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Taxonomic significance of vegetative and reproductive morphology in southern Africa *Rhynchosia* sect. *Rhynchosia* (Fabaceae: Papilionoideae, Phaseoleae)

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Abstract. *Rhynchosia* is the largest genus in the subtribe Cajaninae, tribe Phaseoleae. Due to the lack of a recent taxonomic revision in the genus, the species are poorly known and as a result, are difficult to identify. As part of our ongoing taxonomic studies on the genus in southern Africa, this paper presents a comparative study of vegetative and floral morphological variation in the 47 species currently recognised in the type section *Rhynchosia* in the region. This is with a view to provide useful diagnostic morphological characters that can be used to correctly identify species in the type section and in other sections. The study used morphological data from field observation, herbarium specimens, and literature. Stems, leaves, and floral structures were examined with a dissecting microscope. A stereoscope with a *camera lucida* attachment was used to draw the reproductive morphology. Although morphological characters seem to overlap between the sections, characters such as leaflets size, type of indumentum on leaflet surfaces, stipules shape, type and length of inflorescences, presence or absence of indumentum on standard petals, presence and absence of sculpturing on wing petals, as well as length of upper lobes of the calyx are useful in identifying species.

Keywords: subtribe Cajaninae, tribe Phaseoleae, Leguminosae, Taxonomy.

INTRODUCTION

The significance of morphological characters in the taxonomy of the genera belonging to the family Fabaceae has been stressed by many researchers (Moteetee and Van Wyk 2006; Boatwright et al. 2010; Le Roux et al. 2010; Santos et al. 2012; Jeewon et al. 2013; Borges et al. 2018). Morphology has not only been useful in the identification and description of species within the family Fabaceae but has also been employed in phylogenetic studies and to understand the evolutionary patterns of plant taxa (LPWG 2017; Pinto et al. 2018; Silva et al. 2018). However, not all morphological characters are useful, while others are known to be more consistent, delimitative, or informative (Manoko 2007). For example, a superior ovary with one locule, two to many

ovules arranged in two alternating rows on a single placenta, as well as marginal placentation are the most consistent characters that can be used to distinguish members of the family Fabaceae (Lewis et al. 2005).

The genus *Rhynchosia* Lour. belongs to the cosmopolitan family Fabaceae, tribe Phaseoleae, subtribe Cajaninae (Schrire 2005). It is the largest genus in its subtribe with a pantropical distribution and more than 230 species globally, ca. 55 in America, ca. 35 in Asia, ca. 69 in southern Africa, and ca. 64 in South Africa (Schrire 2005; Germishuizen 2006; Boatwright and Moteetee 2014; Ajao et al. 2018; Bezerra et al. 2019). Globally, it is found in America, Africa and Madagascar, Asia, and Australia. In Africa, its distribution ranges from West Africa (Ghana and Nigeria) to Tropical East Africa (Congo, Kenya, Tanzania, Uganda), Zambesiaca region (Botswana, Caprivi Strip, Malawi, Mozambique, Zambia, and Zimbabwe), and southern Africa (eSwatini, Lesotho, Namibia, and South Africa). In South Africa, it is found in all the nine provinces (Ajao et al. in preparation).

Previously, the South African species of the genus were revised by Baker (1923) whereby 59 species were recognized and placed in five sections, namely: *Rhynchosia* sect. *Arcyphyllum* (Elliott) Torr. & Gray., *R.* sect. *Chrysoscias* Benth., *R.* sect. *Cyanospermum* (Wight & Arnott) Benth., *R.* sect. *Polytropia* (Presl) Harv., and *R.* sect. *Rhynchosia*. However, *Rhynchosia* sect. *Arcyphyllum* is not represented in Africa as it is native to North America, hence the segregation of the *R. densiflora* (Roth) DC. group from the section to avoid phytogeographical confusion (Jaca and Moteetee 2018). Therefore, *R. densiflora* complex is currently recognized as a distinct group pending the outcome of the phylogeny of the genus *Rhynchosia*. Even though reproductive characters are regarded to be more important than vegetative characters, the latter can also be used to provide a distinction between species. Both characters have been used to delineate members of the family Fabaceae. For example, genera of subtribe Cajaninae, namely, *Adenodolichos* Harms, *Bolusafr* Kuntze, *Cajanus* DC., *Dunbaria* Wight & Arn., *Eriosema* (DC.) G. Don, *Flemingia* Roxb. ex W.T. Aiton, *Paracalyx* Ali, and *Rhynchosia*, are generally distinguishable from other members of the tribe by the presence of bulbous-based hairs, capitate trichomes, secretory-base trichomes and vesicular glands (Moteetee and Van Wyk, 2006; de Vargas et al. 2018; de Vargas et al. 2019). Furthermore, within the subtribe, the genus *Adenodolichos* is identified by the presence of bracteoles (absent in all other genera), while the structure of the fruits is of diagnostic importance in separating the genera *Cajanus* and *Dunbaria*, where they are transversely

grooved in *Cajanus* but not in *Dunbaria*. Expanded and papery calyx lobes after flowering is diagnostic of the species in the genus *Paracalyx* while the genus *Flemingia* is identified by the sub-digitate or rarely unifoliate leaves. The genus *Eriosema* is distinguished from *Rhynchosia* by the following morphological characters: growth form or habit (subshrubs or erect, ascending, procumbent or prostrate, and never twining, vs. subshrubs or lianas/ erect, prostrate or twining), free or variably connate stipules (vs. always free stipules), absence of stipels (vs. stipels present in some species), hilum linear in shape (vs. hilum elliptical or oblong in shape), and funicle terminally attached to the hilum (vs. funicle centrally, subcentrally or occasionally terminally attached to the hilum) (Lackey 1981; Moteetee and Van Wyk, 2006; Cândido et al. 2019). A preliminary phylogenetic study in the genus by Manyelo (2014) revealed that the genus is not monophyletic as the other sections are embedded within the type section *Rhynchosia*.

In the ongoing taxonomic studies on the genus *Rhynchosia* in South Africa, reproductive and vegetative morphological characters have been successfully used to delineate species within groups, i.e. *R. densiflora* and *R. totta* groups and to revise *Rhynchosia* sect. *Chrysoscias*, *R.* sect. *Cyanospermum*, and *R.* sect. *Polytropia* (Moteetee et al. 2012; Moteetee et al. 2014; Moteetee and Le Roux 2016; Jaca and Moteetee 2018; Jaca et al. 2018). These morphological studies have also resulted in descriptions of a number of new species (Germishuizen 2011; Boatwright and Moteetee 2014; Moteetee et al. 2014; Ajao et al. 2018). The study here presented the morphological characters (reproductive and vegetative) of the species in the type section *Rhynchosia* in order to evaluate the characters that can be used to delineate species within the type section and between the other sections and group complexes.

MATERIALS AND METHODS

This study was based on the examination of herbarium specimens housed in BNRH, JRAU, and PRE (herbarium acronyms according to Thiers 2019) as well as on morphological observations of *Rhynchosia* species on the field. Stems, leaves, and floral structures were examined, and images were taken with a dissecting microscope with a digital camera attachment (OLYMPUS SZX2-TR30 JAPAN). Flowers were rehydrated in boiling water for 4–5 min, dissected under a binocular stereomicroscope and mounted in glycerol on a microscope slide for observation. A stereoscope with a *camera lucida* attachment was used to draw the reproductive morphology.

Data on both vegetative and reproductive morphology were taken from a minimum of five specimens per species in five replicates on each specimen except for some species with few available specimens. Also, a minimum of five mature flowers was dissected for each species with the exception of the species with few specimens available. Information regarding other sections and groups in the genus *Rhynchosia* was gathered from previously published studies from South Africa (Moteetee et al. 2012; Moteetee et al. 2014; Moteetee and Le Roux 2016; Jaca and Moteetee, 2018; Jaca et al. 2018). The taxon (*Rhynchosia* sect. *Rhynchosia*) studied is predominantly distributed in South Africa with some of the species extended to other southern African countries such as Botswana, eSwatini, Lesotho, Namibia, and Zimbabwe. The terminology used in this study is in accordance with the morphological species concept, as adopted by Gear (1978) and Isely (1990).

RESULTS AND DISCUSSION

A comparison of morphological characters between the species studied is presented in Table 1. Author citations are included here and will not be repeated elsewhere.

