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Vegetation of quartz fields in the Little Karoo, Tanqua Karoo and eastern Overberg (Western Cape Province, South Africa)

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with 3 figures and 7 tables

Abstract. Quartz fields are a very special habitat characterised by occurrence of pavements of angular quartz debris being the result of weathering of quartz veins embedded in soft bedrock (shale, phyllite). Quartz fields support vegetation dominated by leaf-succulent dwarf shrubs, belonging to the Aizoaceae (mainly subfamilies Mesembryanthemoideae and Ruschioideae), Crassulaceae and Asteraceae. In this study we have described and classified plant communities of the quartz fields of the Little Karoo and adjacent regions (Tanqua Karoo, Overberg) in the Western Cape Province (South Africa). Here we present data and ideas on species composition, life-form texture, physiognomic structure, species richness, habitat preferences, geographic distribution, and conservation status of the quartz fields and their constituent plant species. Locally endemic taxa of the genus *Gibbaeum* (Haw.) N. E. Br. (Aizoaceae) are dominating most of the studied quartz fields. This paper features sixteen plant communities, all of them formally described as new associations and all of them, except for the Drosanthemo-Psilocauletum juncei, largely limited to quartz field habitats. They are classified into 5 community groups, of which the Gibbaeion angulipedis, Gibbaeo dispar-Lampranthylion altistyli and Gibbaeo nuciformi-Pteronion viscosi are being formally recognized as alliances. This paper is a pioneering attempt to present a first formal syntaxonomy of the vegetation of a region of the Succulent Karoo Biome in South Africa.

Keywords: Aizoaceae, *Gibbaeum*, phytosociology, semi-desert, Succulent Karoo Biome.

Introduction

In the arid parts of Southern Africa, quartz fields (pavements of angular quartz debris) exemplify ecologically a very special habitat (Schmiedel & Jürgens 1999, 2002, 2004). The quartz debris derives from weathering of quartz veins which are embedded in softer bedrock. The fine material of the substrate is mainly derived from relatively soft shale or phyllite, whereas the quartz is found as stones among the substrate or as pavement on the soil surface.

Quartz fields are found in several regions of the winter-rainfall area as well as at the western fringe of the summer-rainfall area of southern Africa (Fig. 1). Each region supports a quartz-field flora of its own, including a high number of local endemic species (van Wyk & Smith 2001, Schmiedel

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2004). Although remarkably different in floristic terms, the regional quartz-field floras show high similarity as to composition of growth-forms, which is indicative of strong convergence, most probably driven by specific ecological conditions of these habitats (Jürgens 1986, Schmiedel & Jürgens 1999, 2002, 2004). Quartz fields support vegetation dominated by leaf-succulent dwarf shrubs, belonging mainly to the subfamilies Mesembryanthemoideae and Ruschioideae of the family Aizoaceae (formerly known as Mesembryanthemaceae; Bittrich & Hartmann 1988) as well as Crassulaceae and numerous succulent representatives of Asteraceae (Schmiedel 2002b). All quartz-field floras are dominated by chamaephytes with short internodes and highly succulent, either elongated and vertically presented, or subglobose, or subterraneous leaves. The vegetation patterns on southern African quartz fields are characterised by small-scale mosaics of distinct monodominant plant communities. Vegetation-ecological studies in the quartz fields of the Little Karoo and the Knersvlakte (in southern Namaqualand) showed that the distribution of different growth forms is under strong control of chemical (salinity, soil pH, carbonate status) and physical (soil depth, stone content, density of quartz stones on the soil surface) soil factors (Schmiedel 2002b, Schmiedel & Jürgens 1999, 2002).

The quartz fields of the Little Karoo and of the adjacent areas are dominated by taxa of the genus *Gibbaeum* (Aizoaceae; Nel 1953, Glen 1974). The taxa of the genus *Gibbaeum* represent the diagnostic and dominating species of most of the communities recognized, and form 80 % of the regional obligate quartz-field flora, which is otherwise known for low species richness. Eight *Gibbaeum* taxa are not restricted to the quartz fields alone.

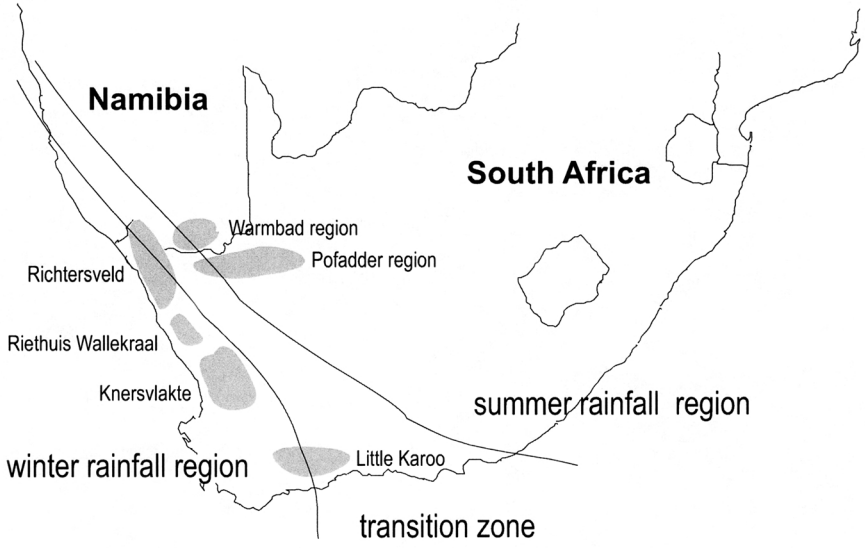


Fig. 1. Regions with frequent occurrence of quartz fields in Southern Africa.

Still, these are typically found in habitats showing special soil conditions (desert pavements of other lithology than quartz). Most taxa of the genus *Gibbaeum* are restricted to the Little Karoo. *Gibbaeum gibbosum* is also found in the southern Tanqua Karoo (Ceres Karoo). *G. haaglenii* and *G. esterhuyseniae* are restricted to a small area south of the Langeberg Mts. (eastern Overberg region).

To-date, only a handful of studies has been conducted into ecology of the quartz fields (Jürgens 1986, von Willert et al. 1992, Schmiedel 1994, 2002a, b, 2004, Schmiedel & Jürgens 1999, 2002, 2004). No classification schemes were suggested for the vegetation of quartz fields and no plant communities were formally described either.

Our paper attempts to fill gaps in our knowledge on distribution, floristic and life-form composition, ecology and conservation status of this unique vegetation by describing plant communities of the quartz-field vegetation of the Little Karoo, Tanqua Karoo and adjacent Overberg (Western Cape Province, South Africa). We further discuss to what extend the habitat conditions control distribution, patterns of diversity, and monodominance in vegetation inside and outside the quartz fields.

Study area

We studied quartz fields of the Little Karoo (33°25′–33°55′ S, 20°10′–22°30′ E) and in adjacent regions to the north (southern fringes of the Tanqua Karoo, South African topographic map sheet 3219D) and to the south (eastern Overberg region near Swellendam; 3420A & 3420B). All study regions are located in Western Cape Province of the Republic of South Africa.

The Little Karoo consists of a series of inter-montane valleys, bounded on all sides by the east-west trending anticlines of the Cape mountains. The Hex River, Witteberg and Swartberg Mountains border the Little Karoo from the north, while a long chain of the Riviersonderend, Langeberg and Outeniqua Mountains separates the Little Karoo basin from coastal peneplains of the Indian Ocean. The latter mountain chain impedes the penetration of both winter frontal rains as well as post frontal rains into the Little Karoo, hence forming a strong rain-shadow effect (Desmet & Cowling 1999). Therefore mean annual rainfall in the Little Karoo is only 244 mm. Rainy season extends from March to November (Fig. 2: Oudtshoorn and Touwsrivier). Winters are mild and without incidence of severe frost; summers are hot and dry.

The predominant bottomland rocks comprise soft sedimentary Bokkeveld Shale (part of Cape Supergroup). Quartz veins and associated quartz patches are concentrated in the western region of the Little Karoo (Schmiedel & Jürgens 1999).

The low altitudes of the Little Karoo have been classified as Little Succulent Karoo, which forms part of the Succulent Karoo Biome (Hoffman 1986a, Milton et al. 1997). The mountainous parts surrounding Little Karoo have been classified as Mountain Fynbos and Central Mountain Reno-

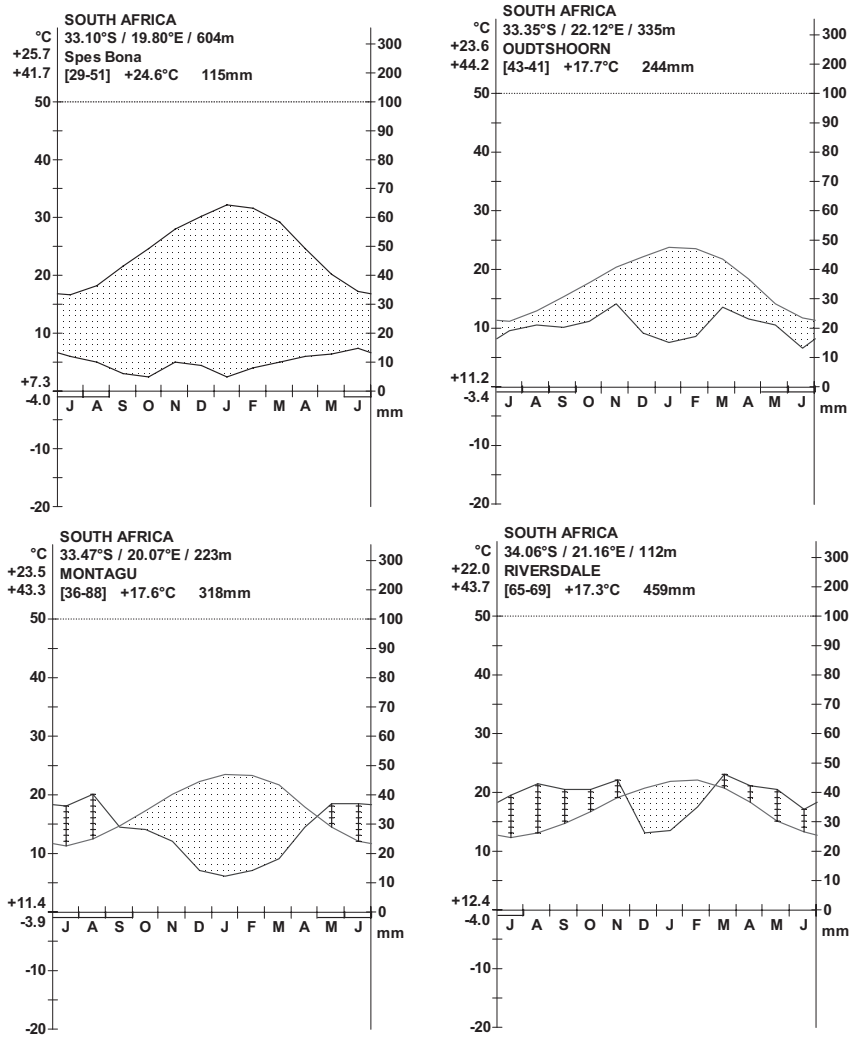


Fig. 2. Climate diagrams or four weather stations of the study area (data from South African Weather Bureau 1988).

sterveld (both forming part of the Fynbos Biome; Rebelo 1996). In the National Vegetation Map (Mucina & Rutherford 2004) the quartz fields of the Little Karoo form a distinct vegetation mapping unit called Little Karoo Vygieveld.

Quartz fields occur also on the southern fringe of the Tanqua Karoo, which is separated from the western part of the Little Karoo by a narrow

belt of Renosterveld (asteraceous shrubland). According to Hoffman (1996b) the Tanqua Karoo forms part of the Lowland Succulent Karoo. The National Vegetation Map (Mucina & Rutherford 2004) does not separate the very localised and small-sized quartz fields of the Tanqua Karoo from vegetation mapping unit called Tanqua Karoo. Shale sandstones of the Karoo Sequence dominate the geology of the region. They support shallow and skeletal soils. The rainfall in the Tanqua Karoo is extremely low (Fig. 2: Spes Bona) and can occur anytime of the year, showing slight increase in winter (June/July). In contrast to other regions of the Succulent Karoo Biome, the Tanqua Karoo is poor in species, which might be ascribed to its transitional character towards true climatic desert.

Vegetation of the Swellendam area south of the Langeberg (eastern Overberg) was classified as South and South-west Coast Renosterveld (Rebelo 1996). The quartz fields of the Overberg form a part of the mapping unit called Swellendam Silcrete Renosterveld (Mucina & Rutherford 2004).

The soils have developed over sedimentary rocks of the Bokkeveld Group and are rich in clays and silt. Most of the rainfall occurs in November and March (Fig. 2: Riversdale). Average annual precipitation (459 mm/yr) is almost twice as high as in the Little Karoo, because of the direct influence of the nearby Indian Ocean, situated only less than 50 km from the studied quartz patches.

All the study regions belong phytogeographically to the Cape Floristic Region (classified also as Cape Floristic Kingdom).

Materials and methods

Vegetation data collection

The field work was conducted from 1995 till 1999 and yielded 240 relevés. Of those, 154 relevés were made on quartz fields and 86 relevés were made outside the quartz fields in related habitats or soils zonal to the region. In almost all relevé plots (except for 9 of them) soil samples were taken and analysed as well.

The relevés were made using a modified Braun-Blanquet (1964) method: the projected canopy cover (%) of each plant species was estimated in 5×5 m relevés. In the relevé tables, the original cover-abundance codes were replaced according to van der Maarel's (1979) ordinal scale ranking between 0 and 9. We consider the size of sampling plot appropriate to depict the small-scale mosaic patterns of the vegetation patches so typical of the quartz fields.

Only two *Gibbaeum* species were not included in our study – the very rare *G. esterhuyseniae*, considered as extinct by Hilton-Taylor (1996), but rediscovered recently, and *G. nebrownii*, a species that occurs in low densities in crevices of brown to grey shale banks which are otherwise devoid of any vegetation cover.

Each species was classified into a life form (Tab. 1) using the system of Ellenberg & Mueller-Dombois (1966) as a basis and modified by Jürgens (1986).

Tab. 1. Life-form system for the plants of quartz fields of Southern Africa.

1. chamaephytes	dwarf shrubs < 50 cm tall
1.1. nano-chamaephytes (nCh)	dwarf shrubs < 5 cm tall
1.1.1. compact chamaephytes	long-leaf nCh with hardly visible internodes
1.1.2. spherical chamaephytes	nCh with leaves forming spherical aerial bodies
1.1.3. submerged chamaephytes	nCh sunken below soil surface
1.2. micro-chamaephytes	dwarf shrubs 5–15 cm tall
1.3. mega-chamaephytes	dwarf shrubs 15–50 cm tall
2. phanerophytes	shrubs or trees > 50 cm tall

Topographic and habitat data

The following topographic and habitat data were measured, estimated or determined in the relevé plots:
- position on national topographic grid system (using topographic maps 1:50000 of Surveyor General, South Africa);
- geographic coordinates using a GPS device;
- slope inclination (%), determined with hand-held inclinometer in the field;
- slope aspect (°), determined with a compass in the field;
- soil depth (cm) by digging soil profiles to the bedrock or crusts;
- stone content (< 2 mm in diam.), quantified as the proportional weight (%) of stones of the entire soil profile by weighing and sieving representative soil samples from the profiles;
- projected cover of quartz stones of 2–200 mm in diam. (%);
- projected cover of stones other than quartz (%);
- soil texture, by employing the finger test of wet soil samples (AG Boden 1994) to estimate the relative proportions of the various particles as well as plasticity; classes: S: sand, U: silt, T: clay, L: loam, Cl: loamy sand, Su: silty sand, Lt: clayey loam;
- electrical conductivity as indication of salinity (in mS/cm), determined in a 1:5 suspension of air-dry fine material;
- soil pH, determined in a 1:2.5 suspension of air-dry fine material and 0.01 M CaCl2;
- Carbonate content employing 10 % HCl (AG Boden 1994); classes: c0 = 0 %, c1 ≤ 0.5 %, c2 = 0.5–2.0 %, c3.2 = 2.1–4.0 %, c3.3 = 4.1–7.0 %, c3.4 = 7.1–10.0 %, c4 = 10.1–25.0 %, c5 = 25.1–50.0 %. c6 ≥ 50 %.

Data analysis and presentation

The phytosociological relevés were sorted by Megatab 2.0 package (Hennekens 1996). A series of TWINSPAN (Hill 1979) analyses were run within Megatab, followed by manual refinement of species-relevé coincidence groups. A synoptic table (Tab. 2) was constructed using Megatab as well. Relevé tables (Tabs. 3–6) feature particular communities and their high-ranked groups. Neutral term *differential species* (see Westhoff & van der Maarel 1978; for a more profound discussion consult Mucina 1993) was adopted to define floristic distinction between the communities (and their upper-hierarchy groups).

Nomenclature of plants and plant communities

The nomenclature of Aizoaceae followed in this paper is according to Hartmann (2002a, b), except for *Muiria hortenseae*, which was classified as a *Gibbaeum hortenseae* (Thiede & Klak in Goldblatt & Manning 2000). The nomenclature of the other taxa follows Goldblatt & Manning (2000). We prefer to designate some taxa as "complexes" (*Gazania krebsiana, Lycium cinereum, Salsola turberculata*) in order to stress intricacy (and controversy) surrounding their present taxonomic status.

Voucher specimens are lodged in the Herbarium Hamburgense (HBG) and selected specimens in the Bolus Herbarium (BOL) of the University of Cape Town.

The new syntaxa were described according to the rules of the 3rd edition of the International Code of Phytosociological Nomenclature (Weber et al. 2000). Conforming current use of informal nomenclature of plant communities in South Africa, we also introduce a name for each community in the form of a combination of taxon/taxa and structural characteristics.

