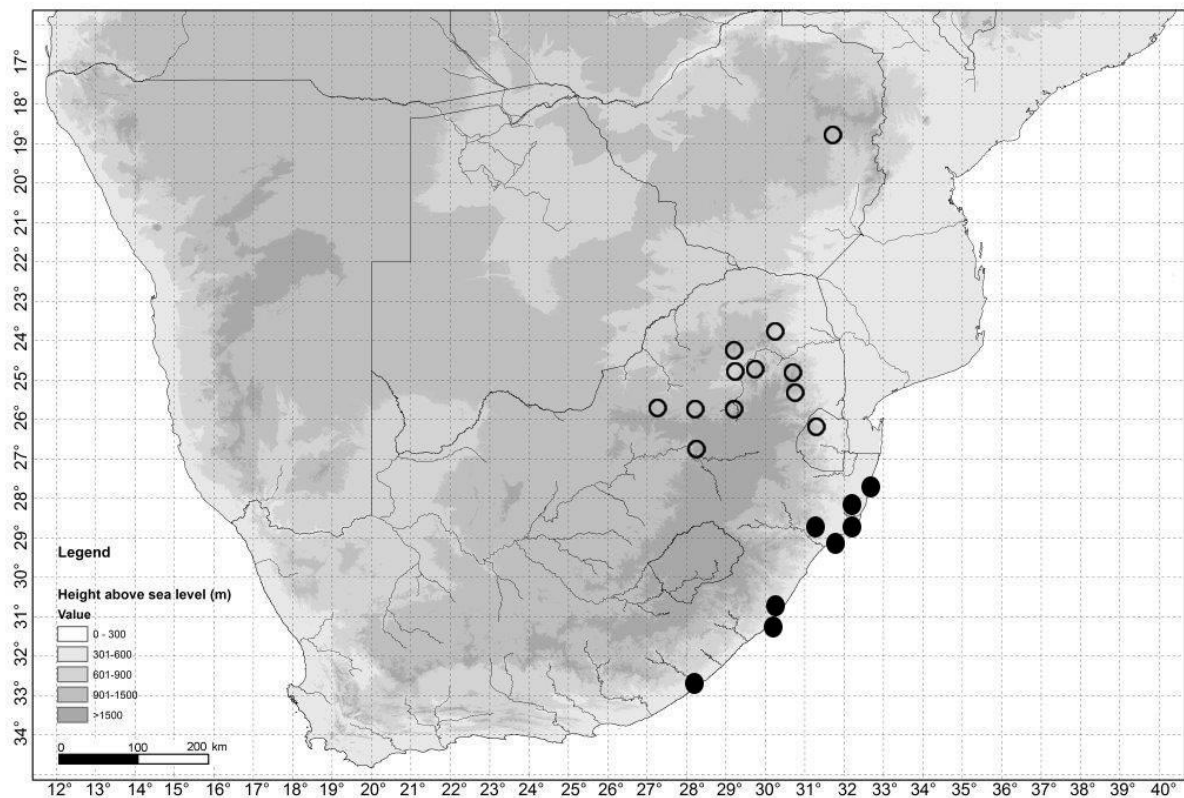


Figure 5.6. Known distribution of *Chamaecrista comosa* subsp. *comosa* (●), and *Chamaecrista comosa* subsp. *capriconia* (○) in southern Africa.

5. *Chamaecrista falcata* Musandiwa & Boatwr., **sp. nov.** Type: South Africa, KwaZulu-Natal Province, Hlabisa (2832): Hluhluwe-Imfolizi Park [Umfolozu Game Reserve], (–AA), 11 Nov 1954, *Ward 2439* (PRE!, holo., NU!, iso.).

Decumbent or prostrate herb to 0.3 m high. **Stems** multiple branching from woody rootstock, erect to semi-erect covered with short curved and long patent hairs. **Leaves** paripinnate, 10–50 × 10–25 mm, tapering distally; stipules, 3–9 mm long, triangular, base oblique, apex acuminate, margin with long hairs; rachis channelled; rachis extension 2–4 mm long; extrafloral nectaries in upper half of the petiole or slightly above the middle, sometimes on rachis of lower leaflets, with a distinct stalk ± 1 mm long, dark brown, 0.02–0.03 mm in diameter, concave at the top. **Leaflets** (2) 5–15–

jugate, 3–15 × 1.5–4.0 mm, falcate, base oblique, apex apiculate, top surface with long scattered hairs, bottom surface glabrous, margin with curved or straight hairs; midrib strongly excentric towards anticous margin. **Inflorescence** axillary, 1–2 flowered; flowers 7–10 × 6–9; bract hairy, base oblique, apex acuminate, ± 2 mm long; bracteoles 2, with long patent hairs, above the upper half of the pedicel or towards top of pedicels. **Pedicels** with long scattered straight or curved hairs, at flowering (20) 35–45 mm long, at fruiting (22) 30–55 mm long. **Sepals** 5, narrowly lanceolate, 6–8 mm long. **Petals** 5, sub-equal, 8–9 × 4–5 mm, obovate, bright yellow. **Stamens** 10, straight or slightly curved, anthers in three series, 5 small ± 3 mm long, 2 medium ± 4 mm long, slightly broader than the rest, 3 large ± 5 mm long, with very short filaments, ± 2 mm long. **Ovary** ± 10 mm long, densely hairy with straight or curved greyish hairs; style glabrous, narrow. **Pods** straight or slightly curved in the middle, 15–50 × 3–5 mm, flattened, with short curved hairs. Seeds not seen. Fig. 5.7.

Diagnostic characters: The long pedicels (35–45 mm long at flowering), widely spaced leaves and wide falcate leaflets (> 1.5 mm long) distinguish *Chamaecrista falcata* from all other *Chamaecrista* species in southern Africa. The species has previously been confused with *C. capensis* but is readily distinguished by the long stalked extrafloral nectaries (stalks ± 1 mm long) (Fig. 5.2H), fewer and wider leaflets and small flowers. It shares the long stalked extrafloral nectaries with *Chamaecrista grantii* (Oliv.) Standl., but differs in the falcate leaflets (oblong in *C. grantii*), the strongly excentric leaflet midribs (rarely strong in *C. grantii*) (Fig. 5.7B) and the smaller petals (8–9 × 4–5 mm in *C. falcata* vs 10–14 × 6–9 mm in *C. grantii*).

Distribution and ecology: The species is currently known only from the summer rainfall region of South Africa. It occurs in the Waterberg in Limpopo, and in the Hluhluwe-Umfolozi Park (formerly known as Hluhluwe-Imfolozi Game Reserve) in

KwaZulu-Natal in grasslands on rocky or sandy soil at elevations below 243.84 m (Fig. 5.8). Flowering from November to January.

Etymology: This species epithet refers to the falcate leaves with strongly excentric midribs.

Additional specimens examined

South Africa. LIMPOPO: **2428 (Nylstroom):** 7 miles (ca. 11 km) E of Magalakwin causeway (–BB), 10 Jan 1955, *Mogg 24430* (PRE).

KWAZULU-NATAL: **2832 (Mtubatuba):** Hluhluwe Game Reserve (–AA), 11 Nov 1954, *Ward 2439* (PRE, NU); Gunjaneni (–AB), 16 Nov 1955, *Ward 2709* (NU). **2732 (Ubombo):** 16 km from Jozini on road to Ingwavuma (–AC), 28 Nov 1978, *Germishuizen 01016* (PRE).



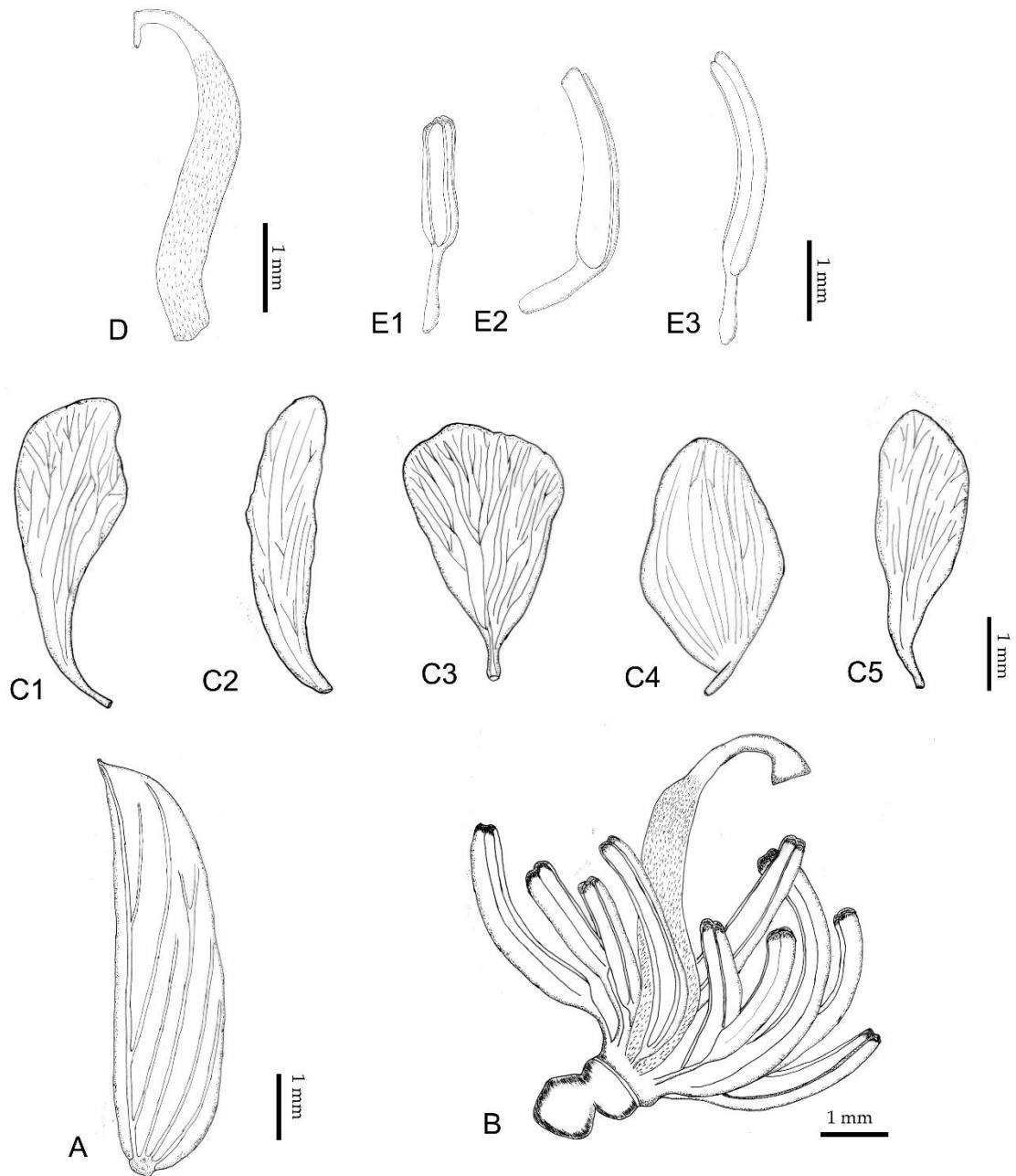


Figure 5.7. Morphology of *Chamaecrista falcata*. (A) falcate leaflet, midrib strongly excentric towards anticous margin, (B) staminal and ovary arrangement, (C1-C5) petals, (D) ovary, densely hairy and, (E1-E3) stamens, with anthers in three series.

Voucher: *Ward 2439* (PRE). Scale bars A–E3= 1.0 mm.

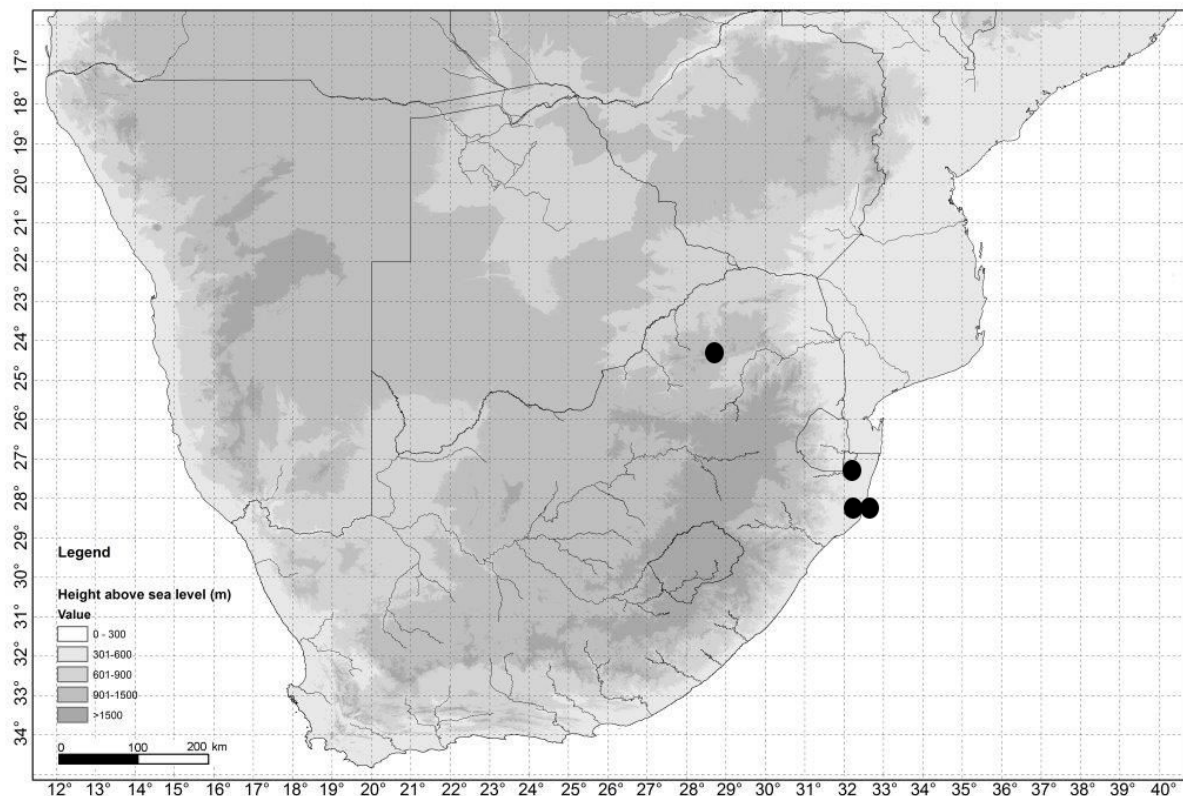


Figure 5.8. Known distribution of *Chamaecrista falcata* in southern Africa.

6. *Chamaecrista falcinella* (Oliv.) Lock in Kew Bull. 43: 336 (1988). *Cassia falcinella* Oliv. in F.T.A. 2: 282 (1871); Bak. f., Leg. Trop. Afr. 3: 641 (1930); Steyaert in F.T.B. 3: 520 (1952); Brenan in Kew Bull. 14: 178 (1960), in F.T.A. Legum. Caesalp.: 90 (1967). Type: Tanzania Bukoba district, Karagwe, *Grant 445* (K [K00232433], holo.–image!).

This species occurs widely from central tropical to southern Africa (Gordon-Gray, 1977). Three varieties are recognised, of which only one, *C. falcinella* var. *parviflora*, occurs in southern Africa. *Chamaecrista falcinella* var. *falcinella* is known from Kenya, Uganda, Tanzania and Democratic Republic of Congo, and *C. falcinella* var. *intermedia* (Brenan) Lock from Tanzania and Zambia (Brenan, 1967).

Chamaecrista falcinella* var. *parviflora (Steyaert) Lock in Kew. Bull. 43: 336 (1988); Brummitt in Fl. Zambesiaca 3 (2): 132 (2007). *Cassia flacinella* var. *parviflora* Steyaert in Bull. Jard. Bot. État 20: 251 (1950); in F.C.B. 3: 521 (1952); Brenan in Kew Bull. 14: 179 (1960); Brenan in F.T.E.A., Legum.-Caesalp.: 91 (1967); Gordon-Gray in F.S.A. 16 (2): 101 (1977). Type: Rwanda, Gabiro, *Becquet* 613 (BR [BR0000008955234] holo.–image!).

Annual herb to 0.6 m high. **Stems** erect, slightly woody at the base, with long spreading and short curved hairs. **Leaves** paripinnate, 25–55 × 7–15 mm, oblong, slightly tapering distally; stipules 9–14 mm long, narrowly falcate, base oblique, apex acuminate, margin ciliate; extrafloral nectaries, sessile to sub-sessile, elliptic to circular, 0.5–1.0 × 0.3–0.5 mm; rachis channelled, with long straight or curved hairs. **Leaflets** 10–19 jugate, 4–15 × 2.5–4.0 mm, slightly curved towards the tip, narrowly oblong to ovate, base asymmetric, apex mucronate, midrib close to the end of one margin, margin pubescent or ciliate. **Inflorescence** supra-axillary, 1–3 flowered; flowers 5–7 × 4–7 mm long; bract narrowly triangular, base oblique, apex acuminate; bracteoles 2, with long curved hairs, towards top of pedicels. **Pedicels** with long curved spreading hairs, at flowering 10–25 mm long. **Sepals** 5, ovate, 5–9 × 1.5–2.0 mm, covered with short hairs. **Petals** 5, obovate. 4–6 × 2–5 mm. **Stamens** 10, straight or slightly curved, anthers in two series, 5 small 1.5–2.0 mm long, 5 large 4–5 mm long, filaments very short 1 mm long. **Ovary** ± 5 mm long, densely covered with white hairs, style ± 1 mm long, glabrous, slightly curved. **Pods** 20–50 × 4–5 mm, sparsely covered with long soft hairs or glabrescent. **Seeds** 2–3 × 1–2 mm, rhomboid, flattened, with dark dots at the top.

Diagnostic characters: *Chamaecrista falcinella* var. *parviflora* is distinguished by the elliptic to circular, sessile to sub-sessile extrafloral nectaries. The species resembles *Chamaecrista biensis* in having small flowers and short pedicels, but can be distinguished by the narrowly falcate stipules (straight in *C. biensis*), and 10–19 leaflets (7–36 leaflets in *C. biensis*).

Distribution and ecology: *Chamaecrista falcinella* var. *parviflora* is widespread in Namibia from Karakuwisa to Grootfontein extending to Mata Mata in the Northern Cape Province (Fig. 5.9). *Chamaecrista falcinella* var. *parviflora* grows in grasslands in sandy or well-drained soil at elevations below 1000 m. Flowering is from February–April.

Additional specimens examined

Namibia. **1819 (Karkuwisa):** Cigarrete, NE of Karakuwisa, 8 Feb 1953, *Maguire 2437* (NBG). **1820 (Tarikora):** near pan, Shakambu (–AA), 05 Apr 2006, *Horn HOR2/357* (WIND); Ndonga Camp at junction of Omuramba Omatako and Okavango River, 12 Feb 1956, *De Winter & Marais 4619* (PRE). **1821 (Andara):** southern border of Mahango Game Reserve (–BC), 22 Feb 1988, *Hines 992* (WIND); **1917 (Atavi):** north of Kombat on Farm Gauss (–DA), 02 Mar 1995, *Germishuizen 7309* (PRE). **1918 (Grootfontein):** 19.3 km from Otovi Farm, 2 Feb 1965, *Hardy 2116* (PRE).

South Africa. NORTHERN CAPE. **(2520): (Mata Mata):** Kalahari Park [Kgalagadi Park] (–DB), Feb 1978, *Van der Walt 5775* (PRE).

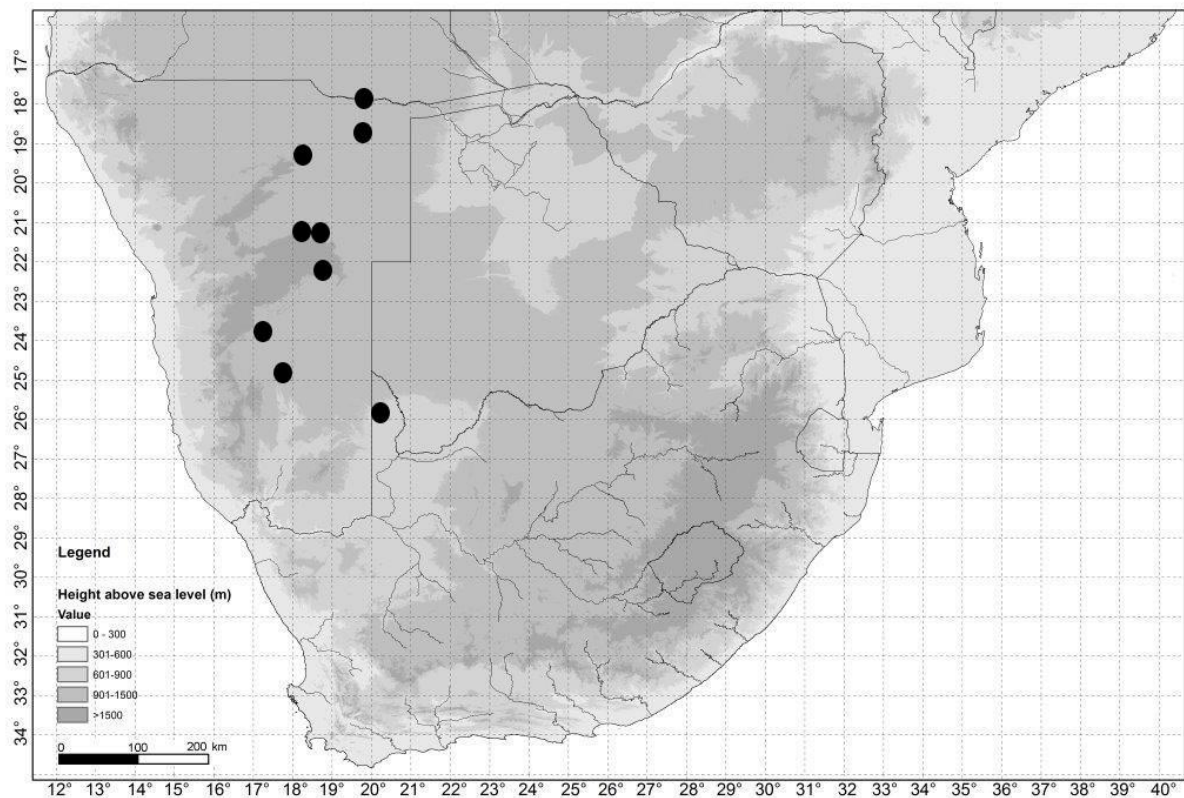


Figure 5.9. Known distribution of *Chamaecrista falcinella* var. *parviflora* in southern Africa.



7. *Chamaecrista gordon-grayei* Musandiwa & Boatwr., **sp. nov.** Type: Namibia, Andara (1821), Caprivi-Zipfel, Popa fälle [Popa Falls] Caprivi Zipfel [Caprivi Strip] (–BA), 9 Mar 1958, *Giess 2020* (WIND!, holo.).

Annual herb to 1.5 m high. **Stems** erect or semi erect stem, with curved hairs. **Leaves** paripinnate, 36 –104 × 2–4 mm, slightly tapering distally; stipules 6–11 mm long, triangular, base oblique, apex acuminate; extrafloral nectaries, sessile or raised on small stalk, ± 0.5 × 0.2–0.4 mm circular; rachis crested. **Leaflets** 20-65 jugate, 15–90 × 0.2–0.3 base oblique, apex acuminate, tapering distally; margin glabrous to ciliate. **Inflorescence** supra-axillary, 1–2 flowered; flowers 4–5 × 4–6; bract glabrous, base oblique, apex acuminate; bracteoles 2, glabrous, towards top of pedicels.

Pedicels with short hairs, at flowering 7–25 mm long, at fruiting 10–30 mm long. **Sepals** 5, narrowly lanceolate, 6–9 × 1–4 mm, with or without appressed hairs, on the outer surface. **Petals** 5, ovate, ± 6 × 2–6 mm; bright yellow. **Stamens** 9–10, slightly curved, anthers in three series, 2 (3) small, 2–3 mm long, 4 middle, ± 4 mm long, 3 (4) large, ± 5 mm long, with very short filament 1–2 mm long. **Ovary** ± 0.5 mm long, densely covered with greyish to whitish hairs, style glabrous, curved. **Pods** (30) 50–63 mm long, straight, or slightly curved with suppressed hairs. Seeds not seen. Fig. 5.10.

Diagnostic characters: *Chamaecrista gordon-grayei* shares the crested leaf rachis with *C. grandiglandulata* and *C. mimosoides*, but is distinguished from those species by the long leaves (36–104 mm long), with sub-sessile to sessile, circular extrafloral nectaries (large extrafloral nectaries that overlaps the sides of petiole in *C. grandiglandulata* and small, circular or circular-elliptic extrafloral nectaries in *C. mimosoides*) and bright yellow flowers.

Etymology: *Chamaecrista gordon-grayei* is named in honour of Kathleen Gordon-Gray (1918–2012) who showed remarkable passion for the southern African flora.

Two subspecies are recognised:

7a. *Chamaecrista gordon-grayei* subsp. *gordon-grayei*

Pedicels when flowering 7–10 mm long, at fruiting 10–15 mm long.

Diagnostic characters: *Chamaecrista gordon-grayei* subsp. *gordon-grayei* is recognised for its short pedicels (7–10 mm long).

Distribution and ecology: *Chamaecrista gordon-grayei* subsp. *gordon-grayei* is known from northern regions of Namibia from Tarikora to Andara, extending to

Harare in Zimbabwe (Fig. 5.11). Occurs in woodlands, on sandy soil at elevations below 1000 m. Flowering from January–February.

Additional specimens examined

Namibia. **1820 (Tarikora):** Kavango, Bogani old point in the shallow water of the Okavango River (–BB), 25 Apr 1977, *Muller and Giess 544* (WIND). **1823 (Siambisso):** Balelwa banks of Channel (–AB), 21 Feb 1988, *Maggs 665* (WIND).

Zimbabwe. **1731 (Harare):** Harare (–AB), without date, *A student s.n.* (NU).

7b. *Chamaecrista gordon-grayei* subsp. *longipedicellata* Musandiwa & Boatwr., **subsp. nov.** Type: Namibia, Andara, Omuramba Mahango between Bangani and Bechuanaland border, 25 Jan 1956, *De Winter and Wiss 4423* (PRE!, holo., WIND!, iso.).

Pedicels when flowering 15–30 mm long, at fruiting 15–30 cm long.

Diagnostic characters: *Chamaecrista gordon-grayei* subsp. *longipedicellata* is recognised by its long pedicels (15–20 mm long).

Distribution and ecology: *Chamaecrista gordon-grayei* subsp. *longipedicellata* is known from Chirundi in Namibia through Katima Mulilo to Tsumkwe, extending to Siambisso in Botswana and Harare in Zimbabwe. Apparently absent from South Africa but with one record in Harare, Zimbabwe (Fig. 5.11). Occurs in woodlands, on sandy soil at elevations below 1000 m. Flowering from January–February.

