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*Full Length Research Paper*

# Systematics, diversity and forage value of indigenous legumes of South Africa, Lesotho and Swaziland

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**The diversity of legumes, indigenous to South Africa, Lesotho and Swaziland is reported using recorded descriptive and distribution data. A total of 24 tribes, 118 genera and 1662 species were documented with the majority of genera belonging to subfamily Faboideae, tribe Phaseoleae, and the majority of species to tribe Crotalarieae. In terms of distribution patterns, most species were present in the Savanna Biome and Central Bushveld Bioregion. Even though most tribes contain species with secondary metabolites (mainly non-protein amino acids), tribes containing poisonous species are far fewer. Herbs are the key growth form, followed by shrubs, dwarf shrubs and trees. The majority of species are perennials. A map representing the collection intensity for the study area showed that the majority of legumes species were collected in the Fynbos, Savanna and Grassland Biome. It is concluded that indigenous South African legumes are extremely diverse and this denotes the importance of further investigating their forage potential or use in other agricultural practices.**

**Key words:** Biomes, bioregions, Fabaceae, fodder, genebank, Leguminosae, pastures, tribes

## INTRODUCTION

Legumes are used extensively in various agricultural practices, for example as high quality pastures, cover and cash crops, for soil improvement and erosion control (Graham and Vance, 2003; Gepts et al., 2005; Lewis et al., 2005). The majority of legumes cultivated in South Africa are introduced species, particularly those used as planted pastures. The most valued commercially produced indigenous legumes are A*spalathus linearis* (rooibos) and C*yclopia intermedia* (honey bush) endemic to the Cape Floristic Region and well-known for their culinary (as tea) and medicinal value. Researchers such as Sprent et al. (2010) argued that by developing indigenous African legumes, especially those well adapted to drought and low soil nutrient levels, agricultural diversity will be retained.

The general believe that indigenous legume species are either poisonous and/or low producers could have attributed to the little attention given to evaluating indigenous legumes for their forage potential (Kruger, pers. com) Nevertheless, cultivars have been released from African legume species such as *Lotononis bainesii* 'INIA Glencoe' (Real and Altier, 2005), *Neonotonia wightii* 'Clarence' and *Lablab purpureus* 'Endurance' (Cook et al., 2005). The majority of recently published work on South African legumes relates to phylogenetic and biological nitrogen fixation studies. Phylogenetic research focused mainly on the Genistoid tribes (Van Wyk, 2003; Moteetee and Van Wyk, 2006), Podalyrieae (Van der Bank et al., 2002), Crotalarieae (Boatwright et al., 2009; Boatwright et al., 2011) and *Hypocalyptus* (Schutte and Van Wyk, 1998). The latest research on biological nitrogen fixation focused on *Lotononis bainesii* (Jaftha et al., 2002), *Lebeckia* spp. (Phalane, 2008) and *Vigna unguiculata* (Makoi et al. 2009). In terms of pasture evaluation Rootman et al. (2004) and Howieson (2010) are among the more recent papers reporting on the use of indigenous legumes in pasture evaluation trials under South African conditions.

The aim of this paper is to report on the current state of knowledge on the indigenous legume genetic diversity in South Africa, Lesotho and Swaziland. This was seen as the first phase in reviewing the possible forage potential of indigenous legumes. Improving adaptive

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species from the underutilized indigenous germplasm pool should be a research emphasis in developing new pasture species.

## MATERIALS AND METHODS

The Leguminosae (Fabaceae) indigenous to South African, Lesotho and Swaziland (hereafter referred to as South Africa) were listed using available descriptive (Germishuizen and Meyer, 2003) and distribution data (PRECIS, 2008; Mucina and Rutherford, 2006). Approximately 63 species were not recorded in PRECIS (2008) and ± 58 species were not recorded in Germishuizen and Meyer (2003) of which 85 species had insufficient records. PRECIS (National Herbarium, (PRE) Computerised Information System) contains a total number of 33726 Leguminosae records. The data was edited for species present within the borders of the above mentioned countries, as well as omitting double records within a quarter degree grid. The edited data resulted in 27618 records.