Results

General syntaxonomic patterns

Five Community Groups (A–E), comprising 16 communities were recognized (Tab. 2). The Community Group A comprises succulent shrublands of the eastern Overberg region and Community Group E comprises a community found in Little Karoo outside the quartz fields. The Community Groups B, C, and D form the core of the quartz-field vygieveld (succulent karoo) communities and were recognized in the Little Karoo as well as in the southern parts of the Tanqua Karoo (the Gibbaeetum gibbosi). The Community Groups B, C, and D are formally described as alliances (see below). The communities are characterised by a low number (often only one) of differential species, which, for the most part, are also the dominant ones. Very few species were found to serve the separation between the Community Groups as well. Summary statistics featuring vegetation cover,

Tab. 2. Synoptic table of the communities of quartz fields of the Little Karoo, Tanqua Karoo and Overberg. Rare, non-diagnostic species have been left out (they can be consulted in particular relevé tables – Tabs. 3–6).

Community Group		**A**	**B**			**C**			**D**								**E**
Community		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Number of relevés		**4**	**5**	**6**	**8**	**4**	**8**	**4**	**30**	**60**	**16**	**10**	**9**	**15**	**13**	**4**	**4**
Gibbaeum haaglenii	d:A1	V	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Delosperma asperulum	d:A1	V	.	.	II	.	.	.	.	.	.	.	.	.	.	.	.
Pentaschistis eriostoma	d:A1	V	I	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gibbaeum velutinum	d:B2	.	V	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Elytropappus rhinocerotis	d:B	.	II	II	.	.	.	.	.	.	.	+	.	.	.	.	.
Gibbaeum angulipes	d:B3, d:B	.	.	V	II	.	.	.	.	.	.	.	.	.	.	.	.
Haworthia aspera	d:B3	.	.	II	.	.	.	.	.	.	+	.	.	.	.	.	.
Gibbaeum album	d:B4	.	.	.	V	.	.	.	.	.	.	.	.	.	.	.	.
Hereroa tenuifolia	d:C+D	.	.	.	.	II	IV	II	II	I	II	II	.	III	I	III	.
Phyllobolus splendens subsp. splendens	d:C+D	.	.	.	.	II	.	.	.	r	I	+	I	+	I	II	.
Felicia filifolia	d:C+D	.	.	.	.	II	II	.	+	I	II	II	I	+	+	II	.
Eriocephalus ericoides	d:C+D	.	.	.	.	II	II	II	.	+	I	I	.	II	.	II	.
Sceletium tortuosum	d:C+D	.	.	.	.	.	.	II	r	I	+	.	.	.	+	II	.
Drosanthemum delicatulum	d:C+D	.	.	.	.	.	I	.	I	r	I	+	II	II	+	.	.
Osteospermum microphyllum	d:C+D	.	.	.	.	.	I	.	II	II	II	+	I	II	I	.	.
Plumbago tristis	d:C+D	.	.	.	.	.	II	II	.	r	.	.	.	.	+	.	.
Crassula tecta	d:C+D	.	.	.	.	.	I	.	r	r	+	.	.	+	.	.	.
Berkheya spinosa	d:C+D	.	.	.	.	.	I	.	I	III	II	II	.	.	.	.	.
Octopoma octojuge	d:C+D	.	.	.	.	.	I	.	I	.	+	.	.	.	II	.	.
Zeuktophyllum calycinum	d:C+D	.	.	.	.	.	I	.	+	r	+	.	.	.	II	.	.
Adromischus filicaulis subsp. marlothii	d:C+D	.	.	.	.	.	II	.	+	r	+	.	.	.	I	.	.
Pteronia empetrifolia	d:C+D	.	.	.	.	.	II	.	r	r	.	II	.	.	+	.	.
Blepharis inermis	d:C+D	.	.	.	.	.	I	.	.	r	.	.	I	.	.	II	.
Dicoma relhanioides	d:C+D	.	.	.	.	.	I	.	I	r	.	I	.	.	.	.	.
Crassula pyramidalis	d:C+D	.	.	.	.	II	II	.	r	I	.	.	.	.	.	.	.
Lampranthus altistylus	d:C	.	I	II	.	IV	V	II	.	r	.	.	.	.	.	.	.
Conophytum joubertii	d:C	.	I	I	.	II	II	.	.	r	.	.	.	.	.	.	.
Gibbaeum dispar	d:C	.	.	.	.	V	I	.	.	.	.	.	.	.	.	.	.
Crassula deltoidea	d:C	.	.	.	.	II	I	.	.	r	.	.	.	.	.	.	.
Glottiphyllum salmii	d:C	.	.	.	.	.	I	II	.	.	.	.	.	.	.	.	.
Zeuktophyllum suppositum	d:C6	.	.	.	.	.	V	.	.	.	.	.	.	.	.	.	.
Othonna cylindrica	d:C6	.	.	.	.	.	IV	.	r	.	.	.	.	.	.	.	.
Crassula tetragona subsp. acutifolia	d:C6	.	.	.	.	.	III	.	.	r	.	.	.	.	.	.	.
Gazania lichtensteinii	d:C6	.	.	.	.	.	II	.	.	.	.	.	.	.	.	.	.
Gibbaeum petrense	d:C7	.	I	.	II	.	.	V	.	.	.	.	.	.	.	.	.
Salsola sp. 104753	d:C7	.	.	.	I	.	.	III	r	r	.	.	.	.	.	.	.
Gibbaeum hortenseae	d:C7	.	.	.	.	.	.	II	.	.	.	.	.	.	.	.	.
Zygophyllum retrofractum	d:D	.	.	.	.	.	.	.	I	+	II	+	IV	III	II	.	.
Octopoma quadrisepalum	d:D	.	.	.	.	.	.	.	+	I	I	+	I	I	.	.	.
Haworthia viscosa	d:D	.	.	.	.	.	.	.	r	.	+	.	.	.	.	II	.
Rosenia humilis	d:D	.	.	.	.	.	.	.	.	.	.	.	.	I	+	II	.
Pteronia viscosa	d:D	.	.	.	.	.	.	.	I	II	I	+	II	III	II	II	.
Salsola sp. US 7302	d:D	.	.	.	.	.	.	.	r	.	I	.	II	.	+	.	.
Pentzia incana	d:D	.	.	.	.	.	.	.	.	+	II	.	.	I	.	.	.
Hereroa sp. 110134	d:D	.	.	.	.	.	.	.	.	r	I	.	.	+	.	.	.
Asparagus recurvispinus	d:D	.	.	.	.	.	.	.	.	.	+	.	.	I	+	.	.
Gazania krebsiana complex	d:D	.	.	.	.	.	.	.	r	r	.	.	.	.	+	.	.
Drosanthemum giffenii	d:D	.	.	.	.	.	.	.	.	+	I	.	.	+	.	.	.
Euphorbia arceuthobioides	d:D	.	.	.	.	.	.	.	+	r	+	.	.	.	.	.	.
Salsola tuberculata complex	d:D	.	.	.	.	.	.	.	+	r	+	.	.	.	.	.	.
Ruschia cradockensis subsp. triticiformis	d:D	.	.	.	.	.	.	.	.	r	.	I	I	.	.	.	.
Pteronia glomerata	d:D	.	.	.	.	.	.	.	I	r	.	I	.	.	.	.	.
Felicia fascicularis	d:D	.	.	.	.	.	.	.	.	r	.	+	.	.	.	.	.

Community Group		A	B			C			D								E
Community		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Number of relevés		4	5	6	8	4	8	4	30	60	16	10	9	15	13	4	4
Gibbaeum nuciforme	d:D8	.	.	.	.	.	.	.	V	II	.	+	I	II	I	.	.
Gibbaeum pubescens	d:D9	.	.	.	.	.	.	.	.	V	+	+	I	.	.	.	.
Aridaria noctiflora subsp. defoliata	d:D10	.	.	.	.	.	.	.	.	.	II	.	.	.	.	.	.
Drosanthemum crassum	d:D10	.	.	.	.	.	.	.	.	r	II	.	.	.	.	.	II
Ruschia cradockensis subsp. cradockensis	d:D10	.	.	.	.	.	.	.	.	.	II	.	.	+	.	.	II
Asparagus sp. US 5099	d:D10	.	.	.	.	.	.	.	.	r	II	.	.	.	.	.	.
Gibbaeum gibbosum	d:D11	.	.	.	.	.	.	.	.	.	.	V	.	.	.	.	.
Gibbaeum geminum	d:D12	.	.	.	.	.	.	.	+	.	.	.	V	.	.	.	.
Gibbaeum shandii	d:D13	.	.	.	.	.	.	.	.	.	.	.	I	V	.	.	.
Rhinephyllum muirii	d:D13	.	.	.	.	.	.	.	I	r	.	.	.	III	.	.	.
Gibbaeum heathii	d:D14	.	.	.	.	.	.	.	I	+	.	.	II	+	V	III	.
Salsola sp. 110026	d:D14	.	.	.	.	.	.	.	r	r	.	.	.	.	II	.	.
Gibbaeum pachypodium	d:D15	.	.	.	.	.	.	.	.	.	.	.	.	.	.	V	.
unknown Asteraceae sp. 109859	d:D15	.	.	.	.	.	.	.	.	.	.	.	.	.	.	III	.
Crassula congesta	d:D15	.	.	.	.	.	.	.	.	.	.	.	.	.	.	III	.
Psilocaulon junceum	d:E16	.	.	.	.	.	.	II	+	r	II	II	.	I	.	.	V
Drosanthemum duplessiae	d:E16	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	III
Phyllobolus nitidus	d:E16	.	.	.	.	.	.	.	.	.	.	.	I	.	.	.	III
Pteronia pallens		.	.	.	.	II	III	II	III	III	V	III	III	IV	III	II	II
Malephora lutea		.	.	.	.	III	IV	II	II	II	III	I	II	II	II	.	III
Tetragonia robusta		.	.	I	.	II	II	II	II	III	II	II	II	III	II	II	II
Tripteris sinuata var. linearis		.	.	.	.	II	II	.	.	+	I	.	I	III	I	III	II
Lycium cinereum complex		.	I	.	.	.	II	.	.	+	IV	.	I	II	+	.	II
Ruschia inclusa		.	.	.	.	.	.	.	.	r	I	I	II	II	.	.	III
Prenia tetragona		.	.	.	.	.	II	II	.	r	.	.	.	+	+	.	II
Crassula subaphylla var. subaphylla		.	.	.	.	.	I	.	+	r	II	+	.	.	+	.	II
Augea capensis		.	.	.	.	.	.	.	.	.	.	.	II	.	.	.	II
Drosanthemum subcompressum		.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	II
Mesembryanthemum subtruncatum		.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	II
Anacampseros papyracea subsp. papyracea		.	.	.	.	II	IV	.	I	+	I	.	.	+	I	.	.
Crassula columnaris subsp. columnaris		.	.	II	I	II	II	.	II	I	.	II	I	+	+	.	.
Salsola sp. 102066		.	.	.	I	.	I	II	I	II	III	+	I	II	I	.	.
Psilocaulon articulatum		.	.	.	II	II	IV	III	II	II	I	+	IV	II	II	II	.
Chrysocoma ciliata		.	.	II	II	II	IV	.	I	II	II	II	.	II	+	.	.
Atriplex lindleyi subsp. inflata		.	.	.	II	.	.	II	I	r	.	.	II	+	+	II	.
Pteronia succulenta		.	.	.	II	.	I	IV	III	III	I	II	II	+	II	II	.
Crassula capitella subsp. thyrsiflora		.	.	.	I	.	.	.	I	.	I	+	.	+	.	.	.
Senecio radicans		.	.	I	.	.	I	.	.	.	+	I	.	+	.	.	.
Salsola sp. 104699		.	.	.	II	.	.	.	+	.	+	.	.	.	II	.	.
Glottiphyllum neilii		.	I	.	.	.	.	.	.	r	+	.	.	.	.	.	.
Trichodiadema densum		.	.	I	.	.	I	.	r	r	.	.	.	.	.	.	.
Drosanthemum praecultum		.	I	.	.	.	I	.	r	I	+	.	.	.	.	.	.
Antegibbaeum fissoides		.	I	I	I	.	II	.	.	I	I	II	I	.	+	II	.
Pteronia flexicaulis		.	III	.	I	.	II	.	+	.	.	+	.	.	.	III	.
Berkheya cuneata		.	II	I	.	.	I	.	r	II	I	+	I	+	.	III	.
Adromischus triflorus		.	I	.	.	.	II	.	r	I	I	.	.	.	+	II	.
Polygala empetrifolia		.	I	.	.	.	I	II	.	.	.	.	.	.	.	.	.

Tab. 2. (cont.)

A Community Group
A1 Delospermo asperuli-Gibbaeetum haaglenii
B Community Group (Gibbaeion angulipedis)
B2 Gibbaeetum velutini
B3 Gibbaeetum angulipedis
B4 Gibbaeetum albi
C Community Group (Gibbaeo dispar-Lampranthion altistyli)
C5 Gibbaeetum dispar
C6 Zeuktophylletum suppositi
C7 Gibbaeetum petrense
D Community Group (Gibbaeo nuciformi-Pteronion viscosi)
D8 Gibbaeetum nuciformis
D9 Gibbaeetum pubescentis
D9a gibaeetosum nuciformis
D9b berkheyetosum cuneati
D10 Aridario defoliati-Pteronietum pallentis
D11 Gibbaeetum gibbosi
D12 Gibbaeetum gemini
D13 Gibbaeetum shandii
D14 Gibbaeetum heathii
D15 Gibbaeetum pachypodii
E Community Group
E16 Drosanthemo duplessiae-Psilocauletum juncei

species richness, and soil properties pertinent to particular plant communities are given in Tab. 7.

We refrain, at this stage, from formal description of the monotypic Community Groups A and E as alliances. Further we refrain from pursuing formal description of supra-ordinate syntaxa, such as order(s) or class(es) since we realize that the vegetation featured in this paper forms only a small segment of the diverse (especially in terms of beta and gamma diversity) vegetation of the Succulent Karoo Biome. Knapp (1968) suggested a single class (the Psilocaulo-Ruschietea) with 3 orders, such as the Gibbaeo-Ruschietalia (to comprise succulent karoo vegetation of the Little Karoo), Psilocaulo-Diplosometalia and Nanantho-Ruschietalia qriquensis. We qualify the attempt of Knapp (1968) as premature and not conforming to principles of syntaxonomic methodology and name-formation. Not only are all the above-mentioned syntaxa invalidly described (no validly described alliances were suggested), no data supporting the syntaxonomic concepts were offered by Knapp (1968). The species lists – the only valuable element of the descriptions – have apparently not been derived on basis of plot data, either original or previously published. The lists contain a number of serious inconsistencies, among the most serious being the listing of phantom taxa (not known to taxonomic literature) and taxa not occurring in the regions claimed by the author.

Community Group A

A1 Delospermo asperuli-Gibbaeetum haaglenii ass. nova hoc loco

Holotypus: Tab. 3, relevé no. 1 (field code: 7284.0)
(*Gibbaeum haaglenii-Delosperma asperulum* Succulent Dwarf Shrub Community)

Tab. 3. Relevé table of the Community Groups A, B and Communities C5 through C7.