Vegetative Morphology

Growth habit

Rhynchosia species in the type section *Rhynchosia* are perennial herbs or shrubs with trailing, climbing, prostrate or erect to sub-erect or woody to sub-woody stems. Out of a total of 47 species that are currently recognized in the type section, 18 have erect or sub-erect growth form, these include *R. albissima*, *R. angulosa*, *R. bolusii*, *R. spectabilis*, *R. emarginata*, *R. pauciflora*, *R. sordida* and *R. sp. nov.* (Ajao et al. in preparation). The remaining species such as *R. caribaea*, *R. cilliata*, *R. fleckii*, *R. monophylla*, and *R. sublobata*, have trailing, climbing, or prostrate stems (Table 1, Figure 1). However, stems are woody at the base in some climbing or trailing species such as *R. capensis*, *R. coddii*, *R. fleckii*, *R. ovata* as well as taxa in the *R. totta* complex group (*R. totta* var. *totta*, *R. totta* var. *longicalyx*, *R. totta* var. *rigidula*, *R. totta* var. *venulosa* (Germishuizen 2011; Moteetee and Le Roux 2016). In sections *Cyanospermum*, *Chrysoscias* and *Polytropia*, stems are climbing, twining and trailing, whereas in the *R. densiflora* group they are twining, erect or prostrate (Moteetee et al. 2012; Moteetee et al. 2014; Jaca and Moteetee 2018; Jaca et al. 2018).

Indumentum

Stems are usually glabrescent to pubescent pilose to tomentose, velvety or villous with bulbous-based hairs and vesicular glands. Species such as *R. albissima*, *R. argentea*, *R. clivorum*, *R. crassifolia*, *R. emarginata*, *R. spectabilis*, and *R. waterberbergensis* have tomentose stems, in *R. woodi* and *R. angulosa* it is cano-pubescent or cano-pilose, while in *R. sordida* it is silky silvery-pilose and pilose in *R. ovata*. Taxa in the *R. totta* complex have stems that are usually glabrescent or pubescent with short hairs which are brownish or grey when young (Moteetee and Le Roux 2016). However, the stems are glandular in species such as *R. adenodes*, *R. arida*, *R. bullata*, *R. capensis*, and *R. cooperi* (Table 1). The indumentum type on the stems can be diagnostic as it can be used to distinguish between *R. caribaea* var. *caribaea* from *R. caribaea* var. *picta* in that it is pubescent in the former and tomentose in the latter.

Adaxial and abaxial surfaces of the leaves are usually glabrescent or pubescent to pilose or villous to velvety or tomentose, and glandular (yellow to orange or golden resin or dotted glands). Absence or presence of glands, and their distribution, can be of diagnostic importance in separating two morphologically similar species. For example, *R. nitens* shares tomentose stems and discoloured, silky silvery or velvety leaflets with *R. galpinii*. The former can be distinguished from the latter by the presence of glands on the surfaces, while they are absent in the latter. *Rhynchosia adenodes* can be easily confused with *R. cooperi* due to morphological similarities, i.e. having ovate-orbicular or subrhomboid leaflets, pubescent standard petals and axillary inflorescences with flowers arranged towards the apex. However, based on the distribution of glands, *R. adenodes* can be distinguished by its leaflets that are glandular on both surfaces while in *R. cooperi* they are glandular on abaxial surfaces only (Figure 2).

Leaf

Like most species in subtribe Cajaninae, the leaves of *Rhynchosia* sect. *Rhynchosia* are usually trifoliolate (Baker 1923), and rarely unifoliolate (e.g. *R. waterbergensis*) or having both types (*R. monophylla*, *R. nervosa*, and *R. totta* var. *totta*). In *Rhynchosia* sect. *Cyanospermum* and *R. sect. Chrysoscias*, the leaves are trifoliolate and never unifoliolate, whereas sect. *Polytropia* have trifoliolate to simply or pedately bipinnate, bi-tri-jugate, paucijugate, or supra-decompound leaves with *R. densiflora* group (*R. densiflora* subsp. *chrysadenia* var. *chrysadenia* (Taub.) Verdc. and *R. densiflora* subsp. *chrysadenia* var.

Table 1. Morphological comparison between taxa in *Rhynchosia* sect. *Rhynchosia*.

Species	Habit	Leaflets shape	Stem indumentum	Inflorescence type	Inflorescence length (mm)	Number of flowers	Standard petal	Wing	Fruits shape
<i>R. adenodes</i> Eckl. & Zey	Prostrate	Ovate-orbicular or subrhomboid,	Puberulous or sparsely pubescent and glandular	Axillary raceme	35–80(100)	2–7	Pubescent and glandular	Glandular, with sculpturing	Oblong
<i>R. albissima</i> Grand.	Erect sub-shrub	Obovate, rhomboid or elliptic,	Tomentose	Axillary raceme	60–130	10–20 or more	Pubescent and glandular	Glandular, with sculpturing	Oblong-falcate
<i>R. angulosa</i> Schinz	Erect herb or shrublet	Elliptic	Cano-pilose or cano-pubescent	Axillary raceme	30–80(120)	4–10	Glabrous	Glabrous, without sculpturing	Oblong-elliptic
<i>R. atropurpurea</i> Germish	Twining or climbing	Deltoid or rhomboid	Pubescent or pilose and glandular	Axillary raceme	60–150	7–13	Glandular	Glandular, with sculpturing	Oblong-falcate
<i>R. argentea</i> (Thunb.) Harv.	Climbing or creeping	Ovate	Tomentose	Axillary umbel	30–40	4–6	Pubescent and glandular	Glabrous, without sculpturing	Falcate
<i>R. arida</i> Stirt.	Erect straggling	Elliptic to ovate	Puberulous or glabrescent and glandular	Axillary raceme	15–30	2–4	Glabrous	Glabrous, with slight or no sculpturing	Oblong-falcate
<i>R. bolusii</i> Boatwr. & Moteetee	Erect or sub-erect (non-twining)	Narrowly oblong to oblong	Densely pilose to glabrescent and glandular	Axillary raceme	±15–40	1 or 2	Glabrous	Glabrous, without sculpturing	Broadly oblong
<i>R. bullata</i> Benth. ex Harv.	Erect	Oblong	Pubescent and glandular	Axillary raceme	25–40(60)	1–2	Glabrous	Glabrous, without sculpturing	Oblong
<i>Rhynchosia harmsiana</i> Schltr. ex Zahlr. var. <i>burchellii</i> Burt Davy	Twining	Rhomboid to deltoid or ovate-rhomboid	Villous, pubescent to pilose	Axillary raceme	20–65	4–10	Glabrous	Glabrous, with sculpturing	Oblong-falcate
<i>R. calvescens</i> Meikle	Twining	Deltoid or rhomboid	Sparsely pubescent	Axillary raceme	20–80(100)	3–8	Glabrous	Glabrous, without sculpturing	Falcate
<i>R. candida</i> (Welw. Ex Hiern)	Erect	Rhomboid or obovate-rhomboid	Canescent-tomentose and glandular	Axillary raceme	10–15	2–4	Pubescent and glandular	Glabrous, with sculpturing	Falcate
<i>R. capensis</i> (Burm. F.) Schinz	Climbing	Oblong to oblong-lanceolate, or ovate	Glandular	Axillary umbel	18–55(70)	2–6	Glabrous	Glabrous, with sculpturing	Oblong-elliptic
<i>R. caribaea</i> (Jacq.) DC. var. <i>caribaea</i>	Twining	Rhomboid to ovate-rhomboid or deltoid	Pubescent	Axillary raceme	35–110	8–22 or more	Glabrous	Glabrous, with sculpturing	Falcate
<i>Rhynchosia caribaea</i> var. <i>picta</i> (E. Mey.) Baker f.	Twining or climbing	Deltoid or rhomboid	Tomentose	Axillary raceme	60–80 (100)	8–12	Pubescent	Glabrous, with sculpturing	Fruit not seen
<i>R. ciliata</i> (Thunb.) Schinz	Prostrating	Elliptic to oblong	Villous	Axillary raceme	15–25	1–2	Glabrous	Glabrous, without sculpturing	Oblong

(Continued)

