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RESEARCH ARTICLE

Oberholzeria (Fabaceae subfam. Faboideae), a New Monotypic Legume Genus from Namibia

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Abstract

Oberholzeria etendekaensis, a succulent biennial or short-lived perennial shrublet is described as a new species, and a new monotypic genus. Discovered in 2012, it is a rare species known only from a single locality in the Kaokoveld Centre of Plant Endemism, north-western Namibia. Phylogenetic analyses of molecular sequence data from the plastid *mat*K gene resolves *Oberholzeria* as the sister group to the Genisteae clade while data from the nuclear rDNA ITS region showed that it is sister to a clade comprising both the Crotalarieae and Genisteae clades. Morphological characters diagnostic of the new genus include: 1) succulent stems with woody remains; 2) pinnately trifoliolate, fleshy leaves; 3) monadelphous stamens in a sheath that is fused above; 4) dimorphic anthers with five long, basifixed anthers alternating with five short, dorsifixed anthers, and 5) pendent, membranous, one-seeded, laterally flattened, slightly inflated but indehiscent fruits.

Introduction

The Fabaceae subfam. Faboideae (Leguminosae subfam. Papilionoideae) is represented in Namibia by 52 genera and ca. 255 species [1], none of which are succulent. In May 2012, during a plant collecting expedition to the far north-western corner of Namibia, a region known as the Kaokoveld, the first author encountered an unusual papilionoid legume but which superficially resembles a member of *Zygophyllum* L. [2] (Zygophyllaceae). The plants were found in two small subpopulations in the Etendeka Mountains (Fig. 1) which form part of the Great Escarpment of southern Africa (Fig. 2).

The taxonomic placement of the new genus is uncertain as it shares morphological characters with both the Crotalarieae (calyces with five equal lobes, rostrate keels, dimorphic anthers with a 5 + 5 arrangement, and slightly inflated, pendent fruits) [3–8] and the Genisteae (lack of

Fig 1. Natural habitat of *Oberholzeria etendekaensis*. Plants of *O. etendekaensis* in their natural habitat (low-growing shrublets in foreground), Etendeka Mountains, Namibia. The plants grow in stony soil and scree derived from basalt of the Etendeka Group, Karoo Supergroup. This section of the Great Escarpment lies to the east of the Namib Desert, about 50 km from the Atlantic Ocean coastline. The climate is very arid, with an average annual rainfall of about 100 mm. Photo: W. Swanepoel.

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an aril, stamen filaments fused into a closed tube and strongly dimorphic anthers) [3, 4, 9–11], but differs from both tribes in being succulent.

Over the past several years, quite a few adjustments were made to the circumscription of these two tribes and several genera were transferred from one tribe to another, e.g. *Anarthrophylum* Benth. [12], *Argyrolobium* Eckl. & Zeyh. [13], *Dichilus* DC. [14] and *Melolobium* Eckl. & Zeyh. [13] were moved from the Crotalarieae to Genisteae [15]. These updated tribal circumscriptions have been confirmed by molecular studies [16–21] and show that both tribes form part of the Genistoid s.l. clade together with the Brongniartieae, Podalyrieae and the newly instated tribes Leptolobieae and Ormosieae [11].

In the present contribution the unusual papilionoid legume from Namibia is formally described as a new genus and species, namely *Oberholzeria etendekaensis*. Included are a diagnosis, morphological description, distribution map, line drawings and photographs, as well as two molecular phylogenies (nuclear rDNA ITS and plastid *mat*K) which aid in determining the phylogenetic placement of the new genus.

Materials and Methods

Ethics statement

The collection location for the new species reported in this work is not protected in any way. The species described here is currently not included in the Namibian Red Data Book. Material

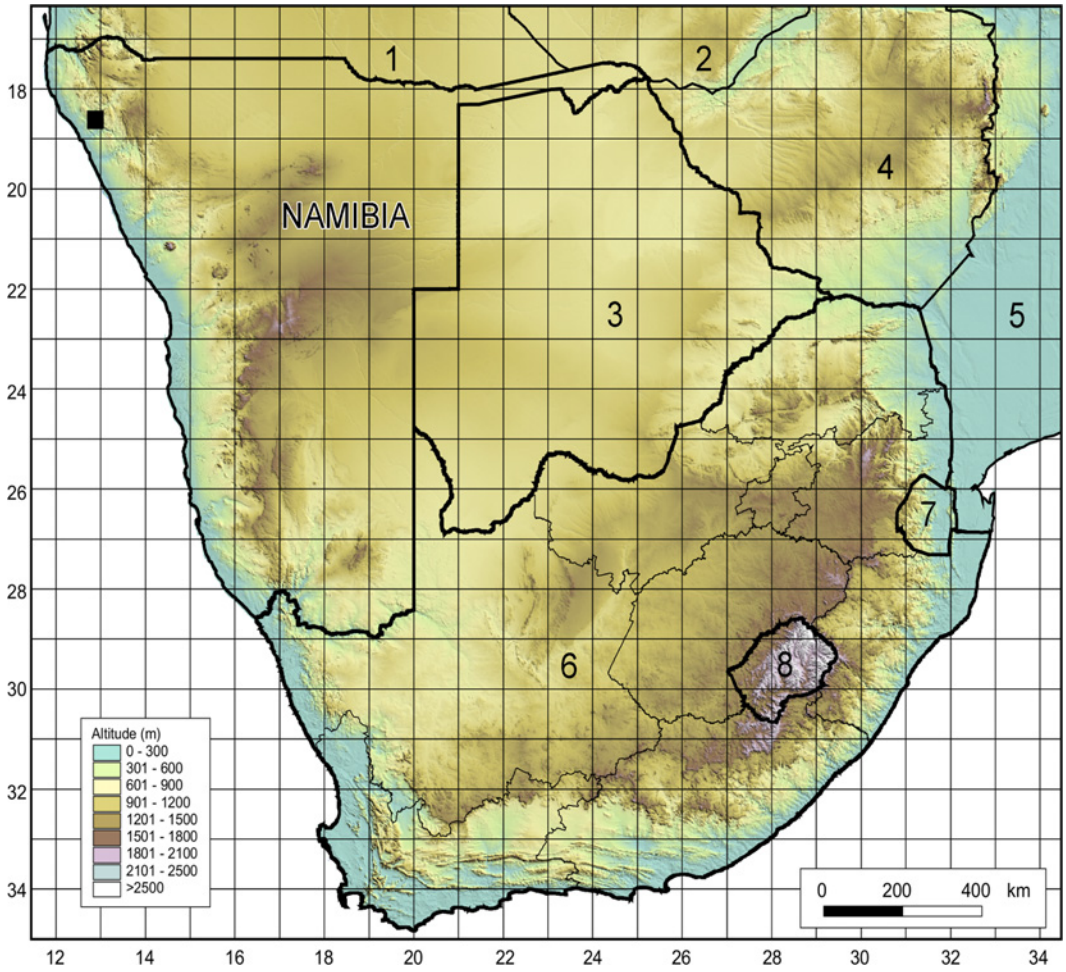

Fig 2. Geographical distribution of *Oberholzeria etendekaensis*. Topographic map of southern Africa showing the known distribution of *O. etendekaensis* (black square) in the far north-western corner of Namibia. The locality falls within the Kaokoveld Centre of Endemism, a biogeographical region rich in restricted-range plants and animals. The new species is known from a single population comprising two small subpopulations growing about 500 m apart in the Etendeka Mountains. These mountains form part of the Great Escarpment of southern Africa. Neighbouring countries indicated by numbers, namely Angola (1), Zambia (2), Botswana (3), Zimbabwe (4), Mozambique (5), South Africa (6), Swaziland (7) and Lesotho (8).

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of the new species was collected under permit no. 1697/2012, issued to one of us (WS) by the Ministry of Environment and Tourism, Republic of Namibia.

Nomenclature

The electronic version of this article in Portable Document Format (PDF) in a work with an ISSN or ISBN will represent a published work according to the International Code of Nomenclature for algae, fungi, and plants, and hence the new names contained in the electronic publication of a PLOS ONE article are effectively published under that Code from the electronic edition alone, so there is no longer any need to provide printed copies.