Etymology: *Chamaecrista gordon-grayei* subsp. *longipedicellata* is named for its long pedicels.

Additional specimens examined

Namibia. **1722 (Chirundi)**: Caprivi Game Park, on road to Angola border from Divundu-Kongola main road (–CC), 20 Jan 2005, *Hochobes MH1122* (WIND). **1724 (Katima Mulilo)**: near Ngoma in Terminalia (–DC), 10 Feb 1988, *Maggs 197* (WIND). **1819 (Karakuwisa)**: Mile 46, observatory, plot 89 (–AD), 18 Feb 2003, *Strohbach BS5621* (WIND); at Camp just S of Mutumpo Observatory (–DA), 06 Feb 2002, *Strohbach BS5275* (WIND). **1920 (Tsumkwe)**: ca. 48.2 km N of Gautscha Pan (–DA), 07 Feb 1958, *Story 6439* (WIND).

Botswana. **1823 (Siambisso)**: *Burkea/Baikiaea* woodland near Movombe village, 14 Feb 1983, *Smith 4034* (PRE).

Zimbabwe. **1731 (Harare)**: Cleveland Dam, 07 Feb 1976, *Daillecourt 25* (NU).

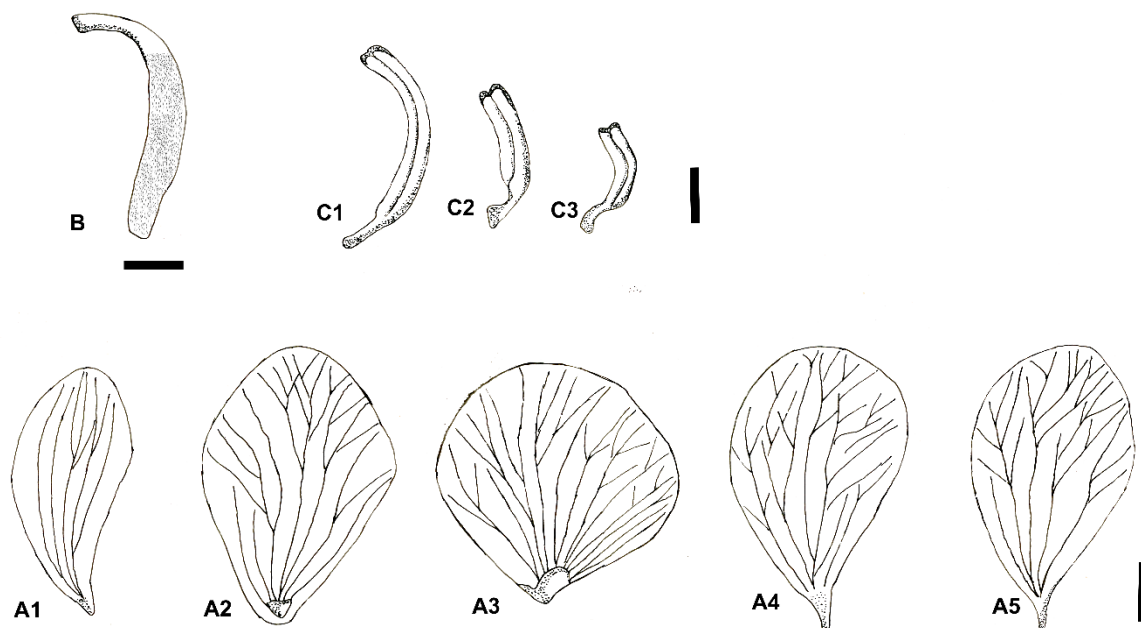


Figure 5.10. Morphology of *Chamaecrista gordon-grayei*. (A1–A5) petals, (B) ovary, densely hairy and, (C1–C3) stamens, with anthers in three series. Voucher: *Muller & Giess 554* (WIND). Scale bars A1–C3= 1 mm.

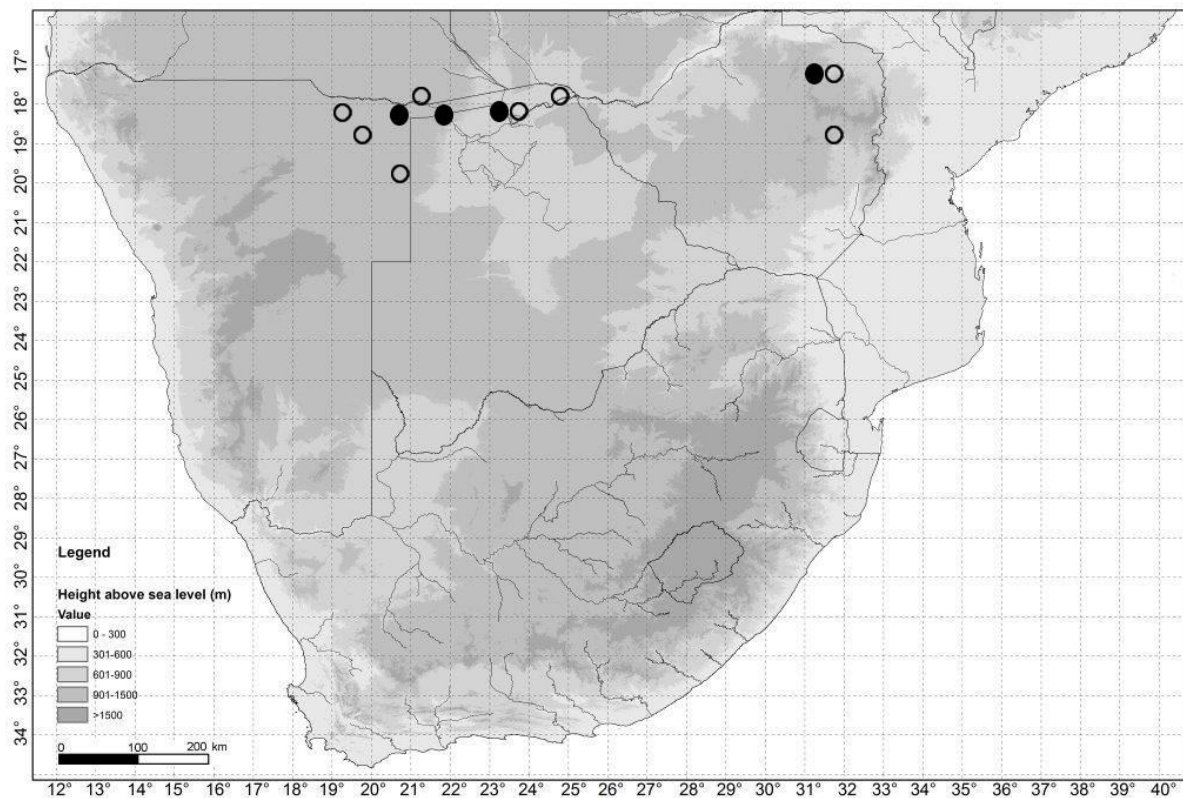


Figure 5.11. Known distribution of *Chamaecrista gordon-grayei* subsp. *gordon-grayei* (●) and *Chamaecrista gordon-grayei* subsp. *longpedicelata* (○) in southern Africa.

8. *Chamaecrista grandiglandulata* Musandiwa & Boatwr., **sp. nov.** Type: South Africa, KwaZulu-Natal, Mutubatuba (2832), 'north coast Richards Bay Harbour' (–CC), 23 Feb 1993, *Ward 12210* (PRE!, holo. NU!, iso.).

Annual herb to 1.5 m high. **Stems** erect, arising from a woody rootstock, erect, usually branching above the middle, pubescent, with short curved hairs. **Leaves** paripinnate, 40–74 × 3–7 mm; slightly tapering distally, stipules triangular, 6–8 (9) mm long, glabrous, base oblique, apex narrowly acuminate, margin with short hairs; extrafloral nectaries at or near top of petiole, large, overlaps the sides of petiole, 1–2 × 0.5–1.0 mm, sessile, oval to circular or elliptic, usually overlaps the sides of petiole,

brown; rachis crested. **Leaflets** 40–74 jugate, base oblique, apex mucronate; margin with curved scattered hairs. **Inflorescence** supra-axillary, 1–2 flowered; flowers 6–10 × 5–8; bracts pubescent, base oblique, apex acuminate; bracteoles 2, glabrous or with short hairs, towards the top of pedicel. **Pedicels** with short or curved hairs, at fruiting 5–7 mm long, at fruiting 7–10 mm long. **Sepals** 5, narrowly lanceolate, 5–6 × 1–4 mm, with short appressed hairs. **Petals** 5, oblong, 5–10 × 3–5 mm, pale yellow. **Stamens** 10, straight or slightly curved, anthers in two series, 6 small 2–4 mm long, 4 large, 5–10 mm long, with short filaments ± 1 mm long. **Ovary** ± 7 mm long, densely covered with greyish to whitish matted hairs, style curved, glabrous. **Pods** straight or slightly curved in the middle, 32–50 × 3–4 mm, flattened, with short or long fine hairs. **Seeds** 2.0–3.5 × 1.5–2.5, rhomboid, flattened, dark brown to blackish. Fig. 5.12.

Diagnostic characters: *Chamaecrista grandiglandulata* shares a crested rachis with *Chamaecrista gordon-grayei*, *C. mimosoides* and *C. plumosa*. It is readily distinguished by its short leaves 40–74 mm long (36–104 mm long in *C. gordon-grayei* and 30–85 mm long in *C. mimosoides*); large, sessile, elliptic extrafloral nectaries that overlaps the sides of petiole, 1–2 × 0.5–1 mm (Fig. 5.2F) (circular, sessile or raised on small stalk, ± 0.5 × 0.2–0.4 mm in *C. gordon-grayei* and small, ± 0.5 mm long, sessile, rounded in *C. mimosoides*) and short pedicels bearing small pale yellow flowers (bright flowers in *C. gordon-grayei* and *C. mimosoides*).

Distribution and ecology: *Chamaecrista grandiglandulata* is restricted to the coastal regions of KwaZulu-Natal in South Africa from Ubombo to Port Shepstone, occurring in open grassland at elevations below 500 m (Fig. 5.13). Flowering from September to July.

Etymology: This species epithet refers to the large, sessile, elliptic extrafloral nectaries characteristic of this species.

Additional specimens examined

South Africa. KWAZULU-NATAL: **2732 (Ubombo)**: Baya Camp, Sibaya south western basin (–BC), 12 Dec 1985, *Ward 1219* (NH); Mkuze Swamps, Ukhovu Pan area (–DC), 9 Sep 1972, *Ward 8102* (NU). **2831 (Nkandla)**: Egodeni, Hluhluwe Game Reserve, Zululand (–AA), 19 Mar 1972, *Nitchins 804* (NU). **2832 (Mtubatuba)**: Khula village (–AA), 18 Mar 2018, *Musandiwa 17* (NBG); Hlabisa, Dukuduku (–AC), 22 Jan 1965, *Strey 5710* (NU); Umfolozi, Richards Bay (–DD), 6 Jul 1974, *Ward 8652* (NU); Umfolozi, Richards Bay (–DD), 14 Jul 1929, *Rump s.n.* (NU); Mtunzini near river estuary (–DD), *Arnold 1408* (PRE). **2930 (Pietermaritzburg)**: Westville Chiltern Hills (–DD), 10 Feb 1968, *Ward 6409* (NU); Greater Durban Metropolitan Area, Kloof extension 13 (–DD), 16 Apr 1995, *Ward 13069* (NU); Umlaas River (–DD), 6 Dec 1973, *Stirton 521* (NU). **2931 (Stanger)**: Lower Tugela (–CA), 27 Mar 1964, *Ross 862* (NU); Merebank East (–CC), 7 Mar 1966, *Ward 5406* (NU); Wentworth (–CC), 29 Feb 1968, *Ward 6514* (NU). **3030 (Port Shepstone)**: 8 km to Kingsburg (–BB), 24 Sep 1974, *Wood 199* (NU); Illovo beach (–BB), 7 March 1972, *Schorn 33* (NU); Koelwaters resort ca. 4 km from Ntwalume (–BC), *Bester 4050* (PRE); Uvongo and Depps road (–CB), 10 Mar 1970, *Strey 9706* (NU); St. Michaels on sea, 1.5 km inland (–CD), 23 Feb 1969, *Nicholson 772* (PRE); Margate (–CD), 6 Apr 1975, *Strey 11320* (NU). **2832 (Mtubatuba)**: Hluhluwe Game Reserve, Zululand (–AA), 28 Mar 1972, *Hutchins 804* (NU).

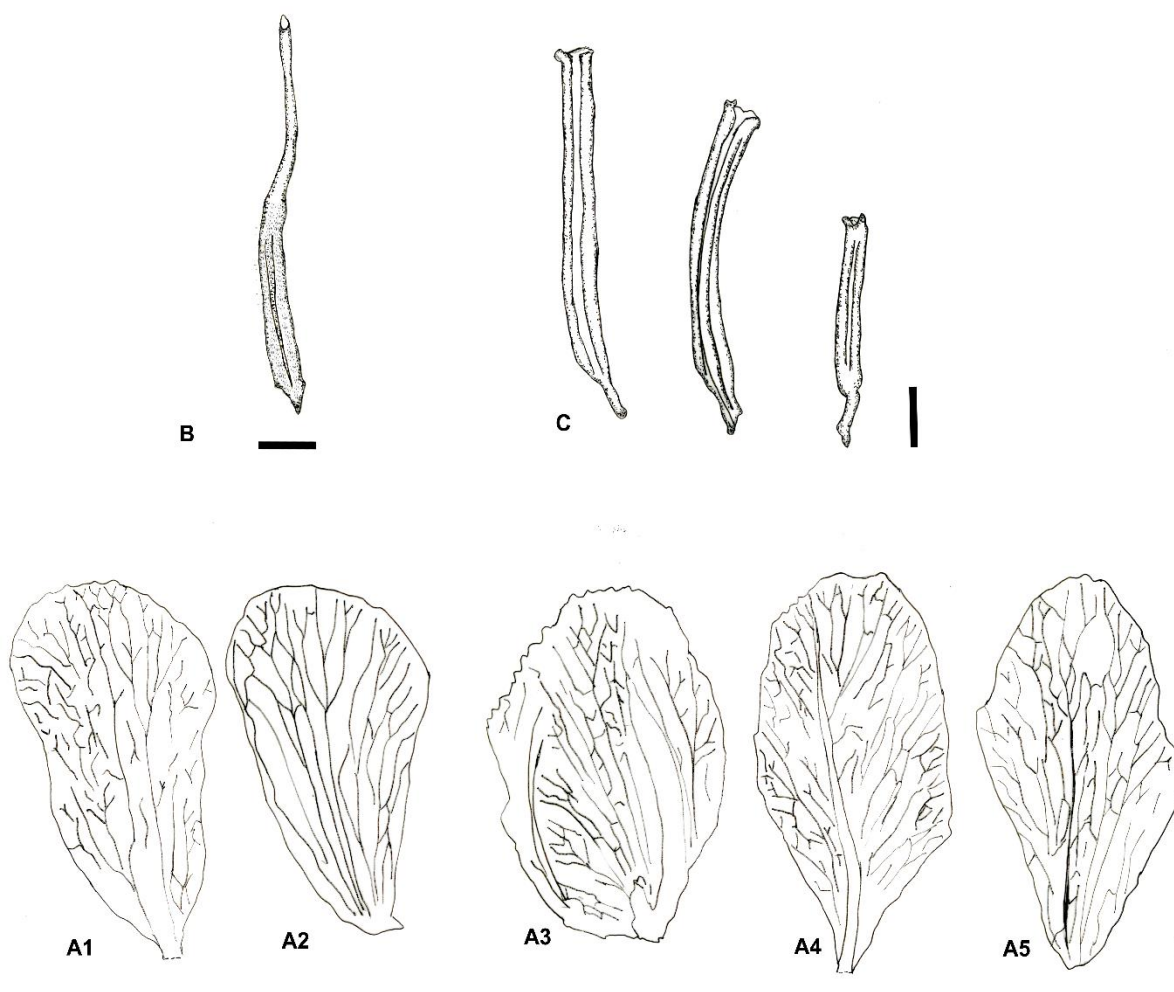


Figure 5.12. Morphology of *Chamaecrista grandiglandulata*. (A1–A5) petals, (B) ovary, densely hairy and, (C1–C3) stamens, with anthers in three series. Voucher: Schorn 33 (NU). Scale bars: A–C= 1 mm.

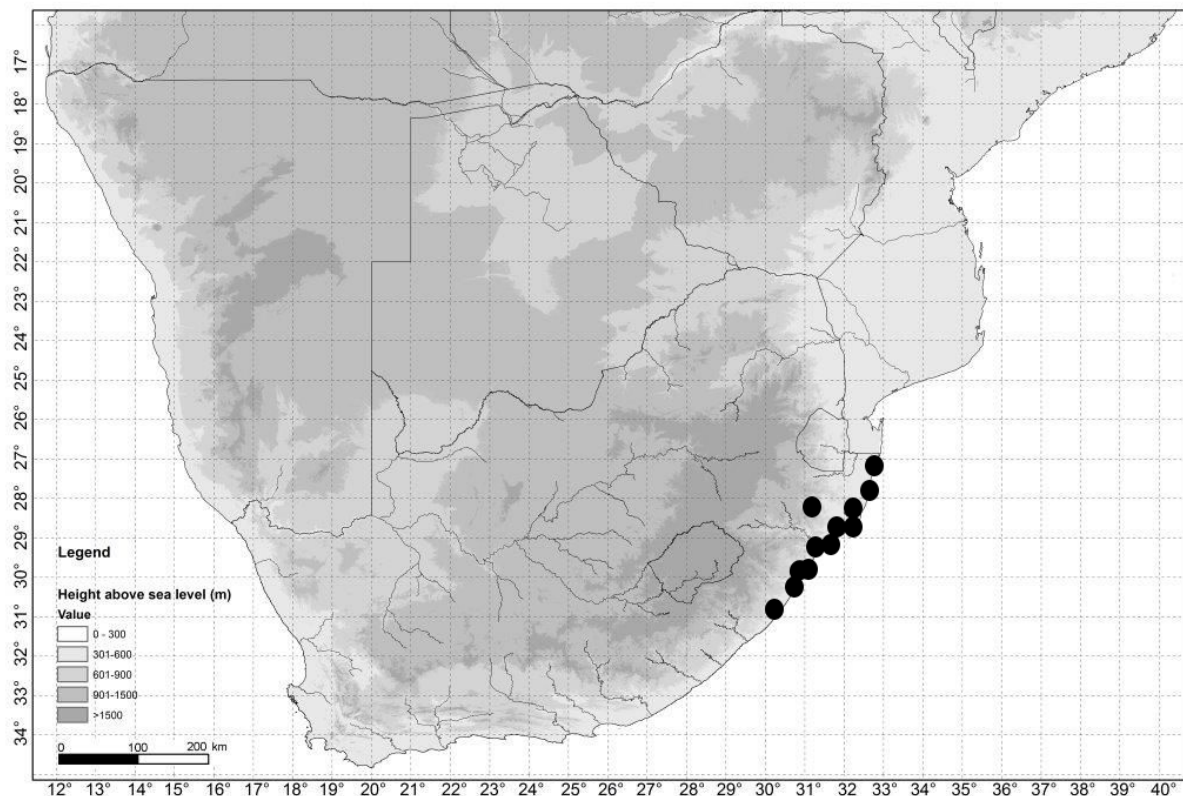


Figure 5.13. Distribution of *Chamaecrista grandiglandulata* in southern Africa.

9. *Chamaecrista kirkii* (Oliv.) Standl. in Smithsonian Misc. Coll. 68 (5): 5 (1917); Brummitt in Fl. Zambesiaca 3 (2): (2007). *Cassia kirkii* Oliv. in F. T. A. 2: 281 (1871); Baker, Legum. Trop. Afr.: 642 (1930); Steyaert in F.C.B. 3: 525 (1952); Mendonça & Torre in C. F.A. 2: 183 (1956); Brenan in F.T.E.A., Legum. Caesalp.: 92 (1967). Type: Malawi, Manganja Hills, 9 March 1862, *Kirki s.n.* (K [K000417618] holo.–image!).

This species occurs widely from central tropical to southern Africa (Brenan, 1967; Gordon-Gray, 1977). Three varieties are currently recognised of which only one, *Chamaecrista kirkii* var. *kirkii*, extends into southern Africa. *Chamaecrista kirkii* var. *guineensis* (Steyaert) Lock is known from Uganda, Kenya and Tanzania, while *C. kirkii* var. *glabrata* is known only from the Democratic Republic of Congo and Uganda (Brenan, 1967).

Chamaecrista kirkii* var. *kirkii

Annual herb 0.6 m high. **Stems** simple or branched, with long spreading and short curved greyish hairs, becoming woody at base. **Leaves** paripinnate, 30–130 × 1.5–3.0 mm, oblong to linear oblong, slightly tapering distally; stipules 8–12 mm long, narrowly triangular, base oblique, apex acuminate, margin ciliate; extrafloral nectaries, 0.8–1.5 × 0.5–1 mm, at or near the top of the petiole, sessile, elliptic; rachis channelled. **Leaflets** in 18–48 jugate, 6–19 × 1.5–4.0 mm, narrowly oblong, apex mucronate, pubescent on both surfaces, margin ciliate. **Inflorescence** supra-axillary, 1–5 flowered; flowers 3–6 × 3–5 mm; bract resembling stipules; bracteoles 2, towards the top of pedicels. **Pedicels** with long spreading hairs, at flowering 10–25 mm, at flowering fruiting 25–30 mm long. **Sepals** 5, narrowly ovate, shortly pubescent to densely hairy. **Petals** 5, 10–15 × 5–10 mm, bright yellow. **Stamens** 10. **Ovary** densely covered with long soft hairs. **Pods** 60–90 × 5 mm, flattened, pubescent. Seeds not seen.

Diagnostic characters: *Chamaecrista kirkii* var. *kirkii* shares small, sessile, extrafloral nectaries and stems with short curved hairs with *Chamaecrista mimosoides*, but is readily distinguished by the pubescent leaflets on both surfaces (in *C. mimosoides*), 1-5 flowered (1(2) flowered in *C. mimosoides*), and long pedicel, 10-30 mm (3–8 mm long in *C. mimosoides*).

Distribution and ecology: Apart from the type locality, *Chamaecrista kirkii* var. *kirkii* is known from Lumagundi and Mutare in Zimbabwe (Fig. 5.14). *Chamaecrista kirkii* var. *kirkii* grows in grasslands below 1000 m. Flowering is from March to April.

Additional specimens examined

Zimbabwe. **1630 (Lomagundi)**: North Silver Mine (–BB), 1 Mar 1967, *Jacobsen*
 3133 (PRE). **1832 (Mutare)**: near Nyamingura River (–AA), 24 Apr 1958 *Phipps* 1237
 (PRE).

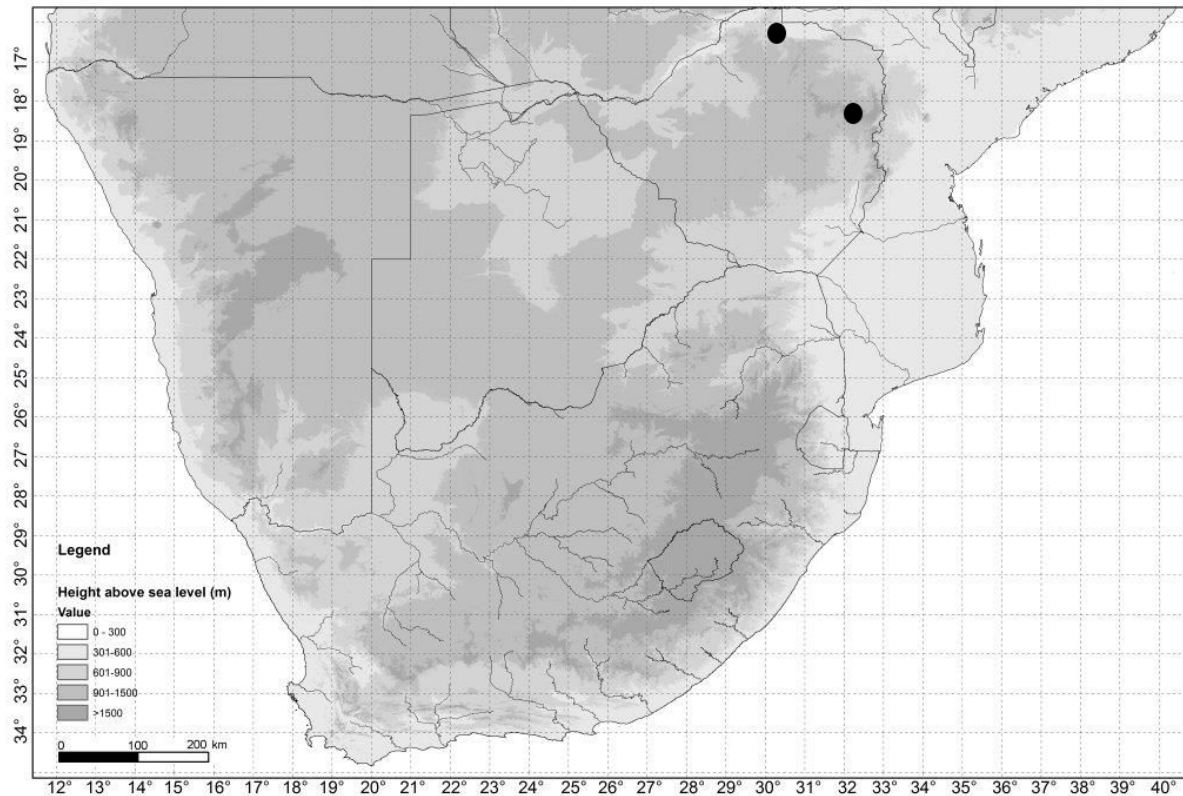


Figure 5.14. Known distribution of *Chamaecrista kirkii* var. *kirkii* in southern Africa.

10. *Chamaecrista mimosoides* (L.) Green, *Pittonia* 4 (20): 27 (1899); Brummitt in *Fl. Zambesiaca* 3 (2): 136 (2007). *Cassia mimosoides* L. *Sp. Pl.*: 379 (1753); Oliver in *F.T.A.* 2: 280 (1871); Baker, *Legum. Trop. Afr.*: 642 (1930); Steyaert in *F.C.B.* 3: 514 (1952); Mendonça & Torre in *C.F.A.* 2: 181 (1956); Keay in *F.W.T.A.*, ed.2, 1: 453 (1958); Brenan in *F.T.E.A.*, *Legum.-Caesalp.*: 100 (1967); Ross, *Fl. Natal*: 195 (1973); Gordon-Gray in *F.S.A.* 16(2): 104 (1977). Type: Sri Lanka, Zeylona, without date, *Hermann* 154 (BM [BM-000594576], lecto.–image! –designated by Larsen & Larsen, 1980).