The phylogeny of Leguminosae as proposed by Lewis et al. (2005) was used to create a bubble diagram showing the evolutionary relationships of subfamilies and tribes of South-African legumes and the proportion between growth form and growth period within each tribe. The data from Germishuizen and Meyer (2003) was used to quantify herbs, dwarf shrubs, shrubs, trees, climbers, creepers, annuals and perennials within each tribe. Mixed growth forms (e.g. species described as both herb and shrub) were not included in the data as 88% of species were accounted for in the single growth form designation.

PRECIS distribution records were superimposed on biome and bioregion vegetation maps published by Mucina and Rutherford (2006). At the quarter degree scale (standard format for PRECIS data capturing) the biomes and bioregions vegetation types were recorded. Where more than one biome or bioregion was present within a quarter degree it was termed an eco-region. The allocation of vegetation types within the quarter degree was thus only applied to pure types, i.e. mixed vegetation types were coded as ecotonal-region and are not presented.

PRECIS data was further used to generate a map indicating the collection intensity for legume species in South Africa. Under-collection was found mainly in the Central Karoo where low legume species numbers were recorded. The history of the PRECIS database has been published by Steenkamp et al. (2005).

## RESULTS AND DISCUSSION

The legumes of South Africa belong to three subfamilies, 24 tribes, 118 genera and a total of 1662 species (Table 1.) The majority of species falls within the subfamily Faboideae with the largest number of species within the tribe Crotalarieae (630 species) followed by Indigofereae (208 species) and Phaseoleae (180 species). Six tribes namely Acacieae, Swartzieae, Hypocalypteae, Abreae, Sesbanieae and Loteae contain only one genus. A total of 27618 PRECIS records were recorded for the Leguminosae in South Africa (Table 1). The number of PRECIS records, relative to the number of species contained within a tribe, compared well. This however, has no reference to individual species. The range in altitude indicated that Swartzieae had the lowest adaptive range, followed by Hypocalypteae and Sophoreae. The remaining 21 tribes' maximum range exceeded the 1500m level.

The wide distribution range of most tribes is noteworthy with 15 of the 24 tribes present in seven or more biomes (Table 1). This includes smaller tribes such as Cercideae and Trifolieae. Hypocalypteae (*Hypocalyptus* spp.) is present in only one biome, namely Fynbos. The Savanna Biome is well represented (16 tribes), followed by the Grassland (4 tribes) and Fynbos Biomes (4 tribes).

Crotalarieae is represented in 29 of the 35 bioregions of South Africa, Galegeae in 27 bioregions, followed by both Genisteae and Indigofereae with 26 bioregions (Table 1). Regardless of the fact that Galegeae contains only 62 species (belonging to *Astragalus*, *Lessertia* and *Sutherlandia*) it is exceptionally widespread. The majority of tribes are present in the Central Bushveld Bioregion (SVC), including the larger tribes such as Crotalarieae and Indigofereae. The Lowveld (SVI), Mesic Highveld Grassland Bioregion (GM) and Eastern Fynbos-Renosterveld Bioregion (F06) follow.

The majority of legume tribes contain species with secondary metabolites that are of agricultural and economic interest. Isoflavonoids (e.g. genistein and rotenone are common in subfamily Faboideae whereas non-protein amino acids (e.g. canavanine and mimosine) are present in most tribes except Cercideae, Podalyrieae and Psoraleeae (Wink and Mohamed, 2003). In the same study isoflavonoids have been reported in most members of the tribes Genisteae, Desmodieae and Phaseoleae and all of the members of the tribes Trifolieae and Sophoreae. Quinolizidine alkaloids occur mainly in tribes from the Genistoid clade (Wink and Mohamed, 2003).

The potential use for forage or soil conservation and presence of poisonous compounds for the different legume tribes is reflected in Table 1 (Lewis et al., 2005). Most tribes contain species with forage and soil conservation potential, e.g. fodder production, ground cover, green manure or soil improvement. In terms of its poisonous traits, nine tribes namely Detarieae, Acacieae, Swartzieae, Crotalarieae, Dalbergieae, Indigofereae, Abreae, Sesbanieae and Galegeae contain poisonous species.

