ELSEVIER
Available online at www.sciencedirect.com
ScienceDirect
South African Journal of Botany 77 (2011) 112–126
SOUTH AFRICAN JOURNAL OF BOTANY
www.elsevier.com/locate/sajb

The Roggeveldberge — Notes on a botanically hot area on a cold corner of the southern Great Escarpment, South Africa

V.R. Clark[a,*], N.P. Barker[a], L. Mucina[b]

[a] Department of Botany, Rhodes University, Grahamstown 6140, South Africa
[b] Department of Environmental and Aquatic Sciences, Curtin University of Technology, GPO Box U1987, Perth WA 6845, Australia

Received 17 December 2009; received in revised form 2 July 2010; accepted 5 July 2010

Abstract

Despite the Roggeveldberge comprising the montane heart of the celebrated Hantam–Roggeveld Centre of Plant Endemism (HRC), this section of the southern Great Escarpment in South Africa is botanically poorly known. A detailed physical, historical and phytogeographical overview of the Roggeveldberge is thus presented, and a checklist of 513 plant taxa is provided as a contribution towards a more complete flora for the Roggeveld–Komsberg Escarpment. The HRC is considered in detail, including various delimitations, and all species purported to be endemic to the HRC are reviewed and separated into actual endemics, near-endemics and species incorrectly considered as endemic.

Keywords: Biogeography; Endemism; Floristics; Great Escarpment; Hantam–Roggeveld Centre of Plant Endemism; Komsberg; Roggeveld

1. Introduction

The south-western edge of the Karoo plateau (Northern and Western Cape, South Africa) is one of the botanically richest areas of the Karoo. This edge – formed by the Hantamberge, the Roggeveldberge and the Komsberg – is part of the Great Escarpment exceedingly rich in local endemics, and is an important component of the Hantam–Roggeveld Centre of Plant Endemism (HRC; Mucina and Rutherford, 2006; Van der Merwe et al., 2008, 2009a,b; Van Wyk and Smith, 2001). Many of these Great Escarpment endemics are poorly known (Manning and Goldblatt, 2006; Van Wyk and Smith, 2001), with new endemics being discovered on a regular basis (Manning and Goldblatt, 2006, 2007, 2008, etc.). The Hantam–Roggeveld is also the section of the southern Great Escarpment deepest within the winter rainfall regime, and is part of probably the richest geophyte area in the world (Van Wyk and Smith, 2001). In addition to this, fynbos is represented by Renosterveld vegetation units (Mucina and Rutherford, 2006), and Succulent Karoo and Nama–Karoo vegetation units converge on the Roggeveld Escarpment (Mucina and Rutherford, 2006; Van der Merwe et al., 2009b; Van Wyk and Smith, 2001). The HRC has been poorly studied (Hilliard, 1999) except for parts of the Nieuwoudtville area (Van der Merwe et al., 2009b; Van Wyk and Smith, 2001), and the Middelpos–Sutherland–Fraserburg area is indicated in particular as requiring major botanical investigation (Van Wyk and Smith, 2001).

The aim of this paper is to contribute towards a flora of the Roggeveld and Komsberg (Fig. 1) and to augment other taxonomic, floristic and biogeographic research in this region (see Van der Merwe et al., 2008, 2009a,b). Such floristic inventories are fundamental to biogeographical analysis (Born et al., 2007) and conservation planning. Although part of a broader biogeographical region (the HRC), this contribution is mostly confined to the first author's activities in the Roggeveld and Komsberg areas of the HRC.

2. The study area

2.1. The Komsberg and Roggeveldberge

The Komsberg forms the 45 km east–west section of the Great Escarpment between Verlatenkloof Pass (R354) and the

* Corresponding author. Tel.: +27 46 6038592; fax: +27 46 6225524.
E-mail address: vincentralph.clark@gmail.com (V.R. Clark).

0254-6299/$ - see front matter © 2010 SAAB. Published by Elsevier B.V. All rights reserved.
doi:10.1016/j.sajb.2010.07.001

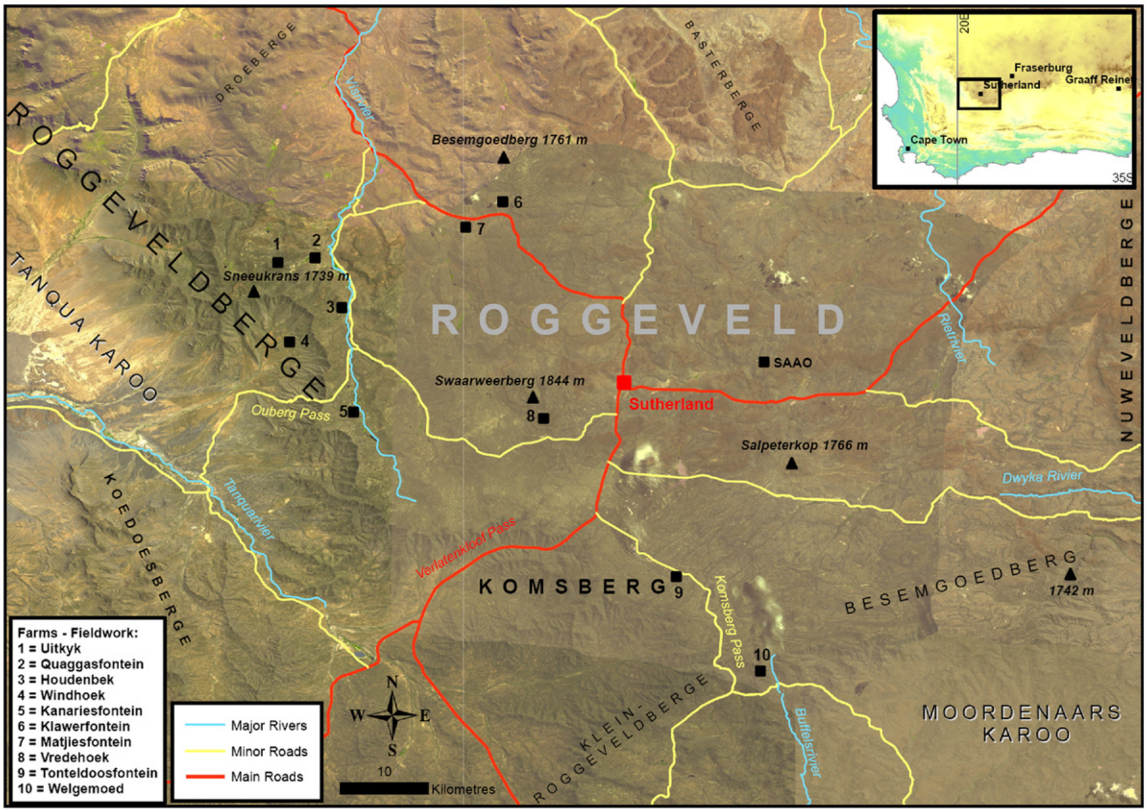

Fig. 1. The southern Roggeveldberge and the Komsberg, indicating the highest points, farms used as bases for fieldwork, and localities mentioned in the text. SAAO = South African Astronomical Observatory. Satellite imagery sourced from the CSIR (2009); data for insert map sourced from Geo Community (2009) and generated by G. Keevey (Department of Botany, Rhodes University).

Dwyka River Gorge in the Sutherland District (Fig. 1). It is also the most southerly section of the Great Escarpment in South Africa, and is situated only 80 km north of the inland Cape Fold Ranges (the Witteberg, Laingsburg District). The Roggeveldberge roughly comprises that section of Great Escarpment between Verlatenkloof Pass north and the Keiskieberge south of Calvinia. It is approximately 90 km long, and runs in a north-westerly direction. The Roggeveld is the plateau inland of the Roggeveldberge, and is roughly bounded by the main road (R354)/South African Astronomical Observatory (SAAO) in the east to Middelpos and the Basterberge and Keiskieberge in the north, and the Roggeveld Escarpment in the south and west. (Please note that for the sake of a suitable scale only the southern Roggeveldberge and the Komsberg are shown in Fig. 1 and not the entire Hantam–Roggeveld Escarpment; as a result of this, some of the names mentioned above are not in Fig. 1).

2.2. Geology and geomorphology

The geology of the Roggeveld and the Komsberg is relatively simple, being composed of horizontal sediments of Beaufort Group (Adelaide Subgroup) sandstones and mudstones of the Karoo Supergroup (Van Wyk and Smith, 2001; Verwoed et al., 1995; Woodford and Chevallier, 2002). Landscapes dominated by this geology are typically "layered", comprising a series of tablelands interspersed by "steps" of harder sandstone. Intrusions of mid-Jurassic dolerite (Woodford and Chevallier, 2002) are common, but in certain areas – such as on the Farms Quaggasfontein and Houdenbek (Fig. 1) – are dominant, resulting in landscapes characterised by rounded batholiths, precarious tors and long ridges of rounded boulders. These dolerites – believed to be the feeder veins of the Drakensberg Basalts during the break-up of Gondwanaland in the Jurassic (Brink, 1983; Van Zijl, 2006) – are virtually at the western and southern limits of their occurrence in this region, co-inciding largely with the Great Escarpment except where they extend west from the Hantamberg to Nieuwoudtville (Manning and Goldblatt, 2002). Their resistance to erosion, compared to the sediments they have intruded, renders them prominent features of the landscape (Agnew, 1958; Van Wyk and Smith, 2001). They have thus no doubt played an essential role in protecting the Roggeveld Escarpment from more rapid erosion (compare Agnew, 1958), and many of the highest points on the Roggeveld are capped with dolerite. Metamorphic or "baked" sediments occur along the contact zones between the sedimentary strata and the dolerite intrusions (e.g. Hill, 1993).

Salpeterkop (Fig. 2F), on the Komsberg plateau, is the volcanic plug of an eroded central volcano from the late Cretaceous (Verwoed et al., 1995). It is the central and largest component of the Sutherland Suite of hypabyssal olivine melilitite intrusions that extend 100 km north and 80 km north-east of Salpeterkop (Verwoed et al., 1995). The crater sediments contain tree trunk fossils and vertebrate fossils, indicating a