Relevé no.	Community Group	Community	Field Code	SA National Grid	Latitude [degrees.minutes] S	Longitude [degrees.minutes] E	Aspect [degrees]	Slope [%]	Soil depth [cm]	Stone cover non-quartz [%]	Stone cover quartz [%]	Stone content in soil [% of mass]	Soil texture	Soil pH	Electric conductivity [mS/cm]	Carbonate [HCl test, class 1-5	Cover [%]	Number of taxa	*Delosperma asperulum* d:A1	*Gibbaeum haaglenii* d:A1	*Pentaschistis eriostoma* d:A1
1	A	1	7284,0	3420AD	34,18	20,27	23	6	10	5	90	32	-	4,0	1,95	0	38,1	5	5	7	3
2	A	1	7285,0	3420AD	34,18	20,27	315	6	20	0	86	12	-	5,2	3,11	0	19,0	3	3	6	1
3	A	1	7286,0	3420AD	34,17	20,24	180	17	10	0	93	44	-	3,8	0,43	0	16,0	3	1	5	5
4	A	1	7287,0	3420AD	34,17	20,24	270	3	15	0	90	5	U	4,2	2,12	0	12,0	3	1	5	1
5	B	2	7073,0	3321CC	33,54	21,08	45	22	5	20	80	31	Ut2	4,8	0,49	0	4,2	5	.	.	.
6	B	2	7290,0	3320DC	33,55	20,42	180	10	5	99	0	20	-	4,3	0,51	0	6,1	5	.	.	1
7	B	2	7291,0	3320DC	33,55	20,42	90	5	5	99	0	50	Sl	5,7	1,65	0	18,3	6	.	.	.
8	B	2	7324,0	3321CC	33,54	21,08	90	8	10	10	60	54	-	6,0	0,34	0	8,7	11	.	.	.
9	B	2	7326,0	3321CC	33,54	21,08	23	4	5	0	83	69	-	5,0	1,55	0	9,0	4	.	.	.
10	B	3	7074,0	3321CC	33,54	21,08	1	10	5	40	60	42	Ut2	3,8	0,71	0	8,0	5	.	.	.
11	B	3	7075,0	3321CC	33,54	21,08	0	0	5	0	30	62	Su4	4,2	0,50	0	12,2	7	.	.	.
12	B	3	7078,0	3321CD	33,54	21,18	1	12	10	0	100	40	Su4	4,1	2,78	0	10,0	1	.	.	.
13	B	3	7080,0	3321CD	33,54	21,18	90	10	10	0	100	1	Su4	3,7	2,25	0	10,3	4	.	.	.
14	B	3	7081,0	3321CD	33,54	21,18	135	8	20	0	100	10	Su4	5,2	3,30	0	12,0	2	.	.	.
15	B	3	7086,0	3321CD	33,54	21,19	1	6	10	70	30		-	-	-	0	8,5	4	.	.	.
16	B	4	5694,0	3321CC	33,53	21,04	1	2	7	5	75	26	-	-	8,59	0	1,4	7	.	.	.
17	B	4	5695,0	3321CC	33,53	21,04	1	4	16	0	81	34,8	Ut2	6,3	1,21	0	0,0	2	.	.	.
18	B	4	5696,0	3321CC	22,53	21,04	1	22	20	0	100	22	Ut2	6,5	4,62	0	2,2	5	.	.	.
19	B	4	5698,0	3321CC	33,53	21,05	225	4	10	4	92	19	Lt	6,6	4,60	0	2,0	1	.	.	.
20	B	4	7077,0	3321CD	33,54	21,18	180	10	20	0	97	20	Sl2	5,1	2,58	0	21,2	4	5	.	.
21	B	4	7079,0	3321CD	33,54	21,18	180	6	10	0	95	62	Ut2	6,3	5,46	0	4,2	4	.	.	.
22	B	4	7082,0	3321CD	33,54	21,18	135	4	5	0	98	30	Lts		3,73	0	1,3	4	.	.	.
23	B	4	7084,0	3321CD	33,54	21,18	135	4	5	0	97	10	Ut2	6,7	4,45	0	16,7	7	1	.	.
24	C	5	7308,0	3321CC	33,49	21,07	0	0	5	99	0	71	-	6,8	1,95	0	5,1	4	.	.	.
25	C	5	7309,0	3321CC	33,49	21,07	1	1	5	90	65	42	-	7,4	0,90	0	5,3	6	.	.	.
26	C	5	7319,0	3321CD	33,45	21,23	45	2	5	15	85	25	-	5,2	0,16	0	5,5	9	.	.	.
27	C	5	7320,0	3321CD	33,46	21,28	90	13	5	0	81	80	-	6,2	0,03	0	3,1	4	.	.	.
28	C	6	5679,0	3321CC	33,52	21,05	1	25	10	45	50	55,5	Sl3-Lts	5,1	0,47	0	7,4	14	.	.	.
29	C	6	5681,0	3321CC	33,51	21,05	1	11	24	35	35	34,3	Ls-Su3	7,1	0,79	0	7,6	20	.	.	.
30	C	6	5683,0	3321CC	33,52	21,05	45	25	35	52	45	50	fsu2	5,9	1,40	0	3,2	17	.	.	.
31	C	6	5684,0	3321CC	33,52	21,05	45	25	20	45	50	70	Su3	5,9	0,06	0	6,6	21	.	.	.
32	C	6	5686,0	3321CC	33,51	21,06	45	11	15	8	92	43	Su4	6,6	0,35	0	8,8	19	.	.	.
33	C	6	5687,0	3321CC	33,51	21,06	45	25	15	5	95	10	-	4,9	0,67	0	2,6	16	.	.	.
34	C	6	5688,0	3321CC	33,51	21,06	45	17	9	0	100	58	Ut2	5,8	1,76	0	1,7	8	.	.	.
35	C	6	7071,0	3321CC	33,49	21,06	90	14	5	0	0	60	Su4	4,3	0,55	0	6,4	6	.	.	.
36	C	7	5680,0	3321CC	33,52	21,05	1	16	10	10	85	30	Su3	8,1	2,96	0	2,1	4	.	.	.
37	C	7	5685,0	3321CC	33,52	21,06	250	9	10	0	90	37	Su3	7,0	6,02	0	4,3	11	.	.	.
38	C	7	5697,0	3321CC	33,53	21,05	180	11	7	0	96	36	Sl3	7,0	5,67	0	30,5	6	.	.	.
39	C	7	7322,0	3321CD	33,54	21,24	1	2	5	0	90	52	-	7,1	3,56	0	8,2	6	.	.	.

Tab. 3 (cont.).

Gibbaeum velutinum	d:B2	. . . .	4 5 5 2 5	. . . . . .	. . . .	. . . .	. . . .	. . . .
Gibbaeum angulipes	d:B3	. . . .	. . . . .	5 5 5 5 5 5	. . . . . 1 1 .	. . . .	. . . .	. . . .
Haworthia aspera	d:B3	. . . .	. . . . .	. . . 1 1 .	. . . .	. . . .	. . . .	. . . .
Gibbaeum album	d:B4	. . . .	. . . . .	. . . . . .	1 1 1 2 6 4 1 6	. . . .	. . . .	. . . .
Gibbaeum dispar	d:C5	. . . .	. . . . .	. . . . . .	. . . .	5 5 5 2	 1	. . . .
Zeuktophyllum suppositum	d:C6	. . . .	. . . . .	. . . . . .	. . . .	. . . .	5 1 1 1 1 2 1 5	. . . .
Othonna cylindrica	d:C6	. . . .	. . . . .	. . . . . .	. . . .	. . . .	1 1 1 1 . . . 1	. . . .
Crassula tetragona subsp. *acutifolia*	d:C6	. . . .	. . . . .	. . . . . .	. . . .	. . . .	1 1 1 1	. . . .
Gazania lichtensteinii	d:C6	. . . .	. . . . .	. . . . . .	. . . .	. . . .	. 1 1 1	. . . .
Gibbaeum petrense	d:C7	. . . .	. . . 1 .	. . . . . .	1 . 1	. . . .	. . . .	2 3 1 5
Salsola sp. 104753	d:C7	. . . .	. . . . .	. . . . . .	1	. . . .	. . . .	. . 1 1
Gibbaeum hortenseae	d:C7	. . . .	. . . . .	. . . . . .	. . . .	. . . .	. . . .	. . 7 .
Elytropappus rhinocerotis	d:B	. . . .	. 1 5 . .	1 1	. . . .	. . . .	. . . .	. . . .
Hereroa tenuifolia	d:C	. . . .	. . . . .	. . . . . .	. . . .	. 1 . .	1 3 1 2 1 . . .	. 1 . .
Pteronia pallens	d:C	. . . .	. . . . .	. . . . . .	. . . .	. . 1 .	. . 1 1 1 1 . .	. 1 . .
Malephora lutea	d:C	. . . .	. . . . .	. . . . . .	. . . .	. 1 1 .	. 1 1 1 . 1 1 .	. 1 . .
Eriocephalus ericoides	d:C	. . . .	. . . . .	. . . . . .	. . . .	. . . 1	. 1 . . 1 1 . .	. . . 1
Felicia filifolia	d:C	. . . .	. . . . .	. . . . . .	. . . .	. . 1 .	. . 1 1 . . . 1	. . . .
Tripteris sinuata var. *linearis*	d:C	. . . .	. . . . .	. . . . . .	. . . .	. 1 . .	1 . . 1	. . . .
Avonia papyracea subsp. *papyracea*	d:C	. . . .	. . . . .	. . . . . .	. . . .	. . 1 .	1 1 . 1 1 1 1 .	. . . .
Crassula pyramidalis	d:C	. . . .	. . . . .	. . . . . .	. . . .	. . 1 .	. . 1 1	. . . .
Crassula deltoidea	d:C	. . . .	. . . . .	. . . . . .	. . . .	1 . . .	. 1	. . . .
Adromischus filicaulis subsp. *marlothii*	d:C	. . . .	. . . . .	. . . . . .	. . . .	. . . .	1 . . 1 . 1 . .	. . . .

Pteronia empetrifolia	d:C	. . . .	. . . . .	. . . . . .	. . . .	. . . .	1 2	. . . .
Lycium cinereum complex	d:C	. . . .	1	. . . . . .	. . . .	. . . .	. . . . 1 1 . .	. . . .
Plumbago tristis	d:C	. . . .	. . . . .	. . . . . .	. . . .	. . . .	. 1 1 1	1 . . .
Glottiphyllum salmii	d:C	. . . .	. . . . .	. . . . . .	. . . .	. . . .	. . . . 1 . . .	. 1 . .
Prenia tetragona	d:C	. . . .	. . . . .	. . . . . .	. . . .	. . . .	. . 1 . 1 . . .	. 1 . .
Pteronia flexicaulis		. . . .	1 . . 4 3	. . . . . .	. . . . 1 . . .	. . . .	. 1 1	. . . .
Conophytum joubertii		. . . .	1	. 1	. . . .	. 1 . .	. . . . 1 1 1 .	. . . .
Berkheya cuneata		. . . .	. . . 1 1	. 1	. . . .	. . . .	. . . 1	. . . .
Lampranthus altistylus		. . . .	. . 1 . .	. . . 2 . 1	. . . .	1 . 1 1	1 . 1 1 1 1 1 1	. . . 1
Drosanthemum praecultum		. . . .	. 1 . . .	. . . . . .	. . . .	. . . .	. . . . 5 . . .	. . . .
Antegibbaeum fissoides		. . . .	. . . 1 .	. . . 1 . .	. 1	. . . .	. . . . 1 1 . .	. . . .
Adromischus triflorus		. . . .	. 1 . . .	. . . . . .	. . . .	. . . .	. . . . . 1 1 .	. . . .
Polygala empetrifolia		. . . .	. . . 1 .	. . . . . .	. . . .	. . . .	. 1	. . . 1
Senecio radicans		. . . .	1	. . . . . .	. . . .	. . . .	. . . . . 1 . .	. . . .
Chrysocoma ciliata		. . . .	. . . . .	1 1	1 1	. . 1 .	1 1 1 1 1 . . .	. . . .
Crassula columnaris subsp. *columnaris*		. . . .	. . . . .	1 1	1	. . 1 .	. . . . . 1 1 .	. . . .
Tetragonia robusta		. . . .	. . . . .	. 1	. . . .	. . . 1	1 1	. 1 . .
Trichodiadema densum		. . . .	. . . . .	. 1	. . . .	. . . .	1	. . . .
Psilocaulon articulatum		. . . .	. . . . .	. . . . . .	. . 1 . . 1 . 1	1 . . .	1 . 1 1 . 1 1 .	1 . . 1
Atriplex lindleyi subsp. *inflata*		. . . .	. . . . .	. . . . . .	. . . . . . 1 1	. . . .	. . . .	. . 1 .
Pteronia succulenta		. . . .	. . . . .	. . . . . .	1 . 1	. . . .	. 1	1 1 1 .
Limonium sp. nova 110025		. . . .	. . . . .	. . . . . .	. . . . 1 . . 1	. . . .	. . . .	. . 1 .
Salsola sp. 104699		. . . .	. . . . .	. . . . . .	. . . . . 1 1 .	. . . .	. . . .	. . . .
Salsola sp. 102066		. . . .	. . . . .	. . . . . .	. . 2	. . . .	. . . . . 1 . .	. 1 . .

Floristic composition: The community is characterised by co-occurrence of *Delosperma asperulum*, *Gibbaeum haaglenii* and *Pentaschistis eriostoma*. Only two taxa found in this community were also recorded in quartz fields north of the Langeberg: *Delosperma asperulum* occurs in the Gibbaeetum albi (B4) and *Pentaschistis eriostoma* was recorded in stands of the Gibbaeetum velutini (B2). The latter species is also known from fynbos of the Cederberg (Taylor 1996) and the coastal fynbos of Southern Cape (Hoare et al. 2000).

Life-form & structure: Cover of vegetation is very high (19 %) when compared to other communities typical of quartz fields. The species richness is low (3–5 spp. per rel.). The community is dominated by subglobose nano-chamaephytes; micro- and mega-chamaephytes are of minor importance.

Distribution & habitat: The community is restricted to the quartz fields of the eastern Overberg (near Swellendam), south of the Langeberg Mts. It typically inhabits moderate to steep slopes covered with medium-sized quartz debris (6–20 cm). The silty, soft soils are shallow (< 20 cm) and have low stone content (22 % of mass). The electrical conductivity is moderately high (average 2 mS/cm) and the soil pH is very low (median: 4.1).

Notes: *Gibbaeum haaglenii* is restricted to the community, whereas *Delosperma asperulum* was recorded from Namaqualand to Riversdale, and *P. eriostoma* is widely distributed from Namaqualand to Eastern Cape (Goldblatt & Manning 2000).

Community Group B

Gibbaeion angulipedis all. nova hoc loco
The communities of this alliance are confined to the Barrydale-Vanwyksdorp area.

Holotypus: Gibbaeetum angulipedis Schmiedel & Mucina 2006 hoc loco
Differential species: *Gibbaeum album, G. angulipes, G. velutinum, Haworthia aspera*

B2 Gibbaeetum velutini ass. nova hoc loco

Holotypus: Tab. 3, relevé no. 9 (field code: 7326.0)
(Gibbaeum velutinum Succulent Dwarf Shrub Community)

Floristic composition: The diagnostic species of this association is *G. velutinum*. Common species with constancy larger than constancy class I include *Berkheya cuneata*, *Elytropappus rhinocerotis*[1] (renosterbos) and *Pteronia flexicaulis*. The latter typically dominates the surrounding renosterveld.

Life-form & structure: Both total cover of the vegetation (< 10 %) and the species richness (5 spp.) are low. The community is structured into two layers: a low layer of compact, leaf-succulent nano-chamaephytes and a higher layer of non-succulent mega-chamaephytes and phanerophytes.

[1] The nomenclature of *Elytropappus rhinocerotis* (L.f.) Less. has changed to *Dicerothamnus rhinocerotis* (L.f.) Koekemoer.

Distribution & habitat: The community is restricted to the southern fringe of the Little Karoo between Barrydale and Muiskraal. It inhabits soft, poorly weathered shale bands on gentle to steep slopes of small hills or mountains with or without quartz cover. The shale bands are often situated between dense stands of *Elytropappus rhinocerotis,* which represents the typical vegetation of this geology in the Karoo. The soils are shallow (5 cm) and the stone content in soil is typically high (median: 50 %). The Gibbaeetum velutini occurs on acid soils (pH < 6), which have a comparatively low salt content (< 2 mS/cm).

B3 Gibbaeetum angulipedis ass. nova hoc loco

Holotypus: Tab. 2, relevé no. 14 (field code: 7081.0)
(*Gibbaeum angulipes* Succulent Dwarf Shrub Community)

Floristic composition: The only diagnostic species of the Gibbaeetum angulipedis are the dominant *G. angulipes* (Fig. 3) and *Haworthia aspera*, of which the latter is also found in other communities. Both species are leaf-succulent dwarf shrubs. *Elytropappus rhinocerotis* dominates the surrounding vegetation at most localities and therefore is occasionally encountered in stands of this community. Common companions include *Lampranthus altistylus* and *Chrysocoma ciliata*.

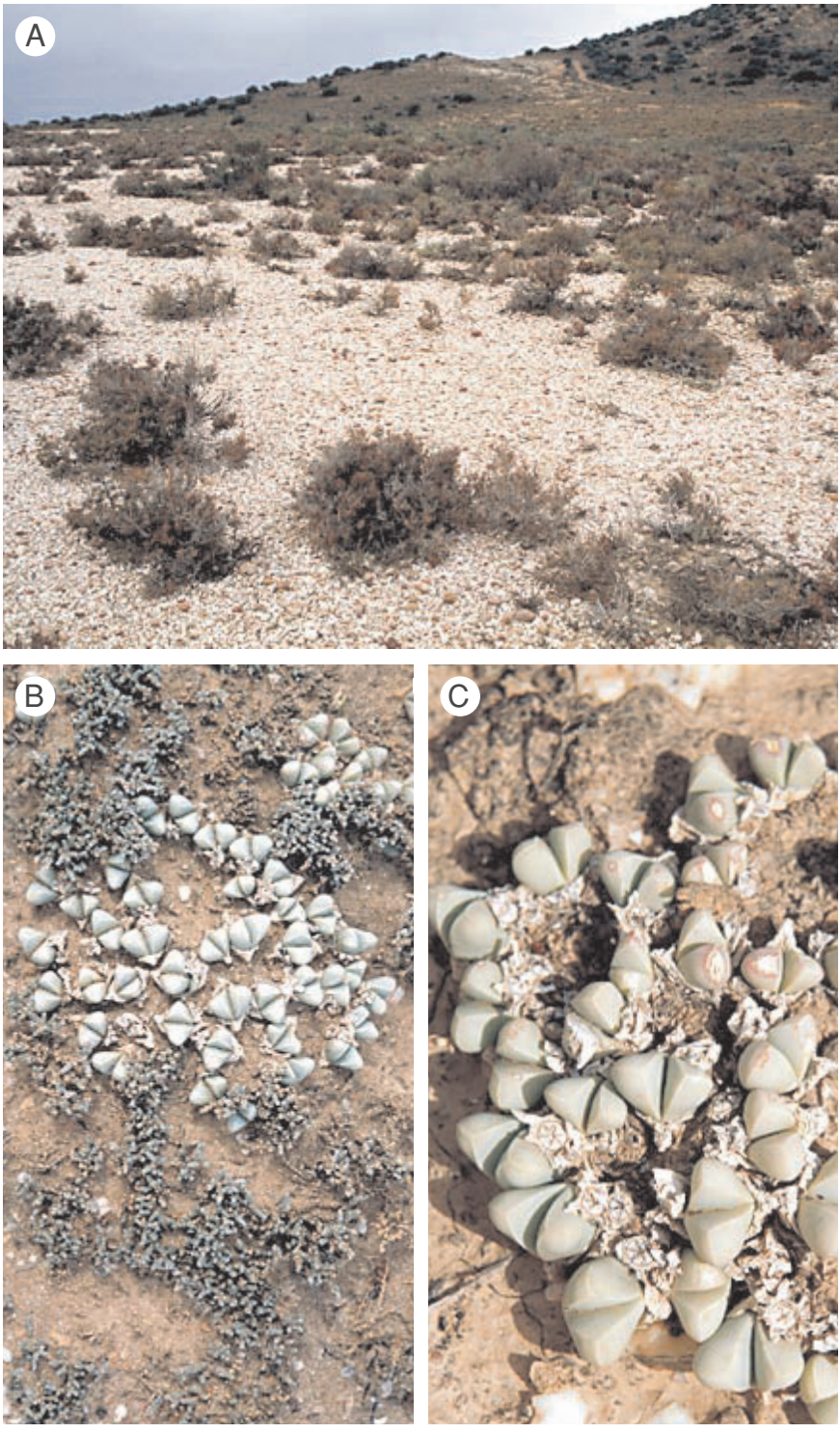
Life-form & structure: Vegetation cover in this community is comparatively high and surpasses that of most of the other quartz-field communities. This goes mainly on the account of the growth form of *G. angulipes* – a mat-forming dwarf shrub, which may cover up to 12 % of the soil surface. The number of species per relevé is not more than 7 species per relevé. This vegetation is typically dominated by creeping nano-chamaephytes *(G. angulipes)*. Other nano-chamaephytes as well as micro- and mega-chamaephytes occur with very low cover values.