In addition, new names contained in this work have been submitted to IPNI, from where they will be made available to the Global Names Index. The IPNI LSIDs can be resolved and the associated information viewed through any standard web browser by appending the LSID contained in this publication to the prefix http://ipni.org/. The online version of this work is archived and available from the following digital repositories: PubMed Central, LOCKSS.

Morphological observations

The morphological description of the new genus was based on examination of fresh specimens. Details of the flowers were examined under a stereomicroscope. The morphological comparison with other species of the subfam. Faboideae was based on the study of live plants in the field as well as in cultivation, herbarium specimens, and information gathered from the literature. Newly collected specimens have been deposited in the herbarium of the National Botanical Research Institute, Windhoek, Namibia (WIND) and the National Herbarium, Pretoria, South Africa (PRE).

Taxon sampling and DNA sequencing

Genomic DNA was extracted from selected herbarium specimens and dried leaf material using DNeasy Plant Minikits (Qiagen, Valencia, California, USA). DNA samples for *Melolobium exudans* Harv. and *Polhillia obsoleta* (Harv.) B.-E. van Wyk were obtained from the DNA Bank at the Royal Botanic Gardens, Kew, UK. The nuclear rDNA ITS region and complete plastid *mat*K gene sequences were amplified by polymerase chain reaction methods as described previously [20, 22]. DNA sequencing was performed at the High Throughput Genomics Center (Seattle, Washington, USA). Sequence output files were assembled into contigs and edited using the program Sequencher 4.9 (GeneCodes, Ann Arbor, Michigan, USA) before alignment. For both loci, primers were used for sequencing reactions in both directions to generate complete overlap (100%) in the assembly of sequences. The sources of plant material used for all new sequences and GenBank information for sequences (both ITS and *mat*K) from all taxa included in this paper are provided in S1, S2 and S3 Tables respectively. The ITS and *mat*K datasets were submitted to TreeBase (submission number 16779, accessible at the URL http://purl.org/phylo/treebase/phylows/study/TB2:S1677).

Complete nrDNA ITS and *mat*K gene sequences were newly obtained from 11 taxa, including two collections of *Oberholzeria*, for this study. The new nrDNA ITS sequences were added to a data set (partially compiled from an existing dataset [23] and sequences retrieved from Genbank), then aligned manually and reduced to 109 taxa before analyses. The new *mat*K sequences were provisionally aligned with an updated version of *mat*K data set [20], which was then reduced in size to include only the representative papilionoids analysed here (74 taxa). Gaps in both data sets were treated as missing data and excluded from all analyses.

Phylogenetic analysis

The nrDNA ITS and *mat*K data sets were analyzed separately, due to lack of significant taxonomic overlap. Maximum parsimony (MP) analyses were performed using *PAUP** 4.0b10 [24]. Multiple tree searches were conducted using heuristic search options that included SIMPLE, CLOSEST, and RANDOM addition sequences (1000 replicates) holding 1–5 trees per replicate, and tree-bisection-reconnection (TBR) branch swapping, with retention of multiple parsimonious trees (MAXTREES = 1000 initially). Non-parametric bootstrap [25] proportions (BS) were estimated from 100–500 bootstrap replicates for each data set, incorporating heuristic search options as used in the standard parsimony searches.

Data sets were also analyzed by Bayesian inference [26] using a general time reversible model with gamma shape parameter and proportion of invariant sites (GTR + I + Γ) selected as the best model for both the nrDNA ITS and *mat*K data sets based on the Akaike Information Criterion (AIC) in MrModeltest (version 2) [27]. Bayesian analyses were run for 5×10^6 generations with four chains, sampling every 5×10^3 generations, using uniform (default) priors. Trees saved prior to stationarity were excluded by "burnin" (25% of samples) and the

remaining 750 trees were used to construct a majority rule consensus tree with clade credibility values (posterior probabilities; PP).

Results

Phylogenetic analysis

ITS nuclear data. The ITS data set (Fig. 3) consisted of 109 taxa and 639 included positions and the MP analysis produced >100,000 trees of 1784 steps (CI = 0.4187, RI = 0.7243). Results of both bootstrap and Bayesian analyses show *Oberholzeria* is supported as the sister to a clade comprising tribes Crotalarieae and Genisteae (76% and 1.0, respectively).

***mat*K plastid data.** Maximum parsimony analysis was conducted on the *mat*K data set (Fig. 4), which consisted of 74 taxa and 1518 included positions, and produced 794 trees of 1076 steps (CI = 0.6988, RI = 0.8885); Table 1. Both bootstrap and Bayesian analyses strongly support *Oberholzeria* as the sister group to the Genisteae clade (100% and 1.0, respectively).

Discussion

Oberholzeria is taxonomically isolated and its phylogenetic placement within the Crotalarieae is not supported by the molecular results. An analysis of the plastid *mat*K gene showed strong support (100% BS, 1.0 PP) for a sister group relationship to the Genisteae. The nuclear ITS analysis indicated that *Oberholzeria* is the sister group to both tribes, although this placement is not as strongly supported (76% BS, 1.0 PP). Due to the conflicting placements between the plastid and nuclear results, we have decided to compare the morphology of *Oberholzeria* with taxa from both tribes. The general morphology (Figs. 5 and 6) suggests an ancestral relationship based on shared characters with Genisteae and Crotalarieae. It is therefore necessary to compare the morphology of the new genus with the early-divergent taxa from both tribes.

The relationship between *Dichilus* DC. and *Melolobium* Eckl. & Zeyh. (Genisteae) is not resolved by our analyses, with alternating placements as early divergent taxa in this tribe. Consequently, we compared the new genus to both genera. *Oberholzeria* shares the following characters with *Dichilus* and *Melolobium*: Calyx shorter than the corolla; standard strongly reflexed (not strongly reflexed in *Melolobium*); anthers dimorphic; and fruits flat or slightly inflated [3, 6, 15, 28, 29].

Dichilus and *Melolobium* were previously included in the Crotalarieae [3, 4, 6] because of the structure of the staminal sheath, where all stamens are fused into a tube that is open along the upper side. In subsequent research done on the Crotalarieae and Genisteae, it was found that stamen fusion is taxonomically less important than previously considered and these two genera were moved to Genisteae [15]. In *Oberholzeria* the stamens are fused into a closed tube, which is a character state commonly found in other genera of the Genisteae [3, 9] but not in *Dichilus* or *Melolobium*. *Oberholzeria* also differs from these two genera in having a succulent, glabrous and unarmed habit (herbaceous and hairy in *Dichilus* and *Melolobium*, armed in the latter); pinnately trifoliolate leaves (digitately trifoliolate in *Dichilus* and *Melolobium*); five equally lobed calyces with dorsiventrally flattened lobes (bi-lobed and campanulate in *Dichilus* and *Melolobium*); callosities absent from the base of the standard lamina (callosities present in *Dichilus* only); wing petals longer than the keel and without spurs (shorter than the keel and with spurs in *Dichilus* and equal or longer than the keel but without spurs in *Melolobium*); rostrate keel apex (rounded or with blunt apices in *Dichilus* and *Melolobium*); and obovate-clavate, pendent and one-seeded fruit (narrowly oblong-linear to ovate, usually pointing upwards and more than one-seeded in *Dichilus* and *Melolobium*, rarely one-seeded in the latter).