Species	Habit	Leaflets shape	Stem indumentum	Inflorescence type	Inflorescence length (mm)	Number of flowers	Standard petal	Wing	Fruits shape
<i>R. divorum</i> S. Moore	Erect	Ovate-elliptic or ovate-lanceolate	Tomentose	Axillary raceme	60–100 (140)	5–10 or more	Glabrous	Glabrous, with sculpturing	Oblong
<i>R. codii</i> Germish.	Trailing	Narrowly elliptic to broadly ovate	Densely pubescent	Axillary raceme	10–25	2–5	Glabrous	Glabrous, without sculpturing	Oblong falcate
<i>R. cooperi</i> (Harv. ex Baker f.) Burt & Davy.	Climbing and twinning	Ovate or suborbicular	Pubescent and glandular	Axillary raceme	80–170(200)	10–20	Pubescent and glandular	Glabrous, with sculpturing	Not seen
<i>R. crassifolia</i> Benth. ex Harv.	Trailing and procumbent	Elliptic-ovate	Tomentose	Axillary raceme	150–230(280)	10–22	Pubescent	Glabrous, without sculpturing	Fruits falcate
<i>R. emarginata</i> Germish.	Erect	Obcordate or broadly obovate	Tomentose and glandular	Axillary raceme	20–70	3–5	Glabrous	Glabrous, without sculpturing	Falcate
<i>R. fleckii</i> Schinz	Climbing, semi-erect	Ovate to obovate or elliptic to sub-rhomboid	Densely Pubescent to tomentose and glandular	Axillary raceme	10–25	2–4	Glabrous	Glabrous, without sculpturing	Oblong
<i>R. galpinii</i> Baker f.	Erect or sub-erect	Obovate to oblong-obovate or elliptic	Tomentose or velvety	Axillary umbel	15–40	2–4	Pubescent	Glabrous, with sculpturing	Oblong
<i>R. grandifolia</i> Steud.	Prostrate	Ovate to suborbicular	Pilose to tomentose	Axillary raceme	70–120	7–10	Glabrous	Glabrous, without sculpturing	Fruit not seen
<i>R. harveyi</i> Baker f.	Prostrate or climbing	Orbicular-rhomboid to deltoïd	Velvety	Axillary raceme	10–20 (40)	2–4	Glabrous	Glabrous, without sculpturing	Oblong
<i>R. hirsuta</i> Eckl. & Zeyh.	Twinning or trailing	Obovate-suborbicular	Pubescent	Axillary raceme	100–170 (190)	6–13	Pubescent	Glabrous, without sculpturing	Oblong-falcate
<i>R. holosericea</i> Schinz	Trailing	Orbicular to orbicular-ovate	Pubescent to pilose	Axillary raceme	40–170	3–10	Glabrous	Glabrous, without sculpturing	Oblong-falcate
<i>R. komatiensis</i> Harms	Erect	Ovate or ovate-orbicular	Tomentose	Axillary umbel	15–25(40)	1–2 or 4–10	Pubescent and glandular	Glabrous, without sculpturing	Oblong-falcate
<i>R. minima</i> (L.) DC. var. <i>minima</i> Meikle	Climbing	Rhomboid, ovate or suborbicular	Glabrous to velvety	Axillary raceme	20–180	Many flowered up to 24	Puberulous to pubescent and glandular	Glabrous, without sculpturing	Semi-falcate or falcate
<i>R. minima</i> (L.) DC. var. <i>glandularis</i> Mothogoane and Moteete	Prostrate	Rhomboid-ovate or suborbicular	Glabrous to velvety	Axillary raceme	40–150	Many flowered	Puberulous to pubescent and glandular	Glandular, without sculpturing	Oblong
<i>R. minima</i> (L.) DC. var. <i>magniflora</i> . Mothogoane and Moteete	Twinning and prostrate	Rhomboid-ovate or suborbicular	Glabrous to velvety	Axillary raceme	30–150 (250)	Many flowered	Puberulous to pubescent and glandular	Glabrous, without sculpturing	Oblong-obovate

(Continued)

Species	Habit	Leaflets shape	Stem indumentum	Inflorescence type	Inflorescence length (mm)	Number of flowers	Standard petal	Wing	Fruits shape
<i>R. minima</i> (L.) DC. var. <i>memmonia</i> (Del.) Meikle	Prostrate	Rhomboid-ovate or suborbicular	Densely velvety	Axillary raceme	30-130	Many flowered	Puberulous to pubescent and glandular	Glabrous, without sculpturing	Oblong
<i>R. minima</i> (L.) DC. var. <i>prostrata</i> (Harv.) Meikle	Prostrate	Rhomboid-ovate or suborbicular	Glabrous to velvety	Axillary raceme	20-130	Many flowered	Puberulous to pubescent and glandular	Glabrous, without sculpturing	Oblong
<i>R. monophylla</i> Schltr.	Trailing	Ovate or ovate-orbicular	Pubescent and sometimes glandular	Axillary raceme	15-25	1-3	Glabrous	Glabrous, with sculpturing	Elliptic
<i>R. nervosa</i> Benth. & Harv	Prostrate or twinning	Elliptic to elliptic-oblong or sub-rhomboid, Broadly ovate to cordate-	Pubescent or hispid-pubescent	Axillary raceme	62-135(210)	3-10	Glabrous	Glabrous, with sculpturing	Oblong-falcate
<i>R. nitens</i> Benth.	Erect	ovate or ovate-elliptic or suborbicular	Silky silvery or velvety to tomentose.	Axillary umbel	15-40	2-3	Pubescent	Glabrous, with sculpturing	Oblong-falcate
<i>R. ovata</i> Wood & Evans.	Trailing, semi-erect	Ovate to ovate-elliptic or suborbicular	Pilose	Axillary raceme	35-60	2-4	Glabrous	Glabrous, with sculpturing	Oblong
<i>R. pauciflora</i> Bolus	Erect	Oblong to linear or oblong-linear	Tomentose and glandular	Axillary raceme	35-80	1	Glabrous	Glabrous, with sculpturing	Oblong
<i>R. pedunculata</i> le Roux & Moteetee	Prostrate	lanceolate-elliptic	Pubescent-glabrescent	Axillary raceme	(30) 45-125	(1)2-4	Glabrous	Glabrous, without sculpturing	Oblong-elliptic
<i>R. pentheri</i> Schltr. ex Zahlbr. var. <i>pentheri</i>	Prostrate	Sub-orbicular or rhomboid-orbicular	Pubescent or puberulous and glandular	Axillary raceme	120-170(240)	8-10	Glabrous sometimes glandular	Glabrous, or sometimes glandular with sculpturing	Oblong-falcate
<i>R. pentheri</i> Schltr. ex Zahlbr. var. <i>hutchinsoniana</i> Burttt Davy	Prostrate	Sub-orbicular or rhomboid-orbicular	Pubescent and glandular	Axillary raceme	145-210(242)	8-20	Glabrous	Glabrous, with sculpturing	Oblong-falcate or falcate
<i>R. reptabunda</i> N.E.Br.	Climbing	Ovate suborbicular	Stems densely pubescent or pilose	Axillary raceme	70-100(130)	4-9	Glabrous	Glabrous, without sculpturing	Oblong-falcate
<i>R. resinosa</i> (Hochst. ex A.Rich.) Baker	Climbing	Deltoid or rhomboid	Puberulous and glandular	Axillary raceme or terminal	60-150	6-12	Pubescent and glandular	Glabrous, with sculpturing	Oblong
<i>R. schlechteri</i> Baker f.	Sub-erect	Ovate	Glandular and Pubescent	Axillary raceme	30-80 (100)	2-6	Glabrous	Glabrous, without sculpturing	Oblong
<i>R. sordida</i> (E. Mey.) Schinz	Erect	Elliptic to elliptic-oblong or oblanceolate	Silky silvery to pilose	Axillary raceme	5-15(30)	1-5	Glabrous	Glabrous, without sculpturing	Oblong

(Continued)

Species	Habit	Leaflets shape	Stem indumentum	Inflorescence type	Inflorescence length (mm)	Number of flowers	Standard petal	Wing	Fruits shape
<i>R. spectabilis</i> Schinz	Erect	Ovate or orbicular or orbicular	Canescent-tomentose	Axillary umbel	18–30	2–5	Pubescent and glandular	Glabrous, with sculpturing	Oblong
<i>R. sublobata</i> Schumach. & Meikle	Trailing, creeping or climbing	Deltoid or rhomboid	Pubescent or pilose	Axillary raceme	90–180 (260)	(10–17) or more	Pubescent	Glabrous, with sculpturing	Oblong-falcate and inflated
<i>R. thornicroffii</i> (Baker f.) Burt Davy	Twining, climbing or trailing	Deltoid or rhomboid-ovate Linear-lanceolate, lanceolate, elliptic or ovate,	Stem pubescent or pilose and glandular	Axillary raceme	30–80 (100)	3–10	Glabrous	Glabrous, without sculpturing	Oblong
<i>R. tottia</i> (Thunb.) DC. var. <i>tottia</i>	Twining or climbing, semi-erect	Lanceolate, lanceolate, elliptic or ovate,	Puberulous or Glabrescent	Axillary raceme	10–40	1–3	Glabrous	Glabrous, without sculpturing	Narrowly oblong
<i>R. tottia</i> var. <i>longicalyx</i> Moteeteete & le Roux	Twining or climbing, semi-erect	Ovate to lanceolate	Puberulous or glabrescent	Axillary raceme	18–55	2–5	Glabrous	Glabrous, without sculpturing	Narrowly oblong
<i>R. tottia</i> var. <i>rigidula</i> (DC.) Moteeteete & le Roux	Twining or climbing, semi-erect	Lanceolate to elliptic	Puberulous or glabrescent	Axillary raceme	13–16	1–3	Glabrous	Glabrous, without sculpturing	Narrowly oblong
<i>R. tottia</i> var. <i>venulosa</i> (Hiem) Verdc.	Twining or climbing, semi-erect	Lanceolate	Puberulous or glabrescent	Axillary raceme	23–40	2–4	Glabrous	Glabrous, without sculpturing	Narrowly oblong
<i>R. villosa</i> (Meisn.) Druce	Prostrate	Ovate to cordate-ovate or suborbicular	Villous to tomentose	Axillary raceme	100–200(250)	12–24	Glabrous	Glabrous, with sculpturing	Oblong-falcate
<i>R. vendae</i> Stirt.	Climbing	Rhomboid	Puberulous or sparsely pubescent	Axillary raceme	110–160	8–14	Pubescent and sometimes glandular	Glabrous, with sculpturing	Oblong-falcate
<i>R. waterbergensis</i> Ajao, Boatwr. & Moteeteete	Erect	Ovate or orbicular-ovate	Canescent-tomentose	Axillary raceme	25–60	4–8	Pubescent and glandular	Glabrous, with sculpturing	Fruit not seen
<i>R. woodii</i> Schinz i	Erect	Obovate or ovate Linear-lanceolate to oblong-lanceolate	Cano-pubescent	Axillary raceme	30–60 (80)	5–10	Glabrous	Glabrous, with sculpturing	Oblong
<i>R. sp. nov.</i>	Erect		Pubescent and glandular	Axillary raceme	(25–)30–42	1	Glabrous	Glabrous, without sculpturing	Oblong to broadly-oblong