Distribution & habitat: This community is restricted to a small area near Muiskraal (3321C) between Groot Phisantefontein and Karreekloof, where it occurs on quartz fields, but also on pavements with a high percentage of dark-coloured sandstone or shale. The soils are usually shallow and rich in fine material (silt). The soil salinity is moderate (median: 2.3 mS/cm) and the soil pH is very acid (median: 4.1).

B4 Gibbaeetum albi ass. nova hoc loco

Holotypus: Tab. 2, relevé no. 23 (field code: 7084.0)
(Gibbaeum album Succulent Dwarf Shrub Community)

Floristic composition: The only diagnostic species of the community is *G. album*, which is also the dominant species (Fig. 3). Other important species are the locally restricted species *Gibbaeum angulipes* and *G. petrense*, as well as widespread taxa, such as alien *Atriplex lindleyi* subsp. *inflata* and native *Chrysocoma ciliata, Psilocaulon articulatum* and *Pteronia succulenta*. Marginal quartz-field habitats of this community (not sampled) support locally dominant taxon of the *Sarcocornia mossiana* complex.


A
B
C

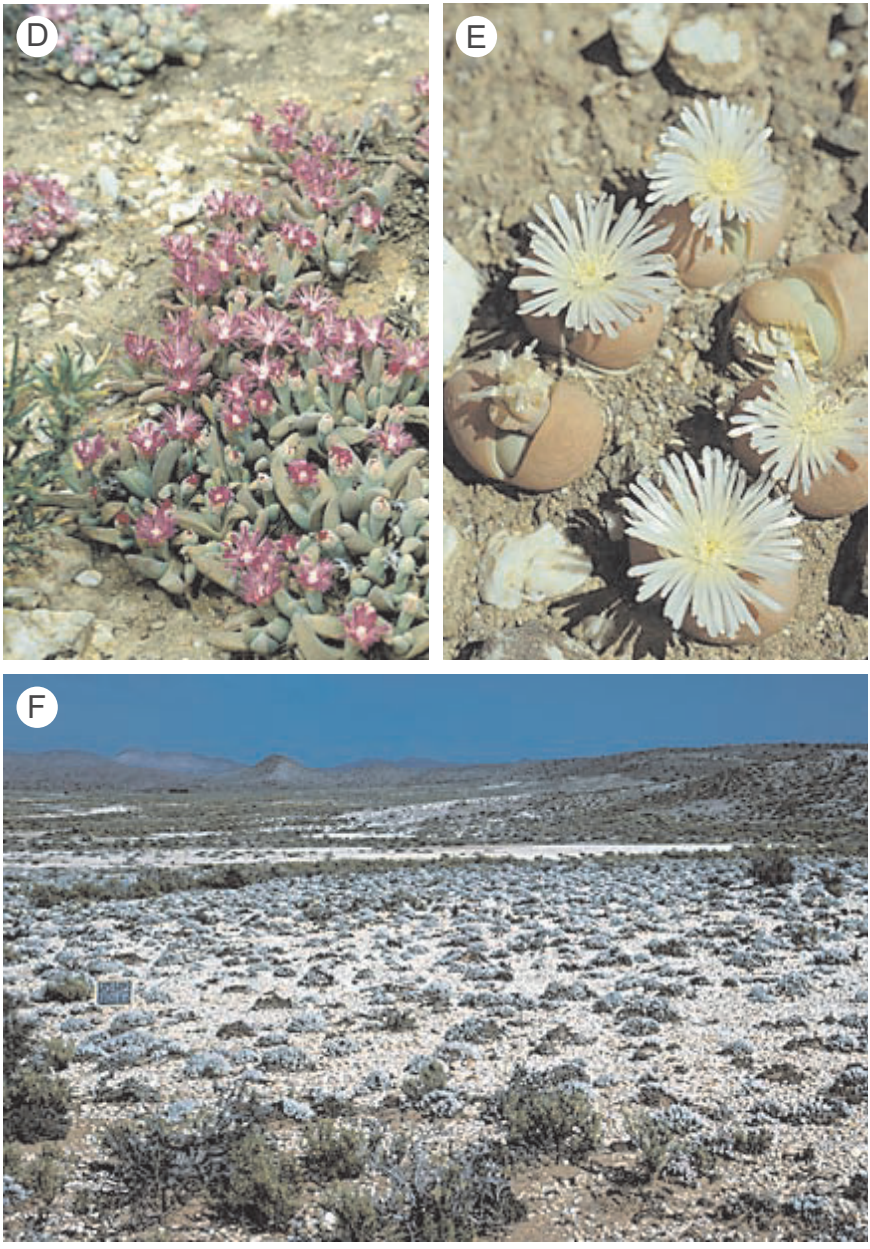


Fig. 3. Quartz fields of the Little Karoo: A: Shrubland with scattered *Sarcocornia mossiana* complex near Springfontein (W of Muiskraal); B: *Gibbaeum petrense* accompanied by a presumably non-described taxon of *Salsola* (Mucina 220303/3 STEU) in a stand of the Gibbaeetum albi at the Phisantefontein farm near Muiskraal; C: detail of the dormant *Gibbaeum petrense* plant; D: *Gibbaeum angulipes* (Krommekloof, Little Karoo); E: *Gibbaeum heathii* (Miertjieskraal, Little Karoo); F: quartz field landscape dominated by stands of the Gibbaeetum pubescentis (Eyerpoort farm, Little Karoo). Photographers: L. Mucina (A–C) and U. Schmiedel (D–F).

Life-form & structure: Vegetation cover varies in this community and is typically low (< 5 %). Species richness is one of the lowest for the quartz-field vegetation (4 spp. per rel.). The community is mainly dominated by nano-chamaephytes, whereas micro-chamaephytes and mega-chamaephytes are of subordinate importance.

Distribution & habitat: The Gibbaeetum albi is found on the tops or on the gentle slopes of low quartz hills in the Springfontein-Muiskraal area in the southern fringe of the Little Karoo (3321CC). The shallow soils are densely covered by medium-sized quartz debris. Stone content in soil is typically low (> 35 %). Fine material consists mainly of fine-grained components (silt and clay). Of high significance for the habitat of the community is the extremely high salt content (4.5 mS/cm on average). The soil pH is slightly acid to neutral.

Community Group C

C Gibbaeo dispar-Lampranthion altistyli all. nova hoc loco

Holotypus: Gibbaeetum dispar Schmiedel & Mucina 2004 hoc loco
Differential species: *Gibbaeum dispar, Glottiphyllum salmii, Lampranthus altistylus* and differential species of the subordinate associations

Structure & texture: Vegetation classified within this alliance is dominated by leaf-succulent dwarf shrubs, which typically occur with low cover values. They might be accompanied by other leaf-succulents (*Malephora lutea*, *Psilocaulon articulatum*, *Tetragonia robusta*) or non-succulent shrubs (*Pteronia pallens*, *Chrysocoma ciliata*).

Distribution & habitat: The communities of this alliance are restricted to the southern fringe of the Little Karoo, where they typically occur on poorly weathered shale bands (the Gibbaeetum dispar and the Zeuktophylletum suppositi) or saline, shallow soils (the Gibbaeetum petrensis) with or without quartz cover.

C5 Gibbaeetum dispar ass. nova hoc loco

Holotypus: Tab. 3, relevé no. 24 (field code: 7308.0)
(*Gibbaeum dispar* Succulent Dwarf Shrub Community)

Floristic composition: The community is defined by the occurrence of dominating *G. dispar. Lampranthus altistylus* is also found here with high constancy. *Hereroa tenuifolia*, *Malephora lutea* and other species occur with low constancy and cover.

Life-form & structure: Typically the vegetation cover is as low as 6 % and the number of species recorded per relevé is also low (4–9 spp.). The community is characterised by nano-chamaephytes, among which micro-chamaephytes and mega-chamaephytes show only low constancy and cover values.

Distribution & habitat: The Gibbaeetum dispar is restricted to a small area between Kromkloof (Springfontein area, 3321CC) and Vanwyksdorp

(3321CD). It is typically found on exposed, poorly weathered shale bands with or without quartz cover. These shale bands are often covered with foliose lichens. The fine-material is restricted to crevices or forms a thin layer on top of the bedrock, and it contains a high stone content (median: 56 %). The soil is well drained; salt content is usually very low (< 1 mS/cm). The soil pH varies between moderately acid and slightly alkaline (5.2–7.4).

C6 Zeuktophylletum suppositi ass. nova hoc loco

Holotypus: Tab. 3, relevé no. 28 (field code: 5679.0)
(*Zeuktophyllum suppositum* Succulent Dwarf Shrub Community)

Floristic composition: The Zeuktophylletum suppositiis defined by the Little Karoo dominant endemic *Zeuktophyllum suppositum* (Hartmann 1998) as well as *Crassula tetragona* subsp. *acutifolia*, *Gazania lichtensteinii*, *Othonna cylindrica* and *Prenia tetragona. Hereroa tenuifolia* can be co-dominant in places as well. The community shows a very heterogeneous composition. Common species with high constancy include *Anacampseros papyracea* subsp. *papyracea*, *Psilocaulon articulatum*, *Chrysocoma ciliata* and *Lampranthus altistylus*.

Life-form & structure: The vegetation cover recorded for this community is typically low. In contrast to most of the other communities of the quartz-field vegetation of the Little Karoo, the number of species per relevé is typically high (> 6 spp.) and associated with a high constancy of more widespread species. The community is mainly dominated by shrubby, micro-chamaephytes and mega-chamaephytes, which are mainly leaf succulents. Nano-chamaephytes are rare and score low cover values.

Distribution & habitat: Due to the small range-size of distribution of *Z. suppositum*, the community is restricted to a very small area between Kromkloof and Miertjieskraal (3321CC) in the southern part of the Little Karoo. The community is found in a similar type of habitat as the Gibbaeetum dispar – on rocky, poorly weathered shale bedrocks supporting shallow, skeletal soils. Slightly acid soil pH (4.8–7.1) and the very low electrical conductivity (median: 0.6 mS/cm) are similar to those of the Gibbaeetum dispar. However, the Zeuktophylletum suppositi is usually found on steeper slopes and on bedrock, which is deeply weathered, resulting in a deeper soil profile, but still a high content of soil skeleton.

C7 Gibbaeetum petrensis ass. nova hoc loco

Holotypus: Tab. 3, relevé no. 39 (field code: 7322.0)
(*Gibbaeum petrense* Succulent Dwarf Shrub Community)

Floristic composition: The diagnostic species of the Gibbaeetum petrensis are *G. petrense, Salsola* sp. (Schmiedel 104753 HBG) and *Gibbaeum hortenseae* (syn. *Muiria hortenseae*). The latter is endemic to the Springfontein Farm (Brown 1927, Hall 1956) and forms very localised,

monodominant stands, which may represent a community on its own. An endemic *Limonium* sp. (preliminary name: "*gibbaeophilum*") (L. Bolus 26602 BOL, Schmiedel 110025 HBG, Mucina 220303/1 STEU) found in this community represents a new taxon, pending description (L. Mucina & U. Schmiedel, in prep.). Common species with high constancy are *Pteronia succulenta* and *Psilocaulon articulatum*.

Life-form & structure: The total vegetation cover of this community is dictated by the dominating *G. petrense*. The species richness is comparatively low (6 spp. per rel. on average). Nano-chamaephytes dominate the vegetation and in some localities they may reach very high cover values. Several micro-chamaephytes and mega-chamaephytes also occur here, but typically they show low cover values.

Distribution & habitat: The community is restricted to a small area in the southern fringe of the Little Karoo, where it is typically found on gentle slopes or foothills with shallow soils (5–35 cm), moderate stone content (median: 36 %) and very high salinity (median: 4.6 mS/cm). The soil pH is about neutral to slightly alkaline (7–8).

Community Group D

D Gibbaeo nuciformi-Pteronion viscosi all. nova hoc loco

Holotypus: Gibbaeetum nuciformis Schmiedel & Mucina 2006 hoc loco
Differential taxa: *Asparagus recurvispinus*, *Drosanthemum giffenii*, *Euphorbia arceutobioides*, *Felicia fascicularis*, *Gazania krebsiana* complex, *Gibbaeum heathii*, *G. nuciforme*, *Haworthia viscosa*, *Octopoma quadrisepalum*, *Pentzia incana*, *Pteronia glomerata*, *P. viscosa*, *Rhinephyllum muirii*, *Rosenia humilis*, *Ruschia cradockensis* subsp. *triticiformis*, *Salsola tuberculata* complex, *Zygophyllum retrofractum*

The communities of this alliance occur on quartz fields located between Kruisrivier and Calitzdorp in the central and northern parts of the Little Karoo.

D8 Gibbaeetum nuciformis ass. nova hoc loco

Holotypus: Tab. 4, relevé no. 7 (field code: 5652.0)
(*Gibbaeum nuciforme* Succulent Dwarf Shrub Community)

Floristic composition: The diagnostic species of the community is *G. nuciforme*, which also dominates the vegetation in the majority of stands. Common species include *Pteronia pallens* and *P. succulenta*.

Life-form & structure: The total cover is low (< 10 %), but some relevés scored high species richness (15–22 spp.) while many can show only less than 5 species. The stands of the Gibbaeetum nuciformis have a multilayered structure. Dwarf leaf-succulent nano-chamaephytes as well as fruticose mega-chamaephytes (majority non-succulent to sub-succulent) are the

constituent growth-forms. At some localities also micro-chamaephytes attain high cover values.

Locality & habitat: The community is widespread in the northern Little Karoo. It was sampled in broad valleys of the Anysberg area (Eyerpoort, Touwsfontein, Vrede), the area north of the Warmwaterberg, the Ockertskraal area as well as in the vicinity of Calitzdorp (Eastern Little Karoo). It mainly occurs on flats or gentle slopes of low hills. The soil surface is typically moderately to densely covered with fine to medium-sized quartz debris with admixture of shale and sandstone gravel. At few localities the community was also recorded for desert pavements with no quartz, but characterised by very high percentage of sandstone gravel. The salinity in soil is often very high (> 3 mS/cm), but for several localities very low values were recorded (< 1 mS/cm) as well. The soil pH is typically slightly alkaline (6.5–8) and the occurrence of carbonate was recorded in several sites – a phenomenon quite unusual for quartz-field habitats.

D9 Gibbaeetum pubescentis ass. nova hoc loco

Holotypus: Tab. 4, relevé no. 61 (field code: 5120.0)
(*Gibbaeum pubescens* Succulent Dwarf Shrub Community)

Floristic composition: The diagnostic species of the community is *Gibbaeum pubescens*, which also dominates the vegetation in most of the stands (Fig. 3). Common species with high constancy are *Pteronia pallens*, *P. succulenta* and *Berkheya spinosa*. Other species occur with low constancy.

Two subassociations were recognised within the Gibbaeetum pubescentis, such as:

D9a Gibbaeetum pubescentis gibbaeetosum nuciformis

D9b Gibbaeetum pubescentis berkheyetosum cuneati

The sub-communities differ from each other with respect to their habitat ecology (see below) and are differentiated by presence/absence of *Gibbaeum nuciforme*, which occurs in the gibbaeetosum unciformis as differential species. *Berkheya cuneata*, which occurs with high constancy in the berkheyetosum cuneati, is largely absent from the gibaeetosum unciformis.

Locality & habitat: The community is found in quartz fields with moderate to dense surface quartz cover, which is often mixed with shale debris. This is significantly different from the other quartz-field communities of the northern Little Karoo, which are typically found on soils with a dense and pure cover of quartz debris or (as in some localities) on soils containing sandstone rubble. The habitats of the Gibbaeetum pubescentis are characterized by shallow soils with a high stone content. The fine material consists of silty sand to clayey loam. The soil acidity ranging between pH 4 and pH 8.5 and the values of electric conductivity spanning from less than 0.01 to more than 5 mS/cm suggest very variable salt content. The gib-

Tab. 4. Relevé table of Communities D8 and D9.

