

The alpine flora on inselberg summits in the Maloti–Drakensberg Park, KwaZulu-Natal, South Africa



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Background: Inselberg summits adjacent to the Maloti–Drakensberg escarpment occupy an alpine zone within the Drakensberg Alpine Centre (DAC). Inselbergs, the escarpment and surrounding mountains such as Platberg experience a severe climate; inselberg summits are distinct by being protected from human disturbance.

Objectives: The aim of this article was to describe for the first time the flora of inselberg summits and to assess their potential contribution to conservation of DAC plant diversity.

Method: We investigated whether the flora of inselberg summits formed a representative subset of the DAC flora in terms of shared, especially endemic or near endemic, species and representation of families. All species were listed for six inselbergs between Giant's Castle and Sentinel, located in the Royal Natal National Park (RNNP) during November 2005. Comparisons, using literature, were made with floras of the DAC, as well as Platberg, an inselberg approximately 60 km north from Sentinel in the RNNP.

Results: We recorded 200 species of pteridophytes and angiosperms on inselbergs, 114 DAC endemics or near endemics, one possible new species, and several range and altitudinal extensions. Asteraceae, Poaceae and Ericaceae comprised 42.1% of endemic and near endemic species, with Scrophulariaceae and Hyacinthaceae contributing 8.8%. Inselberg and DAC floras differed in respective rankings of Crassulaceae (8th vs. > 15th), Polygalaceae, Apiaceae and Rosaceae (10th, 11th, 12th vs. > 15th), Poaceae (2nd vs. 5th), Cyperaceae (3rd vs. 4th) and Scrophulariaceae (6th vs. 2nd). Growth forms on inselbergs were consistent with DAC flora. Inselbergs shared 40% of species with Platberg.

Conclusion: Inselbergs, which supported 7.9% of species occurring in the DAC flora, are well protected from human impact, lack alien plants, but, despite this, are highly vulnerable to climate change. Conservation importance of inselbergs will increase as escarpment vegetation becomes increasingly degraded as a consequence of intensifying land use.

Introduction

Montane systems across the globe are characterised by pronounced environmental gradients in relation to altitude and in most cases a unique flora adapted to an extreme high altitude environment (Körner 2003). The uKhahlamba–Drakensberg (hereafter Drakensberg) range is the most conspicuous montane region in southern Africa, rising to over 3000 m above sea level (asl) from plains at about 1200 m asl (Hilliard & Burt 1987; Killick 1963). Many montane regions consist of a set of relatively separate peaks, whereas the Drakensberg is structured as a dissected plateau bounded by a steep, tall escarpment on the eastern flank (Partridge 1997). This high altitude plateau has been recognised as a centre of plant endemism and a biodiversity hotspot (Cowling & Hilton-Taylor 1997) known as the 'Drakensberg Alpine Centre' (DAC) (Carbutt & Edwards 2004, 2006). Most of the DAC falls within Lesotho although a small portion is situated within South Africa east of the national boundary defined by the summit watershed. The significant biodiversity of the Drakensberg, and specifically of the DAC, contributed to the successful application for the South African portion (plus Sehlabathebe National Park of Lesotho in the southern Drakensberg) to be recognised as a World Heritage site (Krüger & Crowson 2004).

Maintaining biodiversity of montane environments poses a significant challenge in the face of global climate change (Körner 2003). Distribution and abundance of most montane plant species is determined by a complex suite of environmental factors for which altitude serves as a surrogate descriptor (Austin, Cunningham & Good 1983). In the Drakensberg, increasing altitude

Note: †, In memory of Rob Scott-Shaw's contribution to conservation. 21 September 1953 – 08 December 2012.

is synonymous with decreasing temperature, as well as increasing precipitation, severity and duration of frost, duration of snow cover, ultraviolet radiation and exposure to extreme winds (Tyson, Preston-Whyte & Schulze 1976). Temperature has a strong and precipitation a lesser influence on plant distribution and diversity within the broader region containing the Drakensberg (Jewitt et al. 2015b, 2016). Environmental domains defined by climate variables within the Drakensberg are projected to alter considerably in response to climate change, specifically an increase in temperature and a consequent decline in water availability because precipitation may not change markedly (Jewitt et al. 2015a). Climate changes of this nature pose an obvious threat to temperate species whose distributions would likely contract into cool refuges.

Patterns of land use may pose a greater threat to the maintenance of biodiversity in the short to medium term than the threat posed by climate change. Although the DAC has largely been spared radical transformation such as cultivation or urbanisation, it has become subjected to increasingly heavy use by pastoralists over the past few decades (Quinlan & Morris 1994). Stocking densities are very high compared with the low densities of small-bodied antelope supported by the natural Drakensberg system (Rowe-Rowe & Scotcher 1986). No part of the high altitude plateau escapes the attention of livestock, whose foraging extends to the escarpment edge (Quinlan & Morris 1994). Sustained grazing impacts are expected to result in the loss of a number of species, including endemics, of susceptible growth forms over time (O'Connor et al. 2010; Scott-Shaw & Morris 2015).

Environments within the DAC protected from livestock grazing would potentially be especially important for maintaining the plant diversity of this centre of endemism if the main area of the DAC continues to be subjected to severe livestock grazing. Inselbergs (island mountains; Körner 2003) along the eastern flank of the Drakensberg potentially offer such an environment because their high, flat summits are inaccessible to livestock (and most humans), owing to tall cliffs (Armstrong & Brand 2012). Although the flora of the DAC has been relatively well described (Carbutt & Edwards 2004, 2006; Hilliard & Burt 1987; Killick 1963), to our knowledge the flora of Drakensberg inselbergs had never been sampled before this study was initiated. (Companion papers are Brand, Collins and Du Preez [2015] and Armstrong & Brand [2012].) A general aim of this study was therefore to establish whether inselbergs supported a representative sample of DAC flora in terms of species, genera and families, as well as species of conservation concern including endemic and near endemic species. Inselbergs would not be expected to harbour all DAC species on account of their small size and uniform topography relative to the large escarpment plateau, that is, an island biogeographic effect. In addition, tall cliffs should constrain dispersal even for wind-dispersed species. Inselbergs may therefore not be as exposed as the main Drakensberg to the

threat of alien invasive plants (Carbutt 2012). Although the climate of Drakensberg inselbergs has never been recorded, it probably differs from that of surrounding areas, which could further constrain opportunities or alternatively provide different environmental domains to those found within the DAC.

Within the context of assessing the conservation importance of Drakensberg inselbergs, the main aim of this study was to provide a first description of their plants. Specific objectives were (1) to provide an inventory of the plant richness of inselbergs in terms of species, genera and families, (2) to determine whether richness at any of these levels was equivalent to that of the escarpment portion of the DAC, (3) to examine specifically the difference between inselbergs and the escarpment in terms of invasive alien plants, endemics and near endemic species and (4) to identify which growth forms were apparently well adapted to the inselberg summit environment.

Study area

The study area is described in detail in a companion paper dealing with the phytosociology of the same inselberg summits (Brand et al. 2015). Consequently, only a brief summary of salient environmental features is given here. Basaltic lava flows up to 1370 m in thickness were emplaced about 183 million years ago (mya) with the commencement of the Gondwana break-up, subsequently shaped by erosion during the late Cretaceous period (~65 mya) to form an escarpment marked by cliffs and an associated archipelago of sheer inselberg outliers, each with a summit that is mostly flat (Brand et al. 2015). The escarpment, therefore presumably also the inselbergs, receives > 2000 mm of precipitation per annum mainly during summer (Nel 2007). Climate is quite extreme. Snow falls on average eight times a year during any month but the largest falls occur during winter, frost occurs throughout the year and strong winds may accompany fronts (Tyson et al. 1976). Mean monthly temperature ranges from 4°C to 11°C. May to August are the four coldest months, whose mean monthly minimum temperatures range from -1.0°C to -5.4°C (Schulze 1997). Basalt has weathered to produce soils consisting of a mix of clay, coarse and fine sand, which are dark and high in organic matter (Mucina & Rutherford 2006). Soil depth varies from shallow (< 30 mm) on rock sheets to pockets of > 300 mm depth (Brand et al. 2015).

According to international nomenclature (Körner, Paulsen & Spehn 2011), vegetation of the DAC (Carbutt & Edwards 2004) is classified as 'lower alpine' at its upper limit and 'upper montane' at its lower limit. Mucina and Rutherford (2006) identify three units above 1820 m asl in this region, namely uKhahlamba Basalt Grassland (Gd 7) and Lesotho Highland Basalt Grassland (Gd 8) within the upper montane region and Drakensberg Afroalpine Heathland (Gd 10) within the lower alpine region. Brand et al. (2015) identified four main vegetation communities on the six inselberg summits sampled in this study, these being wetland grass

and forblands, sheet rock grass and forblands, high altitude alpine grassland, and high altitude alpine fynbos grassland. Wetland vegetation was recorded in semi-permanent pools or on seasonal seeps over sheet rock, gravel beds or soil. Pools contain obligate wetland (OBW) plants (probability in wetlands > 99%) whereas seep habitats support facultative wetland (FACW) (probability in wetlands 67% – 99%) or facultative (FAC) plants (34% – 66% in wetlands), using a classification system for the expected frequency of occurrence in wetlands (Collins 2005; Tiner 1999).