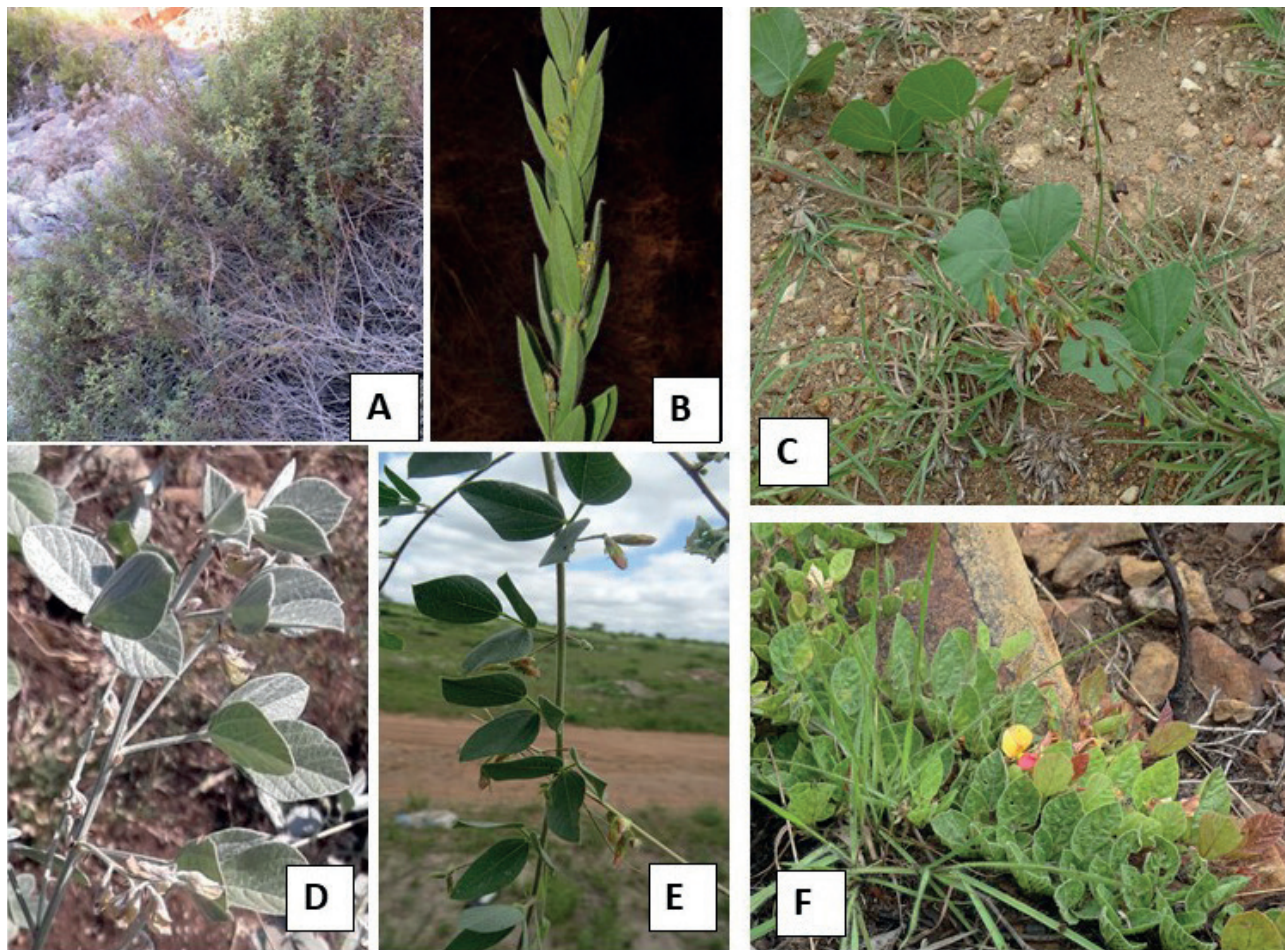


Figure 1. Growth habit of some *Rhynchosia* sect. *Rhynchosia* species. (A) Sub-erect stems of *R. schlechteri* (B) Erect stem of *R. sordida*, (C) Trailing stem of *R. sublobata*. (D) Erect stem of *R. albissima*. (E) Climbing stem of *R. fleckii*. (F) Trailing stem of *R. monophylla*. Photo by Pieter Mier (A), John Burrows (B), Mothogoane (D), Abdulwakeel Ajao (C,E,F).

connata (Baker f.) Jaca & Moteetee) having unifoliate or trifoliate leaves (Moteetee et al. 2012; Moteetee et al. 2014; Jaca and Moteetee 2018; Jaca et al. 2018). In this regard, the latter group is closely allied to the type section. In addition, the leaflet shape varies greatly in *R. sect. Rhynchosia* from oblong, linear to narrowly or broadly elliptic, ovate, obovate, obcordate, lanceolate, rhomboid and deltoid or sub-orbicular. The leaflets are linear to narrowly linear, or linear-lanceolate and lanceolate to oblong-lanceolate in *R. sect. Chrysoscias*, they are broadly elliptic to ovate or cordate in *R. sect. Cyanospermum* and lanceolate to linear-lanceolate, or elliptic to elliptic-lanceolate in *R. sect. in R. sect. Polytropia*. The presence of lanceolate to linear-lanceolate leaflets in both *R. sect. Polytropia* and *R. sect. Chrysoscias* suggests they are morphologically related. Furthermore, they are elliptic-ovate, rhomboidal to rhomboidal-ovate or almost round in *Rhynchosia densiflora* group. Leaf size can be

as small 5–10 × 2–5 mm as in *R. bullata* and can be as big 45–150 (220) × 37–140 (230) mm in *R. villosa*. Leaf margins are usually entire but sometimes revolute in species such as *R. bullata*, *R. capensis*, *R. pauciflora*, and *R. sp. nov.* as well as species belonging to *R. sect. Chrysoscias* (Jaca et al. 2018). Leaf venation usually reticulate to cross-venulate, apices acute to mucronate or apiculate, acuminate or emarginate, bases rounded to oblique or cordate or cuneate.

Petiole and petiolule length is usually varied among the species, petioles are 1–63 mm long while petiolules are 2–30 mm long, and they are both usually pubescent to tomentose or pilose and glandular. Petiole length is of diagnostic importance in separating the different sections, for example, it is much longer in *R. sect. Cyanospermum* (up to 140 mm long), and much shorter in *R. sect. Chrysoscias*, (2.2–8.6 mm long), while *R. sect. Polytropia* and *R. densiflora* group range between the two

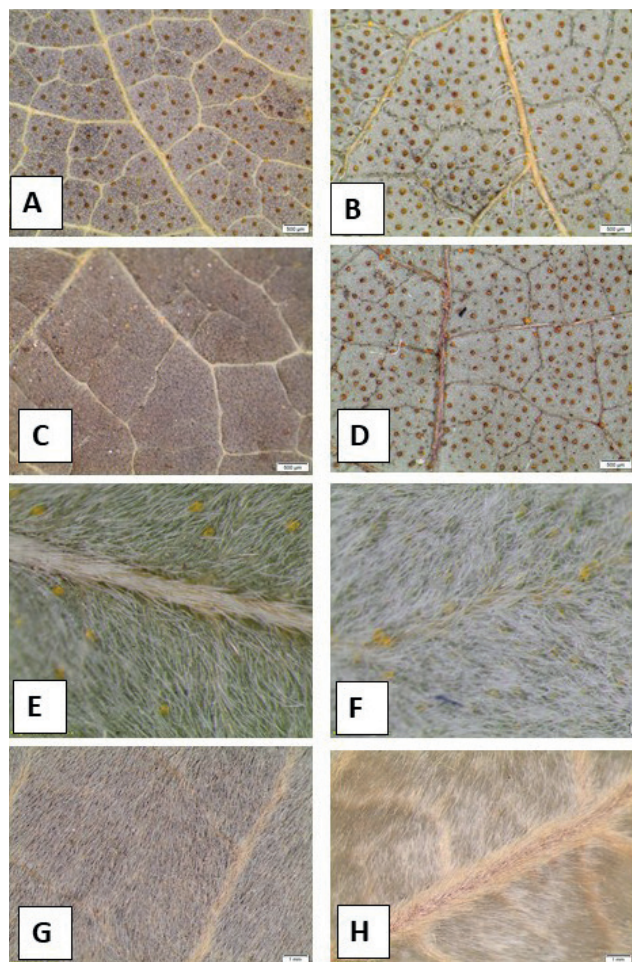


Figure 2. Variation in indumentum type and distribution on the leaflets of *Rhynchosia* sect. *Rhynchosia* species. (A,B) Adaxial and abaxial leaflet surfaces of *R. adenodes*. (C,D) Adaxial and abaxial leaflet surfaces of *R. cooperi*. (E,F) Adaxial and abaxial leaflet surfaces of *R. nitens*. (G,H) Adaxial and abaxial leaflet surfaces of *R. galpini*. Voucher specimens: (A,B) *Grobbelaar* 1345 (PRE); (C,D) *Pienaar* 557 (PRE); (E,F) *Bester* 4429 (PRE); (G,H) *Pott* 5315 (PRE).