Annual herb to 0.8 m high. **Stems** prostrate or decumbent, branching from the ground becoming rounded, with appressed short curved hairs. **Leaves** paripinnate, 30–85 × 2–7 mm, slightly tapering distally; stipules, 4–9 mm long, triangular, base oblique, apex acuminate; extrafloral nectaries at or near top of petiole, small, ± 0.5 mm long, sessile, rounded; rachis crested. **Leaflets** 23–62 jugate, base oblique, apex mucronate; margin ciliate. **Inflorescence** supra-axillary, 1(2) flowered; flowers 3–6 × 3–5; bract with short curved hairs, base oblique, apex acuminate; bracteoles 2, glabrous, towards the top of pedicel. **Pedicels** with short appressed or sometimes with long straight hairs, at flowering 3–8 mm long, at fruiting 6–10 mm long. **Sepals** 5, lanceolate, 4–6 × 1–3 mm, with short curved hairs. **Petals** obovate, 4–8 mm. **Stamens** 9–10, slightly curved, flattened, anthers in three series, 2 (3) small 2–3 mm long, 4 medium ± 4 mm long, 4 large ± 5 mm long, filaments short (1–2 mm long). **Ovary** densely covered with greyish to whitish hairs, style curved, glabrous. **Pods** straight or slightly curved, 35–60 × 3–4 mm, flattened, with appressed hairs. Seeds not seen.

Diagnostic characters: *Chamaecrista mimosoides* can be confused with *C. grandiglandulata* and *C. gordon-grayei* with which it shares a crested rachis, but can be distinguished from those species by its low growing form, and small, circular or circular-elliptic extrafloral nectaries on the petiole (Fig. 5.2G).

Distribution and ecology: *Chamaecrista mimosoides* is widespread in tropical Africa and southern Asia (Gordon-Gray, 1977; Brummitt et al., 2007). In southern Africa, *C. mimosoides* is widespread from Lydenburg in Mpumalanga, through Vryheid and Stanger in Kwa-Zulu Natal to Port St. Johns in the Eastern Cape extending across to Mbabane in Swaziland (Eswatini) (Fig. 5.15), growing in grassland in shallow soil at elevations below 1108 m. Flowering from November to May.

Notes: The variation in *Chamaecrista mimosoides* has led various authors to recognise a number of different forms within the species. Brenan (1967) in his treatment of the Tropical East African species of the genus recognised seven forms. In southern Africa, however, Gordon-Gray (1976) recognised three separate forms. Form 1 was distinguished from typical *C. mimosoides* by its erect stems, often branching in the upper half (Fig. 5.1B), large, sessile, elliptic extrafloral nectaries that overlap the sides of the petiole, short pedicels and small pale flowers. This species is largely confined to the coastal areas of KwaZulu-Natal. Form 2 was distinguished by its low, rounded growth habit (Fig. 5.1A), small, circular-elliptic or circular extrafloral nectaries and short pedicels bearing small bright yellow flowers. This taxon is widely distributed in KwaZulu-Natal, extending to the Eastern Cape and Mpumalanga Provinces. Form 3, distinguished by the small, subsessile to sessile extrafloral nectaries, and larger bright yellow flowers from other forms is known from Chirundi in Namibia through Katima Mulilo to Tsumkwe, extending to Botswana and Zimbabwe.

After examination of available herbarium material and field studies, the three forms are now recognised as separate species. Form 1 distinguished by its erect stems, branched in the upper half, the large, sessile, elliptic extrafloral nectaries that overlaps the sides of petiole, short pedicels, and small pale flowers with 10 stamens and anthers that are divided into two series (6 small 2–4 mm long, 4 large, 5–10 mm long) is now recognised as the separate species *Chamaecrista grandiglandulata*. Form 3 distinguished by small, subsessile to sessile extrafloral nectaries, and slightly larger bright flowers with 9–10 stamens divided into three series (2 (3) small 2–3 mm long, 4 medium \pm 4 mm long, 4 large \pm 5 mm long) is now recognised as separate species *Chamaecrista gordon-grayei*. Gordon-Gray (1977) erroneously considered form 3 as the typical form of *Chamaecrista mimosoides*, however, this form differs from

the type of *Chamaecrista mimosoides* by the subsessile to sessile extrafloral nectaries, and development of branched, and long pedicels. In addition, I recognise two separate forms within *C. gordon-grayei* distinguished by short pedicels 7–10 mm long, and long pedicels 15–30 mm long. Of these forms, I relegate the form with long pedicels to subspecific level and recognise it as *C. gordon-grayei* subsp. *longipedicellata*. No other characters were found warranting the idea of raising the form with long pedicels to species rank.

Form 2, distinguished by small, circular extrafloral nectaries, and short pedicels bearing small pale yellow flowers with 9–10 stamens divided into three series (2 (3) small 2–3 mm long, 4 medium \pm 4 mm long, (3) 4 large \pm 5 mm long) resembles the lectotype of *Chamaecrista mimosoides* designated by Larnsen & Larsen in Aubreville & Leroy (ed.), Fl. Cambodge Loas Viet-Nam 18: 105 (1980). I therefore recognised it as typical *C. mimosoides*. Future studies should investigate *Chamaecrista mimosoides* across its wide distribution range to determine whether it is in fact only one widespread taxon.

Additional specimens examined

South Africa. MPUMALANGA. **2530 (Lydenburg)**: 20 km from Lydenburg on road to Dullstroom (–AC), 05 Mar 1979 (NH). **2531 (Komatipoort)**: Barberton (–CC), Jul 1915 (PRE).

KWAZULU-NATAL: **2730 (Vryheid)**: Itala Nature Reserve (–DD), 23 Jan 1978, *McDonald* 495 (NU). **2731 (Louwsburg)**: Jozini dam (–BD), 13 Dec 1965, *Burt* 3215 (NU). **2732 (Ubombo)**: Nkuzi Game Reserve, Mougeue (Stand 4) (–CB), 10 May 1976, *Goodman* 655 (NU). **2930 (Pietermaritzburg)**: Shongweni dam (–CB), 22 Feb 1966, *Morris* 772 (NU); Isipingo flats (–DD), 20 Mar 1968, *Ward* 6527 (NU). **2931 (Stanger)**: Beachwood, Durban (–CC), 7 Dec 1956, *Lawson* 321 (NU).

EASTERN CAPE: **3129 (Port St. Johns)**: banks of Umgazana River (–CB),
Apr 1976, *Gans* 43 (NU).

Swaziland (Eswatini). **2631 (Mbabane)**: Komati old ferry (–AC), 18 Feb 1960,
Compton 29826 (NH).

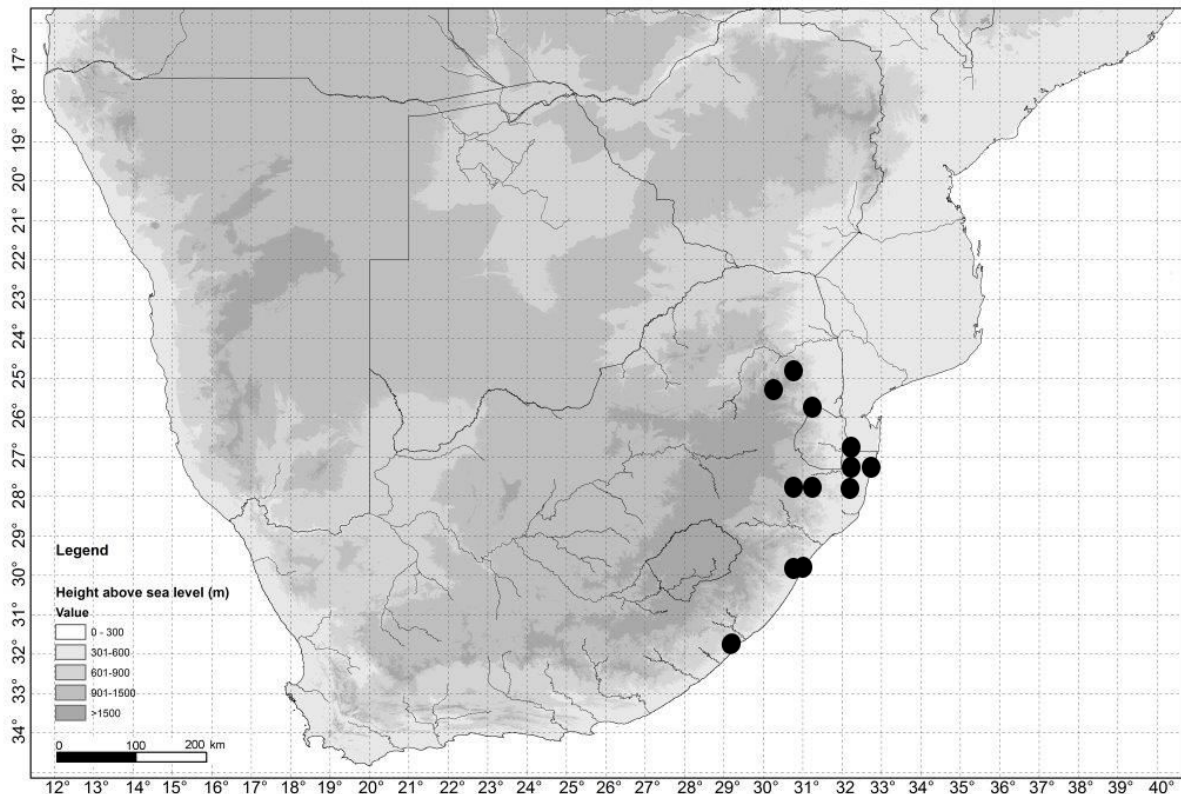


Figure 5.15. Known distribution of *Chamaecrista mimosoides* in southern Africa.

11. *Chamaecrista parva* (Steyaert) Lock in Kew Bull. 43: 337 (1988); Brummitt in Fl. Zambesiaca 3 (2): 142 (2007). *Cassia parva* Steyaert in Bull. Jard. Bot. État. 20: 266 (1950); Brenan in F.T.E.A Legum.-Caesalp.: 88 (1967). Type: Democratic Republic of Congo [Congo], Upemba Nat. Park, Lusinga, *De Witte* 2476 (BR [BR0000008917362] holo.–image!).

Perennial herb to 0.5 m high. **Stems** erect simple or sub-simple, arising from a woody rootstock, pubescent with longer spreading hairs or curved greyish hairs. **Leaves** paripinnate, 30–90 × 8–15 mm, slightly tapering distally; stipules, 7–13 mm, narrowly triangular, base oblique, apex acuminate, surface glabrous, margin ciliate; extrafloral nectaries at or near the top of petiole, 1–2 × 0.7–1.0 mm, sessile, flattened, elliptic, brown to purplish; rachis channelled, channel margin ciliate. **Leaflets** 7–36 jugate, 3–13 × 2–3 mm, narrowly oblong to lanceolate, slightly curved, base asymmetric, apex acuminate, margin ciliate, surface glabrous, or suppressed pubescent, sometimes broadening pubescent, midrib towards one margin. **Inflorescence** axillary to supra axillary, often supra axillary, 1–2(3) flowered; flowers 5–13 × 2–10 mm; bract narrowly triangular, base oblique, apex mucronate; bracteoles 2, towards the top of pedicels. **Pedicels** with long spreading hairs, at flowering 15–20 mm long, at fruiting 25–30. **Sepals** 5, lanceolate, 5–9 × 2–3 mm, with spreading hairs on the outer surface. **Petals** 5, obovate, 10–13 × 4–9.5 mm, bright yellow. **Stamens** 10, straight or slightly curved, in two series 6 small 3–4 mm long, 4 large 5–6 mm long, filaments small ± 1 mm long. **Ovary** appressed with white hairs, style glabrous, slightly curved. **Pods** 35–60 × 3.5–5.0 mm, sparsely hairy. Seeds not seen.

Diagnostic characters: *Chamaecrista parva* is unique in its long stipules 7–13 mm long, large and sessile extrafloral nectaries, 1–2 × 0.7–1.0 mm. The species is similar to *C. comosa* (specially *C. comosa* var. *comosa*) from which it can be distinguished by the densely hairy stems, narrow leaflets, 2–3 mm wide (wider in *C. comosa*, 2–5 mm wide) and 10 stamens (9 in *C. comosa*).

Distribution and ecology: Apart from the type locality in the Democratic Republic of Congo, *Chamaecrista parva* is known otherwise only from Harare in Zimbabwe (Fig. 5.16).

Additional specimens examined

Zimbabwe. **1731 (Harare)**: Mazoe (–BB), 19 Feb 1977, *Van Wyk 65* (NU).

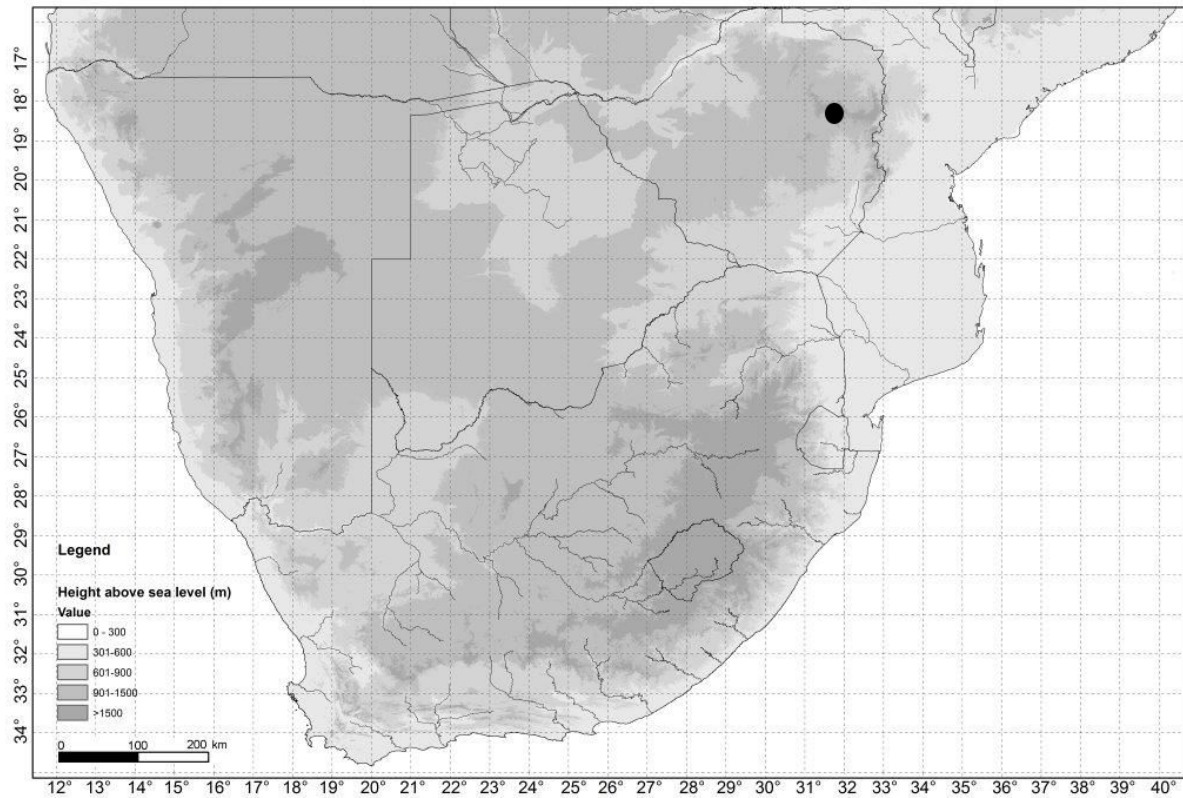


Figure 5.16. Known distribution of *Chamaecrista parva* in southern Africa.

12. *Chamaecrista plumosa* E. Mey. *Comm. Pl. Afr. Austr.*: 159 (1836); Brummitt in *Fl. Zambesiaca* 3 (2): 138 (2007). *Cassia plumosa* (E. Mey.) Vogel, *Syn. Gen. Cassiae* 64 (1837); Ross, *Fl. Natal*: 195 (1973); Gordon-Gray in *F.S.A.* 16 (2): 103 (1977).
Type: Type: South Africa, Eastern Cape, 'between Bashee [Mbashe] River and Umtata', without date, *Drège s.n* (K, [K000417581] lecto.–image! –designated here).
[Note: We could not trace any material in P and other herbaria, therefore we select the collection at K as lectotype].

Chamaecrista plumosa var. *diffusa* E. Mey., Comm. Pl. Afr. Austr.: 159 (1836).
Cassia plumosa var. *diffusa* (E. Mey) Vogel, Syn. Gen. Cassiae 65 (1837). Type: Cape Province [Eastern Cape] near Umzimkulu [Omsamcula], *Drège s.n.* (whereabouts unknown).

Perennial herb, to 1.8 m high. **Stems** single or multiple, erect or semi-erect, arising from woody rootstock, producing branches in the upper half, or prostrate and branched to form spreading mat, glabrous or with appressed curved or straight hairs, often reddish to purplish one side. **Leaves** paripinnate, 10–90 × 1–10 mm, slightly tapering distally; stipules triangular, 0.4–0.9 mm long, base oblique, apex acuminate, glabrous or pubescent; extrafloral nectaries at the top of petiole, sessile, circular, ovate or elliptic, 0.2–0.8 mm long, rachis crenate-crested. **Leaflets** 13–38 jugate, base oblique, apex acuminate, glabrous or pubescent, margin with white hairs. **Inflorescence** axillary, 1–3 flowered; flowers 7–17.0 × 5–10 mm long; bract often with short hairs; base oblique, apex acuminate, margin ciliate; bracteoles 2, glabrous or shortly pubescent, or covered with long appressed hairs. **Pedicles** densely or sparsely covered with appressed hairs, at flowering 10–30 mm long, at fruiting ± 25. **Sepals** 5, ovate, 7–10 × 1–3 mm, sparsely appressed pubescent. **Petals** 5, obovate, 7–15 × 5–9 mm, bright yellow. **Stamens** 10, straight or curved, anthers in two series, 6 small 3–4 mm long, 4 large 6–7 mm long, filaments very short 1 mm long. **Ovary** 5–7 mm long, densely covered with greyish hairs, style glabrous, up to 5 mm long, slightly curved. **Pods** 25–60 × 3–5 mm, flattened, straight or slightly curved sparsely appressed pubescent. **Seeds** 3–4 × 1.5–2.0 mm, rhomboid, flattened, dark brown to light brown.

Diagnostic characters: *Chamaecrista plumosa* can sometimes be confused with *C. capensis* with which it shares the large flowers, but is readily distinguished by

the crested rachis (chanelled in *C. capensis*) and sessile, circular, ovate or elliptic, extrafloral nectaries (sub-sessile or raised in small stalk in *C. capensis*).

Two varieties are recognised:

10a. *Chamaecrista plumosa* E. Mey. var. *plumosa*. *Cassia plumosa* (E. Mey.) Vogel var. *plumosa*, Schorn & Gordon-Gray in J.S. Afr. Bot. 41: 153 (1975); Gordon-Gray in F.S.A. 16(2): 104 (1977).

Prostrate and diffusely branched herb, with several braches from the ground forming spreading mat 0.4 m in diameter. **Stems** glabrous or sub-glabrous, or with short appressed curved greyish becoming dense at the top parts, often reddish or purplish on one side. **Leaves** 10–45 × 1–10 mm.

Diagnostic characters: *Chamaecrista plumosa* var. *plumosa* is distinguished by its short prostrate stems, with several braches from the ground forming spreading mat to 0.4 m in diameter, glabrous or covered with curved appressed greyish hairs and short leaves, up to 45 mm long.

Distribution and ecology: *Chamaecrista plumosa* var. *plumosa* is widespread in KwaZulu-Natal from Ubombo through Mtubatuba to Port Shepstone (Fig. 5.17). Flowering from September to March.

Additional specimens examined

South Africa. KWAZULU-NATAL: **2732 (Ubombo):** Ingwavuma, Tongaland (–AB), 10 Dec 1968, *Pooley 240* (NU); Ingwavuma, Malangeni E of Maputa (–BB), 19 Dec 1966, *Martin 065* (NU); Lake Sibaya S Basin area (–BC), 5 Nov 1969, *Hart 19* (NU); Mpilo Game Reserve (–CA), 19 Nov 1970, *Willo 9* (PRE). **2832 (Mtubatuba):** Hlabisa, Hluhluwe Nature Reserve (–AA), 6 Oct 1983, *Phelan 710* (NU); Hlabisa, Hluhluwe Nature Reserve (–AA), 1 Nov 1962, *Scott-Smith 53* (NU); St Lucia E shores

(–AD), 8 Dec 1974, *Smook 630* (NU). **2930 (Pietermaritzburg):** Farm Ambleside, New Hanover (–BC), 13 Feb 1976, *Abraham 31* (NU); Shongweni Dam, Camperdown (–DC), 21 Feb 1966, *Morris 713* (NU); Isipingo N (–DD), Oct 1948, *Ward 555* (NU). **2931 (Stanger):** Tugela River crossing main N. Coast road (–AB), 8 Dec 1973, *Stirton 402* (NU); Lower Tugela (–AD), 29 Sep 1974, *Stirton 1156* (PRE). **3030 (Port Shepstone):** Umzinto Pennington S Coast (–BB), 5 Jan 6220, *Gordon-Gray 6220* (NU); Oribi Gorge Nature Reserve (–CB), 6 Feb 1972, *Glen 528* (NU). **3029 (Kokstad):** Alfred Harding (–DB), 4 Jan 1964, *Lemox s.n.* (NU).

10b. *Chamaecrista plumosa* var. *erecta* (Schorn & Gordon-Gray) Lock, Kew Bull. 43 (2): 337 (1988). *Cassia plumosa* var. *erecta* Schorn & Gordon-Gray in J. S. Afr. 41: 153 (1975); Gordon-Gray in F.S.A. 16 (2): 104 (1977). Type: KwaZulu-Natal, Pietermaritzburg (2930), ‘Camperdown, Inchanga’, (–DC), 9 March 1972, *Schorn 36* (NU, holo!).

Perennial herb to 1.8 m tall. **Stems** erect, often single stemmed or with few stems, simple or sub-simple, branching on the upper half, glabrous or covered with short, and/or long straight greyish or yellow hairs. **Leaves** 15–90 × 2–10 mm.

Diagnostic characters: *Chamaecrista plumosa* var. *erecta* is distinguished from *C. plumosa* var. *plumosa* by its erect stems up to 1.8 m tall, branching in the upper half, with stems densely covered with short and/or long greyish or yellowish hairs and long leaves, up to 90 mm long.

Distribution and ecology: *Chamaecrista plumosa* var. *erecta* is common in Louwsburg through Pietermaritzburg to Port Edward in KwaZulu-Natal. It occurs in grasslands at altitude below 800 m (Fig. 5.13). Flowering from September to March.

Additional specimens examined

South Africa. KWAZULU-NATAL: **2731 (Louwsburg)**: Tygerskloof Estate, Ngome area (–AD), 9 Feb 2001, *Potgieter 425* (NU). Ngotshe, Ngome Forest (–CD), 11 Feb 1962, *Tinley 743* (NU) **2831 (Nkandla)**: near Dhlinda Forest, Eshowe (–DA), 21 Jan 1963, *Edwards 2870* (NU) **2832 (Mtubatuba)**: Hlabisa, Monzi Settlement (–AD), 7 April 1966, *Strey 6568* (NU) **2930 (Pietermaritzburg)**: Laager Farm, near Harburgh (–BD), 10 Dec 2005, *Majola & Marimuthoo 2986* (NH); 4 km from Pietermaritzburg on the Greytown road (–CB), 10 Dec 1988, *Edwards* (PRE); Richmond, Tala Farm (–CD), 8 Mar 1966, *Moll 3073* (PRE); Cato Ridge, inland of Durban (–DA), 2 Feb 2013, *Styles 3960* (NH); Camperdown, Inchanga (–DC), 23 Feb 1966, *Hilliard 3883* (NU); Camperdown Inchanga (–DC), 23 Feb 1964, *Hilliard 2722* (NU). Pietermaritzburg (–DC), 16 Feb 1969, *Strey 8367* (PRE); Greater Durban area, Queensburgh (–DD), 24 Feb 1993, *Ward 12248* (NH); Maidstone, N coast (–CA), 14 Feb 1944, *Hilliard 12* (NU, 2 Sheets), **3030 (Port Shepstone)**: S Coast, Paddock Altenburg (–CD), 26 Jan 1997, *von Fintel 406* (NH); Port Shepstone, Margate (–CD), 12 Feb 1973, *Strey 11065* (NU). **3130 (Port Edward)**: Umtamvuna Nature Reserve, Beacon Hill (–AA), 19 Mar 2018, *Musandiwa 18* (NBG); Beacon Hill (–AA), 8 Feb 1980, *Nicholson 2057* (PRE).

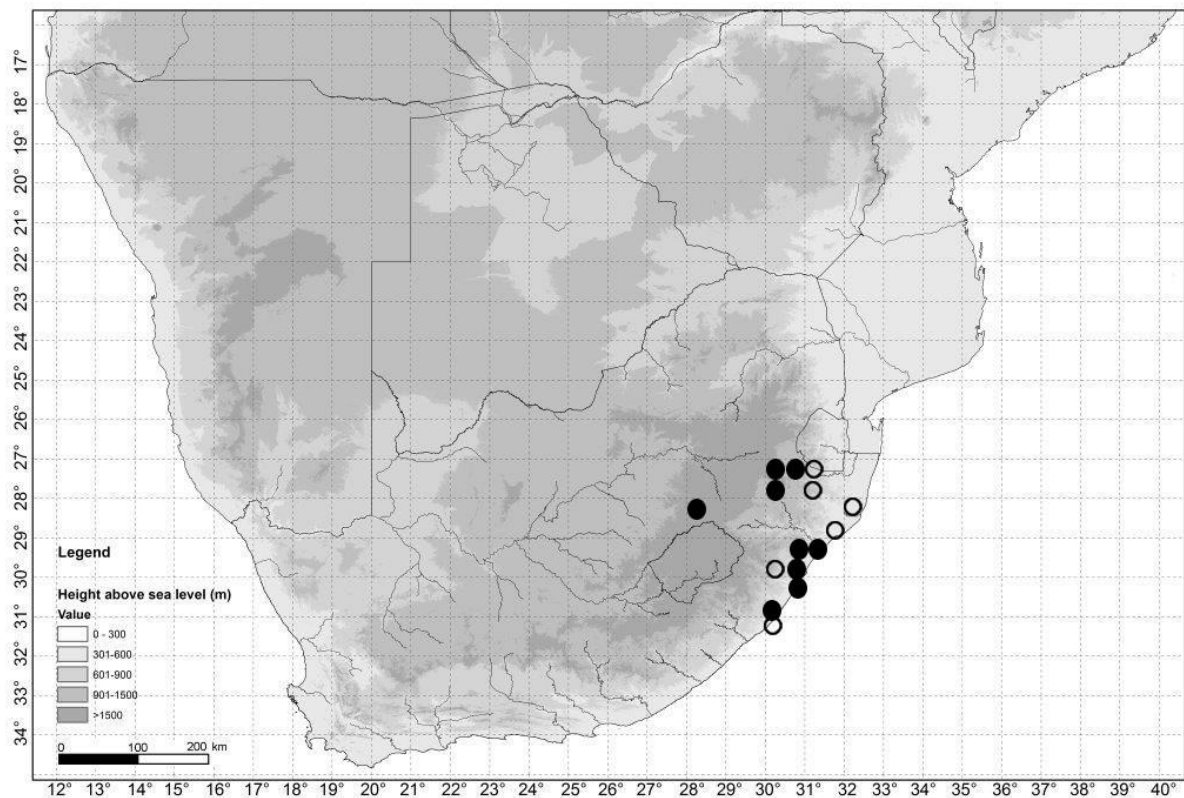


Figure 5.17. Known distribution of *Chamaecrista plumosa* var. *plumosa* (●) and *C. plumosa* var. *erecta* (○) in southern Africa.