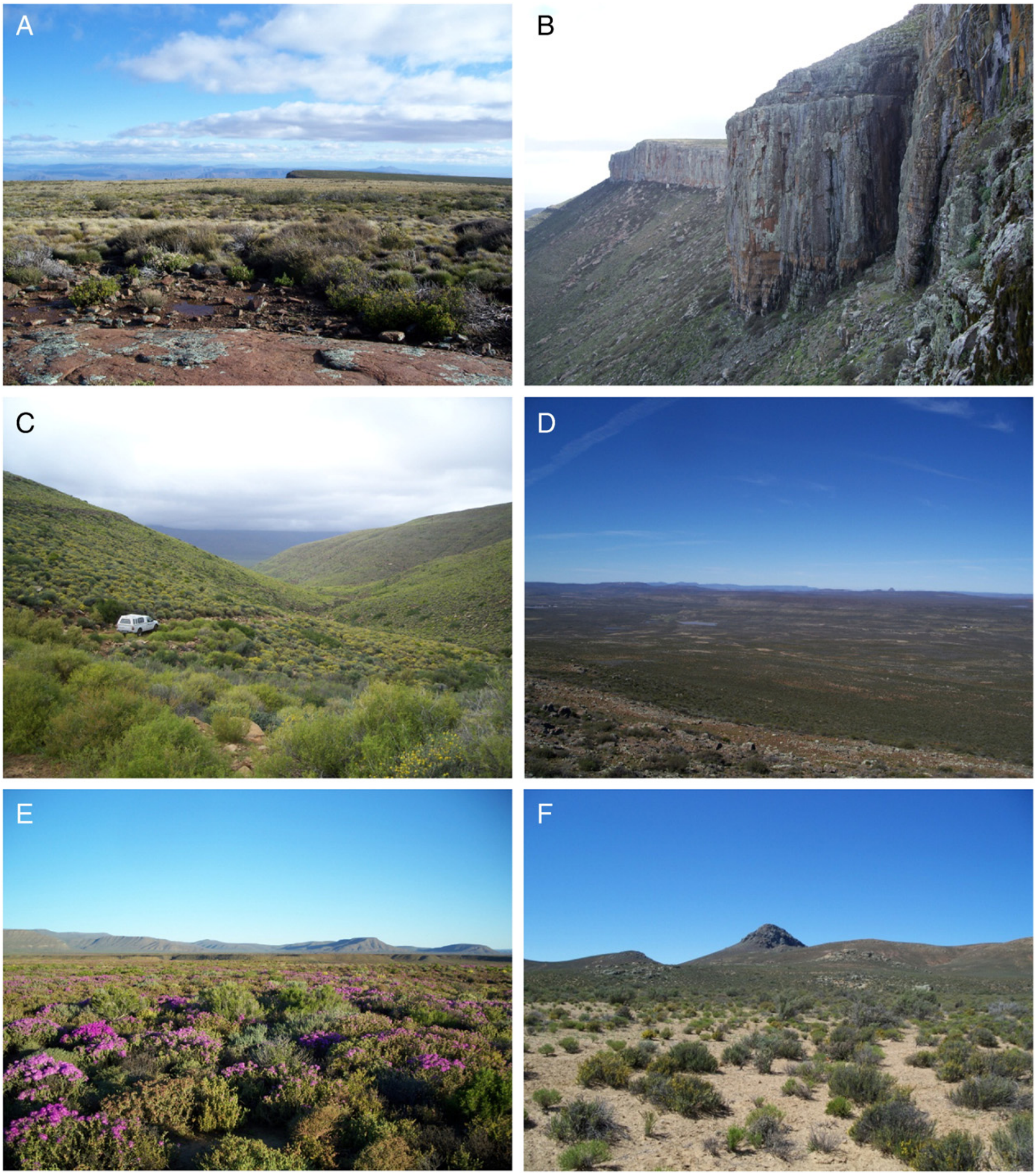

Fig. 2. A selection of photographs of the southern Roggeveldberge and Komsberg: (A) Sneeukrans summit plateau (1700 m), dominated by *Merxmuellera stricta*; (B) Sneeukrans, one of the most dramatic sections of the Roggeveld Escarpment (summit 1700 m); (C) Succulent Karoo on the lower slopes of the Roggeveld Escarpment, below Sneeukrans (950 m); (D) the almost featureless Roggeveld plateau (1400–1600 m) from the Swaarweerberg (1844 m); (E) the Tanqua Karoo in spring, with the Roggeveld Escarpment in the background; (F) Salpeterkop (1766 m), an ancient volcanic plug, on the Komsberg plateau.

crater lake existed at some stage in the past (Verwoed et al., 1995).

The highest point on the Komsberg is 1742 m (on the Besemgoedberge) with Salpeterkop on the plateau reaching 1766 m (Figs. 1 and 2F). The highest points on the Roggeveld are the Swaarweerberg at 1844 m and Sneeukrans at 1739 m (Fig. 2A, B). The Roggeveld Escarpment is not as dramatic as the Great Escarpment further east, but nevertheless represents an altitudinal difference of ca. 500 m (Komsberg) and 1000 m (Roggeveldberge) between the lower Karoo plains and the general summit plateau.

As for the rest of the Great Escarpment, the Roggeveld and Komsberg are defined by Partridge and Maud (1987; their Fig. 12) as “mountainous areas above the African Surface”. The African Surface lies to the north of the Great Escarpment, and dissected areas of various ages lie to the south. It may be possible that some of the higher-lying parts of the Roggeveld (such as Sneeukrans and the Swaarweerberg) represent fragments of the original Gondwanan surface (compare Agnew, 1958), although the Roggeveld is also much lower than other purported Gondwanan landform relicts, such as the Elandsberg (2017 m) and Gaika's Kop (1963 m) in the Great Winterberg–Amatolas (Agnew, 1958; Phillipson, 1992) and the Sneeuberg plateaux (ca. 2100 m; Clark et al., 2009). This suggests that the Great Escarpment sections in southern South Africa furtherest from the Lesotho Highlands have had more time to be planed (Matmon et al., 2002). Another possible reason is there is less igneous rock to protect the easily eroded sedimentary strata (Agnew, 1958; Brink, 1983; Van Wyk and Smith, 2001). A further possible reason is the higher uplift in the east of southern Africa than in the west during the Miocene and Pliocene (McCarthy and Rubidge, 2005; Partridge and Maud, 1987). There is in fact a general decrease in altitude along the southern Great Escarpment from east (2504 m in the Sneeuberg) to west (1844 m in the Roggeveld).

2.3. Hydrology

The Roggeveld Escarpment is drained by the Tankwa and Doorn Rivers, which form part of the Olifants River system, discharging into the Atlantic Ocean at Papendorp. The Komsberg Escarpment is drained by the Buffels and Dwyka Rivers, which from part of the Groot–Gouritz system, discharging into the Indian Ocean at Gouritsmond near Mossel Bay. The continental watershed thus runs along the Klein–Roggeveldberge onto the Komsberg and east towards the Nuweveldberge. The effect of the south- and west-flowing Roggeveld Escarpment streams has been the creation of numerous "embayments" in the Roggeveldberge, especially north of Sneeukrans where the Roggeveld Escarpment becomes increasingly sinuous and disconnected. The Roggeveld plateau is drained by the Vis and Renoster Rivers, which are tributaries of the Sak system that terminates in the large Grootvloer pan in Bushmanland.

2.4. Soils

The Roggeveld and Komsberg region is notorious for its dolerite clays, which are particularly treacherous in winter, when large areas of hillslope covered by of soils 20–50 cm deep that appear dry but are in fact saturated from the continuous movement of water through the soil. On the flat plateaux, extensive areas are covered in reddish sandy-clays (Van Wyk and Smith, 2001) derived from horizontal shale, sandstone and mudstone strata that have been deeply weathered *in situ*. These soils can be as deep as 1 m (pers. obs.), are also typically associated with high seasonal groundwater levels and the irregular drainage systems that characterise the flattest parts of the plateau. These areas usually host an abundance of geophytes.

Soils derived from dolerite flats are fertile, neutral to alkaline, reddish-brown, clay soils (Van Wyk and Smith, 2001). Generally formed *in situ*, these soils occur as a matrix in which rounded dolerite boulders are found, and support most of the endemics in the HRC (Manning and Goldblatt, 2002; Mucina and Rutherford, 2006; Van Wyk and Smith, 2001). The remainder of the soils in the area, such as on dolerite outcrops, among tors and on other shallow stony ground, are lithosols (Van Wyk and Smith, 2001), while colluvium and regolith occupy the steeper mountain slopes. Alluvial boulder piles, and beige alluvium deposits up to 3 m deep occupy the broader valleys at the base of the Great Escarpment (pers. obs.).

2.5. Climate

Cold regions in Africa are often so due to their high elevation, such as the Sneeuberg (>2000 m), Great Winterberg (2369 m), and Main Drakensberg Escarpment (>3000 m). The Roggeveld however is well-known for its cold climate (Van Wyk and Smith, 2001; Mucina and Rutherford, 2006), despite elevation not even reaching 1850 m. The reason for the extreme cold is considered to be a combination of the following (from Mucina and Rutherford, 2006; Van Wyk and Smith, 2001): (1) the Roggeveld Escarpment is the second area of high ground (after the Cederberg) in the path of cool air from temperate cyclones coming in from the south-west; (2) its relative proximity to the cool Atlantic Ocean and Benguela Current; (3) its relatively high elevation; (4) and the effect of continentality. The predominance of a winter rainfall regime ensures that the Roggeveld winter temperatures are not just cold (such as the continental but dry winter climates of the interior Karoo and Highveld) but are also characterised by snow and ice, the Roggeveld receiving about five snowfalls per annum.

Essentially, the Sutherland District occupies a "cool node" on the Karoo plateau, having the lowest mean annual temperature (12.5 °C), the lowest mean daily maximum temperature (<30 °C), the highest mean annual frequency of days with minimum temperature below 0 °C (80 days), and the highest number of frost days (153 days) out of any other region in the Karoo (Venter et al., 1986). Van Wyk and Smith (2001) crown this data stating that the Roggeveld experiences an average of 20 days of maximum temperature below 10 °C per annum, being twice that experienced in the Drakensberg Alpine Centre (DAC), which reaches over 3000 m in elevation.

The Roggeveld and Komsberg receive 60–70% of its rainfall in winter (Venter et al., 1986), with a transition from predominantly winter to summer rainfall taking place just to the east of Sutherland (Van Wyk and Smith, 2001). Mean annual precipitation is between 200 and 300 mm for the Komsberg and between 300 and 400 mm for the Roggeveld Escarpment (Van Wyk and Smith, 2001; Venter et al., 1986). Rainfall is cyclonic and (comparably) reliable, usually in the form of gentle, widespread rain (Mucina and Rutherford, 2006). Some 30% to 40% of the mean annual rainfall falls in summer (Van Wyk and Smith, 2001; Sieberhagen, pers. comm.).

The Tanqua and Koup Karoo plains below the Escarpment are warmer than the Komsberg and Roggeveldberge, with a mean annual temperature of 15.8 °C (Mucina and Rutherford, 2006), although in summer maximum temperatures can exceed 40 °C (Sieberhagen, pers. comm.). Rainfall is lower than on the

Roggeveld Escarpment, at 274 mm per annum (Mucina and Rutherford, 2006). The favourable winter climate at the bottom of the Escarpment is enjoyed by many Roggeveld farmers, who migrate each year with their flocks to the base of the mountains to avoid the harshest winter months (Sieberhagen, pers. comm.; Esterhuyse, pers. comm.).

2.6. Vegetation

The Roggeveldberge and Komsberg comprise a region of transition from Succulent Karoo to Nama–Karoo Biomes, with the Fynbos Biome represented as various Renosterveld vegetation units (Mucina and Rutherford, 2006).

2.6.1. Fynbos Biome

Fynbos Biome vegetation in the Hantam–Tanqua–Roggeveld region is represented by several Renosterveld vegetation units dominated by *Elytropappus rhinocerotis* (species author names are not repeated in the text for species listed in the Roggeveld flora contained in Appendix B). *E. rhinocerotis* (Renosterbos) is part of an endemic Cape lineage (Bergh and Linder, 2009; Bergh et al., 2007), and Renosterveld vegetation units represent the only "true" fynbos on the Roggeveldberge (Low and Rebelo, 1998; Mucina and Rutherford, 2006; Van der Merwe et al., 2009b). In this regard, Renosterveld is perhaps the clearest link between the Cape Floristic Region (CFR; as defined by Van Wyk and Smith, 2001) and the southern Great Escarpment, and – based on palaeoclimate reconstructions for an extended winter rainfall area and associated fynbos during the Last Glacial Maximum – may represent a dry, relict fynbos on the mountains of Namaqualand and the southern Great Escarpment from a much more widely distributed, moister fynbos from that time (Midgley et al., 2005; Bergh et al., 2007). Renosterveld, although only recorded as far east as the Nuweveldberge by Low and Rebelo (1998) and Mucina and Rutherford (2006), also occurs on the Sneeuberg (Clark et al., 2009), suggesting that much of the southern Great Escarpment is an important arm of Renosterveld radiating from the south-western Cape. Low and Rebelo (1998) note that virtually nothing is known about this Great Escarpment Renosterveld.

Van der Merwe et al. (2008) indicate three types of "Mountain Renosterveld" as occurring in the Hantam–Tanqua–Roggeveld region: *Rosenia oppositifolia* Mountain Renosterveld, *E. rhinocerotis* Mountain Renosterveld and *Passerina truncata* Mountain Renosterveld. These Renosterveld entities are paralleled by Mucina and Rutherford's (2006) Roggeveld Shale Renosterveld, Nieuwoudtville Shale Renosterveld, Nieuwoudtville–Roggeveld Dolerite Renosterveld and Hantam Plateau Dolerite Renosterveld vegetation units. All of these Renosterveld units fall into Low and Rebelo's (1998) Escarpment Mountain Renosterveld, which mirrors Acocks's (1988) Mountain Renosterveld (A43) vegetation type. Acocks (1988) considered this Renosterveld to be invasive of a previously much grassier habitat, possibly as a result of overgrazing following the extermination of the original nomadic plains game and replacement by concentrated livestock (Low and Rebelo, 1998; Manning and Goldblatt, 2002; Van der Merwe et al., 2009a).