Although *Crotalaria* L. is not the earliest-diverging taxon in the Crotalarieae, *Oberholzeria* superficially resembles this genus the most in general appearance (equally-lobed calyx, rostrate

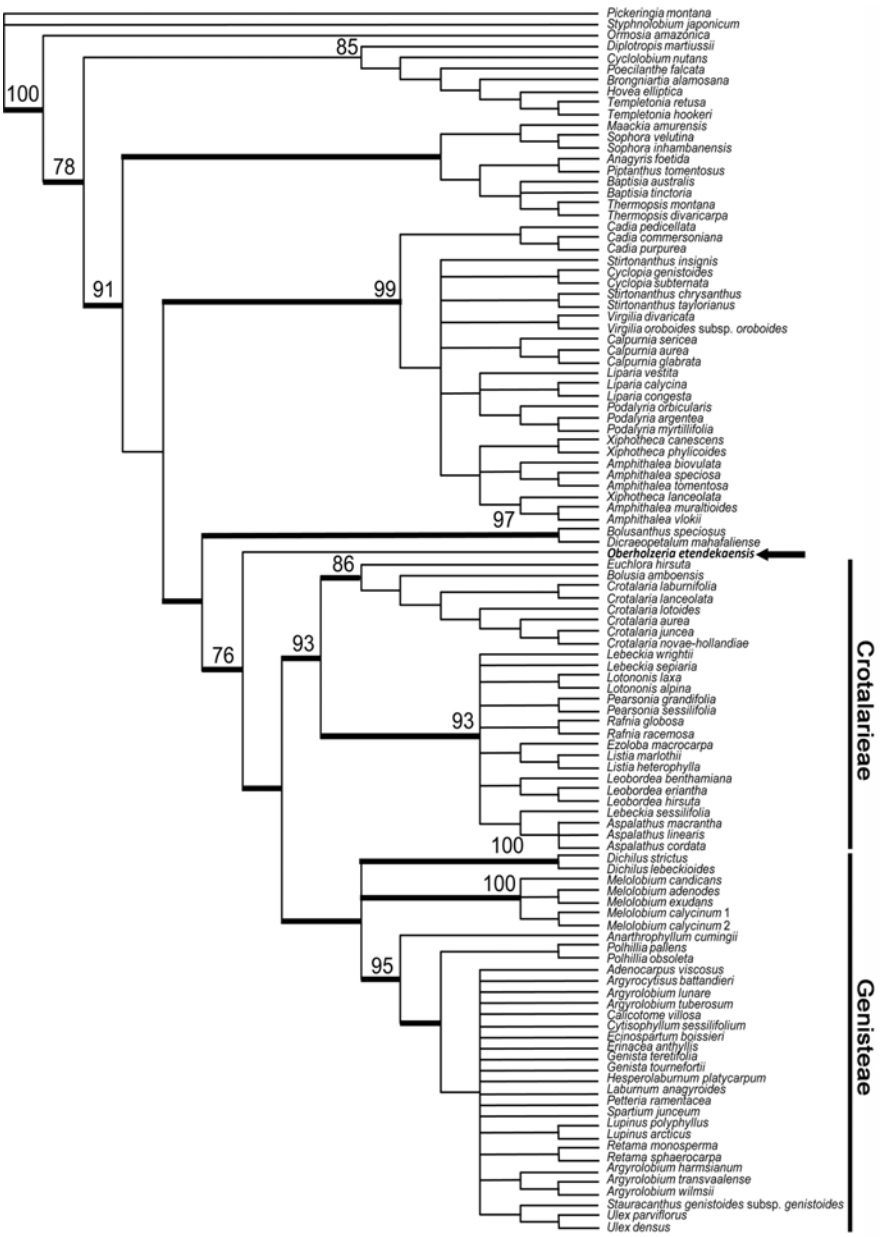

Fig 3. Phylogenetic tree based on nrDNA ITS sequences. Phylogenetic relationship of *Oberholzeria etendekaensis* (arrowed) derived from maximum parsimony analysis of the nrDNA ITS sequences; 109 taxa, 740 total characters with 639 included, of which 330 (52%) were parsimony informative. Tree shown is strict consensus of >100,000 equally most parsimonious trees of 1784 steps. Numbers represent maximum parsimony bootstrap support values (100–500 replicates) greater than 70% for selected clades; thickened branches represent clades with Bayesian posterior probabilities greater than 0.95. *Oberholzeria* is supported as the sister to a clade comprised of tribes Crotalarieae and Genisteae (76% and 1.0, respectively).

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keel, 5 + 5 anther arrangement and oblong-clavate fruit [8, 23]). When compared with two additional, early-diverging taxa from this clade, *Euchlora* Eckl. & Zeyh. and *Bolusia* Benth., *Oberholzeria* shares the following characters: Equally lobed calyx (with the exception of certain taxa in *Crotalaria*); rostrate keel; 5 + 5 anther arrangement; and pendent fruit.

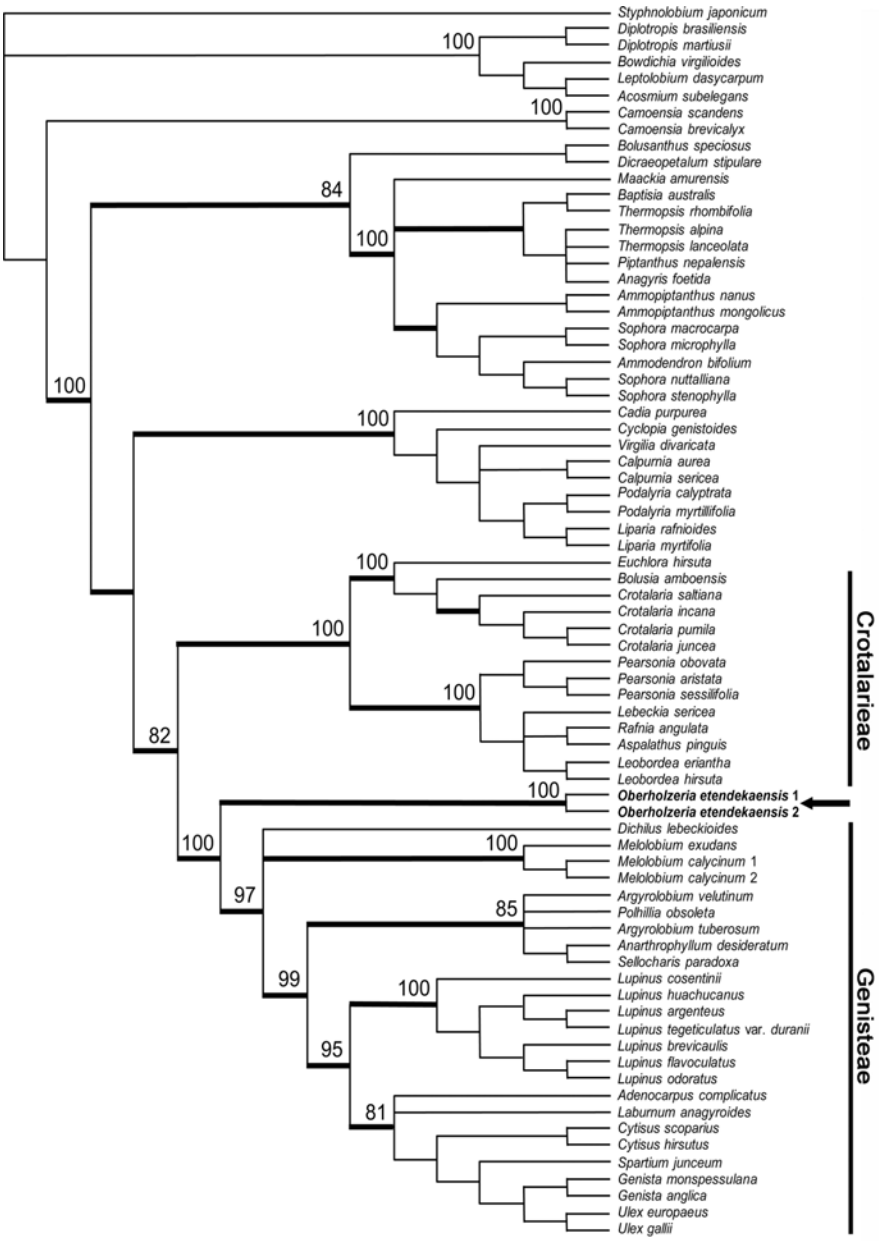

Fig 4. Phylogenetic tree based on plastid *mat*K gene sequences. Phylogenetic relationship of *Oberholzeria etendekaensis* (arrowed) derived from maximum parsimony analysis of the plastid *mat*K gene sequences; 74 taxa, 1572 total characters with 1518 included, of which 456 (30%) were parsimony informative. Tree shown is strict consensus of 794 equally most parsimonious trees of 1076 steps. Numbers represent maximum parsimony bootstrap support values (500 replicates) greater than 70% for selected clades; thickened branches represent clades with Bayesian posterior probabilities greater than 0.95. Both bootstrap and Bayesian analyses strongly support *Oberholzeria* as the sister group to the Genisteae clade (100% and 1.0, respectively).