13. *Chamaecrista stricta* E. Mey., *Comm. Pl. Afr. Austr.* 1: 159 (1836); Brummitt in *Fl. Zambesiaca* 3 (2): 138 (2007). Type: South Africa, Eastern Cape, Butterworth (3228), Bashee River [Mbashe River], (–BD), 07 January 1829, *Drège s.n.* (K [K-000417579] lecto.–image! –designated here, HBG [HBG520216], TUB [TUB000962], MO [MO-1515528] iso.–image!, HAL [HAL0120728] syn.–image!). [Note: I could not trace any material in P where Drège types are most likely to be found, therefore I select the collection at K as lectotype].

Cassia quarrei (Ghesq.) Steyaert., Steyaert in *Bull. Jard. Bot. Brux.* 20: 264 (1950); Brenan in *F.T.E.A Legum.-Caesalp.*: 95 (1967); Gordon-Gray in *F.S.A.* 16(2): 102

(1977). Type: Zaire, Katanga, Etoile, November 1932, *Quarre 380* (BR [BR-0000008917386], lecto.–image! –designated by Steyaert (1950)).

Annual herb to 0.8 m high. **Stems** erect, simple or sub-simple stems, finely pubescent, with small curved hairs, often blackish on one side. **Leaves** paripinnate, 20–100 × 10–22 mm, linear oblong, tapering distally; stipules 4–9 × 1.2–2.0 mm, base oblique, apex acuminate; extrafloral nectaries at the top of the petiole, 0.7–1.1 mm in diameter, sessile, broadly elliptic, dark centre; rachis channelled, channel margin ciliate. **Leaflets** 13–37 jugate, 3–9 × 1–2 mm, linear oblong, base oblique, apex acuminate to apiculate, margin entire or ciliate. **Inflorescence** supra-axillary, (1) 2–3 flowered; flowers 4–6 × 4–6 mm; bracts up to 3 mm long, base oblique, apex acuminate; bracteoles 2, glabrous, towards top of pedicels. **Pedicels** with curled hairs and long patent hairs at flowering 6–10 mm long, at fruiting 10–14 mm long. **Sepals** 5, narrowly ovate, 4–7 × 1.0–1.5 mm, with small appressed hairs. **Petals** 5, obovate, 5.0–7.5 mm long, pale yellow. **Stamens** 8–9, straight or slightly curved, anthers in two series, 5 (4) small 2–3 mm long, 4 large 4–5 mm long, filaments very short, ± 1 mm long. **Ovary** up to 4–6 mm long, densely pubescent with greyish hairs, style curved glabrous, ± 2 mm long. **Pods** 30–60 × 3–5 mm, flattened, slightly curved, with short white to greyish hairs. **Seeds** 2–4 × 1–3, rhomboid, light brown with black dots at the top.

Diagnostic characters: *Chamaecrista stricta* is distinguished by the channelled leaf rachis, the small extrafloral nectaries at the top of the petiole, 0.7–1.1 mm in diameter, sessile, broadly elliptic with a dark centre. *Chamaecrista stricta* shares the small pale flowers with *C. grandiglandulata* but is distinguished from that species by the channelled leaf rachis (crested in *C. grandiglandulata*), small, sessile

extrafloral nectaries as oppose to large extrafloral nectaries that overlaps the sides of the petioles, and 8–9 stamens (10 stamens in *C. grandiglandulata*).

Distribution and ecology: Widely distributed in Limpopo and across the drier regions of the country in North West and Mpumalanga Provinces extending to Port St. Johns in the Eastern Cape (Fig. 5.18). Grows in grasslands, on rocky areas at elevations above 1 000 m. Flowering from January–May.

Additional specimens examined

South Africa. LIMPOPO: **2328 (Baltimore):** Lapalala Wilderness, Welgelegen Farm (–CD), 1 Feb 2004, *Mathogoane 410* (PRE). **2329 (Pietersburg) [Polokwane]:** Pietersburg Nature Reserve (–CD), 7 Feb 1980, *Bredenkamp 388* (PRE).

NORTH WEST: **2527 (Rustenburg):** Scheerpoort (–DD), 20 Apr 1906, *Leendertz 750* (PRE). **2627 (Potchefstroom):** Potchefstroom (–DC), May/Jun 1927, *Lawrance 07* (PRE).

MPUMALANGA: **2630 (Carolina):** 3 km from Amsterdam on road to Piet Retief, Roburnia Estates (–DA), 07 Mar 1986, *Germishuizen 3923* (PRE).

EASTERN CAPE: **3128 (Umtata):** Nqeleni roadside (–DB), 24 Mar 1973, *Strey 11170* (NU, NH). **3129 (Port St. Johns):** Mkambati Nature Reserve (–BD), 15 Jan 1997, *Makwarela 209* (PRE).

Swaziland (Eswatini). **2631 (Mbabane):** north bank of Komati River, E of Mhlatane River (–AB), 5 Mar 1993, *Germishuizen 6112* (PRE).

Zimbabwe. **1829 (Kwekwe):** Sable Park, 8 km from NE of Que-Que (–DD), 5 Apr 1977, *Chipunga 132* (NU). **1731 (Harare):** (–AB), 26 Feb 1954, *Savory 14* (NU).

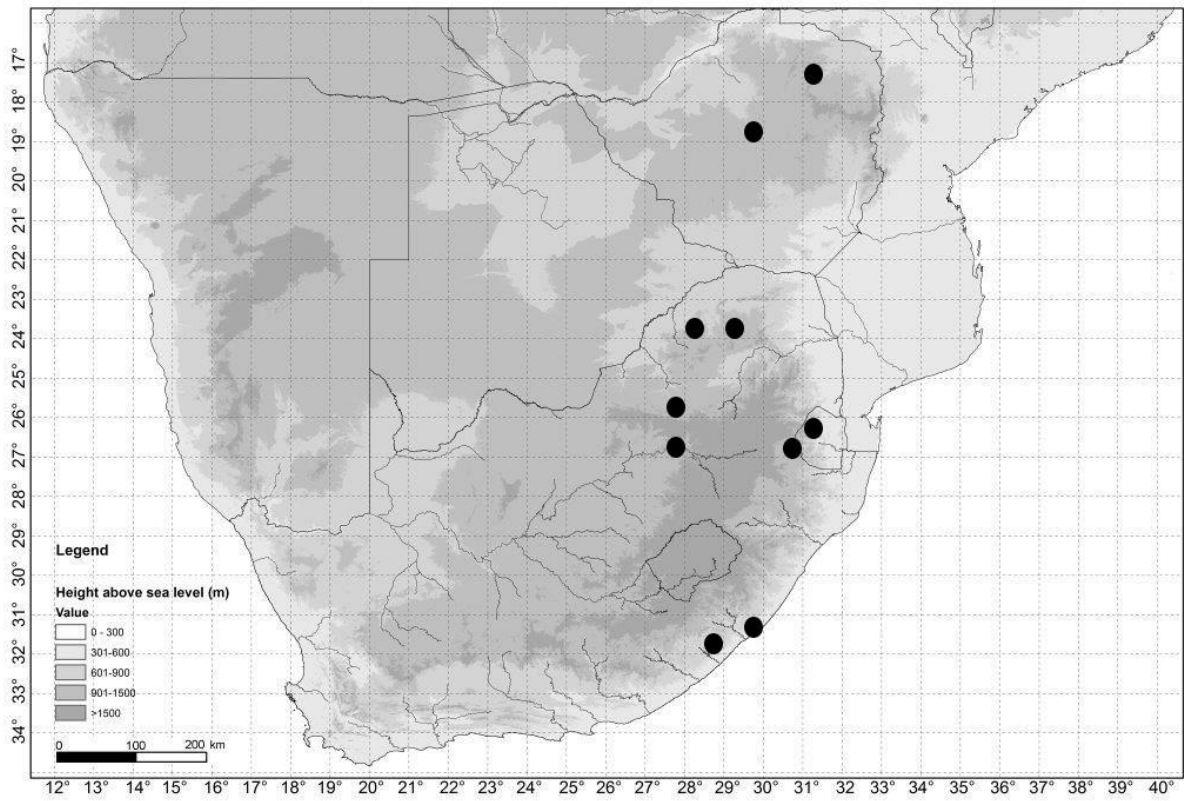
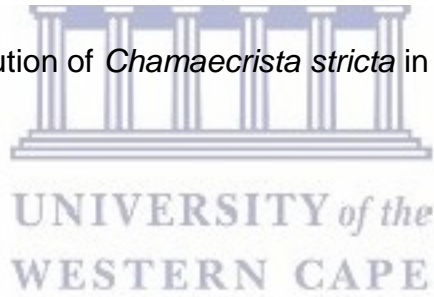


Figure 5.18. Known distribution of *Chamaecrista stricta* in southern Africa.



CHAPTER 6

GENERAL CONCLUSION

The results presented in this study provided insight into the invasion status of naturalizing species of the genera *Cassia* and *Senna*, taxonomy of the indigenous species of *Chamaecrista*, the phylogeny of the southern Africa species of the genus *Chamaecrista* in context of a global phylogeny, and DNA barcoding of invasive species of Cassiinae.

This study evaluated the invasion risk of 16 naturalized species of Cassiinae present in South Africa, using the Australian Weed Risk Assessment (A-WRA) and risk analysis framework developed for South Africa (Chapter 3). Both analysis revealed that 94% of *Cassia* and *Senna* species have high invasive risk. Only one species was excluded from the list due to lack of information. This species would require secondary screening to determine its invasive risk. Several factors, e.g. prolific seed production, dense thickets, rapid growth and seeds that remain viable for years, contributed to the high invasive risk of these Cassiinae species.

In Chapter 4, phylogenetic relationships within the genus *Chamaecrista* were studied, focusing on the placement of the southern Africa species in the context of a published global phylogeny, and to establish a DNA barcoding library of invasive *Cassia* and *Senna* species. The analyses of ITS and *trnL-F* indicated strong support for the monophyly of *Chamaecrista* and confirmed that section *Chamaecrista* is not monophyletic, as revealed by previous studies. The southern African species of *Chamaecrista* are placed together with South American species (*Chamaecrista nictitans*) within section *Chamaecrista* and share several morphological features. The two core barcoding regions (*rbcLa* and *matK*) were sequenced for invasive *Cassia* and

Senna species to establish a DNA library. This library will facilitate the identification process of invasive species each time the morphology-based identification is difficult, time consuming or doubtful. The DNA barcodes were analysed together with sequences from previous studies, which indicated that *matK* especially is useful in elucidating the placement of species, and strongly supported clades are retrieved with multiple accessions of species recovered together.

A taxonomic revision of the genus *Chamaecrista* is presented (Chapter 5). The species of *Chamaecrista* are well represented in southern Africa, largely confined to the Limpopo, Gauteng, Mpumalanga, KwaZulu-Natal and Eastern Cape Provinces of South Africa. Several taxonomic characters such as habit, extrafloral nectaries, leaflet number, degree of hairiness, floral development, pedicel length and stamens were studied and found to be important characters to distinguish between the species. Thirteen species of *Chamaecrista* are recognised in southern Africa. Four new taxa (three species and one subspecies) are described, *Chamaecrista grandiglandulata* Musandiwa & Boatwr., *C. gordon-grayei* Musandiwa & Boatwr., *C. gordon-grayei* Musandiwa & Boatwr. subsp. *longipedicellata* Musandiwa & Boatwr. and *C. falcata* Musandiwa & Boatwr. and one variety raised to the rank of subspecies (*Chamaecrista comosa* E.Mey. subsp. *capriconia* (Stayaert) Musandiwa & Boatwr.).

In addition, accurate descriptions, known geographical distributions (both native range and southern African invasive range) as well as notes on environmental and invasion risk (for naturalized species only) were compiled for all 19 species of *Cassia* and *Senna* currently found in southern Africa (Chapter 3). With the taxonomic revision of *Chamaecrista*, detailed species information is now available for all 32 southern African species of Cassiinae (native and exotic). Together with the electronic

key, also produced in this study, accurate identification and management of these species should be greatly improved.

Future research

Future studies should investigate *Chamaecrista mimosoides* across its wide distribution range to determine whether it is in fact one widespread taxon, or a complex of several species. Furthermore, invasive impact of *Senna multiglandulosa* and *S. sophera* need to be further evaluated in more detail.



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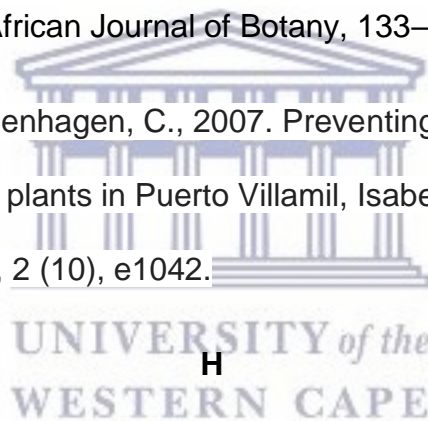
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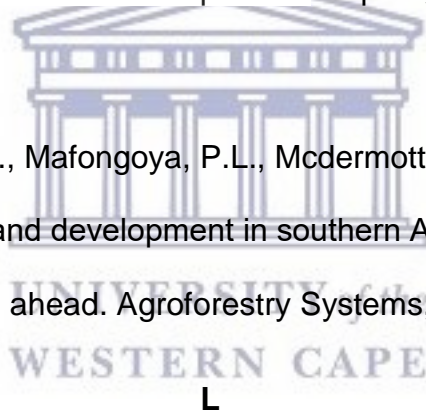
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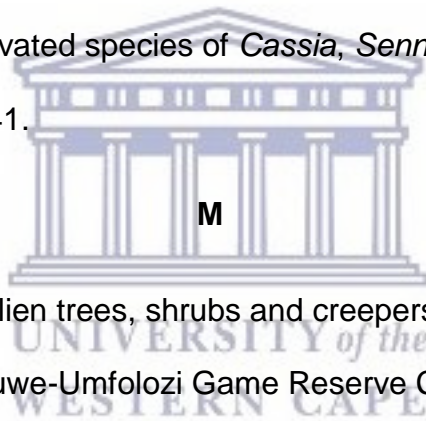
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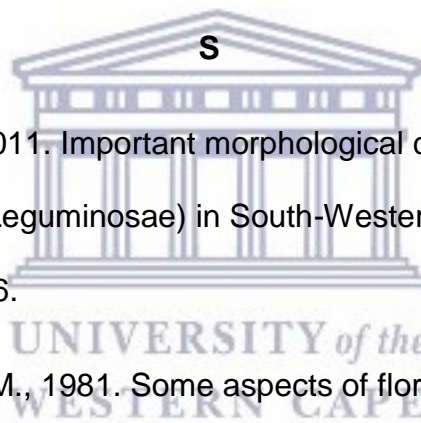
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Appendix 1. A list of species for *Cassia* and *Senna* showing native and non-native species that are known to occur in southern Africa.

Species Name	Native/ cultivated/naturalised
<i>Cassia abbreviata</i> Oliv. subsp. <i>beareana</i> (Holmes) Brenan	Native
<i>Cassia aciphylla</i> Benth.	Not native
<i>Cassia afrofistula</i> Brenan var. <i>afrofistula</i>	Not native
<i>Cassia australis</i> Sims	Not native
<i>Cassia barclayana</i> Sweet var. <i>barclayana</i>	Not native
<i>Cassia brewsteri</i> F.Muell	Not native
<i>Cassia eremophila</i> Vogel	Not native
<i>Cassia ferruginea</i> (Schrad.) Schrad. ex DC.	Not native
<i>Cassia fistula</i> L.	Not native
<i>Cassia grandis</i> L.f.	Not native
<i>Cassia javanica</i> L.	Not native
<i>Cassia latipetiolata</i> Dombey	Not native
<i>Cassia leiandra</i> Benth.	Not native
<i>Cassia nodosa</i> Buch.-Ham. ex Roxb.	Not native
<i>Cassia renigera</i> Benth.	Not native
<i>Cassia roxburghii</i> DC	Not native
<i>Cassia speciosa</i> Schrad.	Not native
<i>Senna alata</i> (L.) Roxb.	Not native
<i>Senna artemisioides</i> (DC.) Randell	Not native
<i>Senna bicapsularis</i> (L.) Roxb.	Not native
<i>Senna cana</i> (Nees & Mart.) H.S.Irwin & Barneby var. <i>pilosula</i> H.S.Irwin & Barneby	Not native
<i>Senna corymbosa</i> (Lam.) H.S. Irwin & Barneby	Not native
<i>Senna didymobotrya</i> (Fresen.) H.S. Irwin & Barneby	Not native
<i>Senna italica</i> Mill. subsp. <i>arachoides</i> (Burch.) Lock	Native
<i>Senna macranthera</i> (Collad.) H.S.Irwin & Barneby var. <i>micans</i> (Nees) H.S.Irwin & Barneby	Not native
<i>Senna multiglandulosa</i> (Jacq.) H.S. Irwin & Barneby	Not native
<i>Senna multijuga</i> (Rich.) Irwin & Barneby	Not native
<i>Senna obtusifolia</i> (L.) H.S. Irwin & Barneby	Not native
<i>Senna occidentalis</i> (L.) Link	Not native
<i>Senna odorata</i> (Morris) Randell	Not native
<i>Senna pendula</i> (Willd.) H.S. Irwin & Barneby var. <i>glabrata</i> (Vogel) H.S. Irwin & Barneby	Not native
<i>Senna pendula</i> (Willd.) H.S.Irwin & Barneby var. <i>pendula</i>	Not native
<i>Senna polyphylla</i> (Jacq.) H.S.Irwin & Barneby	Not native
<i>Senna petersiana</i> (Bolle) Lock	Native
<i>Senna septemtrionalis</i> (Viv.) H.S. Irwin & Barneby	Not native
<i>Senna siamea</i> (Lam.) H.S. Irwin & Barneby	Not native
<i>Senna sophera</i> (L.) Roxb.	Not native
<i>Senna spectabilis</i> (DeCandolle) H.S Irwin & Barneby	Not native
<i>Senna splendida</i> (Vogel) H.S.Irwin & Barneby	Not native
<i>Senna suretensis</i> (Burm. f.) H.S. Irwin & Barneby	Not native
<i>Senna</i> × <i>floribunda</i> H.S. Irwin & Barneby	Not native

Appendix 2.1. A weed risk assessment for *Cassia fistula* adapted from Pheloung et al. (1999) modified for use in South Africa.

Questions	Answers	References	Scores	Possible scores
Is the species highly domesticated?	No		0	0 or -3
Species suited to South African climate?	High			0, 1 or 2
Quality of climate match data (0-low; 1-intermediate; 2-high)	Intermediate			0, 1 or 2
Broad climate suitability (environmental versatility)	Yes	1	1	0 or 1
Native or naturalized in regions with dry extended periods	Yes	2, 3	1	0 or 1
Does the species have a history of repeated introductions outside its natural range?	Yes	1		0 or 2
Naturalized beyond native range	Yes	4	2	-2, -1, 0, 1, 2
Garden/amenity/disturbance weed	Yes	1, 6	2	0, 1 or 2
Weed of agriculture/horticulture/forestry	Yes	1, 6	4	0, 1, 2, 3, 4
Environmental weed	Yes	1, 6	4	0, 1, 2, 3, 4
Congeneric weed	Unknown			0, 1, 2
Produces spines, thorns, or burrs	No	7	0	0 or 1
Allelopathic	Yes	1	1	0 or 1
Parasitic	No	1	0	0 or 1
Unpalatable to grazing animals	Yes	1	1	-1 or 1
Toxic to animals	Unknown			0 or 1
Host for recognised pests and pathogens	Unknown			0 or 1
Causes allergies or is otherwise toxic to humans	No	1	0	0 or 1
Creates a fire hazard in natural ecosystems	Unknown			0 or 1
Is a shade tolerant plant at some stage of its life cycle?	Yes	1	1	0 or 1
Grows on infertile soils	Yes	1	1	0 or 1
Climbing or smothering growth habit	No	2	0	0 or 1
Forms dense thickets	Unknown			0 or 1
Aquatic	No	1	0	0 or 5
Grass	No	1	0	0 or 1
Nitrogen fixing woody plant	Yes	8	1	0 or 1
Geophyte	No	1	0	0 or 1
Evidence of substantial reproductive failure in native habitat	Unknown			0 or 1
Produces viable seed	Yes	1	1	-1 or 1
Hybridises naturally	Unknown			-1 or 1
Self-fertilisation	Unknown			-1 or 1

Requires specialist pollinators	Yes	5	-1	0 or -1
Reproduction by vegetative propagation	Yes	2	1	-1 or 1
Minimum generative time (years)	8-10	1	-1	-1, 0 or 1
Propagules likely to be dispersed unintentionally	No	1	-1	-1 or 1
Propagules dispersed intentionally by people	Yes	1	1	-1 or 1
Propagules likely to disperse as a produce contaminant	No	1	-1	-1 or 1
Propagules adapted to wind dispersal	No	2	-1	-1 or 1
Propagules buoyant	No	1	-1	-1 or 1
Propagules bird dispersed	No		-1	-1 or 1
Propagules dispersed by other animals (externally)	No	1	-1	-1 or 1
Propagules dispersed by other animals (internally)	Yes	1	1	-1 or 1
Prolific seed production	Yes	1	1	-1 or 1
Evidence that a persistent propagule bank is formed (N1 yr)	Yes	1	1	-1 or 1
Well controlled by herbicides	Unknown			-1 or 1
Tolerates or benefits from mutilation, cultivation, or fire	Yes	1	1	-1 or 1
Effective natural enemies present in South Africa	Unknown			-1 or 1

References:

1. CABI (2018)
2. Bosch (2007)
3. Champion and Seth (1968)
4. Randall (2012)
5. Saradhi et al. (1981)
6. Global Compendium of Weeds: [www.hera.org/gcw/species /cassia fistula/](http://www.hera.org/gcw/species/cassia_fistula/) accessed 20 July 2017
7. Personal observation
8. Barthakur et al. (1995)

Appendix 2.2. A weed risk assessment for *Senna alata* adapted from Pheloung et al. (1999) modified for use in South Africa.

Questions	Answers	References	Scores	Possible scores
Is the species highly domesticated?	No		0	0 or -3
Species suited to South African climate?	High			0, 1 or 2
Quality of climate match data (0-low; 1-intermediate; 2-high)	Intermediate			0, 1 or 2
Broad climate suitability (environmental versatility)	Yes	6	1	0 or 1
Native or naturalized in regions with dry extended periods	Yes	2, 6	1	0 or 1
Does the species have a history of repeated introductions outside its natural range?	Yes	7		0 or 2
Naturalized beyond native range	Yes	2, 6	2	-2, -1, 0, 1, 2
Garden/amenity/disturbance weed	Yes	6	2	0, 1 or 2
Weed of agriculture/horticulture/forestry	Yes	5	4	0, 1, 2, 3, 4
Environmental weed	Yes	9	4	0, 1, 2, 3, 4
Congeneric weed	Yes	1, 2, 3, 5, 6, 7, 8	2	0, 1, 2
Produces spines, thorns, or burrs	No	4	0	0 or 1
Allelopathic	Unknown			0 or 1
Parasitic	Unknown			0 or 1
Unpalatable to grazing animals	No	6	-1	-1 or 1
Toxic to animals	No	6	0	0 or 1
Host for recognised pests and pathogens	Yes	6	1	0 or 1
Causes allergies or is otherwise toxic to humans	No	6	0	0 or 1
Creates a fire hazard in natural ecosystems	Unknown			0 or 1
Is a shade tolerant plant at some stage of its life cycle?	No	6	0	0 or 1
Grows on infertile soils	Yes	6	1	0 or 1
Climbing or smothering growth habit	No	4	0	0 or 1
Forms dense thickets	Yes	5, 11	1	0 or 1
Aquatic	No	2	0	0 or 5
Grass	No	2	0	0 or 1
Nitrogen fixing woody plant	No	5	0	0 or 1
Geophyte	No	2	0	0 or 1

Evidence of substantial reproductive failure in native habitat	No	2	0	0 or 1
Produces viable seed	Yes	6	1	-1 or 1
Hybridises naturally	Unknown			-1 or 1
Self-fertilisation	Unknown			-1 or 1
Requires specialist pollinators	No	10	0	0 or -1
Reproduction by vegetative propagation	Yes	6	1	-1 or 1
Minimum generative time (years)	1	6	1	-1, 0 or 1
Propagules likely to be dispersed unintentionally	Yes	6	1	-1 or 1
Propagules dispersed intentionally by people	Yes	2, 6	1	-1 or 1
Propagules likely to disperse as a produce contaminant	Unknown			-1 or 1
Propagules adapted to wind dispersal	Unknown			-1 or 1
Propagules buoyant	Yes	6	1	-1 or 1
Propagules bird dispersed	Unknown			-1 or 1
Propagules dispersed by other animals (externally)	No	6	-1	-1 or 1
Propagules dispersed by other animals (internally)	Yes	6	1	-1 or 1
Prolific seed production	Unknown			-1 or 1
Evidence that a persistent propagule bank is formed (N1 yr)	Yes	6	1	-1 or 1
Well controlled by herbicides	Yes	5	-1	-1 or 1
Tolerates or benefits from mutilation, cultivation, or fire	Yes	6	1	-1 or 1
Effective natural enemies present in South Africa	Unknown			-1 or 1

References:

1. Brenan (1967)
2. Brummitt et al. (2007)
3. Gordon-Gray (1977)
4. Personal observation
5. Weber (2003)
6. CABI (2018)
7. Irwin and Barneby (1982)
8. Henderson (2001)
9. Csurhes and Edwards (1998)
10. Reddi et al. (1997)
11. Boa and Lenne (1994)

Appendix 2.3. A weed risk assessment for *Senna bicapsularis* adapted from Pheloung et al. (1999) modified for use in South Africa.