Methods

Sampling

An inselberg was suitable if it had a sufficiently large summit plateau for sampling of vegetation. Using topocadastral maps, 11 potential inselbergs spread 60 km from the northern to central Drakensberg, KwaZulu-Natal, were selected, of which the six that could be sampled were the Sentinel, Eastern Buttress, Inner Horn, Outer Horn, Dragon's Back and Cathkin Peak (Brand et al. 2015). Position, elevation and surface area of the sampled inselbergs are presented in Armstrong and Brand (2012). Sampling was undertaken during November 2005. All inselbergs surveyed are relatively flat-topped with the exception of the Sentinel, which has three tiers sloping to the east. Sampling was restricted to summits and covered all habitats. All species occurring within 103 Braun-Blanquet sample plots (Brand et al. 2015) were collected. In addition, thorough *ad hoc* collections of species not found in these plots were made by R. Scott-Shaw and R. Lechmere-Oertel on all habitats of the inselberg summit (e.g. ridges, rocky terrain, wetland seeps, gravel plains and open grasslands). Nomenclature of species is presented in Appendix 1.

Voucher plant specimens were prepared according to standard practices (Alexiades 1996). Initial field identifications were confirmed using the Donald Killick Herbarium (CPF) at Ezemvelo KZN Wildlife, the Geo Potts Herbarium (BLFU) at the University of the Free State, and the National Herbarium (PRE) of the South African National Biodiversity Institute (SANBI) in Pretoria. Voucher specimens (172) were housed at the CPF. A species list was compiled and arranged according to the Englerian system (SANBI, Pretoria). Nomenclature follows Fish et al. (2015) for grasses and Germishuizen et al. (2006) for the remainder modified following consultation with the September 2018 SANBI web database (SANBI/POSA BHRAMS; <http://posa.sanbi.org/sanbi/Explore>). Red Data species were checked in September 2018 using a SANBI website (<http://www.redlist.sanbi.org>). Information on endemic or near endemic status (defined according to Carbutt & Edwards [2006]) and distribution, including elevation range, was obtained from published sources (Carbutt & Edwards 2004, 2006; Germishuizen et al. 2006; Pooley 2003; Raimondo et al. 2009; Scott-Shaw 1999).

Growth form was assessed using six relevant categories of Körner's (2003) adjusted Raunkiaer classification, namely small phanerophytes (Ph; shrubs < 2 m in height),

chamaephytes (Ch; dwarf shrubs, thorny cushions), hemicryptophytes (H; perennial herbs and graminoids), geophytes (G; bulbs, rhizomes or tubers), biennial plants (B; mostly rosette plants) and therophytes (annuals, A). Using these symbols, growth form is indicated in Appendix 1 only at the family level except where species within a family differ. Geophyte status for ferns and *Limosella* was determined according to Pooley (2003) and Germishuizen et al. (2006). Growth form is considered to be genetically determined (e.g. cushion plants remain so when grown from seed at low altitude), whereas life form represents an interaction between growth form and environment (e.g. shrubs may develop into trees when environmental constraints are removed) (Körner 2003).

Comparison with Drakensberg Alpine Centre and Platberg floras

The potential conservation value of the Drakensberg inselbergs depends in part on whether the flora they harbour is widely distributed or not. We therefore compared their flora with that of the DAC and the Platberg inselberg to the north. On account of the Drakensberg inselbergs forming part of the DAC, it is expected that they should harbour a subset of species, including endemic and near endemic species, occurring within the DAC, which was examined using the study by Carbutt and Edwards (2004). The endemic or near endemic status of plants on Platberg is taken from Brand, Brown and Du Preez (2010). The Platberg inselberg lies 60 km north of the northernmost inselberg sampled in this study (Sentinel); Platberg's flora was described by Brand et al. (2010) and Brand, Brown and Du Preez (2011). The Platberg supports a large plateau (± 3000 ha) of lower altitude (mean elevation of approximately 2390 m asl), otherwise similar climate and geology to the Drakensberg inselbergs, although grasslands are dominated by C_4 species, especially *Themeda triandra* (Brand et al. 2011). A degree of similarity of their floras was expected owing to their proximity and environmental affinities.

Results

Floral composition of inselbergs

Vegetation physiognomy showed little change across the 60 km range of inselbergs from the Sentinel to Cathkin Peak. It was a mix of short to medium height graminoids, cushion-forming dwarf or low to medium height shrubs, with herbaceous species interspersed. The rugged terrain, alpine plant species and life forms are shown in Figure 1. A total of 200 species representing 45 families and 91 genera (Table 1) were recorded in a total area surveyed of 31.9 ha; a complete list of species is provided in Appendix 1. Of the 200 species, dicotyledons representing 48 genera constituted 66.1%, monocotyledons representing 37 genera constituted 31.2% and five genera of pteridophytes constituted 2.5%. Of the 114 endemic (61) or near endemic (53) species recorded, 75% represented 14 families, of which 42.1% were in the Asteraceae, Poaceae and Ericaceae families. One is a possible new species (*Senecio* sp. nov.). Averaged across the total area



FIGURE 1: Photographs of Drakensberg peaks and inselbergs showing alpine plants on their summits. (a) Looking north, with Sentinel in the background on the skyline to the right, the finger-like Devil's Tooth directly in front, Inner Butte to the left, with an archipelago of smaller inselbergs and Eastern Butte (3060 m) to the right. (b) Helicopter view west, of the escarpment with Sentinel in the foreground, the most northerly inselberg (3109 m – 3156 m), habitat for the endemic alpine grasses *Pentaschistis exserta*, *Polevansia rigida* and the near endemic *Styppeiochloa gynoglossa*. (c) The rugged topography of the Rockeries (3027 m), sprinkled with November snow and the prominent Mweni Peak (3099 m) on the right. (d) Temporary wetlands on Cathkin Peak (3154 m), habitat for the wetland endemics *Aponogeton ranunculiflorus*, *Crassula peplodes*, *Limosella vesiculosa* and *Rhodohypoxis rubella*. (e) Alpine vegetation on Inner Horn (3005 m), showing a typical mix of grasses and shrubs, with a Malachite Sunbird (*Nectarinia famosa*) on *Kniphofia caulescens*, with *Helichrysum trilineatum* surrounded by tall, endemic bunch-grasses *Merxmüllera drakensbergensis* and *M. stereophylla* found on deep, basalt soils. (f) High altitude adapted cushion plant-forms of *Passerina*, *Euryops* and *Erica* shrubs, a response to freezing alpine conditions, on Cathkin Peak (3154 m).

of the six inselbergs sampled, 3.5 endemic or near endemic species were encountered per hectare of inselberg summit.

Table 2 shows the 15 families that contributed the greatest number of species on inselbergs. Asteraceae contributed 27.5% to the total number of species, three times more than the second-ranked Poaceae, the two together contributing 35.5% of the total and 43.8% of the endemic and near endemic species. Other families each contributing at least 5% of the total number of species (≥ 10 species) were Cyperaceae, Ericaceae, Scrophulariaceae, Hyacinthaceae and Iridaceae, totalling 26.5% of the total and 24.6% of endemic and near endemic species. The 61 endemic species belonged to 21 families (6 monocotyledon, 15 dicotyledon), the 53 near endemic species belonged to 20 families (10 monocotyledon, 10 dicotyledon) and the two groups combined belonged in 12 monocotyledon and 19 dicotyledon families. Rank order of the 15 most abundant families for endemic and near endemic species in general mirrored that of their contribution to the total number of species (Table 2). However, families showing a conspicuously high ($> 50\%$) proportion of endemic and near endemic species were the Asphodelaceae, Orchidaceae, Poaceae, Ericaceae, Thymelaeaceae, Scrophulariaceae and Hyacinthaceae. No pteridophyte endemic or near endemic species or any alien plant species were found on any peak.

TABLE 1: Summary of the floral composition of Drakensberg inselberg summits.

Variable	Dicotyledon	Monocotyledon	Pteridophyta	Total
Total species	129.0	66	5.0	200
Percentage of total flora	64.5	33	2.5	100
Total genera	48.0	37	5.0	90
Total families	25.0	16	4.0	45
Endemic species	48.0	13	0.0	61
Near endemic species	28.0	25	0.0	53
Total: endemics and near endemics	76.0	38	0.0	114

TABLE 2: Comparison of the 15 best represented angiosperm families by number of species, including endemics and near endemics, on inselbergs, a subset of the Drakensberg Alpine Centre, together with their representation within the broader Drakensberg Alpine Centre.