2.6.2. Succulent Karoo and Nama–Karoo biomes

Mucina and Rutherford (2006) place the remainder of the Hantam–Tanqua–Roggeveld region into the Succulent Karoo Biome, although much of the area is transitionary between summer and winter rainfall regimes and is therefore biogeographically complicated, being ecotonal to the Fynbos, Succulent Karoo and Nama–Karoo Biomes (Mucina and Rutherford, 2006; Van Wyk and Smith, 2001). Obvious Succulent Karoo vegetation laps the base of the Roggeveld Escarpment as Mucina and Rutherford's (2006) Tanqua Karoo, and comprises an abundance of annuals and succulent and Karoo shrubs, particularly Mesembryanthemaceae (Fig. 2E). Tanqua Karoo grades into Mucina and Rutherford's (2006) Tanqua Escarpment Shrubland on the Roggeveld Escarpment slopes, and varies from grassy shrubland dominated by species such as *Merxmuellera disticha* and *Euryops lateriflorus* to drier slopes dominated by often abundant *Ruschia* and *Drosanthemum* species, with many other shrubs such as *Anisodontea triloba*, *Galenia africana*, *Oedera genistifolia*, *Osteospermum sinuatum*, *Pteronia incana*, *P. pallens* and *Senecio cinarescens* (Fig. 2C). These drier sections of Roggeveld Escarpment are no doubt synonymous with Van der Merwe et al.'s (2008, 2009b) *Pteronia glauca–Euphorbia decussata* Escarpment Karoo. Roggeveld Escarpment vegetation gives way to Renosterveld (discussed above) and Mucina and Rutherford's (2006) Hantam Karoo and Roggeveld Karoo vegetation units on the plateau, the latter two being synonymous with Van der Merwe et al.'s (2008) *Eriocephalus purpureus* Hantam Karoo and *Pteronia glomerata* Roggeveld Karoo vegetation types respectively. Roggeveld Karoo occurs on the higher-lying areas as far east as Fraserburg in the Nuweveldberge, and represents the eastern limit of the Succulent Karoo Biome (Mucina and Rutherford, 2006; Van Wyk and Smith, 2001). Hantam Karoo is confined to the areas between Loeriesfontein, Nieuwoudtville and Calvinia (Mucina and Rutherford, 2006). Much of the broad sedimentary plateaux inland of the Roggeveld Escarpment are dominated by Karoo "tableland shrublands", with *Euryops* Cass. species often dominant.

2.6.3. Other noteworthy vegetation

Riparian *Acacia karroo* thickets occur along the rivers and watercourses at the base of the Roggeveld Escarpment (Mucina and Rutherford's, 2006, Tanqua Wash Riviere vegetation unit), while on the plateau rivers and watercourses are characterised by large beds of *Pseudoschoenis inanis*, *Phragmites australis* and the occasional (alien) *Salix babylonica*. Numerous pans – fresh and saline – occur on the flat areas of the plateau, particularly on the Komsberg plateau and between the Swaarweerberg and the Roggeveld Escarpment. Dry pans are often covered in a fine red carpet of *Crassula* cf. *vaillantii,* and may support a range of geophytes that are evident only in the wet season.

It is worth mentioning that an unusual form of grassland occurs on Sneeukrans (Figs. 1 and 2A), the highest and possibly wettest point on the actual Roggeveld Escarpment. Large (1 m wide) circular tussocks of *Merxmuellera stricta* dominate, with scattered shrubs. Other "high altitude" specialists occurring here are *Ischyrolepis laniger* and *I. distracta* (these being the only Restionaceae encountered in this study, although *I. sieberi* and

I. gossypina are also known from the Hantam–Roggeveld; Born et al., 2007; identifications kindly provided by H.P. Linder), and *Helichrysum trilineatum* (only encountered on Sneeukrans in this study). The Sneeukrans area is rich in local endemics, with several species currently only known from that area (e.g. *Oxalis marlothii*, *Devia xeromorpha* and *Hesperantha ciliolata*).

Cliff communities (and to a similar degree rock-outcrop communities) comprise species seldom found in other habitats in the area. Typical species are *Asparagus asparagoides*, *A. microraphis*, *A.* sp. nov., *Asplenium cordatum*, *Cerastium capense*, *Cineraria alchemillioides* subsp. *alchemillioides*, *Conium sphaerocarpum*, *Cromidon decumbens*, *Diascia parviflora*, *Stilpnogyne bellidioides*, *Troglophyton capillaceum* subsp. *capillaceum* and *Urtica lobulata*. Of particular interest is the very high (100 m+), relatively moist, well-shaded south-east-facing dolerite cliffs of Sneeukrans (Fig. 2B), which support numerous species not encountered elsewhere on the Roggeveld and Komsberg. These species include a variety of soft grasses such as *Vulpia myuros* (an alien), herbs such as *Ranunculus multifidus*, cushion plants such as *Berkheya cardopatifolia,* a *Crassula* sp., and soft shrubs such as *Melianthus major*. *Oxalis marlothii* is abundant at the base of the sandstone cliffs to the south-east in the vicinity.

3. Endemic and near-endemic species and centres of endemism

The high botanical endemism on the south-western Great Escarpment has been recognised since Diels (1909), and the area has been variously termed the “Hantam–Roggeveld Subcentre” by Weimarck (1941), the “Western Upper Karoo Centre” by Nordenstam (1969) and Hilliard (1994), the “Roggeveld and Western Mountain Karoo” by Hilton-Taylor (1987, 1996), the “Hantam Centre” by Koekemoer (1996), the “HRC” by Van Wyk and Smith (2001), and more recently, the “Hantam–Tanqua–Roggeveld Region” by Born et al. (2007). While the geographical delimitation of this endemic-rich section of Great Escarpment varies somewhat according to the above works, it is without exception focused on the Hantam, Roggeveld and Komsberg sections of the Great Escarpment (Van Wyk and Smith, 2001). The most significant variations are that Nordenstam (1969) and Hilliard (1994) included the entire Nuweveldberge into their delimitation, as did Hilton-Taylor (1987, 1996), while Van Wyk and Smith (2001) included the western half of the Nuweveldberge only. Born et al. (2007), on the other hand, excluded the Nuweveldberge completely, due to a shift from a winter rainfall regime on the Hantam–Roggeveld to a summer rainfall regime on the Nuweveldberge. Mucina and Rutherford (2006) provided a vegetation unit basis by which to possibly define an area of endemism, and considered their Nieuwoudtville Shale Renosterveld, Roggeveld Shale Renosterveld, Nieuwoudtville–Roggeveld Dolerite Renosterveld, Hantam Plateau Dolerite Renosterveld, Hantam Karoo and Roggeveld Karoo vegetation units to form the core of their version of the HRC. This concurs largely with Van Wyk and Smith's (2001) delimitation. They also suggest including their Koedoesberge–Moordenaars Karoo vegetation unit, and the areas adjoining the Tanqua Basin, into this Centre (Mucina and Rutherford, 2006).

The area is a centre of diversity for Asteraceae (Koekemoer, 1996) and is an especially marked centre for *Euryops* (Nordenstam, 1969). Annual Manuleae (Scrophulariaceae) are also very well represented, with several annual endemic species in *Diascia* Link and Otto, *Cromidon* Compton and *Zaluzianskya* F.W.Schmidt (Hilliard, 1994; Mucina and Rutherford, 2006; Van Wyk and Smith, 2001), while numerous *Selago* L. species are also local endemics (Hilliard, 1999). The most spectacular array of endemics however – visually and numerically – is in the monocot geophytes (Snijman and Perry, 1987), with numerous representatives in the Amaryllidaceae, Colchicaceae, Iridaceae and Hyacinthaceae. This is particularly evident in genera such as *Hesperantha* Ker Gawl. (for which the centre of diversity is the Hantamsberg, followed by the Roggeveld; Goldblatt, 1984; Snijman and Perry, 1987), *Ixia* L., *Gladiolus* L., *Babiana* Ker Gawl., *Daubenya* Lindl., *Moraea* Mill., *Romulea* Maratti and *Lachenalia* J.Jacq. ex Murray. Such geophytes contribute up to 40% of the flora in certain parts of the HRC (Mucina and Rutherford, 2006), and are concentrated in the western (strictly winter rainfall) area of the HRC. Other endemic-rich families in the HRC are Mesembryanthemaceae (Van Wyk and Smith, 2001) and Oxalidaceae (Salter, 1944), while of the several endemic Poaceae, the origins of *Secale strictum* subsp. *africanum* has been the most speculated over (Van Wyk and Smith, 2001; A. van Wyk, pers. comm.).

Born et al. (2007) place endemism at 8.6% with a flora of 1254 species for their “Hantam–Roggeveld–Tanqua Region”; Van Wyk and Smith (2001) place endemism for their “HRC” at 10% with a flora of 2500 taxa; and Hilton-Taylor (1987) indicates 163 taxa endemic to his “Roggeveld and Western Mountain Karoo”. Given the various geographical delimitations of this endemic-rich area, it is difficult to compile a conclusive and unambiguous list of endemic plants: Appendix A is a review of all species indicated as HRC endemics by (primarily) Hall and Veldhuis (1985), Van Wyk and Smith (2001) and Mucina and Rutherford (2006). Wherever possible, the original description of each species has been obtained in order to verify distribution and edaphic substrate. Many more recently described species have also been added to the list.

In terms of delimiting what constitutes an HRC endemic, we follow Van Wyk and Smith (2001) and have used geology as the primary indicator of endemism in the HRC. Thus the Bokkeveld Escarpment, composed of Cape Supergroup rocks (Manning and Goldblatt, 2002), is excluded from the HRC (Van Wyk and Smith, 2001), and strict HRC endemics are those confined to Karoo sediments, Karoo dolerites, and Dwyka Tillites. Near-endemics are those species that occur on both Karoo and Cape substrates. In this regard it is not easy to confer endemic status to some species in the Nieuwoudtville area, as some literature indicates their presence on the Bokkeveld Escarpment (part of the CFR) while other literature indicates exclusivity to the Bokkeveld Plateau (HRC) for the same species. A detailed study of herbarium material may be required to resolve this. Such uncertainty has been indicated in

Appendix A, and a precautionary approach has been adopted in designating endemism. Dolerite is one of the principal edaphic indicators of HRC endemism (Manning and Goldblatt, 2002; Mucina and Rutherford, 2006; Snijman and Perry, 1987), although sister taxa on adjacent but different substrates are common in the Nieuwoudtville area (Mucina and Rutherford, 2006).

While HRC delimitation in the west is fairly straightforward, it is more complicated in the east and north, where the geology remains constant (Karoo sediments and dolerites) but there is a transition from a winter to a summer rainfall regime on the Nuweveldberge in the east and onto the Great Karoo plateau in the north (Born et al., 2007; Van Wyk and Smith, 2001). In the east, 13 'endemic' species are shared between the Roggeveldberge and Nuweveldberge, seven of which extend to the eastern Nuweveldberge behind Beaufort West. The continuity of these species is biogeographically reasonable, given that the Hantam–Roggeveld–Nuweveld is effectively one continuous section of the Great Escarpment with no major intervals (Born et al., 2007; Clark, 2010; Van Wyk and Smith, 2001). Thus Van Wyk and Smith (2001) include the Nuweveldberge as far west as the Fraserburg area into their HRC, as does Van der Merwe et al. (2009a) and effectively Mucina and Rutherford (2006), while Nordenstam (1969) includes the entire Nuweveldberge. Born et al. (2007) however exclude it completely, based on the change in rainfall regime and the consequent concentration of Cape taxa and endemics in the Hantam–Roggeveld core. Here we follow Born et al. (2007) and exclude the Nuweveldberge component completely, assigning the shared endemics to near-endemic status. Inland, the 50/50% summer–winter transition area is the only suitable (but still nebulous) cut-off point as there are no obvious or distinct land-surface features that offer a convenient and clear cut-off line. The maximum extent is far as Williston. Future detailed collecting in this transition area may provide more detailed distribution patterns of endemic/near-endemic taxa and data for a better floristic delimitation.

In the south, altitude appears to be a main factor, but the HRC can be safely taken to include the Roggeveld and Komsberg scarps down to about 900 m above sea level, together with the adjacent associated ridges of the Klein–Roggeveldberge and Koedoesberge. The Tanqua Karoo is thus excluded and we have relegated species shared between the Tanqua Karoo and the higher-lying areas to near-endemic status.

This issue of boundary delimitation will probably never be completely resolved however (Born et al., 2007). Based on the above delimitation, a total of 176 HRC endemic and 54 near-endemic species are thus identified, with a further 20 purported or possible endemics shown to be neither endemic nor near-endemic. Nine species have uncertain endemicity, the literature being either vague or contradictory.