The suprageneric classification of the legume tribes is shown in the form of a bubble diagram in Figure 1 (based on Lewis et al., 2005). The family Faboideae comprises of three clades, namely the Genistoid clade that includes Crotalarieae with the largest number of species (37.9%) and Swartzieae and Abreae with the lowest number of species (0.1%), the Dalbergioid clade that comprises of the small tribe Dalbergieae (1.6%) and the Old World clade in which the agriculturally important Phaseoleae tribe (10.8%) falls. The highest number of legume species is grouped in the Genistoid clade, containing 51.3% of the species found in South Africa.

Based on a simplified phylogeny of Leguminosae as proposed by Lewis et al. (2005), the different growth form and growth period ratios are depicted in Figure 2. The majority of legumes are herbs, followed by shrubs, dwarf shrubs and trees. The smaller tribes evidently contain only one type of growth form (e.g. trees within Detarieae

**Table 1.** Statistics of tribes, genera and species of Leguminosae indigenous to South Africa, Lesotho and Swaziland.

| Tribe | #genera (#world) | # species | #PRECIS records | Altitude (m) | #Biomes (majority) | #Bioregions (majority) | Secondary metabolites | Fodder/soil conservation value | Poisonous trait |
|---|---|---|---|---|---|---|---|---|---|
| Subfamily Caesalpinioideae | | | | | | | | | |
| Cercideae | 4 (12) | 9 | 269 | 0 - 1850 | 8 (Savanna) | 14 (SVC) | - | X | - |
| Detarieae | 5 (82) | 11 | 283 | 0 - 1800 | 7 (Savanna) | 13 (SVI) | np | X | X |
| Cassieae | 4 (21) | 18 | 702 | 0 - 1750 | 7 (Savanna) | 14 (SVC) | np | - | - |
| Caesalpinieae | 8 (56) | 13 | 288 | 0 - 2000 | 8 (Savanna) | 14 (SVC) | np | - | - |
| Subfamily Mimosoideae | | | | | | | | | |
| Mimoseae | 8 (40) | 19 | 461 | 0 - 1850 | 7 (Savanna) | 12 (SVC) | alk,np | X | - |
| Acacieae | 1 (1) | 49 | 1727 | 0 - 2950 | 8 (Savanna) | 21 (SVC) | alk,np | X | X |
| Ingeae | 3 (36) | 13 | 302 | 0 - 1650 | 4 (Savanna) | 8 (SVI) | np | X | - |
| Subfamily Faboideae | | | | | | | | | |
| Swartzieae | 1 (17) | 1 | 8 | 0 - 200 | 2 (Savanna) | 2 (SVI) | not tested | X | X |
| Sophoreae | 4 (45) | 5 | 95 | 0 -1400 | 2 (Savanna) | 7 (SVC) | alk,np,iso | X | - |
| Podalyrieae | 8 (8) | 139 | 1119 | 0 - 2438 | 7 (Fynbos) | 16 (F06) | alk,iso | - | 1 |
| Crotalarieae | 11 (11) | 630 | 6734 | 0 - 3447 | 8 (Fynbos) | 29 (SVC) | alk, np, iso | X | X |
| Genisteae | 4 (25) | 77 | 1438 | 0 - 3019 | 8 (Grassland) | 26 (GM) | alk, np, iso | X | - |
| Dalbergieae | 8 (49) | 27 | 1059 | 0 - 2100 | 5 (Savanna) | 11 (SVI) | np, iso | X | X |
| Hypocalypteae | 1 (1) | 3 | 70 | 50 - 1350 | 1 (Fynbos) | 3 (F06) | not tested | - | - |
| Indigofereae | 4 (7) | 208 | 3489 | 1 - 3500 | 8 (Savanna) | 26 (SVC) | np | X | X |
| Millettieae | 8 (45) | 75 | 1747 | 0 - 2135 | 8 (Savanna) | 18 (SVC) | np, iso | X | 1,2 |
| Abreae | 1 (1) | 2 | 108 | 15 - 1615 | 2 (Savanna) | 4 (SVI) | not tested | X | X |
| Phaseoleae | 22 (89) | 180 | 4404 | 0 - 2440 | 7 (Savanna) | 22 (SVC) | alk, np, iso | X | 1,2 |
| Desmodieae | 3 (30) | 17 | 370 | 3 - 1950 | 4 (Savanna) | 9 (CB,SVI) | alk, np, iso | X | - |
| Psoraleeae | 3 (9) | 85 | 1483 | 0 - 3200 | 8 (Fynbos) | 25 (F06) | iso | X | - |
| Sesbanieae | 1 (1) | 10 | 114 | 0 - 1800 | 3 (Savanna) | 8 (SVC) | np | X | X |
| Loteae | 1 (22) | 3 | 68 | 0 - 2196 | 5 (Grassland) | 9 (GM) | np, iso | X | - |
| Galegeae | 3 (24) | 62 | 1034 | 0 - 3279 | 8 (Grassland) | 27 (SVK) | alk, np, iso | X | X |
| Trifolieae | 2 (6) | 6 | 246 | 0 - 3250 | 7 (Grassland) | 12 (GM) | np, iso | X | - |
| Total | 118 (638) | 1662 | 27618 | | | | | | |