Relevé no.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Community Group		D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
Community		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Sub-Community																															
Field code		5087,0	5094,0	5107,0	5648,0	5649,0	5650,0	5652,0	5653,0	5665,0	5666,0	5667,0	5668,0	5669,0	5672,0	5689,0	5699,0	5701,0	5702,0	5703,0	5704,0	7068,0	7306,0	7327,0	7329,0	9154,0	9168,0	9175,0	9176,0	9185,0	9187,0
SA National Grid		3320CB	3320CB	3320CB	3320DA	3320DA	3320DA	3322DA	3322DA	3320DA	3320DA	3320DA	3320DA	3322DA	3321BA	3321CC	3322BC	3322BC	3322BC	3322BC	3322BC	3321CC	3320DA	3320DD	3320DD	3320BD	3321CB	3321DA	3321DA	2818BD	2818DB
Latitude [degrees.minutes] S		33,35	33,35	33,35	33,35	33,35	33,35	33,35	33,35	33,35	33,35	33,35	33,35	33,35	33,40	33,49	33,21	33,21	33,21	33,21	33,21	33,48	33,42	33,47	33,47	33,15	33,38	33,37	33,30	33,27	
Longitude [degrees.minutes] E		20,30	20,30	20,30	20,39	20,39	20,39	20,39	20,39	20,39	20,39	20,39	20,39	20,39	21,09	21,05	20,44	20,44	20,44	20,44	20,44	21,06	20,42	20,57	20,57	20,50	21,01	21,43	21,30	20,36	
Aspect [degrees]		270	-	158	0	0	0	1	1	1	1	1	1	1	135	180	270	90	90	1	90	45	0	180	180	90	180	0	1	1	180
Slope [%]		11	0	2	0	0	0	1	1	2	2	2	2	2	2	9	6	4	11	5	11	10	0	3	1	1	3	0	2	1	2
Soil depth [cm]		2	9	18	22	22	22	25	20	32	-	-	-	29	30	20	30	17	35	20	25	5	10	15	15	25	30	10	5	0	25
Stone cover non-quartz [%]		80	2	45	0	0	0	10	5	5	5	5	15	5	25	5	0	0	0	10	0	0	20	88	80	100	80	100	17	35	32
Stone cover quartz [%]		40	80	45	0	90	30	80	76	80	81	70	60	36	70	90	90	91	81	82	90	80	75	0	15	0	11	0	80	30	50
Stone content in soil [% of mass]		70	34	35	20	21,5	43	14	30	42,3	-	-	-	13	80	24	50	10	10	10	30	50	12	7	2	53	15	18,5	27	40	10
Soil texture		-	Lt	Lt	Lts	Lts	Ltu	Lt	Lt	Lts	-	-	-	Lts	Lts	Su3	fS	-	Ls	Su2	fSu2	Lts	-	Su	-	Lts	Ls	Lst	Lst	Sl	Su2
Soil pH		8,1	7,6	7,9	7,4	7,4	7,3	7,1	7,2	6,9	-	-	-	6,4	7,1	6,3	6,5	6,8	7,1	7,1	6,4	6,3	8,0	8,1	8,2	7,4	7,7	7,5	7,3	7,5	8,2
Electric conductivity [mS/cm]		0,62	6,83	1,35	0,66	6,04	3,07	3,00	5,14	5,91	-	-	-	0,83	1,81	0,55	0,22	3,47	0,97	2,16	0,19	4,95	1,73	0,25	0,39	1,84	3,82	4,27	3,11	1,47	1,57
Carbonate [HCl test, class 1-5]		0	0	3,2	0	0	0	0	0	0	0	0	0	0		0	0	0	2	0	0	0	0	0	0	2	0	3,3	0	0	4
Cover [%]		2,2	5,6	4,0	3,3	0,0	1,6	27,6	0,1	1,2	7,5	13,0	8,1	10,6	7,9	10,0	6,8	11,0	5,6	9,3	6,1	4,4	3,5	16,5	19,4	6,6	4,5	12,5	7,4	3,1	9,8
Number of taxa		6	8	12	5	1	3	10	3	2	3	5	5	5	13	14	22	13	15	13	15	11	4	10	8	7	5	9	12	4	5
Gibbaeum nuciforme	d:D8, D9a	1	4	1	1	1	2	6	1	1	5	5	2	2	5	3	1	5	1	5	1	3	2	4	4	2	2	3	3	3	2
Gibbaeum pubescens	d:D9	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Crassula capitella subsp. *thyrsiflora*	d:D8	.	.	.	1	.	.	1	.	.	1	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Octopoma octojuge	d:D8	.	.	1	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.
Salsola sp. 104699	d:D8	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	1	.	.	.	.	3	.	.	.	.
Dicoma relhanioides	d:D8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	1	1	.	.	.	.	.	.	.	.	.	.
Pteronia glomerata	d:D8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1	1	2	.	.	.	.	.	.	.	.	.	.
Pteronia flexicaulis	d:D8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	1	.	.	.	.	.	.	.	.	.
Cephalophyllum subulatoides	d:D8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	1	.	.	.	.	.	.	.	.	.	.
Pteronia staehelinoides	d:D8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	.	1	.	.	.	.	.	.	.	.	.	.
Gibbaeum geminum	d:D8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	1	.	.	.	.	.	.
Pelargonium sp. 5699	d:D8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1	.	.	.	.	.	.	.	.	.	.
Pteronia glauca	d:D8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1	.	.	.	.	.	.	.	.	.	.
Stomatium sp. 104797	d:D8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	.	.	.	.	.	.	.	.	.	.	.
Rhinephyllum muirii		.	.	.	.	.	.	1	1	1	1	1	.	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gibbaeum heathii		1	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	.	.	.	.	.	1	3	1	.	.	.	.	.	.
Drosanthemum delicatulum		.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1	.	.	.	.	.	.	1	1	.
Psilocaulon junceum		.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.
Salsola tuberculata complex		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	.	.	.	.	.	.	.	.	.	.	.
Adromischus filicaulis subsp. marlothii		.	.	.	.	.	.	1	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Salsola sp. 104753		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.
Antegibbaeum fissoides	d:D9	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Bulbine succulenta	d:D9	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Tab. 4. (cont.).

31	D	9	a	5064,0	3320CB	33,35	20,30	202	5	14	50	50	75	–	7,6	5,60	0	3,1	4
32	D	9	a	5072,0	3320CB	33,35	20,30	315	2	15	0	91	38	Lt	7,4	5,19	0	6,5	11
33	D	9	a	5075,0	3320CB	33,35	20,30	180	5	24	0	90	16	Lt	8,0	7,78	0	7,4	8
34	D	9	a	5077,0	3320DA	33,40	20,35	0	4	26	0	95	60	Lt	7,4	2,55	1	14,7	13
35	D	9	a	5079,0	3320DA	33,40	20,35	0	4	15	0	90	73	Lt	7,1	0,00	0	11,1	18
36	D	9	a	5084,0	3320DA	33,40	20,35	–	0	15	0	90	66	Lt	8,5	5,08	0	11,3	7
37	D	9	a	5092,0	3320DA	33,40	20,35	–	0	15	0	80	70	Lt	7,2	0,05	0	13,2	8
38	D	9	a	5101,0	3320DA	33,40	20,35	180	9	23	0	80	44	Sl	8,0	6,27	2	8,1	11
39	D	9	a	5105,0	3320DB	33,43	20,44	0	0	5	10	80	12	–	7,1	3,61	0	10,7	7
40	D	9	a	5110,0	3320DA	33,42	20,42	0	0	32	25	40	28	Lt	7,1	4,07	0	4,9	12
41	D	9	a	5148,0	3320DA	33,42	20,42	35	5	12	0	96	45	Lt	7,9	2,81	0	9,1	9
42	D	9	a	5149,0	3320DA	33,42	20,42	35	5	10	27	71	60	Lt	7,7	6,40	0	6,8	7
43	D	9	a	5150,0	3320CB	33,35	20,30	180	8	8	70	80	50	Su	6,8	5,88	0	5,9	10
44	D	9	a	5151,0	3320CB	33,35	20,30	270	4	4	20	20	70	Ut	5,4	0,65	0	6,1	7
45	D	9	a	5164,0	3320CB	33,35	20,30	0	7	14	65	25	50	Sl	7,7	4,48	1	5,5	9
46	D	9	a	7305,0	3320CB	33,35	20,30	–	0	23	0	95	62	Lt	7,5	7,33	0	9,3	8
47	D	9	a	7334,0	3320DA	33,42	20,42	0	0	10	20	75	21	–	7,9	1,94	0	7,3	5
48	D	9	a	7335,0	3320DB	33,43	20,43	1	2	8	0	92	18	–	7,3	7,60	0	9,3	8
49	D	9	b	5065,0	3320DA	33,42	20,42	–	0	26	0	92	32	Lt	7,3	6,23	0	9,0	4
50	D	9	b	5069,0	3320DA	33,42	20,42	0	4	8	2	98	47	Lt	5,7	2,71	0	9,4	7
51	D	9	b	5080,0	3320CB	33,35	20,30	330	5	8	5	88	75		7,4	5,08	0	11,0	3
52	D	9	b	5081,0	3320CB	33,35	20,30	330	0	13	40	50	60	Su	6,7	0,03	0	10,2	20
53	D	9	b	5082,0	3320CB	33,35	20,30	315	2	3	10	89	60	Sl	7,3	4,91	0	7,0	2
54	D	9	b	5085,0	3320CB	33,35	20,30	270	7	18	10	60	30	Su	4,7	1,92	0	13,9	7
55	D	9	b	5088,0	3320CB	33,35	20,30	0	8	14	27	71	75	Lts	7,4	4,95	0	9,2	6
56	D	9	b	5096,0	3320CB	33,35	20,30	0	2	5	0	85	31	Lt	6,0	1,28	0	2,6	7
57	D	9	b	5097,0	3320CB	33,35	20,30	0	2	8	0	80	80	Sl	6,2	2,77	0	12,1	16
58	D	9	b	5102,0	3320CB	33,35	20,30	–	0	14	1	90	19	–	7,2	3,51	0	5,3	6
59	D	9	b	5108,0	3320CB	33,35	20,30	160	4	12	5	91	50	Lt	7,3	2,93	0	5,3	12
60	D	9	b	5119,0	3320DA	33,40	20,35	340	1	14	0	90	54	Lt	7,4	7,59	0	4,0	4
61	D	9	b	5120,0	3320DA	33,40	20,35	340	5	7	0	80	44	Ul	6,1	1,47	0	9,8	12
62	D	9	b	5123,0	3320DA	33,40	20,35	–	0	14	20	80	42	Su4	4,2	0,09	0	4,7	14
63	D	9	b	5125,0	3320DA	33,40	20,35	315	2	13	50	40	64	Su4-Ul	4,6	0,14	0	10,7	11
64	D	9	b	5126,0	3320DA	33,40	20,35	–	0	2	70	10	44	Ul	4,4	1,14	0	3,2	10
65	D	9	b	5127,0	3320DA	33,40	20,35	260	11	5	20	40	80	Su4	7,2	0,30	0	5,5	12
66	D	9	b	5128,0	3320DA	33,40	20,35	280	5	13	0	15	27	Ul	7,1	0,42	0	6,8	8
67	D	9	b	5132,0	3320DA	33,40	20,35	120	13	6	50	4	31	Su	6,9	1,19	0	3,9	11
68	D	9	b	5134,0	3320DA	33,40	20,35	230	29	14	50	53	65	Su	7,1	0,88	0	8,5	17
69	D	9	b	5135,0	3320DA	33,40	20,35	220	13	8	80	3	33	Su	5,9	1,20	0	5,7	19
70	D	9	b	5136,0	3320DA	33,40	20,35	220	13	13	0	85	78	Lu	4,8	2,48	0	7,9	14
71	D	9	b	5138,0	3320DA	33,40	20,35	180	2	10	0	60	60	Lts	7,6	5,45	0	7,7	11
72	D	9	b	5140,0	3320DA	33,40	20,35	320	2	10	20	80	85	–	4,0	0,36	0	5,1	10
73	D	9	b	5142,0	3320DA	33,40	20,35	320	7	22	0	95	68	Lt	4,1	0,82	0	4,6	14
74	D	9	b	5143,0	3320DA	33,40	20,35	320	7	19	0	80	67	Lt	6,0	0,15	0	11,0	18
75	D	9	b	5145,0	3320DA	33,40	20,35	270	4	16	70	20	33	Ut	5,6	0,74	0	7,2	6
76	D	9	b	5146,0	3320DA	33,40	20,35	–	8	12	95	0	66	Ut	5,4	0,26	0	4,1	5
77	D	9	b	5147,0	3320DA	33,40	20,35	0	2	12	0	95	56	Su	6,6	2,91	0	8,0	3
78	D	9	b	5152,0	3320DA	33,40	20,35	225	2	12	0	95	68	Lts	6,9	3,59	0	10,1	7
79	D	9	b	5153,0	3320DA	33,40	20,35	270	4	6	95	5	67	Su	6,6	0,64	0	4,2	10
80	D	9	b	5161,0	3320DA	33,40	20,35	160	2	9	5	61	85	Su	4,6	0,37	0	7,6	20
81	D	9	b	5162,0	3320DA	33,40	20,35	0	7	14	5	80	62	Su	5,6	2,36	0	7,6	14
82	D	9	b	5165,0	3320DA	33,40	20,35	20	2	27	0	90	80	Sl	6,1	1,98	0	10,3	4
83	D	9	b	5166,0	3320DA	33,40	20,35	20	4	22	1	85	66	Su	4,9	0,36	0	14,1	10
84	D	9	b	5643,2	3320DA	33,38	20,35	45	9	6	10	70	42	Su	4,7	0,56	0	0,0	16
85	D	9	b	5645,0	3320DA	33,38	20,35	270	2	17	0	80	52	Lts	4,2	1,15	0	4,3	10
86	D	9	b	5647,0	3320DA	33,38	20,35	180	4	30	5	90	43,7	Lts	4,2	0,83	0	5,0	17
87	D	9	b	7292,0	3320DD	33,51	20,52	1	2	25	0	85	20	–	4,1	4,65	0	11,8	9
88	D	9	b	9160,0	3320DA	33,38	20,36	1	3	30	0	100	50	Su4	4,6	1,75	0	11,4	9
89	D	9	b	9181,0	3321CA	33,30	21,02	1	2	10	20	75	30	Ls	6,0	4,88	0	7,3	10
90	D	9	b	9182,0	3320DA	33,39	20,33	112	2	8	172	3	60	Ut	6,5	2,87	0	9,4	10

1	3	1	1	2	1	1	5	4	1	5	5	5	5	4	1	5	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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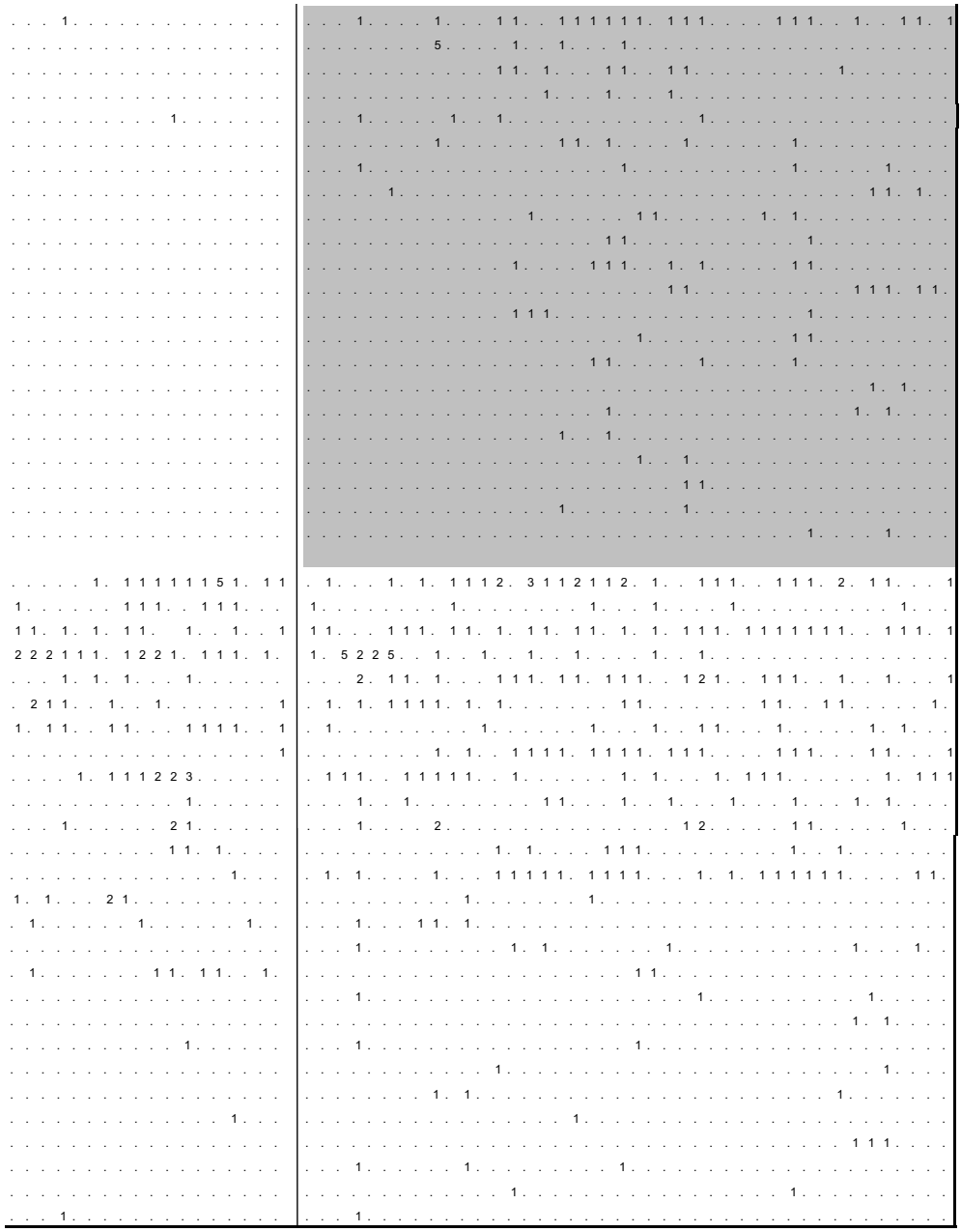
Tab. 4. (cont.).