Faunal endemism in the Roggeveld is known to include *Cordylus minor* (Dwarf Girdled Lizard) in the Matjiesfontein area (Branch, 1998), while *Pseudocordylus microlepidotus namaquensis* (Cape Crag Lizard) is a near-endemic from Sutherland to Beaufort West (Branch, 1998). The recently described bee *Capicola hantamense* is endemic to the Hantamberge, and pollinates *Wahlenbergia* ex Roth species (Michez and Kuhlmann, 2007). 95% of bee species in the xeric winter rainfall area of South Africa is endemic, and includes basal taxa of different families that are of special interest for the understanding of bee phylogeny and evolution (Kuhlmann, 2005). The arid and semi-arid areas of South Africa are the only place in the world where a centre of bee diversity co-incides with a phytogeographical centre, suggesting co-evolution of the both bees and flowers in this area (Kuhlmann, 2005). *Thestor pringlei* (Pringle's Skolly) and *Phasis pringlei* (Pringle's Arrowhead) are butterflies endemic to the Roggeveld Escarpment, while *Chrysoritis azurius* (Azure Opal) extends from the Roggeveldberge to Nieuwoudtville (Woodhall, 2005). *Trimenia wykehami* (Wykeham's Silver-spotted Copper), *Aloeides kaplani* (Kaplan's Copper) and *Chrysoritis midas* (Midas Opal) are shared by the Roggeveldberge and Nuweveldberge (as far as Beaufort West; Woodhall, 2005). *Chrysoritis beaufortius* (Beaufort Opal) extends from the Kamiesberg in the north through the Roggeveld to the Nuweveldberge (Woodhall, 2005). *Lepidochrysops macgregori* (McGregor's Blue) (sic) occurs on the Roggeveld Escarpment and near Nieuwoudtville, and *L. jamesii* (James's Blue) on the Hantam–Roggeveldberge. Interestingly enough, there is a disjunction between higher sections of the Roggeveld (such as the Swaarweerberg) and the Hantamberge in some of these butterfly species (Woodhall, 2005).

4. Biogeographical connections

The HRC has interesting biogeographical connections both locally and abroad. Van Wyk and Smith (2001) elucidate very thoroughly the various biogeographical linkages present, summarised as follows.

4.1. HRC–CFR connections

Weimarck (1941) delimited a Hantam–Roggeveld Subcentre as a satellite part of his North-Western Centre, based on the large number of species common to the northern CFR mountains and this section of the Great Escarpment (Born et al., 2007). He notes Cape elements only occurring on the highest sections of the Roggeveld Escarpment. He cites Diels (1909) as indicating the Hantamberge above 1400 m as "having a purely Cape character" (Weimarck, 1941, p. 67), but notes that typical CFR families such as Ericaceae and Proteaceae are absent while "other Cape species occur in quantities" (Weimarck, 1941, p.67). His conclusion is that the Subcentre is somewhat weakly supported based on the comparatively few Cape elements, but that the Cape species represented have enough biogeographical virility to warrant subcentre delimitation. Nordenstam (1969) likewise noted strong affinities between his "Western Upper Karoo Centre" (i.e. Hantam–Roggeveld–Nuweveld) and the CFR (Van Wyk and Smith, 2001).

The interval between the Hantam–Roggeveld Escarpment and the CFR is referred to by Weimarck (1941) as the Doorn River Interval, referring specifically to the gap between the

Cederberg and the Roggeveld, i.e. the Tanqua (or Ceres) Karoo. Examples of CFR species disjunct across this interval are *Ischyrolepis gossypina*, *I. monanthos* and *I. sieberi* (Born et al., 2007; Linder, 1985; Weimarck, 1941). Weimarck (1941) cited *Elegia asperiflora* (Nees) Kunth as disjunct across this Interval, but this is not supported by Linder (1985). Weimarck (1941) postulates a route across the Doorn River valley in the north-west (i.e. the North-Western connection) or a route further to the east via the Klein–Roggeveldberge and Koedoesberge (i.e. the Matjiesfontein connection). The North-Western connection is supported by the work of Born et al. (2007), who indicate that many species are shared between the mountains of the North-West Centre and the Hantam–Roggeveldberge, and that the North-West Centre is linked floristically with the Hantam–Roggeveld and Namaqualand Escarpments as well as to the coastal plain. The Matjiesfontein connection is also quite feasible considering there is a gap less than 20 km wide between the Witteberg and the Klein–Roggeveldberge in the vicinity of Matjiesfontein, and the Komsberg itself is only 80 km north of the Witteberg (part of the Karoo Mountain Centre). As most CFR species on the Hantam–Roggeveld show close connection to Weimarck's (1941) Karoo Mountain Centre (especially the Witteberg) and North-West Centre (especially the Cederberg), it is probable that local dispersal events can account for most of the abundant examples of species shared between the HRC and adjacent CFR mountains (Van Wyk and Smith, 2001). Similarly, as the HRC abuts the CFR in the west (Bokkeveld Mountains, Nieuwoudtville District), it is not surprising that the HRC has a close affinity with the CFR (Van Wyk and Smith, 2001). Connections are particularly evident in geophytes such as *Lachenalia*, *Babiana*, *Hesperantha*, *Gladiolus, Romulea,* etc. (Duncan, 1997; Duncan and Edwards, 2006; Goldblatt, 1984; Goldblatt and Manning, 1998, 2004; Manning et al., 2002; etc.), and in succulent genera such as *Euphorbia* and *Haworthia* Duval (Van Wyk and Smith, 2001). The Fabaceae genus *Polhillia* C.H. Stirt. (less than 10 species, with *P. involucrata* endemic to the Roggeveld; Stirton, 1986; Van Wyk, 1992), *Euryops* (Nordenstam, 1969), and the grass genus *Prionanthium* Desv. (two species in the CFR and *P. dentatum* endemic to the HRC; Gibbs Russell et al., 1990) are further examples of connections with the CFR. *Ischyrolepis distracta* – a widespread montane Restionaceae (Linder, 1985) – was collected on Sneeukrans, as was *I. laniger*, a species known from the inland Cape mountains between Van Rhynsdorp and Oudtshoorn (Linder, 1985). Both species are common on Sneeukrans but were not encountered elsewhere on the Roggeveld or Komsberg in this study.

More ancient connection and subsequent disjunction is suggested by *Cliffortia arborea, C. dichotoma* Fellingham and *C. conifer* E.G.H.Oliv. and Fellingham*,* the three species in *Cliffortia* section Arboreae (Van Wyk and Smith, 2001; Whitehouse, 2002). While *C. conifera* is confined to the Anysberg (adjacent to the Witteberg in Weimarck's, 1941, Karoo Mountain Centre), *C. arborea* is endemic to the Great Escarpment from the Hantamberge to the Nuweveldberge (Oliver and Fellingham, 1994; Van Wyk and Smith, 2001), and *C. dichotoma* is endemic to the sandstone escarpment of the CFR south of Nieuwoudtville. (Whitehouse, 2002, indicates that a form of *C. arborea* has been found which may constitute a new species). The long-lost *C. bolusii* Diels ex C.Whitehouse from the Sneeuberg (Clark et al., 2009; Whitehouse and Fellingham, 2007) may also be a component of section Arboreae, suggesting Great Escarpment links to the east as well.

4.2. Hantam–Roggeveld–DAC connections

There are several taxa which suggest a connection between the HRC and the Drakensberg Alpine Centre (DAC) (Van Wyk and Smith, 2001; Weimarck, 1941). Weimarck's (1941) *Cliffortia* section Complanatae has four species, three in the CFR (including the previously considered Hantam-endemic *C. hantamensis*; Whitehouse, 2002), and one species in the DAC (Van Wyk and Smith, 2001), although Whitehouse (2002) has revised Weimarck's (1941) classification substantially. Another possible HRC-DAC link is the genus *Saniella* Hilliard and B.L.Burtt, which has two species — *S. verna* Hilliard and B.L.Burtt in the DAC and *S. occidentalis* in the HRC and Kouebokkeveldberge (Burtt, 2000; Manning et al., 2002; Van Wyk and Smith, 2001). Three *Heliophila* L. species occurring in the DAC (*H. carnosa*, *H. rigidiuscula* Sond., *H. suavissima*) are nested in a clade which has the Richtersveld (or the Richtersveld and the Roggeveld) as its ancestral area (Mummenhoff et al., 2005). Mummenhoff et al. (2005) postulate that the harsh DAC “alpine” environment might have similarities to the harsh semi-desert environment of the Namaqualand Escarpment. *Romulea luteoflora* var. *luteoflora* (from the Kamiesberg through the HRC to Riversdale) and *R. luteoflora* var. *sanisensis* M.P.de Vos (DAC), *Manulea incarnata* (an HRC endemic most closely related to *M. dregei* Hilliard and B.L.Burtt and *M. platystigma* Hilliard and B.L.Burtt, both from the DAC), *Aponogeton fugax* J.C.Manning and Goldblatt (from the Bokkeveld through the Elim plain) and *A. ranunculiflorus* Jacot Guill. and Marais (a DAC endemic) are additional examples (Manning et al., 2008; Van Wyk and Smith, 2001). *Cynoglossum obtusicalyx*, which occurs on the Hantam-berge, the Nuweveldberge at Beaufort West, and in the Ceres area, indicates connections along the western Great Escarpment and with the CFR, while other species in the genus are mainly eastern, DAC species (Retief and Van Wyk, 1996).

Given both the DAC and HRC's extreme cold (Van Wyk and Smith's, 2001, Positive Chill Units of 1500 for the Roggeveld are equalled only by the summits of some of the inland Cape Fold Ranges and the Kamiesberg) and clay soils, it is not surprising that certain links between them occur. Another similarity is that HRC endemics are often found on dolerite (Manning and Goldblatt, 2002; Mucina and Rutherford, 2006; Van Wyk and Smith, 2001) — dolerite is geochemically similar to the basalts of the DAC (Marsh and Mndaweni, 1998), and several DAC endemics have recently been discovered on the Sneeuberg, which are largely comprised of dolerite (Clark et al., 2009). Basalt/dolerite-derived soils may thus be a factor in endemism on the southern Great Escarpment, at least in the east where rainfall is higher (e.g. the Drakensberg) and in the HRC where the rainfall is not high but is comparatively reliable than on the Nuweveldberge (Clark, 2010). Key differences between the HRC and DAC however are the rainfall, with the Roggeveldberge having a MAP of 400 mm per annum and the DAC receiving no less than 650 mm per annum (Mummenhoff et al., 2005; Van Wyk and Smith, 2001). The rainfall regime in the HRC is winter rainfall, and summer in the DAC (Mummenhoff et al., 2005; Van Wyk and Smith, 2001) although both have (relatively in terms of the Roggeveld Escarpment compared to other arid areas on the subcontinent including the Nuweveldberge) reliable rainfall and regular snowfalls.

Other species suggestive of remnants of such a Great Escarpment corridor or connection are *Helichrysum trilineatum* (common in the Sneeuberg but only found on the higher peaks of the Roggeveld and Nuweveldberge), *Brachypodium bolusii* (confined to shaded cliff-bases), *Cromidon decumbens* (Hilliard, 1990; Mummenhoff et al., 2005), and *Euryops empetrifolius* (Nordenstam, 1969). As mentioned previously, the Sneeuberg endemic *Cliffortia bolusii* may be a relictual species in section Arboreae, as suggested by Whitehouse and Fellingham (2007), and would strongly support a Great Escarpment connection. Similarly, the morphological similarity of the recently described Sneeuberg endemic *Hesperantha helmei* Goldblatt and J.C. Manning with the Roggeveld species *H. ciliolata* and *H. teretifolia* (Goldblatt and Manning, 2007), suggests connections along the southern Great Escarpment. The lack of Ericaceae and Proteaceae in the HRC is interesting, as elements are present in the Sneeuberg, DAC and Kamiesberg, but are absent from the Hantam–Roggeveld–Nuweveld Escarpment (Oliver et al., 1983).

It is also worth noting the evidence of connection between the Roggeveldberge and the Kamiesberg (Born et al., 2007; Van Wyk and Smith, 2001), which then suggests a greater Great Escarpment "highway" from the Kamiesberg south to the Roggeveldberge (with an "off-ramp/on-ramp" to the CFR) and then across to the DAC.