Questions	Answers	References	Scores	Possible scores
Is the species highly domesticated?	No		0	0 or -3
Species suited to South African climate?	High			0, 1 or 2
Quality of climate match data (0-low; 1-intermediate; 2-high)	Intermediate			0, 1 or 2
Broad climate suitability (environmental versatility)	Yes	11	1	0 or 1
Native or naturalized in regions with dry extended periods	Yes	3	1	0 or 1
Does the species have a history of repeated introductions outside its natural range?	Yes	3		0 or 2
Naturalized beyond native range	Yes	1	2	-2, -1, 0, 1, 2
Garden/amenity/disturbance weed	Yes	3	2	0, 1 or 2
Weed of agriculture/horticulture/forestry	Unknown			0, 1, 2, 3, 4
Environmental weed	Unknown			0, 1, 2, 3, 4
Congeneric weed	Yes	1, 3	2	0, 1, 2
Produces spines, thorns, or burrs	No	5	0	0 or 1
Allelopathic	Unknown			0 or 1
Parasitic	No		0	0 or 1
Unpalatable to grazing animals	Unknown			-1 or 1
Toxic to animals	Yes	2, 14	1	0 or 1
Host for recognised pests and pathogens	Yes	9	1	0 or 1
Causes allergies or is otherwise toxic to humans	Yes	13	1	0 or 1
Creates a fire hazard in natural ecosystems	Unknown			0 or 1
Is a shade tolerant plant at some stage of its life cycle?	No	14	0	0 or 1
Grows on infertile soils	Yes	14	1	0 or 1
Climbing or smothering growth habit	Yes	4	1	0 or 1
Forms dense thickets	Yes	6	1	0 or 1
Aquatic	No	3	0	0 or 5
Grass	No	3	0	0 or 1
Nitrogen fixing woody plant	Yes	15	1	0 or 1
Geophyte	No	3	0	0 or 1
Evidence of substantial reproductive failure in native habitat	No		0	0 or 1

Produces viable seed	Yes	12	1	-1 or 1
Hybridises naturally	Unknown			-1 or 1
Self-fertilisation	Unknown			-1 or 1
Requires specialist pollinators	Unknown			0 or -1
Reproduction by vegetative propagation	Unknown			-1 or 1
Minimum generative time (years)	Unknown			-1, 0 or 1
Propagules likely to be dispersed unintentionally	Unknown			-1 or 1
Propagules dispersed intentionally by people	Yes	5, 7, 8, 10	1	-1 or 1
Propagules likely to disperse as a produce contaminant	No	14	-1	-1 or 1
Propagules adapted to wind dispersal	No	12	-1	-1 or 1
Propagules buoyant	Unknown			-1 or 1
Propagules bird dispersed	Unknown			-1 or 1
Propagules dispersed by other animals (externally)	No	12	-1	-1 or 1
Propagules dispersed by other animals (internally)	Unknown			-1 or 1
Prolific seed production	Unknown			-1 or 1
Evidence that a persistent propagule bank is formed (N1 yr)	Yes	14	1	-1 or 1
Well controlled by herbicides	Unknown			-1 or 1
Tolerates or benefits from mutilation, cultivation, or fire	Unknown			-1 or 1
Effective natural enemies present in South Africa	Unknown			-1 or 1

References:

1. Brummitt et al. (2007)
2. Tabuti et al. (2003)
3. Gordon-Gray (1977)
4. Brenan (1967)
5. Personal observation
6. Weber (2003)
7. Mak et al. (2013)
8. Ondarza (2016)
9. Yang et al. (2017)
10. Schmidt (2002)
11. Peel et al. (2007)
12. Acevedo-Rodríguez (2005)
13. Henderson (2001)
14. Teketay (1996)
15. Boa and Lenne (1994)

Appendix 2.4. A weed risk assessment for *Senna corymbosa* adapted from Pheloung et al. (1999) modified for use in South Africa.

Questions	Answers	References	Scores	Possible scores
Is the species highly domesticated?	No		0	0 or -3
Species suited to South African climate?	High			0, 1 or 2
Quality of climate match data (0-low; 1-intermediate; 2-high}	Intermediate			0, 1 or 2
Broad climate suitability (environmental versatility)	Unknown			0 or 1
Native or naturalized in regions with dry extended periods	Yes	2	1	0 or 1
Does the species have a history of repeated introductions outside its natural range?	Yes	2		0 or 2
Naturalized beyond native range	Yes	2	2	-2, -1, 0, 1, 2
Garden/amenity/disturbance weed	Yes	1, 2, 9	2	0, 1 or 2
Weed of agriculture/horticulture/forestry	Unknown			0, 1, 2, 3, 4
Environmental weed	Unknown			0, 1, 2, 3, 4
Congeneric weed	Yes	1, 2, 4, 5, 6, 9	2	0, 1, 2
Produces spines, thorns, or burrs	No	7	0	0 or 1
Allelopathic	Unknown			0 or 1
Parasitic	Unknown			0 or 1
Unpalatable to grazing animals	Unknown			-1 or 1
Toxic to animals	Unknown			0 or 1
Host for recognised pests and pathogens	Unknown			0 or 1
Causes allergies or is otherwise toxic to humans	Unknown			0 or 1
Creates a fire hazard in natural ecosystems	Unknown			0 or 1
Is a shade tolerant plant at some stage of its life cycle?	Unknown			0 or 1
Grows on infertile soils	Unknown			0 or 1
Climbing or smothering growth habit	No	7	0	0 or 1
Forms dense thickets	Yes	2	1	0 or 1
Aquatic	No	7	0	0 or 5
Grass	No	7	0	0 or 1
Nitrogen fixing woody plant	Yes	8	1	0 or 1
Geophyte	No	7	0	0 or 1
Evidence of substantial reproductive failure in native habitat	Unknown			0 or 1

Produces viable seed	Yes	2	1	-1 or 1
Hybridises naturally	Unknown			-1 or 1
Self-fertilisation	Unknown			-1 or 1
Requires specialist pollinators	Yes	3	-1	0 or -1
Reproduction by vegetative propagation	Yes	2	1	-1 or 1
Minimum generative time (years)	Unknown			-1, 0 or 1
Propagules likely to be dispersed unintentionally	Unknown			-1 or 1
Propagules dispersed intentionally by people	Yes	2	1	-1 or 1
Propagules likely to disperse as a produce contaminant	Unknown			-1 or 1
Propagules adapted to wind dispersal	Unknown			-1 or 1
Propagules buoyant	Unknown			-1 or 1
Propagules bird dispersed	Unknown			-1 or 1
Propagules dispersed by other animals (externally)	Unknown			-1 or 1
Propagules dispersed by other animals (internally)	Unknown			-1 or 1
Prolific seed production	Unknown			-1 or 1
Evidence that a persistent propagule bank is formed (N1 yr)	Unknown			-1 or 1
Well controlled by herbicides	Unknown			-1 or 1
Tolerates or benefits from mutilation, cultivation, or fire	Unknown			-1 or 1
Effective natural enemies present in South Africa	Unknown			-1 or 1

References:

1. Gordon-Gray (1977)
2. Irwin and Barneby (1982)
3. Lin and Li (2011)
4. Weber (2003)
5. Brummitt et al. (2007)
6. Brenan (1967)
7. Personal observation
8. Boa and Lenne (1994)
9. Henderson (2001)

Appendix 2.5. A weed risk assessment for *Senna didymobotrya* adapted from Pheloung et al. (1999) modified for use in South Africa.

Questions	Answers	References	Scores	Possible scores
Is the species highly domesticated?	No		0	0 or -3
Species suited to South African climate?	High			0, 1 or 2
Quality of climate match data (0-low; 1-intermediate; 2-high)	Intermediate			0, 1 or 2
Broad climate suitability (environmental versatility)	Yes	8	1	0 or 1
Native or naturalized in regions with dry extended periods	Yes	1	1	0 or 1
Does the species have a history of repeated introductions outside its natural range?	Yes	1, 8		0 or 2
Naturalized beyond native range	Yes	1	2	-2, -1, 0, 1, 2
Garden/amenity/disturbance weed	Yes	1, 2, 4	2	0, 1 or 2
Weed of agriculture/horticulture/forestry	Yes	5	4	0, 1, 2, 3, 4
Environmental weed	Yes	5	4	0, 1, 2, 3, 4
Congeneric weed	Yes	1, 2, 3, 4, 7	2	0, 1, 2
Produces spines, thorns, or burrs	No	1, 3, 6	0	0 or 1
Allelopathic	Unknown			0 or 1
Parasitic	Unknown			0 or 1
Unpalatable to grazing animals	Unknown			-1 or 1
Toxic to animals	Yes	2	1	0 or 1
Host for recognised pests and pathogens	Yes	10	1	0 or 1
Causes allergies or is otherwise toxic to humans	Yes	10	1	0 or 1
Creates a fire hazard in natural ecosystems	Unknown			0 or 1
Is a shade tolerant plant at some stage of its life cycle?	Yes	1	1	0 or 1
Grows on infertile soils	Yes	5	1	0 or 1
Climbing or smothering growth habit	No	6	0	0 or 1
Forms dense thickets	Yes	8	1	0 or 1
Aquatic	No	1	0	0 or 5
Grass	No	1	0	0 or 1
Nitrogen fixing woody plant	Yes	9	1	0 or 1
Geophyte	No	1	0	0 or 1
Evidence of substantial reproductive failure in native habitat	No	4	0	0 or 1
Produces viable seed	Yes	10	1	-1 or 1

Hybridises naturally	Unknown			-1 or 1
Self-fertilisation	Unknown			-1 or 1
Requires specialist pollinators	Unknown			0 or -1
Reproduction by vegetative propagation	Unknown			-1 or 1
Minimum generative time (years)	2	10	0	-1, 0 or 1
Propagules likely to be dispersed unintentionally	Yes	5	1	-1 or 1
Propagules dispersed intentionally by people	Yes	1	1	-1 or 1
Propagules likely to disperse as a produce contaminant	Yes	5	1	-1 or 1
Propagules adapted to wind dispersal	Unknown			-1 or 1
Propagules buoyant	Unknown			-1 or 1
Propagules bird dispersed	Unknown			-1 or 1
Propagules dispersed by other animals (externally)	Unknown			-1 or 1
Propagules dispersed by other animals (internally)	Unknown			-1 or 1
Prolific seed production	Unknown			-1 or 1
Evidence that a persistent propagule bank is formed (N1 yr)	Unknown			-1 or 1
Well controlled by herbicides	Unknown			-1 or 1
Tolerates or benefits from mutilation, cultivation, or fire	Yes	1	1	-1 or 1
Effective natural enemies present in South Africa	Unknown			-1 or 1

References:

1. Gordon-Gray (1977)
2. Brummitt et al. (2007)
3. Brenan (1967)
4. Irwin and Barneby (1982)
5. [Global Compendium of Weeds:](http://www.hear.org/gcw/species/senna_didymobotrya/)
http://www.hear.org/gcw/species/senna_didymobotrya/ accessed 01 June 2017
6. Observation
7. Henderson (2001)
8. Weber (2003)
9. BioNET-EAFRINET Keys and Facts Sheets:
[https://keys.lucidcentral.org/keys/v3/eafrinet/weeds/key/weeds/Media/Html/Senna_didymobotrya_\(African_Senna\).htm](https://keys.lucidcentral.org/keys/v3/eafrinet/weeds/key/weeds/Media/Html/Senna_didymobotrya_(African_Senna).htm) accessed 01 June 2017
10. PROTA *Senna didymobotrya* (Fresen.) Irwin and Barneby:
[https://www.prota4u.org/database/protav8.asp?q=pe&p=Senna+didymobotrya+\(Fresen.\)+Irwin+&+Barneby](https://www.prota4u.org/database/protav8.asp?q=pe&p=Senna+didymobotrya+(Fresen.)+Irwin+&+Barneby) accessed 01 June 2018

Appendix 2.6. A weed risk assessment for *Senna hirsuta* adapted from Pheloung et al. (1999) modified for use in South Africa.

Questions	Answers	References	Scores	Possible scores
Is the species highly domesticated?	No		0	0 or -3
Species suited to South African climate?	High			0, 1 or 2
Quality of climate match data (0-low; 1-intermediate; 2-high)	Intermediate			0, 1 or 2
Broad climate suitability (environmental versatility)	Unknown			0 or 1
Native or naturalized in regions with dry extended periods	Yes	1, 2	1	0 or 1
Does the species have a history of repeated introductions outside its natural range?	Yes	1		0 or 2
Naturalized beyond native range	Yes	1	2	-2, -1, 0, 1, 2
Garden/amenity/disturbance weed	Yes	1	2	0, 1 or 2
Weed of agriculture/horticulture/forestry	Unknown			0, 1, 2, 3, 4
Environmental weed	Yes	6	4	0, 1, 2, 3, 4
Congeneric weed	Yes	1, 3, 4	2	0, 1, 2
Produces spines, thorns, or burrs	No	1	0	0 or 1
Allelopathic	Unknown			0 or 1
Parasitic	Unknown			0 or 1
Unpalatable to grazing animals	Yes	11	1	-1 or 1
Toxic to animals	Yes	11	1	0 or 1
Host for recognised pests and pathogens	Unknown			0 or 1
Causes allergies or is otherwise toxic to humans	No	10	0	0 or 1
Creates a fire hazard in natural ecosystems	Unknown			0 or 1
Is a shade tolerant plant at some stage of its life cycle?	Unknown			0 or 1
Grows on infertile soils	Unknown			0 or 1
Climbing or smothering growth habit	No	5	0	0 or 1
Forms dense thickets	Yes	7	1	0 or 1
Aquatic	No	1	0	0 or 5
Grass	No	1	0	0 or 1
Nitrogen fixing woody plant	Unknown			0 or 1
Geophyte	No	1	0	0 or 1
Evidence of substantial reproductive failure in native habitat	No	2, 6	0	0 or 1

Produces viable seed	Yes	11	1	-1 or 1
Hybridises naturally	Unknown			-1 or 1
Self-fertilisation	Unknown			-1 or 1
Requires specialist pollinators	Unknown			0 or -1
Reproduction by vegetative propagation	No	11	-1	-1 or 1
Minimum generative time (years)	5	11	-1	-1, 0 or 1
Propagules likely to be dispersed unintentionally	Yes	11	1	-1 or 1
Propagules dispersed intentionally by people	Yes	8, 9	1	-1 or 1
Propagules likely to disperse as a produce contaminant	Yes	7	1	-1 or 1
Propagules adapted to wind dispersal	Unknown			-1 or 1
Propagules buoyant	Yes	7	1	-1 or 1
Propagules bird dispersed	No	11	-1	-1 or 1
Propagules dispersed by other animals (externally)	Unknown			-1 or 1
Propagules dispersed by other animals (internally)	Yes	7	1	-1 or 1
Prolific seed production	Yes	3	1	-1 or 1
Evidence that a persistent propagule bank is formed (N1 yr)	Unknown			-1 or 1
Well controlled by herbicides	Unknown			-1 or 1
Tolerates or benefits from mutilation, cultivation, or fire	Yes	11	1	-1 or 1
Effective natural enemies present in South Africa	Unknown			-1 or 1

References:

1. Gordon-Gray (1977)
2. Brummitt et al. (2007)
3. Irwin and Barneby (1982)
4. Henderson (2001)
5. Personal observation
6. Global Compendium of Weeds: http://www.hear.org/gcw/species/senna_hirsuta/ accessed 22 July 2017
7. BioNET-EAFRINE Keys and Fact sheets: [http://keys.lucidcentral.org/keys/v3/eafrinet/weeds/key/weeds/Media/Html/Senna_hirsuta_\(Hairy_Senna\).htm](http://keys.lucidcentral.org/keys/v3/eafrinet/weeds/key/weeds/Media/Html/Senna_hirsuta_(Hairy_Senna).htm) accessed 23 July 2017
8. Hebbar et al. (2004)
9. Mesia et al. (2008)
10. Essiott and Basseby (2013)
11. Pacific Island Ecosystems at Risk (PIER) http://www.hear.org/pier/species/senna_hirsuta.htm accessed 23 July 2017

Appendix 2.7. A weed risk assessment for *Senna pendula* var. *glabrata* adapted from Pheloung et al. (1999) modified for use in South Africa.

Questions	Answers	References	Scores	Possible scores
Is the species highly domesticated?	No		0	0 or -3
Species suited to South African climate?	High			0, 1 or 2
Quality of climate match data (0-low; 1-intermediate; 2-high)	Intermediate			0, 1 or 2
Broad climate suitability (environmental versatility)	Yes	7	1	0 or 1
Native or naturalized in regions with dry extended periods	Yes	1	1	0 or 1
Does the species have a history of repeated introductions outside its natural range?	Yes	1, 2		0 or 2
Naturalized beyond native range	Yes	1, 2	2	-2, -1, 0, 1, 2
Garden/amenity/disturbance weed	Yes	1, 2	2	0, 1 or 2
Weed of agriculture/horticulture/forestry	Yes	2, 6	4	0, 1, 2, 3, 4
Environmental weed	Yes	6	4	0, 1, 2, 3, 4
Congeneric weed	Yes	1, 2, 3, 4, 5	2	0, 1, 2
Produces spines, thorns, or burrs	No	1	0	0 or 1
Allelopathic	Unknown			0 or 1
Parasitic	Unknown			0 or 1
Unpalatable to grazing animals	Unknown			-1 or 1
Toxic to animals	Unknown			0 or 1
Host for recognised pests and pathogens	Unknown			0 or 1
Causes allergies or is otherwise toxic to humans	Unknown			0 or 1
Creates a fire hazard in natural ecosystems	Unknown			0 or 1
Is a shade tolerant plant at some stage of its life cycle?	Unknown			0 or 1
Grows on infertile soils	Yes	7	1	0 or 1
Climbing or smothering growth habit	Yes	3, 7	1	0 or 1
Forms dense thickets	Unknown			0 or 1
Aquatic	No		0	0 or 5
Grass	No		0	0 or 1
Nitrogen fixing woody plant	Unknown			0 or 1
Geophyte	No	2	0	0 or 1
Evidence of substantial reproductive failure in native habitat	No	2, 7	0	0 or 1

Produces viable seed	Yes	7	1	-1 or 1
Hybridises naturally	Unknown			-1 or 1
Self-fertilisation	Unknown			-1 or 1
Requires specialist pollinators	Unknown			0 or -1
Reproduction by vegetative propagation	Yes	7	1	-1 or 1
Minimum generative time (years)	Unknown			-1, 0 or 1
Propagules likely to be dispersed unintentionally	Unknown			-1 or 1
Propagules dispersed intentionally by people	Yes	1	1	-1 or 1
Propagules likely to disperse as a produce contaminant	Unknown			-1 or 1
Propagules adapted to wind dispersal	Unknown			-1 or 1
Propagules buoyant	Yes	7	1	-1 or 1
Propagules bird dispersed	Unknown			-1 or 1
Propagules dispersed by other animals (externally)	Unknown			-1 or 1
Propagules dispersed by other animals (internally)	Unknown			-1 or 1
Prolific seed production	Yes	7	1	-1 or 1
Evidence that a persistent propagule bank is formed (N1 yr)	Unknown			-1 or 1
Well controlled by herbicides	Yes	6, 7	-1	-1 or 1
Tolerates or benefits from mutilation, cultivation, or fire	Unknown			-1 or 1
Effective natural enemies present in South Africa	Unknown			-1 or 1

References:

1. Gordon-Gray (1977)
2. Irwin and Barneby (1982)
3. Personal observation
4. Henderson (2001)
5. Gordon-Gray (1977)
6. Weeds of Australia:
https://keyserver.lucidcentral.org/weeds/data/media/Html/senna_pendula_var_glabrata.htm accessed 22 October 2017
7. Weber 2013

Appendix 2.8. A weed risk assessment for *Senna multijuga* adapted from Pheloung et al. (1999) modified for use in South Africa.

Questions	Answers	References	Scores	Possible scores
Is the species highly domesticated?	No		0	0 or -3
Species suited to South African climate?	High			0, 1 or 2
Quality of climate match data (0-low; 1-intermediate; 2-high)	Intermediate			0, 1 or 2
Broad climate suitability (environmental versatility)	Yes	1	1	0 or 1
Native or naturalized in regions with dry extended periods	Yes	1	1	0 or 1
Does the species have a history of repeated introductions outside its natural range?	Yes	1		0 or 2
Naturalized beyond native range	Yes	1	2	-2, -1, 0, 1, 2
Garden/amenity/disturbance weed	Yes	2	2	0, 1 or 2
Weed of agriculture/horticulture/forestry	Unknown			0, 1, 2, 3, 4
Environmental weed	Unknown			0, 1, 2, 3, 4
Congeneric weed	Yes	1, 2, 3, 4	2	0, 1, 2
Produces spines, thorns, or burrs	No	1	0	0 or 1
Allelopathic	Unknown			0 or 1
Parasitic	Unknown			0 or 1
Unpalatable to grazing animals	No	8	-1	-1 or 1
Toxic to animals	Unknown			0 or 1
Host for recognised pests and pathogens	Unknown			0 or 1
Causes allergies or is otherwise toxic to humans	No	1	0	0 or 1
Creates a fire hazard in natural ecosystems	Unknown			0 or 1
Is a shade tolerant plant at some stage of its life cycle?	Yes	1	1	0 or 1
Grows on infertile soils	Yes	1	1	0 or 1
Climbing or smothering growth habit	No	4, 7	0	0 or 1
Forms dense thickets	Unknown			0 or 1
Aquatic	No	6	0	0 or 5
Grass	No	6	0	0 or 1
Nitrogen fixing woody plant	Yes	5	1	0 or 1
Geophyte	No	6	0	0 or 1
Evidence of substantial reproductive failure in native habitat	Unknown			0 or 1

Produces viable seed	Yes	1	1	-1 or 1
Hybridises naturally	Unknown			-1 or 1
Self-fertilisation	Unknown			-1 or 1
Requires specialist pollinators	No	8	0	0 or -1
Reproduction by vegetative propagation	Unknown			-1 or 1
Minimum generative time (years)	1	1	1	-1, 0 or 1
Propagules likely to be dispersed unintentionally	No	1	-1	-1 or 1
Propagules dispersed intentionally by people	Yes	1	1	-1 or 1
Propagules likely to disperse as a produce contaminant	Yes	1	1	-1 or 1
Propagules adapted to wind dispersal	Yes	1	1	-1 or 1
Propagules buoyant	Unknown			-1 or 1
Propagules bird dispersed	Unknown			-1 or 1
Propagules dispersed by other animals (externally)	No	1	-1	-1 or 1
Propagules dispersed by other animals (internally)	No	1	-1	-1 or 1
Prolific seed production	Yes	1	1	-1 or 1
Evidence that a persistent propagule bank is formed (N1 yr)	Yes	1	1	-1 or 1
Well controlled by herbicides	Unknown			-1 or 1
Tolerates or benefits from mutilation, cultivation, or fire	Yes	1	1	-1 or 1
Effective natural enemies present in South Africa	Unknown			-1 Or 1

References:

1. CABI (2018)
2. Gordon-Gray (1977)
3. Brummitt et al. 2007)
4. Irwin and Barneby (1982)
5. Boa and Lenne (1994)
6. Personal observation
7. Parrotta et al. (1995)
8. Wolowski and Freitas (2011)

Appendix 2.9. A weed risk assessment for *Senna obtusifolia* adapted from Pheloung et al. (1999) modified for use in South Africa.

Questions	Answers	References	Scores	Possible scores
Is the species highly domesticated?	No		0	0 or -3
Species suited to South African climate?	High			0, 1 or 2
Quality of climate match data (0-low; 1-intermediate; 2-high)	Intermediate			0, 1 or 2
Broad climate suitability (environmental versatility)	Yes	4	1	0 or 1
Native or naturalized in regions with dry extended periods	Yes	4	1	0 or 1
Does the species have a history of repeated introductions outside its natural range?	Yes	1, 2		0 or 2
Naturalized beyond native range	Yes	1, 2, 3	2	-2, -1, 0, 1, 2
Garden/amenity/disturbance weed	Yes	1	2	0, 1 or 2
Weed of agriculture/horticulture/forestry	Yes	2, 7	4	0, 1, 2, 3, 4
Environmental weed	Yes	7	4	0, 1, 2, 3, 4
Congeneric weed	Yes	1, 2, 8	2	0, 1, 2
Produces spines, thorns, or burrs	No	6	0	0 or 1
Allelopathic	Unknown			0 or 1
Parasitic	Unknown			0 or 1
Unpalatable to grazing animals	Unknown			-1 or 1
Toxic to animals	Yes	5	1	0 or 1
Host for recognised pests and pathogens	Yes	4	1	0 or 1
Causes allergies or is otherwise toxic to humans	Unknown			0 or 1
Creates a fire hazard in natural ecosystems	Unknown			0 or 1
Is a shade tolerant plant at some stage of its life cycle?	Unknown			0 or 1
Grows on infertile soils	Yes	4	1	0 or 1
Climbing or smothering growth habit	No	6	0	0 or 1
Forms dense thickets	Yes	4	1	0 or 1
Aquatic	No	1	0	0 or 5
Grass	No	1	0	0 or 1
Nitrogen fixing woody plant	No	4, 7	0	0 or 1
Geophyte	No	1	0	0 or 1
Evidence of substantial reproductive failure in native habitat	No	4	0	0 or 1

Produces viable seed	Yes	4	1	-1 or 1
Hybridises naturally	No	4	-1	-1 or 1
Self-fertilisation	Unknown			-1 or 1
Requires specialist pollinators	Yes	4	-1	0 or -1
Reproduction by vegetative propagation	Unknown			-1 or 1
Minimum generative time (years)	1	4	1	-1, 0 or 1
Propagules likely to be dispersed unintentionally	Yes	4	1	-1 or 1
Propagules dispersed intentionally by people	Yes	4	1	-1 or 1
Propagules likely to disperse as a produce contaminant	Yes	9	1	-1 or 1
Propagules adapted to wind dispersal	Unknown			-1 or 1
Propagules buoyant	Yes	4, 9	1	-1 or 1
Propagules bird dispersed	Unknown			-1 or 1
Propagules dispersed by other animals (externally)	Yes	4, 9	1	-1 or 1
Propagules dispersed by other animals (internally)	Yes	4	1	-1 or 1
Prolific seed production	Yes	4, 7	1	-1 or 1
Evidence that a persistent propagule bank is formed (N1 yr)	Yes	4	1	-1 or 1
Well controlled by herbicides	Yes	4	-1	-1 or 1
Tolerates or benefits from mutilation, cultivation, or fire	Yes	4	1	-1 or 1
Effective natural enemies present in South Africa	Unknown			-1 or 1

References:

1. Brummitt et al. (2007)
2. Irwin and Barneby (1982)
3. Gordon-Gray (1977)
4. CABI (2018)
5. Furlan et al. (2014)
6. Personal observation
7. Weber (2003)
8. Henderson (2001)
9. BioNet-EAFRINET keys and fact sheets:
[https://keys.lucidcentral.org/keys/v3/eafrinet/weeds/key/weeds/Media/Html/Senna_obtusifolia_\(Sicklepod\).htm](https://keys.lucidcentral.org/keys/v3/eafrinet/weeds/key/weeds/Media/Html/Senna_obtusifolia_(Sicklepod).htm) accessed 22 June 2017

Appendix 2.10. A weed risk assessment for *Senna occidentalis* adapted from Pheloung et al. (1999) modified for use in South Africa.