Families ordered by rank of total species on inselbergs (rank within DAC) ¹	Total number of species on inselbergs ²	Total endemics/near endemics on inselbergs	Total percentage of endemics and near endemics on inselbergs	Total species numbers in DAC ³	Percentage of DAC species on inselbergs	Endemics/near endemics in DAC including inselberg species	Percentage of DAC endemics/near endemics on inselbergs
1. Asteraceae (1)	55	20/18 = 38	69.1	430	12.8	103/135	19.4/13.3
2. Poaceae (5)	16	3/9 = 12	75.0	267	6.0	12/27	25/33.3
3. Cyperaceae (4)	12	0/4 = 4	33.3	122	9.0	13/4	9.4/3.3
4. Ericaceae (5)	11	6/2 = 8	72.7	35	31.4	12/12	50/16.7
5. Scrophulariaceae (2)	10	5/1 = 6	60.0	133	7.5	37/44	13.5/2.3
6. Iridaceae (3)	10	3/3 = 6	60.0	97	10.3	23/3	23.7/0.3
7. Hyacinthaceae (7)	10	4/0 = 4	40.0	55	18.2	4/n/a	13.8/0
8. Crassulaceae (>15)	6	1/1 = 2	33.3	34	17.6	1/8	2.9/23.5
9. Fabaceae (7)	4	0/1 = 1	25.0	136	0.7	8/33	0/3.0
10. Polygalaceae (>15)	4	1/0 = 1	25.0	n/a	n/a $\leq 100\%$	1/0	100/0
11. Apiaceae (>15)	4	1/1 = 2	50.0	38	10.5	5/11	20.0/9.1
12. Rosaceae (>15)	4	1/1 = 2	50.0	n/a	n/a	$\geq 1/1$	25/25
13. Orchidaceae (6)	3	1/2 = 3	100.0	130	2.3	11/41	9.1/4.9
14. Asphodelaceae ($\geq 2\%$)	3	0/3 = 3	100.0	≥ 13	≥ 23	$\geq 0/13$	0/23.1
15. Thymelaeaceae (8)	3	1/1 = 2	66.7	≥ 10	30	7/3	14.3/33.3
Total	155	48/46	60.6	-	-	-	-

Source: DAC ranks source: Carbutt, C. & Edwards, T.J., 2004, 'The flora of the Drakensberg Alpine Centre', *Edinburgh Journal of Botany* 60, 581–607. <https://doi.org/10.1016/j.sajb.2005.06.001>; and, Carbutt, C. & Edwards, T.J., 2006, 'The endemic and near endemic angiosperms of the Drakensberg Alpine Centre', *South African Journal of Botany* 72, 105–132. <https://doi.org/10.1016/j.sajb.2005.06.001>

Total number of species on inselbergs source: Appendix 1.

DAC, Drakensberg Alpine Centre.

n/a, not available for the DAC below the alpine zone. Only known from the inselbergs (Carbutt & Edwards 2004, 2006).

Red Data status of all except six species was Least Concern, the exceptions being *Aponogeton ranunculiflorus* (Vulnerable, endemic), *Colpodium drakensbergense* (Vulnerable, endemic), *Helichrysum album* (Rare, endemic), *Helichrysum pagophilum* (Rare, endemic), *Muraltia montana* (Rare), *Berkheya rhapontica* (Not Evaluated) and *Satyrium longicauda* var. *jacottetianum* (Not Evaluated, near endemic). Accordingly, we place emphasis on endemic and near endemic species for consideration of conservation importance.

Growth form and aquatics

Composition of the inselberg flora in terms of growth form is summarised in Table 3. The majority of species were dicotyledenous chamaephytes contributing threefold more species than geophytes. Chamaephytes were made up of dwarf shrubs, herbaceous and filiform forbs. All non-graminoid monocotyledons, representing 10 families, and all four families of pteridophytes were geophytes. Conspicuous within the rich geophyte vegetation (12 genera, 34 species) were the families Hyacinthaceae and Iridaceae, which contributed 28.8% of monocotyledons and 9% of total inselberg plant species. Orchidaceae, represented by three genera and three species, were not as conspicuous on inselbergs as they are in the broader DAC flora (Table 2). Orchid plants occurred singly at low density. Hemicyptophytes were all graminoid

TABLE 3: Representation of growth forms within inselberg vegetation.

Growth form	Taxon	Number of families	Number of species	Percentage of total species
Geophyte	Pteridophyta	4	5	2.5
Geophyte	Monocotyledonae	13	35	17.5
Hemicyptophytes	Monocotyledonae	3	29	14.5
Phanerophytes	Dicotyledonae	3	4	2.0
Chamaephytes	Dicotyledonae	22	127	63.5
Total	-	45	200	100.0

monocotyledons. All 16 grass species (Appendix 1) were perennial, tufted species, and all except *Eragrostis caesia* and *Polevansia ridiga* use the C₃ photosynthetic pathway. The two exceptions use the C₄ pathway. No *Themeda triandra*, the most abundant species below 2900 m asl across the Drakensberg, was found. Phanerophytes, about 2 m tall shrubs, were represented by four species, mostly *Helichrysum trilineatum*, with lesser amounts of *Cliffortia nitidula*, *Passerina montana* and *Passerina drakensbergensis*. No therophytes were found.

Distinct wetland vegetation associated with numerous seasonal pools and seeps supported a number of endemic or near endemic species of OBW, FACW or FAC plant species (Appendix 1). Hydrophytes endemic to the DAC included *Aponogeton ranunculiflorus* and *Limosella vesiculosa*, near endemics included *Crassula gemmifera* and *Limosella grandiflora*, while *Aponogeton junceus* and *Potamogeton thunbergii* were widespread. Facultative wetland and FAC plants associated with seeps included *Aster erucifolius*, *Crassula dependens*, *Psammotropha obtusa*, the DAC endemic *Rhodohypoxis rubella* and the wide-ranging *Rhodohypoxis baurii* var. *baurii*. Facultative plants associated with wetland communities included three DAC near endemic taxa, the geophytes *Wurmbea elatior* and *Dierama robustum*, and the biennial, caespitose grass *Pentaschistis airoides*.

Representation of Drakensberg Alpine Centre flora on Drakensberg inselbergs

The inselberg flora of 200 species was not a simple subset of the DAC flora of 2520 species as seen by differences in the rank order of families by number of species (Table 2). Although Asteraceae was the dominant family of both, Scrophulariaceae and Iridaceae within the DAC were replaced by Poaceae and Cyperaceae on inselbergs as the second and third most dominant families; some families such as Apocynaceae and Lamiaceae were absent from inselbergs but were conspicuous in the DAC, whereas Crassulaceae, Polygalaceae, Apiaceae and Rosaceae were more conspicuous on inselbergs than in the DAC.

At the genus level, the endemic *Polevansia* (Poaceae), *Dracomonticola* (Orchidaceae) and *Glumicalyx* (Scrophulariaceae) occurred on inselbergs and within the DAC, whereas *Heteromma* (Asteraceae) and *Strobilopsis* (Scrophulariaceae) were not recorded on inselbergs. The near endemic genera *Craterocapsa* (Campanulaceae), *Guthriea* (Achariaceae) and *Rhodohypoxis* (Hypoxidaceae) occurred on inselbergs and within the DAC, whereas *Glekia* (Scrophulariaceae), *Huttonaea* (Orchidaceae) and *Thamnocalamus* (Poaceae) occur in the DAC but were not found on inselbergs. Comparing the 61 endemic species recorded on inselbergs (Appendix 1) with a list for the DAC (Carbutt & Edwards 2006) reveals that *Aponogeton ranunculiflorus*, *Senecio cristimontanus*, *Senecio parentalis* and *Senecio* sp. nov. (Scott-Shaw C.R., Brand R., Lechmere-Oertel R., 14363 (CPF)) are 4 of 47 DAC species identified as possibly holo-endemic (a species known from only one or a few highly localised sites; Carbutt and Edwards 2006:108).

Of the 61 endemic and 53 near endemic species recorded on inselbergs, *Helichrysum* (Asteraceae) contained the highest number of all 91 genera with 8 endemic, 11 near endemic and only 3 widespread species. Respective numbers of endemic or near endemic species for other genera were 6 and 2 of 11 *Erica* species (Ericaceae), 1 and 1 of 4 *Cliffortia* species (Rosaceae), 1 endemic of 2 *Passerina* shrub species (Thymelaeaceae), 1 near endemic of 2 *Macowania* shrub species (Asteraceae), while both *Euryops* species (Asteraceae) were endemic. This study recorded a higher maximum elevation than previously recorded (shown in parentheses) for the following DAC endemic or near endemic species: *Cliffortia filicaulis* (1586 m), *Helichrysum albanense* (1675 m), *Helichrysum cymosum* (1200 m), *Passerina drakensbergensis* (1981 m), *Thesium costatum* var. *juniperinum* (1500 m) and *Thesium nationae* (1350 m).

Links between Drakensberg Alpine Centre inselbergs and Platberg

Platberg, with 100-fold greater area than the combined area of six inselberg summits, supported 649 species compared with the 200 species recorded on inselbergs, of which 80 species (40% of the inselberg flora) were shared (Table 4). Representation of families was broadly similar, with Asteraceae, Poaceae and Cyperaceae contributing (in order) the most species at Platberg (35.5%) and on inselbergs (41.5%). Ericaceae were well represented on inselbergs

TABLE 4: A floristic comparison of the Drakensberg Alpine Centre inselbergs with Platberg.