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Oberholzeria also differs from *Euchlora*, *Bolusia* and *Crotalaria* in its succulent habit (herbaceous but non-succulent in *Euchlora*, *Bolusia* and *Crotalaria*); pinnately compound leaves (simple or digitately compound in *Euchlora*, *Bolusia* and *Crotalaria*); calyx with lobes dorsiventrally flattened, distally widely spreading and appearing stellate (campanulate in *Euchlora*,

Table 1. Summary of the statistics of the phylogenetic analyses that were conducted on both the ITS and *mat*K datasets.

	Number of taxa	Number of aligned characters	Number of included characters	Number of parsimony informative characters	Number of steps	Number of trees	CI	RI
ITS	109	740	639	330 (52%)	1784	>100,000	0.4187	0.7243
***mat*K**	74	1572	1518	456 (30%)	1076	794	0.6988	0.8885

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Bolusia and *Crotalaria*); standard without callosities (also absent in *Euchlora*, single callosity in *Bolusia* and paired callosities in *Crotalaria*); keel beak flat (flat in *Euchlora*, coiled in *Bolusia* and flat or sometimes twisted in *Crotalaria*); filaments of stamens fused into a closed tube (stamens fused into a tube that is open along the upper margin in *Euchlora*, *Bolusia* and *Crotalaria*); style glabrous (glabrous in *Euchlora* and *Bolusia*, hairy in almost all species of *Crotalaria*), fruit slightly inflated (strongly inflated in *Euchlora*, *Bolusia* and *Crotalaria* with only a few exceptions in the latter with flattened fruit).

Oberholzeria etendekaensis grows in localized patches of stony soil and scree (see under "Distribution, habitat and ecology" further on) within a semi-desert region of which the vegetation is fire intolerant, comprised of sparsely scattered perennial shrublets, shrubs and trees. Ephemerals and succulents are also present. The specific habitat of our new species is even more sparsely vegetated than the prevailing matrix vegetation, and temperatures here are suspected to be higher due to the rocky terrain. This habitat is best assigned as a local,

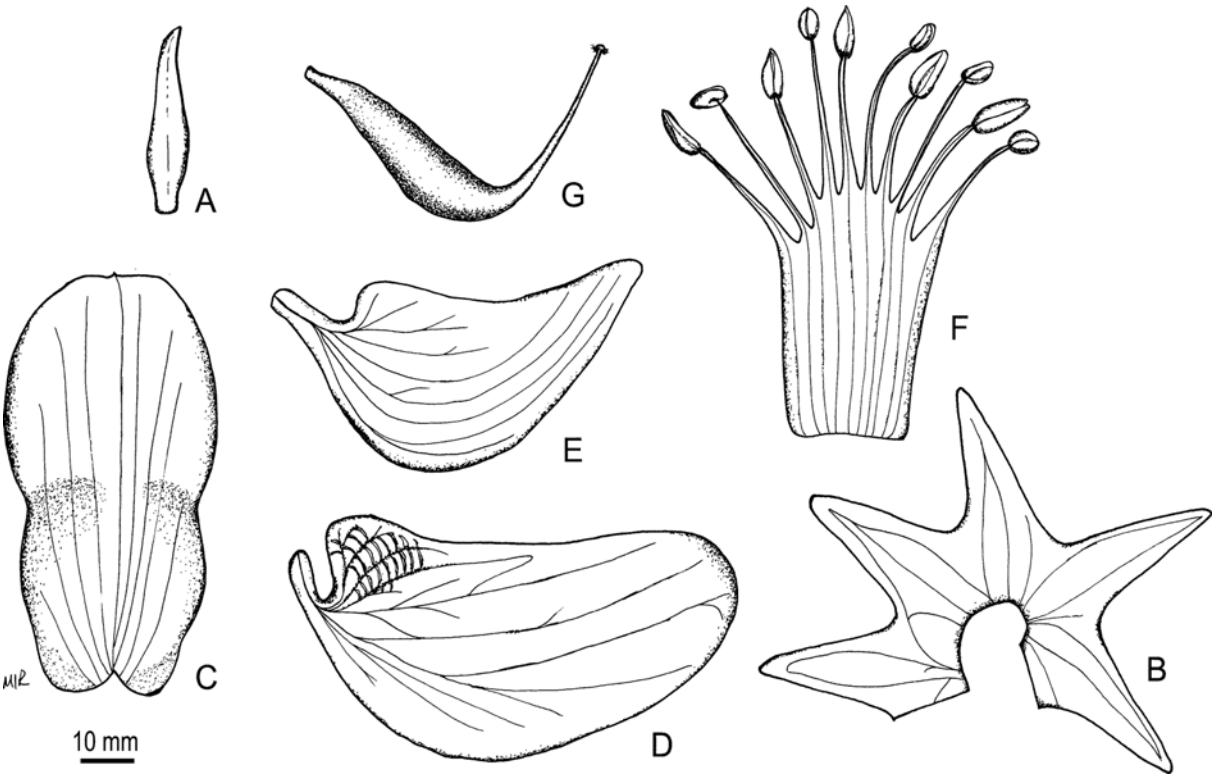

Fig 5. Flower morphology of *Oberholzeria etendekaensis*. Line drawings depicting the flower morphology. (A) Bract. (B) Calyx, opened out; lobes equal, dorsiventrally flattened. (C) Standard; strongly reflexed in the intact flower and lacking callosities. (D) Wing petal; longer than the keel and without a spur. (E) Keel petal. (F) Androecium, opened out; diagnostic for the genus is the stamens which are all fused into a tube that is closed above, and dimorphic anthers with five long, basifixed anthers alternating with five short, dorsifixed anthers. (G) Gynoecium. Voucher: *Swanepoel 316* (WIND). Artist: M.M. le Roux.

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Fig 6. Habit and macromorphology of *Oberholzeria etendekaensis*. Photographs illustrating the morphology of the plants. (A) Flowers with rostrate keels, reflexed standards, paired dark-brown spots at the bottom of the standard blades and dorsiventrally flattened, equally 5-lobed calyces. (B) Laterally flattened and somewhat inflated fruit. (C) Succulent stem. (D) Leaf-opposed inflorescences and pinnately trifoliolate leaves. (E) Habit; biennial or short-lived perennial succulent shrublet. Photos: W. Swanepoel.

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environmentally harsher ecological anomaly within the succulent biome, one of four biomes recognized by Schrire and co-workers [30] as generalised areas of endemism predictive of legume distribution. The succulent habit of this new legume is remarkable in that succulence is rare in legumes. However, the legume family is particularly diverse in areas of the world where other succulent plant species are abundant and diverse. Following Schrire and co-workers' study of *Indigofera* [31], an argument could be made that lineages endemic to patches of the succulent biome are expected to be evolutionary persistent because of the highly dispersal-limited nature of this biome and the absence of corridors to more suitable biomes. Thus, long branch lengths and phylogenetically isolated positions often characterise succulent biome endemics. This is indeed the case for *O. etendekaensis*, clearly a taxonomically isolated relictual species confined to a specialized habitat.

Table 2. Prominent differences between *Oberholzeria* and the early divergent genera from both the tribes Genisteae (*Dichilus* and *Melolobium*) and Crotalarieae (*Euchlora*, *Bolusia* and *Crotalaria*).