4.3. Hantam–Roggeveld–Eurasian connections

Secale strictum subsp. *africanum* presents a biogeographical enigma in that it is the only representative of *Secale* L. to occur in southern Africa (and in the southern hemisphere; Khush and Stebbins, 1961; Van Wyk and Smith, 2001). Van Wyk and Smith (2001) propose long-distance dispersal as a possible means by which it came to be established in the HRC. This is feasible considering the large number of waterfowl that occur in the HRC (pers. obs.). A Eurasian migrant wader or duck may have brought the sub-species precursor in (A. van Wyk, pers. comm.). The similar disjunct distribution pattern is mirrored by the Fumariaceae, which occurs in the northern hemisphere and with three genera in the southern hemisphere endemic to southern Africa (Manning et al., 2009; Van Wyk and Smith, 2001), and by local indigenous versions of Eurasian grass genera such as *Hordeum* L. and *Holcus* L. (Gibbs Russell et al., 1990). Other Eurasian species occurring in the HRC are mostly alien species more recently anthropogenically introduced (Van Wyk and Smith, 2001), particularly Poaceae, Brassicaceae and Boraginaceae. Based on how well such Eurasian aliens do on the Roggeveld, Van Wyk and Smith (2001) suggest that some of the endemic CFR genera with obvious connections to the Mediterranean region (e.g. *Lobostemon* Lehm. and *Echiostachys* Levyns in the CFR vs. *Echium* L. in Europe) may have originally arrived by long-distance dispersal, rather than along the African mountain chain.

4.4. HRC-South American and other connections

The genus *Alonsoa* Ruiz and Pav. has connections to South and Central American Scrophulariaceae, and *Bulbinella* Kunth has centres of diversity in the HRC (on the Bokkeveld Plateau around Nieuwoudtville) and New Zealand (Van Wyk and Smith, 2001). *Salvia* L. is centred in Central and northern South America, with a secondary centre in the CFR, and a few species (none endemic) to the HRC.

5. Human settlement and impacts

The first European farm to be established in the Roggeveld was the Farm Uitkyk in 1746 (Schoeman, 1986). (The Farm Uitkyk includes Sneeukrans, discussed above). The Roggeveld has thus been settled for some 250 years by European pastoralists, although initially impacts on vegetation were probably minimal given the low population numbers, large farm sizes and many absentee landowners (Schoeman, 1986). Prior to this the region was occupied by the Khoikhoi and San (Schoeman, 1986), who would have had a minimal impact on the vegetation. In 1805 there were only 62 farms with 26 landowners in the Middel–Roggeveld, while the Onder–Roggeveld had 47 farms with 22 landowners. The Roggeveld lay on the route to the inland mission stations and interior and was thus passed through by several well-known explorers to the Cape, such as C.P. Thunberg and F. Masson on 1774 and W. Burchell in 1811 (Schoeman, 1986).

The biggest debate over human impact on the Roggeveld has been the demise of *S. strictum* subsp. *africanum*. Acocks (1988 also in Zacharias, 1990) is of the opinion that this grass (and grassland in general) was much more prominent on the Roggeveld plateau at the time of European colonisation (Schoeman, 1986; Van Wyk and Smith, 2001). Acocks (1988 also in Zacharias, 1990) believed that overgrazing exacerbated by soil erosion and drought has resulted in the current Karoo shrublands typical of these mountains, including Renosterveld (Van Wyk and Smith, 2001). Allegedly *S. strictum* subsp. *africanum* was abundant on the Roggeveld at the time of European colonisation, and from which the region got its name (Schoeman, 1986; Van Wyk and Smith, 2001). Although grazing has been implicated in its current virtual extinction (the grass is very soft and nutritious), it is also susceptible to a rust pathogen that possibly contributed to its demise (Van Wyk and Smith, 2001). Widespread use for thatch may have also contributed to its current rarity. Currently, the species is only known to occur on the Farm Kanariesfontein (Sutherland District), where it is being propagated by Mr Koos Esterhuyse (Esterhuyse, pers. comm.; A. van Wyk, pers. comm.). It has since also been reintroduced into the Komsberg Private Game Reserve from this farm (Esterhuyse, pers. comm.).

Suggestions have been made that *S. strictum* subsp. *africanum*, a perennial grass, is naturally confined to such moist areas along the larger rivers and in seeps, and may not ever have covered the upland, drier parts of the Roggeveld (Esterhuyse, pers. comm.; A. van Wyk, pers. comm.), particularly when considering early descriptions such as from William Burchell's visit in 1815 (in Schoeman, 1986, pp. 30–31): "*the country from the Roggeveld mountains to the northern boundary of the colony may be characterised as a high plain, free from large mountains, but thickly strewed over with moderate hills and elevations; having very few rivers, and all of them nearly dried up in summer; quite destitute of trees and grass, but everywhere covered with bushes springing out of a very naked red soil deprived of moisture during a great part of the year*". However Burchell (1822, pp. 255–256) notes, referring to the summit of the Roggeveld Escarpment, "*It is probable that many plants which grow on the snowey tops of great mountains, will endure the cold of the English climate*" and "*I saw non of the wild rye which has been said to be so abundant as to give the name to this district, but this might be owing to the season of the year*". It doesn't sound like *S. strictum* subsp. *africanum* was very widespread in 1815, at least not at that time of the year, although farmers at beginning of the 1800s reported a decline in rainfall over the previous six years. It is possible though that a purported reduction in rainfall over the past 200–300 years (A. van Wyk, pers. comm.) may have assisted in constricting its range to perennially wet areas. It is possible that the species' range expanded and contracted with wetter and drier cycles. The combination of grazing, susceptibility to rust, dam building, and cultivation of its moist refugial areas along the major rivers has interrupted that cycle (e.g. Van Wyk and Smith, 2001). Perhaps *S. strictum* subsp. *africanum* was only perennial in places such as the higher areas of the Roggeveld Escarpment, where it is the wettest and best for farming (Schoeman, 1986), and to mesic areas along larger rivers, which have also been mostly converted into agricultural lands.

The region has low alien infestation (Mucina and Rutherford, 2006), although the presence of innocuous (?) annual aliens such as *Erodium cicutarium* and *Amsinckia retrorsa* are abundant in disturbed areas around homesteads and along roads, while others such as *Alyssum minutum, Bromus diandrus* and *B. tectorum* are abundant in the natural veld (pers. obs.). (According to Mucina and Rutherford, 2006, in the Nieuwoudtville area *Avena fatua* L., *Bromus pectinatus*, *Hordeum murinum*, *Lolium rigidum* Gaudin and *Medicago polymorpha* are becoming locally dominant and are suppressing the unique bulb flora.) Potential future threats to the vegetation of the area are possible uranium mining (Verwoed et al., 1995), wind farms, soil erosion, further cultivation and dam building, and overgrazing (Mucina and Rutherford, 2006; Van Wyk and Smith, 2001). Mineral concerns require only basic environmental authorisation processes to be adhered to prior to any exploration or prospecting, and significant potential remains for detrimental impacts associated with mining. Van Wyk and Smith (2001) suggest priority areas for conservation being the Komsberg and Roggeveldberge and the plateau area around Sutherland. Given the high interest in the flora by the local farming community, it may be practical to implement a landowner-based conservation initiative, especially regarding local rarities such as *Cliffortia arborea*, *Daubenya aurea* and *Polhillia involucrata.*

The main threat to the biological diversity of the Roggeveld – and perhaps the most difficult to manage – is that of global warming. There is virtually no higher ground to which most of the local endemics can migrate, and a warming of the area may result in mass extinctions and a change in vegetation to a more arid Nama–Karoo or Succulent Karoo-type flora.

6. Pioneer botanical work

Botanical collectors in the Roggeveld and Komsberg have been numerous, dating from C.P. Thunberg and F. Masson in 1774 (Manning and Goldblatt, 2002; Masson, 1776) to the present. It is not possible to list all of the collectors but they include well-known historical and contemporary names such as A. Batten, W. Burchell, W.F. Barker, M.P. de Vos, P. Goldblatt, N. Helme, K. Hiemstra, J. Lavranos, F.M. Leighton, J.C. Manning, E.M. Marais, R. Marloth, E. Meyer, E.G.H. Oliver, J. Rourke, E.A. Schelpe, F.R.R. Schlechter, D. Snijman, K.E. Steiner, G.C. Summerfield, M.L. Thomas, A.M. van der Merwe, H. van Zijl, A.M. Venter, etc. (Barker, 1979, 1984; Burtt, 2000; De Vos, 1987; Goldblatt, 1979a,b; Leighton, 1945; Manning and Goldblatt, 2006; Marais, 1998; Steiner, 1992, 1995; Van der Merwe and Marais, 2002; Venter, 2007). Recent floristic work has been undertaken by Van der Merwe et al. (2009a,b), and the area has been receiving more collecting focus in recent years.

7. Compilation of a flora of the Roggeveld and Komsberg

Three extensive fieldtrips were undertaken between 2007 and 2009 (Table 1), covering a wide variety of habitat on the Roggeveld and Komsberg. The highest peaks and plateaux – such as the Swaarweerberg and Sneeukrans – were targeted in particular as they may be refugia or nodes of higher endemism, but an attempt was made to sample all habitat types in the area, i.e. the Escarpment foot, the Escarpment front itself, the summit plateau, the inland plateau, various substrates (dolerite, sandstone, shales etc.). Micro-habitats such as cliff-bases, wetlands, riparian systems and dolerite outcrops harbouring unique communities were sampled intensively.

A total of 1098 specimens were collected. The identification of specimens was undertaken in the Selmar Schönland Herbarium (GRA), Albany Museum, Grahamstown. Numerous taxonomists assisted with more difficult groups and with groups that were being revised at the time (see Acknowledgements). Specimens have been lodged in GRA, with duplicates of various groups sent to BLFU, BOL, J, JRAU, K, MO, NBG, NU, PRE, S, and STEU. Nomenclature of the resultant flora (Appendix B) was updated from available revisions, otherwise essentially follows the nomenclature of Germishuizen and Meyer (2003). The species obtained from the fieldwork have

Table 1
Collecting localities in the Roggeveld and Komsberg during the study period (2007–2009).

Localities	Dates	Collectors	Grids
1. Komsberg	September 2007	Clark VR, Kelly C.	3220DA
2. Roggeveld	September 2008	Clark VR, O'Connor R.	3220AB, AD, BC, BD
3. Roggeveld	October 2008	Clark VR, Coombs G; Clark VR.	3220AD, BA

been augmented by species noted from literature sources (mostly being taxonomic revisions and treatments housed in GRA or obtained via Inter-library Loan and the Internet), and historical specimens housed in GRA.

A total of 513 taxa have been recorded (Appendix B). While this list is by no means exhaustive, it provides a contribution towards a comprehensive flora that will be useful for biogeographical analysis (Born et al., 2007) and conservation assessments.

8. Important collections

Several finds of interest have been made since 2007, including several new species, contributions to several previously collected but as yet undescribed new species, and collections of several poorly-collected and poorly known endemics.

8.1. New species

A new species of *Asparagus*, confined to south-facing cliff-bases on the Roggeveld and western Nuweveld, was discovered and is being investigated further (Burrows, pers. comm.). A new species of *Euryops* was discovered on Sneeukrans (Nordenstam, pers. comm.). The first flowering material of the locally abundant *Agathosma* sp. nov. (Trinder-Smith, pers. comm.) was also obtained.

8.2. Collections of poorly known endemics

Polhillia involucrata, previously only known from the Middelpos area (Stirton, 1986), was collected on the southern Roggeveld, closer to Sutherland on the Farm Kanariesfontein. This rare species requires considerable conservation attention (B.-E. van Wyk, pers. comm.), and the landowner has been advised in this regard. Additional material of the very poorly known endemic *Arctotis sulcocarpa* (McKenzie et al., in press) was collected. The poorly-collected species *Delosperma sphalmantoides* was collected on the Swaarweerberg, while *Oxalis marlothii*, only known from the type (Salter, 1944) was recollected twice from near the Sneeukrans type locality (Oberlander, pers. comm.). *Oxalis* sp. aff. s*trigosa* – a local anomaly very similar to the rare Western Cape species *O. strigosa* (Oberlander, pers. comm.; Salter, 1944) – was collected below Sneeukrans. It is probably the same species as that collected at Hoenderhoek on the Roggeveld by Marloth (Salter, 1944). The plant has yet to be collected in flower however (Oberlander, pers. comm.; Salter, 1944). Further material of an endemic *Spiloxene* sp. nov. (Snijman, pers. comm.) was collected. *Delosperma acocksii* – apparently not collected since Acocks's collection (published by Bolus in 1958; Hartmann, 2001a) – was recollected on the Roggeveld Escarpment below Kanariesfontein. *Drosanthemum floribundum*, indicated by Hartmann (2001a) as having an unknown distribution, is abundant on the Roggeveld Escarpment at Ouberg Pass. *Stomatium villettii*, described from Beaufort West (probably on the Nuweveldberge; Hartmann, 2001b) has now also been collected on the Roggeveld.