Berkheya cuneata	d:D9b	. . . . . 1 . . . . .
Eriocephalus ericoides	d:D9b	. . . . .
Crassula pyramidalis	d:D9b	. . . . . 1 . . . . .
Conophytum joubertii	d:D9b	. . . . .
Asparagus sp. US 5099	d:D9b	. . . . .
Pentzia incana	d:D9b	. . . . .
Drosanthemum giffenii	d:D9b	. . . . .
Tripteris sinuata var. *linearis*	d:D9b	. . . . .
Lycium cinereum complex	d:D9b	. . . . .
Glottiphyllum neilii	d:D9b	. . . . .
Drosanthemum praecultum	d:D9b	. . . . . 1 . . . . .
Adromischus triflorus	d:D9b	. . . . . 1 . . . . .
Crassula cotyledonis	d:D9b	. . . . .
Helichrysum asperum var. *asperum*	d:D9b	. . . . .
Hirpicium integrifolium	d:D9b	. . . . .
Phyllobolus splendens subsp. *splendens*	d:D9b	. . . . .
Felicia fascicularis	d:D9b	. . . . .
Hyobanche glabrata	d:D9b	. . . . .
Ornithogalum thyrsoides	d:D9b	. . . . .
Oxalis sp.	d:D9b	. . . . .
Zygophyllum flexuosum	d:D9b	. . . . .
Crassula deceptor	d:D9b	. . . . .
Pteronia pallens		. 1 1 1 . . 1 . . . . . 1 3 1 1 1 1 . . . . 1 . 1 1 . 1
Malephora lutea		. 1 1 1 . 1 1 . . . . . 1 . . . . . 1 . . . . .
Tetragonia robusta		. 1 1 . . . . . 1 . 1 1 1 . . 1 . . . 1 1 . . 1 .
Salsola sp. 102066		1 1 1 . . . 1 . . . . . 2 6 . . . . .
Berkheya spinosa		. . . . . 1 1 . 1 1 1 . . . . .
Pteronia viscosa		. . . . . 1 . . . . 3 . 1 . . . . . 1 . . . . 1 . .
Psilocaulon articulatum		. . . . . 1 . 1 1 1 . . 1 . 3 . . . . 1 . .
Chrysocoma ciliata		. . . . . 1 . . . 2 3 5 . . 1 . . . . . 1 . . . . .
Pteronia succulenta		. 1 1 . . . . . 1 3 1 1 1 2 1 1 . . 1 . . . 1 . 5
Hereroa tenuifolia		1 . 1 . . . . . 3 . 1 1 1 . . . . . 1 1
Felicia filifolia		. . . . . 1 1 . . . . . 1 . . . . .
Sceletium tortuosum		. . . . . 1 . . . . .
Osteospermum microphyllum		. 1 . . . . . 1 . 1 1 1 1 1 . . . . . 1 . .
Zygophyllum retrofractum		1 . 1 . . . . . 1 . 1 . 1 . . .
Octopoma quadrisepalum		. . 1 . . . . . 1 . . . . .
Avonia papyracea subsp. *papyracea*		. . . . . 1 . . 1 1 1 . . . . . 1 . .
Crassula columnaris subsp. *columnaris*		. . . . . 1 1 . . . . . 1 . 1 . 1 . 1 . . 1 1 . . 1 . . .
Crassula tecta		. . . . . 1 . . .
Zeuktophyllum calycinum		. . . . . 1 . . . . . 1 . .
Pteronia empetrifolia		. . . . . 1 . .
Euphorbia arceuthobioides		. . . . . 1 . . . . 1 . . . . .
Crassula subaphylla var. *subaphylla*		. . . 1 . . . . . 1 . . . . .
Atriplex lindleyi subsp. *inflata*		. . . . . 1 . . . . . 1 1 1 1 . .
Conophytum minimum		. . . . . 1 1 . . . . .
Crassula muscosa var. *muscosa*		. . . . . 1 1 . .
Hermannia cuneifolia		. . . . . 1 . . . . .
Ruschia impressa		1 . . . . .

Tab. 4. (cont.).



baeetosum nuciformis usually occurs on neutral to alkaline soils (pH > 7; median: 7.5; > 2 mS/cm, median: 4.8 mS/cm). In contrast, the berkheyetosum cuneati shows broader variation with respect to soil pH and salinity, and the median values are considerably lower (pH 6.0 and 1.4 mS/cm, resp.).

D9a Gibbaeetum pubescentis gibbaeetosum nuciformis subass. nova hoc loco

Holotypus: Tab. 4, rel. no. 36 (field code: 5084.0)
(*Gibbaeum pubescens-G. cryptopodium* Sub-Community)

Floristic composition: The differential species of this subassociation is *G. nuciforme. G. pubescens* and *G. nuciforme* are co-dominant. The abundance of the two species varies considerably, mainly depending on the composition of the stone pavement. High cover values of *G. nuciforme* were only recorded for sites with dense quartz cover on the soil surface, whereas *G. pubescens* may dominate on both pavements with high or low percentage of quartz debris.

Life-form & structure: The stands of this subassociation are dominated by subterranean nano-chamaephytes and dense, cushion-like micro-chamaephytes. Fruticose mega-chamaephytes, represented in the upper layer, have low cover values.

Distribution & habitat: So far this vegetation has only been recorded in the quartz-field area north of the Warmwaterberg (from Eyerpoort to Jakkalsfontein), where it is found on plains. The quartz cover is moderate to dense, often mixed with shale. The average soil pH is slightly alkaline (pH 7.5) and the salinity of the soil is very high for most of the stands (4.7 mS/cm). The high content of clayey loam in the fine material is reminiscent of the soil characteristics of the Gibbaeetum nuciformis.

D9b Gibbaeetum pubescentis berkheyetosum cuneati subass. nova hoc loco

Holotypus: Tab. 4, rel. no. 61 (field code: 5120.0)
(*Gibbaeum pubescens-Berkheya cuneata* Sub-Community)

Floristic composition: This subassociation is differentiated by *Berkheya cuneata*, *Adromischus triflorus*, *Conophytum joubertii*, *Crassula cotyledonis*, *C. deceptor*, *C. pyramidalis*, *Drosanthemum giffenii*, *D. praecultum*, *Eriocephalus ericoides*, *Felicia fascicularis*, *Glottiphyllum neilii*, *Helichrysum asperum* var. *asperum*, *Hirpicium integrifolium*, *Hyobanche glabrata*, *Lycium cinereum* complex, *Ornithogalum thyrsoides*, *Pentzia incana*, *Phyllobolus splendens* subsp. *splendens*, *Tripteris sinuata* var. *linearis* and *Zygophyllum flexuosum*. It is further characterised by the dominant status of *Gibbaeum pubescens*. In contrast to the gibbaeetosum nuciformis (D9a), *Gibbaeum nuciforme* is absent here.

Life-form & structure: Like in the gibbaeetosum nuciformis, the vegetation cover is low, typically below 10 %. The average number of spe-

cies per relevé is 10 spp. Compact, leaf-succulent micro-chamaephytes dominate this vegetation. Among those, fruticose, non-succulent micro-chamaephytes and mega-chamaephytes are also present, but seldom reach higher cover values.

Distribution & habitat: The sub-community was recorded for the area north and east of the Warmwaterberg, between Touwsfontein Farm in the west and Lemoenshoek in the east. It occurs on very gentle slopes of small hills, shale bands, or on slightly inclined valley bottoms. The soil surface is moderately or densely covered with quartz debris, which is often mixed with dark shale. At some localities the shale component may dominate. The fine-material is sandy silt or clayey loam. The soils are shallow (median: 12.5 cm) and rich in stone content (30–70 %). The soils supporting the berkheyetosum cuneati show a comparatively wide range of pH (acid and slightly alkaline, mostly with pH below 7) and electric conductivity (0.1–7 mS/cm, median 1.4 mS/cm).

D10 Aridario defoliati-Pteronietum pallentis ass. nova hoc loco

Holotypus: Tab. 5, rel. no. 5 (field code: 5116.0)
(*Pteronia pallens-Aridaria noctiflora* subsp. *defoliata* Shrubland Community)

Floristic composition: This community is characterised by dominance of *Pteronia pallens* and occurrence of *Aridaria noctiflora* subsp. *defoliata*, *Ruschia cradockensis* subsp. *cradockensis* and *Drosanthemum crassum*. Although this community occurs outside the quartz fields, it shares a number of taxa with the latter habitats, of which only *Malephora lutea*, *Lycium cinereum* complex and *Salsola* sp. (Schmiedel 102066 HBG) occur with higher constancy.

Life-form & structure: The Aridario-Pteronietum pallentis does not differ significantly from other communities of special habitats such as quartz fields or other rocky habitats either in terms of vegetation cover or species richness. The community is dominated by fruticose mega-chamaephytes, which are mainly non-succulent or sub-succulent. Micro-chamaephytes occur with low constancy and cover. Nano-chamaephytes are largely absent, but in some localities creeping chamaephytes reach high cover values.

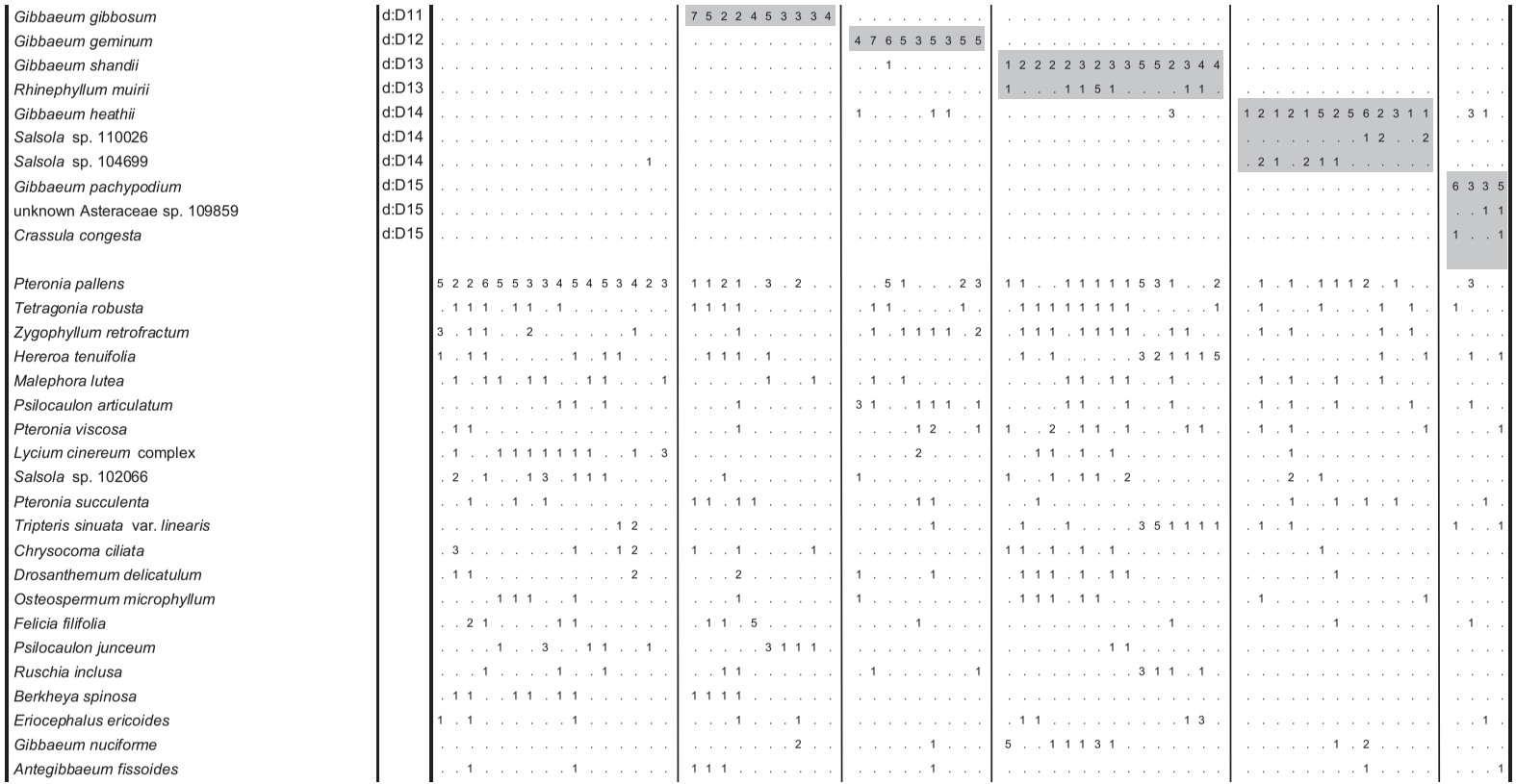
Locality & habitat: The most characteristic feature of the habitats of this community is the highest carbonate status of all studied communities. None of the quartz-field communities, except in part for the Gibbaeetum shandii (D13), showed any association with carbonate. Due to the high carbonate content, the soil pH is typically neutral to alkaline (7–8). The values of conductivity are very low (often < 0.1 mS/cm).

Notes: *Pteronia pallens* is a common species of the intermountain plains of the Little Karoo. It has been recorded with high constancy but low cover values for most of the quartz-field communities (5–15 %) as well. *P. pallens* is supposed to be unpalatable and has often been interpreted as indicator for overgrazing (Yeaton & Esler 1990, Milton & Wiegand 2000).

Tab. 5. Relevé table of Communities D10 through D15.

Relevé no.																					
Community Group	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
Community																					
Field code	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
SA National Grid	5076,0	5100,0	5109,0	5115,0	5116,0	5120,0	5121,0	5124,0	5131,0	5137,0	5141,0	5154,0	5157,0	5644,0	5655,0	5690,0	5111,0	5113,0	5114,0	5158,0	7337,0
	3320DA	3320CB	3320CB	3320CB	3320DA	3320DA	3320DA	3320DA	3320DA	3320DA	3320DA	3320DA	3320DA	3320DA	3322DA	3321CC	3320CB	3320CB	3320CB	3320DA	3320CA
Latitude [degrees.minutes] S	33,42	33,35	33,35	33,33	33,40	33,40	33,40	33,40	33,40	33,40	33,40	33,40	33,40	33,38	33,35	33,49	33,33	33,33	33,33	33,40	33,33
	20,42	20,30	20,39	20,18	20,35	20,35	20,35	20,35	20,35	20,35	20,35	20,35	20,35	20,35	20,39	21,10	20,18	20,18	20,18	20,35	20,14
Longitude [degrees.minutes] E	315	160	230	337	340	315	280	230	180	320	180	45	35	180	180	270	180	180	180	180	180
Aspect [degrees]	10	0	13	4	2	2	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Slope [%]	6	18	4	18	7	22	17	60	0	4	0	18	6	0	10	6	11	4	11	15	0
Soil depth [cm]	51	25	80	1	10	60	50	0	0	20	0	21	90	40	50	31	3	40	50	100	0
Stone cover non-quartz [%]	0	0	5	3	0	0	10	0	0	0	0	1	0	40	0	69	95	60	45	0	5
Stone cover quartz [%]	78	60	63	13	17	62	62	47	42	70	84	8	68	53,5	0	26	60	22	70	63	75
Stone content in soil [% of mass]	Sl	Su	Lt	Sl	Sl	Sl	Su4	Su4	Su	Sl	Lt	Su	Sl	Lts	Su	'	Su	Su	Lt	Sl	Su
Soil texture	7,6	7,7	7,9	7,6	7,5	7,2	7,9	7,9	8,1	7,8	6,0	7,7	7,8	6,7	'	8,3	5,4	5,4	8,2	6,8	7,2
Soil pH	0,05	0,03	0,17	0,05	0,03	0,17	0,18	0,10	0,42	1,22	0,10	0,06	0,41	2,00	'	1,04	1,36	0,00	0,35	0,49	0,22
Electric conductivity [mS/cm]	4	2	3,3	4	2	2	2	0	4	2	0	0	4	0	0	3,3	0	0	0	0	0
Carbonate [HCl test, class 1-5]	24,9	14,7	6,7	7,6	5,3	11,3	6,2	9,3	6,2	7,2	8,9	4,4	9,8	5,6	10,2	37,0	37,7	7,1	7,3	10,0	11,7
Cover [%]	15	9	16	14	9	10	11	10	10	14	19	6	8	11	9	7	11	10	13	17	6
Number of taxa	11	15	15	10	5	9	6	11	10	14	5	6	8	11	9	9	11	10	13	17	6
Aridaria noctiflora subsp. *defoliata*	d:D10																				
Asparagus sp. US 5099	d:D10																				
Ruschia cradockensis subsp. *cradockensis*	d:D10																				
Drosanthemum crassum	d:D10																				

Relevé no.																					
Community Group	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
Community																					
Field code	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
SA National Grid	5158,0	5114,0	5113,0	5111,0	7338,0	7302,0	7298,0	5074,0	7314,0	7328,0	7299,0	7304,0	7300,0	7301,0	7663,0	7662,0	7660,0	7659,0	7658,0	7657,0	7656,0
	3320DA	3320CB	3320CB	3320CB	3320CA	3320DA	3320DA	3320DA	3321CA	3320DD	3320DA	3320DA	3322DA	3322DA	3322DA	3322DA	3320DB	3322DA	3322DA	3322DA	3322DA
Latitude [degrees.minutes] S	33,40	33,33	33,33	33,33	33,31	33,39	33,41	33,42	33,43	33,47	33,40	33,40	33,35	33,35	33,35	33,37	33,44	33,35	33,35	33,35	33,35
	20,40	20,18	20,18	20,18	20,19	20,44	20,37	20,42	21,10	20,57	20,40	20,40	20,39	20,39	20,39	20,37	20,57	20,39	20,39	20,39	20,39
Longitude [degrees.minutes] E	20	45	0	0	135	0	0	35	45	180	180	180	1	270	1	1	1	1	1	1	1
Aspect [degrees]	0	0	0	0	2	0	0	2	6	1	1	2	1	2	7	1	1	2	2	2	2
Slope [%]	30	0	4	11	30	17	10	6	5	10	17	10	17	23	24	8	7	18	25	25	28
Soil depth [cm]	1	0	4	13	55	15	10	45	0	60	41	92	71	0	90	80	70	48	10	86	0
Stone cover non-quartz [%]	0	0	11	40	0	44	0	50	90	6	40	0	15	18	11	0	7	52	86	55	57
Stone cover quartz [%]	0	0	50	60	0	0	10	50	0	6	41	0	1	0	80	0	73	30	55	Lts	39
Stone content in soil [% of mass]	Su	Su	Lt	Su	Sl	Sl	'	Lt	Sl	Sl	'	Su	Su	Su	Su	Lst	'	Su	Lts	Lt	Lt
Soil texture	6,8	6,5	8,2	5,4	7,9	7,9	7,8	7,9	7,7	6,7	7,9	7,3	7,0	8,0	6,9	5,0	6,6	8,1	6,7	7,6	7,5
Soil pH	0,49	0,24	0,35	1,36	0,24	0,09	0,07	4,02	1,19	0,06	1,57	0,02	0,02	0,69	0,04	0,06	0,93	0,02	1,25	0,69	4,74
Electric conductivity [mS/cm]	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	3,2	0	0	2
Carbonate [HCl test, class 1-5]	10,0	13,2	7,3	37,7	14,2	10,4	31,3	7,5	11,7	6,7	33,6	22,0	6,9	8,5	4,8	8,4	5,7	4,0	12,2	9,6	3,6
Cover [%]	17	6	13	11	6	7	9	7	12	12	7	5	15	17	10	9	9	11	10	17	8
Number of taxa	17	6	13	11	6	7	9	7	12	12	7	5	15	17	10	9	9	11	10	17	8
Aridaria noctiflora subsp. *defoliata*	d:D10																				
Asparagus sp. US 5099	d:D10																				
Ruschia cradockensis subsp. *cradockensis*	d:D10																				
Drosanthemum crassum	d:D10																				