Character	Character state	Genus					
		Oberholzeria	*Dichilus*	*Melolobium*	*Euchlora*	*Bolusia*	*Crotalaria*
Habit	- Succulent	-	+	+	+	+	+
	+ Herbaceous (but non-succulent)						
Leaves	- Pinnately compound	-	+	+	+/++	+	+/(++)
	+ Digitately compound						
	++ Simple						
Calyx (symmetry)	- Equally five-lobed	-	+	+	-	-	-/(+)
	+ Bilabiate						
Calyx (shape)	- Stellate (lobes widely spreading)	-	+	+	+	+	+
	+ Campanulate						
Callosities (on standard lamina)	- Absent	-	+	-	-	+	+
	+ Present						
Standard	- Strongly reflexed	-	-	+	+	+	+
	+ Not strongly reflexed						
Wing petals	- Longer than keel	-	++	-/+	-	++	-/+/++
	+ Equal to keel						
	++ Shorter than keel						
Staminal tube	- Fused; without a slit	-	+	+	+	+	+
	+ Fused; open along upper margin						
Anther configuration	- 5 + 5	-	+	+	++	-	-
	+ 4 + 1 + 5						
	++ 4 + 6						
Style surface	- Glabrous	-	-	-	-	-	+
	+ Hairy						
Fruit shape	- Obovate-clavate	-	+	+	-/+	-/+	-/(+)/++
	+ Oblong to linear-oblong						
	++ Round (in two dimensions)						
Fruit inflation	- Compressed or slightly inflated	-	-	-	+	+	(-)/+
	+ Highly inflated						
Fruit orientation	- Pendent	-	+	+	-	-	-
	+ Pointing to the sides/upwards						
Habitat	- Succulent Biome	-	(-)/+	-/+/+++	-/+++	-/+	(-)/+/(++)/(+++)
	+ Grass Biome						
	++ Rainforest Biome						
	+++ Temperate Biome						

Biomes referred to under habitat follow Schrire and co-workers [30].

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A summary of the most prominent diagnostic characters for these taxa is presented in Table 2; information on biomes in this table follows Schrire and co-workers [30]. It is clear from the morphology that some characters of *Oberholzeria* fit better with the Crotalarieae than with the Genisteae but there is stronger molecular support for its placement with the Genisteae than the Crotalarieae. This incongruent pattern is also reflected in the different placements in the phylogenies based on analyses of plastid and nuclear sequence data. It is therefore difficult

to include this new genus with certainty in either tribe, although the *mat*K phylogeny provides much stronger support for a sister relationship to the Genisteae. We recommend the inclusion of *Oberholzeria* in the Genisteae but further studies, with more extensive sampling, are required to further clarify this relationship. More taxonomic evidence might even suggest it belongs to a new monogeneric tribe at the base of the Crotalarieae-Genisteae.

Taxonomic Treatment

Oberholzeria Swanepoel, M.M.le Roux, M.F.Wojc. & A.E.van Wyk, *gen. nov*. [urn:lsid:ipni.org:names: 77145129–1] (Figs. 1, 5 and 6). Type:—*Oberholzeria etendekaensis* Swanepoel, M.M.le Roux, M.F.Wojc. & A.E.van Wyk, here designated.

Differs from *Dichilus* and *Melolobium* in the following suite of characters: Plants invariably succulent, glaucous, glabrous and unarmed; leaves fleshy and pinnately compound; calyx equally five-lobed, lobes reflexed and dorsiventrally flattened; standard lacking callosities at the base of the lamina; wings longer than keel; keel apex rostrate; filaments of stamens fused into a closed tube; and fruit obovate-clavate and one-seeded. In *Dichilus* and *Melolobium* the plants are herbaceous and hairy but armed in *Melolobium*; leaves not fleshy and digitately compound, calyx bilabiate, lobes not strongly reflexed, campanulate; standard with callosities at the base of the lamina in *Dichilus*, callosities absent in *Melolobium*; wings shorter than keel in *Dichilus*, wings equal to longer than the keel in *Melolobium*; keel apex obtuse; filaments of stamens fused into a tube with a slit in the sheath on the upper side; and fruit oblong to linear-oblong and more than one-seeded.

Oberholzeria also shares morphological characters with genera in the tribe Crotalarieae but differs from the early-divergent members of the clade *Euchlora*, *Bolusia* and *Crotalaria* in the following characters: Plants succulent; leaves pinnately compound; calyx dorsiventrally flattened, equally five-lobed with lobes distally widely spreading (calyx appearing stellate), standard without callosities; keel beak flat; filaments of stamens fused into a closed tube; style glabrous, fruit slightly inflated. In *Euchlora*, *Bolusia* and *Crotalaria* the plants are herbaceous; leaves simple to digitately compound; calyx campanulate and equally five-lobed but sometimes bilabiate in *Crotalaria*; standard without callosities in *Euchlora*, a single callosity present in *Bolusia* and paired callosities in *Crotalaria*; keel beak flat in *Euchlora*, coiled in *Bolusia* and flat or twisted in *Crotalaria*; filaments of stamens fused into a tube that is open along the upper margin; style glabrous in *Euchlora* and *Bolusia* but rarely glabrous in *Crotalaria*; fruit markedly inflated with only a few exceptions in *Crotalaria*.

Erect, single-stemmed, biennial or short-lived perennial succulent, up to 1 m tall, 1.2 m diam., glabrous. Stem and branches fleshy, yellow-green, with woody remains, lower branches deciduous, leaving prominent crescent-shaped scars, stem up to 0.4 m tall before branching. Stipules paired, linear-lanceolate or linear-triangular, 2.0–2.4 × 0.3–0.4 mm, fleshy, deciduous, stipels absent. Leaves spirally arranged, pinnately trifoliolate, leaflets often patent and erect; lamina ovate, rarely suborbicular, fleshy, glabrous, green or glaucous with a white bloom, 10–25 × 9–22 mm, lateral leaflets slightly smaller than terminal leaflet, margin entire, venation somewhat cladodromous, 3–7 lateral veins on each side, midrib prominent abaxially, lateral veins less so; base subcordate or truncate, apex obtuse or retuse, mucronulate abaxially, petiole 7–30 mm long, rachis 4–17 mm long, petiolules 1–3 mm long, petiolule of lateral leaflets 1–3 mm long, petiole and petiolules fleshy, petiolule of terminal leaflet inflexed proximally; strong pea-like scent when crushed. Inflorescences leaf-opposed due to sympodial growth, terminally disposed on young branches and branchlets, racemose, with 35–65 flowers, petals white with yellow-green venation; rachis 25–50 mm long, peduncle 9–17 mm long; flowers spirally arranged, each subtended by a lanceolate, fleshy, caducous bract, 2.6–3.0 × 0.7–0.9 mm, glabrous

or adaxially with few tortuous hairs; bracteoles absent; pedicels 10–12 mm long and 0.5 mm wide. Calyx dorsiventrally flattened, 3.5–4.4 × 3.7–4.1 × 1.9–2.0 mm with five triangular lobes that are longer than the tube, lobes 2.3–3.2 × 1.5–1.7 mm, carinal lobe longest, sinuses equal, lobes distally widely spreading (calyx appearing stellate), glabrous or with few tortuous hairs adaxially. Standard narrowly obovate, retuse (folded medially, appearing oblanceolate in-situ), 6.2–7.5 × 2.9–3.2 mm, reflexed, lamina folded medially towards the apex, basal part fleshy, claw broad, indistinct and cucullate, lamina white with yellow in the central part and paired large dark-brown spots towards the basal margins. Wings broadly falcate, lamina 7.1–7.5 × 3.1–3.5 mm, longer than keel, auriculate at base with five columns of 3–12 crescent-shaped minute intercostal pockets; claw short but distinct, ± 0.6 mm long. Keel rostrate, lamina 5.7–5.9 × 2.6 mm, apex yellow to brown; claw short but distinct, 0.7–1.0 mm long. Stamens monadelphous, fused into a sheath that is closed above, anthers dimorphic, five long basifixed anthers, narrowly ovate, 0.8–1.4 × 0.5–0.6 mm, filaments up to 2.5 mm long, alternating with five short dorsifixed anthers, oblong, 0.4–0.6 × 0.3 mm, filaments up to 4.2 mm long. Ovary shortly stipitate, ventricose, ± 2.2 × 0.8 mm, with two ovules, style terete, tapering towards the stigma, slightly curved upwards, ± 2.2 mm long, glabrous; stigma terminal, penicillate, small, 0.15 mm diam. Fruit obovate-clavate, ± 23 × 14 × 6 mm, laterally flattened, slightly inflated, pendent, single seeded, green, khaki-coloured when dry, valves thin and papery, indehiscent with persistent calyx. Seeds asymmetrically obovate, laterally compressed, ± 8 × 7 × 3 mm, faintly verrucose, khaki or khaki-green, hilum not fleshy, cream-coloured, funicles ± 1.3 mm long.