Biome and bioregion classification from Mucina and Rutherford (2006) where CB=Indian Ocean Coastal Belt, SVC=Central Bushveld, F06=Eastern Fynbos Renosterveld, GM=Mesic Highveld Grassland, SVI=Lowveld, SVK=Eastern Kalahari Bushveld. Secondary metabolites from Wink and Mohamed (2003) where alk=quinolizidine pyrrolozidine, indolizidien, indole and *Erythrina* alkaloids, np=non-protein amino acids, iso=isoflavonoids. Fodder value and poisonous traits from Lewis et al. (2005). [1]Insecticide; [2]Piscicide.

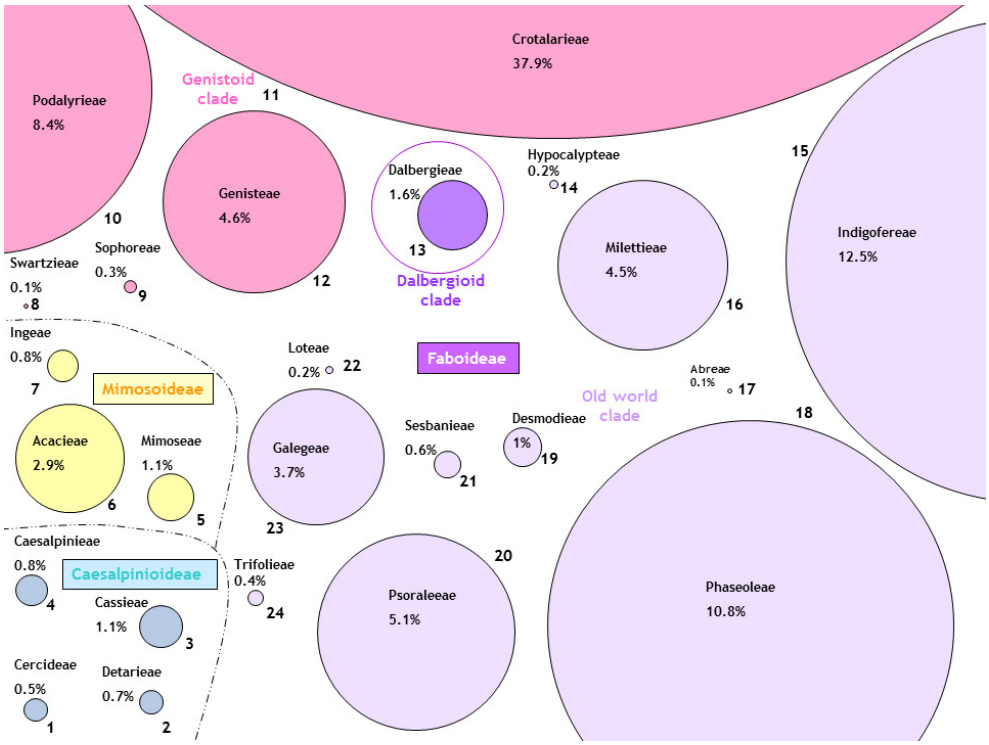


**Figure 1.** Bubble diagram depicting the subfamilies (3) and tribes (24) of Leguminosae indigenous to South African, Lesotho and Swaziland. The number in a bubble indicates the percentage species of a tribe in relation to the total number of species present. The number outside a bubble displays the order in the suprageneric classification according to Lewis et al. (2005).