Locality	DAC inselbergs	Platberg
Percentage endemism	30.0	3.0
Altitude (m)	3012–3166	2394
Number of DAC endemic or near endemic species	61	24
Number of families	45	95
Number of genera	90	304
Number of species	200	669
	1. Asteraceae 27.5% (14, 55)	1. Asteraceae 18.8% (40, 126)
	2. Poaceae 8.0% (10, 16)	2. Poaceae 10.9% (39, 73)
	3. Cyperaceae 6.0% (5, 12)	3. Cyperaceae 5.8% (18, 39)
	4. Ericaceae 5.5% (1, 11)	4. Fabaceae 4.9% (13, 33)
	5. Scrophulariaceae 5.0% (7, 10)	5. Scrophulariaceae 4.0% (13, 27)
	6. Hyacinthaceae 5.0% (6, 10)	6. Hyacinthaceae 3.1% (10, 21)
	7. Iridaceae 5.0% (4, 10)	7. Iridaceae 2.5% (6, 17)
	8. Crassulaceae 3.0% (1, 6)	8. Orchidaceae 2.4% (8, 16)
	9. Fabaceae 2.0% (2, 4)	9. Crassulaceae 1.9% (3, 13)
	10. Polygalaceae 2.0% (2, 4)	10. Geraniaceae 1.8% (3, 12)
	11. Apiaceae 2.0% (1, 4)	11. Thymelaeaceae 1.8% (3, 12)
	12. Rosaceae 2.0% (1, 4)	12. Lobeliaceae 1.8% (3, 12)
	13. Orchidaceae 1.5% (2, 3)	13. Asphodelaceae 1.8% (3, 12)
	14. Asphodelaceae 1.5% (1, 3)	14. Apocynaceae 1.5% (6, 10)
	15. Thymelaeaceae 1.5% (2, 3)	15. Campanulaceae 1.5% (2, 10)

Source: Drakensberg Alpine Centre (DAC) inselbergs: Authors' own work; Platberg: Brand, R.F., Brown, L.R. & Du Preez, P.J., 2010, 'A floristic analysis of the vegetation of Platberg, Eastern Free State, South Africa', *Koedoe* 52, 1–11. <https://doi.org/10.4102/koedoe.v52i1.710>

Note: Each column below the summary data presents the 15 families that contribute the greatest number of species of that locality in rank order. Content per cell of the table: rank, family, percentage of total number of species and, in parentheses, number of genera and number of species.

but were less prominent on Platberg, although eight species were supported. Asteraceae, Crassulaceae, Iridaceae and Hyacinthaceae were families better represented on DAC Inselbergs than on Platberg, with four of six Crassulaceae species shared with Platberg; the converse pattern shown by the Fabaceae, Lobeliaceae and Campanulaceae. Shared species comprised three ferns, 25 monocotyledons (11 DAC endemic or near endemic), including 6 of 12 Cyperaceae species shared, and 52 dicotyledons (13 DAC endemic or near endemic). Grassland on Platberg was dominated by *Themeda triandra*, a species not recorded on Inselbergs.

Discussion

Role of Inselbergs in plant conservation

Inselbergs supported a small proportion of the plant diversity found in the DAC, but they supported a large proportion of high altitude endemic and near endemic species (Table 2). Sampled Inselbergs supported significant plant diversity of 200 species on a surface area of only 31.9 hectares, of which 114 were endemic or near endemic. A large number of endemic and near endemic taxa in an alpine environment is usually explained by numerous small-scale microhabitats and a wide range of edaphic conditions created by slope and aspect (Hedberg, 1955, 1964; Körner 2003), although the level summits of most Drakensberg Inselbergs probably offer less habitat diversity than mountain peaks. Endemic and near endemic species offer a strong focus for conservation owing to their limited ranges, small population sizes and a limited but significant genetic pool (Bangert et al. 2005; Carbutt & Edwards 2006). Assessing the value of Inselbergs for conservation of plant diversity depends on the threats and changes Inselbergs are likely to face relative to those faced within the DAC on the adjacent escarpment.

Inselbergs and the escarpment portion of the DAC differ markedly in terms of exposure to the threats of land use, climate change, alien vegetation and resource extraction by humans. Sustained, severe grazing by livestock is the most important contemporary threat to DAC flora on the escarpment plateau (Nüsser 2002; Quinlan & Morris 1994), a threat to which Inselbergs are unlikely to ever be exposed owing to their inaccessibility. Certain non-graminoid growth forms are vulnerable to local extirpation by sustained livestock grazing (O'Connor et al. 2010; Scott-Shaw & Morris 2015), an impact that is possibly occurring on the escarpment. It is not known if sustained grazing on the escarpment has altered fire-return interval; grazing may have promoted grasses at the expense of shrubs, hence increasing the likelihood of burning, or it may have decreased this likelihood through reducing fuel load. The current healthy representation of heath-like elements on Inselbergs is, however, evidence of relatively long fire-return intervals compared with other Drakensberg grasslands (De Villiers & O'Connor 2011; Killick 1963). Alien plants pose an increasing threat to the main DAC system, in which 166 taxa, or 6% of its total angiosperm flora, has been recorded as alien (Carbutt 2012; Carbutt & Edwards 2004). In contrast, aliens were absent from Inselbergs, a fact

attributed to their extreme climate and isolation that restricts arrival of plant propagules associated with humans and livestock, or from natural means. Inaccessibility of Inselbergs protects them from harvesting of plants for medicinal purposes, a practice resulting in a substantial local loss of species elsewhere in KwaZulu-Natal (Scott-Shaw 1999). Inselbergs are therefore spared three threats facing the DAC, namely livestock, alien plants and harvesting, all threats set to continue if not increase within the DAC. Inselbergs may contain only a small proportion of DAC flora but they afford this flora strong protection.

Climate change is an impending threat against which Inselbergs are poorly protected compared with the escarpment owing to differences in topography. Changes in temperature regime are expected to exert a strong impact on plant distribution in the general region (Jewitt et al. 2015a). Specifically, current altitudinal distribution of C_3 and C_4 grasses in the Drakensberg appears to be strongly controlled by temperature (Bentley & O'Connor 2018; Morris 2017), with a transition from C_4 to C_3 grasses at an altitude of approximately 200 m below the average altitude of Inselberg summits (Morris 2017; Morris, Tainton & Boleme 1993). An expected altitudinal increase of C_4 grasses in response to temperature increases resulting from climate change (Stock, Chuba & Verboom 2004) might displace C_3 grasses from Inselberg summits, as they have no opportunity for contraction into an elevation refuge or aspect-related topographic refuge owing to the flat-topped nature of Inselbergs (Sentinel excluded). In contrast, such opportunities for range adaptation exist on the main escarpment for C_3 grasses and other temperature-sensitive species. A first threat is that all except two of the 16 grasses sampled are C_3 species; representation of this key group may therefore decrease with a consequent reduction of endemic or near endemic grasses, three of which are represented by monotypic genera. On account of C_3 grasses currently providing a matrix for Inselberg vegetation, a novel threat might arise if these grasses were to be replaced as this would probably considerably alter matrix structure. This threat would be acute if a novel matrix created an inappropriate or poor environment for other species, especially considering a large proportion of these are endemic and near endemic species that generally display a narrow environmental distribution.

Uncertainty exists about likely changes in rainfall of this region resulting from climate change (Engelbrecht, McGregor & Engelbrecht 2009), but if the region became drier perhaps the most conspicuous threat would be to the hydrophilic flora, including endemic and near endemic species, found in pools and seeps because desiccation would become commonplace.

The potential contribution of Drakensberg Inselbergs to conservation of DAC flora will be aided to some degree by other nearby Inselbergs such as Platberg. Although 60 km distant, at lower elevation and with differing vegetation, Platberg nonetheless shared a proportion of Drakensberg

inselberg species (Table 4) including 24 DAC endemic and near endemic species, illustrating that some DAC endemics may be more widespread than currently known (Table 4). A number of such inselbergs exist within the KwaZulu-Natal lowlands, eastern Free State and extending north archipelago-like along the main escarpment forming connections with Afro-alpine vegetation to the north (Carbutt & Edwards 2001; White 1983). Phytogeographic affinities also extend to the south into the Cape Floristic Region (Goldblatt & Manning 2000) via the Sneeuberg (Clark, Barker & Mucina 2009) and Zuurberg (Carbutt & Edwards 2001; Van Wyk et al. 1988), as well as into the interior Hantam-Roggeveldberge and Nuweveldberge (Clark et al. 2011a, 2011b). Notwithstanding that comparison among these would be compounded by the response of temperature to the combined effects of altitude and latitude, a spatially explicit assessment of phytogeographic affinities between the DAC and its inselbergs with these other montane regions, especially surrounding inselbergs similar to Platberg, would provide a broad geographic context for working toward conservation of the Drakensberg hotspot and centre of endemism of plant diversity.

Growth forms and environment

Inselbergs supported a preponderance of chamaephytes, geophytes and hemicryptophytes, a paucity of phanerophytes, while therophytes were absent (Table 3), showcasing growth forms well or not adapted for this high altitude environment (Gröger & Barthlott 1996; Körner 2003; Parmentier et al. 2006; Wesche, Miede & Kaepell 2008) that experiences severe temperatures, freezing conditions, desiccation including through freezing, and high wind speeds (Tyson et al. 1976). The common forms observed of dwarf and sclerophyllous shrubs, cushion plants, caespitose graminoids with filiform xeromorphic leaves and acaulescent rosette plants (Appendix 1) are characteristic of alpine regions (Körner 2003; White 1983). By contrast, geophytes below-ground bulbs ensure protection in fire-prone grasslands and high altitude alpine conditions of freezing temperatures and heave soils (Mucina & Rutherford 2006). However, fire does occasionally penetrate inselbergs, as revealed by burned *Helichrysum trilineatum* shrubs (R. Brand pers. obs., November 2005).