Oberholzeria etendekaensis Swanepoel, M.M.le Roux, M.F.Wojc. & A.E.van Wyk, sp. nov. [urn:lsid:ipni.org: names: 77145130–1] (Figs. 2–4). Type:—NAMIBIA. Kunene Region: Etendeka Mountains, 32 km NNW of Puros, 1812 (–DB), 850 m, 3 May 2012, *Swanepoel 316* (HOLOTYPE: WIND; ISOTYPE: PRE).

Description: Same as for the genus. Figs. 1, 5 and 6.

Distribution, habitat and ecology

Oberholzeria etendekaensis is known from a single population (comprising two small subpopulations) in the Kaokoveld Centre of Endemism, a biogeographical region rich in restricted-range plants and animals [32], in north-western Namibia (Fig. 2). Its only known locality is from the Great Escarpment, in the Etendeka Mountains, on the watershed between the Khumib and Hoarusib Rivers, ± 50 km from the Atlantic coast at elevations ranging from 850–950 m. Average annual rainfall is around 100 mm and the substrate is derived from basalt of the Etendeka Group, Karoo Supergroup [33]. *Oberholzeria etendekaensis* is rare and has only been found in one location. It grows in two south-facing ravines (two subpopulations), approximately 500 m apart, in association with another succulent, *Euphorbia pergracilis* Meyer [34], also a restricted-range species. It is found on stony soil and scree in small colonies of usually less than ten plants each, in full sun (Fig. 1).

Flowering occurs in April and May; this follows the end of the main rainy season (late summer).

Conservation status

Although rare and localised, *O. etendekaensis* does not appear to be threatened at present. No signs of browsing by livestock or game were noticed and plants seem to be healthy and occur in an area unpopulated or sparsely populated by humans.

Etymology

Johanna Allettha Oberholzer [1965–], beloved and venerated wife of the first author, is commemorated in the genus name. Known as Hannelie, she proposed that this specific part of the Etendeka Mountains be explored, accompanied the expedition during which the new species was discovered and first saw and brought the plants to the attention of one of us (WS). The specific epithet refers to the Etendeka Mountains, the type locality of the new species.

Supporting Information

S1 Table. Collection details of voucher specimens used to generate new sequences during the current study.
(DOCX)

S2 Table. List of accessions used in the study of the ITS region. Included are the taxon name, respective GenBank number and the place of publication, or alternatively collector name, number and the herbarium where the voucher was deposited in the case of newly generated sequences.
(DOCX)

S3 Table. List of accessions used in the study of the *mat*K region. Included are the taxon name, respective GenBank number and the place of publication, or alternatively the collector name, number and herbarium where the voucher was deposited in the case of newly generated sequences.
(DOCX)

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Author Contributions

Conceived and designed the experiments: WS MMLR MFW AEVW. Performed the experiments: WS MMLR MFW. Analyzed the data: WS MMLR MFW AEVW. Contributed reagents/materials/analysis tools: WS MMLR MFW AEVW. Wrote the paper: WS MMLR MFW AEVW.

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Supporting information

Table S1. Collection details of voucher specimens used to generate new sequences during the current study. (DOC)

Taxon	Collector name	Collector number	Herbarium	Country	State/province	General locality	Year
Argyrolobium transvaalense Schinz	A.R. Gotze	298	PRE	South Africa	Limpopo	Sekhukhuneland, Farm Zwartkoppies	11/02/2010
Argyrolobium tuberosum Eckl. & Zeyh.	S.P. Bester	10865	PRE	South Africa	Mpumalanga	Farm Haverklip 265 IR. Road crossing over Wilge River, ± 2 km SE of Delmas Colliery and 23 km SE of Delmas	17/12/2011
Argyrolobium wilmsii Harms	S. Krynauw	584	PRE	South Africa	Limpopo	The Downs 34 KT; Ca. 3 km from Makwens homestead	22/05/1985
Leobordea eriantha (Benth.) B.-E.van Wyk & Boatwr.	D. Cardoso et al.	3273	HUEFS	South Africa	Mpumalanga	Long Tom Pass, Regional Road R37, entre Lydenburg e Sabie	13/01/2013
Leobordea hirsuta (Schinz) B.-E.van Wyk & Boatwr.	S.P. Bester	11922	PRE	South Africa	Gauteng	Pretoria National Botanical Gardens, NE side of large piece of natural grassland. LATLONG: 25°44'17" S, 28°16'44" E	07/04/2014
Melolobium calycinum Benth.	A.E. van Wyk	13662	PRU	South Africa	North West	Leeuwfontein, ca. 10 km W of Wolmaransstad	04/04/2014
Melolobium calycinum Benth.	A.E. van Wyk	13663	PRU	South Africa	North West	Leeuwfontein, ca. 10 km W of Wolmaransstad	04/04/2014
Melolobium calycinum Benth.	A.E. van Wyk	13664	PRU	South Africa	North West	Leeuwfontein, ca. 10 km W of Wolmaransstad	04/04/2014
Oberholzeria etendekaensis Swanepoel, M.M.le Roux & A.E.van Wyk 1	W. Swanepoel	316-1	WIND	Namibia	Kunene	Etendeka Mountains, 32 km NNW of Puros	03/05/2012
Oberholzeria etendekaensis Swanepoel, M.M.le Roux & A.E.van Wyk 2	W. Swanepoel	316-2	WIND	Namibia	Kunene	Etendeka Mountains, 32 km NNW of Puros	23/03/2013
Pearsonia aristata (Schinz) Dümmer	D. Cardoso et al.	3272	HUEFS	South Africa	Mpumalanga	Nelspruit, Havelock Road	13/13/2013
Pearsonia obovata (Schinz) Polhill	D. Cardoso et al.	3274	HUEFS	South Africa	Mpumalanga	Long Tom Pass, Regional Road R37, entre Lydenburg e Sabie	13/13/2013
Pearsonia sessilifolia (Harv.) Dümmer	D. Cardoso et al.	3271	HUEFS	South Africa	Mpumalanga	Nelspruit, Havelock Road	13/13/2013
Sellocharis paradoxa Taub.	R. Lüdtke & M.S. Pereira	488	ICN	Brazil	Rio Grande do Sul	Viamão, Parque Estadual de Itapuã	22/12/2005

S2 Table. List of accessions used in the study of the ITS region.