Questions	Answers	References	Scores	Possible scores
Is the species highly domesticated?	No		0	0 or -3
Species suited to South African climate?	High			0, 1 or 2
Quality of climate match data (0-low; 1-intermediate; 2-high)	Intermediate			0, 1 or 2
Broad climate suitability (environmental versatility)	Yes	2	1	0 or 1
Native or naturalized in regions with dry extended periods	Yes	3	1	0 or 1
Does the species have a history of repeated introductions outside its natural range?	Yes	1, 2, 3		0 or 2
Naturalized beyond native range	Yes	3	2	-2, -1, 0, 1, 2
Garden/amenity/disturbance weed	Yes	1, 2, 3	2	0, 1 or 2
Weed of agriculture/horticulture/forestry	Yes	1	4	0, 1, 2, 3, 4
Environmental weed	Yes	5	4	0, 1, 2, 3, 4
Congeneric weed	Yes	1, 2	2	0, 1, 2
Produces spines, thorns, or burrs	No	4	0	0 or 1
Allelopathic	Unknown			0 or 1
Parasitic	Unknown			0 or 1
Unpalatable to grazing animals	Unknown			-1 or 1
Toxic to animals	Yes	3, 6	1	0 or 1
Host for recognised pests and pathogens	Yes	3	1	0 or 1
Causes allergies or is otherwise toxic to humans	No	3	0	0 or 1
Creates a fire hazard in natural ecosystems	Unknown			0 or 1
Is a shade tolerant plant at some stage of its life cycle?	Unknown			0 or 1
Grows on infertile soils	Yes	3	1	0 or 1
Climbing or smothering growth habit	No	4	0	0 or 1
Forms dense thickets	Yes	3	1	0 or 1
Aquatic	No	1, 2	0	0 or 5
Grass	No	1, 2	0	0 or 1
Nitrogen fixing woody plant	Unknown			0 or 1
Geophyte	No	1, 2	0	0 or 1
Evidence of substantial reproductive failure in native habitat	No	3	0	0 or 1
Produces viable seed	Yes	3	1	-1 or 1
Hybridises naturally	Unknown			-1 or 1
Self-fertilisation	Unknown			-1 or 1

Requires specialist pollinators	Unknown			0 or -1
Reproduction by vegetative propagation	Unknown			-1 or 1
Minimum generative time (years)	1	3	1	-1, 0 or 1
Propagules likely to be dispersed unintentionally	Yes	3	1	-1 or 1
Propagules dispersed intentionally by people	Yes	3	1	-1 or 1
Propagules likely to disperse as a produce contaminant	Yes	3	1	-1 or 1
Propagules adapted to wind dispersal	Unknown			-1 or 1
Propagules buoyant	Yes	3	1	-1 or 1
Propagules bird dispersed	Unknown			-1 or 1
Propagules dispersed by other animals (externally)	Yes	3	1	-1 or 1
Propagules dispersed by other animals (internally)	Unknown			-1 or 1
Prolific seed production	Unknown			-1 or 1
Evidence that a persistent propagule bank is formed (N1 yr)	Yes	3	1	-1 or 1
Well controlled by herbicides	Yes	3	-1	-1 or 1
Tolerates or benefits from mutilation, cultivation, or fire	Yes	3	1	-1 or 1
Effective natural enemies present in South Africa	Unknown			-1 or 1

References:

1. Gordon-Gray (1977)
2. Brummitt et al. (2007)
3. CABI (2018)
4. Personal observation
5. BioNet-EAFRINET Keys and Fact sheets:
[https://keys.lucidcentral.org/keys/v3/eafrinet/weeds/key/weeds/Media/Html/Senna_occidentalis_\(Coffee_Senna\).htm](https://keys.lucidcentral.org/keys/v3/eafrinet/weeds/key/weeds/Media/Html/Senna_occidentalis_(Coffee_Senna).htm) accessed 22 June 2017
6. Simpson et al., 1971

Appendix 2.11. A weed risk assessment for *Senna multiglandulosa* adapted from Pheloung et al. (1999) modified for use in South Africa.

Questions	Answers	References	Scores	Possible scores
Is the species highly domesticated?	No		0	0 or -3
Species suited to South African climate?	High			0, 1 or 2
Quality of climate match data (0-low; 1-intermediate; 2-high)	Intermediate			0, 1 or 2
Broad climate suitability (environmental versatility)	Yes	1	1	0 or 1
Native or naturalized in regions with dry extended periods	Yes	1, 8	1	0 or 1
Does the species have a history of repeated introductions outside its natural range?	Yes	2		0 or 2
Naturalized beyond native range	Yes	2, 4	2	-2, -1, 0, 1, 2
Garden/amenity/disturbance weed	Yes	1, 2	2	0, 1 or 2
Weed of agriculture/horticulture/forestry	Unknown			0, 1, 2, 3, 4
Environmental weed	Unknown			0, 1, 2, 3, 4
Congeneric weed	Yes	1, 2, 3, 7, 10	2	0, 1, 2
Produces spines, thorns, or burrs	No	1, 2	0	0 or 1
Allelopathic	Unknown			0 or 1
Parasitic	Unknown			0 or 1
Unpalatable to grazing animals	Unknown			-1 or 1
Toxic to animals	Unknown			0 or 1
Host for recognised pests and pathogens	Unknown			0 or 1
Causes allergies or is otherwise toxic to humans	Unknown			0 or 1
Creates a fire hazard in natural ecosystems	Unknown			0 or 1
Is a shade tolerant plant at some stage of its life cycle?	Unknown			0 or 1
Grows on infertile soils	Yes	9, 10	1	0 or 1
Climbing or smothering growth habit	No	3	0	0 or 1
Forms dense thickets	Unknown			0 or 1
Aquatic	No	1, 2	0	0 or 5
Grass	No	1, 2	0	0 or 1
Nitrogen fixing woody plant	Unknown			0 or 1
Geophyte	No	1, 2	0	0 or 1
Evidence of substantial reproductive failure in native habitat	No	1	0	0 or 1
Produces viable seed	Unknown			-1 or 1
Hybridises naturally	Yes	1, 6	1	-1 or 1
Self-fertilisation	Unknown			-1 or 1

Requires specialist pollinators	Unknown			0 or -1
Reproduction by vegetative propagation	Yes	8	1	-1 or 1
Minimum generative time (years)	Unknown			-1, 0 or 1
Propagules likely to be dispersed unintentionally	Unknown			-1 or 1
Propagules dispersed intentionally by people	Yes	5, 8	1	-1 or 1
Propagules likely to disperse as a produce contaminant	Unknown			-1 or 1
Propagules adapted to wind dispersal	Unknown			-1 or 1
Propagules buoyant	Unknown			-1 or 1
Propagules bird dispersed	Unknown			-1 or 1
Propagules dispersed by other animals (externally)	Unknown			-1 or 1
Propagules dispersed by other animals (internally)	Unknown			-1 or 1
Prolific seed production	Yes	1	1	-1 or 1
Evidence that a persistent propagule bank is formed (N1 yr)	Unknown			-1 or 1
Well controlled by herbicides	Unknown			-1 or 1
Tolerates or benefits from mutilation, cultivation, or fire	Yes	2	1	-1 or 1
Effective natural enemies present in South Africa	Unknown			-1 or 1

References:

1. Irwin and Barneby (1982)
2. Gordon-Gray (1977)
3. West (1996)
4. Teketay (1996)
5. Randell (1988)
6. Chaulagain and Sakya (2002)
7. Weber (2013)
8. SAN FRANCISCO Botanical Garden, collections:
https://www.sfbotanicalgarden.org/garden/bloom_15_06.shtml accessed 29 July 2017
9. Henderson (2001)
10. Plant Information Database: <http://www.tradewindsfruit.com/content/buttercup-bush.htm> accessed 29 July 2017

Appendix 2.12. A weed risk assessment for *Senna septemtrionalis* adapted from Pheloung et al. (1999) modified for use in South Africa.

Questions	Answers	References	Scores	Possible scores
Is the species highly domesticated?	No		0	0 or -3
Species suited to South African climate?	High			0, 1 or 2
Quality of climate match data (0-low; 1-intermediate; 2-high)	Intermediate			0, 1 or 2
Broad climate suitability (environmental versatility)	Yes	2	1	0 or 1
Native or naturalized in regions with dry extended periods	Yes	2	1	0 or 1
Does the species have a history of repeated introductions outside its natural range?	Yes	2		0 or 2
Naturalized beyond native range	Yes	1, 3	2	-2, -1, 0, 1, 2
Garden/amenity/disturbance weed	Yes	1, 2, 3	2	0, 1 or 2
Weed of agriculture/horticulture/forestry	Yes	2, 3	4	0, 1, 2, 3, 4
Environmental weed	Yes	2, 3	4	0, 1, 2, 3, 4
Congeneric weed	Yes	1, 2, 3	2	0, 1, 2
Produces spines, thorns, or burrs	No	4	0	0 or 1
Allelopathic	Unknown			0 or 1
Parasitic	Unknown			0 or 1
Unpalatable to grazing animals	Yes	5	-1	-1 or 1
Toxic to animals	Yes	2	1	0 or 1
Host for recognised pests and pathogens	Unknown			0 or 1
Causes allergies or is otherwise toxic to humans	Yes	2	1	0 or 1
Creates a fire hazard in natural ecosystems	Yes	2	1	0 or 1
Is a shade tolerant plant at some stage of its life cycle?	Yes	2	1	0 or 1
Grows on infertile soils	Yes	2	1	0 or 1
Climbing or smothering growth habit	No	5	0	0 or 1
Forms dense thickets	Unknown			0 or 1
Aquatic	No	5	0	0 or 5
Grass	No	5	0	0 or 1
Nitrogen fixing woody plant	Yes	6	1	0 or 1
Geophyte	No	5	0	0 or 1
Evidence of substantial reproductive failure in native habitat	No	2	0	0 or 1
Produces viable seed	Yes	3	1	-1 or 1
Hybridises naturally	Yes	1, 2, 3	1	-1 or 1

Self-fertilisation	Unknown			-1 or 1
Requires specialist pollinators	Unknown			0 or -1
Reproduction by vegetative propagation	Unknown			-1 or 1
Minimum generative time (years)	1	2	1	-1, 0 or 1
Propagules likely to be dispersed unintentionally	Yes	2	1	-1 or 1
Propagules dispersed intentionally by people	Yes	2	1	-1 or 1
Propagules likely to disperse as a produce contaminant	Unknown			-1 or 1
Propagules adapted to wind dispersal	Unknown			-1 or 1
Propagules buoyant	Yes	2	1	-1 or 1
Propagules bird dispersed	Yes	2	1	-1 or 1
Propagules dispersed by other animals (externally)	Yes	2, 4	1	-1 or 1
Propagules dispersed by other animals (internally)	Yes	2	1	-1 or 1
Prolific seed production	Yes	2	1	-1 or 1
Evidence that a persistent propagule bank is formed (N1 yr)	Yes	2, 4	1	-1 or 1
Well controlled by herbicides	Yes	2	-1	-1 or 1
Tolerates or benefits from mutilation, cultivation, or fire	Yes	4	1	-1 or 1
Effective natural enemies present in South Africa	Unknown			-1 or 1

References:

1. Irwin and Barneby (1982)
2. CABI (2018)
3. Gordon-Gray (1977)
4. West (1996)
5. Personal observation
6. Boa and Lenne (1994)

Appendix 2.13. A weed risk assessment for *Senna sophora* adapted from Pheloung et al. (1999) modified for use in South Africa.

Questions	Answers	References	Scores	Possible scores
Is the species highly domesticated?	No		0	0 or -3
Species suited to South African climate?	High			0, 1 or 2
Quality of climate match data (0-low; 1-intermediate; 2-high)	Intermediate			0, 1 or 2
Broad climate suitability (environmental versatility)	Unknown			0 or 1
Native or naturalized in regions with dry extended periods	Unknown			0 or 1
Does the species have a history of repeated introductions outside its natural range?	Unknown			0 or 2
Naturalized beyond native range	Unknown			-2, -1, 0, 1, 2
Garden/amenity/disturbance weed	Yes	5	Yes	0, 1 or 2
Weed of agriculture/horticulture/forestry	Unknown			0, 1, 2, 3, 4
Environmental weed	Unknown			0, 1, 2, 3, 4
Congeneric weed	Yes	4, 5	2	0, 1, 2
Produces spines, thorns, or burrs	No	4	0	0 or 1
Allelopathic	Unknown			0 or 1
Parasitic	Unknown			0 or 1
Unpalatable to grazing animals	Unknown			-1 or 1
Toxic to animals	Unknown			0 or 1
Host for recognised pests and pathogens	Yes	3	1	0 or 1
Causes allergies or is otherwise toxic to humans	No	3	0	0 or 1
Creates a fire hazard in natural ecosystems	Unknown			0 or 1
Is a shade tolerant plant at some stage of its life cycle?	Unknown			0 or 1
Grows on infertile soils	No	3	0	0 or 1
Climbing or smothering growth habit	No	4	0	0 or 1
Forms dense thickets	Unknown			0 or 1
Aquatic	No	1	0	0 or 5
Grass	No	1	0	0 or 1
Nitrogen fixing woody plant	Yes	2	1	0 or 1
Geophyte	No	1	0	0 or 1
Evidence of substantial reproductive failure in native habitat	Unknown			0 or 1
Produces viable seed	Unknown			-1 or 1
Hybridises naturally	Unknown			-1 or 1
Self-fertilisation	Unknown			-1 or 1

Requires specialist pollinators	Unknown			0 or -1
Reproduction by vegetative propagation	Unknown			-1 or 1
Minimum generative time (years)	Unknown			-1, 0 or 1
Propagules likely to be dispersed unintentionally	Unknown			-1 or 1
Propagules dispersed intentionally by people	Unknown			-1 or 1
Propagules likely to disperse as a produce contaminant	Unknown			-1 or 1
Propagules adapted to wind dispersal	Unknown			-1 or 1
Propagules buoyant	Unknown			-1 or 1
Propagules bird dispersed	Unknown			-1 or 1
Propagules dispersed by other animals (externally)	Unknown			-1 or 1
Propagules dispersed by other animals (internally)	Unknown			-1 or 1
Prolific seed production	Unknown			-1 or 1
Evidence that a persistent propagule bank is formed (N1 yr)	Unknown			-1 or 1
Well controlled by herbicides	Unknown			-1 or 1
Tolerates or benefits from mutilation, cultivation, or fire	Unknown			-1 or 1
Effective natural enemies present in South Africa	Unknown			-1 or 1

References:

1. Boa and Lenne (1994)
2. Personal observation
3. Useful
<http://tropical.theferns.info/viewtropical.php?id=Senna+sophera>
accessed 18 August 2017
4. Gordon-Gray (1977)
5. Irwin and Barneby (1982)

Plants:

Appendix 2.14. A weed risk assessment for *Senna siamea* adapted from Pheloung et al. (1999) modified for use in South Africa.

Questions	Answers	References	Scores	Possible scores
Is the species highly domesticated?	No		0	0 or -3
Species suited to South African climate?	High			0, 1 or 2
Quality of climate match data (0-low; 1-intermediate; 2-high)	Intermediate			0, 1 or 2
Broad climate suitability (environmental versatility)	Yes	4	1	0 or 1
Native or naturalized in regions with dry extended periods	Yes	4	1	0 or 1
Does the species have a history of repeated introductions outside its natural range?	Yes	4		0 or 2
Naturalized beyond native range	Yes	5	2	-2, -1, 0, 1, 2
Garden/amenity/disturbance weed	Yes	5	2	0, 1 or 2
Weed of agriculture/horticulture/forestry	Yes	5	4	0, 1, 2, 3, 4
Environmental weed	Yes	5	4	0, 1, 2, 3, 4
Congeneric weed	Yes	6	2	0, 1, 2
Produces spines, thorns, or burrs	No	6	0	0 or 1
Allelopathic	Unknown			0 or 1
Parasitic	Unknown			0 or 1
Unpalatable to grazing animals	Unknown			-1 or 1
Toxic to animals	Yes	1, 4	1	0 or 1
Host for recognised pests and pathogens	Yes	4	1	0 or 1
Causes allergies or is otherwise toxic to humans	No	4	0	0 or 1
Creates a fire hazard in natural ecosystems	Unknown			0 or 1
Is a shade tolerant plant at some stage of its life cycle?	Unknown			0 or 1
Grows on infertile soils	No	4	0	0 or 1
Climbing or smothering growth habit	No	4	0	0 or 1
Forms dense thickets	Yes	4	1	0 or 1
Aquatic	No	6	0	0 or 5
Grass	No	2, 6	0	0 or 1
Nitrogen fixing woody plant	No	2, 3	0	0 or 1
Geophyte	No	2, 6	0	0 or 1
Evidence of substantial reproductive failure in native habitat	No	4	0	0 or 1
Produces viable seed	Yes	4	1	-1 or 1
Hybridises naturally	Unknown			-1 or 1
Self-fertilisation	Unknown			-1 or 1
Requires specialist pollinators	Unknown			0 or -1
Reproduction by vegetative propagation	Yes	3	1	-1 or 1
Minimum generative time (years)	2-3	4	0	-1, 0 or 1

Propagules likely to be dispersed unintentionally	No	4	-1	-1 or 1
Propagules dispersed intentionally by people	Yes	4	1	-1 or 1
Propagules likely to disperse as a produce contaminant	No	4	-1	-1 or 1
Propagules adapted to wind dispersal	Unknown			-1 or 1
Propagules buoyant	Yes	4	1	-1 or 1
Propagules bird dispersed	No	4	-1	-1 or 1
Propagules dispersed by other animals (externally)	No	4	-1	-1 or 1
Propagules dispersed by other animals (internally)	No	4	-1	-1 or 1
Prolific seed production	Yes	4	1	-1 or 1
Evidence that a persistent propagule bank is formed (N1 yr)	Yes	4	1	-1 or 1
Well controlled by herbicides	Unknown			-1 or 1
Tolerates or benefits from mutilation, cultivation, or fire	Yes	4	1	-1 or 1
Effective natural enemies present in South Africa	Unknown			-1 or 1

References:

1. Irwin and Barneby (1982)
2. Personal observation
3. Kwesiga et al. (2003)
4. CABI (2018)
5. Global  Compendium of Weeds: http://www.hear.org/GCW/species/senna_siamea/ accessed 22 June 2017
6. Gordon-Gray (1977)

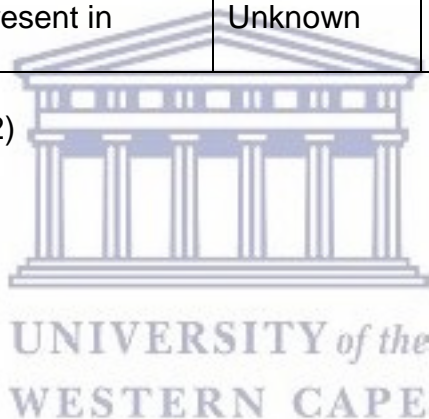
Appendix 2.15. A weed risk assessment for *Senna spectabilis* adapted from Pheloung et al. (1999) modified for use in South Africa.

Questions	Answers	References	Scores	Possible scores
Is the species highly domesticated?	No		0	0 or -3
Species suited to South African climate?	High			0, 1 or 2
Quality of climate match data (0-low; 1-intermediate; 2-high)	Intermediate			0, 1 or 2
Broad climate suitability (environmental versatility)	Yes	2	1	0 or 1
Native or naturalized in regions with dry extended periods	Yes	2	1	0 or 1
Does the species have a history of repeated introductions outside its natural range?	Yes	2		0 or 2
Naturalized beyond native range	Yes	1, 2	2	-2, -1, 0, 1, 2
Garden/amenity/disturbance weed	Yes	7	2	0, 1 or 2
Weed of agriculture/horticulture/forestry	Unknown			0, 1, 2, 3, 4
Environmental weed	Yes	7	4	0, 1, 2, 3, 4
Congeneric weed	Yes	1, 2, 5, 7, 8	2	0, 1, 2
Produces spines, thorns, or burrs	No	3	0	0 or 1
Allelopathic	Unknown			0 or 1
Parasitic	No		0	0 or 1
Unpalatable to grazing animals	Unknown			-1 or 1
Toxic to animals	Unknown			0 or 1
Host for recognised pests and pathogens	Unknown			0 or 1
Causes allergies or is otherwise toxic to humans	No	2	0	0 or 1
Creates a fire hazard in natural ecosystems	Unknown			0 or 1
Is a shade tolerant plant at some stage of its life cycle?	Unknown			0 or 1
Grows on infertile soils	Yes	2	1	0 or 1
Climbing or smothering growth habit	No	3	0	0 or 1
Forms dense thickets	Yes	2	1	0 or 1
Aquatic	No	3	0	0 or 5
Grass	No	3	0	0 or 1
Nitrogen fixing woody plant	Yes	4	1	0 or 1
Geophyte	No	3	0	0 or 1
Evidence of substantial reproductive failure in native habitat	No	1, 2	0	0 or 1
Produces viable seed	Yes	2	1	-1 or 1
Hybridises naturally	Unknown			-1 or 1
Self-fertilisation	Unknown			-1 or 1
Requires specialist pollinators	Unknown			0 or -1
Reproduction by vegetative propagation	Yes	1, 2	1	-1 or 1
Minimum generative time (years)	3	2	0	-1, 0 or 1

Propagules likely to be dispersed unintentionally	Yes	2	1	-1 or 1
Propagules dispersed intentionally by people	Yes	2	1	-1 or 1
Propagules likely to disperse as a produce contaminant	Unknown			-1 or 1
Propagules adapted to wind dispersal	Unknown			-1 or 1
Propagules buoyant	Yes	2	1	-1 or 1
Propagules bird dispersed	Unknown			-1 or 1
Propagules dispersed by other animals (externally)	Unknown			-1 or 1
Propagules dispersed by other animals (internally)	Unknown			-1 or 1
Prolific seed production	Unknown			-1 or 1
Evidence that a persistent propagule bank is formed (N1 yr)	Yes	2	1	-1 or 1
Well controlled by herbicides	Unknown			-1 or 1
Tolerates or benefits from mutilation, cultivation, or fire	Yes	2	1	-1 or 1
Effective natural enemies present in South Africa	Unknown			-1 or 1

References:

1. Irwin and Barneby (1982)
2. CABI (2018)
3. Personal observation
4. Boa and Lenne (1994)
5. Gordon-Gray (1977)
6. Weber (2013)
7. Randall (2012)
8. Henderson (2001)



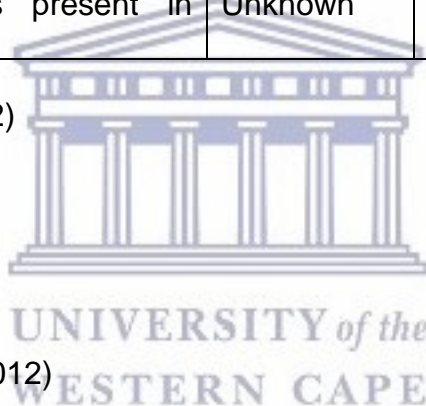
Appendix 2.16. A weed risk assessment for *Senna surattensis* adapted from Pheloung et al. (1999) modified for use in South Africa.

Questions	Answers	References	Scores	Possible scores
Is the species highly domesticated?	No		0	0 or -3
Species suited to South African climate?	High			0, 1 or 2
Quality of climate match data (0-low; 1-intermediate; 2-high)	Intermediate			0, 1 or 2
Broad climate suitability (environmental versatility)	Yes	2	1	0 or 1
Native or naturalized in regions with dry extended periods	Yes	2	1	0 or 1
Does the species have a history of repeated introductions outside its natural range?	Yes	2		0 or 2
Naturalized beyond native range	Yes	2	2	-2, -1, 0, 1, 2
Garden/amenity/disturbance weed	Yes	2	2	0, 1 or 2
Weed of agriculture/horticulture/forestry	Yes	2	4	0, 1, 2, 3, 4
Environmental weed	Yes	2	4	0, 1, 2, 3, 4
Congeneric weed	Yes	1, 2, 6, 7	2	0, 1, 2
Produces spines, thorns, or burrs	No	3	0	0 or 1
Allelopathic	Unknown			0 or 1
Parasitic	Unknown			0 or 1
Unpalatable to grazing animals	Unknown			-1 or 1
Toxic to animals	Unknown			0 or 1
Host for recognised pests and pathogens	Unknown			0 or 1
Causes allergies or is otherwise toxic to humans	No	2	0	0 or 1
Creates a fire hazard in natural ecosystems	Unknown			0 or 1
Is a shade tolerant plant at some stage of its life cycle?	Unknown			0 or 1
Grows on infertile soils	Unknown			0 or 1
Climbing or smothering growth habit	No	2	1	0 or 1
Forms dense thickets	No	2	0	0 or 1
Aquatic	No	3	0	0 or 5
Grass	No	3	0	0 or 1
Nitrogen fixing woody plant	Yes	4	1	0 or 1
Geophyte	No	3	0	0 or 1
Evidence of substantial reproductive failure in native habitat	No	2	0	0 or 1
Produces viable seed	Yes	2	1	-1 or 1
Hybridises naturally	Unknown			-1 or 1
Self-fertilisation	Unknown			-1 or 1
Requires specialist pollinators	Unknown			0 or -1
Reproduction by vegetative propagation	Unknown			-1 or 1
Minimum generative time (years)	>1	2	0	-1, 0 or 1


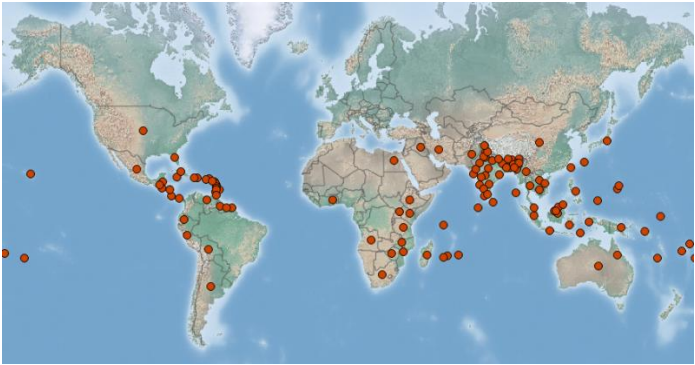
Propagules likely to be dispersed unintentionally	Yes	2	1	-1 or 1
Propagules dispersed intentionally by people	Yes	4	1	-1 or 1
Propagules likely to disperse as a produce contaminant	Unknown			-1 or 1
Propagules adapted to wind dispersal	No	8	-1	-1 or 1
Propagules buoyant	Unknown			-1 or 1
Propagules bird dispersed	No	2	-1	-1 or 1
Propagules dispersed by other animals (externally)	No	2	-1	-1 or 1
Propagules dispersed by other animals (internally)	No	2	-1	-1 or 1
Prolific seed production	Yes	2	1	-1 or 1
Evidence that a persistent propagule bank is formed (N1 yr)	Yes	2	1	-1 or 1
Well controlled by herbicides	Yes	5	-1	-1 or 1
Tolerates or benefits from mutilation, cultivation, or fire	Unknown			-1 or 1
Effective natural enemies present in South Africa	Unknown			-1 or 1

References:


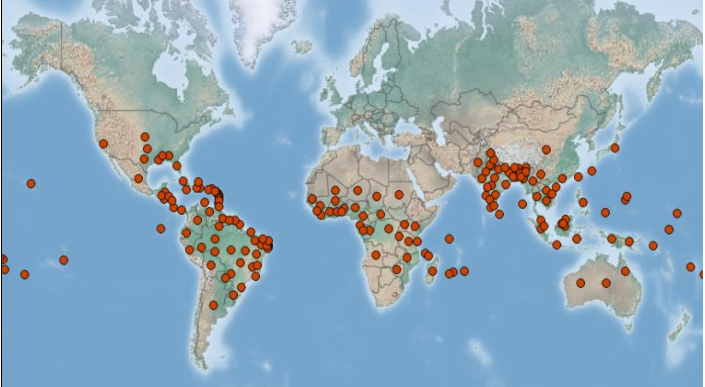
1. Irwin and Barneby (1982)
2. CABI (2018)
3. Personal observation
4. Boa and Lenne (1994)
5. Motooka et al. (2003)
6. Randall (2012)
7. Henderson (2001)
8. Poorten and Poorten (2012)




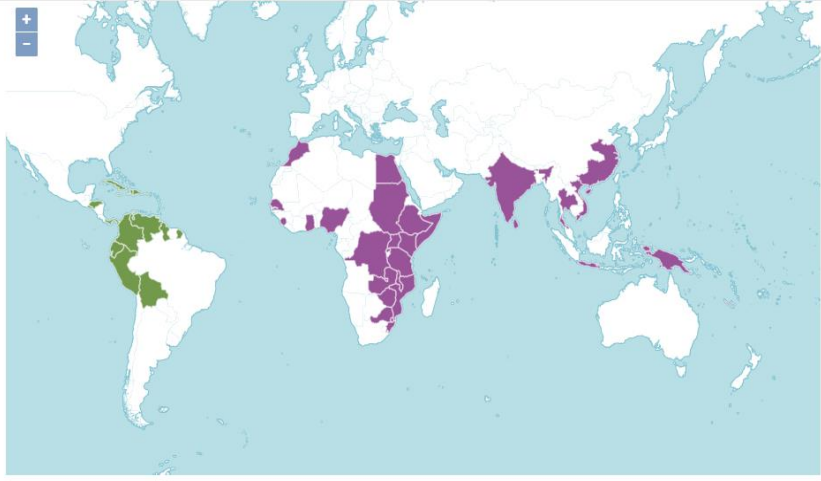
Appendix 3.1. Risk analysis report of *Cassia fistula* using framework and guideline for conducting risk analysis under NEM:BA (Kumschick et al., in press) in South Africa.