(Moteetee et al. 2012, Moteetee et al. 2014; Jaca & Moteetee, 2018; Jaca et al., 2018). Within the sections, petiole length can sometimes be of diagnostic value, most especially in *R.* sect. *Rhynchosia* and *R.* sect. *Chrysoscias*. In *R.* sect. *Rhynchosia*, *R. nitens*, and *R. galpinii* are morphologically similar in having tomentose stems, discolorous, silky silvery or velvety leaflets, and pubescent standard petals. But the former can be distinguished from the latter in the longer petiole [(3)7–15(19) mm vs. 1–6 mm]. In *R.* sect. *Chrysoscias*, *R. leucoscias* with much longer petioles (8–20 mm) can be distinguished from the other species in having shorter petioles, for example, *R. angustifolia* (2.2–4.5 mm), *R. chrysoscias* (3.5–7.8 mm), and *R. microscias* (3.0–) 4.3–8.6 mm) (Jaca et al. 2018).

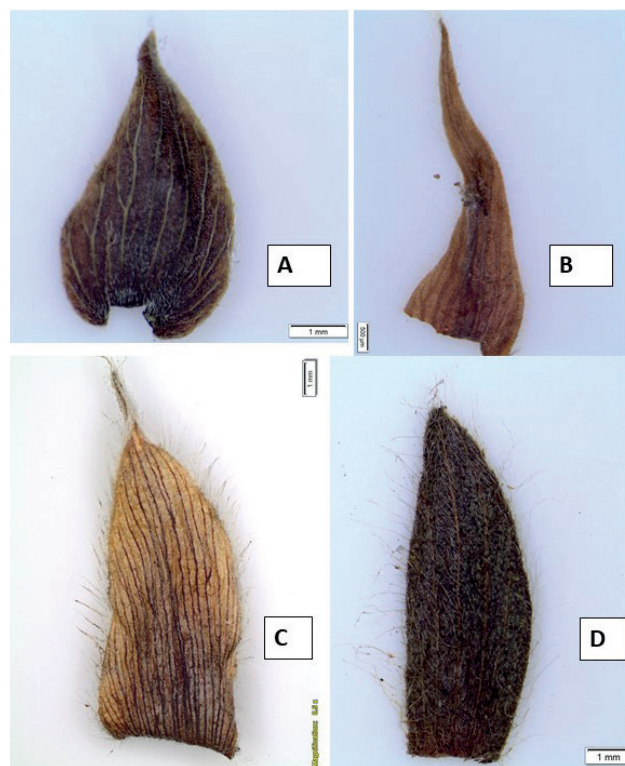


Figure 3. Variation in stipules shape in *Rhynchosia* sect. *Rhynchosia* species. (A) Deltoid shaped stipule in *R. calvescens*, (B) Narrow lanceolate stipule in *R. caribaea* var. *caribaea*. (C) Large oblong-ovate with aristate or caudate apex in *R. clivorum*. (D) Long oblong-lanceolate or oblong-ovate in *R. reptabunda*. Voucher specimens: (A) *Acocks* 20080 (PRE); (B) *Wells* 4216 (PRE); (C) *Klein* 197 (PRE); (D) *Ellan-Puttick* 168 PRE).

Stipules are persistent, deciduous or caducous, pubescent or pilose to tomentose and glandular. They are quite varied in shape and can sometimes be useful in separating two morphologically similar species such as *R. calvescens* and *R. caribaea* which both have deltoid or rhomboid leaflets. However, the former can be identified by its deltoid stipules as opposed to lanceolate in the latter. *Rhynchosia clivorum* can also be identified by its large (7–13 × 4–6 mm), oblong-ovate stipules with aristate or caudate apex (Figure 3C). Stipule shape can also be used to some extent to distinguish different sections, for example in *R.* sect. *Cyanospermum* stipules are elliptic-lanceolate while in *R.* sect. *Polytropia*, they are ovate, but in *R.* sect. *Chrysoscias* the shape is quite variable. Within the latter section, *Rhynchosia leucoscias* and *R. angustifolia* are morphologically related in that they both have broad oblong stipules while *R. chrysoscias* and *R. microscias* have ovate-lanceolate stipules (Moteetee et al. 2012, Moteetee et al. 2014; Jaca et al. 2018). Stipels are usually absent in members of subtribe *Cajaninae*. How-

ever, there are few exceptions in some taxa of *Rhynchosia* sect. *Rhynchosia* (namely, *R. adenodes*, *R. cooperi*, and *R. pentheri* var. *pentheri*) where minute, caducous linear-lanceolate stipels occur. The presence of linear-lanceolate stipels was also reported in *R.* sect. *Cyanospermum* (Moteetee et al. 2012).

Reproductive Morphology

Inflorescence

In *Rhynchosia* sect. *Rhynchosia* flowers are usually arranged in axillary or terminal racemes or umbels (Wood and Key 2009). However, sometimes inflorescences are in axillary racemes but arranged towards the apex or summit as in *R. adenodes* and *R. cooperi* (Figure 4B). The inflorescence length ranges from 5 to 200 (280) mm, bears 1 to many flowers and can also be branched or unbranched. The inflorescence in *R.* sect. *Cyanospermum*, *R.* sect. *Polytropia*, and the *R. densiflora* group is an axillary raceme, while *R.* sect. *Chrysoscias* has axillary umbels or solitary to sub-solitary flowers. On the other hand, the inflorescence is occasionally branched in *R.* sect. *Cyanospermum* (Moteetee et al. 2012; Moteetee et al. 2014; Jaca and Moteetee, 2018; Jaca et al. 2018). The branching pattern as well as the length of the inflorescences can sometimes be of diagnostic importance within *R.* sect. *Rhynchosia*. For example, *R. caribaea* var. *caribaea* and *R. caribaea* var. *picta* can be separated from other species in southern Africa with deltoid, rhomboid, or ovate-rhomboid leaflets such as *R. burchellii*, *R. atropurpurea*, *R. calvescens*, *R. sublobata*, and *R. thorncroftii*, by their branched inflorescences.

The peduncle is usually glabrescent to pubescent or pilose to tomentose in the genus (Ajao et al. in preparation). Regarding the usefulness of inflorescence length in species delimitation, *R. sordida* is a species that is similar to *R. angulosa* in that the leaflets are elliptic. *Rhynchosia sordida* can be distinguished from the latter by the inflorescence that is usually shorter than the leaflets (5–15(30) mm) versus inflorescence that is longer than the leaflets (30–80(120) mm) in *R. angulosa*. Therefore, species in the type section of *Rhynchosia* can be grouped into two groups based on the length of inflorescences. Species such as *R. ciliata*, *R. nitens*, *R. sordida*, *R. spectabilis*, and *R. komatiensis* etc. have inflorescences that are shorter than the leaflets while species such as *R. angulosa*, *R. atropurpurea*, *R. caribaea*, *R. clivorum*, *R. holosericea*, and *R. sublobata* have inflorescences that are longer than the leaflets (Figure 4).

Flowers are usually pedicellate and yellow in all the species in the genus. To some extent, the number of flow-

ers per inflorescence could be used to separate identical species in the genus. In the type section, for example, *R. ovata* is morphologically similar to *R. reptabunda* in that the stems are pilose, the leaflets are ovate or suborbicular and the bracts are persistent. However, *R. ovata* can be distinguished by its shorter inflorescence (35–60 mm long) with fewer flowers (2–4-flowered), whereas in *R. reptabunda* the inflorescence is 70–100(130) mm long and 4–9-flowered. Another example is found between *R. bolusii* and *R. capensis* which are similar in leaflet shape, but the former can be identified by its 1- or 2-flowered inflorescences vs. 1–6-flowered in the latter (Boatwright and Moteetee 2014). In *Rhynchosia* sect. *Polytropia*, *R. ferulaefolia* is similar to *R. pinnata* in having a non-twinning habit and clustered inflorescences, but they can be distinguished based on the number of flowers, i.e. 5–12 in the former and 5–8 in the latter (Moteetee et al. 2014).