8.3. Range extensions and other collections of interest

The range of *Gladiolus karooicus* was extended from the western extremity of the Great Karoo (Matjiesfontein, Prince Albert) onto the Komsberg section of the Roggeveld Escarpment (Manning, pers. comm.). Several specimens of what appears to be a range extension of the Sneeuberg endemic *Helichrysum tysonii* (Clark et al., 2009; Hilliard, 1983) across the Nuweveldberge (Clark, 2010) onto the Roggeveld were collected, but the species-complex of which *H. tysonii* is a part should probably be revised. Several specimens of *Asparagus* sp. nov. "ferox", a newly discerned species occurring from the Roggeveld across the Nuweveld to the Sneeuberg (Burrows, pers. comm.), were collected. Material of the recently described (but not endemic) *Ixia sobolifera* subsp. *sobolifera* was collected (Manning, pers. comm.), as was material of a more widely distributed *Lachenalia* sp. nov. from Komsberg Pass (Duncan, pers. comm.). *Euphorbia eustacei* was collected on the Komsberg and Roggeveldberge, a species otherwise only known from the Matjiesfontein area (White et al., 1941). *Aethephyllum pinnatifidum*, a CFR species occurring from Worcester to Van Rhynsdorp (Hartmann, 2001a) has now also be collected on the Roggeveld (Burgoyne, pers. comm.). *Cleretum lyratifolium*, *Ruschia altigena* and *R. nana* are all range extensions from the Laingsburg area (Hartmann, 2001a,b) onto the Roggeveld, while *R. putterillii* is a DAC near-endemic (Carbutt and Edwards, 2006) now also known from the Komsberg (Burgoyne, pers. comm. — but not from the Nuweveldberge interestingly enough; Clark, 2010). *Trichodiadema setuliferum*, with distribution listed as "Somerset East?" by Hartmann (2001b), is now known from the eastern Nuweveldberge (Clark, 2010) and from the Roggeveld (Burgoyne, pers. comm.). *Anthospermum monticola*, a DAC near-endemic (Carbutt and Edwards, 2006) previously considered to occur only as far west as the Sneeuberg (Clark et al., 2009), has been recorded across the Nuweveldberge (Clark, 2010) and also now on Sneeukrans in the Roggeveldberge. The sedge *Isolepis angelica*, previously considered to be a DAC endemic (Carbutt and Edwards, 2006), is now also known from the Roggeveld. *Ischyrolepis laniger*, a species from the inland CFR mountains from Van Rhynsdorp to Oudtshoorn (Linder, 1985), is now recorded on the Roggeveld at Sneeukrans (Linder, pers. comm.).

9. Conclusion

The Hantam–Roggeveldberge (including the Komsberg) forms the key montane component of the HRC. Despite an increase in plant collecting in recent years the area still remains poorly overall botanised. It is possible that, with increased collecting and the collation of existing data, a flora of between 1500 and 2000 species will become available. This will substantially increase the accuracy of phytogeographical analysis of this section of the Great Escarpment and of the HRC. A contribution of 513 taxa is made to the flora of the Roggeveldberge, including two new species and contributions to other previously collected new species, poorly known endemics and near-endemics, and several range extensions from elsewhere on the Great Escarpment and from areas adjacent to the Hantam–Roggeveld. Strong linkages to the North-West and Karoo Mountain Centres of the CFR are evident, as well as well as east and north along the Great Escarpment.

It is hypothesised that the higher sections of mountain on the Hantam–Roggeveldberge are nodes of speciation or refugia and host a higher level of endemism and diversity than the remainder of the Great Escarpment in this region. This is evident by the numerous endemics only known from Sneeukrans and the Hantamberge. This is probably also true for other high points such as the Swaarweerberg. These high points should be important foci for future public–private conservation initiatives in the HRC.

The HRC is a difficult centre of endemism to delimit. In the west the best delimitation is geological substrate, being confined to Karoo sediments and dolerites as well as Dwyka Tillites. In the east, the boundary can be arbitrarily defined as between SAAO and the Dwyka River Gorge (the latter being the topographical boundary between the Komsberg and the Nuweveldberge), as here the dominant rainfall regime switches from winter to summer. It must be stated however that the vegetation types characteristic of the Roggeveld are also considered by most authors to reach as far east as Fraserburg, and that this broad rainfall transition zone makes for a nebulous and unsatisfying boundary. Inland, the 50/50% summer–winter transition area as far north as Williston is the only suitable (but again nebulous) cut-off point, as there are no obvious or distinct land-surface features that offer a convenient boundary. Detailed collecting in this transition area may provide more data for a better floristic delimitation. In the south, altitude appears to be the main factor, and the HRC can be safely taken to include the Roggeveld and Komsberg scarps down to about 900 m above sea level, and also the adjacent associated ridges of the Klein–Roggeveldberge and Koedoesberge. Based on the above delimitation, a total of 176 HRC endemic and 54 near-endemic species are thus identified, with a further 20 purported or possible endemics shown to be neither endemic nor near-endemic. Nine species have uncertain endemicity, the literature being either vague or contradictory, particularly for species in the Nieuwoudtville area.

Acknowledgements

We are very grateful for the permissions to access private land and for the warm hospitality of the local farming community: Hannes Visagie (Uitkyk), the Sieberhagens (Vredehoek and Windhoek), Chrisjan Jordaan (Matjiesfontein), the Esterhuyses (Kanariesfontein and Kranzkraal), Henry Engelbrecht (Swaarweerberg), Witjan and Elsie van der Merwe (Houdenbek), the Millers (Tonteldoosfontein and Schietfontein), Kassie and Alta Steenkamp (Koringlandskloof), Koos van der Merwe (Fransplaas) and the Symingtons (Quaggasfontein). Sven Kaehler (Rhodes University Department of Zoology) kindly allowed us to use his 4 × 4 research vehicle on several of the fieldtrips, and without it we would not have gone very far — especially around Sutherland in a wet September. Fieldtrips were more productive and made much more fun by the able assistance and companionship of Gareth Coombs, Chris Kelly, Dan Parker and Ryan O'Connor. The reliable identification and confirmation of numerous specimens was very kindly undertaken by Ihsan Al-Shehbaz (Brassicaceae), Kevin Balkwill (Polygalaceae), Angela Beaumont (*Gnidia* and *Struthiola*), Pieter Bester (Apocynaceae), Priscilla Burgoyne (Mesembryanthemaceae), Lyn Fish (Poaceae), Peter Goldblatt (petaloid monocots), Glynis Goodman-Cron (*Cineraria*), Dave Gwynne-Evans (*Hermannia*), Peter Linder (Resionaceae), John Manning (petaloid monocots), Robert McKenzie (*Arctotis* and *Berkheya*), Bertil Nordenstam (*Euryops* and *Othonna*), Ted Oliver (Orchidaceae), Brian Schrire (*Indigofera*), Graham Duncan (petaloid monocots), Dee Snijman (petaloid monocots), Andor Venter (*Lycium*), Elizabeth Retief (Boraginaceae and Rubiaceae), Ben-Erik van Wyk (Fabaceae), Chris Whitehouse (*Cliffortia*), John and Sandie Burrows (*Asparagus* and Pteridophytes), Pieter Winter (Apiaceae), Stephen Boatwright (Fabaceae), Gerhard Jakubowsky (*Cotula*), Muasya Muthuma (Cyperaceae), Terry Trinder-Smith (*Agathosma*), Kenneth Oberlander (*Oxalis*), Miguel García (*Thesium*), Kim Steiner (*Nemesia* and *Diascia*) and Tim Lowrey (*Pteronia*). Tony Dold, Curator of the Selmar Schönland Herbarium (GRA) in the Albany Museum, kindly provided working and specimen storage space for the duration of the project. Ashley-Kate Davidson, Tellula Habib, Thomas King, Daudi Nabaasa, Mike Rathje, Nomiki Benya, Ntombekhaya Api, Liziwe Nkwinti, Fikile Phaliso and Carl Cloete have provided invaluable administrative assistance in the Selmar Schönland Herbarium by mounting specimens, filing specimens and updating determinations. This paper is a product from a PhD, the financial viability of which was made possible by the National Research Foundation (NRF) in the form of Grant GUN 2069059, a freestanding South African Biosystematics Initiative (SABI) grant, Buk'Indalo Consultancy cc (Durban), the National Geographic Society and the Cape Tercentenary Foundation. Permits for the sections of Great Escarpment in the Western and Northern Cape Provinces were kindly issued by Cape Nature and Northern Cape Conservation respectively. Nick Helme very kindly commented on an earlier draft of this paper, Helga van der Merwe generously forwarded us the final manuscripts of her work in the region, and Braam van Wyk kindly gave comments on *Secale strictum* subsp. *africanum*. Lastly, the first author would like to thank the Lord for protection and for the enjoyable fieldtrips.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the onlineversion, at doi:10.1016/j.sajb.2010.07.001.

References associated with Supplementary Material

Adamson, R.S., 1956. The South African species of Aizoaceae, III, *Galenia* L. Journal of South African Botany 22, 87–127.

African Flowering Plants Database, 2009. South Africa National Biodiversity Institute, Conservatoire et Jardin botaniques de la Ville de Genève & Tela Botanica. http://www.ville-ge.ch/musinfo/bd/cjb/africa/index.php?langue=an.

Barker, W.F., 1978. Ten new species of *Lachenalia* (Liliaceae). Journal of South African Botany 44, 391–418.

Barker, W.F., Gerstner, F.J., Adamson, R.S., Compton, R.H., 1949. *Plantae novae africanae*. Journal of South African Botany 9, 145–160.

Bayer, M.B., 1982. The New *Haworthia* Handbook. The National Botanical Gardens of South Africa, Kirstenbosch.

Beyers, J.B.P., 2002. Notes on African Plants—Asteraceae. A new species of *Arctotheca* from Northern Cape, South Africa. Bothalia 32, 185–199.

Bolus, H.M.L., 1929. Notes on Mesembrianthemum and allied genera, Part 2, 154.

Bolus, L., 1930. Notes on Mesembrianthemum and allied genera, Part 2, 186.

Bolus, H.M.L., 1969. Notes on Mesembrianthemum and allied genera. Journal of South African Botany 35, 143–144.

Bremer, K., 1976. The genus *Rosenia* (Compositae). Botaniska Notiser 129, 97–111.

Bruyns, P.V., 2005. Stapeliads of Southern Africa and Madagascar. Vols I & II. Umdaus, Hatfield.

Codd, L.E., 1985. Flora of Southern Africa, Vol. 28, Part 4, Lamiaceae. Botanical Research Institute, Department of Agriculture and Water Supply.

Dahlgren, R., 1988. Flora of Southern Africa, Vol. 16, Fabaceae, Part 3, Papilionoideae, Fascicle 6, Crotalarieae (*Aspalathus*). Botanical Research Institute, Department of Agriculture and Water Supply.

De Bustos, A., Jouve, N., 2002. Phylogenetic relationships of the genus *Secale* based on characterisation of rDNA ITS sequences. Plant Systematics and Evolution 235, 147–154.

De Vos, M.P., 1972. The genus *Romulea* in South Africa. Journal of South African Botany Supplementary 9, 1–307.

Duncan, G.D., 1998. Five new species of *Lachenalia* (Hyacinthaceae) from arid areas of Namibia and South Africa. Bothalia 28, 131–139.

Goldblatt, P., 1987a. Systematics of the southern Africa genus *Hexaglottis* (Iridaceae–Iridoideae). Annals of the Missouri Botanical Garden 74, 542–569.

Goldblatt, P., 1987b. New species and notes on southern African *Hesperantha* (Iridaceae). South African Journal of Botany 53, 459–463.

Goldblatt, P., Anderson, F., 1986. The Moraeas of Southern Africa. Annals of the Kirstenbosch Botanic Gardens 14, 1–224.