Taxon:	Area:	
 <p>Photo by Jim Conrad</p>	 <p>Map credit: CABI, 2018.</p>	
<p>Risk Assessment summary: <i>Cassia fistula</i> is known from a few sites from in Limpopo and KwaZulu-Natal Provinces. The species is suspected to have been introduced for ornamental purposes. It is considered an environmental weed (Randall, 2012), however, its impact is not quantified. It is also considered a host of serious pests (PIER, 2014).</p>	<p>Risk score: High</p>	
<p>Management options summary: <i>Cassia fistula</i> is widely used in cultivation for ornamental, medicinal and timber purposes (CABI, 2018). There is currently no information on management of the species.</p>	<p>Risk management: Medium</p>	
<p>Recommendations: Given its small distribution and its impact on the environment, <i>C. fistula</i> should be listed as Category 1a under NEM:BA, future studies should evaluate eradication feasibility of the species.</p>	<p>Listing category: 1a</p>	

Appendix 3.2. Risk analysis report of *Senna alata* using framework and guideline for conducting risk analysis under NEM:BA (Kumschick et al., in press) in South Africa.

<p>Taxon: <i>Senna alata</i></p>	<p>Area: South Africa</p>
 <p>Photo by Jim Conrad</p>	 <p>Map credit: CABI, 2018.</p>
<p>Risk Assessment summary: <i>Senna alata</i> is currently known from a limited number of sites in KwaZulu-Natal Province. The species is known to pose a serious threat to the environment and has the potential of spreading rapidly without control. It is an eradication target in the Galapagos Islands (Guézou et al., 2007).</p>	<p>Risk score: High</p>
<p>Management options summary: The species is used for ornamental and medicinal purposes (Ngarivhume et al., 2015). <i>Senna alata</i> is controlled by applying herbicide (picloram + 2, 4-D) to the cut surface of the stem (Weber, 2013; CABI, 2018).</p>	<p>Risk management: Medium</p>
<p>Recommendations: <i>Senna alata</i> forms dense thickets, species richness is strongly reduced under canopies of this species (Weber, 2013). In the first year, seedlings are known to establish extensive root systems and compete for nutrients and space with native plants (Weber, 2013; CABI, 2018). As such listing as Category 1a under the NEM:BA regulations appears warranted. Evaluation for eradication feasibility is recommended, before the species is widely spread.</p>	<p>Listing category: 1a</p>


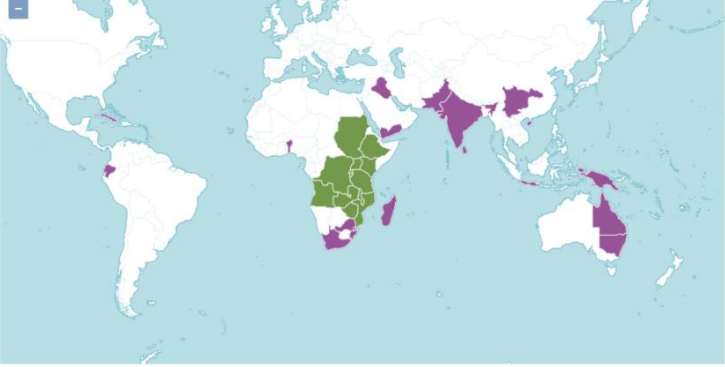
Appendix 3.3. Risk analysis report of *Senna bicapsularis* using framework and guideline for conducting risk analysis under NEM:BA (Kumschick et al., in press) in South Africa.

<p>Taxon: <i>Senna bicapsularis</i></p>	<p>Area: South Africa</p>	
 <p>Photo by Liada Musandiwa</p>	 <p>Map credit: plant of the world online database.</p>	
<p>Risk Assessment summary: <i>Senna bicapsularis</i> is currently known from Limpopo and KwaZulu-Natal Provinces of South Africa. This species scrambles and compete with other native species (Weber, 2013). It is also known to be poisonous to chickens, birds and bees (Henderson, 2001).</p>	<p>Risk score: High</p>	
<p>Management options summary: <i>Senna bicapsularis</i> is used for fencing, ornamental and medicinal purposes (Gordon-Gray; 1977; Olckers, 2004; Mak et al., 2013). The species can be controlled by digging out seedlings early after detection or removal by hand. Adult plants can be controlled by foliar or basal bark herbicide application (PIER, 2014).</p>	<p>Risk management: Medium</p>	
<p>Recommendations: <i>Senna bicapsularis</i> poses a significant invasion threat by climbing over native vegetation, impeding growth, and regeneration of native species (Weber, 2013). Furthermore, in China the species is known as host of <i>Diaporthe</i> species associated with canker disease (Yang et al., 2017). As such listing as Category 1b under the NEM:BA regulations appears warranted. Future studies should focus on the detail assessment of cost and potential success of control. Measures should also be taken to prohibit further cultivation of this species as this facilitates the spread of this species.</p>	<p>Listing category: 1b</p>	


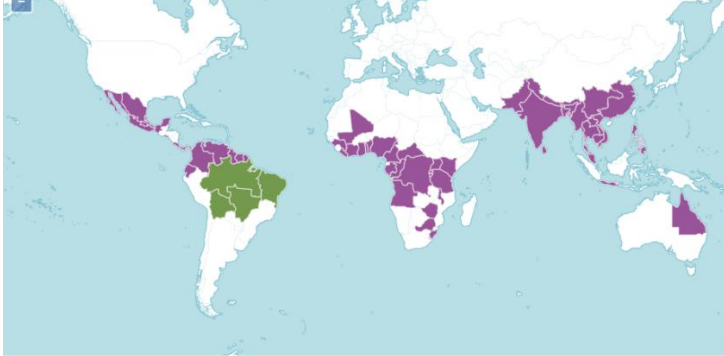
Appendix 3.4. Risk analysis report of *Senna corymbosa* using framework and guideline for conducting risk analysis under NEM:BA (Kumschick et al., in press) in South Africa.

<p>Taxon: <i>Senna corymbosa</i></p>	<p>Area: South Africa</p>	
 <p>Photo by Debbie Magnes</p>	 <p>Map credit: CABI, 2018.</p>	
<p>Risk Assessment summary: <i>Senna corymbosa</i> is known from a few sites in Mpumalanga, Gauteng, Free State, and KwaZulu-Natal. The species possesses invasive traits such as, high production of viable seeds, ability to reproduce by vegetation propagation (Irwin and Barneby, 1982), and formation of dense thickets (Boa and Lenne, 1994). Dense thickets impede the growth and regeneration of native plants (Weber, 2013; CABI, 2018).</p>	<p>Risk score: High</p>	
<p>Management options summary: The species is often grown for ornamental purposes in South Africa (Gordon-Gray; 1977). There is currently no records of management of <i>S. corymbosa</i>.</p>	<p>Risk management: Medium</p>	
<p>Recommendations: <i>Senna corymbosa</i> should be listed as Category 1a under NEM:BA, given its high risk and small distribution in South Africa. Future studies should evaluate the eradication feasibility.</p>	<p>Listing category: 1a</p>	


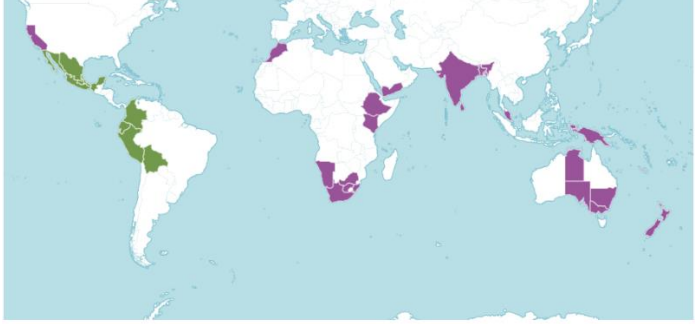
Appendix 3.5. Risk analysis report of *Senna didymobotrya* using framework and guideline for conducting risk analysis under NEM:BA (Kumschick et al., in press) in South Africa.

Taxon: <i>Senna didymobotrya</i>	Area: South Africa	
 <p>Photo by Liada Musandiwa</p>	 <p>Map credit: plant of the world online database.</p>	
<p>Risk Assessment summary: <i>Senna didymobotrya</i> has long been recognised as serious problem in South Africa (Henderson and Musil, 1984; Macdonald, 1983; Foxcroft et al., 2008). It is widely distributed in the Western Cape, Eastern Cape, KwaZulu-Natal, Mpumalanga, Gauteng and Limpopo Provinces. The species forms dense thickets and climbs over native plants, reducing growth and regeneration of native vegetation (Weber, 2013). Extensive thickets also affect wildlife movement and restrict them access to water (Weber, 2013). It is also known to be poisonous to fish (Neuwinger, 2004).</p>	High	
<p>Management options summary: <i>Senna didymobotrya</i> is valued for ornamental (Macdonald, 1983) and medicinal purposes (Cos et al., 2002; Jeruto et al., 2008; Namukobe et al., 2011; Nagappan, 2012). It is not clear how the species is controlled (Weber, 2013).</p>	Risk management: Medium	
<p>Recommendations: There is enough evidence that suggests the listing of the species as Category 1b under NEM:BA regulation. The national management programme should be developed to control and prohibit further spreading of the species.</p>	Listing category: 1b	


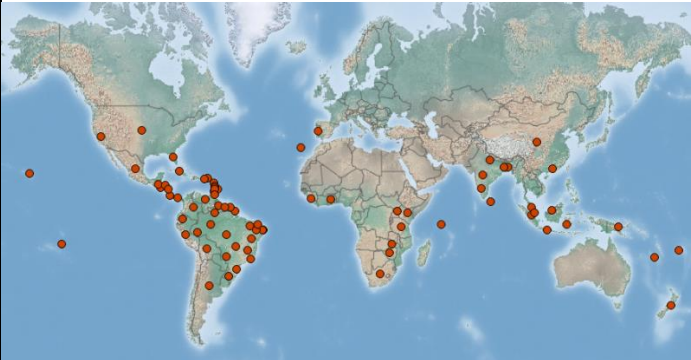
Appendix 3.6. Risk analysis report of *Senna hirsuta* using framework and guideline for conducting risk analysis under NEM:BA (Kumschick et al., in press) in South Africa.

<p>Taxon: <i>Senna hirsuta</i></p>	<p>Area: South Africa</p>
 <p>Photo by Lalithamba Nellore</p>	 <p>■ Native ■ Introduced Map credit: plant of the world online database.</p>
<p>Risk Assessment summary: <i>Senna hirsuta</i> is widely spread along the coast of KwaZulu-Natal. It is a weed in disturbed areas, roadsides, forest margins, plantations, coastal areas and riparian zones. It competes with the indigenous species and is poisonous to animal (Invasive species South Africa).</p>	<p>Risk score: High</p>
<p>Management options summary: <i>Senna hirsuta</i> is cultivated for ornamental and medicinal purposes (Hebbar et al., 2004; Singh et al., 2006; Mesia et al., 2008). There is no information available on control and management of the species.</p>	<p>Risk management: Medium</p>
<p>Recommendations: Evidence suggests that <i>S. hirsuta</i> should be listed as Category 1b under NEM:BA regulation. The national management programme should be developed to control and prohibit further spreading of the species.</p>	<p>Listing category: 1b</p>


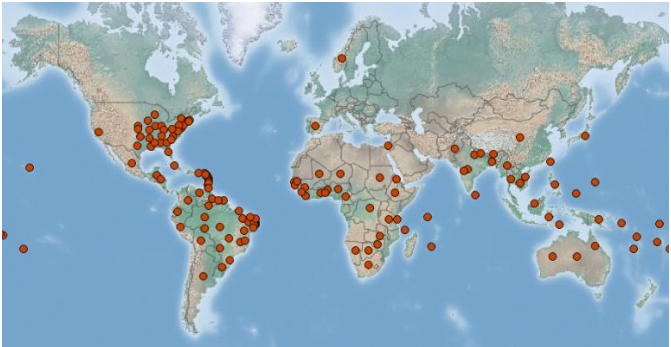
Appendix 3.7. Risk analysis report of *Senna multiglandulosa* using framework and guideline for conducting risk analysis under NEM:BA (Kumschick et al., in press) in South Africa.

Taxon: <i>Senna multiglandulosa</i>	Area: South Africa	
	 <p>■ Native ■ Introduced</p>	
Photo by Mona Bourell	Map credit: plant of the world online database.	
Risk Assessment summary: <i>Senna multiglandulosa</i> is currently distributed in the Western Cape and Eastern Cape. It is a prolific seeder, of easy culture and prone to colonize disturbed habitats and has ability to grow in different climates (broad climate suitability) (Irwin and Barneby, 1982) which constitute the high invasive risk of the species. It is garden weed (Teketay, 1996).	Risk score: High	
Management options summary: Information on management of the species is unknown.	Risk management: Medium	
Recommendations: Evidence suggest that <i>S. multiglandulosa</i> should be listed as Category 1a under NEM:BA. However, the impact of the species is not quantified. Future studies should focus on the impact assessment of the species before any action is taken.	Listing category: 1a	


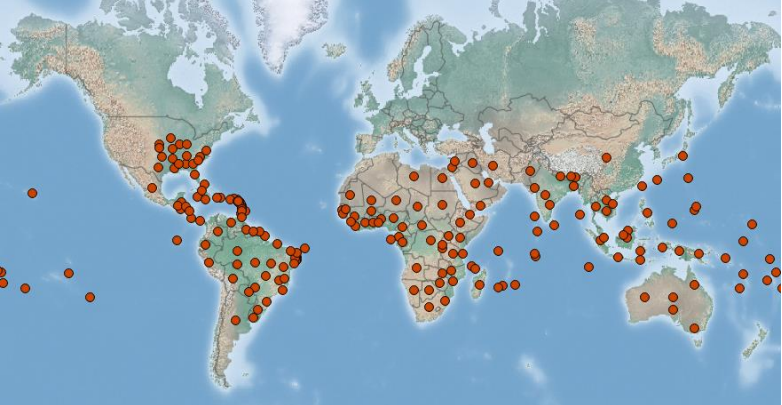
Appendix 3.8. Risk analysis report of *Senna multijuga* using framework and guideline for conducting risk analysis under NEM:BA (Kumschick et al., in press) in South Africa.

<p>Taxon: <i>Senna multijuga</i></p>	<p>Area: South Africa</p>	
 <p>Photo by Kim Starr</p>	 <p>Map credit: CABI, 2018.</p>	
<p>Risk Assessment summary: <i>Senna multijuga</i> is known from KwaZulu-Natal Province, and is currently known from a limited number of sites. The species has been identified as a potential threat to the environment due to its invasive traits such as, the production of viable seed, multiple vectors for seed dispersal, tolerates different types soil types and being a member of a weedy genus (<i>Senna</i>) (CABI, 2018). <i>Senna multijuga</i> negatively impacts agriculture and reduce native biodiversity (CABI, 2018). It is known to have high invasive risk in Hawaii (PIER, 2014).</p>	<p>Risk score: High</p>	
<p>Management options summary: <i>Senna multijuga</i> is used as ornament and in traditional medicine (Francisco et al., 2012). It is not clear how the species is managed. However, considering its small distribution, it is suitable for eradication.</p>	<p>Risk management: Medium</p>	
<p>Recommendations: Evidence suggests that <i>S. multijuga</i> should be listed as Category 1a under NEM:BA. Evaluation for eradication feasibility is recommended.</p>	<p>Listing category: 1a</p>	

Appendix 3.9. Risk analysis report of *Senna obtusifolia* using framework and guideline for conducting risk analysis under NEM:BA (Kumschick et al., in press) in South Africa.

<p>Taxon: <i>Senna obtusifolia</i></p>	<p>Area: South Africa</p>
 <p>Photo by <u>Ahmad Fuad Morad</u></p>	 <p>Map credit: CABI, 2018.</p>
<p>Risk Assessment summary: <i>Senna obtusifolia</i> is known from a few stands in the Eastern Cape, KwaZulu-Natal, Mpumalanga and Limpopo Provinces. It is a prolific seed producer and seeds may remain viable in the soil for many years (Weber, 2003). It forms dense thickets and competes with indigenous vegetation for nutrients, light and water (Weber, 2003). <i>Senna obtusifolia</i> has a negative impact on agriculture and has the potential to reduce crop production (CABI, 2018). It colonises and displaces native vegetation (Weber, 2003). In the Galapagos Islands, it is suspected to be causing significant ecological change (Weber, 2003). The seeds are poisonous to chickens (Cock and Evans, 1984).</p>	<p>Risk score: High</p>
<p>Management options summary: Single plants can be uprooted before flowering. Effective herbicides include 2,4-D plus picloram, dichlorprop or glyphosate (Weber, 2003). Seedlings can be sprayed before flowering (Weber, 2003). Polypropylene fabric inhibits the growth of the species (Martin et al., 1987).</p>	<p>Risk management: Medium</p>
<p>Recommendations: The evidence suggests a Category 1b listing under NEM:BA regulations. The species should be evaluated for eradication feasibility.</p>	<p>Listing category: 1a</p>



Appendix 3.10. Risk analysis report of *Senna occidentalis* using framework and guideline for conducting risk analysis under NEM:BA (Kumschick et al., in press) in South Africa.

Taxon: <i>Senna occidentalis</i>	Area: South Africa
 <p>Photo by Musandiwa Liada</p>	 <p>Map credit: CABI, 2018.</p>
<p>Risk Assessment summary:</p> <p><i>Senna occidentalis</i> is invasive in Limpopo, Mpumalanga, KwaZulu-Natal, and North West Provinces. It has the potential to spread widely in different environments. It has been reported as invasive in various countries in Africa, Asia and throughout Oceania (PIER, 2016). It considered to have high risk of introduction in tropical and subtropical regions (CABI, 2018). The species has a negative impact on agriculture, animal health and ecosystem services (PIER, 2016). <i>Senna occidentalis</i> is poisonous to children, it has been reported to be the cause of hepatomyoencephalopathy in western Uttar Pradesh (Vashishtha et al., 2007). Seeds have compound that damages the liver, heart, lungs and vascular system of livestock which result to a death of horses (Martin et al., 1981), goats (Suliman and Shommein, 1986), cattle (Rogers, 1979, Simpson et al., 1971), chicken (Haraguchi et al., 1998) and pigs (Martins et al., 1986).</p>	<p>Risk score:</p> <p>High</p>
<p>Management options summary:</p> <p><i>Senna occidentalis</i> is used for traditional medicine and ornamental purposes (Jain et al., 1998; Yadav et al., 2010). Seedlings are easily controlled by herbicides such as: bromoxynil, fluometuron, cyanazine, prometryn and imazapic (CABI, 2018).</p>	<p>Risk management:</p> <p>Medium</p>



<p>Recommendations: <i>Senna occidentalis</i> poses a significant threat to native vegetation, livestock and agriculture and as such a listing as Category 1b under NEM:BA is warranted. Assessment of potential control and managing of <i>S. occidentalis</i> in South Africa is recommended.</p>	<p>Listing category: 1b</p>
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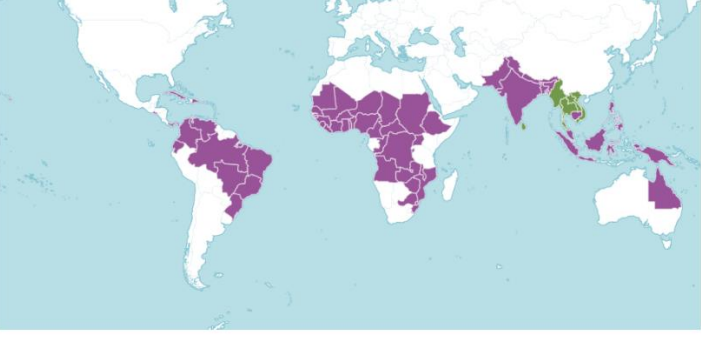
Appendix 3.11. Risk analysis report of *Senna pendula* var. *glabrata* using framework and guideline for conducting risk analysis under NEM:BA (Kumschick et al., in press) in South Africa.

<p>Taxon: <i>Senna pendula</i> var. <i>glabrata</i></p>	<p>Area: South Africa</p>	
	 <p>■ Native ■ Introduced</p> <p>Map credit: plant of the world online database.</p>	
<p>Photo by Sheldon Navie</p>		
<p>Risk Assessment summary: <i>Senna pendula</i> var. <i>glabrata</i> is distributed from the Eastern Cape Province, through KwaZulu-Natal, Mpumalanga and Limpopo. It is a fast growing shrub and prolific seed producer (Weber, 2003). <i>Senna pendula</i> var. <i>glabrata</i> is a salt tolerant and grows well in sandy soil, it has the ability to climb over indigenous vegetation, supressing their growth and displacing them (Weber, 2003).</p>	<p>Risk score: High</p>	
<p>Management options summary: <i>Senna pendula</i> var. <i>glabrata</i> is cultivated for ornamental purposes (Invasive species of South Africa). Seedlings and small plants can be easily removed manually. Seedlings and fresh regrowth are best treated by foliar sprays (Weber, 2013).</p>	<p>Risk management: Medium</p>	
<p>Recommendations: Listing of species as Category 1b under NEM:BA is recommended. Planting or trading species for ornamental or medicinal purpose should be prohibited. A national management programme should be developed to control or manage this species.</p>	<p>Listing category: 1b</p>	



Appendix 3.12. Risk analysis report of *Senna septemtrionalis* using framework and guideline for conducting risk analysis under NEM:BA (Kumschick et al., in press) in South Africa.

<p>Taxon: <i>Senna septemtrionalis</i></p>	<p>Area: South Africa</p>	
 <p>Photo by Musandiwa Liada</p>	 <p>Map credit: CABI, 2018.</p>	
<p>Risk Assessment summary: <i>Senna septemtrionalis</i> is naturalised and has become invasive in Limpopo, Gauteng, KwaZulu-Natal, North West, Gauteng and the Eastern Cape. The species is commonly used for ornamental purposes. According to the Global Compendium of Weeds, <i>Senna septemtrionalis</i> is agricultural and environmental weed (Randal, 2012). It is also known to invade disturbed areas, roadsides, forest margins and riverbanks (CABI, 2018). It is poisonous to fish (Neuwinger, 2004) and threat to endangered species and native vegetation (CABI, 2018). It is an eradication target in New Zealand and Raoul Island (CABI, 2018).</p>	<p>Risk score: High</p>	
<p>Management options summary: <i>Senna septemtrionalis</i> is cultivated for ornament, food (Devi and Salam, 2016) and traditional medicine (Ngarivhume et al., 2015; Singh et al., 2013). It is controlled by pulling/digging up seedlings. Seeds of matured plants are burnt before cutting the plant down (CABI, 2018).</p>	<p>Risk management: Medium</p>	
<p>Recommendations: Given the wide range of distribution in South Africa and its impact, listing as Category 1b under NEM:BA appears warranted. Measures should be undertaken to control and manage this species. Furthermore, cultivation of the species should be prohibited.</p>	<p>Listing category: 1b</p>	


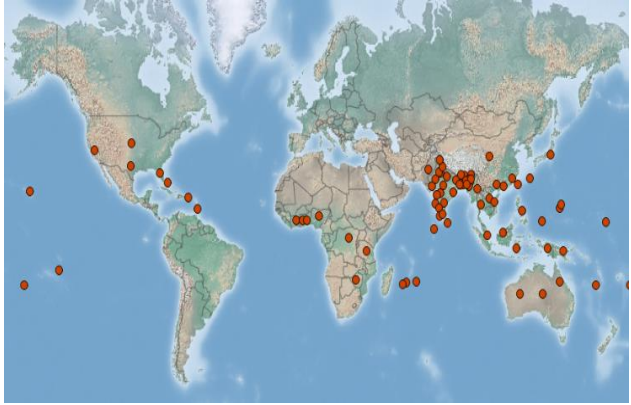
Appendix 3.13. Risk analysis report of *Senna siamea* using framework and guideline for conducting risk analysis under NEM:BA (Kumschick et al., in press) in South Africa.