Bracts and bracteoles

In *Rhynchosia* sect. *Rhynchosia* bracts are usually lanceolate to ovate, deciduous or caducous to persistent, 1–6 × 0.2–3.0 mm, pilose or pubescent and glandular; bracteoles are absent. The absence of bracteoles is one of the diagnostic characters that separate the genus *Rhynchosia* and other genera in the subtribe Cajaninae (namely, *Bolusafraga*, *Cajanus*, *Dunbaria*, *Eriosema*, *Flemingia*, and *Paracalyx*) from the genus *Adenodolichos* (Moteetee and Van Wyk 2006).

Flower structure

The calyx is generally bilabiate in all the species in the genus, with unequal lips and lanceolate to acuminate, broadly lanceolate or obtuse lobes. The calyx tube is 1–6 mm long, the upper lobes are usually the shortest and are always connate almost to the apex, sometimes halfway and rarely below halfway, 0.3–13 mm long, the lateral lobes are 1.5–18 mm long while the carinal lobe is usually longer than the other lobes (2–21 mm long). The length of lobes, as well as the extent of connation of the upper calyx lobes, can be of diagnostic value within the type section and the *R. densiflora* group. A noteworthy example in the type section is found between *R. sordida* and *R. angulosa* which share elliptic leaflets as well as an erect habit. However, *R. sordida* can be distinguished by its much longer upper calyx lobes (6–10 mm) when compared to those of *R. angulosa* (1–3 mm) (Figure 5). In the *R. densiflora* group, the upper lobes of the calyx are connate less than halfway to almost entirely, these character states are useful to separate the species in the complex. In *R. densiflora*

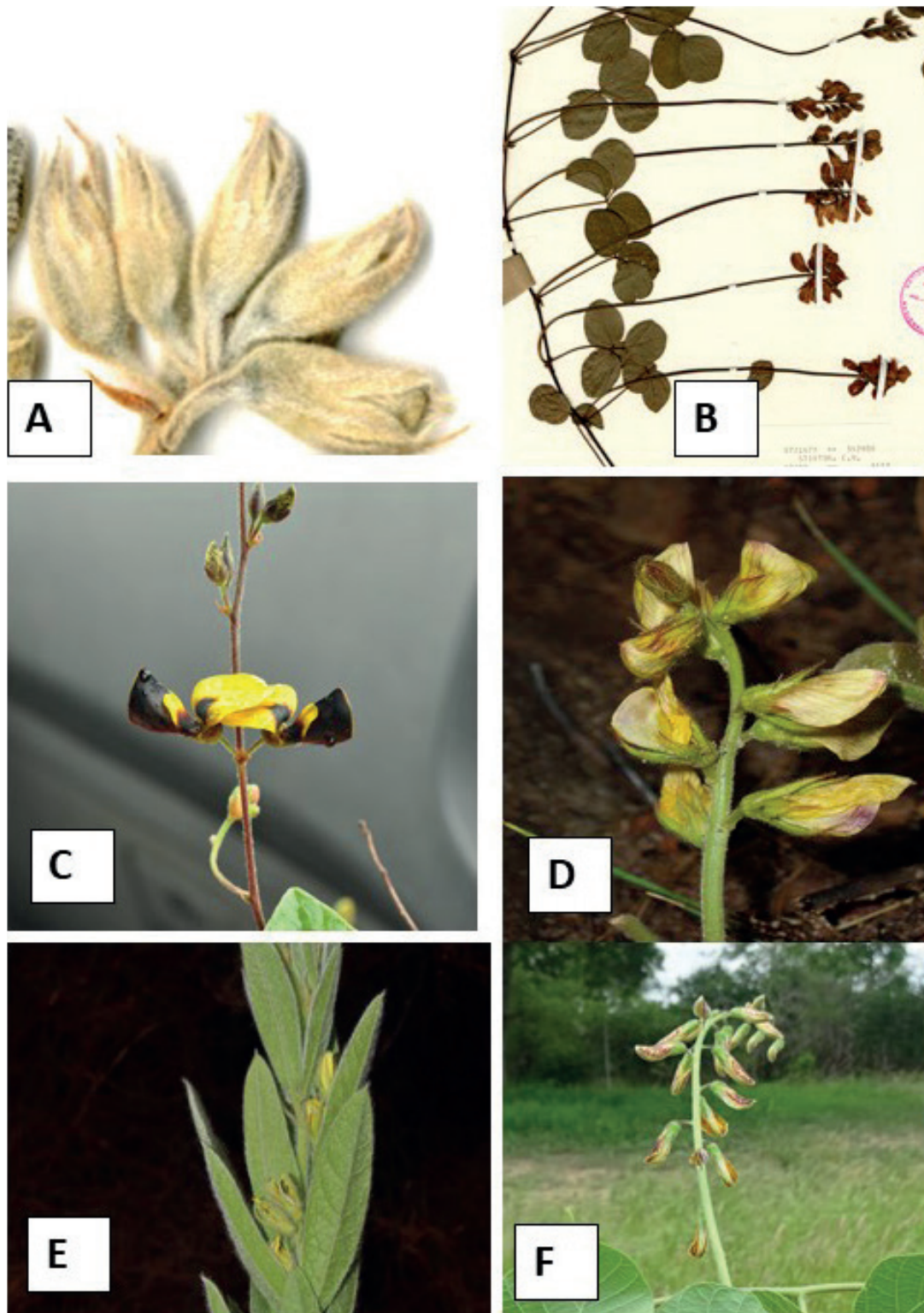


Figure 4. Variation in inflorescence type and length in *Rhynchosia* sect. *Rhynchosia* species. (A) Umbel inflorescence shorter than the leaflets in *R. spectabilis*. (B) Axillary inflorescence arranged towards the apex in *R. cooperi*. (C) Axillary inflorescence with flowers with purplish keel petals in *R. atropurpurea*. (D) Axillary inflorescence longer than the leaflets in *R. angulosa*. (E) Inflorescences shorter than the leaflets in *R. sordida*. (F) Axillary inflorescence in *R. sublobata*. Voucher specimens: (A) Bester 11418 (JRAU); (B) Stirton 8107 (PRE). Photo by John Burrows (C,D,E), Abdulwakeel Ajao (F).

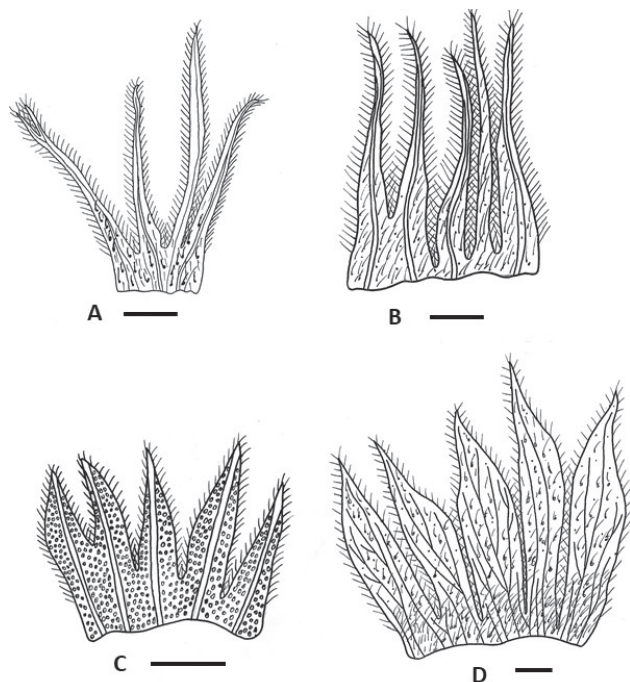


Figure 5. Variation in length of the calyx lobes in *Rhynchosia* sect. *Rhynchosia* species. (A) Upper lobes of the calyx connate to the apex in *R. angulosa*. (B) Upper lobes of the calyx connate to the base in *R. sordida*. (C) Upper lobes of the calyx connate to the apex or halfway in *R. capensis*. (D) Upper lobes of the calyx connate to the base in *R. clivorum*. Voucher specimens: (A) Rogers 21907 (PRE); (B) Mngomezulu 9 (PRE); (C) Vlok 708 (PRE); (D) Galpin 14290 (PRE). Scale bar 1 mm. Drawn by Abdulwakeel Ajao.

subsp. *chrysadenia* var. *chrysadenia*, they are connate up to halfway while in *R. densiflora* subsp. *chrysadenia* var. *connata* they are connate more than halfway and sometimes to the apex (Jaca and Moteetee 2018). *Rhynchosia* sect. *Cyanospermum* and *R. sect. Polytropia* have upper calyx lobes connate to the apex while in *R. sect. Chrysoscias*, they are somewhat connate at the base.