Gibbaeum gibbosum d:D11
Gibbaeum geminum d:D12
Gibbaeum shandii d:D13
Rhinephyllum muirii d:D13
Gibbaeum heathii d:D14
Salsola sp. 110026 d:D14
Salsola sp. 104699 d:D14
Gibbaeum pachypodium d:D15
unknown Asteraceae sp. 109859 d:D15
Crassula congesta d:D15
Pteronia pallens
Tetragonia robusta
Zygophyllum retrofractum
Hereroa tenuifolia
Malephora lutea
Psilocaulon articulatum
Pteronia viscosa
Lycium cinereum complex
Salsola sp. 102066
Pteronia succulenta
Tripteris sinuata var. linearis
Chrysocoma ciliata
Drosanthemum delicatulum
Osteospermum microphyllum
Felicia filifolia
Psilocaulon junceum
Ruschia inclusa
Berkheya spinosa
Eriocephalus ericoides
Gibbaeum nuciforme
Antegibbaeum fissoides

Octopoma quadrisepalum		. 1 1 4	. . 1	. 1	1 . . 1 . . . . 1	. . . .	. . . .
Phyllobolus splendens subsp. *splendens*		. . . 1 . . . . 1 . . .	. . . . 1	. . 1	 1	. . . . 1 1	. . . 1
Berkheya cuneata		. . . . 1 1	. . . 1	. . . . . 1 . . .	. . . . 1 . .	. . . .	. . 1 1
Crassula subaphylla var. *subaphylla*		1 1 1 1 . . . . 1 .	. . 1	. . . .	. . . .	. . . . . . 1	. . . .
Pentzia incana		. 1 . . 1 . . . 1 . . . . 1 . .	. . . .	. . . .	. 1 1 . . . . . 1	. . . .	. . . .
Atriplex lindleyi subsp. *inflata*		. . . .	. . . .	. . 1 1 . . . 2 .	. . . . 1	. . . . 1	1 . . .
Crassula columnaris subsp. *columnaris*		. . . .	1 1 1	. . . . . 1 . . .	1	. . . . 1	. . . .
Asparagus recurvispinus		. . . . 1 . .	. . . .	. . . .	. . . 1 . 1 . . 1	. . . 1	. . . .
Avonia papyracea subsp. *papyracea*		. . 1 . . . . . . 1	. . . .	. . . .	. . . . . . 1	. 1 . . . . 1	. . . .
Rosenia humilis		. . . .	. . . .	. . . .	. . . 1 . 1 . . 1	. . . 1	1 . . .
Adromischus triflorus		. . . . 1 . . 1 . . .	. . . .	. . . .	. . . .	. 1	1 . . .
Crassula capitella subsp. *thyrsiflora*		. . . 1 1	. . 1	. . . .	1	. . . .	. . . .
Hereroa sp. 110134		. . . . . 1 1 . . . . . 1 . . .	. . . .	. . . .	. . 1	. . . .	. . . .
Octopoma octojuge		1	. . . .	. . . .	. . . .	. . . . . 1 1 . 1	. . . .
Pteronia empetrifolia		. . . .	. . . 1 . . . 2 . 2	. . . .	. . . .	. . . . 1 . .	. . . .
Salsola sp. 7302		3 5	. . . .	. . 1 1	. . . .	. . . . 1	. . . .
Senecio radicans		. . . 1	1 . 1	. . . .	1	. . . .	. . . .
Zeuktophyllum calycinum		. . . . 3 .	. . . .	. . . .	. . . .	. 1 . 1 . . 1	. . . .
Adromischus filicaulis subsp. *marlothii*		1	. . . .	. . . .	. . . .	. . . . . . 1 . 1	. . . .
Drosanthemum giffenii		. . . . 1 . . . 1 . . .	. . . .	. . . .	. . . . 1 .	. . . .	. . . .
Felicia fascicularis		. . . .	 1	. . . .	. . . . 1	 1	. . . .
Gibbaeum pubescens		. . . . 1	1	1	. . . .	. . . .	. . . .
Pteronia flexicaulis		. . . .	. . . . 2	. . . .	. . . .	. . . .	. . 1 1
Ruschia cradockensis subsp. *triticiformis*		. . . .	. . . . . . 3 . . 1	. 1	. . . .	. . . .	. . . .
Sceletium tortuosum		. . . . . . 1	. . . .	. . . .	. . . .	. . . 1	. . . 1

D11 Gibbaeetum gibbosi ass. nova hoc loco

Holotypus: Tab. 5, rel. no. 17 (field code: 5111.0)
(*Gibbaeum gibbosum* Succulent Dwarf Shrub Community)

Floristic composition: The dominant and diagnostic species of the community is *G. gibbosum*. Common species include *Pteronia pallens*, *P. succulenta* and *Psilocaulon junceum*.

Life-form & structure: The vegetation cover varies strongly, but is typically below 15 % (median: 10 %). The average number of species per relevé recorded was about 10 spp. The community is characterised by two layers: the low layer is built of compact nano-chamaephytes, while the higher layer consists of shrubby mega-chamaephytes, which dominate the vegetation at some localities. Micro-chamaephytes are of subordinate importance.

Distribution & habitat: The community is widespread in the central and western part of the Little Karoo along southern fringes of the Tanqua Karoo. It is typically found on nearly level plains or pediments with a moderate to dense pavement of dark-brown shale, and less frequently also on quartz fields. The substrate can be shallow to moderately deep (up to 30 cm). The stone content in soil differed considerably (1–75 %). The community typically colonises slightly acid to alkaline soils (pH: 5–8) of low salinity (median: 0.8 mS/cm).

D12 Gibbaeetum gemini ass. nova hoc loco

Holotypus: Tab. 5, rel. no. 28 (field code: 7298.0)
(*Gibbaeum geminum* Succulent Dwarf Shrub Community)

Floristic composition: *Gibbaeum geminum* is the diagnostic and dominating species of the community. Among the common species only *Zygophyllum retrofractum* and *Psilocaulon articulatum* occur with higher constancy.

Life-form & structure: The total cover of the vegetation varies strongly between less than 5 % and more than 30 % – this mainly depends on abundance of the dominant species *G. geminum*. The community is typically species-poor and supports less than 10 spp. per relevé. The community is dominated by the low-growing, mat-forming nano-chamaephyte *G. geminum*, accompanied by a low cover of micro-chamaephytes and fruticose mega-chamaephytes.

Distribution & habitat: The community occurs on level plains in the central part of the Little Karoo, between Middelplaas (north of the Warmwaterberg) and Ockertskraal in the east (3320D–3321C). The soil surface is covered with a stone pavement of quartz, shale or sandstone. The soils are shallow and the stone content in soil is less than 50 %. Fine soil material consists mainly of fine-grained fractions (sandy loam or loamy sand). The soil has an unusually high pH (neutral to alkaline: 6.7–7.9) and often shows very high values of electrical conductivity (6.6 mS/cm), although in some localities electrical conductivity was as low as 0.06 mS/cm.

D13 Gibbaeetum shandii ass. nova hoc loco

Holotypus: Tab. 5, rel. no. 49 (field code: 9163.0)
(*Gibbaeum shandii* Succulent Dwarf Shrub Community)

Floristic composition: The diagnostic species of the community are *G. shandii* (dominant) and *Rhinephyllum muirii*, compact dwarf shrubs with succulent leaves. *G. shandii* was recognised as a subspecies of *G. pubescens* by Glen (1974), the differences in habit and the anatomy of the epidermal hairs support its ranking as a separate species (Hartmann 2002b).

Life-form & structure: The vegetation cover in the Gibbaeetum shandii stands is high in some sites (> 10 %) and surpasses the values for most of the quartz-field vegetation units. However most of the stands would still not show cover more than 10 %. Also the average number of species per relevé is comparatively low (10 spp.). The community is dominated by both leaf-succulent as well as non-succulent, fruticose mega-chamaephytes. However, compact micro-chamaephytes dominate in sites where mega-chamaephytes have low cover values.

Distribution & habitat: The community is restricted to broad valleys of the area north of the Warmwaterberg in the central Little Karoo. It occurs there either on moderately or sparsely covered quartz fields or on stone pavements with high coverage of dark shale debris. The soils have low salt content (0.45 mS/cm) and are slightly alkaline (median pH: 7.3). In some localities carbonate was detected as well.

D14 Gibbaeetum heathii ass. nova hoc loco

Holotypus: Tab. 5, rel. no. 59 (field code: 9151.0)
(*Gibbaeum heathii* Succulent Dwarf Shrub Community)

Floristic composition: The diagnostic species are *G. heathii* and *Salsola* sp. (Schmiedel 110026 HBG). *G. heathii* (Fig. 3) dominates most stands, but *Salsola* sp. (Schmiedel 110026 HBG) as well as *Pteronia pallens* often occur with high cover values. Common species with high constancy include *Hereroa tenuifolia*, *Pteronia pallens*, *P. viscosa*, *Tetragonia robusta* and *Zygophyllum retrofractum*.

Life-form & structure: Although in one vegetation stand (rel. 9195) we recorded cover value as high as 21 %, the average cover is low – around 5 %. The species richness here varies considerably between 2 and 16 species. The growth-form composition of the community is heterogeneous, comprising nano-, micro-, and mega-chamaephytes. However, the subglobose nano-chamaephytes *(G. heathii)* dominate. In some localities the mega-chamaephytes reach higher cover values, which results in a two-layer structure of the vegetation.

Distribution & habitat: The community is widespread in the northern part of the Little Karoo from Kruisrivier (3320CA) to Calitzdorp (3321DA). It is mainly found on level plains or plateaus of low hills. These are typically covered by medium-sized quartz debris which is often mixed

with sandstone or shale. Shallow to moderately deep soils (5–25 cm) consist of loamy sand or clayey-sandy loam with medium stone content (40 % of mass). Soil pH is generally neutral to slightly alkaline (median: 7.6) and the salinity is high to very high (0.29–9.8 mS/cm).

D15 Gibbaeetum pachypodii ass. nova hoc loco

Holotypus: Tab. 5, rel. no. 67 (field code: 7318.0)
(*Gibbaeum pachypodium* Succulent Dwarf Shrub Community)

Floristic composition: The diagnostic species of this community are *G. pachypodium* (dominating), *Crassula congesta* and an unknown taxon of Asteraceae (Schmiedel 109859 HBG). Common taxa with high constancy include *Hereroa tenuifolia*, *Tripteris sinuata* var. *linearis*, *Berkheya cuneata* and *Pteronia flexicaulis*.

Life-form & structure: Depending on the cover of *G. pachypodium*, the total cover of the vegetation varies greatly between 5 and 25 %. The average number of species per relevé is 8 spp. The community is dominated by compact, cushion-like micro- and nano-chamaephytes such as *Gibbaeum pachypodium* and *G. heathii*. However, high constancy of fruticose, non-succulent mega-chamaephytes (e. g. *Pteronia flexicaulis*, *Tripteris sinuata* var. *linearis*, *Berkheya cuneata*, and unknown taxon of Asteraceae: Schmiedel 109859 HBG) as well as fruticose, leaf-succulent micro-chamaephytes and nano-chamaephytes (e. g. *Hereroa tenuifolia*, *Crassula congesta*) result in a heterogeneous structural pattern.

Distribution & habitat: The community is restricted to the vicinity of Ockertskraal (3321C) in the central part of the Little Karoo. It occurs here on very gentle slopes, shallow, stony soils densely covered with medium-sized to coarse quartz debris or sandstone rubble. The soils are slightly acid (pH: 5.0–6.5) and moderately saline (> 2.5 mS/cm).

Community Group E

E16 Drosanthemo duplessiae-Psilocauletum juncei ass. nova hoc loco

Holotypus: Tab. 6, rel. no. 2 (field code: 5068.0)
(*Psilocaulon junceum* Shrubland Community)

Floristic composition: The diagnostic species of this association are *Psilocaulon junceum, Drosanthemum duplessiae* and *Phyllobolus nitidus. Psilocaulon junceum* usually dominates, at some localities being joined by *Malephora lutea* and *Prenia tetragonia*. All dominant species are typical indicators of disturbance and are often found on "heuweltjies" (paleo-termitaria) characterised by biogenic disturbance and high carbonate content (Lovegrove & Siegfried 1986). Other common species of high constancy include *Hereroa tenuifolia* and *Ruschia inclusa*.

Life-form & structure: The vegetation cover in the community is very high (> 30 %) and surpasses all other communities. The species richness is very low – only one relevé listed more than 6 species. The Drosan-

Tab. 6. Relevé table of the Drosanthemo-Psilocauletum juncei (Comm. E16).

Relevé No.	1	2	3	4
Community Group	E	E	E	E
Community	16	16	16	16
Field code	5066,0	5068,0	5112,0	5130,0
SA National Grid	3320DA	3320DA	3320CB	3320DA
Latitude [degrees.minutes] S	33,42	33,42	33,33	33,40
Longitude [degrees.minutes] E	20,42	20,42	20,18	20,35
Aspect [degrees]	-	-		-
Slope [%]	0	0	4	0
Soil depth [cm]	38	23	38	37
Stone cover non-quartz [%]	0	0	0	0
Stone cover quartz [%]	0	0	0	0
Stone content in soil [% of mass]	33	42	12	62
Soil texture	Su	Lt	Su	Sl
Soil pH	8,3	8,0	8,1	8,3
Electric conductivity [mS/cm]	0,12	2,01	0,31	0,15
Carbonate [HCl test, class 1-5]	5	3,2	5	3,2
Cover [%]	57,7	35,1	66,1	60,5
Number of taxa	6	14	4	2
Psilocaulon junceum	7	6	8	8
Malephora lutea	2	5	.	.
Drosanthemum duplessiae	1	1	.	.
Phyllobolus nitidus	1	1	.	.
Ruschia inclusa	.	1	1	.
Prenia tetragona	5	.	.	.
Mesembryanthemum subtruncatum	1	.	.	.
Ruschia cradockensis subsp. *cradockensis*	.	2	.	.
Crassula subaphylla var. *subaphylla*	.	1	.	.
Tetragonia robusta	.	1	.	.
Tripteris sinuata var. *linearis*	.	1	.	.
Augea capensis	.	1	.	.
Lycium cinereum complex	.	1	.	.
Drosanthemum subcompressum	.	1	.	.
Galenia papulosa	.	1	.	.
Othonna alba	.	1	.	.
Pteronia pallens	.	.	1	.
Drosanthemum archeri	.	.	1	.
Drosanthemum crassum	.	.	.	1

themo-Psilocauletum juncei is a community of mega-chamaephytes. Besides, only fruticose, leaf-succulent micro-chamaephytes occur with moderate cover values.

Distribution & habitat: The community was recorded for the eastern (Geen Bedrog, 3320CA) and central part (area north of Warmwaterberg) of the Little Karoo. It is widespread here and typically populates "heuweltjies" (Lovegrove & Siegfried 1986, Moore & Picker 1991, Midgley

et al. 2002) with deep, well-drained, alkaline soils with low salt and high carbonate content.

Notes: *P. junceum* also occurs in the Namaqualand, south of Buffels Rivier (Klak & Linder 1998). In the Knersvlakte it has been ubiquitously recorded outside quartz fields (Schmiedel 2002b).

Discussion

Vegetation cover and species richness patterns

The sparse vegetation cover is one of the most characteristic features of the vegetation of quartz fields, both in the Little Karoo as well as in the Knersvlakte – the region with the highest concentration (and extent) of quartz fields (9 and 8 %, resp.). On the other hand, the vegetation occupying habitats outside the quartz fields in the Knersvlakte had higher cover (23 %) than in the Little Karoo (13 %) (Schmiedel & Jürgens 1999). The low vegetation cover of the Succulent Karoo shrublands of the Little Karoo can be attributed to a combination of low rainfall (240 mm per year) and shallow, stony soils. Similarly low plant cover (18 % on average) was recorded for Succulent Karoo vegetation occurring near Prince Albert (north of the Swartberg Mts.) with similarly low (167 mm) rainfall (Milton et al. 1992). The higher cover values of vegetation outside quartz field of the Knersvlakte are going on the account of to relatively more favourable water-supply conditions positively influenced by the regular occurrence of fog (Desmet & Cowling 1999) despite the low average annual rainfall (120–150 mm; South African Weather Bureau 1988).