and Swartzieae and herbs within Loteae) whereas the larger tribes display most of the growth forms (e.g. Crotalarieae, Psoraleeae and Indigofereae). A remarkable attribute noted for Phaseoleae was the considerable number of climbers present within this tribe. This is a result of two genera, namely *Rhynchosia* and *Vigna*. Whereas members of *Vigna* are well established pasture plants, *Rhynchosia minima* and *Rhynchosia totta* are not, but has been proposed by Maposse et al. (2003) as species with range-reseeding and cultivated pasture potential. A quarter degree frequency count shows that *R. totta* is the most abundant species, present in 238 grids. The majority of legume species are perennials. Sesbanieae, containing only one genus namely *Sesbania*, was the only tribe containing a majority of annuals.

In Table 2 the genera within each tribe is listed. Caesalpinioideae have only one endemic genus namely *Umtiza* whilst the Faboideae contains a large number of endemic genera, mainly grouped in tribes Hypocalypteae, Genisteae, Podalyrieae, Psoraleae, Galegeae and Crotalarieae of which the largest is *Aspalathus* with 335 species. The most important genera containing species that have been selected and bred for forage production worldwide are *Lotononis* (147 spp.), *Stylosanthes* (1 sp.), *Canavalia* (5 spp.), *Mucuna* (4 spp.), *Neonotonia* (1 sp.), *Teramnus* (1 sp.), *Dolichos* (12 spp.), *Macrotyloma* (5 spp.), *Lablab* (1 sp.), *Vigna* (20 spp.), *Desmodium* (11 spp.), and *Trifolium* (5 spp.). The Red Data List (Golding, 2002) recorded none of the Leguminosae to be extinct, threatened or at a low risk in South Africa. Lesotho, however, has three threatened species and Swaziland seven species at a low risk. 'The Plants of southern Africa' website of the South African National Botanical Institute (SANBI, 2011) provides the current status of all species, for example species of *Aspalathus*, *Cyclopia*, *Indigofera* and *Lotononis* are listed to be either critically endangered or extinct.

In Figure 3 the number of PRECIS records per quarter degree is mapped, showing the collection intensity at the specimen level. The Fynbos Biome has been well represented, probably due to extensive collecting by herbaria in the Western Cape. Other distinct collection sites were the Savanna and Grassland Biomes, close to the Great Escarpment and the Indian Ocean Coastal Belt Biome. Plant collections are mainly done by SANBI, the Department of Agriculture and local Universities where accessibility and diversity plays a role in collection intensity. The large number of uncollected sites in southern Africa was also noted by Steenkamp et al. (2005).