Plant growth form and vegetation structure of alpine regions is commonly ascribed to the temperature regime of the coldest period (Hedberg 1970; Körner 2003; Körner et al. 2011). A consequent explanation for the dominance of chamaephytes and hemicryptophytes (Table 3) is the extent to which their growth forms enable decoupling of a plant's climate from the ambient climate through increasing heat accumulation in the leaf canopy (Körner 2003) that allows physiological processes to proceed when ambient temperature may be at or below freezing for extended periods (Wesche et al. 2008). An apparent contradiction is provided by the large number of non-graminoid monocotyledon genera with relatively large, semi-succulent,

water-rich leaves (e.g. *Agapanthus*, *Albuca*, *Eucomis*, *Gladiolus*, *Hesperantha*, *Kniphofia*, *Ledebouria* and *Moraea*) recorded on inselbergs; however, these long-lived perennial geophytes are in leaf only during the warmer summer season. Leaves, stems and flowers die after summer, leaving no visible, above-ground trace, while the bulbs are protected below ground from freezing, desiccation and heave soils (Wesche et al. 2008).

Growth habit contributes to graminoid species meeting the demands of a high altitude climate (Gibbs-Russell et al. 1991; Körner 2003). Most graminoid species recorded possessed a caespitose growth form (Appendix 1), which not only protects meristems against fire or herbivory (Briske & Richards 1995) but also confers a temperature advantage to a plant. Thermal advantages also accrue to graminoids with a cushion form (e.g. *Pentaschistis* spp.), rhizomatous species (e.g. *Koeleria capensis* and *Festuca* spp.), species with a combination of a decumbent growth form, rhizomes and stolons (e.g. *Colpodium*, *Polevansia*) and even to loosely tufted stoloniferous species (e.g. *Karoochloa*, *Schoenoxiphium* and *Scirpus*). Graminoids, especially caespitose forms, therefore appear well adapted to the climate challenge of this high altitude environment. Furthermore, nearly all graminoid species possessed a C_3 photosynthetic pathway, enabling efficient photosynthesis at the temperatures of high elevation (Pitterman & Sage 2000; Sage 2001, 2004). In correspondence, C_4 grasses are dominant on the main escarpment up to 2950 m asl on north and 2750 m asl on south aspects, above which C_3 grasses are dominant (Morris 2017; Morris et al. 1993), and altitude exerts a strong influence on the distribution of individual C_3 grass species (Bentley & O'Connor 2018).

Water balance may become critical for evergreen plants receiving seasonal precipitation, especially as water availability may be further interrupted by soil freezing (Tranquillini 1979). Effective coping strategies for non-deciduous species (84% of those recorded) include succulence owing to water-use efficiency, stomatal control and, for mosses, desiccation tolerance (Körner 2003; Rutherford & Westfall 1994). There is no knowledge about stomatal control within species of this flora. Although succulent species were evident on inselbergs, they contributed only 1.1% of the flora (6 Crassulaceae; 2 Aizoaceae; 2 *Euryops*; 12 *Senecio*; *Othonna burtii*; *Psammotropha obtusa*). Crassulaceae and Aizoaceae species also benefit through use of the crassulacean acid metabolism (CAM) photosynthetic pathway that is effective at low temperatures (Pitterman & Sage 2000). The conspicuous presence of Crassulaceae species on Drakensberg inselbergs by comparison with the DAC (Table 2) is consistent with a pattern evident for inselbergs in west (Parmentier et al. 2006), central and east Africa (Hauman 1955; Hedberg 1970), suggesting their abundance owes to reduced exposure to fire.

Thick roots capable of withstanding the shearing forces exerted by frost heaving of soils (Körner 2003; White 1983)

were possessed by Orchidaceae, Apiaceae, many Asteraceae, Brassicaceae, Caryophyllaceae, Fabaceae, Gentianaceae, Scrophulariaceae and the genera *Craterocapsa*, *Cyphia*, *Epilobium*, *Geranium*, *Polygala*, *Scabiosa* and *Valeriana*. Poor representation of phanerophytes suggests an influence of strong winds (Grace 1977), growth rates inhibited by low temperatures (Tranquillini 1979) or even the inhibiting effect of high ultraviolet radiation on stem extension (Hedberg 1964), ecological factors that have been largely ignored in the Drakensberg.

Conclusions

The significance of this study lies in documenting the unique, intact alpine flora found on inselbergs and their value for biodiversity conservation. The majority of the alpine belt of the DAC lies in Lesotho, which has poor rangeland management and only one small protected area. The inselbergs are located in South Africa and are statutorily protected as part of the Maloti–Drakensberg Park World Heritage site. The inselbergs are detached from the main escarpment, which makes them inaccessible to livestock impacts of grazing, trampling and erosion, harvesting and frequent fire. The inselbergs protect a near-pristine flora and provide a benchmark for alpine plants, vegetation and habitat with no evidence of invasive alien plant species. The conservation value of all the inselbergs represents sites of unique potential for future conservation management and assessment of climate change and other anthropogenic transformation. Outside of the Drakensberg, other inselbergs are not yet formally recognised as sites requiring protection under conservation legislation. The Free State Department of Environmental Affairs is currently in the process of including inselbergs in its biodiversity strategy – the first step in providing formal status for statutory conservation management and protection. An integrated national approach toward the protection of inselbergs should be the desired outcome.

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Competing interests

The authors declare that they have no competing interests with regard to the writing of this article.

Authors' contributions

R.F.B. was the principal investigator and the first author, obtained the National Geographic Grant, organised the collaborators, field and herbarium collection and identified the plant material. C.R.S.-S. assisted with field identification and collection of plants, herbarium curation, production of

vouchers, including the labels. T.G.O. performed extensive revision of the manuscript, the addition of supporting references and critical comments of key concepts including fire, grazing and conservation value of inselberg flora.

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Appendix 1 starts on the next page →

Appendix 1

List of species recorded on inselberg summits of the Drakensberg are arranged according to the Englerian system, and includes notes on species distribution, endemic status and specimen details. Nomenclature was checked against the South African National Biodiversity Institute site (<http://posa.sanbi.org/sanbi/Explore>) during September 2018.

Abbreviations for distribution: DAC, Drakensburg Alpine Centre; EMR, Eastern Mountain Region (Pooley 2003, p. 13; synonymous with the DAC); EC, Eastern Cape; KZN, KwaZulu-Natal; L, Lesotho; M, Mpumalanga; N, Namibia; SA, South Africa; alt., altitude; end., endemic; nr-end., near endemic; prev. alt., previous altitude.

Growth form is only indicated for a family except where genus or species differ (e.g. Rosaceae: 3 Ch, 1 Ph). Key to growth form: Ch, chamaephytes (dwarf shrubs, thorny cushions, buds close to the ground); G, geophytes (bulbs, rhizomes or tubers, below soil surface); H, hemicryptophytes (perennial herbs and graminoids, buds at the surface of the ground); Ph, phanerophytes (shrubs, 2 m or less).

Abbreviations for collectors: B, Brand; L-O, Lechmere-Oertel; S-S, Scott-Shaw. Only plants that were collected and vouchered have a collector's number (e.g. S-S, B & L-O 14237). No vouchers were collected for widespread or common species, which were identified in the field, and accordingly the right-hand column remains blank.

TABLE 1-A1: Pteridophyta – Four families, five genera, five species, zero endemics or near endemics.

Family plus no. genera and no. species; list of species	Notes; altitude, endemism, range	References, Voucher specimen in Killick Herbarium (CPF) or record ID, growth form (blank = no voucher collected)
ANEMACEAE 1, 1		G
<i>Mohria vestita</i> Barker	Afromontane, Platberg to Kenya	Germishuizen et al. (2006)
ASPLENIACEAE 1, 1		G
<i>Asplenium cordatum</i> (Thunb.) Desv.	Alt. 2700 m	Pooley (2003)
LYCOPODIACEAE 1, 1		G
<i>Huperzia saururus</i> (Lam.) Trevis.	Afromontane, prev. alt. 2590 m – 2800 m	S-S, B & L-O 14306/14336
PTERIDACEAE 2, 2		G
<i>Cheilanthes eckloniana</i> (Kunze) Mett.	SA end., Platberg, prev. alt. 1900 m – 2700 m	Pooley (2003); Germishuizen et al. (2006)
<i>Pellaea calomelanos</i> (Sw.) Link	Platberg, prev. alt. 2100 m – 2700 m	Pooley (2003); Germishuizen et al. (2006)

TABLE 2-A1: Angiosperms – Monocotyledons, 16 Families, 37 Genera, 66 Species, 13 endemics, 25 near endemics = 38.