Calyx indumentum varies from glabrescent to pubescent or pilose, villous to tomentose and glandular in the type section (Figure 5), it is pubescent or pilose and glandular-punctate in the *R. densiflora* group, pubescent, glandular-dotted in *R. sect. Polytropia* and entirely velvety canescent or sometimes brownish pubescent at base in *R. sect. Cyanospermum* (Moteetee et al. 2012; Moteetee et al. 2014; Jaca and Moteetee 2018; Jaca et al. 2018).

Standard petals

Species in the type section have standard petals that are persistent, yellowish, purplish to brownish or brown-

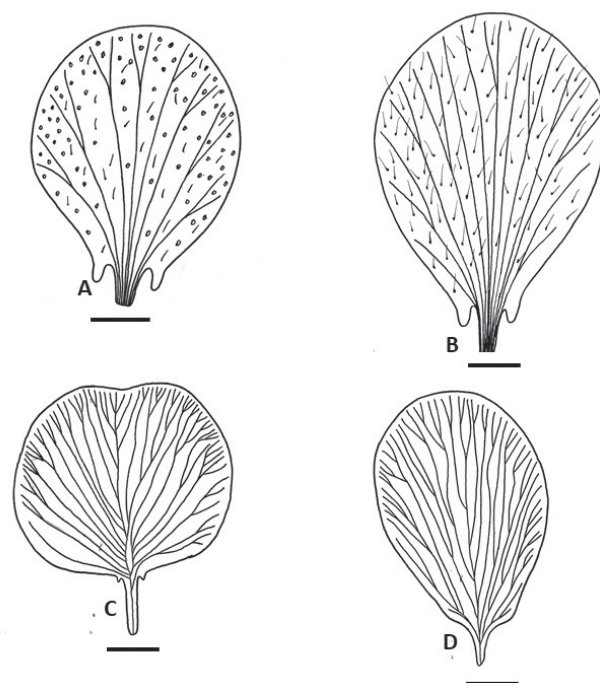


Figure 6. Variation in standard petals indumentum in *Rhynchosia* sect. *Rhynchosia* species. (A) Pubescent and glandular standard petal in *R. adenodes*. (B) Pubescent standard petal in *R. vendae*. (C) Glabrous standard petal in *R. bullata*. (D) Glabrous standard petal in *R. pauciflora*. Voucher specimens: (A) Grobbelaar 1345 (PRE); (B) Grobbelaar 02336 (PRE); (C) Compton 11157 (PRE); (D) Compton 27501 (PRE). Scale bar 1 mm. Drawn by Abdulwakeel Ajao.

maroon veined, with or without callosities, 5–18 × 4–21 mm, claw (0.5) 1–3 mm. It also varies in shape from ovate to obovate or cordate to orbicular or elliptic in the type section, suborbicular in *R. sect. Cyanospermum* and *R. sect. Polytropia*, ovate to broadly obovate in *R. sect. Chrysoscias* and elliptic to oblong in *R. densiflora* group (Moteetee et al. 2012; Moteetee et al. 2014; Jaca and Moteetee 2018; Jaca et al. 2018).

In terms of indumentum, the standard petals are glabrous and eglandular in all the sections and the *R. densiflora* group, with the exception of *R. sect. Rhynchosia* in which the standard petals are glabrous to pubescent or glandular. The indumentum on the standard petals is of great taxonomic importance as it can be used to separate morphologically similar species in this section. For example, *R. sublobata* and *R. caribaea* are similar in having deltoid or rhomboid leaflets, but the former can be differentiated by pubescent standard petals compared to glabrous in the latter. Also, *R. caribaea* var. *picta* can be differentiated from *R. caribaea* var. *caribaea* by its pubescent standard petals. Other species with pubescent and glandular standard petals in the type section are *R.*

adenodes, *R. argentea*, *R. cooperi*, *R. crassifolia*, *R. galpinii*, *R. hirsuta*, *R. nitens*, *R. komatiensis*, *R. resinosa*, *R. spectabilis*, *R. vendae*, *R. waterbergensis*. In addition, *Rhynchosia pentheri* var. *pentheri* is occasionally glandular (Figure 6). Despite the absence of indumentum on standard petals in *R.* sect. *Chrysoascias*, its size is of diagnostic value. The standard petal is larger in *R. leucoscias* (10.0–15.5 × 7.0–15.0 mm) when compared to *R. microscias* (8–11 × 6–9 mm) and *R. leucoscias* (9.5–13.0 × 7.5–12.5 mm) (Jaca et al. 2018).

Wing petals

Oblong wings that are usually spurred at the base, 3–13 × 0.5–5.5 mm with linear claw 1–5 mm long is typical of the genus *Rhynchosia*. However, size, absence or presence of glands and surface sculpturing are of diagnostic importance. Wings are usually shorter than the keels in most of the species in the type section except in species such as *R. clivorum*, *R. cooperii*, *R. ovata*, *R. resinosa* that have wings that are sometimes the same length as keel or even slightly longer than the keels as in *R. argentea*. Interestingly, in *R.* sect. *Chrysoascias*, the wing petals are equal to or longer than the keel petals in all species except in *R. microscias*, where they are slightly shorter than the keel. This character thereby separated *R. microscias* from the remaining species in the section (Jaca et al. 2018). Furthermore, the wings are generally longer than keels in *R. pinnata* and *R. smithiana* in *R.* sect. *Polytropia* (Moteetee et al. 2014). Most of the species in the genus have glabrous wings with the exception of *R. adenodes*, *R. albissima*, *R. atropurpurea*, *R. bullata*, and sometimes *R. pentheri* var. *pentheri* (all in the type

section), which have glandular wings. Surface sculpturing can either be present or absent in the species in the type section and can be used to separate identical species. For example, *R. komatiensis* and *R. spectabilis* with similar ovate-orbicular or ovate leaflets, are distinguishable by the presence of sculpturing on the wings of *R. spectabilis*. Furthermore, *R. pauciflora* and *R. sp. nov.* are similar in having erect habit, linear or oblong leaflets and 1-flowered inflorescence. However, the former is separated from the latter by the presence of sculpturing on wing petals (Figure 7). The presence of surface sculpturing on the wing petals is also of taxonomic value in *R.* sect. *Polytropia* as it is used to distinguish *R. ferulaefolia* (where it is absent) from *R. pinnata* and *R. smithiana* (Moteetee et al. 2014). However, it is absent in *R.* sect. *Chrysoascias*, *R.* sect. *Cyanospermum*, and the *R. densiflora* group.

Keel petals

Keel petals are uniform in shape in the genus *Rhynchosia*, they are usually yellow, veined, pocketed, rostrate or boat-shaped, 5–15 × 2–9 mm, with a claw, 1–5 mm long. They are usually larger than the wings with the exception of those mentioned in the previous section and smaller than the standard petals. However, in *R. atropurpurea* the keels are almost the same length as the standard petals and entirely purplish colour, hence the specific name *atropurpurea* (Figures 4C & 8). The colour of the keels in *R. atropurpurea* is the most important character to distinguish it from the remaining species in the genus.

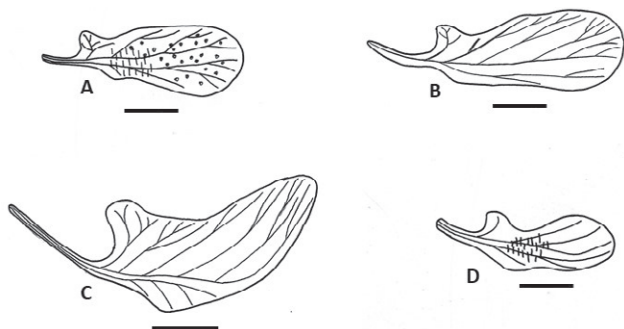


Figure 7. Variation in wing petals indumentum in *Rhynchosia* sect. *Rhynchosia* species. (A) Glandular with sculpturing in *R. adenodes*. (B) Glabrous without sculpturing in *R. calvescens*. (C) Glabrous without sculpturing and narrow in *R. thorncroftii*. (D) Glabrous with sculpturing in *R. villosa*. Voucher specimens: (A) Grobbelaar 1345 (PRE); (B) Steyn 75 (PRE); (C) Dlamini 3060 (PRE); (D) Tyson 3085 (PRE). Scale bar 1 mm. Drawn by Abdulwakeel Ajao.

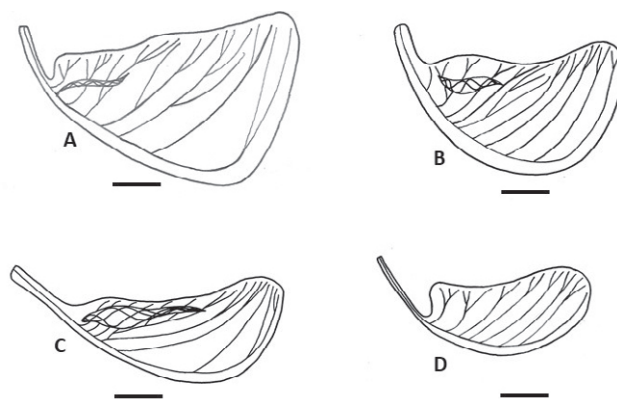


Figure 8. Variation in keel petals size in *Rhynchosia* sect. *Rhynchosia* species. (A) *R. atropurpurea*. (B) *R. arida*. (C) *R. nitens*. (D) *R. ovata*. Voucher specimens: (A) Nkoane 33 (PRE); (B) Van wyk 3029 (JRAU); (C) Lansdell 16078 (PRE); (D) Acocks 12979 (PRE). Scale bar 1mm. Drawn by Abdulwakeel Ajao.