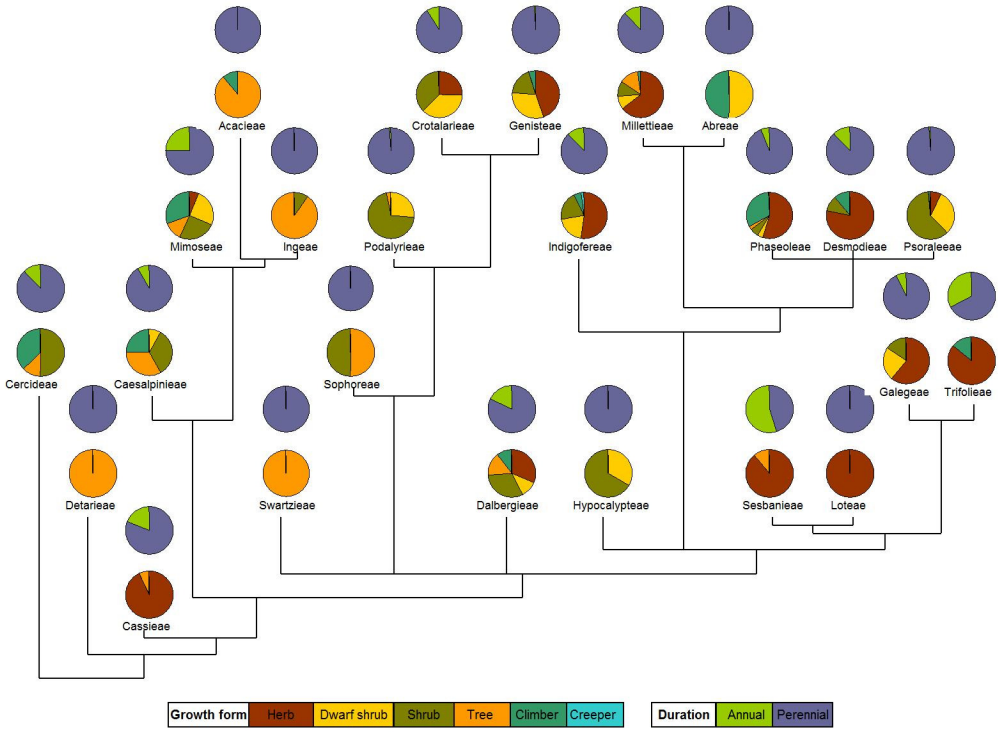


**Figure 2.** The different growth form and duration ratios plotted on a simplified phylogeny of Leguminosae in South African, Lesotho and Swaziland. Phylogeny based on Lewis et al. (2005) and Boatwright et al. (2011) for the tribe Crotalarieae.

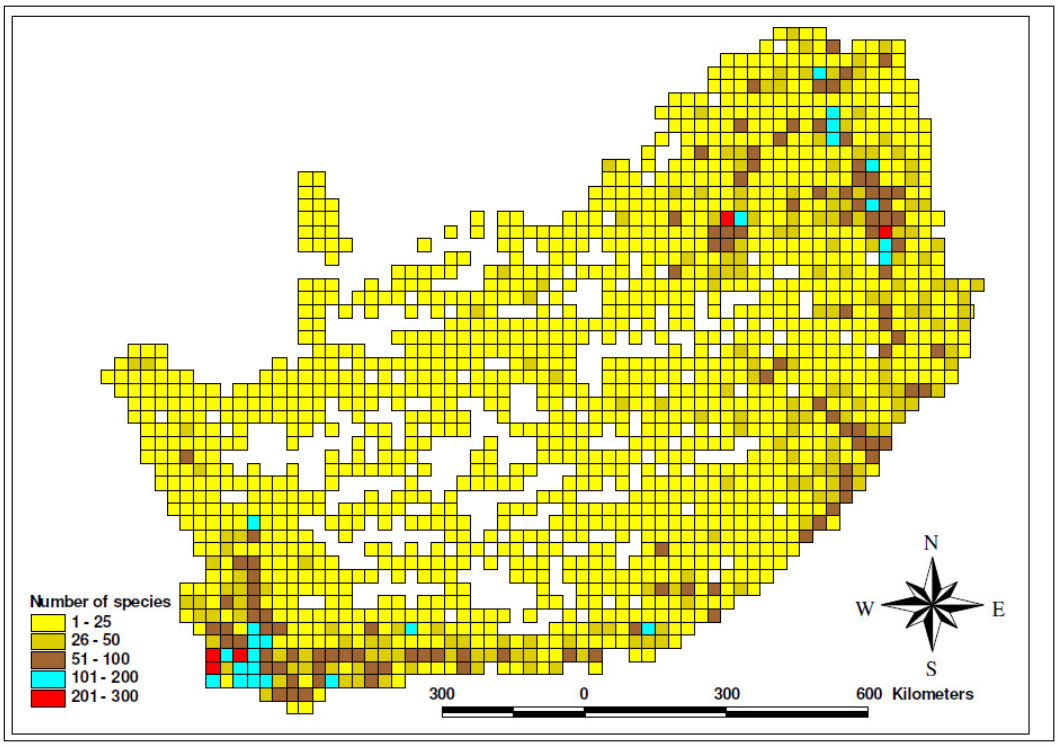


**Figure 3.** Collection intensity for Leguminosae in South African, Lesotho and Swaziland as recorded in PRECIS (2008).

**Table 2.** Subfamilies, tribes and genera of Leguminosae indigenous to South Africa, Lesotho and Swaziland following the suprageneric classification of Lewis et al. (2005) and Boatwright et al. (2011) for the tribe Crotalarieae.