Family plus no. genera and no. species; list of species	Notes; altitude, endemism, range	References, Voucher specimen in Killick Herbarium (CPF) or record ID, growth form (blank = no voucher collected)
AGAPANTHACEAE 1, 1	1 nr-end.	G
<i>Agapanthus campanulatus</i> Leight	DAC nr-end.	Carbutt & Edwards (2006)
ALLIACEAE 1, 1		G
<i>Tulbaghia leucantha</i> Baker	Widespread	S-S, B & L-O 14318
AMARYLLIDACEAE 1, 1	1 nr-end.	G
<i>Cyrtanthus flanaganii</i> Baker	9 DAC spp., 1 nr-end.	S-S, B & L-O 14297/14298/14316
APONOGETONACEAE 1, 2	1 end.	G
<i>Aponogeton junceus</i> Lehm.	Hydrophyte, Platberg	S-S, B & L-O 14349
<i>Aponogeton ranunculiflorus</i> Jacot Guill. & Marais	DAC end., hydrophyte	Carbutt & Edwards (2006)
ASPHODELACEAE 1, 3	2 nr-end.	G
<i>Kniphofia caulescens</i> Baker	DAC nr-end., Platberg	S-S, B & L-O 14347/14348
<i>Kniphofia ritualis</i> Codd	DAC nr-end., Platberg	Carbutt & Edwards (2006); Brand et al. (2010)
<i>Kniphofia fluviatilis</i> Codd	SA montane end, prev. alt. 2225 m	S-S, B & L-O 14346
COLCHICACEAE 1, 1	1 nr-end.	G
<i>Wurmbea elatior</i> B.Nord.	DAC nr-end.	S-S, B & L-O 14197
CYPERACEAE 5, 12	4 nr-end.	H
<i>Bulbostylis humilis</i> (Kunth) C.B.Clarke	Platberg	Brand et al. (2010)
<i>Bulbostylis schlechteri</i> C.B.Clarke	None	
<i>Cyperus schinzii</i> Boeck.	None	
<i>Cyperus schlechteri</i> C.B.Clarke	DAC nr-end.	Carbutt & Edwards (2006)
<i>Ficinia cinnamomea</i> C.B.Clarke	DAC nr-end.	Carbutt & Edwards (2006)
<i>Ficinia gracilis</i> Schrad.	Platberg	Brand et al. (2010)
<i>Schoenoxiphium filiforme</i> Kük.	DAC nr-end., Platberg	Carbutt & Edwards (2006)
<i>Schoenoxiphium madagascariense</i> Cherm.	Drakensberg, alt. 2000 m	S-S, B & L-O 14280
<i>Schoenoxiphium rufum</i> Nees	Platberg	S-S, B & L-O 14281
<i>Schoenoxiphium schweickerdtii</i> Merxm. & Podlech	DAC nr-end.	S-S, B & L-O 14237/14284
<i>Scirpus falsus</i> C.B.Clarke	None	S-S, B & L-O 14236/14302/14283
<i>Scirpus ficinioides</i> Kunth	None	

Table 2-A1 continues on the next page →

TABLE 2-A1: Angiosperms – Monocotyledons, 16 Families, 37 Genera, 66 Species, 13 endemics, 25 near endemics = 38.

Family plus no. genera and no. species; list of species	Notes; altitude, endemism, range	References, Voucher specimen in Killick Herbarium (CPF) or record ID, growth form (blank = no voucher collected)
ERIOSPERMACEAE 1, 1 <i>Eriospermum ornithogaloide</i> Baker	1 nr-end. DAC nr-end., Platberg	G Carbutt & Edwards (2006)
HYACINTHACEAE 6, 10 <i>Albuca humilis</i> Baker <i>Albuca polyphylla</i> Baker	4 end. DAC end., Platberg Widespread	G Carbutt & Edwards (2006)
<i>Drimia calcarata</i> (Baker) Jessop <i>Drimia depressa</i> (Baker) Jessop	DAC end. Widespread	Carbutt & Edwards (2006) S-S, B & L-O 14317
<i>Eucomis schiffii</i> Reyneke <i>Ledebouria cooperi</i> (Hook.f.) Jessop <i>Ledebouria ovatifolia</i> (Baker) Jessop	DAC end., Platberg Platberg Platberg	Carbutt & Edwards (2006) Brand et al. (2010) Brand et al. (2010)
<i>Litanthus pusillus</i> Harv. <i>Ornithogalum paludosum</i> Baker <i>Ornithogalum sephtonii</i> Hilliard & B.L.Burt	None None DAC end.	 S-S, B & L-O 14252/14256/14258 S-S, B & L-O 14243
HYPOXIDACEAE 1, 2 <i>Rhodohypoxis baurii</i> (Baker) Nel <i>Rhodohypoxis rubella</i> (Baker) Nel	1 end., 1 nr-end. DAC nr-end., Platberg DAC end.	G S-S, B & L-O 14257/14367 S-S, B & L-O 14194/14259
IRIDACEAE 4, 10 <i>Dierama robustum</i> N.E.Br. <i>Gladiolus longicollis</i> Baker <i>Hesperantha baurii</i> Baker <i>Hesperantha grandiflora</i> G.J.Lewis <i>Moraea albicuspa</i> Goldblatt <i>Moraea alpina</i> Goldblatt <i>Moraea alticola</i> Goldblatt <i>Moraea brevistyla</i> (Goldblatt) Goldblatt <i>Moraea dracomontana</i> Goldblatt <i>Moraea modesta</i> Killick	3 end., 3 nr-end. DAC nr-end. Platberg Platberg Platberg KZN, L, EC. DAC end. DAC end. DAC nr-end., Platberg DAC end. DAC nr-end.	G Carbutt & Edwards (2006) S-S, B & L-O 14195/14253 S-S, B & L-O 14293 Pooley (2003); Carbutt & Edwards (2006); Germishuizen et al. (2006) S-S 14271 Carbutt & Edwards (2006) B & L-O 239578/239580/239587 Carbutt & Edwards (2006)
JUNCACEAE 1.1 <i>Luzula africana</i> Drège ex Steud.	None Widespread, Platberg	H S-S, B & L-O 14322
ORCHIDACEAE 2, 3 <i>Disa crassicornis</i> Lindl. <i>Dracomonticola virginea</i> (Bolos) H.P.Linder & Kurzweil <i>Satyrium longicauda</i> Lindl. var. <i>jacottetianum</i> (Kraenzl.) A.V.Hall	1 end., 2 nr-end. DAC nr-end. DAC end. DAC nr-end., Platberg	G S-S, B & L-O 14292 S-S, B & L-O 14196/14355/14366/14368 Carbutt & Edwards (2006)
POACEAE 9, 16 <i>Colpodium drakensbergense</i> Hedberg & I. Hedberg syn. <i>C. hedbergii</i> sensu Gibbs Russ. <i>Eragrostis caesia</i> Stapf <i>Festuca caprina</i> Nees <i>Festuca costata</i> Nees <i>Karoochloa purpurea</i> (L.f.) Conert & Türpe <i>Koeleria capensis</i> (Steud.) Nees <i>Merxmüllera disticha</i> (Nees) Conert now <i>Tenaxia disticha</i> (Nees) N.P.Barker & H.P.Linder <i>Merxmüllera drakensbergensis</i> (Schweick.) Conert <i>Merxmüllera stereophylla</i> (J.G.Anderson) Conert <i>Merxmüllera stricta</i> (Schrud.) Conert now <i>Tenaxia stricta</i> (Schrud.) N. P. Barker & H.P.Linder <i>Pentaschistis airoides</i> (Nees) Stapf subsp. <i>jugorum</i> (Stapf) Linder <i>Pentaschistis basutorum</i> Stapf <i>Pentaschistis exserta</i> H.P.Linder <i>Pentaschistis oreodoxa</i> Schweick. <i>Polevansia rigida</i> De Winter <i>Styppeiochloa gynoglossa</i> (Gooss.) De Winter	3 end., 9 nr-end. DAC end., hydrophyte Afromontane, nr-end.? Platberg, Cave Sandstone seeps, C ₄ Afromontane, Platberg DAC nr-end., Afromontane SA end. Mountains, monotypic SA genus DAC nr-end., alpine bog, distinct Drakensberg form DAC nr-end., Platberg, M DAC nr-end., Platberg DAC end., Afromontane, Platberg DAC nr-end., Afromontane Afromontane, DAC nr-end. Afromontane, DAC end. Afromontane, DAC nr-end. DAC nr-end., monotypic genus, N, EC, L, B, C ₄ DAC nr-end., Afromontane, monotypic genus, hydrophyte, distinct Drakensberg variety	H Gibbs-Russell et al. (1991); Germishuizen et al. (2006); Gibbs-Russell et al. (1991); Germishuizen et al. (2006) Gibbs-Russell et al. (1991) Gibbs-Russell et al. (1991); Carbutt & Edwards (2006) Germishuizen et al. (2006) Germishuizen et al. (2006) Ellis (1980a); Gibbs-Russell et al. (1991); Germishuizen et al. (2006); Fish et al. (2015) Gibbs-Russell et al. (1991); Carbutt & Edwards (2006); Germishuizen et al. (2006) Gibbs-Russell et al. (1991); Carbutt & Edwards (2006); Germishuizen et al. (2006) Ellis (1980b); Gibbs-Russell et al. (1991); Germishuizen et al. (2006); Fish et al. (2015) Carbutt & Edwards (2006); Germishuizen et al. (2006) Carbutt & Edwards (2006); Germishuizen et al. (2006) Carbutt & Edwards (2006); Germishuizen et al. (2006) Gibbs-Russell et al. (1991); Carbutt & Edwards (2004) Gibbs-Russell et al. (1991); Germishuizen et al. (2006)
POTAMOGETONACEAE 1, 1 <i>Potamogeton thunbergii</i> Cham. & Schltdl.	Widespread Platberg	G
VELLOZIACEAE 1,1 <i>Xerophyta viscosa</i> Baker	 Widespread, prev. alt. 1800 m	Ch S-S, B & L-O 14303

Table 2-A1 continues on the next page →

TABLE 2-A1: Angiosperms – Monocotyledons, 16 Families, 37 Genera, 66 Species, 13 endemics, 25 near endemics = 38.