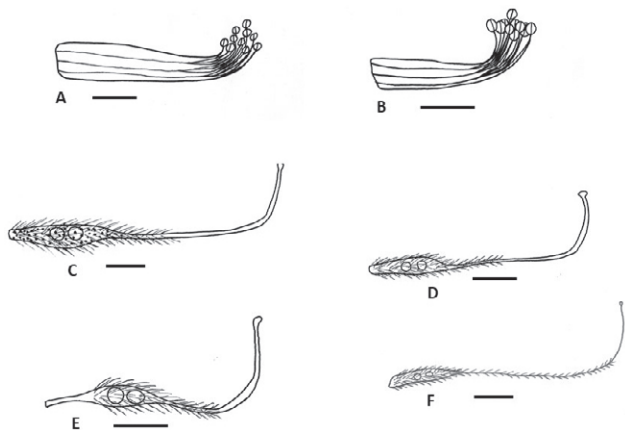


Figure 9. Variation in stamens and pistils in *Rhynchosia* sect. *Rhynchosia* species. (A) Stamens of *R. nervosa*. (B) Stamens of *R. reptabunda*. (C) Glandular and pubescent ovary in *R. capensis*. (D) Pubescent ovary in *R. calvescens*. (E) Stipitate ovary in *R. thorncroftii*. (F) Pubescent ovary with a very long style. Voucher specimens: (A) Muller 1285 (PRE); (B) Ngwenya 1337 (PRE); (C) Vlok 708 (PRE); (D) Steyn 75 (PRE); (E) Dlamini 3060 (PRE); (F) Nkoane 33 (PRE). Scale bar 1 mm. Drawn by Abdulwakeel Ajao.

Androecium

Stamens are uniform in the genus, and usually dialophous with nine filaments fused and vexillary stamens free to the base. Anthers are also uniform, monomorphic, dorsifixed and somewhat dehiscent (Figures 9A-B).

Gynoecium

Ovaries are elliptic-oblong to oblong-lanceolate, sessile to subsessile or stipitate, puberulous or pubescent to pilose or glandular in *Rhynchosia* sect. *Rhynchosia*. However, they are narrowly oblong and subsessile in other sections but vary in terms of indumentum as it is densely silky-villous and glandular-punctate in the *R. densiflora* group and pubescent in *R. sect. Chrysoscias*, *R. sect. Cyanospermum*, and *R. sect. Polytropia* (Moteetee et al. 2012; Moteetee et al. 2014; Jaca and Moteetee 2018; Jaca et al. 2018). Styles are usually glabrous but sometimes pubescent to pilose or glandular most especially at the lower part. In the type section, it is usually 4–18 mm long and the variation in length can be of diagnostic importance. For example, *R. atropurpurea* can be distinguished from *R. calvescens* by a longer style (13–15 mm) as opposed to the shorter style (7–10 mm) in *R. calvescens* (Figures 9C-D).

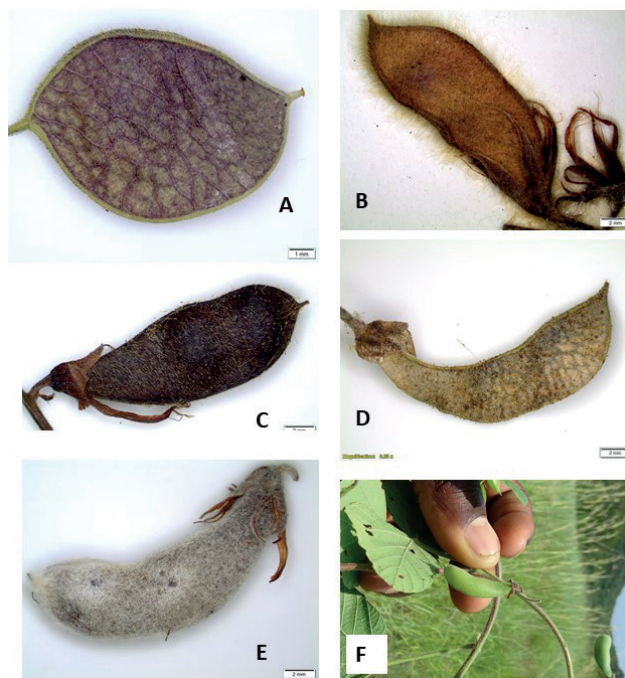


Figure 10. Variation in fruits in *Rhynchosia* sect. *Rhynchosia* species. (A) Elliptic, compressed or flattened in *R. monophylla*. (B) Oblong and pilose in *R. ovata*. (C) Oblong, stiped, pubescent and glandular in *R. adenodes*. (D) Falcate, pubescent to tomentose and glandular in *R. emarginata*. (E) Oblong-falcate, canescent-tomentose in *R. albissima*. (F) Oblong-falcate, glabrescent, and inflated in *R. sublobata*. Voucher specimen: (A) Nkonki 76 (PRE); (B) Ward 4421 (PRE); (C) Van Wyk 1589 (JRAU); (D) Smook 7965 (PRE); (E) Leendertz 484 (PRE). Photo by Abdulwakeel Ajao.

Fruits

The shape, size, and type of indumentum on the surface of the fruits vary greatly in the genus, but it can sometimes be of diagnostic importance. In the type section, fruits are 1–2-seeded, oblong to elliptic or falcate, 10–42 × 3–13 mm, compressed or inflated, stiped, glabrescent to pubescent or pilose to tomentose and glandular. It is important to note fruits of most species in this section are compressed and sometimes inflated as seen in *R. sublobata* (Figure 10F). In *R. sect. Cyanospermum*, the fruits are narrowly oblong, 2-seeded, 15–20 × 5–6 mm, densely velvety canescent or rusty-brown pubescent. However, they are oblong, broadly-oblong to ovoid, and 1–2-seeded in *R. sect. Chrysoscias* while they are narrowly oblong, 2-ovuled, densely silky-villous, and glandular-punctate in the *R. densiflora* group (Moteetee et al. 2012; Moteetee et al. 2014; Jaca and Moteetee, 2018; Jaca et al. 2018).

CONCLUSIONS

In this study, we investigated the reproductive and vegetative characters that can be used to delineate species within *Rhynchosia* sect. *Rhynchosia* and between the different sections in the genus *Rhynchosia* in southern Africa. The type section seems to more be variable, which might be due to the higher number of the species (47) as well as wider distribution in southern Africa when compared to the other sections. Within *Rhynchosia* sect. *Rhynchosia*, both vegetative and reproductive characters appear to be useful in the grouping of the species. These characters include growth habit, leaflet shape and indumentum as well as inflorescence length and type (branched or not), extent of connation of upper lobes of the calyx, indumentum on standard petals as well as presence or absence of surface sculpturing on the wing petals. However, structures such as stamen, pistil and keel petals are of lower taxonomic value as they tend to be similar within the section as well as between the sections. All the sections and the *R. densiflora* group overlap in terms of leaflet structure in that they all have either trifoliolate or unifoliolate leaflets with the exception of *R. sect. Polytropia* in which the leaves are trifoliolate to simply or pedately bipinnate, bi-tri-jugate, paucijugate, or supra-decompound. *Rhynchosia* sect. *Chrysoscias* and *R. sect. Polytropia* are morphologically related in that they both exclusively have lanceolate to linear-lanceolate leaflets. It is worth mentioning that these two sections are restricted to the Eastern and Western Cape Provinces (South Africa).

Flowers can either be solitary, sub-solitary (e.g., *R. sect. Chrysoscias*) on in axillary inflorescences which are either racemes or umbels. Reproductive morphological characters are more variable in the type section when compared to other sections. Standard petals indumentum varies from being glabrous to pubescent or glandular in the type section, but they are consistently glabrous and eglandular in all other sections including *R. densiflora* group. Although, *R. sect. Rhynchosia* and *R. sect. Polytropia* appear to be related when it comes to the presence or absence of surface sculpturing on the keel petals which are consistently absent in *R. sect. Arcyphylum*, *R. sect. Cyanospermum*, and *R. densiflora* group. However, *R. sect. Arcyphylum* is close to *R. sect. Cyanospermum* in the twinning growth habit and the many-flowered inflorescences which occur in dense sessile axillary raceme. Morphologically, there are a number of overlapping characters between the sections, but we are not oblivious of the fact that Baker's sectional classification is natural. Hence the reason phylogenetic relationships were also investigated between the sections in the

genus in this study to determine whether Baker's sectional classification will be upheld when using a combination of morphological and DNA sequencing data.

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