Goldblatt, P., Manning, J.C., 1990. *Devia xeromorpha*, a new genus and species of Iridaceae–Ixioideae from the Cape Province, South Africa. Annals of the Missouri Botanical Garden 77, 359–364.

Goldblatt, P., Manning, J.C., 2000. Cape plants: a conspectus of the Cape flora of South Africa. Strelitzia 9. National Botanical Institute, Cape Town and Missouri Botanical Garden, St Louis.

Goldblatt, P., Manning, J.C., 2008. Systematics of the southern African genus *Ixia* (Iridaceae). 1. The *I. rapunculoides* complex. Bothalia 38, 1–22.

Goldblatt, P., Manning, J.C., 2009. New species of *Moraea* (Iridaceae: Iridoideae), with range extensions and miscellaneous notes for southern Africa species. Bothalia 39, 1–10.

Goldblatt, P., Raven, P.H., 1997. FSA Contributions 9: Onagraceae. Bothalia 27, 149–165.

Goldblatt, P., Bernhardt, P., Manning, J.C., 2002. Floral biology of *Romulea* (Iridaceae: Crocoideae): a progression from a generalist to a specialist pollination system. Adansonia 24, 243–262.

Goldblatt, P., Manning, J.C., Gereau, R., 2008. Two new species of *Babiana* (Iridaceae: Crocoideae) from western South African, new names for *B. longiflora* and *B. thunbergii*, and comments on the original publication of the genus. Bothalia 38, 49–55.

Goldblatt, P., Manning, J.C., Nänni, I., 2009. New species of *Geissorhiza* (Iridaceae: Crocoideae) from the southern African winter rainfall zone, range extensions, taxonomic changes, and notes on pollen morphology and floral ecology. Bothalia 39, 123–152.

Hammer, S., 1993. A new dwarf *Delosperma* from South Africa. Cactus and Succulent Journal 65, 123–125.

Hilliard, O.M., Burtt, B.L., 1984. A revision of *Diascia* section *Racemosae*. Journal of South African Botany 50, 269–340.

Lewis, G.J., 1962. South African Iridaceae. The genus *Ixia*. Journal of South African Botany 28, 45–196.

Linder, H.P., Kurzweil, H., 1999. Orchids of Southern Africa. Balkema, Rotterdam.

Manning, J.C., Goldblatt, P., 2001. A new species of *Emilia* (Senecioneae) from South Africa. Bothalia 31, 46–48.

Manning, J.C., Goldblatt, P., 2009. Three new species of *Gladiolus* (Iridaceae) from South Africa, a major range extension for *G. rubellus* and taxonomic notes for the genus in southern and tropical Africa. Bothalia 39, 37–45.

Manning, J.C., Forest, F., Vinnersten, A., 2007a. The genus *Colchicum* L. redefined to include *Androcymbium* Willd. based on molecular evidence. Taxon 56, 872–882.

Manning, J.C., Martínez-Azorín, M., Crespo, M.B., 2007b. A revision of *Ornithogalum* subgenus *Aspasia* section *Aspasia*, the chincherinchees. Bothalia 37, 133–164.

Marais, W., 1970. Cruciferae. In: Codd, L.E., De Winter, B., Killick, D.J.B. (Eds.), Flora of Southern Africa, 13. Department of Agricultural Technical Services, Republic of South Africa, pp. 1–118.

Marais, E.M., 1990. *Pelargonium torulosum* (Geraniaceae): a new species from the south-western Cape Province, southern Africa. South African Journal of Botany 56, 565–570.

Moffett, R.O., 1979. The genus *Sarcocaulon*. Bothalia 12, 581–613.

Müller, M.A.N., Herman, P.P.J., Kolberg, H.H., 2001. Flora of Southern Africa, Vol. 33, Part 4: Anthemideae, Fascicle 1: *Eriocephalus* and *Lasiospermum*. National Botanical Institute, Pretoria.

Müller-Doblies, D., 1998. De Liliifloris Notulae 6. De decuria prima specierum novarum generis *Androcymbium* sect. *Androcymbium* (Colchicaceae) in Africa Australi s.l. Praeterea novitates de huius sectionis nonnullarum specierum distributione (praesertim aucta speciminibus Stellenbosensibus i.a. collectis a botanico vero E.G.H. Olivero). Feddes Repertorium 109, 551–572.

Müller-Doblies, U., Müller-Doblies, D., 1996. Revisionula incompleta Ornithogalorum Austro-Africanorum (Hyacinthaceae). Feddes Repertorium 107, 361–548.

Müller-Doblies, U., Müller-Doblies, D., 2002. De Liliifloris Notulae. 7. De decuria altera specierum novarum generis *Androcymbium* (Colchicaceae) in Africa Australis s.l. Feddes Repertorium 113, 545–599.

Obermeyer, A.A., 1978. *Ornithogalum*: a revision of the southern African species. Bothalia 12, 323–376.

Perry, P.L., 1989. Ten more species of *Eriospermum* (Eriospermaceae/ Liliaceae) from the western Cape. Bothalia 55, 83–102.

Perry, P.L., 1994. A revision of the genus *Eriospermum* (Eriospermaceae). Contributions from the Bolus Herbarium 17, 1–320.

Schrire, B., Personal Communication. Legume Systematist, Kew Botanic Gardens, England.

Snijman, D., 1984. A revision of the genus *Haemanthus* L. (Amaryllidaceae). Journal of South African Botany Supplementary 12, 1–139.

Snijman, D., 1992. Notes on the Strumariinae (Amaryllidaceae–Amaryllideae). Six new taxa in *Strumaria* and *Hessea* from the central and northwestern Cape, South Africa, and southern Namibia. Bothalia 22, 1–11.

Steiner, K.E., 2009. Two new species of *Nemesia* (Scrophulariaceae) from arid areas of the Northern Cape, South Africa. Bothalia 39, 67–72.

Steiner, K.E., Personal Communication. Associate Curator, California Academy of Sciences.

Tölken, H.R., 1977. A revision of the genus *Crassula* in southern Africa. Parts 1 & 2. Contributions from the Bolus Herbarium, 8. University of Cape Town, Rondebosch.

Van der Walt, J.J.A., Vorster, P.J., Ward-Hilhorst, E., 1981. Pelargoniums of Southern Africa. Vol. 2. Juta, Cape Town.

Van Wyk, B.-E., 1990. Studies in the genus *Lotononis* (Crotalarieae, Fabaceae). 13. Two new species and notes on the occurrence of cleistogamy in the section *Leptis*. Bothalia 20, 17–22.

Van Wyk, B.-E., 1991. A synopsis of the genus *Lotononis* (Fabaceae: Crotalarieae). Contributions from the Bolus Herbarium, 14–19. University of Cape Town, Rondebosch.

Verdoorn, I.C., 1963. Loganiaceae. In: Dyer, R.A., Codd, L.E., Rycroft, H.B. (Eds.), Flora of Southern Africa, 26. Department of Agricultural Technical Services, Republic of South Africa, pp. 134–171.

References

Acocks, J.P.H., 1988. Veld types of South Africa. Memoirs of the Botanical Survey of South Africa, 57. Botanical Research Institute, Pretoria.

Agnew, S., 1958. The landforms of the Hogsback area in the Amatola Range. Fort Hare Papers 2, 1–14.

Barker, W.F., 1979. Ten more species of *Lachenalia* (Liliaceae). Journal of South African Botany 45, 193–219.

Barker, W.F., 1984. Three more new species of *Lachenalia* and one new variety of an early species (Liliaceae). Journal of South African Botany 50, 535–547.

Bergh, N.G., Linder, H.P., 2009. Cape diversification and repeated out-of-southern-Africa dispersal in paper daisies (Asteraceae–Gnaphalieae). Molecular Phylogenetics and Evolution 51, 5–18.

Bergh, N.G., Hedderson, T.A., Linder, H.P., Bond, W.J., 2007. Palaeoclimate-induced range shifts may explain current patterns of spatial and genetic variation in renosterbos (*Elytropappus rhinocerotis*, Asteraceae). Taxon 56, 393–408.

Born, J., Linder, H.P., Desmet, P., 2007. The Greater Cape floristic region. Journal of Biogeography 34, 147–162.

Branch, B., 1998. Field Guide to Snakes and Other Reptiles of Southern Africa, 3rd ed. Struik, Cape Town.

Brink, A.B.A., 1983. Engineering Geology of Southern Africa, Vol. 3: The Karoo Sequence. Building Publications, Pretoria.

Burchell, W.J., 1822. Travels in the Interior of Southern Africa. Vol. 1. Longman, Hurst, Reece, Orme and Brown, London.

Burgoyne, P., Personal Communication. Principal Scientist, National Herbarium, South African National Biodiversity Institute, Pretoria.

Burrows, S., Personal Communication. Buffelskloof Nature Reserve Herbarium. *Asparagus*.

Burtt, B.L., 2000. *Saniella* and its relation to other South African genera of Hypoxidaceae. Edinburgh Journal of Botany 57, 63–70.

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.

Centre for Scientific and Industrial Research (CSIR), 2009. Satellite imagery of South Africa. Complimentary CD.

Clark, V.R., 2010. The Phytogeography of the Sneeuberg, Nuweveldberge and Roggeveldberge (Great Escarpment): Assessing Migration Routes and Endemism. Unpublished PhD Thesis, Department of Botany, Rhodes University, Grahamstown.

Clark, V.R., Barker, N.P., Mucina, L., 2009. The Sneeuberg: a new centre of floristic endemism on the Great Escarpment, South Africa. South African Journal of Botany 75, 196–238.

De Vos, M.P., 1987. A new species of *Romulea* (Iridaceae) from the Great Roggeveld Plateau, Cape Province. South African Journal of Botany 53, 247–248.

Diels, L., 1909. Formationen un Florenelemente im nordwestlichen Kapland. Botanische Jahrbucher fur Systematik, Pflanzengeschichte und Pflanzengeographie 44, 91–124.

Duncan, G.D., 1997. Five new species of *Lachenalia* (Hyacinthaceae) from arid areas of South Africa. Bothalia 27, 7–15.

Duncan, G.D., Personal Communication. Compton Herbarium, South African National Biodiversity Institute.

Duncan, G.D., Edwards, T.J., 2006. Three new species of *Lachenalia* (Hyacinthaceae: Massonieae) from Western and Northern Cape, South Africa. Bothalia 36, 147–155.

Esterhuyse, K., Personal Communication. Farm Kanariesfontein, Sutherland District.

Geo Community, 2009. http://www.geocomm.com/.

Germishuizen, G., Meyer, N.P. (Eds.), 2003. Plants of Southern Africa: an Annotated Checklist. Strelitzia, 14. National Botanical Institute, Pretoria.

Gibbs Russell, G.E., Watson, L., Koekemoer, M., Smook, L., Barker, N.P., Anderson, H.M., Dallwitz, M.J., 1990. Grasses of Southern Africa. Memoirs of the Botanical Survey of South Africa No. 58. National Botanic Garden/ Botanical Research Institute.

Goldblatt, P., 1979a. *Roggeveldia*, a new genus of the southern African Iridaceae–Irideae. Annals of the Missouri Botanical Garden 66, 839–844.

Goldblatt, P., 1979b. New species of Cape Iridaceae. Journal of South African Botany 45, 81–89.

Goldblatt, P., 1984. A revision of *Hesperantha* (Iridaceae) in the winter rainfall area of southern Africa. Journal of South African Botany 50, 15–141.

Goldblatt, P., Manning, J.C., 1998. *Gladiolus* in Southern Africa. Fernwood, Vlaeberg.

Goldblatt, P., Manning, J.C., 2004. Taxonomic notes and new species of the southern African genus *Babiana* (Iridaceae: Crocoideae). Bothalia 34, 87–96.

Goldblatt, P., Manning, J.C., 2007. New species and notes on *Hesperantha* (Iridaceae) in southern Africa. Bothalia 37, 167–182.

Hall, A.V., Veldhuis, H.A., 1985. South African red data book: plants — Fynbos and Karoo biomes. South African National Scientific Programmes Report, 117. CSIR, Pretoria.

Hartmann, H.E.K. (Ed.), 2001a. Illustrated Handbook of Succulent Plants. Aizoaceae A–E. Springer, Berlin.

Hartmann, H.E.K. (Ed.), 2001b. Illustrated Handbook of Succulent Plants. Aizoaceae F–Z. Springer, Berlin.