Family plus no. genera and no. species; list of species	Notes; altitude, endemicity, range	References, Voucher specimen in Killick Herbarium (CPF) or record ID, growth form (blank = no voucher collected)
DICOTYLEDONS		
25 Families, 48 Genera, 129 Species, 48 endemics, 28 near endemics = 76		
Family plus no. genera and no. species; list of species	Notes; altitude, endemicity, range	References, Voucher specimen in Killick Herbarium (CPF) or record ID, growth form (blank = no voucher collected)
ACHARIACEAE 1, 1	1 nr- end.	Ch
<i>Guthriea capensis</i> Bolus	DAC nr-end., Monotypic genus	S-S, B & L-O 14313
APIACEAE 1, 4	1 end., 1 nr-end.	Ch
<i>Alepidea amatymbica</i> Eckl. & Zeyh	Widespread, Platberg	
<i>Alepidea basynuda</i> Pott	Widespread	S-S, B & L-O 14294
<i>Alepidea galpinii</i> Dummer	DAC nr-end.	S-S, B & L-O 14254/14255
<i>Alepidea pusilla</i> Weim.	DAC end., Platberg	Carbutt & Edwards (2006)
ASTERACEAE 14, 55	20 end. (1 new species), 18 nr-end.	Ch with 1 Ph
<i>Arctotis arctotoides</i> (L.f.) O.Hoffm.	Widespread, Platberg	
<i>Arctotis leiocarpa</i> Harv.	Alt. 460 m–1548 m, N, NC, WC, EC, widespread	S-S, B & L-O 14199
<i>Aster bakerianus</i> Burtt Davy ex C.A.Sm.	Widespread, Platberg	
<i>Aster erucifolius</i> (Thell.) W.Lippert	EMR, DAC end.	Pooley (2003); Carbutt & Edwards (2006)
<i>Berkheya rhapsontica</i> (DC.) Hutch. & Burtt Davy subsp. <i>aristosa</i> (DC.) Roessler var. <i>aristosa</i>	DAC nr-end., Platberg	S-S, B & L-O 14295
<i>Berkheya setifera</i> DC.	Widespread, Platberg	
<i>Chrysocoma ciliata</i> auct.	Widespread, Platberg	
<i>Dimorphotheca jucunda</i> E.Phillips	DAC nr-end., Platberg	S-S, B & L-O 14206/14359
<i>Euryops decumbens</i> B.Nord.	DAC end.	S-S, B & L-O 14285
<i>Euryops montanus</i> auct.	DAC end.	Carbutt & Edwards (2006)
<i>Felicia linearis</i> N.E.Br.	DAC end.	S-S, B & L-O 14288
<i>Felicia rosulata</i> Yeo	DAC nr-end.	S-S, B & L-O 14204/14272/14310
<i>Felicia uliginosa</i> (J.M.Wood & M.S.Evans) Grau	DAC end.	Pooley (2003); Carbutt & Edwards (2006)
<i>Gazania krebsiana</i> Less.	Widespread, Platberg	
<i>Haplocarpha scaposa</i> Harv.	Widespread, Platberg	
<i>Helichrysum albanense</i> Hilliard	Alt. extension, EC, max. 1675 m	Germishuizen et al. (2006)
<i>Helichrysum albo-brunneum</i> S.Moore	DAC nr-end., alt. extension, WC, EC, KZN, FS, L	S-S, B & L-O 14266/14357
<i>Helichrysum album</i> N.E.Br.	DAC end., KZN >2000 m, Platberg	S-S, B & L-O 14210/14260/14261/14262/14358
<i>Helichrysum bellidiastrum</i> Moeser	DAC nr-end., KZN, EC, L	S-S, B & L-O 14211/14270/14340
<i>Helichrysum bellum</i> Hilliard	DAC end., KZN, L, EC	Pooley (2003); Carbutt & Edwards (2006)
<i>Helichrysum cymosum</i> (L.) D.Don subsp. <i>calvum</i> Hilliard	DAC nr-end., Platberg	S-S, B & L-O 14212/14209/14263
<i>Helichrysum flanaganii</i> Bolus	DAC end.	S-S, B & L-O 14266
<i>Helichrysum glaciale</i> Hilliard	DAC end.	S-S, B & L-O 14216
<i>Helichrysum infaustum</i> J.M.Wood & M.S.Evans	DAC nr-end., M, FS, KZN, L	S-S, B & L-O 14264/14356
<i>Helichrysum krookii</i> Moeser	DAC nr-end., KZN, L, EC	Carbutt & Edwards (2006); Germishuizen et al. (2006)
<i>Helichrysum lineatum</i> Bolus	DAC nr-end., EC, L	Carbutt & Edwards (2006)
<i>Helichrysum marginatum</i> DC.	DAC end.	S-S, B & L-O 14267/14341
<i>Helichrysum montanum</i> DC.	DAC nr-end., FS, KZN, L, EC	Carbutt & Edwards (2006)
<i>Helichrysum monticola</i> Hilliard	DAC nr-end., M, S, FS, KZN, EC	Carbutt & Edwards (2006)
<i>Helichrysum nanum</i> Klatt	DAC nr-end., FS, KZN, L, EC	S-S, B & L-O 14214/14215
<i>Helichrysum pagophilum</i> M.D.Hend.	DAC end.	Carbutt & Edwards (2006)
<i>Helichrysum pallidum</i> DC.	SA montane, widespread	Germishuizen et al. (2006)
<i>Helichrysum retortoides</i> N.E.Br.	DAC end.	S-S, B & L-O 14265
<i>Helichrysum sessilioides</i> Hilliard	DAC end.	S-S, B & L-O 14269
<i>Helichrysum subglomeratum</i> Less	SA montane, Platberg	S-S, B & L-O 14342
<i>Helichrysum sutherlandii</i> Harv.	DAC nr-end., Platberg, M, FS, KZN, L	Carbutt & Edwards (2006); Germishuizen et al. (2006)
<i>Helichrysum trilineatum</i> DC.	DAC nr-end., KZN, EC, L	Ph. S-S, B & L-O 14213
<i>Macowania glandulosa</i> N.E.Br.	DAC end., Platberg	S-S, B & L-O 14201/14312/14289
<i>Macowania sororis</i> Compton	DAC nr-end.	Mt. Currie, Griqualand, 10-01-2010, Bergh (NBG)
<i>Othonna burttii</i> B.Nord.	DAC end.	S-S, B & L-O 14301
<i>Senecio adnatus</i> DC.	Widespread	
<i>Senecio barbatus</i> DC.	DAC nr-end.	S-S, B & L-O 14306
<i>Senecio cristimontanus</i> Hilliard	DAC end.	S-S, B & L-O 14203/14273
<i>Senecio glaberrimus</i> DC.	Widespread	
<i>Senecio gramineus</i> Harv.	DAC nr-end., Platberg	S-S, B & L-O 14205/14276/14311/14360/14361
<i>Senecio othonniflorus</i> DC.	Widespread, Platberg	Brand et al. (2010)
<i>Senecio parascitis</i> Hillard	DAC end.	Carbutt & Edwards (2006)
<i>Senecio parentalis</i> Hilliard & B.L.Burtt	DAC end., KZN, alt. 1800–2165m	Carbutt & Edwards (2006); Germishuizen et al. (2006)

Table 2-A1 continues on the next page →

TABLE 2-A1: Angiosperms – Monocotyledons, 16 Families, 37 Genera, 66 Species, 13 endemics, 25 near endemics = 38.