<p>Taxon: <i>Senna siamea</i></p>	<p>Area: South Africa</p>	
 <p>Photo by Sheldon Navie.</p>	 <p>Map credit: plant of the world online database.</p>	
<p>Risk Assessment summary: <i>Senna siamea</i> is known from Limpopo, Mpumalanga and KwaZulu-Natal Provinces. Only a few sites of infestation are currently known in the country. Like many other <i>Senna</i> species, <i>S. siamea</i> is suspected to have been introduced for ornamental purposes. Due to its prolific seed production, rapid growth, and viable seeds it is likely to pose a serious invasion risk where introduced (CABI, 2018). The species is reported to have the potential of habitat alteration and outcompeting native vegetation (CABI, 2018). The pods and seeds are toxic to pigs (CABI, 2018).</p>	<p>Risk score: High</p>	
<p>Management options summary: <i>S. siamea</i> has significant economic impact through the production of high quality timber, fodder, mulch and fuel in the United States (CABI, 2018). In south eastern Nigeria is planted as hedgerow tree and interrow for maize/cassava intercrop (Hauser, 1993). It is also widely cultivated for ornamental and medicinal use (Jiraungkoorskul and Jiraungkoorskul, 2015; Mehta et al., 2017). There is no information on the control and management of the species.</p>	<p>Risk management: Medium</p>	
<p>Recommendations: <i>Senna siamea</i> should be listed as Category 3 and a national management programme should be developed. Stakeholders should engage to assess potential permit conditions for the effectiveness in reducing invasion risk.</p>	<p>Listing category: 3</p>	

Appendix 3.14. Risk analysis report of *Senna spectabilis* using framework and guideline for conducting risk analysis under NEM:BA (Kumschick et al., in press) in South Africa.

<p>Taxon: <i>Senna spectabilis</i></p>	<p>Area: South Africa</p>
 <p>Photo by Mauro Guanandi.</p>	 <p>Map credit: CABI, 2018.</p>
<p>Risk Assessment summary: <i>Senna spectabilis</i> is known from limited sites in the Mpumalanga Province. According to the Global Compendium of Weeds, <i>S. spectabilis</i> is environmental weed (Randall, 2012). The species poses a high risk because of its invasive traits including prolific seed production, and propagules that can remain viable for more than a year (CABI, 2018). The impact of <i>S. spectabilis</i> includes habitat alteration, native vegetation reduction, and loss of endangered and native species (CABI, 2018).</p>	<p>Risk score: High</p>
<p>Management options summary: <i>Senna spectabilis</i> is cultivated for ornamental purposes (Irwin and Barneby, 1982). It is not clear how the species is controlled.</p>	<p>Risk management: Medium</p>
<p>Recommendations: The evidence suggests a Category 1a listing under NEM:BA. <i>S. spectabilis</i> should be evaluated for eradication feasibility in South Africa.</p>	<p>Listing category: 1a</p>

Appendix 3.15. Risk analysis report of *Senna surattensis* using framework and guideline for conducting risk analysis under NEM:BA (Kumschick et al., in press) in South Africa.

<p>Taxon: <i>Senna surattensis</i></p>	<p>Area: South Africa</p>	
 <p>Photo by Kim Starr.</p>	 <p>Map credit: CABI, 2018.</p>	
<p>Risk Assessment summary: <i>Senna surattensis</i> is known in limited sites in the KwaZulu-Natal Province. The species was introduced for ornamental purposes. <i>Senna surattensis</i> is an environmental, agricultural or garden weed (Randall, 2012). It is known to outcompete native vegetation by shading (CABI, 2018).</p>	<p>Risk score: High</p>	
<p>Management options summary: <i>Senna surattensis</i> is cultivated as an ornamental and for hedging. The species has been shown to be sensitive to triclopyr (CABI, 2018). In Hawaii, a bioherbicide method based on the fungus <i>Acremonium</i> has been reported to have saved the cattle industry from collapse (CABI, 2018).</p>	<p>Risk management: Medium</p>	
<p>Recommendations: The evidence suggests Category 1a listing. The species should be evaluated for eradication feasibility.</p>	<p>Listing category: 1a</p>	



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Chamaecrista falcata (Caesalpinioideae, Cassieae, Cassiinae), a new species from South Africa

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Abstract

Chamaecrista falcata Musandiwa & Boatwr., a new species from the northern coastal regions of KwaZulu-Natal and the Waterberg in Limpopo, is described bringing the number of recognised species of *Chamaecrista* in southern Africa to 13. This taxon was previously confused with *Chamaecrista capensis* and treated under this species in the Flora of Southern Africa. The new species shares stipitate extrafloral nectaries with *Chamaecrista grantii* but is distinguished by its falcate leaflets with a strongly excentric midrib. A detailed description of the new species is presented, together with a distribution map and illustrations of its diagnostic characters.

Keywords: Extrafloral nectaries, *Cassia*, *Chamaecrista grantii*, *Chamaecrista capensis*, taxonomy

Introduction

Chamaecrista (L.) Moench. (1794: 272) is a large genus of about 330 species of trees, shrubs and herbs (Lewis *et al.*, 2005). The genus was previously included in *Cassia* L. (1753: 376) by Irwin and Barneby (1981), however, Irwin and Barneby's (1982) revision of Cassiinae species in the New World led to the subdivision of *Cassia* into three genera: *Cassia* s. str., *Chamaecrista*, and *Senna* Mill. (1754: 3). *Chamaecrista* is most diverse in South America, with about 259 species (Flora do Brazil, 2019). In contrast there are currently about 36 species recognised in Africa, 12 species in Australia and 6 species in Madagascar (Lewis *et al.*, 2005). The genus is divided into six morphologically distinguishable sections: Section *Absus* (Colladon 1816: 116) Irwin and Barneby (1982: 644), Section *Apoucouita* (Irwin and Barneby 1977: 281) Irwin and Barneby (1982: 641), Section *Calciopsis* Irwin and Barneby (1982: 857), Section *Chamaecrista*, Section *Grimaldia* (Schrank 1805: 184) Irwin and Barneby (1982: 664), and Section *Xerocalyx* (Bentham 1870: 155) Irwin and Barneby (1982: 862). The sections are easily recognised by a combination of glandular hair type, presence or absence of extrafloral nectaries and inflorescence structure (Irwin and Barneby, 1982). The new species described herein, *Chamaecrista falcata* Musandiwa and Boatwr., belongs to the section *Chamaecrista*. The species of this section are characterised by few or multiple leaflets, sessile or stipulate extrafloral nectaries, and axillary or supra-axillary inflorescences with 5 to 10 stamens (Brenan, 1967; Gordon-Gray, 1977; Irwin and Barneby, 1982; Brummitt *et al.*, 2007).

Here we describe a new species of *Chamaecrista* from the coastal region of KwaZulu-Natal and the Waterberg in Limpopo, South Africa, as part of ongoing taxonomic studies on the genus in this region. Gordon-Gray (1977) treated this taxon as an entity (Group 1) separate from the two varieties of *Chamaecrista capensis* E. Mey. (1832: 172) recognised in southern Africa, due to the long pedicels and leaflets with strongly excentric midribs. However, upon closer examination it is clear that this taxon differs from *C. capensis* in the long stalked extrafloral nectaries, fewer and wider leaflets, and smaller flowers. A detailed description of the newly recognised species is provided, together with its known geographical distribution and illustrations of the diagnostic characters.

Material and methods

Herbarium specimens from PRE and NU were examined (abbreviations according to Holmgren *et al.*, 1990) for *C. capensis* and the new species. Only six specimens of the new species could be found, and a search for more collections in other herbaria (NH, BNRH, WIND, and NBG including SAM) yielded no results. The distribution was mapped using habitat information obtained from herbarium collections and was recorded using the Quarter Degree Reference System for South Africa (Edward and Leistner, 1971). Illustrations were prepared using a ZEISS stemi 305 stereomicroscope with a ZEISS AxioCam 105 colour camera attached. Terminology for morphological features follows Gordon-Gray (1977), Irwin and Barneby (1982), and Harris and Harris (2001).

Key to *Chamaecrista falcata* in southern Africa

- 1a. Extrafloral nectaries present on petiole and between leaflet pairs, raised on distinct stalk 1.0–1.5 mm long; leaflets falcate *C. falcata*
- 1b. Extrafloral nectaries present on petiole only, sessile, or sub-sessile, or raised on small stalk less than 1 mm long; leaflets linear, oblong, obovate or elliptic other southern African *Chamaecrista* species

Taxonomy

Chamaecrista falcata Musandiwa & Boatwr., *sp. nov.* Type:—SOUTH AFRICA, KwaZulu-Natal Province, Hlabisa (2832): Hluhluwe-Imfolizi Park [Umfolozozi Game Reserve] (–AA), 11 November 1954, Ward 2439 (PRE!, holo., NU!, iso.). Fig. 1 & Fig. 2.

The new species is similar to *Chamaecrista grantii* (Oliver 1871: 279) Standl. (1917: 5) in the stalked extrafloral nectaries, but differs in that the extrafloral nectaries are on longer stalks, 1.0–1.5 mm (less than 1 mm in *C. grantii*), leaflets falcate (oblong in *C. grantii*), the leaflet midribs strongly excentric (rarely strong in *C. grantii*) and the petals smaller, ≤ 9 mm long and ≤ 5 mm wide (≥ 10 mm long and ≥ 6 mm wide in *C. grantii*).

Decumbent or prostrate herb, ± 0.3 m tall. *Stems* multiple branching from woody rootstock, erect to semi-erect covered with short curved and long patent hairs. *Leaves* paripinnate, 1–5 x 1.0–2.5 cm, tapering distally; stipules, 3–9 mm long, triangular, base oblique, apex acuminate, margin with long hairs; rachis channelled; rhachis extension 2–4 mm long; extrafloral nectaries in upper half of the petiole or slightly above the middle, sometimes on rhachis of lower leaflets, with a distinct stalk 1.0–1.5 mm long, dark brown, 0.02–0.03 mm in diameter, concave at the top. *Leaflets* 4–15-jugate, 3–15 x 1.5–4.0 mm, falcate, base oblique, apex apiculate, top surface with long scattered hairs, bottom surface glabrous, margin with curved or straight hairs; midrib strongly excentric towards anticous margin. *Inflorescences* axillary; 1–2 flowered; bract hairy, base oblique, apex acuminate, ± 3 mm long; bracteoles 2, narrowly triangular, base oblique, apex acuminate, with long patent hairs, above the upper half of the pedicel or towards top of pedicels. *Pedicels* with long scattered straight or curved hairs, at flowering (20) 30–45 mm long, at fruiting (22) 30–55 mm long. *Sepals* 5, narrowly lanceolate, 6–8 mm long; petals 5, sub-equal, 8–9 x 4–5 mm, obovate, bright yellow. *Stamens* 10, with very short filaments, ± 2 mm long, straight or slightly curved, anthers in three series, 5 small ± 3 mm long, 2 medium ± 4 mm long, slightly broader than the rest, 3 large ± 5 mm long. *Ovary* ± 10 mm long, densely hairy with straight or curved greyish hairs; style glabrous, narrow. *Pods* straight or slightly curved in the middle, 15–50 x 3–5 mm, flattened, with short curved hairs. Seeds not seen.

Diagnostic characters: The long stalked extrafloral nectaries (1.0–1.5 mm), long pedicels (30–45 mm long at flowering), widely spaced leaves and broad falcate leaflets (> 1.5 mm wide) distinguish *Chamaecrista falcata* from all other *Chamaecrista* species in southern Africa. The species has previously been confused with *C. capensis*. Two varieties have been recognised within *Chamaecrista capensis*. Meyer (1836) established *Chamaecrista capensis* var. *flavescens* E. Mey. (158: 1836) for plants with robust patent hairy stems, branches with yellow spreading hairs and extrafloral nectaries that are often obsolete or lacking. Steyaert (1950) described *Chamaecrista capensis* var. *keieusis* Steyaert (251: 1950) for plants with fairly long straight, more or less silky hairs except on the leaves and petals. *Chamaecrista capensis* var. *keieusis* was later included within *C. capensis* var. *flavescens* (Gordon-Gray, 1977). *Chamaecrista falcata* is readily distinguished from the *C. capensis* varieties by the long stalked extrafloral nectaries 1.0–1.5 mm long (Fig. 1F) (less the 1 mm in *C. capensis*), fewer and wider leaflets (more and narrower leaflets in

C. capensis) and small flowers (large in *C. capensis*) (Table 1). *Chamaecrista falcata* is further distinguished from *C. capensis* by the falcate leaflets (linear to linear-oblong in *C. capensis*). It shares the stalked extrafloral nectaries, present on the petiole and between leaflet pairs, with *Chamaecrista grantii* but differs in the falcate leaflets (oblong in *C. grantii*), extrafloral nectaries on longer stalks, 1.0–1.5 mm (less than 1 mm in *C. grantii*), the strongly excentric leaflet midribs (rarely so in *C. grantii*) (Fig. 1B) and the smaller petals (8–9 × 4–5 mm in *C. falcata* vs 10–14 × 6–9 mm in *C. grantii*). *Chamaecrista grantii* is absent from southern Africa (Brummitt *et al.*, 2007).

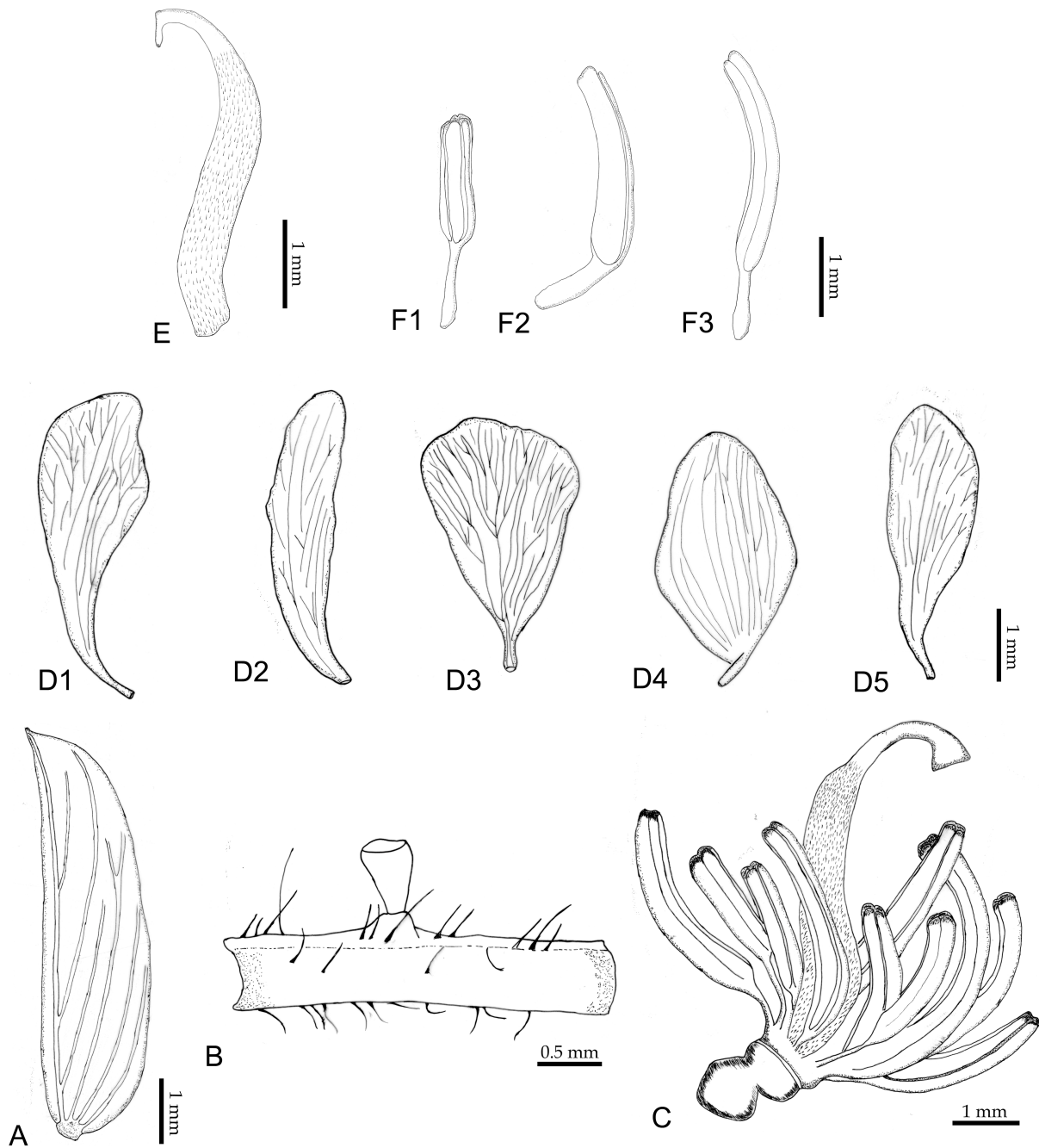


FIGURE 1. Morphology of *Chamaecrista falcata*. (A) falcate leaflet, midrib strongly excentric towards anticus margin, (B) long stalked extrafloral nectary, (C) staminal and ovary arrangement, (D1–D5) petals, (E) ovary, densely hairy and, (F1–F3) stamens, with anthers in three series. Voucher specimen: Ward 2439 (PRE).

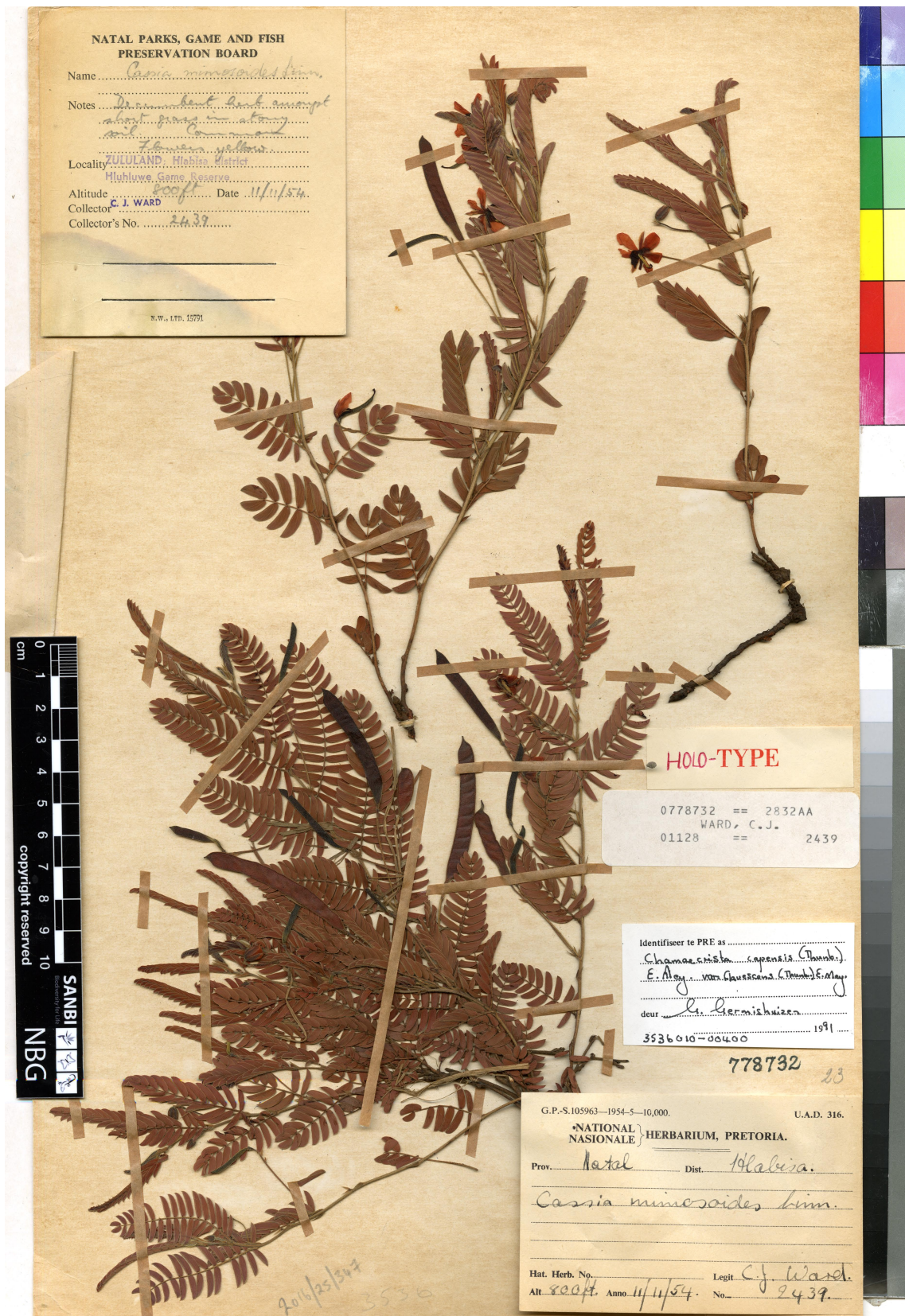


FIGURE 2. Holotype specimen of *Chamaecrista falcata*.

Additional specimens examined:

SOUTH AFRICA. Limpopo: **2428 (Waterberg)**: 7 miles (11,27 km) east of Magalakwin Causeway (–BB), 10 January 1955, Mogg 24430 (PRE).

KwaZulu-Natal: **2732 (uMkhanyakude)**: 16 km from Jozini on road to Ingwavuma (–AC), 28 November 1978, *Germishuizen 01016* (PRE). **2832 (Hlabisa)**: Gunjaneni (–AB), 16 November 1955, *Ward 2709* (NU, two sheets).

Distribution and habitat: The species is currently known only from the summer rainfall region of South Africa. It occurs in the Waterberg in Limpopo, and in the Hluhluwe-Imfolozi Park (formerly known as Hluhluwe-Imfolozi Game Reserve) in KwaZulu-Natal (Fig. 3) in grasslands on rocky or sandy soil.

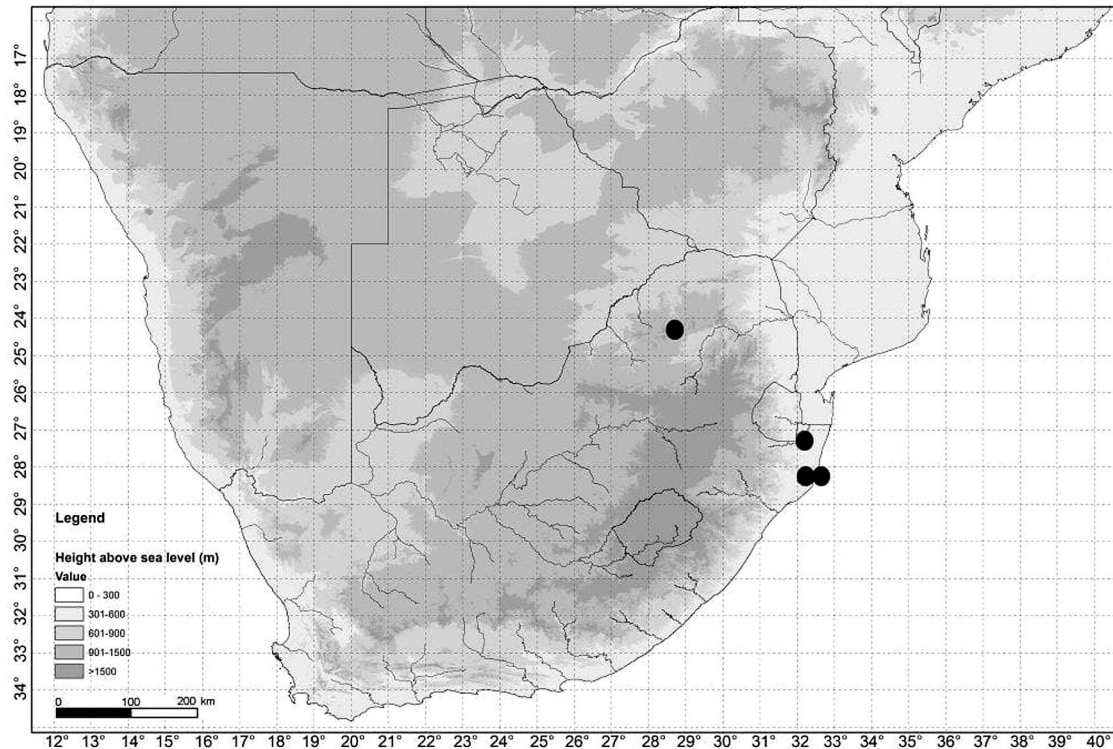


FIGURE 3. Known distribution of *Chamaecrista falcata* in southern Africa.

Etymology: the new species is named for its falcate leaves with strongly excentric midribs.

Flowering period: November–January.

Conservation status: *Chamaecrista falcata* is fairly widespread, occurring in Limpopo and KwaZulu-Natal, with at least one population within a protected area. The species is, however, still vulnerable to threats from overgrazing and urbanisation. A detailed conservation assessment will be conducted by the Threatened Species Programme of the South African National Biodiversity Institute (SANBI).

TABLE 1. Morphological characters that distinguish *Chamaecrista falcata* from *C. capensis* var. *capensis* and *C. capensis* var. *flavescens*.

	<i>Chamaecrista capensis</i> var. <i>capensis</i>	<i>Chamaecrista capensis</i> var. <i>flavescens</i>	<i>Chamaecrista falcata</i>
Stems	Prostrate or decumbent, glabrate or covered with silky straight or curved hairs.	Prostrate, decumbent or erect, often with one or a few stems branched in the upper half, with greyish or yellowish indumentum composed of long and short patent hairs or short curved appressed hairs, occasionally appearing glabrate or glabrous.	Prostrate or decumbent, multiple branches arising from a woody rootstock, covered with short curved and long patent hairs.

...continued on the next page

TABLE 1. (Continued)

	<i>Chamaecrista capensis</i> var. <i>capensis</i>	<i>Chamaecrista capensis</i> var. <i>flavescens</i>	<i>Chamaecrista falcata</i>
Extrafloral nectaries	Sub-sessile, circular, with stalk less than 1 mm long.	Sub-sessile, circular, with stalk less than 1 mm long, often obsolete.	Raised on a distinct stalk 1.0–1.5 mm long, dark brown, concave at the top.
Leaflet shape	Linear to oblong linear.	Linear to oblong linear.	Falcate.
Leaflet length and width	2–10 × 1–2 mm.	2–10 × 1–2 mm.	3–15 × 1.5–4.0 mm.
Leaflet number	14–20 jugate.	11–24 jugate.	4–15 jugate.
Pedice length	23–40 mm long.	18–40 mm long.	30–55 mm long.
N° of flowers	(1) 2–4 flowered.	(1) 2–4 flowered.	1–2 flowered.
Flower length	10–15 × 5–15 mm.	10–15 × 5–15 mm.	7–9 × 8–10 mm.

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