The extraordinarily high vegetation cover in stands of the Drosanthemo duplessiae-Psilocauletum juncei are undoubtedly related to special habitat conditions – ancient termitaria (locally known as heuweltjies). These are of zoogenic origin, and formerly inhabited by termites, ants, and burrowing small mammals (Lovegrove & Siegfried 1986, Dean & Yeaton 1993, Laurie 2002, Midgley et al. 2002). Due to the accumulation of organic matter by ants and termites, the status of soil nutrients and soil organic matter is twice as high as in the soils of their surroundings (Dean & Yeaton 1993, Midgley & Musil 1990). The soils of the termitaria are also soft and well-drained (Lovegrove & Siegfried 1986). These conditions promote a vegetation of its own, typically dominated by species of vigorous growth with a higher nutrient requirement (Midgley & Musil 1990, Midgley et al. 2002), tolerance for pedoturbation and other kinds of disturbance.

As for species richness, the quartz fields and related habitats generally did not differ from the surrounding vegetation (11 spp. per rel.). Only the Zeuktophylletum suppositi (C6) showed a considerably high species richness (17 spp. per rel.). This again can be a reflection of special habitat conditions, including rocky, steep slopes, low electrical conductivity, and slightly acid soil pH. Such conditions are typical for the Upland Succulent Karoo (Hoffman 1986c) of the central Namaqualand and the Richtersveld

(Jürgens 1986). They provide a small-scale mosaic of substrate resulting in a mosaic of micro-habitats, resembling a rock garden. Habitat heterogeneity hence reduces competition and allows coexistence of different species in a small area (Hanski 1995). Such micro-habitats can support only dwarf plants, each having a very restricted root volume and clearly depicting the small-scale patterns of soil conditions (Desmet et al. 1998). The other communities are found on more homogeneous habitats, still exposed to stress resulting from high salinity, low soil pH, and low nutrient status. These extreme conditions restrict the species spectrum to a small number of specialists.

Mono-dominance of communities

Mono-dominance (tendency to exclusive dominate the above-ground biomass) by certain species in plant communities is a characteristic feature of many southern African quartz fields (Schmiedel 1994, 2002b, Schmiedel & Jürgens 1999). This phenomenon is not a universal phenomenon across the quartz-field communities, but it seems to be more frequently encountered in habitats suffering from (at least seasonal) edaphic aridity associated with high salt contents in soil. Rocky, non-saline quartz fields, with a moderate soil depth, typically support poly-dominant plant communities (Schmiedel 2002b).

Adverse growing conditions (e.g., low water storage capacity and negative osmolarity due to high concentration of salts) have been serving as effective abiotic filters and supposedly performing an important evolutionary role in selecting for morphological-anatomical and physiological traits leading to increased fitness of the plants in habitat such as quartz fields.

Edaphic specialists are typically restricted to habitats where potential competitors are excluded (Gankin & Major 1964, Proctor & Woodell 1975, Kruckeberg & Rabinowitz 1985, Baskin & Baskin 1988, Ware 1990). This leads to spatial monopoly of these specialists and can result in formation of mono-dominant vegetation stands.

The presumed role of salt content in quartz fields corroborates well the ecological conditions in salt marshes also being characterised by high salinity. These habitats are notorious for supporting species-poor and mono-dominant plant assemblages (Adam 1981, 1990, Adam et al. 1988, Ellenberg 1996). The ecological phenomenon of salt-tolerance and its relations to species diversity and vegetation patterning is a well-studied phenomenon (see for instance Chapman 1975, Albert 1982, Adam 1990, Grillas et al. 1993).

Patterns of geographic distribution

Most of the obligate quartz-field taxa have a very restricted distribution (Schmiedel 2002a, 2004). This is also true for several *Gibbaeum* taxa and other Mesembryanthema recorded in this study. *G. dispar*, *G. hortenseae*, *G. pachypodium*, *G. petrense*, and *G. velutinum* as well as *Zeuktophyllum suppositum* are restricted to triangle spanning between Barrydale, Vanwyksdorp and Ockertskraal (3320DC, 3321CC, CD, DA) in the southern sec-

tion of the Little Karoo. This area forms a local centre of endemism within the Little Karoo. *G. haaglenii* is confined to the Swellendam area south of the Langeberge.

Obviously the restricted distribution of the studied plant communities reflects the limited distribution of the diagnostic taxa of the genus *Gibbaeum*, and it is also closely associated with the discontinuous distribution of the quartz-field habitats (Schmiedel 2004). However, not all locally endemic communities in the Little Karoo are restricted to the quartz fields. Some of them are found in other habitats, such as shale bands (the Gibbaeetum dispar and the Gibbaeetum velutini), sandstone gravel beds (the Gibbaeetum pachypodii), and other rocky outcrops (the Zeuktophylletum suppositi). The Gibbaeetum nuciformis, Gibbaeetum gemini, Gibbaeetum gibbosi, Gibbaeetum heathii, Gibbaeetum pubescentis, Gibbaeetum shandii, Aridario-Pteronietum pallentis as well as the Drosanthemo-Psilocauletum juncei are widespread in the western part of the Little Karoo and one of them (the Gibbaeetum gibbosi) also occurs in the neighbouring Tanqua Karoo. The majority of the widespread communities are therefore phytosociologically related to Community Group D, defined by a number of widespread succulents and non-succulent karoo shrubs.

The broader geographical distribution of Communities 8–14 is associated with a broader range of soil conditions as compared to Communities 1–7, and 15 (Tab. 7), which show a restricted distribution. The soils of the latter group are acid and their pH is generally lower than that of the widely distributed communities. The difference between the lowest and highest values of the soil pH is < 2 for most of the locally restricted communities, whereas it reaches pH values 2 or more for the majority of the widespread communities. Only the Gibbaeetum gemini shows a narrow range of soil pH (1.3). As to the electrical conductivity, the locally restricted communities show generally higher mean values and a narrower amplitude (< 3 mS/cm) for most communities (except for the Gibbaeetum albi). Carbonate has not been detected in soils supporting any of the locally restricted communities, in contrast to the widely distributed group. Soil depth and stone cover also show lower variance in the localised communities than in the widespread communities. The differences are less pronounced though.

The very narrow amplitude of soil conditions of Communities 1–7, and 15 (Tab. 7) corroborates with strong ecological specialisation of the diagnostic and dominating species – dry, often extremely saline habitat conditions generating water and nutritional stress. Such specialisation and its subsequent structural adaptations obviously go along with decreased competitive capacity, which excludes these communities from nutrient-rich (and mesic) habitats and therefore impede the extension of their distribution beyond the archipelago-like habitat islands in a small area. The quartz-field vegetation in the Namaqualand shows a very similar association between habitat specialisation and restricted range of distribution (Schmiedel 2002b).

Tab. 7. Statistics about the communities and habitat conditions. Median, minimum and maximum of plant cover values, species numbers and abiotic habitat features.

Community		1	2	3	4	5	6	7	8	9.1	9.2	10	11	12	13	14	15	16
Plant cover values	Median	17.5	8.7	10.1	2.1	5.2	6.5	6.3	6.7	7.7	7.6	9.6	10.8	10.4	8.4	4.4	9.8	59.1
	Min	12.0	4.2	8.0	0.1	3.1	1.7	2.1	0.1	3.1	2.6	4.4	6.6	4.1	3.6	0.2	4.7	35.1
	Max	38.1	18.3	12.2	21.2	5.5	8.8	30.5	27.6	14.7	14.1	37.0	37.7	33.6	22.0	21.4	26.2	66.1
Number of species	Median	3	5	4	4	5	17	6	8	8	10	11	6	7	10	6	8	5
	Min	3	4	1	1	4	6	4	1	4	2	6	5	4	5	2	7	2
	Max	5	11	7	7	9	21	11	22	18	20	19	17	12	17	16	11	14
Inclination	Median	6	8	9	4	2	21	10	2	4	4	4	3	1	2	2	5	0
	Min	3	4	0	2	0	11	2	0	0	0	0	0	0	0	0	3	0
	Max	17	22	12	22	13	25	16	11	9	29	15	11	6	7	17	6	4
Soil depth	Median	13	5	10	10	5	15	9	21	15	13	18	15	10	18	20	13	38
	Min	10	5	5	5	5	5	5	2	4	2	4	5	5	6	5	5	23
	Max	20	10	20	20	5	35	10	35	32	30	32	30	20	28	30	15	38
Stone cover non-quartz	Median	0	20	0	0	52.5	21.5	0	7.5	0	5	32.5	37.5	40	60	60	0	0
	Min	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Max	5	99	70	5	99	52	10	100	70	172	90	100	90	105	90	80	0
Stone cover quartz	Median	90	60	80	96	73	50	90	72.5	80	80	0.5	12.5	15	18	36	90	0
	Min	86	0	30	75	0	0	85	0	20	0	0	0	0	0	0	0	0
	Max	93	83	100	100	85	100	96	91	96	100	75	95	90	86	95	95	0
Stone content	Median	22	50	4	24	57	53	37	24	50	58	50	35	25	33	41	38	38
	Min	5	20	1	10	25	10	30	2	12	19	0	1	1.5	8	27	33	12
	Max	44	69	62	62	80	70	52	80	75	85	84	70	50	80	60	56	62
Soil pH	Median	4.1	5.0	4.1	6.4	6.5	5.8	7.0	7.3	7.5	6.0	7.7	6.8	7.8	7.3	7.6	5.9	8.2
	Min	3.8	4.3	3.7	5.1	5.2	4.3	7.0	6.3	5.4	4.0	6.0	5.4	6.7	5.0	5.6	5.1	8.0
	Max	5.2	6.0	5.2	6.7	7.4	7.1	8.1	8.2	8.5	7.6	8.3	8.2	7.9	8.1	8.1	6.5	8.3
El. Conductivity	Median	2.0	0.5	2.3	4.5	0.5	0.6	4.6	1.8	4.8	1.4	0.1	0.4	1.6	0.5	3.4	1.7	0.2
	Min	0.4	0.3	0.5	1.2	0.03	0.1	3.0	0.2	<0.01	0.03	0.03	<0.01	0.1	0.0	0.3	0.3	0.1
	Max	3.1	1.7	3.3	8.6	1.9	1.8	6.0	6.8	7.8	7.6	2.0	2.9	6.6	5.7	9.8	2.3	2.0
Carbonate	Median	0	0	0	0	0	0	0	0	0	0	1.5	0	0	0	0	0	4.1
	Min	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.2
	Max	0	0	0	0	0	0	0	4	2	0	4	1	2	4	2	0	5

Conservation status of the plant communities

Most of the quartz-field communities of the Little Karoo have a very restricted size of distribution area and are highly specialised to particular habitat conditions. Agricultural land-use in the Little Karoo is largely restricted to rangeland farming with sheep, goats, game and ostrich. Only few quartz-field habitats are formally protected in nature reserves (e.g., the Anysberg Nature Reserve of Western Cape Nature Conservation Board). Overstocking of sheep and game, and particularly the very intensive ostrich farming in the western part of the study area (Oudtshoorn area), have a devastating impact on the dwarf succulents typically dominating the quartz-field vegetation. Due to the restricted distribution range and habitat specialisation the quartz-field communities in the Little Karoo and adjacent regions (incl. the Gibbaeetum velutini, Gibbaeetum angulipeds, Gibbaeetum albi, Gibbaeetum dispar-Lampranthion altistyli, Gibbaeetum dispar, Zeuktophylletum suppositi, Gibbaeetum

pubescentis, Gibbaeetum gibbosi, Gibbaeetum gemini, Gibbaeetum shandii, and Gibbaeetum pachypodii) have to be regarded as highly vulnerable.

The Drosanthemo duplessiae-Psilocauletum juncei, Aridario defoliati-Pteronietum pallentis, Gibbaeetum heathii, and the Gibbaeetum nuciformis have a broader distribution and are therefore less affected by the current land-use practices.

The Delospermo-Gibbaeetum haaglenii is an endemic community to a small area experiencing strong pressure from agriculture (extensive ploughing for grain fields). Only very shallow and rocky soils as well as hills are left out of the ploughing schemes. The small islands of the stands of this community are limited to unploughed hillocks. It is likely that the community used to be more common in the past, but became extremely limited due to demise of suitable habitats.

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Appendix 1: Lists of taxa with one or two occurrences in the Tables 3, 4 and 5. Transformed cover-abundance value is followed by the relevé number given in brackets.

Tab. 3: *Atriplex semibaccata* 1(10), *Berkheya spinosa* 1(32), *Blepharis inermis* 1(28), *Braunsia geminata* 1(8), *Cephalophyllum subulatoides* 1(31), *Crassula capitella* subsp. *thyrsiflora* 1(16), *Crassula cotyledonis* 1(1), *Crassula muscosa* var. *muscosa* 1(32), *Crassula muscosa* var. *obtusifolia* 1(31), *Crassula rupestris* 1(30), *Crassula subaphylla* var. *subaphylla* 1(32), *Crassula tecta* 1(32), *Dicoma relhanioides* 1(29), *Drosanthemum delicatulum* 1(29), *Euphorbia pillansii* 1(31), *Euphorbia susannae* 1(8), *Euryops subcarnosus* subsp. *subcarnosus* 1(32), *Glottiphyllum depressum* 1(15), *Glottiphyllum neilii* 1(8), *Gnidia deserticola* 1(30), *Hirpicium alienatum* 1(31), *Octopoma octojuge* 1(29), *Oedera squarrosa* 1(7), *Osteospermum microphyllum* 1(35), *Osteospermum polygaloides* 1(8), *Phyllobolus splendens* subsp. *splendens* 1(25), *Psilocaulon junceum* 1(37), *Pteronia incana* 1(8), *Pteronia membranacea* 1(23), *Ruschia cymosa* 1(33), *Salsola* sp. US 7329 1(9), *Sceletium tortuosum* 1(37), *Tripteris tomentosa* 1(1), *Zeuktophyllum calycinum* 1(32), *Zygophyllum divaricatum* 1(7), *Zygophyllum flexuosum* 1(29).

Tab. 4: *Albuca longifolia* 1(56), *Albuca* sp. 9182 1(90), *Antimima fergusoniae* 1(80), *Antimima* sp. 104745 1(21), *Antimima wittebergensis* 1(68), *Asparagus capensis* var. *capensis* 1(19), *Blepharis inermis* 1(52), *Brownanthus ciliatus* subsp. *ciliatus* 1(25), *Crassula congesta* subsp. *laticephala* 1(15), *Crassula deltoidea* 1(52), *Crassula nudicaulis* var. *platyphylla* 1(31), *Crassula rupestris* 1(74), *Crassula tetragona* subsp. *acutifolia* 1(42), *Crassula tomentosa* 1(74), *Eriocephalus grandiflorus* 1(81), *Euphorbia juglans* 1(61), *Euryops subcarnosus* subsp. *subcarnosus* 1(16), *Gazania krebsiana* complex 1(21), 1(65), *Gibbaeum nebrownii* 5(90), *Glottiphyllum fergusoniae* 1(87), *Glottiphyllum regium* 5(27), *Haworthia viscosa* 1(15), *Hereroa* sp. 110134 1(62), *Hermannia filifolia* 1(73), *Lampranthus altistylus* 1(87), *Malephora flavo-crocea* 1(27), *Othonna cylindrica* 1(15), *Othonna protecta* 1(31), *Othonna quercifolia* 1(47), *Plumbago tristis* 1(37), 1(57), *Prenia tetragona* 1(86), *Pteronia oblanceolata* 1(73), *Pteronia* sp. 110033 1(89), *Ruschia cradockensis* subsp. *triticiformis* 1(52), *Ruschia inclusa* 1(71), *Ruschia leucosperma* 1(30), *Salsola* sp. 110026 2(25), 1(89), *Salsola* sp. US 7302 1(22), *Sarcocaulon salmoniflorum* 1(13), *Trichodiadema densum* 1(17), 1(80), *Trichodiadema* sp. US 5148 1(41), 1(84), *Tripteris sinuata* var. *sinuata* 1(90), *Tylecodon paniculatus* 1(86), *Tylecodon wallichii* 1(59), unknown Fabaceae sp. 110034 1(88), unknown geophyte sp. 104793 1(16).

Tab. 5: *Aloe variegata* 2(52), *Augea capensis* 1(30, 34), *Blepharis inermis* 1(35), 2(65), *Brownanthus ciliatus* subsp. *ciliatus* 1(62), *Bulbine succulenta* 1(6), *Crassula muscosa* var. *obtusifolia* 1(15), *Crassula nudicaulis* var. *nudicaulis* 1(13), *Crassula subaphylla* var. *virgata* 1(64), *Crassula tecta* 1(10, 49), *Cylindrophyllum* sp. 102162 1(48), *Dicoma relhanioides* 1(17, 18), *Drosanthemum praecultum* 1(10), *Drosanthemum subcompressum* 2(2), *Elytro-*

pappus rhinocerotis 1(23), *Euphorbia arceuthobioides* 1(6), *Felicia cana* 1(15), *Galenia africana* 1(16), *Galenia fruticosa* 1(22), *Gazania krebsiana* complex 1(56), *Glottiphyllum fergusoniae* 1(54, 63), *Glottiphyllum neilii* 1(10), *Glottiphyllum regium* 5(61), *Haworthia aspera* 1(10), *Haworthia viscosa* 1(15, 64), *Hirpicium integrifolium* 1(20), *Malephora* sp. 109847 6(16), *Mesembryanthemum guerichianum* 1(8), *Mesembryanthemum subtruncatum* 1(51), *Othonna protecta* 1(34), *Phyllobolus nitidus* 1(28), *Plumbago tristis* 1(56), *Prenia tetragona* 1(44, 54), *Pteronia glauca* 1(3), *Pteronia glomerata* 5(23, 25), *Pteronia oblanceolata* 1(8), *Ruschia leucosperma* 1(59), *Ruschia spinosa* 1(21), 2(25), *Salsola* sp. 110095 1(35, 62), *Salsola* sp. US 9174 1(61), *Salsola tuberculata* complex 1(2), *Sarcocaulon salmoniflorum* 1(39), *Selago* sp. 104748 1(15), *Trichodiadema attonsum* 1(9), *Trichodiadema setuliferum* 1(10).