Taxon	**Genbank number - ITS region**	**Publication/voucher**
Adenocarpus viscosus Webb & Berthel.	Z72300 and Z72301	Käss (1995)
Amphithalea biovulata (H.Bolus) Granby	AM261219	Boatwright et al. (2008a)
Amphithalea speciosa Schltr.	AM261235	Boatwright et al. (2008a)
Amphithalea tomentosa (Thunb.) Granby	AM261430	Boatwright et al. (2008a)
Amphithalea muraltioides (Benth.) A.L.Schutte	AM261230	Boatwright et al. (2008a)
Amphithalea vlokii (A.L.Schutte & B.-E.van Wyk) A.L.Schutte	AM261435	Boatwright et al. (2008a)
Anagyris foetida L.	AY091571	Wang et al. (2006)
Anarthrophyllum cumingii F.Phil.	AY609186 and AY609196	Ainouche and Misset s.n.
Argyrocytisus battandieri (Maire) Raynaud	Z95580 and Z95581	Käss and Wink (1997)
Argyrolobium lunare Druce	AF287686	Crisp et al. (2000)
Argyrolobium tuberosum Eckl. & Zeyh.	KP230719	Bester 10865 (PRE)
Argyrolobium harmsianum Schltr. ex Harms	AF287685	Crisp et al. (2000)
Argyrolobium transvaalense Schinz	KP230720	Gotze 298 (PRE)
Argyrolobium wilmsii Harms	KP230721	Krynauw 584 (PRE)
Aspalathus macrantha Harv.	EU347728	Boatwright et al. (2008b)
Aspalathus linearis (Burm.f.) R.Dahlgren	EU347739	Boatwright et al. (2008b)
Aspalathus cordata (L.) R.Dahlgren	AF287681	Crisp et al. (2000)
Baptisia australis (L.) R. Br.	AY091572	Wang et al. (2006)
Baptisia tinctoria (L.) Vent.	Z72314 and Z72315	Käss (1995)
Bolusanthus speciosus Harms	AM262451	Motsi (2004)
Bolusia amboensis Harms	JQ067344	Le Roux et al. (2013)
Brongniartia alamosana Rydb.	AF467022	Hu et al. (2002)
Cadia pedicellata Baker	AM261738	Boatwright et al. (2008a)
Cadia commersoniana Baill.	AM261737	Boatwright et al. (2008a)
Cadia purpurea (G. Piccioli) Aiton	AM261740	Boatwright et al. (2008a)
Calicotome villosa (Poir.) Link	Z72252 and Z72253	Käss (1995)
Calpurnia sericea Harv.	AM268374 and AM268375	Boatwright et al. (2008a)
Calpurnia aurea Benth.	AJ409913	Van der Bank et al. (2002)
Calpurnia glabrata Brummitt	AM177372	Boatwright et al. (2008a)
Crotalaria laburnifolia L.	JQ067130	Le Roux et al. (2013)
Crotalaria lanceolata E.Mey.	JQ067145	Le Roux et al. (2013)
Crotalaria lotoides Benth.	JQ067299	Le Roux et al. (2013)
Crotalaria aurea Dinter ex Baker f.	JQ067157	Le Roux et al. (2013)
Crotalaria juncea L.	JQ067144	Le Roux et al. (2013)
Crotalaria novae-hollandiae DC.	JQ067289	Le Roux et al. (2013)
Cyclolobium nutans Rizzini & Heringer	AF467041	Hu et al. (2002)
Cyclopia genistoides (L.) Vent.	AM050819	Boatwright et al. (2008a)
Cyclopia subternata Vogel	AM050821	Boatwright et al. (2008a)
Cytisophyllum sessilifolium O.Lang	Z72254 and Z72255	Käss (1995)
Dichilus strictus E.Mey.	AF287684	Crisp et al. (2000)
Dichilus lebeckioides DC.	EU347894	Boatwright et al. (2008a)
Dicraeopetalum mahafaliense (M.Peltier) Yakovlev	EF457716	Edwards and Hawkins (2007)

Diplotropis martiusii Benth.	AY553711	Beck, Henner, and Jo. Cardosa 166 (US)
Echinospartum boissieri (Spach) Rothm.	AY609188 and AY609193	MAF 148150 (Univ Complutense, Madrid)
Erinacea anthyllis Link	Z72256 and Z72257	Käss (1995)
Euchlora hirsuta Druce	EU347881	Boatwright et al. (2008b)
Ezoloba macrocarpa (Eckl. & Zeyh.) B.-E.van Wyk & Boatwr.	FM875935 and FM875936	Boatwright et al. (2011)
Genista teretifolia Willk.	AY263668	Pardo et al. (2004)
Genista tournefortii Spach	AY263669	Pardo et al. (2004)
Hesperolaburnum platycarpum (Maire) Maire	AY263678	Pardo et al. (2004)
Hovea elliptica (Sm.) DC.	AF287640	Crisp et al. (2000)
Laburnum anagyroides Medik.	AY263679	Pardo et al. (2004)
Lebeckia wrightii Bolus	AM262447	Motsi (2004)
Lebeckia sessilifolia (Eckl. & Zeyh.) Benth.	AF287678	Crisp et al. (2000)
Lebeckia sepiaria (L.) Thunb.	EU347853	Boatwright et al. (2008b)
Leobordea benthamiana (Dümmer) B.-E.van Wyk & Boatwr.	EU347771	Boatwright et al. (2008b)
Leobordea eriantha (Benth.) B.-E.van Wyk & Boatwr.	EU347784	Boatwright et al. (2008b)
Leobordea hirsuta (Schinz) B.-E.van Wyk & Boatwr.	EU347881	Boatwright et al. (2008b)
Liparia vestita Thunb.	AM261492	Boatwright et al. (2008a)
Liparia calycina (L.Bolus) A.L.Schutte	AM261481	Boatwright et al. (2008a)
Liparia congesta A.L.Schutte	AM261484	Boatwright et al. (2008a)
Listia marlothii (Engl.) B.-E.van Wyk & Boatwr.	EU347825	Boatwright et al. (2008b)
Listia heterophylla E.Mey.	EU347826	Boatwright et al. (2008b)
Lotononis laxa Eckl. & Zeyh.	AF287677	Crisp et al. (2000)
Lotononis alpina (Eckl. & Zeyh.) B.-E.van Wyk	AM262446	Boatwright et al. (2008a)
Lupinus polyphyllus Lindl.	AF007496	Ainouche and Bayer (1999)
Lupinus arcticus S.Watson	AF007495	Ainouche and Bayer (1999)
Maackia amurensis Rupr.	Z72336 and Z72352	Käss (1995)
Melolobium candicans Eckl. & Zeyh.	AM050833	Moteetee (2003)
*Melolobium adenode*s Eckl. & Zeyh.	AM050832	Moteetee (2003)
Melolobium exudans Harv.	KP230725	Manning and Manning 2857 (K)
Melolobium calycinum Benth.	KP230723	Van Wyk 13662 (PRU)
Melolobium calycinum Benth.	KP230724	Van Wyk 13663 (PRU)
Oberholzeria etendekaensis Swanepoel, M.M.le Roux , M.F.Wojc. & A.E.van Wyk	KP247506	Swanepoel 316 (WIND)
Ormosia amazonica Ducke	EF457724	Edwards and Hawkins (2007)
Pearsonia grandifolia (Bolus) Polhill	AM262450	Boatwright et al. (2008a)
Pearsonia sessilifolia Dümmer	AJ287675	Crisp et al. (2000)
Petteria ramentacea C.Presl	Z72232 and Z72233	Käss (1995)
Pickeringia montana Torr. & A. Gray	AY091568	Wang et al. (2006)
Piptanthus tomentosus Franch.	AY091570	Wang et al. (2006)
Podalyria orbicularis E.Mey.	AM261675	Boatwright et al. (2008a)
Podalyria argentea Salisb.	AM261493	Boatwright et al. (2008a)
Podalyria myrtillifolia Willd.	AJ409901	Van der Bank et al. (2002)
Poecilanthe falcata (Vell.) Heringer	AF467492	Hu et al. (2002)

Polhillia pallens C.H.Stirt.	EF457695	Edwards and Hawkins (2007)
Polhillia obsoleta (Harv.) B.-E.van Wyk	KP230726	Manning 2847 (K)
Rafnia globosa G.J.Campb. & B.-E.van Wyk	EU347743	Boatwright et al. (2008b)
Rafnia racemosa Eckl. & Zeyh.	EU347741	Boatwright et al. (2008b)
Retama monosperma (L.) Boiss.	AY263681	Pardo et al. (2004)
Retama sphaerocarpa (L.) Boiss.	AY263682	Pardo et al. (2004)
Sophora velutina Lindl.	FN813569	Boatwright and Van Wyk (2011)
Sophora inhambanensis Klotzsch	FN813570	Boatwright and Van Wyk (2011)
Spartium junceum L.	AF351088	Cubas et al. (2002)
Ulex genistoides Brot. subsp. *genistoides*	AF384340 and AF384341	Ainouche et al. (2003)
Stirtonanthus insignis (Compton) B.-E. van Wyk & A.L. Schutte	AJ409906	Van der Bank et al. (2002)
Stirtonanthus taylorianus (L. Bolus) B.-E. van Wyk & A.L. Schutte	AJ409907	Van der Bank et al. (2002)
Stirtonanthus chrysanthus (Adamson) B.-E.van Wyk & A.L. Schutte	AM268386 and AM268387	Boatwright et al. (2008a)
Styphnolobium japonicum (L.) Schott	AJ409920	Van der Bank et al. (2002)
Templetonia retusa (Vent.) R. Br.	AF287636	Crisp et al. (2000)
Templetonia hookeri (F. Muell.) Benth.	GQ250085	Queiroz et al. (2010)
Thermopsis montana Torr. & A. Gray	AF384336 and AF384337	Ainouche et al. (2003)
Thermopsis divaricarpa A. Nelson	AY091575	Wang et al. (2006)
Ulex parviflorus Pourr.	AF007470	Ainouche and Bayer s.n.
Ulex densus Welw. ex Webb	AF384356	Ainouche et al.
Virgilia divaricata Adamson	AJ409910	Van der Bank et al. (2002)
Virgilia oroboides (P.J.Bergius) T.M.Salter subsp. *oroboides*	AJ409912	Van der Bank et al. (2002)
Xiphotheca canescens (Thunb.) A.L.Schutte & B.-E.van Wyk	AM268388 and AM268389	Boatwright et al. (2008a)
Xiphotheca phylicoides A.L.Schutte & B.-E.van Wyk	AM261743	Boatwright et al. (2008a)
Xiphotheca lanceolata Eckl. & Zeyh.	AM261742	Boatwright et al. (2008a)

S3 Table. List of accessions used in the study of the matK region.