| Subfamily | Tribe | Genera |
|---|---|---|
| Caesalpinioideae | | |
| | Cercideae | *Adenolobus* (1), *Bauhinia* (5), *Tylosema* (2), *Piliostigma* (1), |
| | Detarieae | *Schotia* (7), *Colophospermum* (1), *Guibourtia* (1), *Afzelia* (1), *Brachystegia* (1) |
| | Cassieae | *Dialium* (1), *Chamaecrista* (12), *Senna* (4), *Cassia* (1) |
| | Caesalpinieae | *Umtiza* (1), *Pterolobium* (1), *Caesalpinia* (3), *Pomaria* (4), *Peltophorum* (1), *Parkinsonia* (1), *Erythrophleum* (1), *Burkea* (1) |
| Mimosoideae | | |
| | Mimoseae | *Xylia* (1), *Entada* (2), *Elephantorrhiza* (8), *Newtonia* (1), *Xerocladia* (1), *Neptunia* (1), *Dichrostachys* (4), *Adenopodia* (1) |
| | Acacieae | *Acacia* (49) |
| | Ingeae | *Faidherbia* (1), *Calliandra* (1), *Albizia* (11) |
| Faboideae | | |
| | Swartzieae | *Cordyla* (1) |
| | Sophoreae | *Xanthocercis* (1), *Bolusanthus* (1), *Sophora* (1), *Baphia* (2) |
| | Podalyrieae | *Cyclopia* (23), *Xiphotheca* (9), *Amphithalea* (45), *Stirtonanthus* (3), *Podalyria* (25), *Liparia* (21), *Virgilia* (3), *Calpurnia* (10) |
| | Crotalarieae | *Aspalathus* (335), *Wiborgia* (11), *Wiborgiella* (7), *Rafnia* (31), *Lebeckia* (14), *Calobota* (13), *Lotononis* (147), *Pearsonia* (15), *Rothia* (1), *Bolusia* (1), *Crotalaria* (55) |
| | Genisteae | *Melolobium* (16), *Dichilus* (5), *Polhillia* (6), *Argyrolobium* (50) |
| | Dalbergieae | *Zornia* (4), *Pterocarpus* (3), *Stylosanthes* (1), *Dalbergia* (5), *Aeschynomene* (9), *Smithia* (1), *Kotschya* (2), *Ormocarpum* (2) |
| | Hypocalypteae | *Hypocalyptus* (3) |
| | Indigofereae | *Cyamopsis* (2), *Indigastrum* (7), *Microcharis* (3), *Indigofera* (196) |
| | Millettieae | *Xeroderris* (1), *Craibia* (1), *Philenoptera* (3), *Millettia* (2), *Mundulea* (1), *Tephrosia* (62), *Requienia* (2), *Ptycholobium* (3) |
| | Abreae | *Abrus* (2) |
| | Phaseoleae | *Canavalia* (5), *Galactia* (1), *Ophrestia* (2), *Mucuna* (4), *Bolusafra* (1), *Rhynchosia* (59), *Eriosema* (46), *Flemingia* (1), *Erythrina* (10), *Otoptera* (1), *Decorsea* (2), *Neorautanenia* (3), *Neonotonia* (1), *Dumasia* (1), *Teramnus* (1), *Sphenostylis* (2), *Alistilus* (1), *Dolichos* (12), *Macrotyloma* (5), *Dipogon* (1), *Lablab* (1), *Vigna* (20) |
| | Desmodieae | *Desmodium* (11), *Pseudarthria* (1), *Alysicarpus* (5) |
| | Psoraleeae | *Otholobium* (45), *Psoralea* (37), *Cullen* (3) |
| | Sesbanieae | *Sesbania* (10) |
| | Loteae | *Lotus* (3) |
| | Galegeae | *Astragalus* (1), *Lessertia* (56), *Sutherlandia* (5) |
| | Trifolieae | *Trifolium* (5), *Trigonella* (1) |

## CONCLUSION

The descriptive and distribution data used in this study confirm the considerable diversity of the legumes indigenous to South Africa, Lesotho and Swaziland. The majority of species falls in the tribe Crotalarieae, mainly due to the presence of diverse genera such as *Aspalathus* and *Lotononis*. The agriculturally important Phaseoleae tribe is well represented with 22 genera and 180 species, including 20 species of the well known *Vigna* pasture plant. Species grown in the Savanna Biome and Central Bushveld Bioregion were well presented. The diverse growth forms and distribution patterns of legumes are potentially useful in screening, selecting and breeding pasture legumes or for specific agricultural applications.

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