Family plus no. genera and no. species; list of species	Notes; altitude, endemism, range	References, Voucher specimen in Killick Herbarium (CPF) or record ID, growth form (blank = no voucher collected)
<i>Senecio paucicalyculatus</i> Klatt	Widespread	
<i>Senecio speciosus</i> Willd.	Widespread	S-S, B & L-O 14320
<i>Senecio</i> sp. nov.	Outer Horn, undescribed DAC end.	S-S, B & L-O 14363
<i>Senecio tugelensis</i> J.M.Wood & M.S.Evans	DAC end., KZN, L, EC	S-S, B & L-O 14275
<i>Ursinia alpina</i> N.E.Br.	Drakensberg, alt. 2745 m	S-S, B & L-O 14290
<i>Ursinia montana</i> DC.	DAC nr-end., high altitude form, SA montane, Platberg	Carbutt & Edwards (2006)
<i>Ursinia tenuiloba</i> DC.	SA montane, LIM, M, S, KZN, EC	S-S, B & L-O 14287
BRASSICACEAE 1, 2	1 end.	Ch
<i>Heliophila formosa</i> Hilliard & B.L.Burt	DAC end.	Carbutt & Edwards (2006)
<i>Heliophila rigiduscula</i> Sond.	Widespread, Platberg	S-S, B & L-O 14193/14291/14296
CAMPANULACEAE 1, 1	1 nr-end.	Ch
<i>Craterocapsa tarsodes</i> Hilliard & B.L.Burt	DAC nr-end., Montane genus, Platberg	Carbutt & Edwards (2006); Germishuizen et al. (2006)
CARYOPHYLLACEAE 2, 2	Cosmopolitan	Ch
<i>Cerastium arabis</i> E.Mey. ex Fenzl	Widespread, Platberg	
<i>Silene bellidioides</i> Sond.	Genus mostly northern hemisphere, Platberg	Pooley (2003)
CRASSULACEAE 1, 6	1 end., 1 nr-end., succulents	Ch
<i>Crassula dentata</i> Thunb.	WC, alt. 200 m–1400 m, range extension?	Germishuizen et al. (2006)
<i>Crassula dependens</i> Bolus	Platberg	S-S, B & L-O 14248/14321
<i>Crassula gemmifera</i> Friedrich	DAC nr-end., FS, EC, L, KZN, alt. 1000 m–3200 m	Carbutt & Edwards (2006); Germishuizen et al. (2006)
<i>Crassula lanceolata</i> (Eckl. & Zeyh.) Endl. ex Walp.	Widespread, Platberg	
<i>Crassula lanceolata</i> (Eckl. & Zeyh.) Endl. ex Walp. subsp. <i>transvaalensis</i> (Kuntze) Tölken	Widespread, Platberg	
<i>Crassula peplodes</i> Harv.	Possible end., Platberg, FS, KZN, L, and M, alt. 1200 m–3000 m	Germishuizen et al. (2006)
DIPSACEAE 1, 1	No end.	Ch
<i>Scabiosa columbaria</i> L.	Widespread, Platberg	S-S, B & L-O 14307
ERICACEAE 1, 11	6 end., 2 nr-end., all 11 montane species	Ch
<i>Erica aestiva</i> Markötter	DAC end.	Carbutt & Edwards (2006)
<i>Erica algida</i> Bolus	DAC nr-end., Platberg	S-S, B & L-O 14337
<i>Erica alopecurus</i> Harv.	DAC nr-end., Platberg, E Cape to M, Afromontane	Carbutt & Edwards (2006); Germishuizen et al. (2006)
<i>Erica dissimulans</i> Hilliard & B.L.Burt	DAC end.	B & L-O 239583
<i>Erica dominans</i> Killick	DAC end.	S-S, B & L-O 14207/14208/14228
<i>Erica flanaganii</i> Bolus	DAC end.	Carbutt & Edwards (2006)
<i>Erica frigida</i> Bolus	DAC end.	S-S, B & L-O 14218/14219/14364
<i>Erica glaphyra</i> Killick	Not end. to SA	S-S, B & L-O 14328/9/30/31
<i>Erica maesta</i> Bolus	E Cape to M, Afromontane, Platberg	Germishuizen et al. (2006)
<i>Erica reenensis</i> Zahlbr.	E Cape to M, Afromontane	B & L-O 239573/239582
<i>Erica thodei</i> Gilg	DAC end., Platberg	S-S, B & L-O 14220/14338
EUPHORBIACEAE 1,1	1 end.	Ch
<i>Clutia nana</i> Prain	DAC end., Platberg, EC, KZN, L.	S-S 14299; Carbutt & Edwards (2006)
FABACEAE 2, 4	1 nr-end.	Ch
<i>Argyrobolium marginatum</i> Bolus	Widespread, Platberg	
<i>Lotononis eriantha</i> Benth.	Widespread	S-S, B & L-O 14230
<i>Lotononis galpinii</i> Dummer	DAC nr-end., Platberg	Carbutt & Edwards (2006)
<i>Lotononis procumbens</i> Bolus	Widespread and Platberg	S-S, B & L-O 14334
GENTIANACEAE 1, 3	3 end.	Ch
<i>Sebaea marlothii</i> Gilg	DAC end., Platberg	Carbutt & Edwards (2006)
<i>Sebaea spathulata</i> (E.Mey.) Steud.	DAC end.	S-S, B & L-O 14250/14257
<i>Sebaea thodeana</i> Gilg	DAC end., Platberg	S-S, B & L-O 14200/14229/14344/14345
GERANIACEAE 1, 1	1 nr-end.	Ch
<i>Geranium multisectum</i> N.E.Br.	DAC nr-end., Platberg	S-S, B & L-O 14352
LOBELIACEAE 1, 1	Widespread, no end.	Ch
<i>Cyphia schlechteri</i> E.Phillips	Platberg	
AIZOACEAE 1, 2	1 end., succulents,	Ch
<i>Delosperma nubigenum</i> (Schltr.) L.Bolus	DAC end.	S-S, B & L-O 14300
<i>Delosperma sphalanthoides</i> S.A.Hammer	Widespread	
MOLLUGINACEAE 1, 1	1 end.	Ch
<i>Psammotropha obtusa</i> Adamson	DAC end.	S-S, B & L-O 14202/14315
ONAGRACEAE 1, 2	No end.	Ch
<i>Epilobium capense</i> Buchinger ex Hochst.	Widespread, Platberg	
<i>Epilobium salignum</i> Hausskn.	Widespread, Platberg	

Table 2-A1 continues on the next page →

TABLE 2-A1: Angiosperms – Monocotyledons, 16 Families, 37 Genera, 66 Species, 13 endemics, 25 near endemics = 38.

Family plus no. genera and no. species; list of species	Notes; altitude, endemicity, range	References, Voucher specimen in Killick Herbarium (CPF) or record ID, growth form (blank = no voucher collected)
OXALIDACEAE 1, 3 <i>Oxalis depressa</i> Eckl. & Zeyh. <i>Oxalis obliquifolia</i> Steud. ex Rich. <i>Oxalis obtusa</i> Jacq.	No end. Widespread, Platberg Widespread, Platberg Widespread	Ch
POLYGALACEAE 2, 4 <i>Muraltia alticola</i> Schltr. <i>Muraltia flanaganii</i> Bolus <i>Muraltia montana</i> Levyns <i>Polygala hottentotta</i> C.Presl	1 end., both fynbos genera SA Mountains EMR end., Afromontane, Platberg WC, prev. alt. 1800 m, range extension? Platberg, prev. alt. 2505 m	Ch S-S, B & L-O 14278 Pooley (2003); Germishuizen et al. (2006) Germishuizen et al. (2006) Germishuizen et al. (2006)
ROSACEAE 1, 4 <i>Cliffortia browniana</i> Burt & Davy <i>Cliffortia filcaulis</i> E.Mey. <i>Cliffortia filcauloides</i> Weim. <i>Cliffortia nitidula</i> (Engl.) R.E. and T.C.E. Fr. subsp. <i>pilosa</i> Weim.	1 end., 1 nr-end. DAC nr-end., Afromontane KZN, EC, WC, alt. 185 m–1586 m DAC end., KZN, prev. alt. 1525 m Afromontane, Platberg, prev. alt. 2669 m	3 Ch, 1 Ph Carbutt & Edwards (2006); Germishuizen et al. (2006) Germishuizen et al. (2006) Carbutt & Edwards (2006); Germishuizen et al. (2006) S-S, B & L-O 14274; B & L-O 239572 Ph
RUBIACEAE 1, 3 <i>Anthospermum basuticum</i> Puff <i>Anthospermum hispidulum</i> E.Mey. ex Sond. <i>Anthospermum monticola</i> Puff	2 end., Fynbos genus DAC end., KZN, EC Mountain species DAC end., alt. 2500 m	Ch S-S, B & L-O 14305/14343 Pooley (2003); Germishuizen et al. (2006) Carbutt & Edwards (2006); Germishuizen et al. (2006)
SANTALACEAE 1, 3 <i>Thesium costatum</i> var. <i>juniperinum</i> A.W.Hill <i>Thesium nationae</i> A.W.Hill <i>Thesium pallidum</i> A.DC.	No end., parasitic on forb Platberg, prev. alt. 1500 m Prev. alt. 1350 m Widespread, Platberg	Ch Germishuizen et al. (2006) Germishuizen et al. (2006) Brand et al. (2010)
SCROPHULARIACEAE 7, 10 <i>Aptosimum procumbens</i> (Lehm.) Steud. <i>Cycnium racemosum</i> Benth. <i>Glumicalyx flanaganii</i> (Hiern) Hilliard & B.L.Burt <i>Glumicalyx goseloides</i> (Diels) Hilliard & B.L.Burt <i>Glumicalyx montanus</i> Hiern <i>Hebenstretia dura</i> Choisy <i>Jamesbrittenia dentatisepala</i> (Overkott) Hilliard <i>Limosella grandiflora</i> Benth. <i>Limosella vesiculosa</i> Hilliard & B.L.Burt <i>Zaluzianskya pulvinata</i> auct.	5 end., 1 nr-end. Highest alt. 2745 m Widespread DAC end. DAC end. DAC end. Platberg DAC end. Hydrophyte. Hydrophyte, EMR, DAC end. DAC nr-end., Platberg	Ch Germishuizen et al. (2006) Carbutt & Edwards (2006) B & L-O CPF ID no. 239586 S-S, B & L-O 14286, S-S 14351 S-S, B & L-O 14249 S-S, B & L-O 14191 Germishuizen et al. (2006) Pooley (2003); Germishuizen et al. (2006) S-S, B & L-O 14190/14247/14277
THYMELAEACEAE 2,3 <i>Gnidia aberrans</i> C.H.Wright <i>Passerina drakensbergensis</i> Hilliard & B.L.Burt <i>Passerina montana</i> Thoday	2 end., both fynbos genera DAC end., Platberg DAC end., alt. 1981 m Afromontane, Platberg, N, LIM, NW, M, S, FS, KZN, L, EC, alt. 2700 m	Ch S-S, B & L-O 14231 Carbutt & Edwards (2006) Ph S-S, B & L-O 14362; Carbutt & Edwards (2006) Ph
VALERIANACEAE 1,1 <i>Valeriana capensis</i> Thunb. var. <i>nana</i> B.L. Bartt	1 end. DAC end., Platberg	Ch S-S, B & L-O 14323/4

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