Hill, R.S., 1993. The Geology of the Graaff–Reinet Area. Geological Survey, Department of Mineral and Energy Affairs, Republic of South Africa, Pretoria.

Hilliard, O.M., 1983. Flora of Southern Africa, Vol. 33, Asteraceae, Part 7, Inuleae, Fascicle 2, Gnaphaliinae (First Part). Department of Agriculture, Botanical Research Institute.

Hilliard, O.M., 1990. A brief survey of Scrophulariaceae–Selagineae. Edinburgh Journal of Botany 47, 315–343.

Hilliard, O.M., 1994. The Manuleae: a Tribe of Scrophulariaceae. Edinburgh University Press, Edinburgh.

Hilliard, O.M., 1999. The Tribe Selagineae (Scrophulariaceae). Royal Botanic Garden, Edinburgh.

Hilton-Taylor, C., 1987. Phytogeography and origins of the Karoo flora. In: Cowling, R.M., Roux, P.W. (Eds.), The Karoo Biome: a Preliminary Synthesis, Part 2 — Vegetation and History. South African National Scientific Programmes Report, 142. CSIR, Pretoria.

Hilton-Taylor, C., 1996. Patterns and characteristics of the flora of the Succulent Karoo Biome, southern Africa. In: Van der Maesen, L.J.G., Van der Burgt, X.M., Van Medenbach de Rooy, J.M. (Eds.), The Biodiversity of African plants. Kluwer, Netherlands, pp. 58–72.

Khush, G.S., Stebbins, G.L., 1961. Cytogenetic and evolutionary studies in *Secale*. 1. Some new data on the ancestry of *S. cereale*. American Journal of Botany 48, 723–730.

Koekemoer, M., 1996. An overview of the Asteraceae of Southern Africa. Proceedings of the International Compositae Conference 1, 95–110.

Kuhlmann, M., 2005. Diversity, distribution patterns and endemism of southern African bees (Hymenoptera: Apoidea). In: Huber, B.A., Sinclair, B.J., Lampe, K.-H. (Eds.), African Biodiversity. Molecules, Organisms, Ecosystems. Springer, Netherlands, pp. 167–172.

Leighton, F.M., 1945. A revision of the South African species of *Ornithogalum* L. Journal of South African Botany 11, 137–189.

Linder, H.P., 1985. Conspectus of the African species of Restionaceae. Bothalia 15, 387–503.

Linder, H.P., Personal Communication. Director, Institute for Systematic Botany, University of Zurich.

Low, A.B., Rebelo, A.G. (Eds.), 1998. Vegetation of South Africa, Lesotho and Swaziland. Department of Environmental Affairs and Tourism, Pretoria.

Manning, J.C., Personal Communication. Research Leader: Systematics, Compton Herbarium, South African National Biodiversity Institute.

Manning, J.C., Goldblatt, P., 2002. Nieuwoudtville, Bokkeveld Plateau & Hantam. South African Wild Flower Guide 9, 2nd ed. Botanical Society of South Africa and the National Botanical Institute.

Manning, J.C., Goldblatt, P., 2006. New species of Iridaceae from the Hantam–Roggeveld Centre of Endemism, and the Bokkeveld, Northern Cape, South Africa. Bothalia 36, 139–145.

Manning, J.C., Goldblatt, P., 2007. New species of *Drimia* (Hyacinthaceae: Urgineoideae) allied to *Drimia marginata* from Western and Northern Cape, South Africa. Bothalia 37, 183–187.

Manning, J.C., Goldblatt, G., 2008. Oxalidaceae: a new species of *Oxalis* from the Hantam–Roggeveld Plateau, Northern Cape, South Africa. Bothalia 38, 75–78.

Manning, J.C., Goldblatt, P., Snijman, D., 2002. The Color Encyclopaedia of Cape Bulbs. Timber, Portland.

Manning, J.C., Goldblatt, P., Sieben, E.J.J., Roux, J.P., 2008. *Aponogeton fugax*. A new endemic species from the Cape Floral Region, South Africa. Bothalia 38, 156–159.

Manning, J.C., Goldblatt, P., Forest, F., 2009. A revision of Fumariaceae (Fumarioideae) in southern Africa, including naturalized taxa. Bothalia 39, 47–65.

Marais, E.M., 1998. *Pelargonium githagineum* (Geraniaceae), a new species from the Roggeveld plateau and the Matjiesfontein area. South African Journal of Botany 64, 308–311.

Marsh, J.S., Mndaweni, M.J., 1998. Geochemical variations in a long Karoo dyke, Eastern Cape. South African Journal of Geology 101, 119–122.

Masson, F., 1776. Mr. Masson's Botanical Travels: Philosophical Transactions of Royal Society of London, pp. 268–317.

Matmon, A.M., Bierman, P., Enzel, Y., 2002. Pattern and tempo of Great Escarpment erosion. Geology 30, 1135–1138.

McCarthy, T., Rubidge, B., 2005. The Story of Earth & Life. Struik, Cape Town.

McKenzie, R.J., Herman, P.P.J., Korniyenko, O., Barker, N.P., in press. Revision of *Arctotis* sect. *Anomalae* (Asteraceae, Arctotideae), including the description of a new species from Northern Cape Province, South Africa. South African Journal of Botany 76. doi:10.1016/j.sajb.2010.05.002.

Michez, D., Kuhlmann, M., 2007. Phylogenetic analysis of the bee genus *Capicola* with the description of *Capicola hantamensis* sp. nov. (Hymenoptera: Dasypodaidae). Zootaxa 1444, 61–68.

Midgley, G.F., Reeves, G., Klak, C., 2005. Late Tertiary and Quaternary climate change and centres of endemism in the southern African flora. In: Purvis, A., Gittleman, J.L., Brooks, T. (Eds.), Phylogeny and Conservation. Cambridge University, Cambridge, pp. 230–242.

Mucina, L., Rutherford, M.C. (Eds.), 2006. The Vegetation of South Africa, Lesotho and Swaziland. : Strelitzia, 19. South African National Biodiversity Institute, Pretoria.

Mummenhoff, K., Al-Shebaz, I.A., Bakker, F.T., Linder, H.P., Mühlhausen, A., 2005. Phylogeny, morphological evolution, and speciation of endemic Brassicaceae genera in the Cape flora of southern Africa. Annals of the Missouri Botanical Garden 92, 400–424.

Nordenstam, B., 1969. Phytogeography of the genus *Euryops* (Compositae). A contribution to the phytogeography of southern Africa. Opera Botanica 23, 7–77.

Nordenstam, B., Personal Communication. Professor Emeritus, Department of Phanerogamic Botany, Swedish Museum of Natural History.

Oberlander, K.C., Personal Communication. Department of Botany and Zoology, Stellenbosch University (at that time).

Oliver, E.G.H., Fellingham, A.C., 1994. A new serotinous species of *Cliffortia* (Rosaceae) from the southwestern Cape with notes on *Cliffortia arborea*. Bothalia 24, 153–162.

Oliver, E.G.H., Linder, H.P., Rourke, J.P., 1983. Geographical distribution of Cape taxa and their phytogeographical significance. Bothalia 14, 427–440.

Partridge, T.C., Maud, R.R., 1987. Geomorphic evolution of southern Africa since the Mesozoic. South African Journal of Geology 90, 179–208.

Phillipson, P.B., 1992. A new species of *Indigofera* L. (Fabaceae) from the eastern Cape. South African Journal of Botany 58, 129–132.

Retief, E., Van Wyk, A.E., 1996. *Cynoglossum obtusicalyx* (Boraginaceae), a new species from South Africa. South Africa Journal of Botany 62, 169–172.

Salter, T.M., 1944. The genus *Oxalis* in South Africa: a taxonomic revision. The Journal of South African Botany Supplementary 1, 1–355.

Schoeman, K., 1986. Die Wêreld Van die Digter. 'n boek oor Sutherland en die Roggeveld ter ere Van N.P. Van Wyk Louw. Human & Rousseau, Cape Town.

Sieberhagen, S., Personal Communication. Farm Vredenhoek, Sutherland District.

Snijman, D., Personal Communication. Specialist Scientist, Compton Herbarium, South African National Biodiversity Institute.

Snijman, D., Perry, P.L., 1987. A floristic analysis of the Nieuwoudtville Wild Flower Reserve, north-western Cape. South African Journal of Botany 53, 445–454.

Steiner, K.E., 1992. Two new *Diascia* (Scrophulariaceae) from the Nieuwoudtville area, western Cape. South African Journal of Botany 58, 202–206.

Steiner, K.E., 1995. Three new *Diascia* species from arid areas of the western and northern Cape provinces, South Africa. South African Journal of Botany 61, 72–79.

Stirton, C.H., 1986. *Melolobium involucratum* (Fabaceae), a new combination for South Africa. South African Journal of Botany 52, 354–356.

Trinder-Smith, T.H., Personal Communication. Curator, Bolus Herbarium, Department of Botany, University of Cape Town, Rondebosch.

Van der Merwe, A.M., Marais, E.M., 2002. *Daubenya alba* (Hyacinthaceae, tribe Massonieae), a new species from the Roggeveld, Northern Cape Province. South African Journal of Botany 68, 308–311.

Van der Merwe, H., Van Rooyen, G., Van Rooyen, N., 2008. Vegetation map of the Hantam–Tanqua–Roggeveld. Veld & Flora 94, 132–133.

Van der Merwe, H., Van Rooyen, M.W., Van Rooyen, N., 2009a. Vegetation of the Hantam–Tanqua–Roggeveld subregion, South Africa. Part 1: Fynbos biome related vegetation. Koedoe 50, 61–71.

Van der Merwe, H., Van Rooyen, M.W., Van Rooyen, N., 2009b. Vegetation of the Hantam–Tanqua–Roggeveld subregion, South Africa. Part 2: Succulent Karoo Biome related vegetation. Koedoe 50, 160–183.

Van Wyk, B.-E., 1992. The identity of *Argyrolonium obsoletum* and the correct names for some species of *Polhillia* (Crotalarieae). Bothalia 22, 42–43.

Van Wyk, A., Personal Communication. Professor, Botany Department, University of Pretoria.

Van Wyk, B.-E., Personal Communication. Professor, Department of Botany and Plant Biotechnology, University of Johannesburg.

Van Wyk, A.E., Smith, G.F., 2001. Regions of Floristic Endemism in Southern Africa. Umdaus Press, Hatfield.

Van Zijl, J.S.V., 2006. Physical characteristics of the Karoo sediments and mode of emplacement of the dolerites. South African Journal of Geology 109, 329–334.

Venter, A.M., 2007. *Lycium hantamense* (Solanaceae), a new species from the Hantam–Roggeveld Centre of Plant Endemism, South Africa. South African Journal of Botany 73, 214–217.

Venter, J.M., Mocke, C., De Jager, J.M., 1986. Climate. In: Cowling, R.M., Roux, P.W., Pieterse, A.J.H. (Eds.), The Karoo Biome: a Preliminary Synthesis. Part 1 — Physical Environment. South African National Scientific Programmes Report, 124. CSIR, Pretoria.

Verwoed, W.J., Viljoen, E.A., Chevallier, L., 1995. Rare metal mineralization at the Salpeterkop carbonatite complex, Western Cape Province, South Africa. Journal of African Earth Science 21, 171–186.

Weimarck, H., 1941. Phytogeographical groups, centres and intervals within the Cape Flora. Lund, Leipzig.

White, A., Dyer, R.A., Sloane, B.L., 1941. The succulent Euphorbieae (Southern Africa). Abbey Garden, Pasadena.

Whitehouse, C.M., 2002. Systematics of the genus *Cliffortia* L. [Rosaceae]. Unpublished PhD Thesis, Department of Botany, University of Cape Town, Rondebosch.

Whitehouse, C.M., Fellingham, A.C., 2007. New species and notes on the genus *Cliffortia* (Rosaceae). Bothalia 37, 9–22.

Woodford, A.C., Chevallier, L., 2002. Hydrogeology of the Main Karoo Basin: Current Knowledge and Future Research Needs. Water Research Commission Report No. TT 179/02.

Woodhall, S., 2005. Field Guide to Butterflies of South Africa. Struik, Cape Town.

Zacharias, P.K.K., 1990. Acocks' Notes: Key Grasses of South Africa. Grassland Society of South Africa, Pietermaritzburg.

Edited by JC Manning