Taxon	**Genbank number - *mat*K region**	**Publication/voucher**
Acosmium subelegans (Mohlenbr.) Yakovlev	JX124410	J.E. Meireles 489 (RB)
Adenocarpus complicatus J.Gay ex Gren. & Godr.	JQ858229	Cunha et al. (2012)
Ammodendron bifolium (Pall.) Yakovlev	AY386957	A. Whittemore s.n. (MONT)
Ammopiptanthus mongolicus (Maxim.) S.H.Cheng	JQ820169	Strain 09050101
Ammopiptanthus nanus (Popov) S.H.Cheng	JQ820170	Strain 200802
Anagyris foetida L.	KP230736	Duran 6932 (KNYA)
Anarthrophyllum desideratum Benth.	AY386923	Wojciechowski et al. (2004)
Argyrolobium tuberosum Eckl. & Zeyh.	KP230727	Bester 10865 (PRE)
Argyrolobium velutinum Eckl. & Zeyh.	JQ412199	JWB 503
Aspalathus pinguis Thunb.	JQ412203	JWB 512
Baptisia australis R.Br.	AY386900	Wojciechowski et al. (2004)
Bolusanthus speciosus Harms	AF142685	Hu et al. (2000)
Bolusia amboensis Harms	JQ040984	Le Roux et al. (2012)
Bowdichia virgilioides Knuth	AY386937	Wojciechowski et al. (2004)
Cadia purpurea (G. Piccioli) Aiton	JX295932	Cardoso et al. (2012)
Calpurnia aurea Benth.	AY386951	Wojciechowski et al. (2004)
Calpurnia sericea Harv.	JX518205	Abbott 9196
Camoensia brevicalyx Benth.	JX295946	Cardoso et al. (2012)
Camoensia scandens (Welw.) J.B.Gillett	JX295919	Cardoso et al. (2012)
Crotalaria incana L.	GQ246141	Queiroz et al. (2010)
Crotalaria juncea L.	JQ619982	Bala s.n. (ASU)
Crotalaria pumila Ortega	AY386867	Wojciechowski et al. (2004)
Crotalaria saltiana Andrews	JQ619981	Chuang 4723 (ASU)
Cyclopia genistoides Sieber ex C.Presl	JX518243	JWB 022
Cytisus hirsutus L.	HE967392	Bruni et al. (2012)
Cytisus scoparius (L.) Link	AY386902	Wojciechowski et al. (2004)
Dichilus lebeckioides DC.	GQ246143	Queiroz et al. (2010)
Dicraeopetalum stipulare Harms	GQ246142	Queiroz et al. (2010)
Diplotropis brasiliensis (Tul.) Benth.	AY386939	Wojciechowski et al. (2004)
Diplotropis martiusii Benth.	AY386938	Wojciechowski et al. (2004)
Euchlora hirsuta Druce	JQ041113	Le Roux et al. (2012)
Genista anglica L.	JN894663	NMW 4174
Genista monspessulana (L.) L.A.S.Johnson	AY386862	Wojciechowski et al. (2004)
Laburnum anagyroides Medik.	HE967423	Bruni et al. (2012)
Lebeckia sericea Thunb.	GQ246144	Queiroz et al. (2010)
Leobordea eriantha (Benth.) B.-E.van Wyk & Boatwr.	KP230706	Cardoso et al. 3273 (HUEFS)
Leobordea hirsuta (Schinz) B.-E.van Wyk & Boatwr.	KP230728	S. P. Bester 11922 (PRE)
Leptolobium dasycarpum Vogel	JX124408	Cardoso et al. (2012)
Liparia myrtifolia Thunb.	JX517632	JWB 039
Liparia rafnioides A.L.Schutte	JX517668	JWB 033

Lupinus argenteus Pursh	AY386956	Wojciechowski et al. (2004)
Lupinus brevicaulis Griseb.	EU025879	A. Tiehm 13819 (ASU)
Lupinus cosentinii Guss.	AY386943	Wojciechowski et al. (2004)
Lupinus flavoculatus A.Heller	EU025898	A. Tiehm 13537 (ASU)
Lupinus huachucanus M.E.Jones	EU025906	M. Baker 13435 (ASU)
Lupinus odoratus A.Heller	EU025914	Van Devender 86-111 (ARIZ)
Lupinus tegeticulatus var. duranii (Eastw.) Barneby	AY386910	Wojciechowski et al. (2004)
Maackia amurensis Rupr.	AY386944	Wojciechowski et al. (2004)
Melolobium calycinum Benth. 1	KP230729	Van Wyk 13662 (PRU)
Melolobium calycinum Benth. 2	KP230730	Van Wyk 13663 (PRU)
Melolobium exudans Harv.	KP230731	Manning & Manning 2857 (K)
Oberholzeria etendekaensis Swanepoel, M.M.le Roux, M.F.Wojc. & A.E.van Wyk 1	KP230732	Swanepoel 316-1 (WIND)
Oberholzeria etendekaensis Swanepoel, M.M.le Roux, M.F.Wojc. & A.E.van Wyk 2	KP230733	Swanepoel 316-2 (WIND
Pearsonia aristata Dümmer	KP230707	Cardoso et al. 3272 (HUEFS)
Pearsonia obovata (Schinz) Polhill	KP230708	Cardoso et al. 3274 (HUEFS)
Pearsonia sessilifolia subsp. *marginata* (Schinz) Polhill	KP230709	Cardoso et al. 3271 (HUEFS)
Piptanthus nepalensis Sweet	AY386924	Wojciechowski et al. (2004)
Podalyria calyptrata Willd.	JX518039	MWC 16091
Podalyria myrtillifolia Willd.	JX517747	AMM 5052
Polhillia obsoleta (Harv.) B.-E.van Wyk	KP230734	Manning 2847 (K)
Rafnia angulata Thunb.	JQ412281	JWB 510
Sellocharis paradoxa Taub.	KP230740	Lüdtke & Pereira 488 (ICN)
Sophora macrocarpa Sm.	JQ619975	Landrum 5855 (ASU)
Sophora microphylla Aiton	JQ619976	Landrum 7622 (ASU)
Sophora nuttalliana B.L.Turner	AY386865	Wojciechowski et al. (2004)
Sophora stenophylla A.Gray	JQ669580	Gierisch 4997 (ASU)
Spartium junceum L.	AY386901	Wojciechowski et al. (2004)
Styphnolobium japonicum (L.) Schott	AY386962	Wojciechowski et al. (2004)
Thermopsis alpina Ledeb.	JQ669594	Long et al., Sino-British Qinghai Exp. 497 (E)
Thermopsis lanceolata R.Br.	JQ669595	Long et al., Sino-British Qinghai Exp. 526 (E)
Thermopsis rhombifolia (Nutt. ex Pursh) Richardson	AY386866	Wojciechowski 807 (MONT)
Ulex europaeus L.	JQ669586	Damrel 2304 (ASU)
Ulex gallii Planch.	JN895798	NMW 4258
Virgilia divaricata Adamson	JX517500	OM 3169